

Working Paper

Exploring Driving Forces of Green Shopping Behavior

How to utilize user tracking data to design more effective
pro-environmental behavior interventions

Author: Robin Jadkowski

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Contact: info@green-consumption-assistant.de

Abstract

This study evaluates psychological and socio-demographic driving forces of pro-environmental behavior (PEB) in an online shopping environment. Previous empirical studies substantiate the role and strengths of numerous psychological driving forces that influence individual PEB. However, the type of PEB operationalization is heterogeneous, as well as the type and operationalization of the driving forces. Steg & Vlek (2009) stress the point that effective interventions have to be aimed at these driving forces and that the strengths and relationship differs for specific types of PEB. Up to date, studies that use actual behavior as operationalizations of PEB in online shopping environments are rare, therefore this study pursued two main goals: (1) Test a method to link user tracking data of a digital shopping assistant (as indicators for pro-environmental shopping decisions) with self-reported survey items; (2) Exploratively assess the relationship of four socio-demographic and 14 psychological variables that may act as driving forces for PEB. The click behavior of N = 35 beta users of an online shopping assistant was tracked over a period of five months and successfully linked to previously obtained survey data. It was not possible to reliably detect effects of the assessed driving forces – PEB relationship with the achieved sample size. In conclusion, this studies procedure revealed great potential for future research to evaluate the effects of psychological variables on PEB in a real shopping environment.

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Introduction

E-commerce is one of the fastest growing sectors with a mean yearly revenue increase of 14.4% over the past decade, from 20.2 billion Euro in 2010 to 59.2 billion in 2019 (Handelsverband Deutschland, 2020). In a connected, globalized world, each consumer decision has manifold impacts on the environment. The consumption of each product includes direct and indirect environmental impacts that arise in different product lifecycles from cradle to grave. Considering carbon emissions at each step of a product lifecycles can give a glance of the shopping decision's impact on the climate; other environmental impacts of consumer decisions on *planetary boundaries* (Rockström et al., 2009), such as biodiversity loss, chemical pollution or ocean acidification, are harder to quantify.

There are numerous ways to mitigate these impacts, such as a more energy efficient production, policy regulations or 'nudging' people towards a more sustainable consumption lifestyle. While there are some interventions that can successfully be addressed by top down measures, interventions targeting specific actions and lifestyles need to be designed to take inter-individual differences of driving forces of consumer behavior into account. To achieve a behavior change for individual consumer decisions, Geller (2002) proposed an approach where four steps need to be considered: (1) *Define*: thorough selection of target behavior that is beneficial for the environment; (2) *Observe*: detect which factors cause these target behaviors; (3) *Intervene*: develop well-tuned interventions according to the identified factors and (4) *Test*: evaluate the effects of these interventions on the behavior themselves, the factors and the environmental impact. This study focuses on step two of this approach, proposing a method to identify driving forces that lead people to arriving at a more sustainable shopping decision. The unique method of evaluating these driving forces by analyzing user tracking data in a real online shopping environment sets this study apart from other studies that use self-reported questionnaire items as behavior indicators. Building on the insights of this study it is possible to develop more effective behavior interventions in online shopping environments.

Driving forces of sustainable consumption behavior

Throughout the last decades, studies have identified many different driving forces of pro-environmental behavior (PEB), and have empirically tested whether these are causal determinants or correlational antecedents of the latter (e.g., Bamberg, 2007; Gatersleben et al., 2002). The goal of these studies is usually two-sided: Foremost, they aim to explain what drives individuals or groups to show PEB and secondly, by identifying antecedents as determinants of PEB they can be used to design interventions to increase PEB in specific contexts.

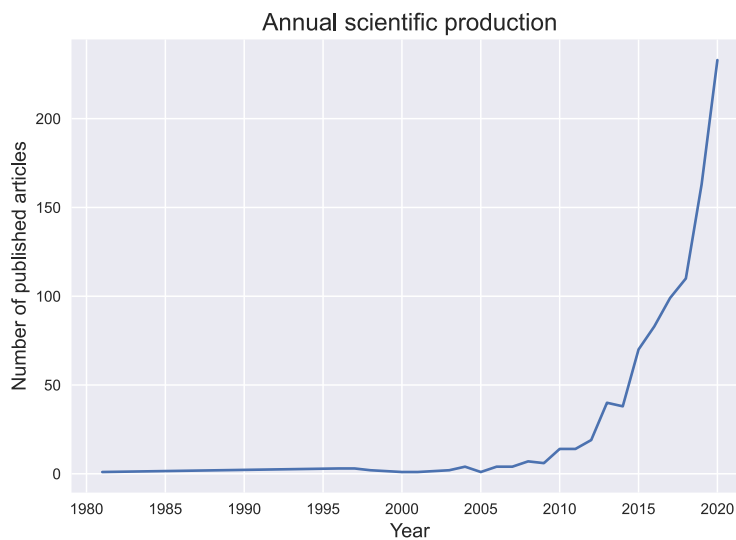
The factors that drive PEB can be categorized into three groups (see Gifford et al., 2011; Peattie, 2010):

- (1) *Socio-demographic /socio-economic factors*: e.g., income, cultural/societal norms, etc.
- (2) *Psychological antecedents*: e.g., perceived behavioral control, norms, attitudes, cognitive factors, etc.
- (3) *Context factors*: e.g., nudges in choices architectures, spatial/emotional/social context of decision-making environment, etc. (e.g., Byerly et al., 2018)

A large number of these factors have been included and empirically tested via structural equation models (e.g., Bamberg, 2007; Frick et al., 2020) while the theoretical backbone for these models is drawn from many varied disciplines, such as marketing, psychology, sociology, economics and sustainability studies. According to Steg & Vlek (2009) and Michie et al. (2018) the effectiveness of behavioral interventions depends on whether they are aimed at antecedents of the relevant behavior.

