



# Toward a comprehensive dimensional model of sustainable behaviors

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## Abstract

The goal of this study was to identify the underlying latent dimensions that account for variation in sustainable behaviors (SBs) among American adults. Our strategy was to assess all of the SBs sampled in existing measures, as well as a number of other variables relevant to individual differences in SBs, in a community sample (N = 1234). Variation in SBs could be accounted for by four broad dimensions: (1) goods, (2) food, (3) transportation, and (4) engagement. These dimensions were related to a range of criterion variables involving values, attitudes, personality traits, and demographic characteristics. Some potentially important and unique links with outcomes supported the importance of distinguishing the dimensions that underlie SBs. This work provides an evidence-based organizational scheme for SBs in future studies and points to important new directions in research on individual differences in proenvironmental behavior.

**Keywords** Environment · Sustainability · Climate change · Individual differences · Attitudes · Personality

## 1 Introduction

Because climate change is a major threat to human welfare (Lamb & Steinberger, 2017; Obradovich et al., 2018), it is in humans' interest to mitigate this threat via more sustainable behavior (SB; Clayton & Brook, 2005; Saunders, 2003). Most global interventions aimed at increasing SBs, like tax (Avi-Yonah & Uhlmann, 2009), education (Monroe et al., 2019), or waste management (Barr, 2004) programs, focus on the population level. Psychological research can contribute to addressing the challenge of climate change by generating knowledge about why people do or do not behave sustainably and identifying ways to encourage SBs at an individual level (Nielsen et al., 2021; Wynes & Nicholas, 2017). However, while a large amount of evidence has been accumulated about SBs (Clayton & Manning, 2018; Ivanova et al., 2020), the effects of individual interventions to increase SBs have been somewhat disappointing (Nisa et al., 2019).

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The premise of this study is that a model of the underlying dimensions of the broad range of individual behaviors that impact the climate would be a powerful tool for conceptualizing and measuring individual differences in SBs. Such a tool could be used to understand the covariation of SBs with one another, harmonize previous studies examining SBs, generate content-valid measurement instruments for studying SBs, examine differences in the nature of SBs across cultures and contexts, establish the psychological correlates of different types of SBs, evaluate the sensitivity of different types of SBs to different types of interventions, and test hypotheses about personalized approaches to encourage pro-environmental behavior. In this study, principles of construct validation (Loevinger, 1957) were used to identify the dimensions that underlie the wide array of ways that people may behave sustainably and to examine the psychological correlates of those dimensions.

## 1.1 Measuring sustainable behaviors

The most common way to assess SBs in this literature is by surveying people about how often they engage in them. Lange and Dewitte (2019) recently identified dozens of SB questionnaires. By and large, these measures have used one of three approaches to conceptualize variation in SB content. In the first approach, researchers focus on one SB or a small set of SBs that are relevant to their specific research question. For instance, Jalil et al. (2020) tested the impacts of an intervention designed to increase plant-based diets. They found that a brief workshop on the climate impacts of eating meat had a significant albeit small effect on meat purchasing among college students that persisted for a full academic year. In this project, meat purchasing behavior was an appropriately narrow measure of SBs given the study aims.

In the second approach, researchers aggregate a number of different SBs into a single score (Brick et al., 2017; Casey & Scott, 2006; Kaiser, 1998). This approach is supported by research suggesting a rather strong correlation among different types of SBs (Kaiser & Wilson, 2004). However, it has the downside that potential differences in types of SBs cannot be identified when various kinds of SBs are aggregated. For instance, this kind of model assumes that people who go out of their way to recycle will also tend to eat plant-based foods, take public transportation rather than private automobiles, and vote for pro-environmental legislation, even though some people may differ in their likelihood to engage in these different SBs.

In the third approach, researchers use combinations of rational and empirical methods to cluster SBs together in scales based on their content (Gilg et al., 2005; Karp, 1996; Larson et al., 2015; Markle, 2013; Stern et al., 1999). For instance, Green-Demers et al. (1997) distinguished recycling, purchasing environmentally friendly products, and self-education SBs, whereas Li & Kallas (2021) differentiated between SBs that are costly versus those that are costless. In the most thorough model to date, Markle (2013) organized items from 49 independent questionnaires of environmental behavior into 19 distinct SBs that clustered empirically into four dimensions: Goods (Conservation), Food, Transportation, and Engagement (Environmental Citizenship). Based on these findings, we used these four dimensions, described in more detail presently, to structure the introduction and hypotheses of the current report.

*Goods.* Goods represent a broad class of consumption, use, and waste elimination behaviors having to do with how people interact with the things they buy. Generally speaking, the less people buy (Dietz et al., 2009; Swim et al., 2011) and the less they waste (Ackerman, 2000; Koop & van Leeuwen, 2017), the more they promote sustainability. These

different kinds of behaviors are sometimes distinguished in studies of SBs. For instance, from a set of 50 SBs, Kaiser and Wilson (2004) distinguished energy conservation, waste avoidance, recycling, and consumerism. However, in that study, the correlations between these sets of behaviors were generally  $>0.50$ , leading the authors to conclude that there was very marginal utility in distinguishing between these dimensions rather than treating them as a single factor.

