UNIVERSITY OF WAIKATO

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From willingness to engage to willingness to pay: A behavioral experiment on green consumer information in a digital product passport

Zack Dorner, Steven Tucker, Abraham Zhang and Anna Heuber

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Corresponding Author

Zack Dorner
Department of Environmental Management
Lincoln University, NZ
Email: zack.dorner@lincoln.ac.nz

Steven Tucker
School of Accounting Finance and Economics
Te Raupapa – Waikato Management School
University of Waikato
Email: steven.tucker@waikato.ac.nz

Abraham Zhang
Adam Smith Business School
University of Glasgow
Email: Abraham.Zhang@glasgow.ac.uk

Anna Huber
University of Natural Resources and Life Sciences, Vienna
Email: anna.huber@boku.ac.at

Abstract

Information represents the "third wave" of environmental policy. Existing evidence shows consumers increase their willingness to pay (WTP) for environmentally friendly products with clear labelling. However, there is a gap in the literature regarding whether consumers have a willingness to engage (WTE) with detailed information, for example, through a Digital Product Passport (DPP). This technological innovation is part of the European Union's new circular economy action plan. In our theoretical model, a green consumer decides whether to invest in information on how to mitigate their environmental damage, but at a cognitive cost. We test the model in a lab experiment selling an environmentally friendly toothbrush, but information about its environmental credentials is only available through a DPP. We find education on the DPP's purpose is key to increasing revealed WTE when a DPP is available. Participants with a high stated WTE engage with the DPP regardless; the increase in revealed WTE comes from those with a lower stated WTE. Engagement with the DPP, in the case that it contains positive environmental information, increases WTP. The policy implications of our results are that education about the purpose of the DPP is required in order to increase the likelihood of actual consumer engagement with it, as long as it is user friendly. However, engagement with a DPP may not lead to further shifts in environmental orientation and behavior. Our study also demonstrates novel measures of WTE, and how these can be used to understand pro-environmental consumer behavior in a theoretically informed manner.

JEL Classification

C92, D12, D18, D63, D64, D91.

Keywords

Circular economy
digital product passport
consumer behavior
ecolabel
green consumerism
information-based instruments
pro-environmental behavior

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Introduction

Information disclosure has been called the "third wave" of environmental policy, after command and control regulations and pricing mechanisms (Kotchen, 2013; Tietenberg, 1998). While Pigouvian pricing has the potential to be first best, correcting information asymmetries can be utilized when pricing policies are difficult to implement, for example when political will is insufficient (Lohmann et al., 2022); or when the cost of external damages are hard to estimate and currently unavailable, such as the impact of plastic production and consumption (Baker et al., 2024). There is ample evidence of consumers' willingness to pay (WTP) for environmentally friendly product attributes (Majer et al., 2022). Therefore, one type of "third wave" environmental policy is independently increasing credible information disclosure to consumers, thus increasing demand for environmentally friendly products, and helping correct market failure by shifting production towards more environmentally sustainable practices (Cason & Gangadharan, 2002; Shimshack, 2020). It may also provide benefits to "green" consumers by providing access to information about environmental or public good attributes of the goods they are purchasing, allowing them alter their choices as per their environmental preferences and increase their utility (Kotchen, 2013; Shimshack, 2020).

In general, the literature conceptualizes green consumers as somewhat passive recipients of information, rather than taking an active role in seeking information (Heyes et al., 2020). Consumers are said to lack information, for reasons ranging from a knowledge deficit about environmental impacts of specific products and behaviors (van Valkengoed et al., 2022), to firms with low environmental performance intentionally greenwashing when environmental claims are hard to understand and verify (Cason & Gangadharan, 2002; Fernandes & Valente, 2021). One logical solution is providing environmental information by a credible and independent party; there is a range of evidence that consumers indeed take this new information into account and adjust their WTP for products according to their pro-environmental preferences (Cason & Gangadharan, 2002; Fernandes & Valente, 2021; Lohmann et al., 2022; Shimshack, 2020). These motivations have successfully supported the implementation of a range of government supported consumer information programs, such as the now ubiquitous Energy Star energy efficiency rating system, and mandatory fuel efficiency labels on vehicles (Brucal & Roberts, 2019; Newell & Siikamäki, 2014; Taufique et al., 2022). On the other hand, mass media information campaigns have proven less successful (Ölander & Thøgersen, 2014). However, there is a gap in terms of understanding consumers as active participants who invest in obtaining information (Heyes et al., 2020).

In contrast, the wider economic literature on consumption includes the search cost approach, whereby consumers acquire information on consumption goods up until the point where the expected marginal benefit of further information acquisition is equal to the expected marginal cost (Caplin & Dean, 2015; Stigler, 1961). In our case, as consumers now shop with access to the internet regardless of whether they are in-store or online (e.g. through smartphones), there is increasing potential for consumers to seek out detailed product information, such as blockchain enabled supply chain data (Fan et al., 2022). Hence, there is a need to broaden the conception in the literature of how a green consumer becomes informed. It should include the willingness to search out and engage with information about products, in addition to the response to the provision of ecolabels and prominent information labels such as Energy Star.

The Digital Product Passport (DPP) is a regulatory element in the European Union (EU)'s new circular economy action plan. As a technological innovation, DPP is designed to collect a product's information throughout its lifecycle and share it with a wide range of stakeholders by easily accessible means, for example, a QR code on a product or an online link. Such data may cover basic product attributes such as country of origin and model number, as well as sustainability and circularity related information on production and transport emissions, embedded components and materials, chemical substances, and instructions for repair, disassembly, recycling, and sustainable disposal (Adisorn et al., 2021). By enhancing product traceability and supply chain transparency, DPP is meant to empower consumers to make more informed and sustainable purchase and consumption decisions leading to greater resource circularity and emissions reductions (Zhang & Seuring, 2024). A successful DPP rollout hinges on consumers' willingness to engage (WTE) with it to inform their purchase and consumption decisions. It is possible that many consumers may ignore the DPP and continue making purchase and consumption decisions without accessing this new information source. There is a gap in the literature on the extent to which consumers are willing to engage with detailed information such as that contained within the DPP, how they will use that information if they do engage, and whether they connect their consumption decisions with the transition to the circular economy. Indeed, filling this gap is important to maximize the potential benefits of the DPP in its implementation, as well as any future increase in information available to consumers about product circularity attributes.

The aim of this paper is to investigate consumer WTE with detailed environmental product information, how WTE can be influenced, and whether the level of engagement with

positive environmental information about a product increases WTP. We do this by running a lab experiment eliciting WTP for an environmentally friendly toothbrush. The toothbrush does not appear particularly eco-friendly in absence of the information contained in a DPP. We elicit a baseline WTP, and then a second WTP whereby we assign participants into a control group (baseline repeated), a DPP group (DPP is made available for participants to review) and a DPP+ group (participants are additionally given an educational video about the purpose of the DPP in supporting a circular economy). We measure revealed WTE on whether participants access the DPP and the amount of time spent looking at the DPP, as well as a stated WTE measure through a series of Likert-scale questions.

We find the educational video and knowledge about the product's environmental attributes (DPP+ treatment) increases revealed WTE, which increases WTP. However, it does not shift stated WTE, or any other environmental orientation measures. Our results show the potential for the DPP to increase demand for green products, and the role that educating consumers of the importance of using the DPP for this purpose. We also contribute methodologically by providing a measure of both stated and revealed WTE, and demonstrate their role in consumer demand in a theoretically informed manner.

Literature review

A handful of papers have utilized lab and field experiments to study the impact of information labels in environmentally friendly consumption. In the lab, the focus of several papers has been understanding information disclosure regimes (such as voluntary and certified) on market efficiency, looking at both buyer and seller behavior (Bougherara & Piguet, 2009; Cason & Gangadharan, 2002; Fernandes & Valente, 2021; Jin, 2021). Bougherara and Piguet (2009) specifically include information costs that consumers must bear if they are to understand the ecolabels on the products. They find a high information cost (relative to low) induces adverse selection with consumers looking to other signals of quality rather than bearing the information cost. These past efforts underline the value of the lab in providing a high level of control over the setting and treatments, and being able to collect extensive data on the participants to understand their choices.

A range of field experiments that focus on consumer behavior test the effectiveness of product information provision, alongside other interventions such as nudges. Lohmann et al. (2022) test a carefully designed carbon footprint information label, which led to a 4.3% reduction in average carbon emissions per meal across 5 university cafeterias. In a similar

study, Beyer et al. (2024) show the importance of label design and information contents, with carbon footprint expressed in monetary terms being the most effective label for reducing the carbon footprint of meal choices. Jalil et al. (2020) point to the role of education, finding that a 50 minute lecture on climate impacts of food choices led to a persistent switch in student meal choices compared to a control group with a placebo lecture.

Other field or stated preference experiments have shown the role of type of information provided, and the importance of understanding consumer heterogeneity such as differing levels of environmental orientation or knowledge deficit. Asensio and Delmas (2015) trial environmental, health and monetary information messaging to encourage US consumers to save electricity. They find the environmental and health messages were more effective than monetary, leading to 8% electricity savings on average. Skourtos (2021) find adding annual running cost information to energy efficiency labels for refrigerators does not impact stated consumer choice, given these costs are small to begin with. Gao and Tavoni (2024) test both private savings and environmental information treatments on online lightbulb purchases in China. They find a temporary effect for informed consumers, suggesting a saliency channel of behavior change, and a lasting impact on uninformed consumers, pointing to the role of information when there is a genuine knowledge deficit. Indeed, Alcott and Knittel (2019) find no effect of fuel efficiency information provision on car purchases, arguing that it is evidence that consumers are not poorly informed or inattentive to this attribute of vehicles.

From a policy perspective, a key point to note is that improved product information can potentially have an enduring impact on demand if green consumers are uninformed about the environmental attributes of a product. Once the uninformed receive more information, they update their beliefs and hence increase or decrease their WTP for a product depending on whether they receive good or bad news (Gao & Tavoni, 2024; Lohmann et al., 2022). This contrasts information interventions with green nudges, which leverage behavioral insights to shift consumer choices, particularly in situations where typically cognitive investment is low and individuals rely more heavily on heuristics to make decisions (van Valkengoed et al., 2022). The limited studies to date on the long run impacts of nudges suggests their influence wanes over time (Carlsson et al., 2021). Nudges by their nature may not speak to individual's deeper motivations and values in the same way as information.

Van Valkengoed et al. (2022) point out that the literature has developed and tested a wide range of interventions to increase pro-environmental behaviors (PEBs), including

provision of information and education. However, in order to effectively apply an intervention to increase a specific PEB, the barriers and drivers of that behavior need to be understood and matched to the appropriate intervention. Information provision assumes a knowledge deficit. In our case there are two potential knowledge deficits – first, about the product itself, and second, about the purpose of the DPP; how it can be utilized, and how it contributes to a transition to a circular economy. Whether an understanding about the policy (or intervention) and its purposes can increase its effectiveness is a gap in van Valkengoed et al. (2022), and something we test here. Indeed, a number of papers look at whether interventions to increase PEBs can increase policy support (Carrico et al., 2015; Knook et al., 2022; Tobler et al., 2012; Werfel, 2017), but there is a gap in terms of the other way around; whether policy understanding and support can increase its effectiveness.

One other related literature is the energy-efficiency gap, which is a longstanding puzzle whereby consumers and firms systematically fail to adopt the most cost-effective technologies. Agents do not invest upfront in initially more expensive physical capital/durable goods that would save them money over time in reduced energy bills, for example energy efficient refrigerators or hybrid cars (Gerarden et al., 2017). There are multiple dimensions to this puzzle, from information-based market failure (e.g. landlords obscuring energy usage of buildings for let) to cognitive limitations of individual consumers in understanding and calculating the long term energy savings of an upfront investment (Brent & Ward, 2018; Gerarden et al., 2017).

Interestingly, the energy-efficiency gap literature does not in general consider the possibility of green consumers, who wish to reduce their energy consumption to reduce their environmental impacts, but do so sub optimally for behavioral reasons (cf. Dorner, 2019 and their comments on the rebound effects literature; see Gerarden et al., 2017). This is despite the evidence that, for example, energy efficiency purchases are seen as a political statement, whereby left-leaning consumers are more likely to purchase them whereas right-leaning ones do not (Gromet et al., 2013). Hence, there is also a need to broaden the conception of energy efficiency gap to include moral or warm glow motivations regarding their environmental (public) benefit (Andreoni, 1990; Chan & Kotchen, 2014; Dorner, 2019), and consider behavioral drivers of these choices. This is relevant to both energy efficiency and more complete, life-cycle environmental impact of consumption goods.

As previously mentioned, environmental product labelling, or eco-labelling, has been shown to increase WTP for products with positive environmental attributes. Research to understand this has looked into specific labels and attributes, the value of these, and whether interventions such as providing information or behavioral interventions such as nudges has an impact on WTP (Majer et al., 2022). Some work has been done on consumer preferences on the environmental performance of products throughout the products' lifecycle, but there are many gaps in both the research as well as actual consumer information available at the point of purchase (Marcon et al., 2022). However, as Majer et al. (2022) note, much of this literature is based on stated preference surveys, and does not involve theoretical models. In our paper, we use revealed preferences within a highly controlled lab environment, and draw on theory around pro-environmental behaviors and spillovers to provide testable hypotheses related to our research aims.

The eco-labelling literature looks at a wide range of products and eco-labels, with a strong focus on specific areas such as food (Majer et al., 2022). Boyer et al. (2021) provide one of the few studies looking specifically at circularity attributes for mobile phones and robot vacuums. They conduct a conjoint analysis from a stated preference survey of 800 UK consumers and find that overall consumers have a positive WTP for circularity. However, their results show that consumers generally have a lower WTP for products with a high level of recycled content (compared with medium and low), plus refurbished or reused products. In a representative household survey in Germany, Olsthoorn et al. (2023) find that consumers with a higher environmental identity are willing to pay for lower embedded energy usage (from manufacture) of refrigerators, and that durability is also valued by consumers on average. Additionally, we note Feuβ et al. (2022) show ecolabels are effective in increasing WTP in an online shopping environment too. We do not estimate WTP for specific circularity attributes, such as recycled content, as that is not the aim of our study. Our study investigates the application of the DPP on revealed WTP, by measuring both willingness to engage (WTE) with the DPP and actual purchasing decisions, as previously mentioned. We also test whether education about the goals of circularity changes WTE and WTP.

Method

Theoretical framework

We sketch a simple theoretical model to illustrate a few pertinent insights. We represent utility as a linear function of goods/attributes. This accords our model with the random utility model (RUM) from the valuation literature. In this literature, utility is a linear function of goods as a collection of attributes, and the aim is to uncover the value of these attributes in a comparative static context, such as the value of recreation in a natural area (Lancaster, 1966; Lupi et al., 2020). In our case, it fits with our experimental context where we are measuring discrete WTP for a single product, given varying levels of information about the product. We draw on A. Lange and Ziegler's (2017) formulation of a green consumer in the context of offsetting, who gains utility from reducing their damages of consumption. We note as well the relevance of related literatures, including impure public goods (Chan & Kotchen, 2014), behavioral rebounds (Dorner, 2019) and indeed the wider green consumption technology literature (Chan, 2024). Our conception of information is that it provides the ability to consume in a more environmentally friendly manner, making it a green technology in the sense outlined by Chan (2024).