Figure 1: Number of article publications with the thematic focus on PEB and sustainable consumption from 1981 to 2021.

To extract important factors that drive PEB, it is necessary to take a closer look at the theoretical models



used to describe the formation of PEB. A bibliometric analysis¹ of previous research efforts reveals not only a growing interest in this field of research (see figure 1), but also the most used keywords in published journal articles (see figure 2).

¹ The bibliometric analyses was carried out using the bibliometrix package in R (Aria, 2017). The analyzed articles consisted of the results on Web of Science that got returned using the following query parameters: *search query*: 'pro-environmental behavio*' OR 'sustainab* consum* behavio*' OR 'green* consum* behavio*' | *refined by*: document types: article OR review | *timespan*: All years (1981-2020). The query yielded a total result of 1,037 articles on the 12.04.2021.

The twenty most commonly cited articles (see table 1) give a glimpse of the four major theories that are resorted to when explaining PEB: (1) Theory of planned behavior (2) Value-Belief-Norm Theory (3) Model of pro-environmental behavior and (4) Norm-Activation model.



Figure 2: Word cloud of the most frequently used keywords in articles that focus on PEB (using the Bibliometrix Keyword Plus method, counted the absolute frequencies, limited to 30 keywords).

Theory of planned behavior

The most prevalent theory to explain PEB is the Theory of planned behavior (TPB) by Ajzen (1991) (see figure 3). The TPB is a rational choice model, implying that individuals make a rational behavioral choice by evaluating behavioral consequences, where they seek to receive rewards and avoid punishments. The TPB states that the sum of this evaluation comprises the attitude towards a

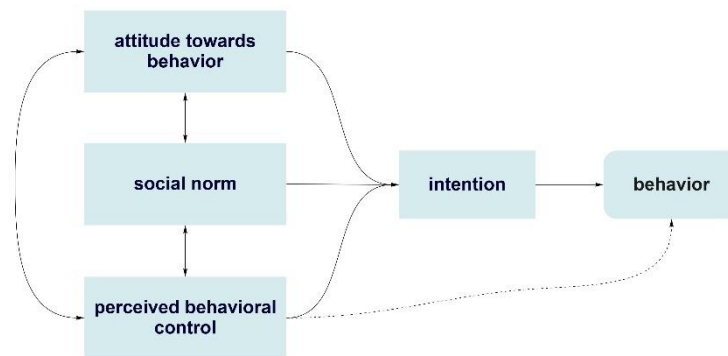


Figure 3: The Theory of planned behavior, according to Ajzen (1991) (own figure).

behavior. The TPB presents two more factors that determine the behavioral intention: Perceived behavioral control (PBC) and subjective norms. PBC “refers to people’s perception of the ease or difficulty of performing the behavior of interest” (Ajzen, 1991, p. 183). Along with the third factor of social norms, which are viewed as the pressure to perform a certain behavior exerted by meaningful reference persons, these three factors are theorized to determine the actual behavior indirectly via an intention to show this behavior. PBC is the only of the three factors that predicts the actual behavior directly.

Citations	Year	Author	Title	Theory
288	1991	Ajzen I.	The theory of planned behavior.	Theory of planned behavior
272	2000	Stern P.C.	Toward a Coherent Theory of Environmentally Significant Behavior.	Value-Belief-Norm Theory
240	2002	Kollmuss A. & Agyeman J.	Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?	Model of pro-environmental behavior
230	2009	Steg L. & Vlek C.	Encouraging pro-environmental behaviour: An integrative review and research agenda.	None / Proposition of intervention framework
172	2007	Bamberg S.	Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psychosocial determinants of pro-environmental behaviour.	None / Meta-analytic structural equation model
160	1981	Fornell C. & Larcker D. F.	Evaluating structural equation models with unobservable variables and measurement error.	None / statistical paper
139	2000	Dunlap R.E. et al.	New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale.	None / revision of new environmental paradigm scale
123	1999	Stern P.C. et al.	A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism.	Value-Belief-Norm Theory
111	1977	Schwartz S.H.	Normative Influences on Altruism.	Norm-Activation Model
104	1980	Ajzen I., Fishbein M.	Understanding attitudes and predicting social behavior.	Theory of planned behavior (predecessor)
93	2003	Podsakoff P.M. et al.	Common method biases in behavioral research: A critical review of the literature and recommended remedies.	None / methodological paper
93	2010	Whitmarsh L. & O'Neill S.	Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours.	None / empirical study on evaluation self-identity as a driving force of PEB
87	1988	Anderson J.C. & Gerbing D.W.	Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach.	None / statistical paper
81	1993	Stern P.C. et al.	Value Orientations, Gender, and Environmental Concern.	Value-Belief-Norm Theory (predecessor)
79	2001	Laroche M. et al.	Targeting consumers who are willing to pay more for environmentally friendly products.	None / study on willingness to pay for green products
73	2014	Steg L.	An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals.	None / empirical study on goal framing theory
71	1992	Schwartz S.H.	Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries.	Value-Belief-Norm Theory (predecessor)
70	1975	Fishbein M. & Ajzen I.	Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research.	Theory of planned behavior (predecessor)
69	2003	Diamantopoulos A. et al.	Can socio-demographics still play a role in profiling green consumers? A review of the evidence and an empirical investigation.	None / empirical study on socio-demographic factors for PEB
69	1999	Hu L.T. & Bentler P.M.	Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives.	None / statistical paper

Table 1: Results of 20 most frequently locally cited references from the bibliometric analyses. 'Local citations measure how many times an author (or a document) included in this collection have been cited by the documents also included in the collection.' (Aria, 2017)

Norm-Activation model

The Norm-Activation model by Schwartz (1977) describes moral or personal norms as direct determinants of pro-social behavior (see figure 4). Moral norms are defined as a person's feeling that one is obliged to perform a certain behavior (as opposed to a perceived social pressure). Moral norms are determined by two factors: (1) Being aware of the consequences a behavior has and (2) ascribing the responsibility to oneself for performing a specific behavior. According to Bamberg (2007), antecedents that are specific to PEB and contribute to the formation and activation of moral norms are the knowledge about environmental problems, feelings of guilt and social norms.