*Food.* Food is a consumption behavior that can be distinguished from general purchasing behaviors because of the unique and important role agriculture plays in climate change. Variation in agricultural practices, and in particular animal agriculture, can have a dramatic impact on greenhouse gas production both because of emissions from animals and the relative inefficiency of growing animals who must eat plants to grow (Domingo et al., 2021; Godfray et al., 2018; Shepon et al., 2018). Humans typically eat multiple meals a day; thus, food choices have a consistent effect on the environment. Most economic markets offer options to buy local and seasonal food, eat plant-based food, and consume foods that were produced sustainably (Verain et al., 2021), and people vary in the degree to which they make these choices. Food-related behaviors are thus likely to emerge as a factor in multidimensional models of SBs (e.g., Markle, 2013).

*Transportation.* People typically move from place to place on a daily basis, and they have a number of options for how to do that, depending in part on where they live and where they are going. Choices about which options to take can have a stark impact on climate footprints. Whereas fuel-burning cars and planes are a major contributor to climate change, walking or biking has relatively little negative climate impact (Maibach et al., 2009). Other behaviors, like using public transportation, regular automobile maintenance, or alternative fuels can appreciably reduce climate impact (Ivanova et al., 2020). Mobility was not only an independent dimension in Markle (2013), it was also the most distinct dimension to emerge in the Kaiser and Wilson (2004) study of SBs, suggesting that transportation behavior may emerge as a separate factor in relation to other sustainability variables.

*Engagement.* Engagement involves activities such as participation in environmental organizations, work for environmental causes, communication and persuasion activities, and charitable giving. Engagement is qualitatively different from the other variables listed above in that it has indirect rather than direct impacts on sustainability. However, these kinds of behaviors demonstrate an active interest in environmental causes and people who engage with this issue indirectly might also be expected to also have the highest level of SBs and influence others (Cogut et al., 2019; Narksompong & Limjirakan, 2015).

## 1.2 Structure of sustainable behaviors

The periodic table of the elements exemplifies the value of a coherent and comprehensive model of how different variables fit together. Such a model ensures that all of the content (i.e., variables) within a system is accounted for and that the relations among all of the variables within the system are specified. This, in turn, leads to a coordinated and integrated framework for examining issues such as what causes their variation, how they change over time, and how they are related to various outcomes (Loevinger, 1957). In other areas of psychology, using empirical methods to map the structure of a system of variables has led to significant impact and advance. In personality psychology, thousands of human-descriptive terms in the English dictionary were identified and systematized empirically (Allport & Odbert, 1936). In psychopathology, a similar process was applied to all of the symptoms

in the psychiatric diagnostic manual (Krueger et al., 2018). In both of these examples, a progression of factor analytic studies conducted over many decades yielded to a highly replicable structure, which in turn was used to generate measures that contributed to a robust literature on the sources, development, and correlates of personality (Bleidorn et al., 2021a, b; Soto, 2019; Wagner et al., 2020) and psychopathology (Conway et al., 2019; Krueger et al., 2018; Olino et al., 2018) variables.

As described above, Markle (2013) provided arguably the strongest evidence to date regarding the empirical structure of individual differences in SBs. However, it is worth noting that in both personality and psychopathology research, the nature and structure of variables were only established by multiple independent efforts, each of which built upon the next (Goldberg, 1993). The current study was designed to build upon Markle (2013) and similar efforts in three ways. First, the content identified by Markle was expanded to include an even wider range of SBs. Doing so raises the possibility of identifying additional dimensions and helps evaluate where SBs that have not been examined in multi-dimensional studies fit within the overall structure. Second, a model was generated that was as inclusive as possible, in contrast to the relatively brief (19-item) scale generated by Markle (2013). Brief scales have virtues, in that identifying the core markers of each dimension is helpful for creating robust and efficient tools. However, longer scales increase content validity by ensuring that a wide variety of items are included, and can help increase the reliability and validity of the resulting measurement model. This can help with the third innovation, the examination of the external validity of the resulting scales against a wide array of correlates. This is generally considered the last step in construct validation, critical for explicating the nature of the variables identified via structural analysis (Cronbach & Meehl, 1955). The next section briefly reviews previous research on correlates of SBs.

### 1.3 Correlates of sustainable behaviors

Several psychological domains have shown robust patterns of association with individual differences in SBs, in general. One of the strongest and most consistent predictors in the literature is pro-environmental attitudes and concerns about the environment (Balderjahn et al., 2013; Bleidorn et al., 2021; Dunlap et al., 2000; Grob, 1995; Hines et al., 1987). It is possible to identify facets of sustainable attitudes (Milfont & Duckitt, 2010), but these facets tend to be highly correlated, have similar correlations with criterion variables and thus can be treated as a single factor, particularly when the primary goal is to identify general correlates of proenvironmental attitudes (Dunlap et al., 2000).