Let a green consumer's utility from consuming polluting good x be given by:

$$u = \beta_w(w - px) + \beta_x x + \beta_{-d}(-d) - ck. \quad (1)$$

Here, w is the consumer's endowment of a numeraire good, which we assume for simplicity is non-polluting and provides marginal utility β_w; this provides a budget constraint given price p for good x. Next, β_x is the marginal utility from consuming the polluting good x. The consumer gains marginal utility β_{-d} from mitigating or offsetting what they believe to be the environmental damage associated with their own consumption, $-d$. Thus, β_{-d} represents on the extent to which the consumer cares about the environmental damage from their own consumption and will be 0 for the consumer who does not care, and negative if a consumer gains utility from environmental damage. This form is akin to A. Lange and Ziegler (2017), though we depart from their conceptualization by specifying that it is *believed* environmental damage. The consumer can also invest their time in gaining information, k, at marginal cost to their utility, c. To fit within the discrete choice set up of our model, we assume $x, k \in \{0,1\}$.

Additionally, we assume available information is believed by the consumer, and its use allows the consumer to reduce their believed environmental damage from consumption.[1]

The consumer's belief about their own damage from consumption is determined by:

$$d = (\bar{\delta} - \theta k)x, \tag{2}$$

where $\bar{\delta}$ is what they believe to be the average marginal environmental damage from consuming good x. The next part of the equation represents investing in information, k, in order to understand how to consume the good in a more environmentally friendly manner. This includes privately researching the various products sold into the market by different firms, to determine which one is most environmentally friendly, or engaging with the information in a DPP, if one is available. Thus, θ is the consumers' expected ability to reduce their environmental damage from consuming good x after investing in information.

Therefore, there are two ways in which the green consumer can reduce their believed own environmental damage; reducing their consumption of good x, or investing in information such that they can purchase the most environmentally friendly version of good x. A third option would be to offset their damage by essentially directly purchasing an environmental public good, for example by purchasing carbon credits or donating to an environmental charity (Chan & Kotchen, 2014). For the present exposition there is little to be gained from adding this option; thus, we assume that there is a no cost effective option available. This option should be included in a model that considers whether total environmental impact is improved with an information intervention; this is beyond the scope of the present paper. We also note that the cost of purchasing good x (and the cost of offsetting) directly enters the consumer's budget constraint, whereas the cost of investing in information, k, enters directly into the utility function as disutility.

Thus, substituting equation (2) into (1):

$$u = \beta_w(w - px) + [\beta_x + \beta_{-d}(\theta k - \bar{\delta})]x - ck. \tag{3}$$

The consumer purchases the good when $\beta_x > \beta_{-d}(\theta k - \bar{\delta})$, and $[\beta_x + \beta_{-d}(\theta k - \bar{\delta})] > \beta_w p$. The value of information is that it allows consumers to shift their consumption to more

[1] This assumption is made as our focus is specifically on consumer behavior in the presence of credible information; it is beyond the scope of the present paper to consider market changes on the producer side.

environmentally friendly goods, hence increasing their demand/WTP for more environmentally friendly options.

Therefore, the consumer will invest in information when they believe the information will provide them with sufficient ability to reduce the damages of their own purchasing behavior, relative to the cognitive or psychological disutility of seeking out this information; that is when $\beta_{-d}\theta x > c$. This condition shows that there are multiple factors that enter this decision, including their own disutility of their own believed damage, β_{-d}, their believed benefit from investing in information, θ, their level of consumption of the good, and their marginal disutility from investing in information, c.

Hence, we can generate predictions about sources of heterogeneity in propensity to access information, and policy interventions that could influence any of these channels. For example, we can see that consumers who consume a lot of the good are more likely to invest in information, *ceteris paribus*.[2] We might also predict that well educated consumers have a lower cost to accessing and processing information, c, and therefore are more likely to do so. This also points to the value of education for reducing c, but also increasing the perceived benefits of investing in information, θ. Indeed, our experiment measures revealed WTE with information, as well as whether it is possible to increase WTE through educating consumers about the benefits of doing so.

Thus, we reiterate and highlight some important points: i) consumers do have an active role in acquiring information about the environmental performance of products (Heyes et al., 2020), ii) consumers will engage with information to the point where their perceived benefits of their additional effort outweighs the cost (what we call revealed WTE), iii) educating consumers about a given ecolabel/information scheme such as the DPP may increase their perceived benefits of engaging with the label or information scheme, and iv) reducing the difficulty of engagement should increase the likelihood of engagement.

Behavioral considerations

A range of behavioral drivers are relevant in relation to green consumer decision making, as shown by a growing literature. We focus on two main aspects, relevant to our topic. First, we look at the pro-environmental behavior (PEB) literature based in behavioral sciences, and the

[2] This points to a potential information behavioral rebound, whereby consumers who are discouraged from consuming the good through Pigouvian pricing or other policies are then less likely to engage with environmental information about the good (adding to Dorner, 2019).

insights it can provide into drivers of PEBs and how interventions can influence PEBs. Second, we draw on these insights to consider persistent behavior change and spillovers; that is, the extent to which an information and education intervention supports enduring behavior change, and whether this leads to behavioral spillovers in other PEBs.

Van Valkengoed et al. (2022) provides an overview of a range of social psychology models that explain barriers and enablers of PEBs that can be target using interventions. These include the knowledge deficit model, protection motivation theory, norm activation model, value–belief–norm theory, value–identity–personal norm model, theory of planned behavior and focus theory of normative conduct. They then state that understanding the various drivers identified by the list of main theories provides guidance for which behavioral intervention/s are likely to increase a specific PEB, given their identified list of drivers that can be shifted using interventions.

According to the classification provided by van Valkengoed et al. (2022), the DPP constitutes an intervention of "Information about the environmental consequences of a specific behavior." These types of interventions are useful when problem awareness, ascription of responsibility, personal norms, self-focused emotions, attitudes and outcome efficacy are key determinants of the behavior (see Figure 1 in van Valkengoed et al. (2022, p. 1488)). We assume the DPP can help with some of these areas and thus increase WTE with the DPP and WTP for the product with the (positive) DPP information. We test these assumptions as well as the theory provided by van Valkengoed et al. (2022), by surveying subjects at the end of the experiment on these constructs. We add in many of the other determinants of behavior according to van Valkengoed et al. (2022) to test for any changes in those either, noting that van Valkengoed et al. (2022) includes only behavioral determinants that can be shifted through interventions.

Next, we test whether we can enhance the impact of the DPP with a between subject treatment that informs subject about the purpose of the DPP before they make their decisions. This treatment is supported by evidence in terms of enhancing ecolabels and product information, specifically increased education and framing (Truelove et al., 2022). On the other hand, the literature does provide for the possibility that consumers will not engage with DPP. If consumers suspect it holds bad news about the environmental impact of the toothbrush, they may keep their head in the sand and not engage (Benabou & Tirole, 2011; Karlsson et al., 2009), as that may decrease their utility and not provide a means to correct this. We of course

allow for this possibility of an "ostrich effect" in our design (Karlsson et al., 2009), and it would be one possible explanation if we find a null effect.

Finally, we investigate whether increased WTP for environmental attributes is associated with behavioral spillovers (Carlsson et al., 2020; Eby et al., 2019; Goetz et al., 2024; Maki et al., 2019; Truelove et al., 2014). The challenge of shifting to a more circular and sustainable economy requires widespread behavioral and economic system changes (Ellen MacArthur Foundation, 2013; Shevchenko et al., 2023). Hence, it important to understand behavioral spillovers; how an intervention to increase one PEB can lead to increases or decreases in a subsequent PEB (Goetz et al., 2024; Truelove et al., 2014). Positive behavioral spillovers could greatly enhance the effectiveness of a policy such as DPP, which is aimed at being an enabler for wider economic system change. Thus, our study considers how consumer engagement with the DPP is associated with further PEBs.

We measure this in revealed preferences using an environmental charity donation decision, and in stated intentions to change behavior in future. We then test the behavioral spillover theory. Positive behavioral spillovers should be supported by an aversion to cognitive dissonance (behavioral inconsistencies), whereby one PEB leads to further PEBs through an increased pro-environmental identity and personal norms. Negative behavioral spillovers would be consistent with moral licensing, warm glow or moral credits model, whereby the first PEB reduces negative emotions such as guilt and worry around a PEB, or alternatively satisfies the consumption of "warm glow", and thus reduces the need for a second PEB.

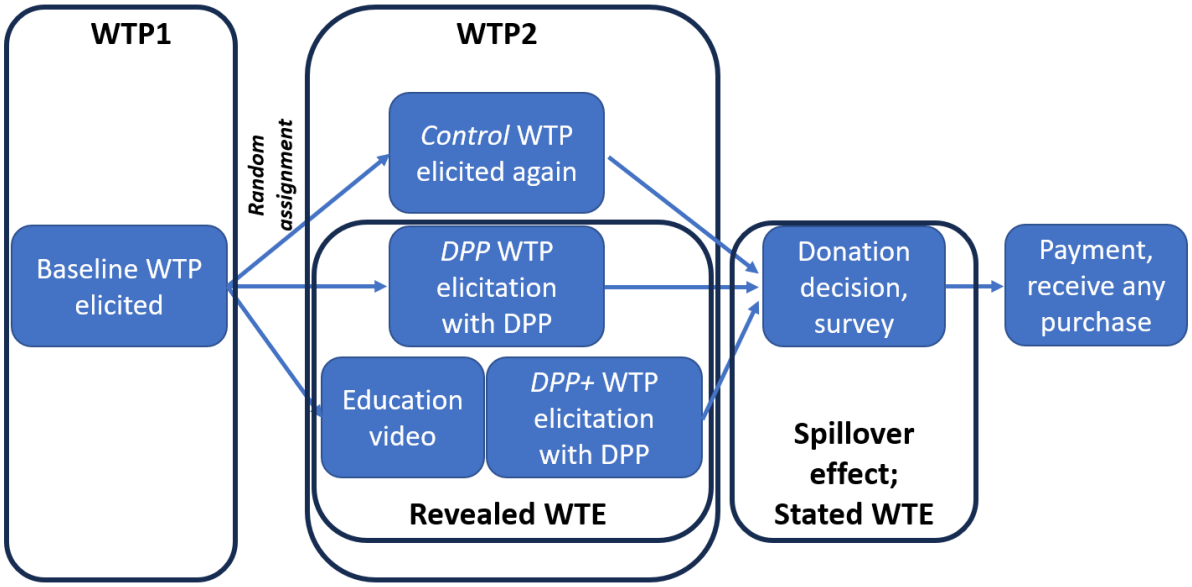
Experiment and Procedures

The experiment was conducted in the [REMOVED TO PROTECT ANONYMITY] between August 31 and September 7, 2023. A total of 131 subjects participated across 11 sessions. The Online Recruitment System for Economics Experiments (ORSEE)[3] was used to recruit participants university wide, and each participant only participated in a single session of the study. The experiment was computerized and programmed using the z-Tree software package (Fischbacher, 2007). Participants made all decisions via a computer within privacy screens, and thus all external stimuli were controlled and minimized. Participants progressed through the experiment independently at their own pace. Even though participants may have completed

[3] See Greiner (2015) for a discussion of the ORSEE program.

the experiment at different times, each session concluded when the last subject completed their tasks. Participants were asked to wait quietly until the experimenter announced the end of the experiment upon which they were paid privately as they left the laboratory. Each session lasted approximately 45 minutes on average.

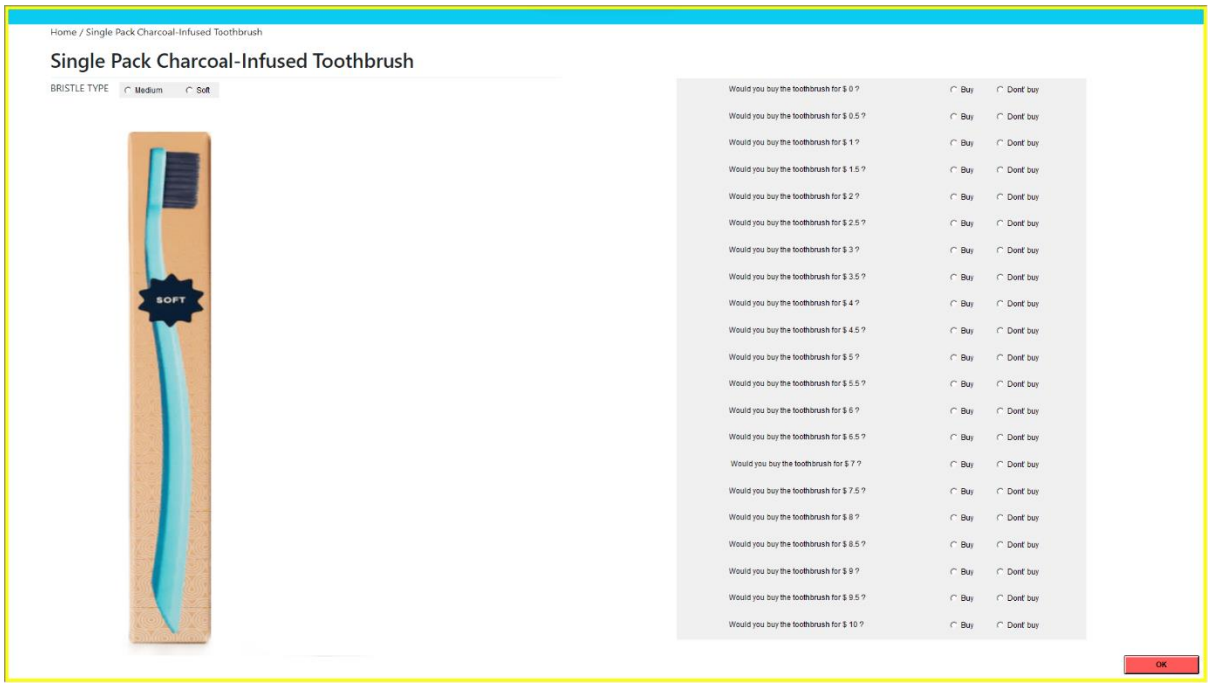
Figure 1 Full experimental design.



The experiment consists of three treatments: Control, DPP and DPP+. The full experimental design is shown in Figure 1.[4] First, all treatment groups participated in the Baseline WTP elicitation (WTP1), whereby participants were presented with the opportunity to purchase a toothbrush in an interface similar to an online shopping experience. The toothbrush is environmentally friendly, but as presented does not appear to be environmentally friendly, nor is there any brand or marketing information regarding these attributes. This is so that the DPP provided new information to participants about its environmental attributes, and accords with the important features of our theoretical model. That is, a typical consumer will assume it has average environmental impact for a toothbrush in absence of more information.[5] The decision screen is presented in Figure 2.

[4] Instructions are presented in the Appendix.
[5] Our results align with this assumption; the DPP and DPP+ treatments show significantly higher perceived environmental performance (see Table 3).

Figure 2: Decision Screen for the Baseline WTP elicitation, with close up on the top of the multiple price list (below).