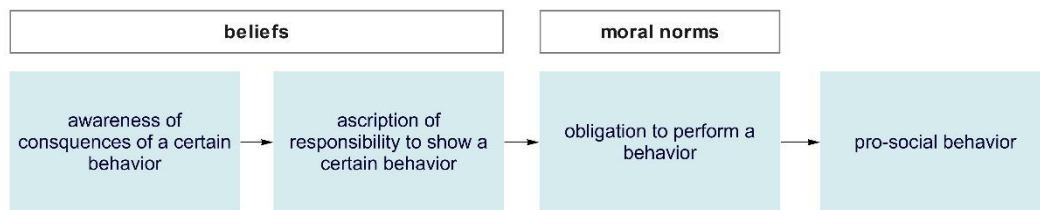
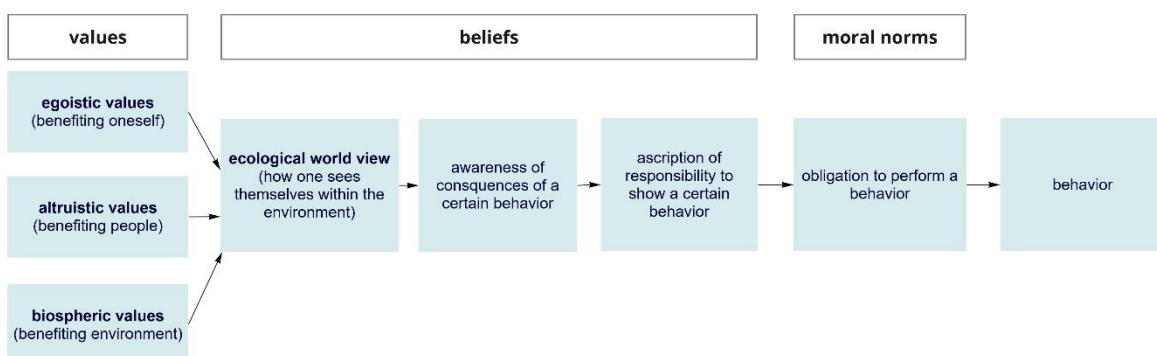


Figure 4: The Norm-Activation model, according to Schwartz (1977) (own figure).

Value-Belief-Norm theory

The Value-Belief-Norm theory by Stern (2000) is a derivative of the Norm Activation model, adding value theory and the new ecological paradigm to Schwartz' framework in order to better explain environmental behavior (see figure 5). The Value-Belief-Norm theory emphasizes the role of three value types: egoistic values (maximizing the personal benefits), altruistic values (maximizing the welfare of others) and biospheric values (maximizing the benefits for the environment). These result in the ecological world view that an individual holds which in turn results in the beliefs, moral norms and ultimately in a specific environmentally related behavior. De Groot & Steg (2009) empirically tested this framework and validated the proposed sequential process of values → beliefs → moral norms → behavior (-intention).

Figure 5: The Value Belief Norm theory, according to Stern (2000) (own figure).



Model of pro-environmental behavior

The goal of the model of pro-environmental behavior by Kollmuss & Agyeman (2002) was to better understand the gap between environmental knowledge and the actual

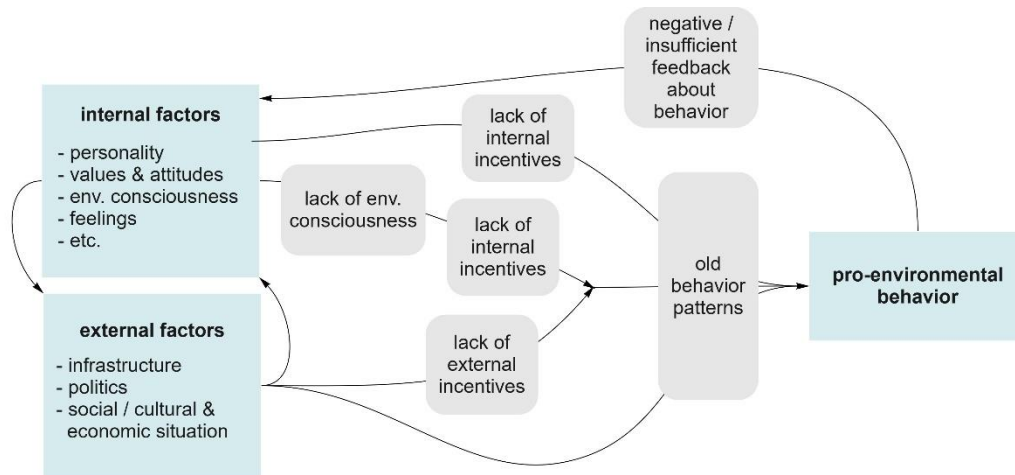


Figure 6: Model of pro-environmental behavior, according to Kollmuss & Agyemmann (2002), grey boxes represent barriers to perform a behavior. The depicted model is a summary of the original concept (own figure).

behavior that people elicit, the 'intent-behavior-gap', by merging multiple theories on drivers and barriers of PEB (see figure 6). The authors describe two main factors as driving pro-environmental behavior: internal and external factors. Internal factors are described as an interplay between environmental knowledge, emotions (emotional involvement, feelings of fear) and values / attitudes that make up environmental consciousness as a whole. These three parts are either driving each other (e.g., increased environmental knowledge can increase environmental values) or present themselves as barriers to each other (e.g. feelings of fear can block the intake of new knowledge). The internal factors are affected by external factors (e.g. social / cultural norms) and can affect external factors (e.g. by political activism). While both, internal and external factors, are driving PEB, they are inhibited by barriers along the way: a lack of environmental consciousness or incentives reduces PEB, as well as habitual behavior patterns. Furthermore, the feedback loop after PEB has been shown is considered. This loop can lower future PEB, if the feedback is negative or insufficient.