A variety of demographic variables have also been identified as predictors of SBs. Studies consistently find that women are more likely to engage in SBs than men (Ajibade & Boateng, 2021; Meyer, 2016; Patel et al., 2017) and that higher socioeconomic status (SES) is positively associated with SBs (Balderjahn et al., 2013; Gelissen, 2007; Marquart-Pyatt, 2008). Age is more ambiguous. Some studies suggest that younger people are more likely to engage in SBs (Ajibade & Boateng, 2021; Gilg et al., 2005; Kaiser & Wilson, 2004) and others that age is positively associated with SBs (Wiernik et al., 2013). This discrepancy may be due to differential correlations of age with different types of SBs.

Personality traits are reliably correlated with SBs (Bamberg & Möser, 2007; Brick & Lewis, 2016; Hines et al., 1987; Hopwood et al., 2021; Markowitz et al., 2012; Milfont, 2021; Nielsen, 2017). Soutter et al. (2020) meta-analytically synthesized this literature. They reported positive correlations between SBs and the personality traits agreeableness, openness, extraversion, honesty/humility, and conscientiousness. Higher levels in in

well-being and life satisfaction have also been connected to higher rates of SBs (De Neve & Sachs, 2020).

Motivation and values are also consistently related to SBs (Black et al., 1985; De Groot & Steg, 2010; De Young, 1985; Green-Demers et al., 1997; Guagnano et al., 1995; Harland et al., 1999; Pelletier et al., 1998; Thøgersen & Olander, 2006). This includes generally prosocial motives and values (Pepper et al., 2009; Schwartz, 1977) as well as motives and values that are more explicitly related to the environment (Ajzen, 1991; Gilg et al., 2005; Mayer & Frantz, 2004). Awareness or knowledge about environmental issues is another factor that has been linked to SBs (Zsóka et al., 2013). Finally, politically liberal people tend to be more likely to support climate change policies and engage in SBs than conservatives (Gilg et al., 2005; Grob, 1995; Hall et al., 2018; Hines et al., 1987).

#### 1.4 Discriminant validity of sustainable behavior dimensions

One advantage of identifying the underlying dimensions of SBs is the possibility of articulating different patterns of association between predictors and different dimensions of SB. Doing so would help generate a more precise account of the causes of variation in SBs across individuals and groups and could be used to tailor interventions to target certain classes of behavior. There is some evidence that different types of SBs are related to other individual differences characteristics. For instance, Ferguson et al. (2019) found that prosocial behaviors, including those related to sustainability, could be distinguished as costly (e.g., donating time or money to charity) vs. costless (e.g., donating unwanted clothes or toys to charity) via factor analysis, and that the resulting dimensions had different patterns of correlation with personality traits. Specifically, people high in openness were more likely to engage in costless behaviors, whereas people high in agreeableness were more likely to engage in costly behaviors. Gatersleben et al. (2002) found that attitudes were stronger correlates of pro-environmental behaviors outside the household, such as recycling, than household energy use, which was predicted more strongly by SES. Pepper et al. (2009) found a similar effect: frugal behavior with positive implications for the environment were related to income, whereas socially conscious behavior was related to prosocial values. As evidenced by these examples, conceptualizing and assessing SBs in terms of its underlying dimensions promise to offer a more nuanced understanding of the unique ways in which individual difference variables predict specific types of SBs.

#### 1.5 The current study

Our first aim was to examine the structure of SBs. Based on findings from Markle (2013), we expected a four-factor model of sustainable behaviors with dimensions reflecting goods, food, transportation, and engagement. Our second aim was to examine correlates of SB dimensions. We expected all four SB dimensions to correlate positively with younger age, being a woman, higher SES, agreeableness, openness, environmental motives for plant-based eating, environmental motives, environmental values, connectedness to nature, environmental knowledge, and liberal political views.

We also classified each SB as either costly or costless prior to data collection, in order to test the differential associations of costly and costless SBs with criterion variables. We expected costly items to be negatively related to extrinsic environmental motivation. Following Ferguson et al. (2019), we also expected costly behaviors to be positively associated

with compassion, politeness, and assertiveness, and we expected costless behaviors to be positively associated with intellect, politeness, and low industriousness.

Finally, we examined discriminant validity with a specific focus on the food dimension. We expected speciesism, meat eating motives, and vegetarian motives to be more strongly related to SBs involving food than to other kinds of sustainable behaviors. We planned to explore other potential patterns of discriminant validity with regard to SB dimensions.