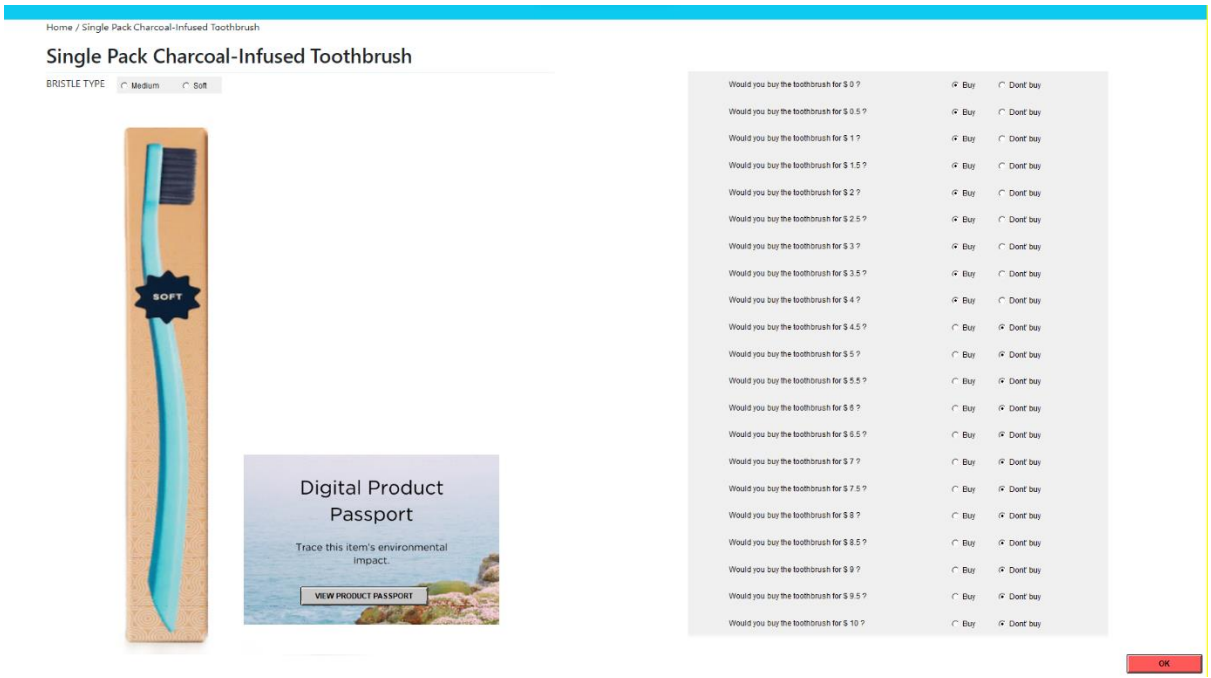
Participants were given $10 that could be used to purchase a toothbrush. Any unspent money was theirs to keep. To make a purchase decision, participants were asked to select their preference for bristle type (soft/medium) as well as indicate their maximum WTP via a list of 21 possible prices.[6] The prices ranged from $0.00 to $10.00 in increments of $0.50. For each price, participants selected whether to BUY or NOT TO BUY. Once a participant selected BUY (NOT TO BUY) for a given price, the computer automatically set all lower (higher) prices as BUY (NOT TO BUY). They could amend their decisions freely until clicking the "OK" button.

[6] There were a wide range of colors available, but the color would be randomly drawn to ensure the product was available upon purchase.

They were told that they would be making two sequential "decisions" (denoted WTP1 and WTP2 in Figure 1 and referred to as period 1 and period 2 in our analysis/discussion), with one decision being randomly selected to be paid. After decision 1 or 2 was randomly selected by the computer (ie. WTP1 or WTP2 in Figure 1), then the computer randomly drew a price between $0.00 and $10.00 for each participant. If the randomly drawn price was less than or equal to the participant's maximum WTP, they purchased a toothbrush at the randomly drawn price. If the drawn price was above their maximum WTP, then they did not purchase a toothbrush.

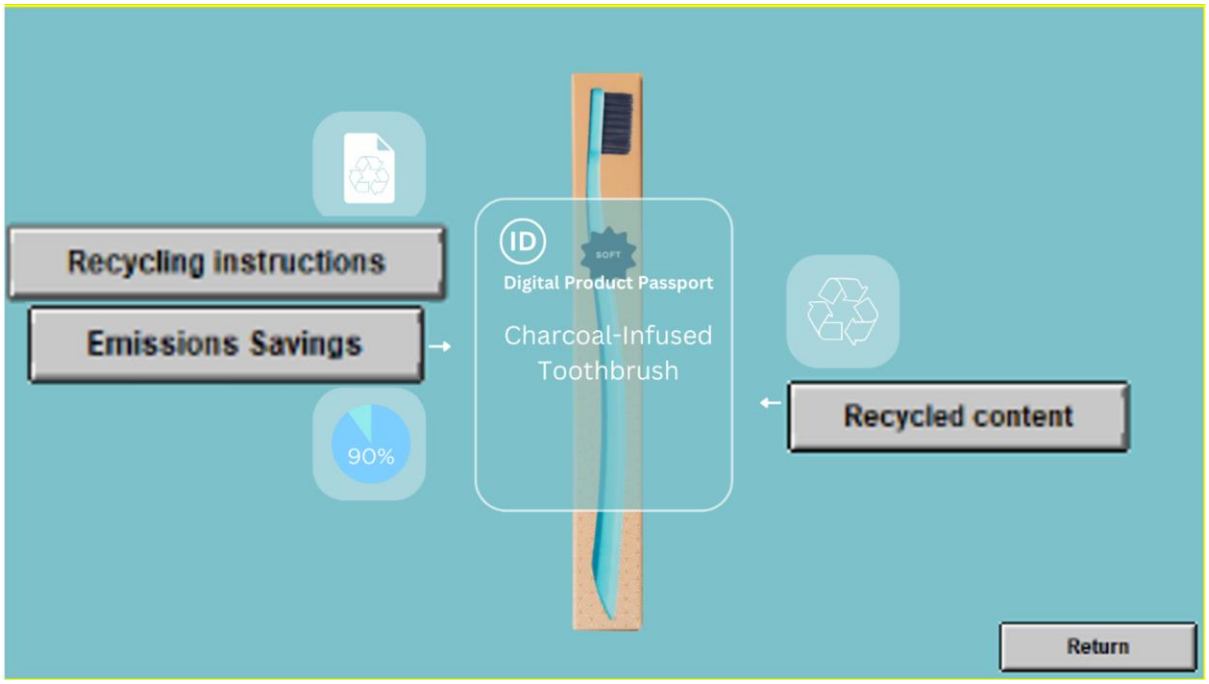
As shown in Figure 1, the control group was given the baseline decision twice, to act as a control for the difference-in-difference measure between WTP2 and WTP1. The DPP treatment is identical to the Baseline treatment, but in the second decision has the addition of a link to the DPP on the decision screens. Figure 3 presents the decision screen for the DPP and DPP+ treatments, for WTP2. Subjects can click on the DPP link to access information associated with the environmental impact of the toothbrush. No additional information other than the link itself was provided to subjects regarding the DPP. On the DPP information screen, presented in Figure 4, subjects could click on the specific links to access information on that specific topic.[7] Participants were allowed to view the DPP information for as long as they wanted, and the duration spent viewing each of the DPP pages were recorded to comprise our measure of revealed WTE. As shown in Figure 1, we have this measure for the two treatments with the DPP, for the WTP2 decision.

Figure 3: Decision Screen for the DPP and DPP+ Treatments, for WTP2 elicitation.



[7] Screenshots of all the DPP information screens are presented in the Appendix.

Figure 4: Digital Product Passport Information Screen, with buttons enlarged for presentation purposes.



The DPP+ treatment is identical to the DPP treatment with the addition of an educational video prior to the decisions screen that defines a DPP and the role it plays in supporting a circular economy.[8] The following statement was provided to subjects prior to the presentation of the video.

> The Digital Product Passport (DPP) is being introduced in Europe to provide better information to consumers and to encourage the circular economy. We could introduce a similar consumer information platform in Aotearoa New Zealand. Please click the button to watch a short video explaining what a DPP is and why this policy is being implemented in Europe.

It was common knowledge that only one of the two decision rounds would be randomly selected at the end of the session to determine the outcome of the experiment. After the completion of both purchase decision rounds, subjects were told that they will receive a $10 payment for completing a survey at the end of the experiment. They were then given an opportunity to donate any portion of these $10 to one of three local environmental charities (Forest and Bird, Go Eco Waikato, and Greenpeace Aotearoa) or refrain from donation. A

[8] To view the video, see https://www.youtube.com/watch?v=G2wYqEAzt6U

detailed description of each organization was provided. If they made a donation, they received a receipt of the completed donation via email.

Upon completing the charity donation decision, the program proceeded to the survey to collect data on the subjects' knowledge of the toothbrush, attitudes towards the toothbrush, locus of control, norms, environmental self-identity, emotional states, future WTE with a DPP, and general demographic information.[9]

The quiz testing subjects' knowledge of the toothbrush was incentivized. The questions were regarding the sustainability aspects of the toothbrush and taken directly from the information provided within the DPP. Subjects earned an additional $0.50 for each correct answer. They were not pre-warned about the quiz or the incentive, so the inclusion of the quiz does not impact our measure of WTE.

Hypotheses

We test the following hypotheses. We pre-registered our study and hypotheses before data collection.[10] The first hypothesis is:

H1: The DPP treatments increase willingness to pay (WTP) for an environmentally friendly toothbrush, with the DPP + treatment having the highest WTP.

This hypothesis tests our theoretical model, following from our experimental design. In absence of information about the environmental attributes of the toothbrush, our theoretical model predicts the participants will assume an average level of environmental performance. Those who choose to engage with the DPP, will be those with stronger pro-environmental preferences. Therefore, when they discover it is strongly environmentally friendly, they will increase their WTP for it. The DPP+ treatment will have higher WTP due to our predicted H2.

H2: The DPP + treatment increases engagement with the DPP, compared with DPP only.

The DPP+ treatment increases perceived expected marginal benefits from engaging with the DPP (θ in our model), through an educational video. Thus, we predict DPP+

[9] Screenshots of the survey are presented in the Appendix.
[10] See https://aspredicted.org/nvt4-4g6h.pdf

participants are more likely to click on the DPP and more likely to spend more time looking at the DPP.

H3: There is a positive relationship between engagement with the DPP and WTP.

This prediction follows our theoretical model and the above, particularly due to the fact that the information contained in the DPP is positive regarding the product within this experiment.

H4: The DPP treatments increase knowledge and positive attitudes towards the toothbrush.

We test this hypothesis using the post-experiment incentivized quiz and survey. Knowledge that we measure includes both knowledge about the environmental impact of the toothbrush itself, as well as end of life recyclability and methods. It is an important check on whether participant engagement with the DPP is in fact aimed at gathering information about mitigating their environmental impact through purchasing the toothbrush, rather than some other reason.

H5: The DPP+ treatment increases positive attitudes towards the DPP, locus of control and pro-environmental norms, over the DPP treatment.

This final hypothesis tests the extent to which the educational video influenced the participants, including their views about the DPP itself, how much they feel able to make a difference with their actions (locus of control) and their perceptions of wider pro-environmental norms. These are all drivers of pro-environmental behavior, relevant to information interventions, and that can be shifted through interventions such as provision of the DPP (van Valkengoed et al., 2022).

Additionally, we look for evidence of behavioral spillovers in the subsequent environmental donation decision, by looking for differences between treatments groups. We pre-registered this as a secondary analysis, hence we do not give this hypothesis a number.

Data analysis

We follow our pre-registered data analysis plan (see footnote 10). We use differences-in-differences in the relevant variables to test hypotheses H1 and H3-5, and differences to test H2. This latter hypothesis looks at differences in revealed WTE, which we can only observe in the DPP and DPP+ treatments for their second WTP2 decision; that is, only when the DPP is present. We initially test the hypotheses (except for H2, which is better tested parametrically)

using the non-parametric Mann-Whitney U Test, except for the binary measure of WTE (clicked on DPP), for which we utilize a Chi-squared test. We use one-sided tests as pre-registered, as our hypotheses and theory suggest the direction of the effect should be in one direction or null. The one exception is our test on donation behavior, which is our test for behavioral spillovers. As these may be positive or negative, we use a two-sided test. Additionally, we run multiple hypothesis testing for all of the outcome variables that we include in all of our hypotheses (List et al., 2019).

Finally, we test hypotheses H1-3 parametrically, again as pre-registered, including controls in the models. We model differences-in-differences of WTP (H1 and H3) for the toothbrush as follows:

$$y^*_{i,r} = \alpha + \beta_r r + \boldsymbol{\beta_t t_i} + \boldsymbol{\beta_{rt}} r\boldsymbol{t} + \boldsymbol{\beta_x x_i} + \varepsilon_{i,r}. \quad (4)$$

Here, $y^*_{i,r}$ is the true WTP of individual i in decision round $r = \{1,2\}$. Our data is censored at 0 and 10 as our minimum and maximum possible WTP with the experimental set up, therefore we estimate a Tobit model (using maximum likelihood) to take this into account. The term α is a constant intercept, β_r is the coefficient on the decision period 2 dummy r, $\boldsymbol{\beta_t}$, which picks up whether there is a different WTP in the second decision for the control treatment group. The vector of coefficients on the treatment groups is $\boldsymbol{\beta_t}$, which controls for whether there are any differences between the DPP and DPP+ treatment group first WTP decision and the control. Next, $\boldsymbol{\beta_{rt}}$ is a vector of coefficients on the interactions between the decision 2 dummy, r, and the vector of treatment group dummies, $\boldsymbol{t}$. These coefficients estimate the differences-in-differences between the treatment groups, and hence are the key coefficients for hypothesis testing. Next, $\boldsymbol{\beta_x}$ is a vector of coefficients on the vector of control variables, $\boldsymbol{x_i}$, which vary at the individual level but do not vary by decision period. We add interactions between control variables and the other coefficients as needed; more details are in the results section when we discuss Table 4. Finally, $\varepsilon_{i,r}$ is an error term.

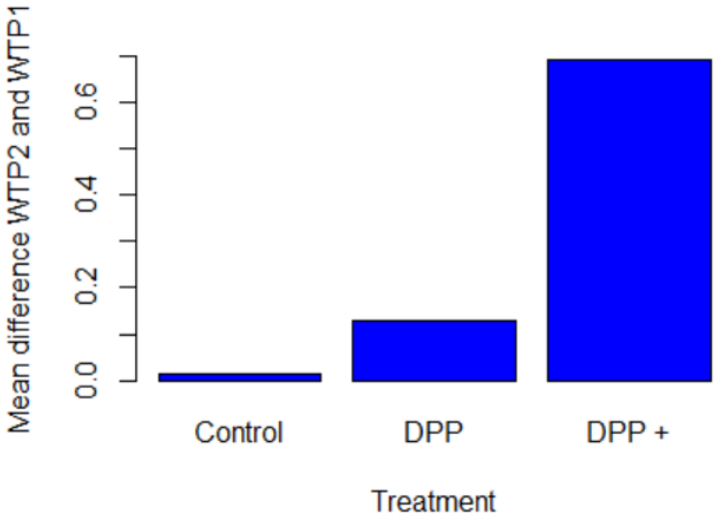
To parametrically test hypothesis H2, we again just look at differences in WTE, and engagement is measured only in decision period 2 for the DPP and DPP+ treatments. Thus, we model engagement time as above, but with engagement time as the dependent variable (censored at 0 only), and no decision period dummies. We model the decision to click on the DPP similarly, but using a linear probability model as it is a binary outcome variable.