There are numerous other theories that include different driving factors, barriers and their moderating and mediating relations with PEB, e.g. the social cognitive theory of reciprocal determinism (Phipps et al., 2013), the goal framing theory (Lindenberg & Steg, 2007) or the stage model of self-regulated behavioral change (Bamberg, 2013). This wide array of concepts has left researchers in the past years and up to this day with heterogeneous results on the existence, direction and size of specific driving forces of PEB, making it hard to draw valid conclusions on how to increase PEB of individuals. Furthermore, individual PEB is fairly inconsistent across different behaviors (Steg & Vlek, 2009), which indicates that different factors play different roles for specific types of PEB, e.g. recycling may be driven by other factors than sustainable shopping decisions.

Assessment of pro-environmental behavior in online shopping environments

PEB is usually defined as a “purposeful action that can reduce a negative impact on the environment” (Li et al., 2019, p. 29). According to Li and colleagues the purchase of green products & waste management is one of three domains that are prevalently considered in empirical studies, the other two being recycling and reuse of products. Multiple driving forces for green purchase behavior have been evaluated in for shopping environments and purchase behavior: e.g. Atkinson & Rosenthal (2014) have found environmental knowledge communication through eco-labels to increase environmental shopping behavior; Rezvani et al. (2017) have found anticipated emotions to be deterministic of green consumer behavior; Kim et al. (2012) found social norms to influence green products purchase intentions. These studies follow different methodological approaches, but the overwhelming majority of studies use survey data with items assessing a certain shopping intent. This is a large methodological deficit of existing research, especially regarding the ‘intent-behavior-gap’ (e.g. Carrington et al., 2010; Moser & Kleinhüchelkotten, 2018; Nguyen et al., 2019), stating a difference in the way people behave (PEB) vs. how they say they would behave (intention) . There are many possible explanations to these differences, such as strong habitual behavior, financial constraints, strong brand loyalties, a prevailing (unsustainable) lifestyle, perceived sacrifices of sustainable choice (see Peattie, 2010) and social desirability bias brought about by the surveys or interventions themselves (Brick & Sherman, 2021). There are studies that include the experimental assessment of actual observed PEB (e.g., Lange et al., 2018), but the amount is outweighed by self-reported PEB studies to a large degree.

Furthermore, regarding online shopping environments, new context factors, like the exposure to online advertising content (Frick et al., 2020) or the dynamics of social media (Zhao et al., 2019), need to be considered. Therefore, it is indispensable to examine if effects of driving forces of PEB can be replicated in online shopping contexts, with using real life purchase behavior instead of purchase intent. To the best knowledge of the authors of this paper, there are no studies that examine exactly this relationship.

Another dilemma of scientific research on green consumption is that studies mostly aim to explain or try to shift consumers' purchase behaviors to the consumption of more sustainable products. This might be because a large share of studies is rooted in economics or marketing which focus on goods or services that are bought. However, the term ‘green consumption’ is an oxymoron, because it alludes to the notion that it is possible to consume and simultaneously have a positive impact on the environment. The assessment of PEB that is portrayed as consumption sufficiency rather than the selection of ‘green’ products is necessary (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES, 2019). A movement towards a more sustainable shopping behavior should include the reduction of purchases, or choosing substitutions that don’t rely on the production of new goods (García-de-Frutos et al., 2018).

Therefore, studies that combine an assessment of psychological variables as driving factors and the assessment of more ‘objectively assessed’ PEB are necessary, especially when evaluating the impact of interventions to increase sustainable behavior not only on the intent of behavioral change, but also on the actual behavior shown and, therefore, the actual impact that this behavior has on the environment.

This study aims at closing these research gaps by exploratively identifying the strongest driving forces of PEB in an online shopping environment and assessing PEB as click data, which is 'real' user behavior instead of evaluating self-reports. Furthermore, sustainable shopping behavior is defined, not only as showing an interest in sustainable products, but also includes parts of green consumerism that are more related to sufficiency.

Methods

Procedure and sampling

Data collection was administered from German users of an online shopping assistant, the [Green Consumption Assistant](#) (GCA). It is a Chrome browser extension that provides users with sustainable alternatives when searching for electronic devices (smartphones, tablets, notebooks) on search engines (Google, Ecosia, Duckduckgo, etc.) or online stores (Amazon, Mediamarkt, Otto, etc.) (see figure 7). Users then have the option to click on any of the presented four options: ‘*Neu kaufen*’ - buy new; ‘*Gebraucht kaufen*’ - buy used; ‘*Reparieren*’ - repair or ‘*Länger nutzen*’ - use longer. Subsequently they will get more detailed information on and have the ability to visit recommended websites to perform the behavior for the selected option (see figure 7 and 8).

Figure 7: A representation of the how the GCA users are presented with the sustainable shopping alternatives.