## 2 Methods

Hypotheses and methods for this study were preregistered at [https://osf.io/q5w8d/?view\\_only=9de49cc0e5544be7ab11cafae594f653](https://osf.io/q5w8d/?view_only=9de49cc0e5544be7ab11cafae594f653). Participants were 1247 US individuals recruited through the survey platform Prolific. A sample size of 960 provides 80% power to find bivariate correlations  $>0.10$  and would be sufficient for item-level factor models with 100 items (10 participants per item). People were removed if they failed more than two attention checks and completed the study in  $<5$  min, resulting in a sample size of 1234. Participants were paid \$7.50 for participating. The sample were 49.84% women, 48.46% men, and 1.30% non-binary;  $M_{age}=46.27$ ,  $SD_{age}=16.05$ ; 56.56% Democrat, 23.09% Republican, 1.86% libertarian, 1.05% green party, 17.34% independent or nonaffiliated.

Socioeconomic Status (SES) was measured by education status, employment status, and personal and household income. Of the total sample, 16% had not graduated from high school, 29.25% earned a high school diploma or equivalent, 39.22% of people earned an associate's or vocational degree, 20.34% earned a bachelor's degree, 4.13% earned a master's degree, and 6.56% earned a doctorate. For employment, 50.24% participants were employed full-time, 15.56% employed part-time, 5.67% seeking employment, 28.36% unemployed. For personal income, 37.44% of participants earned \$50,000 or more annually. For household income, 60.13% of participants earned \$50,000 or more annually.

### 2.1 Measures

*Sustainable Behaviors.* The literature on SBs was reviewed to construct as comprehensive a list of as possible for this study (i.e., measures reviewed in Lange & Dewitte, 2019, as well as from Balderjahn et al., 2013; Brick & Lewis, 2016; Gatersleben et al., 2002; Gilg et al., 2005; Geiger et al., 2018; Green-Demers et al., 1997; Hall et al., 2018; Markowitz et al., 2012; Soutter et al., 2020; Verain et al., 2021). Our list included 97 items, which were arrayed into goods, food, transportation, and engagement categories. Each item was rated on a 7-point Likert scale. Psychometric details about this measure can be found below.

*Sustainable Attitudes* were measured using 7 items created for this study. Based on findings from Dunlap et al. (2000) sustainable attitudes were expected to form a single factor, as indicated by only one eigenvalue that exceeds random values from a parallel analysis in an item-level factor analysis and strong positive loadings of all items onto that factor. The first eigenvalue from an Exploratory Factor Analysis was 4.69, second was 0.35. All loadings were  $>0.70$ . This result confirmed that a single factor could be used to represent sustainable attitudes ( $\omega_h=0.83$ ).

The *Big Five Aspect Scale* (BFAS; DeYoung et al. 2007) is a measure of personality traits with 100 items answered on a 5-point Likert scale. It measures two aspects of each of the big five domains of personality: Neuroticism (Volatility  $\omega_h=0.82$  and Withdrawal  $\omega_h=0.73$ ), Extraversion (Enthusiasm  $\omega_h=0.66$  and Assertiveness  $\omega_h=0.85$ ), Openness

(Intellect  $\omega_h=0.65$  and Curiosity  $\omega_h=0.62$ ), Agreeableness (Compassion  $\omega_h=0.80$  and Politeness  $\omega_h=0.66$ ), and Conscientiousness (Industriousness  $\omega_h=0.81$  and Orderliness  $\omega_h=0.62$ ).

*Speciesism* (Caviola et al. 2018;  $\omega_h=0.79$ ), the belief that humans are superior to non-human animals, was measured with 6 items responded to on a 7-point Likert scale.

The *Motivations to Eat Meat Inventory* (MEMI; Hopwood et al., 2021) was used to measure Natural ( $\omega_h=0.81$ ), Normal ( $\omega_h=0.75$ ), Necessary ( $\omega_h=0.85$ ), and Nice ( $\omega_h=0.87$ ) motives for eating meat. The 19 MEMI items are responded to on a 7-point Likert scale.

The *Vegetarian Motives Inventory* (VEMI; 15; Hopwood et al., 2020) was used to measure Health ( $\omega_h=0.90$ ), Environmental ( $\omega_h=0.89$ ), and Animal Rights ( $\omega_h=0.88$ ) motives to adopt or consider a plant-based diet. Its 15 items are responded to on a 7-point Likert scale.

*Dietary Pattern* was measured by asking people how often people ate red meat, pork, chicken, fish or seafood, dairy, or eggs.

The *Social and Economic Conservatism Scale* (12; Everett, 2013;  $\omega_h=0.63$ ) is a 12-item measure of liberalism-conservatism with attitudes about different political issues rated on a 0 (liberal) to 100 (conservative) scale.

The *Satisfaction with Life* scale (SWL; Pavot et al. 1991;  $\omega_h=0.83$ ) is a five-item measure of life satisfaction with a 7-point Likert response scale.