Table 1: Summary statistics

Statistic	N	Mean	St. Dev.	Min	Max
Demographics					
Age	131	28.5	10.8	18	80
Female	131	0.45			
Diverse	131	0.02			
Outcome variable					
WTP1	131	3.31	1.93	0	10
WTP2	131	3.61	1.97	0	10
Difference WTP2 WTP1	131	0.29	0.78	-3	3
Quiz earnings	131	0.97	0.51	0	2
Donations	131	0.89	2.16	0	10
Final payment	131	19.25	2.75	5	22
Engagement Time	90	145.99	183.58	0	965
Statistic	N	Mean	St. Dev.	Min	Max
Outcome variable control					
Age	41	29.6	12.9	18	80
Female	41	0.46			
Diverse	41	0			
WTP1	41	3.06	1.52	0	6.5
WTP2	41	3.07	1.46	0	6.5
Difference WTP2 WTP1	41	0.01	0.33	-0.5	1
Quiz earnings	41	0.66	0.44	0	1.5
Donations	41	1.12	2.81	0	10
Final payment	41	18.72	3.37	5	21.5
Outcome variable DPP					
Age	43	26.1	8.24	18	48
Female	43	0.44			
Diverse	43	0.02			
WTP1	43	3.07	1.82	0	6
WTP2	43	3.20	1.83	0	6
Difference WTP2 WTP1	43	0.13	0.76	-3	1
Quiz earnings	43	0.94	0.47	0	2
Donations	43	0.65	1.53	0	5
Final payment	43	19.63	2.22	12	21.5
Engagement Time	43	43.42	64.91	0	295
Outcome variable DPP+					
Age	47	29.7	10.8	18	64
Female	47	0.45			
Diverse	47	0.02			
WTP1	47	3.76	2.29	0	10
WTP2	47	4.45	2.22	1	10
Difference WTP2 WTP1	47	0.69	0.93	-3	3
Quiz earnings	47	1.26	0.44	0.5	2
Donations	47	0.92	2.03	0	10
Final payment	47	19.36	2.56	11.5	22
Engagement Time	47	239.83	206.21	0	965

Note: “Male” proportion is given by 1 – Female – Diverse, so has been left off for brevity.

Figure 5 Mean difference between WTP2 and WTP1 by treatment group.



Results

In this section we first describe the summary statistics, non-parametric and then parametric testing. We conclude by stating our findings in relation to each hypothesis.

Summary statistics

Table 1 shows the summary statistics for the participants in the experiment. Our participants are from a university experimental economics lab pool, including staff and students. Overall, we can see there is reasonable gender balance, and balance between treatment groups. Engagement time is our measure of revealed WTE with the DPP; this is observed only for the DPP and DPP+ treatments, as there is no DPP present in the control group to engage with. In Figure 5, we show one of the key outcome variables, difference-in-differences in WTP between treatment groups.

Table 2 shows the summary statistics for the range of survey items collected after the main experiment, combined for all treatment groups. These variables are relevant for H4 and H5 in particular, as well as providing control variables where appropriate. They are produced using 1-7 Likert scale questions, except for environmental worry, which uses a 1-5 Likert scale (adapted from Truelove et al., 2016). The bottom section of Table 2 shows the multi-item variables and their Cronbach's alpha. We dropped one item from environmental self-identity scale (adapted from Truelove et al., 2016), in order to increase Cronbach's alpha

from 0.67 to 0.7 (*I would be embarrassed to be seen as having an environmentally-friendly lifestyle*, reverse coded). Otherwise, each of these items has a relatively high Cronbach's alpha. We measure locus of control using 11 questions adapted from Cleveland et al. (2020), and environmental worry is measured using questions adapted from Truelove et al. (2016), as stated above. The DPP support and stated WTE with the DPP are constructed from a set of 10 questions. Survey questions are provided in the Appendix.

Table 2: Internal Consistency, Means, and Standard Deviations for survey variables

	Cronbach's alpha	Mean	St. Dev.
Single item variables			
Toothbrush appealing		3.9	1.7
Toothbrush envi friendly		5.1	1.4
Toothbrush recyclable*		4.4	1.6
Personal norm		4.9	1.3
Friends injunctive norm		3.5	1.6
Societal injunctive norm		4.3	1.6
Societal descriptive norm		3.5	1.5
Multi-item variables			
Locus of control	0.89	5.6	0.9
Environmental self-identity^{+}	0.7	4.9	1.2
Environmental worry*	0.80	4.3	0.72
DPP support	0.75	5.9	0.92
Stated WTE	0.87	4.5	1.3

Notes: Cronbach's alpha only for multi-item variables. *Reverse coded; $^{+}$One item dropped to increase alpha. All items 1-7 Likert, except Environmental worry, 1-5. N=130 for all variables.

Non-parametric testing

We show our non-parametric hypothesis testing in Table 3. At the top of the table, we show two two-sided Mann-Whitney U tests. First, we test for differences in the first period (or baseline) WTP, between treatment groups. This is a check on properly randomized groups,

Table 3: p-values for hypotheses tests between the treatment groups.

	p values		
	Control vs		DPP vs
	DPP	DPP+	DPP+
		Two-sided Mann-Whitney U test	
WTP1	0.840	0.157	0.230
Donation	0.840	0.624	0.467
		One-sided Mann-Whitney U test	
WTP2	0.336	0.001***	0.006***
Difference WTP2 WTP1	0.014**	0.000***	0.000***
Engagement (time)			0.000***
Quiz Earnings	0.004***	0.000***	0.001***
Appeal of toothbrush	0.950	0.678	0.114
Toothbrush envi friendly	0.003**	0.000***	0.065*
Toothbrush recyclable^{+}	0.048**	0.007**	0.215
Personal norm	0.820	0.116	0.011**
Friends injunctive norm	0.796	0.696	0.371
Societal injunctive norm	0.445	0.640	0.688
Societal descriptive norm	0.930	0.836	0.263
Locus of control	0.781	0.560	0.215
Environmental self identity^	0.814	0.537	0.196
Environmental worry	0.165	0.099*	0.460
DPP support	0.412	0.454	0.534
Stated WTE	0.814	0.612	0.238
		Chi-Square Test	
	χ^2	df	p-value
Engagement (clicks on DPP)	13.251	1	0.000***

Notes: ∗p < 0.1; ∗∗p < 0.05; ∗∗∗p < 0.01. $^{+}$Reverse coded. ^One item dropped to increase Cronbach‘s alpha.

as all treatments had the same set up for WTP1. We can see there are no significant statistical differences. Second, we test for differences in donations to an environmental charity between treatment groups. The behavioral spillover literature predicts both positive and negative differences could occur here, hence we perform a two-sided test. There were no statistical differences between treatment groups.

The middle section of Table 3 shows one-sided Mann-Whitney U Tests, according to our pre-registered hypotheses. We discuss the results here and summarize them in relation to our hypotheses at the end of the results section. First, WTP2 shows the first differences in willingness to pay in the second period, after participants were treated. There is no statistical difference between the DPP group and control (column 1 of p-values), however, DPP+ has a higher willingness to pay compared with both DPP and control at the 1% level (columns 2 and 3 respectively). Next, *Difference WTP2 WTP1* shows the difference-in-differences between treatment groups, which are all significant at the 5 or 1% levels. Third, *Engagement (time)* shows differences in seconds spent looking at the DPP. As the DPP was only present for DPP and DPP+, we only show the difference between those two treatment groups. This is significant at the 1% level.

The next row in Table 3 shows differences in the quiz results between treatment groups. This shows significant differences between each treatment, hence the DPP+ group knew the most about the toothbrush's properties, followed by DPP and then control. Next, we see the DPP and DPP+ treatments did not have a positive effect on the appeal of the toothbrush. However, the DPP and DPP+ treatment groups both rated the toothbrush as more environmentally friendly and more recyclable compared with the control group. There was less difference between DPP and DPP+ here, with DPP+ considering the toothbrush more environmentally friendly at the 10% level, but no difference in how recyclable they perceived the toothbrush.

The next part of Table 3 shows the range of other environmental survey variables collected on the participants. These were more general rather than related specifically to the toothbrush. Here there are few differences between treatment groups, showing that the DPP and DPP+ treatments had little or no short term impact on these variables. This is an important finding, with theoretical and policy implications, which we pick up in the Discussion.

Finally, the bottom of Table 3 shows the Chi-Square test on difference in clicks on the DPP between the DPP and DPP+ treatments. It shows there were significantly more participants clicking on the DPP in the DPP+ treatment, compared with the DPP.

As a robustness check, we provide our multiple hypothesis testing results in the appendix, for which we are cautious and only conduct two-sided rather than one-sided hypotheses. The results presented in Table 3 are almost all robust to this, with a handful of exceptions. Specifically, there is no difference in WTP2 between DPP+ and DPP (but the difference in differences remains); and among the results on toothbrush environmentally friendly, recyclable and personal norms, only environmentally friendly holds and only for DPP+ to control.

Parametric testing

We conduct the pre-registered parametric testing in Table 4. The first five results columns of the table model WTP for the toothbrush. This is modelled using a Tobit model as the data are censored at 0 and 10, and their distributions are approximately normal (see graphs in the appendix). These models for WTP are all difference-in-differences. We have two observations for each respondent, period 1 WTP and period 2 WTP. Robust standard errors are clustered at the individual level to take these multiple observations into account.

Column (1) of Table 4 shows the base model that tests for difference-in-differences between treatment groups. The first coefficient shows the period 2 dummy. The estimated coefficient is close to 0 and not statistically significant, hence the control group had the same WTP in both periods as expected. The second and third coefficients are for the DPP and DPP+ treatment group dummies. These coefficients show whether there are differences in period 1 WTP between the treatment groups, to test for any differences. Unlike the non-parametric testing, here we see the DPP+ treatment group had a higher initial WTP, but only at the 10% level of significance. The difference-in-differences testing allows us to control for this appropriately. Next, the treatment-period 2 interaction dummy variables tests for the difference-in-differences in WTP between treatment groups. We find there is no difference-in-difference in WTP for DPP and the control, however, there is a significant difference-in-difference between DPP+ and the control, at the 1% level. Those in the DPP+ treatment increased their WTP by 71c on average after being given this treatment. Column (2) repeats

Table 4 Tobit (columns 1-6) and linear probability (column 7) models on WTP, engagement time and clicks on the DPP.

Dependent variable:	WTP					Engagement time	Click on DPP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Period 2	0.012	0.012	0.078	0.112	0.075		
	(0.051)	(0.051)	(0.051)	(0.121)	(0.122)		
DPP treat	0.011	0.063	0.849				
	(0.383)	(0.414)	(0.788)				
DPP+ treat	0.715*	0.717*	0.985	0.665	0.562	236.107***	0.368***
	(0.429)	(0.390)	(0.673)	(0.499)	(0.576)	(38.894)	(0.076)
DPP*P2	0.097	0.102	-0.265				
	(0.130)	(0.129)	(0.207)				
DPP+*P2	0.712***	0.712***	0.720***	0.617***	0.454*		
	(0.148)	(0.148)	(0.252)	(0.185)	(0.235)		
High WTE		0.978	1.486*				
		(0.621)	(0.848)				
Mid WTE		0.298	0.713				
		(0.464)	(0.668)				
High WTE*P2			-0.078				
			(0.135)				
Mid WTE*P2			-0.103				
			(0.098)				
High WTE*DPP			-2.094*				
			(1.189)				
Mid WTE*DPP			-0.870				
			(0.984)				
High WTE*DPP+			-0.048				
			(1.287)				
Mid WTE*DPP+			-0.499				
			(0.932)				
High WTE*DPP*P2			0.681**				
			(0.304)				
Mid WTE*DPP*P2			0.510*				
			(0.279)				
High WTE*DPP+*P2			0.066				
			(0.351)				
Mid WTE*DPP+*P2			-0.043				
			(0.344)				
Engagement time					0.001		
					(0.002)		
Engagement time*P2					0.001*		
					(0.000)		
Log(scale)	0.674***	0.613***	0.602***	0.693***	0.690***	5.031***	
	(0.070)	(0.064)	(0.065)	(0.078)	(0.079)	(0.127)	
Constant	3.020***	3.537***	3.230***	3.255***	3.281***	5.224	1.133***
	(0.252)	(0.759)	(0.893)	(1.054)	(1.039)	(80.141)	(0.152)
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Obs	262	262	262	180	180	90	90
N	131	131	131	90	90	90	90
Log-likelihood	-538.7	-523.2	-520.2	-373.4	-372.8	-474.8	-
AIC	1091.4	1100.4	1114.4	792.7	795.7	991.5	-

*Notes: (Cluster robust std. errs, by individual). *p<0.1, **p<0.05, ***p<0.01.*

the model of column (1), but with a full set of control variables, with little difference in the estimated coefficients.[11]

In Column (3) of Table 4, we add in all relevant terms for three-way interactions between the stated WTE variable, the treatment groups and period dummy. This allows us to test for heterogeneity in treatment response, by stated general WTE with the DPP. We turn this variable into a dummy of high, medium and low stated WTE, as this is a measure constructed from multiple 1-7 Likert questions. High is an average score 6 and above, medium between 4 and 6, and low is below 5. The key interaction variables to observe are the three-way ones.

First, High WTE*DPP*P2 is positive and significant at the 5% level. This shows that those with a high stated WTE see an increase in their WTP after receiving the DPP treatment. The Mid WTE*DPP*P2 interaction term is positive and significant at the 10% level. In contrast, High WTE*DPP+*P2 and Mid WTE*DPP+*P2 are both close to 0 and not statistically significant. This finding suggests that those with higher general WTE were the participants engaging with the DPP in the DPP treatment, and thus they had a higher WTP in that treatment. In contrast, the DPP+ treatment convinced a wider group to engage with the DPP, including those with a lower general WTE. This wider group increased their WTP for the toothbrush, regardless of their general WTE with the DPP.

We test the effect of engagement with the DPP on WTP in columns (4) and (5) of Table 4. As engagement is only possible in DPP and DPP+ treatments, we remove the control group from this analysis. Column (4) thus provides a point of comparison; it tests for difference-in-differences between the DPP and DPP+ treatments, with control variables. It shows that there is no statistical difference in period 1 WTP between these treatment groups, and the difference-in-differences is 61.7c and statistically significant at the 1% level. Column (5) adds seconds of engagement time as a variable to the model of column (4), as well as an interaction between engagement time and period 2, given engagement time is only relevant to the second WTP. This interaction is positive and significant at the 10% level. However, it also reduces the size

[11] Control variables included are age, gender, all norm variables, locus of control, environmental identity, environmental worry, DPP support and stated WTE. As per the multiple hypothesis testing results in the appendix, treatment group assignment did not influence these variables, hence they are suitable for use as controls.

and significance of the DPP+*P2 coefficient. This finding suggests that engagement time with the DPP is a significant contributor to the increase in WTP in the DPP+ treatment.

We complete this picture with columns (6) and (7) in Table 4. The dependent variable in column (6) is engagement time, thus this is a Tobit model censored at 0. This shows a strong positive relationship between the DPP+ treatment and engagement time, relative to the DPP treatment, with an average increase in engagement time of 236 seconds. Column (7) is a linear probability model on the binary variable of whether the participant clicked on the DPP or not, and shows a 36.8% higher likelihood of clicking on the DPP at all in the DPP+ treatment compared with the DPP treatment.

We conclude this section with a summary of our findings in relation to our hypotheses, shown in Table 5.