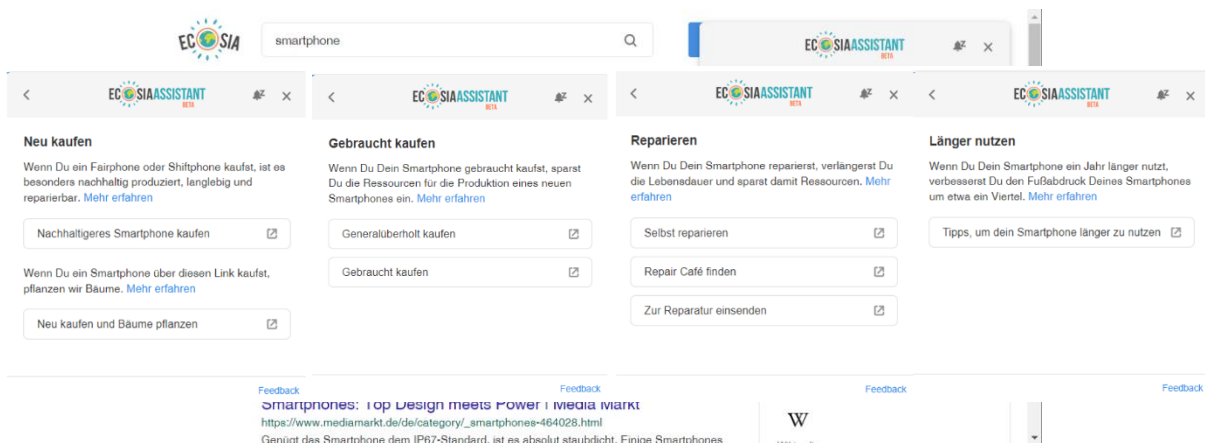


Figure 8: The screens which the users are presented with, when they click on the sustainable alternatives within the GCA. They show detailed information on the behavior itself and present links to websites that let users perform these behaviors.

The sampling was performed as an opportunity sample from beta users of the GCA, which were recruited through the index page and social media channels of the search engine [Ecosia](#). The survey was administered two weeks after the users installed the GCA via a notification within the Chrome browser. A total of 868 beta users were prompted to participate in the study. 211 clicked on the link to the survey, 69 completed the general product feedback, 65 completed the research survey (total response rate = 13.78%) and accepted the consent statement. Two respondents chose not to specify their socio-demographic information. That accounts for a N=65 for the analyses of the psychological antecedents and N=63 for analyses of socio-demographic data. Tracking events, i.e. interaction the users had with the GCA, have been collected over the period of five months, starting on the 17.02.2021. Out of the N=65 respondents there was tracking data available for N = 35 respondents, which concludes the final sample size for all statistical analyses. The participation in the study was voluntary and no monetary compensation was received.

Operationalization of driving forces of PEB

Socio-demographic and psychological constructs were chosen to be evaluated as driving forces for PEB in this study. By scanning the journal articles that were returned from the bibliometric analyses (see footnote 1) and empirical studies and reviews were checked for relevance (ie. whether there is sufficient evidence for driving PEB). This led to the selected constructs, depicted in table 2, describing the definitions, empirical evidence, existing measures of these constructs and the operationalizations that were used in this study. For each construct the operationalization was reduced to one or two items to ensure an economical testing set up. Survey items were created according to the following process: (1) highest item-total correlation (2) medium item difficulty (3) greatest face validity of item and (4) items were translated into German. If data for certain steps was not accessible in the cited articles (see table 2, column 'measures'), the steps were skipped. For the construct 'social desirability' the appropriate dichotomous item ('Ich habe geliehene Sachen schonmal nicht zurückgegeben') from the SES-17 (Stöber, 1999) was discarded and replaced to match the 7-point Likert-scale of the other survey items. The answer format of all items was set to a 7-point Likert scale from 1 ('I completely disagree') to 7 ('I completely agree').

Operationalization of PEB

The methods to assess PEB are diverse with measures ranging from self-report questionnaires, field or laboratory observations or interviews, each of them offering different benefits (Lange & Dewitte, 2019). For calculating the PEB variable in this study, an observation of online behavior in a field context was chosen. The advantage of this measurement is the assessment of real behavior instead of self-reports, thus avoiding assessment problems due to the intent-behavior-gap. Furthermore, online shopping behavior is likely mediated by habits (Chiu et al., 2005) and it might therefore be harder for participants to conceal the PEB that they would show without being part of a study. The assessment of the PEB variable was also uncoupled from the survey which means that at the point of PEB assessment, participants might not have been aware that their clicks were being used in the study.

For this study, the user tracking events (i.e. pop-ups and clicks within the GCA) that were gathered were analyzed. The data was prepared using the following data preparation process: (1) Data cleaning: Raw event data was cleared of (a) tracking events that came from part of the research group and software developers while testing the tracking functionalities and (b) false positive pop-