*Environmental Literacy* was measured with 8 items taken from the Assessment of Sustainability Knowledge survey (Zwickle et al., 2014;  $\omega_h=0.56$ ). Each item asks a factual question with one correct answer; 5 options are given. Scores reflect the number of correct answers.

*General values* were measured with 8 pairs of items from the Schwarz values set based on the results of Pepper et al. (2009) Each set was composed of 2 values, and each pair of values was rated on a 1–10 scale. Given the potential for ceiling effects on values scales, respondents were asked to spread their answers around so that different values received different scores.

*Environmental values* were measured with 10 items from Gilg et al. (2005). These items were separated into Faith in Growth (i.e., the belief that humans should do with nature what they please, 5 items,  $\omega_h=0.53$ ), and Biospherism (i.e., the belief that the balance of nature should be protected, 5 items,  $\omega_h=0.69$ ) scales.

To measure *Environmental Motives*, a measure of Extrinsic (3 items,  $\omega=0.81$ ), Intrinsic (4 items,  $\omega_h=0.91$ ), and Social (4 items,  $\omega_h=0.85$ ) motives for sustainable behaviors was created for this study. Items were responded to on a 5-point Likert response scale.

The *Connectedness to Nature Scale* (CNS; Mayer & Frantz, 2004;  $\omega_h=0.20$ ) is a 14-item measure of one's feelings toward nature and the environment, with items rated on 5-point Likert scale.

The *Conscientious Responders Scale* (CRS; Marjanovic et al., 2014) is a five-item validity scale designed to detect random or inattentive responding. Items are rated on a 7-point Likert scale in which one particular score is correct. Given that the items are designed to measure random responding, internal consistency is not a relevant estimate of reliability and was not computed. Participants with incorrect scores on more than 2 items ( $N=4$ ) or who took less than 5 min to respond to the survey ( $N=9$ ) were excluded.

## 2.2 Analyses

Analyses described in the Results section in the context of each specific hypothesis. All analyses were conducted in R (R Core Team, 2021) and Mplus (Muthén & Muthén, 2017), and all data are available at [https://osf.io/5r9ac/?view\\_only=9de49cc0e5544be7ab11cafae594f653](https://osf.io/5r9ac/?view_only=9de49cc0e5544be7ab11cafae594f653). The ‘MplusAutomation’ package for R was used to conduct all Mplus analyses (Hallquist & Wiley, 2018). Two-tailed tests at  $p < 0.01$  with Holms’ correction were used to determine the significance of correlations and the significance of differences between dependent correlations.

## 3 Results

All items designed to measure sustainable attitudes and behaviors had sufficient variance ( $SD > 0.10$ ).

### 3.1 Structure of sustainable behaviors

Our first aim was to examine the structure of SBs. As described above and in our preregistration, we expected a 4-factor model of SBs with dimensions reflecting goods, food, transportation, and engagement. This model was tested using exploratory structural equation modeling (ESEM) with target rotation. Factors were extracted if they exceeded random values from a parallel analysis, and trimmed based on weak primary loadings (i.e.,  $< 0.40$ ) and excessively high cross-loadings (i.e.,  $< 0.10$  smaller than primary loading). This was done in an iterative manner to identify an optimal solution.

A target-rotated 4-factor ESEM was fit with all 97 items. Pattern coefficients for this model are found in Table S2 (Supplemental Materials can also be found at [https://osf.io/8hbnw/?view\\_only=9de49cc0e5544be7ab11cafae594f653](https://osf.io/8hbnw/?view_only=9de49cc0e5544be7ab11cafae594f653)). Upon inspection of the results, 28 had weak primary loadings (i.e.,  $< 0.40$ ) on intended factors and high cross-loadings (within 0.10) on unintended factors, leaving a total of 69 items. However, removing all 28 items would have resulted in a food factor with only 2 items. Given the goal of creating robust dimensions for each factor, 5 food factor items with loadings  $> 0.30$  in the initial model (*Buy organic produce*, *Buy food from a local store*, *Buy fair trade food*, *Buy products in refillable packages*, *Buy food with eco-labels*) were reintroduced. A 4-factor ESEM with these 74 items had two items (*Buy food from a local store*; *Buy goods from a local store*) with cross-loadings within 0.10 of the primary loading. These items were removed, resulting in 72-item 4-factor ESEM. This model had adequate fit ( $CFI = 0.89$  and  $RMSEA = 0.07$ ). The items, pattern coefficients, and omegas for each scale (Goods [29 items], Food [6 items], Transportation [6 items], and Engagement [31 items]) are found in Table S1; items and pattern coefficients are also depicted in Fig. 1. This model was used to examine correlates of SBs. Excluded items are found in Table S3.