Table 5 Summary of pre-registered hypotheses and our findings.

Hypothesis	Description	Finding
H1	The DPP treatments increase willingness to pay (WTP) for an environmentally friendly toothbrush, with the DPP + treatment having the highest WTP.	Supported
H2	The DPP+ treatment increases engagement with the DPP, compared with DPP only.	Supported
H3	There is a positive relationship between engagement with the DPP and WTP.	Supported
H4	The DPP treatments increase knowledge and positive attitudes towards the toothbrush.	Partially supported; knowledge is increased, appeal of the toothbrush is unchanged.
H5	The DPP+ treatment increases positive attitudes towards the DPP, locus of control and pro-environmental norms, over the DPP treatment.	Not supported – the DPP+ treatment has no effect on the general environmental orientation variables including stated WTE.
Additional	There is a spillover effect in environmental donations from the DPP treatments.	Not supported.

Discussion

In this paper we find that environmentally motivated consumers are willing to engage with the DPP, and do adjust their WTP after discovering that the good is better than average from the perspective of its environmental impact. More participants spend more time engaging with the DPP if they are first educated about its purpose, particularly its role in a circular economy transition. This increased engagement significantly increases their WTP for the environmentally friendly product. Thus, we find a role for the DPP as a consumer information tool, as part of the "third wave" of environmental policy, which can help support a higher WTP

for environmentally friendly goods, and therefore help reduce environmental damage (Kotchen, 2013; Tietenberg, 1998). Consumer buy-in to and engagement with circular economy is key to enable a sustainable transition (Shevchenko et al., 2023); our study demonstrates that consumers can indeed be an active participant in this transition, but it is important to inform them about the value of their engagement.

In line with the extant eco-labelling literature, we find that when the DPP contains positive information about the environmental attributes of a product, consumer WTP will, on average, increase (Majer et al., 2022). However, we go several steps further than most of the eco-labelling literature, driven in part by a motivation to fill a gap in the literature, and in part by the development of new technologies such as blockchain, which allow consumers access to a magnitude-level increase in available information about a product. Namely, we show in fine detail that consumers can be active, rather than passive consumers of information, and using our novel measure of revealed WTE, we show that consumers are WTE with information and use it to alter their revealed WTP for a product. Thus, this represents an important extension of the eco-labelling literature, rather than any kind of conflict with it.

The DPP+ treatment in particular increase revealed WTE with the DPP, knowledge about the environmental attributes of the product, knowledge about how to recycle the product, and WTP for the product. However, it did not alter stated WTE, or any other measures of pro-environmental orientation, social norms, or perceived impacts of their own actions (locus of control). These are constructs that influence pro-environmental behavior, such as a higher WTP for an environmentally friendly product. It is possible to shift these constructs through interventions (van Valkengoed et al., 2022); however, we find that in this case they are not influenced by the presence of the DPP or education about the DPP. Additionally, we did not find evidence of behavioral spillovers, either positive or negative. Therefore, on our evidence, the DPP is more likely to enable existing green consumers to change their purchasing behavior to mitigate their environmental impact, rather than create more green consumers.

Limitations and future research

While we find strong evidence in support of our main hypotheses (H1-3) in the lab, we need to consider the extent to which these findings will translate to the field. We may perhaps see our experiment as an upper bound, in terms of how engaged the participants were, and how effective the DPP and DPP+ treatment in particular was at increasing WTP. We might expect

the strength of our findings to be moderated through the following channels, when translated to the field: i) lab participants may act more pro-socially, given they are under observation (Levitt & List, 2007), although the extent to which this applies to pro-environmental behavior and to this study is unclear (F. Lange et al., 2020); ii) the typical lab participant pool is likely to have a different environmental orientation and behavior than the general population (Levitt & List, 2007), although this may in fact be a lower bound (Falk et al., 2013); iii) the opportunity cost of time is likely higher in the field than in lab (Erkal et al., 2018), making the cost of engaging with information higher in the field; and iv) it may be important that the education on the DPP occurs close to the purchasing decision, but this may be difficult to implement in the field (for example it may require retailers to do so voluntarily, which they may not wish to do). Nevertheless, there is no reason to believe that we cannot replicate our results in the field, perhaps with a marginally smaller effect size when balancing out the list above; this is an area for future research.

We do not find any evidence of an "ostrich effect", whereby green consumers did not engage with the DPP in case it contained bad news about the environmental performance of the good (Benabou & Tirole, 2011; Karlsson et al., 2009). The "ostrich effect" would be most likely to occur when green consumers have some initial indication that the DPP will contain bad news (Karlsson et al., 2009). This is one potential explanation for why the DPP+ treatment has so much higher engagement; perhaps the education video provides some clues that they will see good news in the DPP, or allays concerns that it will just be a means through which to receive bad news about products they are purchasing. We cannot rule out this explanation and it may be an area for future research. Nevertheless, it does not take away from the fact that the DPP+ treatment was so effective. Even if the "ostrich effect" is a factor in the lower engagement within the DPP only treatment, this does not contradict our conclusion that education about the DPP increases the expected value of engagement, and therefore increases engagement.

Another area for future research is to test whether changes in WTP for products, after engaging with information, are persistent. Indeed, as outlined earlier in this paper, there is evidence to show that behavior change is somewhat persistent when driven by new information. This is in contrast with nudges, which may only change behavior in the short term, but lacks a mechanism to change behavior in a persistent manner (Gao & Tavoni, 2024; Lohmann et al., 2022). Thus, if it is possible to convince consumers of the value of initial engagement with the DPP, this may lead to persistent changes in purchasing behavior. Green

consumers may switch to more environmentally friendly products, through engaging with credible information. They need not engage with the DPP every time they purchase the same product, rather until such time as they believe it is important to double check for new information or refresh their existing knowledge.

Policy implications

The DPP is currently being rolled out in EU, and is aimed at being a source of credible information about product sustainability to empower sustainable purchase and consumption behaviors. It may be copied or emulated in other jurisdictions over time. The potential for it to be a source of consumer information is there, even if it is not its primary purpose. Therefore, it is important to use research such as ours to understand how consumers can be engaged with it, by convincing them of its value as a tool for reducing their own environmental damage and supporting a transition to a circular economy.

In our experimental design, we aimed to make the information presented in a user-friendly format, with images and further details provided through other links, rather than putting all details in one page. It was beyond the scope of the study to test different designs, but no doubt this is an important consideration in the design of the DPP to ensure that the cognitive costs of engaging with the DPP are kept to a minimum and thus WTE is maximized (as per our theory).

However, it is important that policymakers do not overestimate the likely impacts of a DPP. We note in our limitations above that our study is likely an upper bound of WTE (and therefore changes in WTP). Additionally, our finding of no evidence for changes in consumer underlying environmental orientation or positive behavioral spillovers implies that the DPP may only have an impact on the specific product it is attached to, and not obviously galvanize wider systemic and cultural shifts.

Conclusion

In this paper, we have developed a theoretical model of an environmentally motivated consumer who takes an active role in deciding whether to invest their time in information about the environmental attributes of a good. This is in contrast with much of the literature, in which consumers are conceptualized as passive (Heyes et al., 2020). Our model builds on A. Lange and Ziegler (2017) and provides the green consumer with the ability to seek information to better understand the level of environmental damage from their consumption, and thus they

gain an avenue through which they can mitigate the damage of their consumption. They will therefore invest in the information if they expect it to sufficiently offset the costs of doing so (eg. cognitive, time). We design an experiment to test this model, using the case of the DPP. These elements of our paper fill several important gaps in the literature on green consumer behavior. We further contribute by widening the scope of the literature on eco-labels to include modern forms of product information provision (the DPP), enabled by new technologies such as blockchain. As far as we are aware, we are the first to bring these disparate but related literatures and technological advances together in this important way.

Within our experimental design, we have developed a novel measure of revealed WTE with product information, which we show leads to an increase in knowledge. Additionally, we demonstrate that this new knowledge is used by consumers to increase their WTP for an environmentally friendly product, as predicted by our theory. While some consumers have a high underlying level of WTE with the information, we can increase WTE among a wider group when the consumers are provided with education about the wider purpose of engagement; in this case, we play a video that discusses the importance of the DPP for supporting the transition to a more sustainable, circular economy. However, the presence of, and WTE with the DPP does not lead to a stronger environmental orientation or positive spillovers. Thus, our paper provides a number of key advancements for the literature, as well as evidence and for optimal design of "third wave" information-based policy.

References

Adisorn, T., Tholen, L., & Götz, T. (2021). Towards a Digital Product Passport Fit for Contributing to a Circular Economy. *Energies*, *14*(8), 2289. https://doi.org/10.3390/en14082289

Allcott, H., & Knittel, C. (2019). Are Consumers Poorly Informed about Fuel Economy? Evidence from Two Experiments. *American Economic Journal: Economic Policy*, *11*(1).

Andreoni, J. (1990). Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving. *The Economic Journal*, *100*(401), 464. https://doi.org/10.2307/2234133

Asensio, O. I., & Delmas, M. A. (2015). Nonprice incentives and energy conservation. *Proceedings of the National Academy of Sciences*, *112*(6). https://doi.org/10.1073/pnas.1401880112

Baker, A.-E., Ekberg, J., Ramos, J. C. M., & Sutaria, S. S. (2024). *Exploring the social costs of plastics: Global review of impacts and economic damages*. Duke University. https://dukespace.lib.duke.edu/server/api/core/bitstreams/40094459-414c-4074-b289-73e2c6799bb4/content

Benabou, R., & Tirole, J. (2011). Identity, Morals, and Taboos: Beliefs as assets. *The Quarterly Journal of Economics*, *126*(2), 805–855. https://doi.org/10.1093/qje/qjr002

Beyer, B., Chaskel, R., Euler, S., Gassen, J., GROßKOPF, A., & Sellhorn, T. (2024). How Does Carbon Footprint Information Affect Consumer Choice? A Field Experiment. *Journal of Accounting Research*, *62*(1), 101–136. https://doi.org/10.1111/1475-679X.12505

Bougherara, D., & Piguet, V. (2009). Market Behavior with Environmental Quality Information Costs. *Journal of Agricultural & Food Industrial Organization*, *7*(2). https://doi.org/10.2202/1542-0485.1272

Boyer, R. H. W., Hunka, A. D., Linder, M., Whalen, K. A., & Habibi, S. (2021). Product Labels for the Circular Economy: Are Customers Willing to Pay for Circular? *Sustainable Production and Consumption*, *27*, 61–71. https://doi.org/10.1016/j.spc.2020.10.010

Brent, D. A., & Ward, M. B. (2018). Energy efficiency and financial literacy. *Journal of Environmental Economics and Management*, *90*, 181–216. https://doi.org/10.1016/j.jeem.2018.05.004

Brucal, A., & Roberts, M. J. (2019). Do energy efficiency standards hurt consumers? Evidence from household appliance sales. *Journal of Environmental Economics and Management*, *96*, 88–107. https://doi.org/10.1016/j.jeem.2019.04.005

Caplin, A., & Dean, M. (2015). Revealed Preference, Rational Inattention, and Costly Information Acquisition. *American Economic Review*, *105*(7), 2183–2203. https://doi.org/10.1257/aer.20140117

Carlsson, F., Gravert, C., Johansson-Stenman, O., & Kurz, V. (2021). The Use of Green Nudges as an Environmental Policy Instrument. *Review of Environmental Economics and Policy*, *15*(2), 216–237. https://doi.org/10.1086/715524

Carlsson, F., Jaime, M., & Villegas, C. (2020). Behavioral spillover effects from a social information campaign. *Journal of Environmental Economics and Management*, 102325. https://doi.org/10.1016/j.jeem.2020.102325

Carrico, A. R., Truelove, H. B., Vandenbergh, M. P., & Dana, D. (2015). Does learning about climate change adaptation change support for mitigation? *Journal of Environmental Psychology*, *41*, 19–29. https://doi.org/10.1016/j.jenvp.2014.10.009

Cason, T. N., & Gangadharan, L. (2002). Environmental Labeling and Incomplete Consumer Information in Laboratory Markets. *Journal of Environmental Economics and Management*, *43*(1), 113–134. http://dx.doi.org/10.1006/jeem.2000.1170

Chan, N. W. (2024). A unifying algebra of green consumption technologies. *Journal of the Association of Environmental and Resource Economists*, *11*(4), 797–825. https://doi.org/10.1086/727792

Chan, N. W., & Kotchen, M. J. (2014). A generalized impure public good and linear characteristics model of green consumption. *Resource and Energy Economics*, *37*, 1–16. https://doi.org/10.1016/j.reseneeco.2014.04.001

Cleveland, M., Robertson, J. L., & Volk, V. (2020). Helping or hindering: Environmental locus of control, subjective enablers and constraints, and pro-environmental behaviors. *Journal of Cleaner Production*, *249*, 119394. https://doi.org/10.1016/j.jclepro.2019.119394

Dorner, Z. (2019). A behavioral rebound effect. *Journal of Environmental Economics and Management*, *98*, 102257. https://doi.org/10.1016/j.jeem.2019.102257

Eby, B., Carrico, A. R., & Truelove, H. B. (2019). The influence of environmental identity labeling on the uptake of pro-environmental behaviors. *Climatic Change*, *155*(4), 563–580. https://doi.org/10.1007/s10584-019-02501-x

Ellen MacArthur Foundation. (2013). *Towards the circular economy Vol 1: An economic and business rationale for an accelerated transition*.

https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an
Erkal, N., Gangadharan, L., & Koh, B. H. (2018). Monetary and non-monetary incentives in real-effort tournaments. *European Economic Review*, *101*, 528–545. https://doi.org/10.1016/j.euroecorev.2017.10.021
Falk, A., Meier, S., & Zehnder, C. (2013). Do Lab Experiments Misrepresent Social Preferences? The case of self-selected student samples. *Journal of the European Economic Association*, *11*(4), 839–852. https://doi.org/10.1111/jeea.12019
Fan, Z.-P., Wu, X.-Y., & Cao, B.-B. (2022). Considering the traceability awareness of consumers: Should the supply chain adopt the blockchain technology? *Annals of Operations Research*, *309*(2), 837–860. https://doi.org/10.1007/s10479-020-03729-y
Fernandes, M. E., & Valente, M. (2021). What you get is not what you paid for: New evidence from a lab experiment on negative externalities and information asymmetries. *Journal of Behavioral and Experimental Economics*, *93*, 101712. https://doi.org/10.1016/j.socec.2021.101712
Feuß, S., Fischer-Kreer, D., Majer, J., Kemper, J., & Brettel, M. (2022). The interplay of eco-labels and price cues: Empirical evidence from a large-scale field experiment in an online fashion store. *Journal of Cleaner Production*, *373*, 133707. https://doi.org/10.1016/j.jclepro.2022.133707
Fischbacher, U. (2007). z-Tree: Zurich Toolbox for Ready-made Economic Experiments. *Experimental Economics*, *10*(2), 171–178. https://doi.org/10.1007/s10683-006-9159-4
Gao, Y., & Tavoni, M. (2024). Forget-Me-Not: The Persistent Effect of Information Provision for Adopting Climate-Friendly Goods. *Management Science*, *70*(7), 4480–4501. https://doi.org/10.1287/mnsc.2023.4910
Gerarden, T. D., Newell, R. G., & Stavins, R. N. (2017). Assessing the Energy-Efficiency Gap. *Journal of Economic Literature*, *55*(4), 1486–1525. https://doi.org/10.1257/jel.20161360
Goetz, A., Mayr, H., & Schubert, R. (2024). One thing leads to another: Evidence on the scope and persistence of behavioral spillovers. *Journal of Public Economics*, *236*, 105166. https://doi.org/10.1016/j.jpubeco.2024.105166
Greiner, B. (2015). Subject Pool Recruitment Procedures: Organizing experiments with ORSEE. *Journal of the Economic Science Association*, *1*(1), 114–125. https://doi.org/10.1007/s40881-015-0004-4
Gromet, D. M., Kunreuther, H., & Larrick, R. P. (2013). Political ideology affects energy-efficiency attitudes and choices. *Proceedings of the National Academy of Sciences*, *110*(23), 9314–9319. https://doi.org/10.1073/pnas.1218453110
Heyes, A., Kapur, S., Kennedy, P. W., Martin, S., & Maxwell, J. W. (2020). But What Does It Mean? Competition between Products Carrying Alternative Green Labels When Consumers Are Active Acquirers of Information. *Journal of the Association of Environmental and Resource Economists*, *7*(2), 243–277.
Jalil, A. J., Tasoff, J., & Bustamante, A. V. (2020). Eating to save the planet: Evidence from a randomized controlled trial using individual-level food purchase data. *Food Policy*, *95*, 101950. https://doi.org/10.1016/j.foodpol.2020.101950
Jin, G. Z. (2021). *Is No News (Perceived As) Bad News? An Experimental Investigation of Information Disclosure*. *13*(2).
Karlsson, N., Loewenstein, G., & Seppi, D. (2009). The ostrich effect: Selective attention to information. *Journal of Risk and Uncertainty*, *38*(2), 95–115. https://doi.org/10.1007/s11166-009-9060-6

Knook, J., Dorner, Z., & Stahlmann-Brown, P. (2022). Priming for individual energy efficiency action crowds out support for national climate change policy. *Ecological Economics*, *191*, 107239. https://doi.org/10.1016/j.ecolecon.2021.107239

Kotchen, M. J. (2013). Voluntary- and Information-Based Approaches to Environmental Management: A Public Economics Perspective. *Review of Environmental Economics and Policy*, *7*(2), 276–295. https://doi.org/10.1093/reep/ret012

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 132–157.