		construct definition	empirical evidence	measures	final item in survey	
socio-demographic variables	individuals	age, education level, gender	manifest variables	inconsistent results (Gifford & Nilsson, 2014; Grendstad & Wollebaek, 1998; Patel et al., 2017)	-	1. "Wie alt bist Du?" 2. "Welchen höchsten akademischen Abschluss hast Du?" 3. "Welchem Geschlecht fühlst Du Dich zugehörig?"
		income	manifest variable	significant influence on PEB (Moser & Kleinhüchelkotten, 2018)	-	"Wieviel Einkommen steht dir pro Monat zur Verfügung?"
related to social context	individuals	reference persons	the behavior and norms that are shown by persons who's opinion is relevant to the subject (S.-Y. Kim et al., 2012)	significant influence on PEB (S.-Y. Kim et al., 2012; Welsch & Kühling, 2009)	3-item measure (Kim et al 2012)	"Mein soziales Umfeld verhält sich im Alltag nachhaltiger als ich."
		social norms	Subjective feeling that significant others expect a certain behavior from someone (Schwartz, 1977). According to the focus theory of normative conduct (Cialdini et al., 1991) social norms can be separated into injunctive norms (what other people think is the right thing to do) and descriptive norms (how other people actually behave).	it's mainly used as a type of intervention rather than an antecedent driving force of PEB	usually used in intervention development and evaluation and not as survey items	1. "Beim Online-Kauf wählen viele Menschen die nachhaltigere Option" 2. "Ich glaube es ist in der Gesellschaft anerkannt, nachhaltige Produkte online zu kaufen"
		perceived consumer effectiveness	Perceived consumer effectiveness refers to the consumer's belief that one can make a difference or impact the environment by purchasing or using environmentally friendly products (Nguyen et al., 2019)	significant influence on PEB (Gifford & Nilsson, 2014)	4-item measure (Nguyen et al 2018)	"Mein individuelles Kaufverhalten hat einen signifikanten Einfluss auf ökologische und soziale Nachhaltigkeit."
		social desirability	"the tendency of subjects to attribute to themselves in self-description, personality statements with socially desirable scale values, and to reject those with socially undesirable scale values" (Edwards, 1957, p. vi)	weak direct effect on the environmental attitudes - PEB relationship (Milfont, 2009)	Soziale Erwünschtheitskala (SES-17, Stöber, 1999)	„Mir fällt es schwer, Dinge über mich zuzugeben, die gesellschaftlich nicht anerkannt sind."
cognitive aspects	individuals	Environ-mental attitudes	"the collection of beliefs, affect, and behavioral intentions a person holds regarding environmentally related activities or issues" (Schultz et al., 2004, p. 34)	significant influence on PEB (Bamberg, 2007)	(revised) New environmental paradigm scale (NEP, Dunlap et al., 2000)	1. "Wenn Dinge so weiter verlaufen wie bisher, werden wir bald eine große ökologische Katastrophe erleben." 2. "Die Umwelt kann nur gerettet werden, wenn wir alle weniger konsumieren."
		Techno-salvation	"believe that technology alone [...] can solve the problems associated with climate change" (Gifford et al., 2011)	no empirical studies available	no measure available	"Ich glaube, dass technologischer Fortschritt die Probleme in Zusammenhang mit ökologischer und sozialer Nachhaltigkeit lösen kann."
		personal affectedness	"perceived proximity to related environmental issues, i.e. the extent to which individuals believe to be directly affected by those issues" (Markle, 2011)	significant influence on PEB (Markle, 2011)	1-item measure (Baldassare & Katz, 1992)	"Die Nachhaltigkeitskrise hat heute oder wird in naher Zukunft einen großen negativen Einfluss auf mein Leben haben."
		voluntary simplicity	"the choice out of free will [...] to limit expenditures on consumer goods and services and to cultivate non-materialistic sources of satisfaction and meaning (Etzioni, 1998, p. 620)	significant influence on PEB (Iwata, 2006)	Voluntary Simplicity Engagement Scale (Rich et al., 2020)	1. "Ich repariere kaputte Dinge, anstatt sie neu zu kaufen." 2. "Ich versuche nur wenig Gegenstände zu besitzen."
		PBC	"perceived ease or difficulty of performing a behavior" (Ajzen, 1991, p. 188)	significant influence on PEB (Bamberg, 2007)	2-item measure (Onwezen et al., 2013)	"Für mich ist es ein Leichtes immer die nachhaltigste Option beim Kauf zu wählen."
		personal norms	Personal norms refer to internalized moral norms about certain action, where one believes that they pose a threat to other people, species or the biosphere. (Schwartz, 1977)	significant influence on PEB (Bamberg, 2007)	4-item measure (Wu & Chen, 2014)	"Ich glaube, dass der Kauf von nachhaltigen Produkten richtig ist."
emotional aspects	individuals	Connected-ness to nature	"The experience of connectivity involves dissolution of boundaries and a sense of a shared or common essence between the self, nature, and others." (Dutcher et al., 2007, p. 474)	significant influence on PEB (Gosling, 2010)	10-item measure (Dutcher et al., 2007)	"Ich fühle mich der Natur ganz nah."
		feeling of guilt	"guilt is an emotion that is] evoked by evaluations of one's self after failing to follow personal or social standards." (Onwezen et al., 2013, p. 143)	significant influence on PEB (Bamberg, 2007)	guilt inventory (Kugler & Jones, 1992)	"Ich habe ein schlechtes Gewissen, wenn ich etwas weniger Nachhaltiges kaufe."
behavioral aspects	individuals	intention to change behavior	"An indication of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1991, p. 181)	significant influence on PEB (Bamberg, 2007)	multiple different measures, e.g. 3-item measure (Bamberg, 2007)	1. "Ich bin aufgrund von Nachhaltigkeitsaspekten bereit, Produkte einer anderen Marke zu kaufen." 2. "Ich habe vor meine zukünftigen Konsumentscheidungen stärker an Nachhaltigkeit auszurichten als bisher."
		self-reported PEB	"Actions which contribute towards environmental preservation and/or conservation" (Axelrod & Lehman, 1993, p. 153)	-	General ecological behavior scale (Kaiser, 1998)	1. "Ich spreche häufig mit Freunden über Probleme, die sich auf ökologische oder soziale Nachhaltigkeit beziehen." 2. "Ich nutze Weichmacher für meine Wäsche." ^R

Table 2: description of chosen variables for survey (definition, empirical evidence, measures and final survey items). ^R: reverse scored.

ups of the GCA, i.e. tracking events that were recorded while users were not searching for electronic products (2) Event data was transformed into a variable of PEB, i.e. the number of clicks that a user did within popped up for the GCA, if the GCA this user (3) Data matching: Event tracking data that was recorded, was matched to the survey responds by using unique user id identifiers. Therefore, the variable of PEB that was used in this study represents a count of clicks within the GCA.