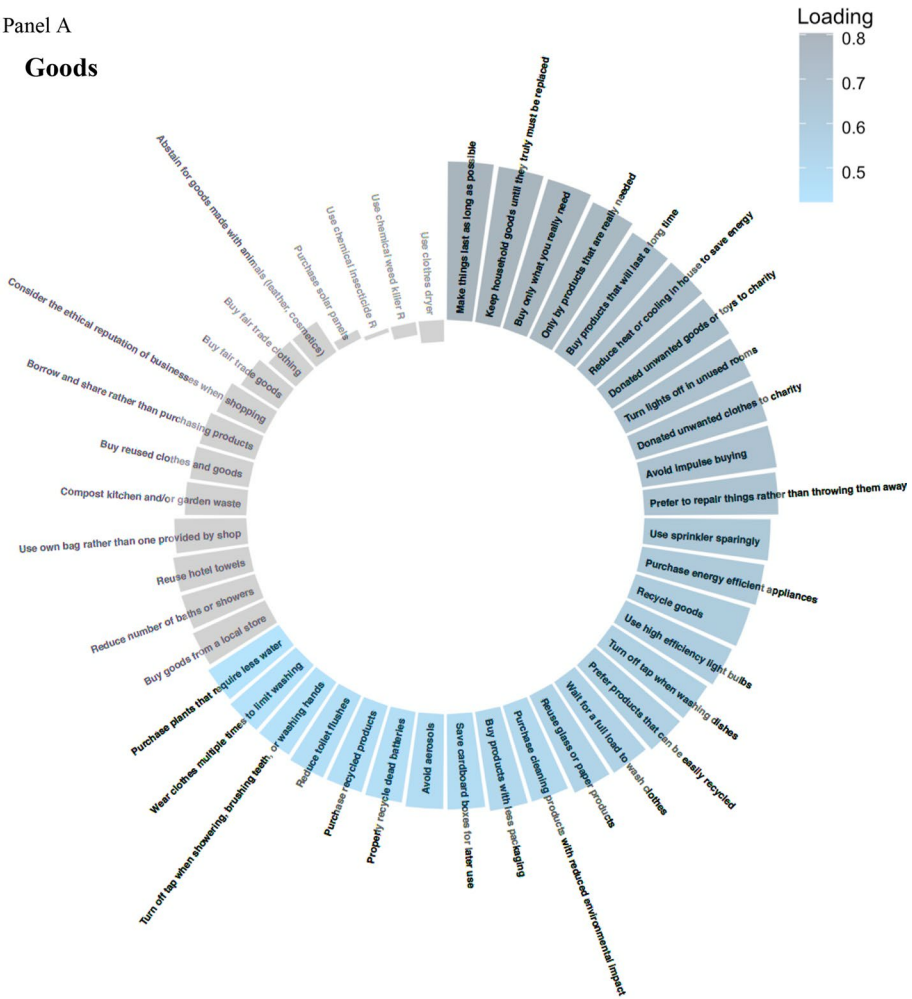
### 3.2 Correlates of sustainable behavior dimensions

Our second aim was to correlate sustainable attitudes and the SB dimensions described above with external correlates. Results are depicted in Table 1. As predicted, younger people had higher scores on Environmental Attitudes and the Food and Engagement SB factors. However, contrary to our hypotheses, younger people had significantly lower scores



Panel A

Goods



**Fig. 1** Items for four sustainable behavior factors. All items in black font were retained; items in gray font were excluded. Bars indicate the strength of the pattern coefficient. Items with loadings > .40 that were not excluded had cross-loadings that exceeded the pre-registered threshold. Items with loadings < .40 that were included were retained to support the content validity and breadth of scales

for Goods, and the correlation with Transportation was not significant. Also contrary to our predictions, gender was unrelated to sustainable attitudes or behaviors.

We hypothesized that SBs would be related to higher SES, as indicated by personal income, household income, education, and employment status. All four SES indicators were positively correlated with the Food and Engagement factors. Only education was associated with Sustainable Attitudes, only personal income and education were associated with Goods, and only household income was (negatively) associated with transportation.

We hypothesized that the personality traits Agreeableness and Openness would be positively related to SBs. Agreeableness was related to Sustainable Attitudes and to the SB Goods factor, but not to the other three factors. However, this pattern was due, in part, to differences in the Agreeableness aspects Politeness and Compassion. Specifically,