Lange, A., & Ziegler, A. (2017). Offsetting versus mitigation activities to reduce CO2 emissions: A theoretical and empirical analysis for the U.S. and Germany. *Environmental and Resource Economics*, *66*(1), 113–133. https://doi.org/10.1007/s10640-015-9944-7

Lange, F., Brick, C., & Dewitte, S. (2020). Green when seen? No support for an effect of observability on environmental conservation in the laboratory: a registered report. *Royal Society Open Science*, *7*(4), 190189. https://doi.org/10.1098/rsos.190189

Levitt, S. D., & List, J. A. (2007). What do Laboratory Experiments Measuring Social Preferences Reveal about the Real World? *The Journal of Economic Perspectives*, *21*(2), 153–174.

List, J. A., Shaikh, A. M., & Xu, Y. (2019). Multiple hypothesis testing in experimental economics. *Experimental Economics*, *22*(4), 773–793. https://doi.org/10.1007/s10683-018-09597-5

Lohmann, P. M., Gsottbauer, E., Doherty, A., & Kontoleon, A. (2022). Do carbon footprint labels promote climatarian diets? Evidence from a large-scale field experiment. *Journal of Environmental Economics and Management*, *114*, 102693. https://doi.org/10.1016/j.jeem.2022.102693

Lupi, F., Phaneuf, D. J., & Von Haefen, R. H. (2020). Best Practices for Implementing Recreation Demand Models. *Review of Environmental Economics and Policy*, *14*(2), 302–323. https://doi.org/10.1093/reep/reaa007

Majer, J. M., Henscher, H. A., Reuber, P., Fischer-Kreer, D., & Fischer, D. (2022). The effects of visual sustainability labels on consumer perception and behavior: A systematic review of the empirical literature. *Sustainable Production and Consumption*, *33*, 1–14. https://doi.org/10.1016/j.spc.2022.06.012

Maki, A., Carrico, A. R., Raimi, K. T., Truelove, H. B., Araujo, B., & Yeung, K. L. (2019). Meta-analysis of pro-environmental behaviour spillover. *Nature Sustainability*, *2*(4), 307–315. https://doi.org/10.1038/s41893-019-0263-9

Marcon, A., Ribeiro, J. L. D., Dangelico, R. M., De Medeiros, J. F., & Marcon, É. (2022). Exploring green product attributes and their effect on consumer behaviour: A systematic review. *Sustainable Production and Consumption*, *32*, 76–91. https://doi.org/10.1016/j.spc.2022.04.012

Newell, R. G., & Siikamäki, J. (2014). Nudging Energy Efficiency Behavior: The Role of Information Labels. *Journal of the Association of Environmental and Resource Economists*, *1*(4), 555–598. https://doi.org/10.1086/679281

Ölander, F., & Thøgersen, J. (2014). Informing Versus Nudging in Environmental Policy. *Journal of Consumer Policy*, *37*(3), 341–356. https://doi.org/10.1007/s10603-014-9256-2

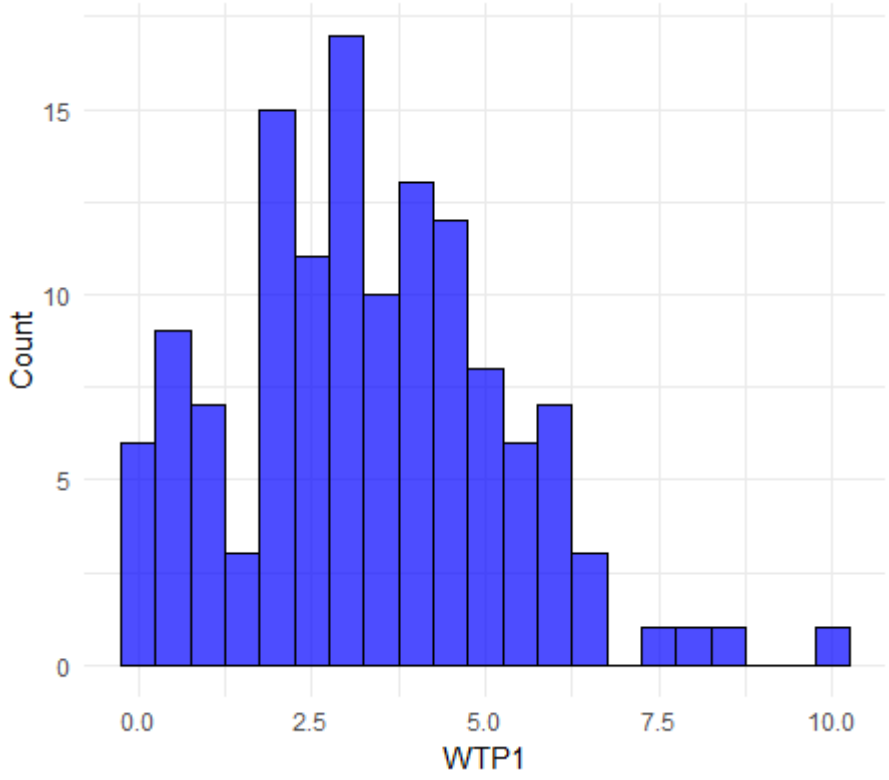
Olsthoorn, M., Schleich, J., Guetlein, M.-C., Durand, A., & Faure, C. (2023). Beyond energy efficiency: Do consumers care about life-cycle properties of household appliances? *Energy Policy*, *174*, 113430. https://doi.org/10.1016/j.enpol.2023.113430

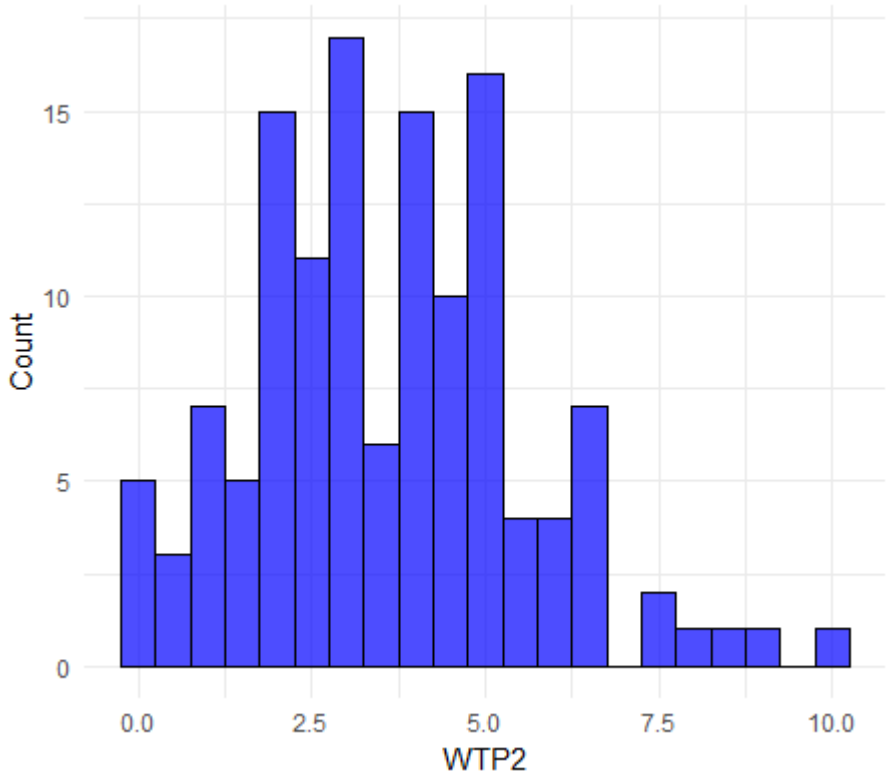
Shevchenko, T., Saidani, M., Ranjbari, M., Kronenberg, J., Danko, Y., & Laitala, K. (2023). Consumer behavior in the circular economy: Developing a product-centric

framework. *Journal of Cleaner Production*, *384*, 135568. https://doi.org/10.1016/j.jclepro.2022.135568
Shimshack, J. P. (2020). Information provision. In D. M. Konisky (Ed.), *Handbook of U.S. Environmental Policy* (pp. 231–242). Edward Elgar Publishing. https://books.google.co.nz/books?id=5i3eDwAAQBAJ&lpg=PA231&lr&pg=PA231#v=onepage&q&f=false
Skourtos, M., Damigos, D., Tourkolias, C., & Kontogianni, A. (2021). Efficient energy labelling: The impact of information content and style on product choice. *Energy Efficiency*, *14*(6), 58. https://doi.org/10.1007/s12053-021-09950-3
Stigler, G. J. (1961). The Economics of Information. *Journal of Political Economy*, *69*(3), 213–225.
Taufique, K. M. R., Nielsen, K. S., Dietz, T., Shwom, R., Stern, P. C., & Vandenbergh, M. P. (2022). Revisiting the promise of carbon labelling. *Nature Climate Change*, *12*(2), 132–140. https://doi.org/10.1038/s41558-021-01271-8
Tietenberg, T. (1998). Disclosure Strategies for Pollution Control. *Environmental and Resource Economics*, *11*(3–4), 587–602. https://doi.org/10.1023/A:1008291411492
Tobler, C., Visschers, V. H. M., & Siegrist, M. (2012). Addressing climate change: Determinants of consumers' willingness to act and to support policy measures. *Journal of Environmental Psychology*, *32*(3), 197–207. https://doi.org/10.1016/j.jenvp.2012.02.001
Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change*, *29*, 127–138. https://doi.org/10.1016/j.gloenvcha.2014.09.004
Truelove, H. B., Raimi, K. T., & Carrico, A. R. (2022). Curbing single-use plastic with behaviour change interventions. *Nature Reviews Earth & Environment*, *3*(11), 722–723. https://doi.org/10.1038/s43017-022-00356-y
Truelove, H. B., Yeung, K. L., Carrico, A. R., Gillis, A. J., & Raimi, K. T. (2016). From plastic bottle recycling to policy support: An experimental test of pro-environmental spillover. *Journal of Environmental Psychology*, *46*, 55–66. https://doi.org/10.1016/j.jenvp.2016.03.004
van Valkengoed, A. M., Abrahamse, W., & Steg, L. (2022). To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour. *Nature Human Behaviour*, *6*(11), 1482–1492. https://doi.org/10.1038/s41562-022-01473-w
Werfel, S. H. (2017). Household behaviour crowds out support for climate change policy when sufficient progress is perceived. *Nature Climate Change*, *7*(7), 512–515. https://doi.org/10.1038/nclimate3316
Zhang, A., & Seuring, S. (2024). Digital product passport for sustainable and circular supply chain management: A structured review of use cases. *International Journal of Logistics Research and Applications*, *27*(12), 2513–2540. https://doi.org/10.1080/13675567.2024.2374256

Appendix

Supplementary results





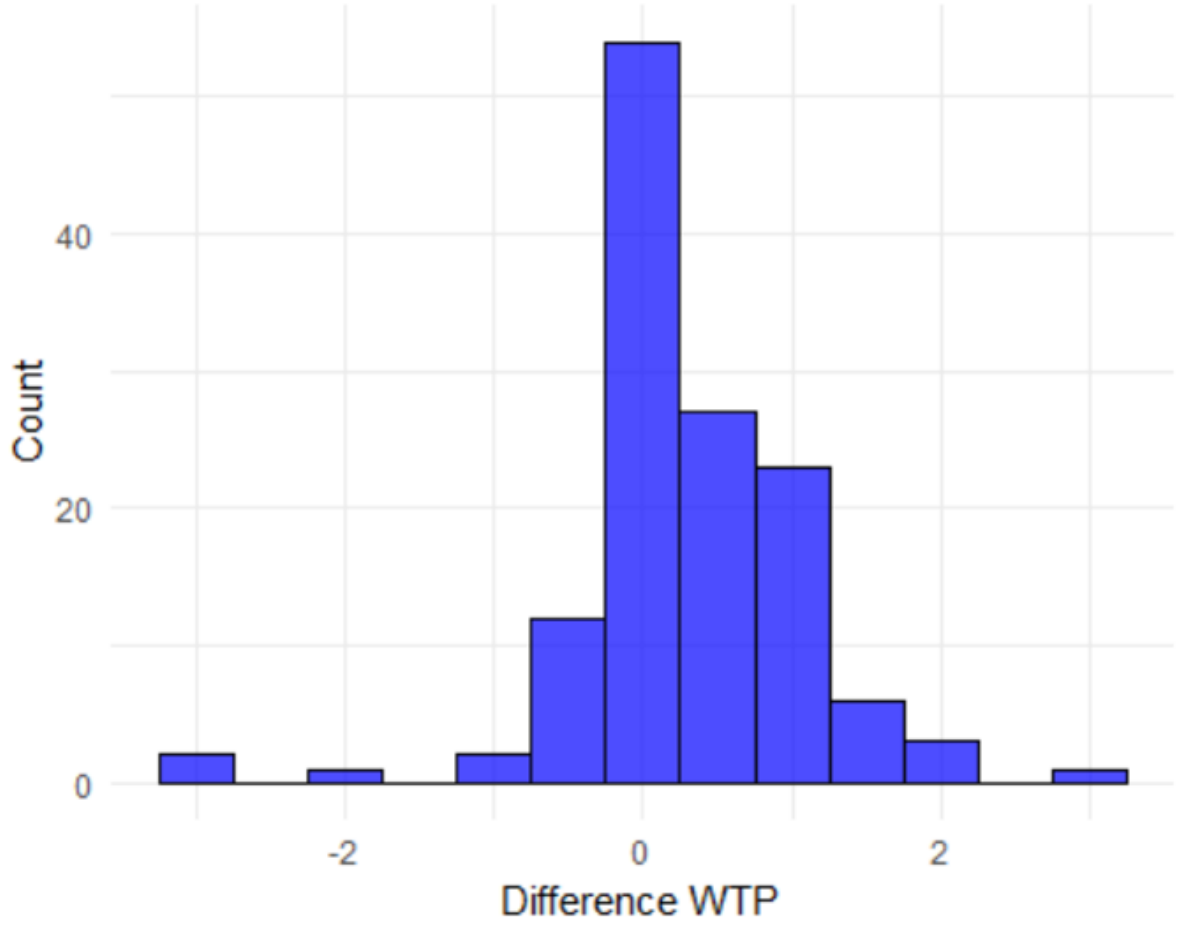

Count
40
20
0
-2
0
2
Difference WTP

Table 6 Multiple hypothesis testing all comparisons from Table 3 using List et al. (2019). Remark 3.1 is uncorrected two-sided tests, Theorem 3.1 is adjusted for multiple hypotheses.