Statistical procedure

Statistical analyses were calculated using the Pandas (McKinney, 2010) and SciPy (Virtanen et al., 2020) packages in Python 3.8.5. First, reversed items scores were inverted and means for two-item construct operationalizations were calculated. Non-normality of the data was assessed, based on a visual analysis of the histograms, skew, kurtosis and the Shapiro-Wilk-test for each measure. The inter-item correlation was calculated which were used to indicate overlapping items (Clark & Watson, 1995). Correlation analyses were done via the Kendall's Tau correlation coefficient, because the use of a non-parametric coefficient was indicated due to non-normality of the variables, ordinal data and a rather small sample size (according to Field, 2013).

Preliminary results

This section describes the preliminary results with tracking data that was obtained till the 20.04.2021. Up to this point the sample size is not sufficient for most statistical analyses. Therefore, these results are to be interpreted with care. The data analyses are regularly updated while more tracking data is available and can be accessed via a rendered jupyter notebook on [github](#).

Descriptive statistics

A descriptive analysis of the socio-demographics of the samples reveals a bias towards younger study respondents (mean = 26.3 years) and towards a higher education (51.4% with a university degree), see table 3. Five psychological variables were mostly answered with a 6 or more (50% percentile ≥ 6), revealing a either a highly environmentally conscious sample or a low item difficulty for these variables (see table 4). The Shapiro-Wilk test, skew, kurtosis and a visual analysis of the histograms indicates a non-normal distribution for most of the variables.

	categories	percentage
Education level	High school student	22.9%
	Did not graduate	0%
	“Hauptschulabschluss”	0%
	“Realschulabschluss”	0%
	“Fachhochschulabschluss”	2.9%
	“Abitur”	22.9%
	University degree	51.4%
gender	Diverse	2.9%
	Female	40.0%
	male	57.1%

Table 3: Sample characteristics of study participants.

	N	mean	std	min	25%	50%	75%	max	skew	kurtosis	S-W statistic	S-W p-value
age	35	26.31	10.18	14	20	24	30	67	2.06	6.51	0.83	0.00*
income	35	4.03	1.71	1	3	5	5	7	-0.42	-0.56	0.90	0.01*
reference persons	36	2.75	1	1	2	3	3	5	0.36	0.01	0.90	0.00*
injunctive norm	36	4.19	1.65	1	3	4	5	7	-0.17	-0.66	0.95	0.11
descriptive norm	36	2.33	1.07	1	2	2	3	5	0.61	-0.26	0.87	0.01*
perceived consumer effectiveness	36	5.31	1.56	2	4	5	7	7	-0.45	-1.02	0.88	0.00*
social desirability	36	3.78	1.59	1	3	4	5	7	-0.11	-0.63	0.95	0.09
environmental attitudes	36	6.22	0.97	2.5	6	6.5	7	7	-2	5.27	0.76	0.00*
technosalvation	36	4.83	1.56	1	4	5	6	7	-0.91	0.64	0.89	0.00*
personal affectedness	36	5.14	1.57	2	4	5.5	6.25	7	-0.38	-1.02	0.90	0.00*
voluntary simplicity	36	4.67	1.06	1.5	4	4.75	5.5	7	-0.5	1.33	0.97	0.33
perceived behavioral control	36	3.92	1.56	1	3	4	5	7	-0.05	-0.87	0.95	0.08
personal norms	36	6.89	0.32	6	7	7	7	7	-2.58	4.95	0.32	0.00*
connectedness to nature	36	4.44	1.87	1	3	4	6	7	-0.14	-1.19	0.92	0.01*
guilt	36	5.5	1.46	1	5	6	7	7	-1.3	1.86	0.82	0.00*
intention to change behavior	36	6.61	0.6	4.5	6.5	7	7	7	-1.83	3.4	0.70	0.00*
self-reported PEB	36	5.38	1.3	2.5	4.88	5.75	6.12	7	-0.96	0.19	0.88	0.00*
assessed PEB	36	1.19	2	0	0	0	2	9	2.31	6.18	0.67	0.00*

Table 4: Descriptive statistics on assessed variables. *: p-value < .05. S-W: Shapiro-Wilk.

Inference statistics

A sensitivity analysis to compute the minimum detectable effect size was performed by graphical interpolation of the diagrams by May & Looney (2020) for the Kendall-Tau correlation coefficient (power = 0.8, $\alpha = .05$, two-tailed test, $N=35$). Given these parameters, with the current sample size, we could detect any effect size greater than or equal to .5 reliably.

Table 4 shows the Kendall-Tau correlations between the assessed variables. A tentative examination of the correlation coefficients and p-values reveals 13 significant inter-construct correlations between items measuring different psychological or socio-demographic constructs. This could indicate either a relationship between these variables, overlapping constructs or redundant items. A thorough assessment of these items is recommended with a bigger sample size. There are five negative significant inter-construct correlations. The largest correlation is found between guilt and the intention to change behavior ($r = .41^{**}$). However, this correlation is still lower than the minimum detectable effect size, indicating that the significance tests in this correlational analysis cannot be interpreted reliably.

It is necessary to perform these analyses with a bigger sample size to detect smaller effect sizes, which are still practically significant ($r \geq .3$). Once a sufficient sample size is reached, there is also the possibility to perform a poisson regression model for count outcome variables with carefully selected predictors, which could be used to examine the explained variance on the assessed PEB. There would also be the opportunity to use a Least Angle regression model (Efron et al., 2004) to aid selecting most relevant psychological or socio-demographic predictors for explaining PEB behavior in this online shopping environment.