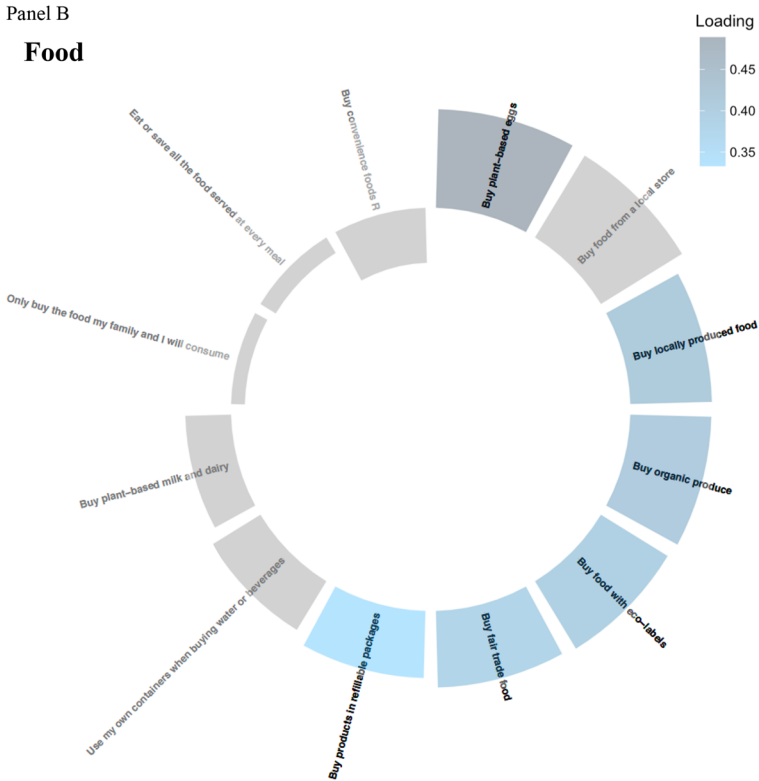


Fig. 1 (continued)

Compassion was positively correlated with Sustainable Attitudes as well as the Goods and Engagement SB factors, whereas Politeness was positively correlated with the Goods factor but negatively correlated with Engagement and Food factors (the correlation between Compassion and the Food factor was positive but not significant). Openness was related to all SBs other than Transportation. However, again the association with Transportation could be explained by variation at the level of aspects. Whereas the Curiosity aspect was positively correlated with the SB Transportation factor, the Intellect aspect was not.

There were also personality effects that were not hypothesized. Higher Neuroticism was associated with lower scores on the SB Goods and Food factors. Both aspects of Extraversion were positively correlated Sustainable Attitudes and all of the SB factors other than Transportation. The two aspects of Conscientiousness had different patterns of correlates with sustainable attitudes and behaviors. Industriousness was positively correlated with the Goods, Food, and Engagement SB factors, whereas Orderliness was only positively correlated with the Goods factor.

We expected environmental motives for plant-based eating to be related to sustainable attitudes and all four SB dimensions, and this hypothesis was confirmed. We had the same hypothesis for intrinsic and social motives for sustainable behavior. Intrinsic Motives were related to Sustainable Attitudes and all four SB dimensions and were more strongly related than Extrinsic or Social motives. Social Motives were correlated with Food, Transportation, and Engagement behaviors, but not to the Goods dimension or Sustainable Attitudes.



Fig. 1 (continued)

Our measure of Extrinsic Motives asked respondents if they would engage in SBs only if it was cheap, easy, or rewarded. As expected, Extrinsic Motives were negatively related to Sustainable Attitudes and all SB dimensions except Transportation.

We expected environmental values (Biospherism) to be positively related to Sustainable Attitudes and all four SB dimensions, and this hypothesis was confirmed. In contrast, the Faith in Growth value was negatively associated with Sustainable Attitudes, but positively correlated with Food and Engagement SB dimensions. General values showed a range of correlates with sustainable attitudes and behaviors. As predicted, the strongest and most consistent of these correlates were with values involving Social Justice and the Environment.

Environmental Knowledge was positively related to Sustainable Attitudes and the Goods dimension, but negatively related to Food and Engagement dimensions and unrelated to Transportation. Connectedness to Nature was associated with Sustainable Attitudes and all four SB dimensions, as predicted. Finally, Political Conservatism and identifying as Republican were negatively related to Sustainable Attitudes and the Transportation dimension. Republican identification was also negatively related to Engagement.