	p values					
	Control vs				DPP vs	
	DPP		DPP+		DPP+	
	Remark 3.1	Theorem 3.1	Remark 3.1	Theorem 3.1	Remark 3.1	Theorem 3.1
WTP1	0.9853	1.0000	0.0963*	0.9143	0.1187	0.9407
Donation	0.3490	0.9997	0.6987	1.0000	0.4857	1.0000
WTP2	0.7400	1.0000	0.0013***	0.0413**	0.0057***	0.1737
Difference WTP2 WTP1	0.3747	1.0000	0.0003***	0.0003***	0.0013***	0.0410**
Engagement (time)					0.0003***	0.0003***
Quiz Earnings	0.0107**	0.2853	0.0003***	0.0003***	0.0020***	0.0647*
Appeal of toothbrush	0.1073	0.9313	0.7043	1.0000	0.1923	0.9873
Toothbrush envi friendly	0.0157**	0.3790	0.0003***	0.0003***	0.1833	0.9857
Toothbrush recyclable+	0.0917*	0.9103	0.0163**	0.3817	0.5473	1.0000
Personal norm	0.3353	1.0000	0.1803	0.9850	0.0107**	0.2897
Friends injunctive norm	0.3400	0.9997	0.5263	1.0000	0.6647	1.0000
Societal injunctive norm	0.9273	1.0000	0.6570	1.0000	0.5803	1.0000
Societal descriptive norm	0.1327	0.9477	0.3700	1.0000	0.5030	1.0000
Locus of control	0.7247	1.0000	0.7910	1.0000	0.4570	1.0000
Environmental self identity^	0.3563	0.9997	0.9680	1.0000	0.3227	0.9990
Environmental worry	0.5610	1.0000	0.1030	0.9270	0.3807	0.9997
DPP support	0.8920	1.0000	0.8977	1.0000	0.9923	0.9923
Stated WTE	0.3777	0.9997	0.8223	1.0000	0.4540	1.0000
Engagement (clicks on DPP)					0.0003***	0.0003***

Notes: ∗p < 0.1; ∗∗p < 0.05; ∗∗∗p < 0.01. [+]Reverse coded. ^One item dropped to increase Cronbach‘s alpha.

General Instructions

Welcome to the Individual Consumption Decision Experiment.

The instructions we have distributed to you are solely for your private information. **It is prohibited to communicate with the other participants during the experiment.** Should you have any questions please ask us. If you violate this rule, we shall have to exclude you from the experiment and from all payments.

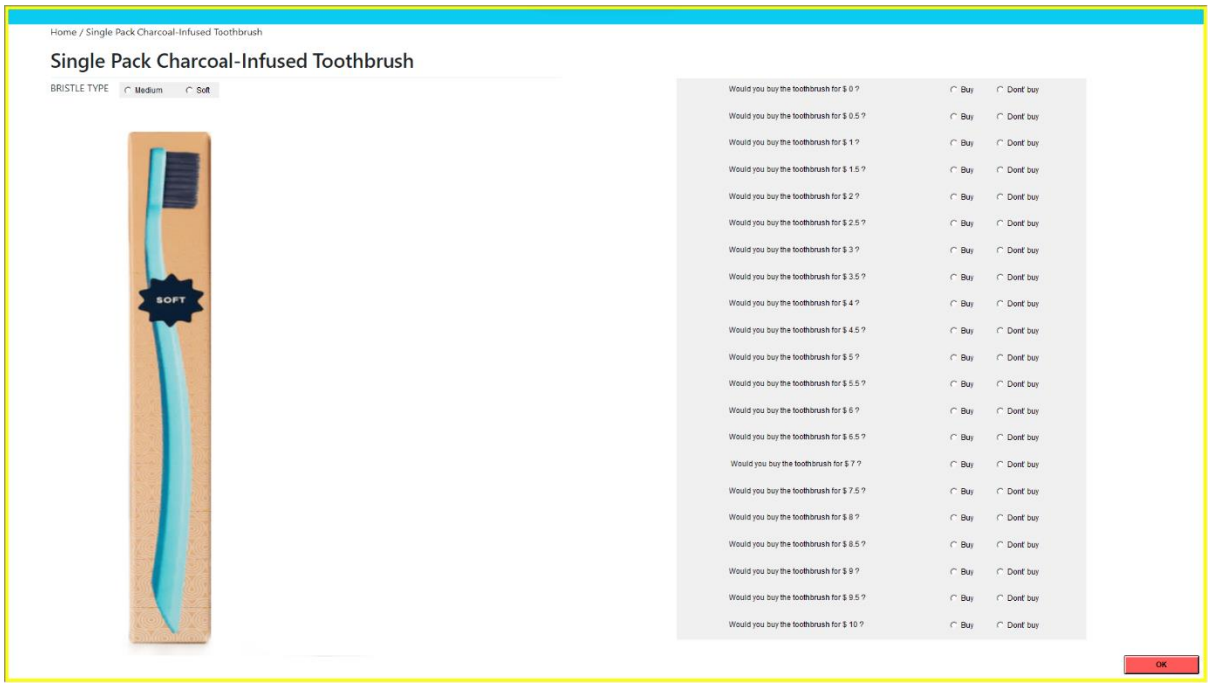
This is an experiment to gain an understanding of individual consumption decisions for toothbrushes. You will have an opportunity to make an actual purchase of a toothbrush in today's experiment, i.e., if you decide to purchase a toothbrush, you will pay the determined price and leave the experiment with the toothbrush.

At the beginning of the experiment, you will be given $10, which can be used to purchase a toothbrush. Any unspent cash is yours to keep.

To assist with making your purchase decisions, please think about the following situation. You are on your way to the grocery store to consider purchasing a toothbrush. Before you get to the store, you do not know the price of the toothbrush, but you might already have a price in mind of what you would be willing to pay for the toothbrush. In other words, you might think about what is the maximum price at which you would still buy the toothbrush. Let's call this maximum price that you are willing to pay for the toothbrush as your valuation. After you enter in the shop, you observe the actual price of the toothbrush, and you decide whether to buy the toothbrush or not. Your decision will depend on the actual price of the toothbrush: if the price is higher than your valuation, you will not buy the toothbrush. If instead the price is equal or lower than your valuation, you will buy the toothbrush.

In the experiment today, you will face decisions like the situation we provide above. You will be presented a list of possible prices to purchase a toothbrush. For each of these prices, you will need to compare this price to your valuation and decide whether you are willing to pay this price to purchase a toothbrush or not.

All transactions will take place via your computer terminal. The decision environment is very similar to an online shopping experience. Below is a hypothetical example of a Decision Screen.



On the left-hand side of the Decision Screen, an image of the toothbrush is provided. The actual colour of the toothbrush to be purchased is randomly drawn.

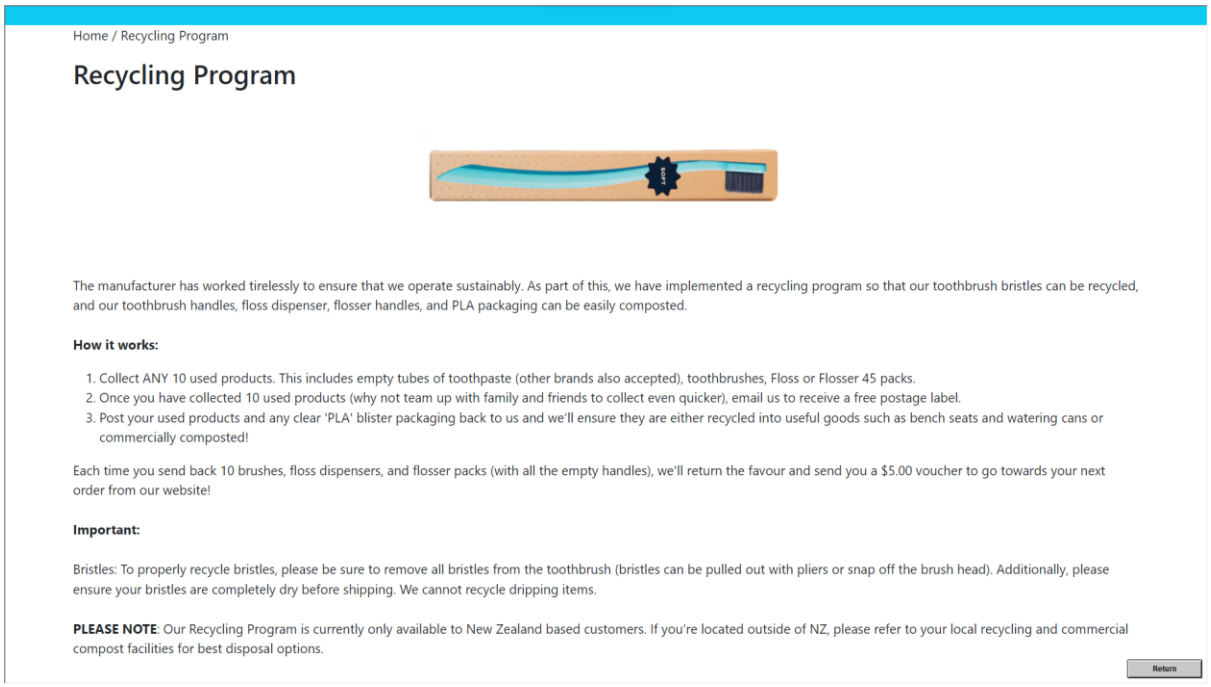
You must select your preference for bristle type by clicking either the "Soft" or "Medium" button directly above the toothbrush image.

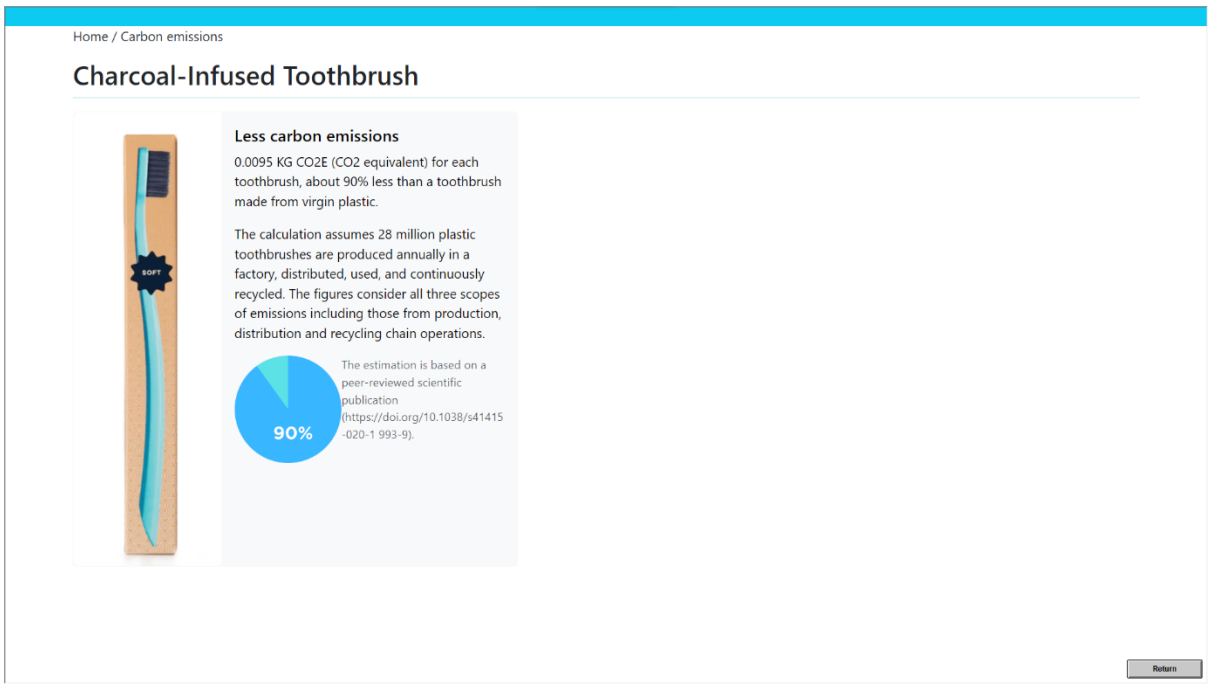
On the right-hand side of the Decision Screen, we provide a list of 21 possible prices for this toothbrush, which range from $0.00 to $10 in $0.50 increments. For each of these prices, you need to decide whether you are willing to pay this price to purchase a toothbrush by clicking either BUY or DO NOT BUY. For any price you select DO NOT BUY, all higher prices will automatically be set to DO NOT BUY. You can amend your decisions as much as you like until you click the OK button at the bottom of the screen. Once you click the OK button, all decisions are final.

To determine the actual price of the toothbrush, the computer will randomly draw a price between zero and $10. If you stated that you are willing to purchase a toothbrush for at least this price, then you will pay this price from the initially provided $10 and receive a toothbrush. If you stated that you are not willing to pay this price, then you will not buy a toothbrush and receive the $10.

In today's experiment, you will participate in two sequential purchase rounds. Even though you are making purchase decisions in two rounds, only one of these rounds will eventuate. More specifically, the computer will randomly select one of these purchase rounds and that round will be carried out to determine the outcome of today's experiment.

DPP Screenshots





Home / Materials and recycled content

Charcoal-Infused Toothbrush

Materials and recycled content

- Handle (20g): 100% recycled polypropylene plastic
- Bristle (0.4g): nylon and infused charcoal
- Packaging (7g): polylactic acid (plant-based bioplastic), cardboard and epoxy glue

Note: Please click on the links above to access general and technical information related to the materials.

Polypropylene
Nylon
Charcoal
Polylactid
Cardboard
Epoxy

Return

Digital library

Home / Polypropylene

Polypropylene

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene.
Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat-resistant. It is a white, mechanically rugged material and has a high chemical resistance.[1]
Bio-PP is the bio-based counterpart of polypropylene (PP).[2][3]
Polypropylene is the second-most widely produced commodity plastic (after polyethylene).