	age	in- come	reference persons	injunctive norm	descriptive norm	PCE	social desire- ability	env. attitudes	techno- salvation	personal affected- ness	voluntary simplicity	PBC	personal norms	connected- ness to nature	guilt	intention to change behavior	self- reported PEB	assessed PEB
age	1.0**	0.16	-0.16	0.03	0.18	-0.25*	-0.23*	-0.09	0.17	-0.16	0.1	0.05	-0.11	-0.06	-0.19	0.01	0.16	-0.27**
income	0.16	1.0**	0.01	0.1	0.01	-0.33**	-0.16	0.06	0.27**	-0.02	-0.12	0.01	-0.24	-0.22*	-0.06	-0.15	-0.13	-0.28**
reference persons	-0.16	0.01	1.0**	-0.02	-0.11	0.18	0.28**	-0.25*	0.19	-0.06	-0.15	-0.19	-0.13	-0.14	-0.16	-0.18	0.03	0.13
injunctive norm	0.03	0.1	-0.02	1.0**	0.23*	-0.31**	-0.09	-0.15	0.13	0.03	-0.03	-0.15	-0.22	-0.18	-0.28**	-0.2	-0.09	-0.16
descriptive norm	0.18	0.01	-0.11	0.23*	1.0**	-0.03	-0.26*	-0.13	0.21	0.09	0.17	0.34**	-0.24	0.24*	-0.03	-0.04	0.18	-0.12
PCE	-0.25*	-0.33**	0.18	-0.31**	-0.03	1.0**	-0.06	-0.04	-0.14	0.26*	0.1	0.18	0.23	0.11	0.24*	0.29**	0.17	0.23
social desireability	-0.23*	-0.16	0.28**	-0.09	-0.26*	-0.06	1.0**	0.03	-0.17	-0.15	-0.16	-0.18	-0.04	-0.1	-0.13	-0.03	-0.27**	0.17
env. attitudes	-0.09	0.06	-0.25*	-0.15	-0.13	-0.04	0.03	1.0**	0.02	0.05	-0.14	0.06	0.24	0.04	0.12	0.29**	0.13	0.2
techno- salvation	0.17	0.27**	0.19	0.13	0.21	-0.14	-0.17	0.02	1.0**	0.06	-0.12	0.12	-0.04	0.06	-0.24*	-0.16	0.08	0.03
personal affected- ness	-0.16	-0.02	-0.06	0.03	0.09	0.26*	-0.15	0.05	0.06	1.0**	-0.05	0.07	0.1	0.06	0.24*	0.07	0.16	0.05
voluntary simplicity	0.1	-0.12	-0.15	-0.03	0.17	0.1	-0.16	-0.14	-0.12	-0.05	1.0**	0.3**	0.12	0.36**	0.25*	0.13	0.24*	0.08
PBC	0.05	0.01	-0.19	-0.15	0.34**	0.18	-0.18	0.06	0.12	0.07	0.3**	1.0**	-0.02	0.42**	0.07	0.09	0.31**	0.08
personal norms	-0.11	-0.24	-0.13	-0.22	-0.24	0.23	-0.04	0.24	-0.04	0.1	0.12	-0.02	1.0**	0.2	0.3*	0.34**	0.31**	0.26*
Connected- ness to nature	-0.06	-0.22*	-0.14	-0.18	0.24*	0.11	-0.1	0.04	0.06	0.06	0.36**	0.42**	0.2	1.0**	0.21	0.3**	0.21	0.31**
guilt	-0.19	-0.06	-0.16	-0.28**	-0.03	0.24*	-0.13	0.12	-0.24*	0.24*	0.25*	0.07	0.3*	0.21	1.0**	0.41**	0.18	0.2
intention to change behavior	0.01	-0.15	-0.18	-0.2	-0.04	0.29**	-0.03	0.29**	-0.16	0.07	0.13	0.09	0.34**	0.3**	0.41**	1.0**	0.22	0.14
self-reported PEB	0.16	-0.13	0.03	-0.09	0.18	0.17	-0.27**	0.13	0.08	0.16	0.24*	0.31**	0.31**	0.21	0.18	0.22	1.0**	-0.03
assessed PEB	-0.27**	-0.28**	0.13	-0.16	-0.12	0.23	0.17	0.2	0.03	0.05	0.08	0.08	0.26*	0.31**	0.2	0.14	-0.03	1.0**

Table 4: Kendall-Tau correlation coefficient with significance indicators. *: $p \leq 0.1$, **: $p \leq 0.05$. Blue highlight: $p \leq .05$.

Discussion

This study attempted to evaluate driving forces of PEB by analyzing user behavior in an online shopping environment. The study design and data collection has been carefully planned and executed successfully. However, analyzing and interpreting the results proved to be challenging due to the small sample size. Therefore, it is sensible to continue the data collection until we can reliably make valid conclusions about the examined driving forces of PEB. In general, this study revealed great potential of using tracking data of online shopping assistant users for scientific studies, because it provides real-life data as indicators of PEB, instead of self-reported behavior intentions. Through linking these tracking data with the assessment of psychological constructs via surveys, it is possible to (1) examine the strengths and relationship of driving forces and barriers to PEB and (2) to subsequently design more effective interventions to increase PEB that take these relationships into account. Future research within the user base of the GCA should consider the sampling response rate and the rate of interaction of individual users with the GCA that was achieved in this study to better estimate an accessible sample size.

Limitations

The sample cannot be regarded as representative for the general population. Furthermore, a sampling bias towards a high sustainability awareness is present. The sample size is too small for the performed statistical analyses, therefore these analyses were not sensitive to detect small effect sizes. The calculation of the assessed PEB variable represents the clicks that individuals executed within the GCA. Interpreting these clicks as PEB directly is questionable and further studies should consider tracking the actual shopping behavior, e.g. a product bought / repaired / kept longer. Furthermore, latent psychological constructs were assessed with one item, which comes with flaws in terms of measurement theory and the holistic measurement of these constructs (Döring & Bortz, 2016). A potential solution to that could be the use of a psychometrically valid measure (e.g. the new ecological paradigm scale by Dunlap et al., 2000), which would allow for a psychometrically stronger assessment of a few psychological factors instead of a more complete assessment of all possible driving factors of PEB.

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