History

Phillips Petroleum chemists J. Paul Hogan and Robert Banks first demonstrated the polymerization of propylene in 1951.[4] The stereoselective polymerization to the isotactic was discovered by Giulio Natta and Karl Rehn in March 1954.[5] This pioneering discovery led to large-scale commercial production of isotactic polypropylene by the Italian firm Montecatini from 1957 onwards.[6] Syndiotactic polypropylene was also first synthesized by Natta.

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Digital library

Home / Nylon

Nylon

Nylon (PP) is a generic designation for a family of synthetic polymers composed of polyamides (repeating units linked by amide links).Nylon is a silk-like thermoplastic, generally made from petroleum,that can be melt-processed into fibers, films, or shapes.Nylon polymers can be mixed with a wide variety of additives to achieve many property variations. Nylon polymers have found significant commercial applications in fabric and fibers (apparel, flooring and rubber reinforcement), in shapes (molded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging).

History

Researchers at DuPont began developing cellulose-based fibers, culminating in the synthetic fiber rayon. DuPont's experience with rayon was an important precursor to its development and marketing of nylon.
DuPont's invention of nylon spanned an eleven-year period, ranging from the initial research program in polymers in 1927 to its announcement in 1938, shortly before the opening of the 1939 New York World's Fair. The project grew from a new organizational structure at DuPont, suggested by Charles Stine in 1927, in which the chemical department would be composed of several small research teams that would focus on "pioneering research" in chemistry and would "lead to practical applications". Harvard instructor Wallace Hume Carothers was hired to direct the polymer research group. Initially he was allowed to focus on pure research, building on and testing the theories of German chemist Hermann Staudinger.[10] He was very successful, as research he undertook greatly improved the knowledge of polymers and contributed to the science.

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Digital library

Home / Activated carbon

Activated carbon

Activated carbon , also called activated charcoal, is a form of carbon commonly used to filter contaminants from water and air, among many other uses. It is processed (activated) to have small, low-volume pores that increase the surface area available for adsorption (which is not the same as absorption) or chemical reactions. Activation is analogous to making popcorn from dried corn kernels: popcorn is light, fluffy, and its kernels have a high surface-area-to-volume ratio. Activated is sometimes replaced by active.
Due to its high degree of microporosity, one gram of activated carbon has a surface area in excess of 3,000 m2 (32,000 sq ft) as determined by gas adsorption. Charcoal, before activation, has a specific surface area in the range of 2.0–5.0 m2/g. An activation level sufficient for useful application may be obtained solely from high surface area. Further chemical treatment often enhances adsorption properties.
Activated carbon is usually derived from waste products such as coconut husks; waste from paper mills has been studied as a source.These bulk sources are converted into charcoal before being 'activated'. When derived from coalit is referred to as activated coal. Activated coke is derived from coke.

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Digital library

Home / Polylactic acid

Polylactic acid

Polylactic acid , also known as poly(lactic acid) or polylactide (PLA), is a thermoplastic polyester with backbone formula (C3H4O2)n or [–C(CH3)HC(=O)O–]n, formally obtained by condensation of lactic acid C(CH3)(OH)HCOOH with loss of water (hence its name). It can also be prepared by ring-opening polymerization of lactide [–C(CH3)HC(=O)O–]2, the cyclic dimer of the basic repeating unit.

PLA has become a popular material due to it being economically produced from renewable resources. In 2021, PLA had the highest consumption volume of any bioplastic of the world, although it is still not a commodity polymer. Its widespread application has been hindered by numerous physical and processing shortcomings. PLA is the most widely used plastic filament material in 3D printing. Its low melting point, high strength, low thermal expansion, good layer adhesion, and high heat resistance when annealed make it an ideal material for this purpose. Without annealing, however, PLA has the lowest heat resistance of the common 3D printing plastics.

Although the name "polylactic acid" is widely used, it does not comply with IUPAC standard nomenclature, which is "poly(lactic acid)". The name "polylactic acid" is potentially ambiguous or confusing, because PLA is not a polyacid (polyelectrolyte), but rather a polyester.

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Home / Epoxy

Epoxy

Epoxy is the family of basic components or cured end products of epoxy resins. Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. The epoxide functional group is also collectively called epoxy. The IUPAC name for an epoxide group is an oxirane.

Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols (sometimes called mercaptans). These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing.

Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance. Epoxy has a wide range of applications, including metal coatings, composites,use in electronics, electrical components (e.g. for chips on board), LEDs, high-tension electrical insulators, paint brush manufacturing, fiber-reinforced plastic materials, and adhesives for structural and other purposes.

The health risks associated with exposure to epoxy resin compounds include contact dermatitis and allergic reactions, as well as respiratory problems from breathing vapor and sanding dust, especially when not fully cured.

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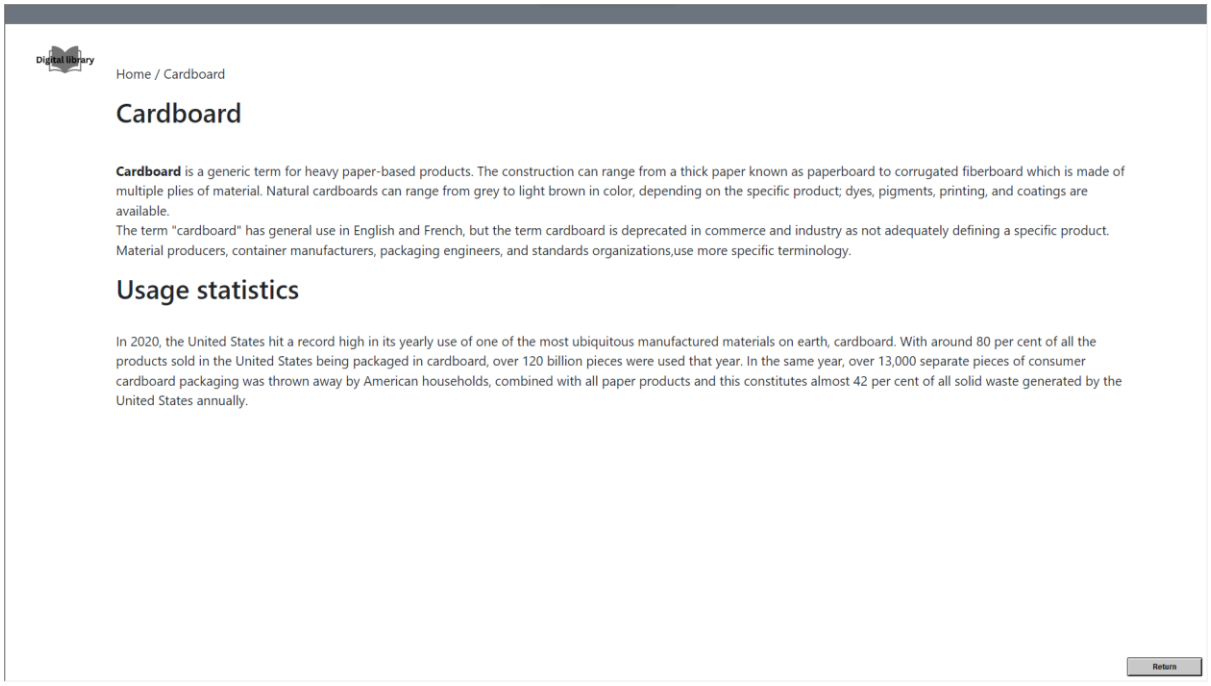
Digital library
Home / Cardboard
Cardboard
Cardboard is a generic term for heavy paper-based products. The construction can range from a thick paper known as paperboard to corrugated fiberboard which is made of multiple plies of material. Natural cardboards can range from grey to light brown in color, depending on the specific product; dyes, pigments, printing, and coatings are available.
The term "cardboard" has general use in English and French, but the term cardboard is deprecated in commerce and industry as not adequately defining a specific product. Material producers, container manufacturers, packaging engineers, and standards organizations,use more specific terminology.
Usage statistics
In 2020, the United States hit a record high in its yearly use of one of the most ubiquitous manufactured materials on earth, cardboard. With around 80 per cent of all the products sold in the United States being packaged in cardboard, over 120 billion pieces were used that year. In the same year, over 13,000 separate pieces of consumer cardboard packaging was thrown away by American households, combined with all paper products and this constitutes almost 42 per cent of all solid waste generated by the United States annually.
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Post-experiment Survey

[Note – all text in square brackets was not displayed to participants]

Survey

Thank you for completing the first part of today's experiment.

You now have a survey to complete. You will receive a payment of $10 for completing the survey.

[Donation]

You have the opportunity to donate up to $10 of your final earnings today to either Forest and Bird, Go Eco Waikato or Greenpeace Aotearoa.

We will email you your donation receipt in the coming days as proof that the donation has been made. If you choose to donate, you will need to provide us with your email address for this purpose only.

Which organization would you like to donate to?

- ○ Forest and Bird
- ○ Go Eco Waikato
- ○ Greenpeace Aotearoa
- ○ I do not wish to donate

A bit more about the organisations:

For 100 years, Forest and Bird have been protecting and restoring Aotearoa's wildlife and wild places - on land and in the sea. They advocate for conservation, as well as carry out conservation projects around the country.

Go Eco Waikato are a local voice for the environment, a centre for learning, and a hub for environmental activity in and around Hamilton. They are located at 188 Commerce Street in Hamilton.

Greenpeace Aotearoa is an independent, global environmental campaigning organisation. Here in Aotearoa, they seek to bring to life a vision of a land and an ocean full of diversity and life, unpolluted and protected, for all to enjoy.

[NEXT PAGE IF SELECT AN ORGANISATION, IF SELECT "I DO NOT WISH…" THEN SKIP]

How much would you like to donate? Please enter a value between 0 and 10:

____

What is your email address so that we can email you your receipt?

___

[NEW PAGE]

[Attitudes to the toothbrush]

[IF WTP = 0 for at least one of the purchase decisions:]

For at least one of your two purchase decisions, you said you were willing to pay $0 for the toothbrush.

Choose the option below that best explains why:

[Radio buttons]

- I do not use this type of toothbrush
- I do not buy the toothbrushes in my household
- The toothbrush does not appeal to me
- The toothbrush is not environmentally friendly enough
- I do not like environmentally friendly products
- Other (please state)

[NEW PAGE]

[All participants:]

This next set of questions relate to the toothbrush we presented to you today.

Please indicate how strongly you disagree or agree with each statement.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
The toothbrush design was appealing to me							
I think this toothbrush is environmentally friendly							
I think this toothbrush would be difficult to recycle							
I have not used this toothbrush before and would like to try it							
I recognise this toothbrush							
I already use this toothbrush							

[NEW PAGE]

[Quiz]

We will now give you a short quiz. Please do your best to select the best answer for each question. You will receive an additional $0.50 on your final payment today for every question you get correct.

[CORRECT ANSWERS NOTED IN SQUARE BRACKETS, NOT DISPLAYED TO PARTICIPANTS]

[NEW PAGE]

1. Which of the following component of this toothbrush are made from 100% recycled materials? Choose all that apply:

The bristles [NO]

The handle [YES]

The packaging [NO]

[NEW PAGE]

2. A toothbrush with a handle made from recycled plastic produces what % less emissions than one made from virgin (brand new) plastic:

0%

10%

50%

90% [CORRECT]

[NEW PAGE]

3. All components of this toothbrush and its packaging are able to be recycled – TRUE / FALSE

[TRUE]

[NEW PAGE]

4. Referring to the recycling scheme the toothbrush manufacturer runs: how many of these toothbrushes do you need to collect before you can post them back to the company?

1

4

10 [CORRECT]

20

[NEW PAGE]

The next set of questions ask more about your attitudes and values. The following statements represent different points of view or opinions. Remember, the best answer is your own opinion.

[Locus of control]

Please indicate how strongly you disagree or agree with each statement.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

The sooner consumers start buying greener products, the sooner companies will transform to respond to their demands.

The more I buy ‘green’ products, the more I help persuade companies to become ‘friendlier’ to the environment.

By buying greener products, I can make a difference in helping the environment.

The efforts deployed by environmental groups (such as Greenpeace) have an impact on the end result of many ecological challenges.

By making donations to pro-environmental groups (such as Greenpeace), I can help make a positive difference on the state of the environment.

I am able to convince some of my friends to take some kind of action with regards to environmental challenges.

If willing, people can generally influence their friends' environmentally-friendly purchasing habits.

By re-using or recycling, I am helping to reduce pollution.

By re-using or recycling, I am doing my part to help the state of the environment.

The more paper I recycle, the more trees I save.

By re-using or recycling, I am saving valuable natural resources.

[Adapted from (Cleveland et al., 2020)]

[NEW PAGE]

[Environmental self identity]

Please indicate how strongly you disagree or agree with each statement.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I think of myself as an environmentally-friendly consumer							
I do not think of myself as someone who is very concerned with environmental issues							
I would be embarrassed to be seen as having an environmentally-friendly lifestyle							
I want my family and friends to think of me as someone who is concerned about environmental issues							

[(Adapted from (Truelove et al., 2016))]

[NEW PAGE]

[Emotions]

To what extent do you feel the following feelings right now

	Does not apply at all	Does not apply	Slightly does not apply	Neither applies nor does not apply	Slightly applies	Applies	Applies very much
Guilt							
Shame							
Pride							
Joy							

[NEW PAGE]

How personally worried are you about:

	Very worried	Somewhat worried	Neither worried nor not worried	Somewhat not worried	Not at all worried
Climate change					

Plastics pollution

The impact people are having on the environment

[Adapted from (Truelove et al., 2016)**]**

[NEW PAGE]

[Future willingness to engage with DPP]

Please indicate how strongly you disagree or agree with each statement.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

I want to have access to more information about the environmental performance of the products I am buying

I think it should be compulsory for information to be easily available about the environmental performance of the products I am buying

I think it should be easy to re-use and recycle all products and their packaging

In a supermarket, I would open a QR code on a product like a toothbrush to read more information about how environmentally friendly it is

In a shop, I would open a QR code on a product like a cellphone to read more information about how environmentally friendly it is

When shopping online, I would click a link on a product like a cellphone to read more information about how environmentally friendly it is

For a product like a toothbrush, I would be willing to pay more for a more environmentally friendly option

For a product like a toothbrush, I make sure I find the most environmentally friendly way to dispose of it when it is worn out

For a product like a cellphone, I would be willing to pay more for a more environmentally friendly option

For a product like a cellphone, I make sure I find the most environmentally friendly way to dispose of it when it is worn out

[NEW PAGE]

[Norms]

[agree/disagree 7 point scale]

Please indicate how strongly you disagree or agree with each statement.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
It is important to me to know that I have made environmentally friendly purchasing decisions							
My friends expect me to try to make environmentally friendly purchasing decisions							
Most people think that everyone should try to make environmentally friendly purchasing decisions							
Most people try to make environmentally friendly purchasing decisions							

[Demographics]

Finally, we have some quick questions to help us know a bit more about you

What is your age?

_____[enter value between 18-100]_____

Q12 What is your gender identity?

○ Male

○ Female

Non-binary/Gender diverse

What ethnic group do you belong to? (Please select as many that apply to you)

- ▢ New Zealand European
- ▢ Māori
- ▢ Samoan
- ▢ Cook Islands Māori
- ▢ Tongan
- ▢ Niuean
- ▢ Chinese
- ▢ Indian
- ▢ Other (please specify) _____