Panel D

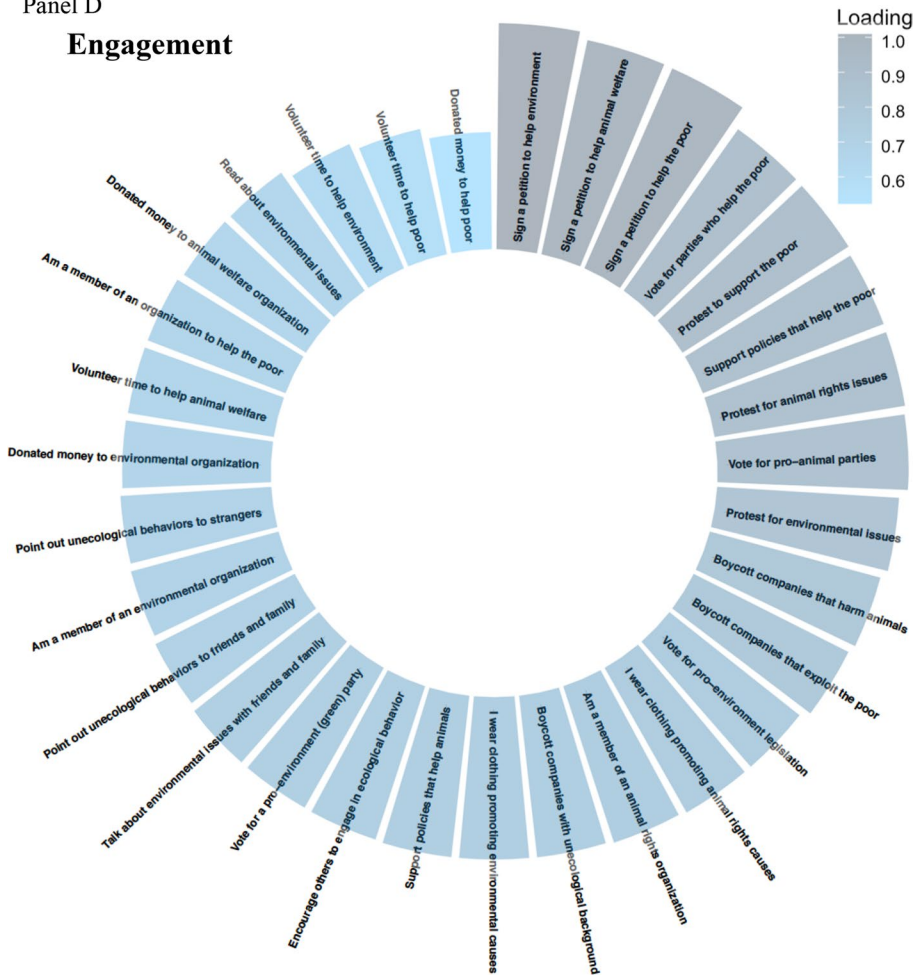
**Engagement**

Fig. 1 (continued)

Non-hypothesized associations were observed between Life Satisfaction and the Goods, Food, and Engagement dimensions.

### 3.3 Correlates of costly vs. costless sustainable behaviors

We expected costly and costless items to be differentially related to the Intrinsic Environmental Motivation scale. Following Ferguson et al. (2019), we also expected costly behaviors to be predicted by Compassion, Politeness, and Assertiveness, and costless behaviors to be predicted by Intellect, Politeness, and low Industriousness. All sustainable behavior items were classified as costly or costless prior to data collection (see preregistration) and correlated the totals of these item sets with these preregistered variables (Table 2). Both costly and costless SBs were positively related to Intrinsic Environmental Motivations,

**Table 1** External correlates of sustainable attitudes and behaviors

	Behaviors														
	Attitudes			Goods			Food			Transportation			Engagement		
	<i>r</i>	95% CI		<i>r</i>	95% CI		<i>R</i>	95% CI		<i>r</i>	95% CI		<i>r</i>	95% CI	
Age	<b>-.14</b>	-.24, -.03		<b>.15</b>	.04, .26		<b>-.13</b>	-.24, -.02		-.08	-.19, .02		<b>-.17</b>	-.27, -.06	
Female gender	.09	-.02, .20		.06	-.04, .17		-.03	-.13, .07		-.05	-.15, .06		-.01	-.10, .08	
SES															
Personal Income	.08	-.03, .18		<b>.13</b>	.02, .23		<b>.27</b>	.17, .38		-.11	-.22, -.01		<b>.22</b>	.11, .33	
Household Income	.08	-.03, .18		.11	.00, .21		<b>.22</b>	.11, .33		<b>-.14</b>	-.25, -.03		<b>.17</b>	.06, .28	
Higher Education	<b>.14</b>	.03, .25		<b>.17</b>	.06, .28		<b>.26</b>	.15, .36		.01	-.08, .11		<b>.25</b>	.14, .36	
Higher Employment	.10	.00, .21		.09	-.02, .19		<b>.23</b>	.12, .33		-.04	-.15, .06		<b>.23</b>	.12, .33	
Neuroticism	-.01	-.09, .08		<b>-.27</b>	-.37, -.16		<b>-.15</b>	-.25, -.04		.06	-.05, .16		<b>-.08</b>	-.19, .03	
Withdrawal	.02	-.08, .12		<b>-.25</b>	-.35, -.14		<b>-.15</b>	-.26, -.04		.09	-.02, .20		<b>-.08</b>	-.18, .03	
Volatility	-.03	-.14, .07		<b>-.25</b>	-.35, -.14		-.12	-.23, -.01		.02	-.08, .11		<b>-.07</b>	-.17, .04	
Extraversion	<b>.18</b>	.07, .28		<b>.30</b>	.19, .40		<b>.33</b>	.23, .43		-.06	-.16, .05		<b>.37</b>	.26, .46	
Assertiveness	<b>.15</b>	.04, .26		<b>.23</b>	.13, .34		<b>.32</b>	.22, .42		-.05	-.15, .06		<b>.36</b>	.25, .45	
Enthusiasm	<b>.15</b>	.04, .26		<b>.29</b>	.18, .39		<b>.26</b>	.15, .36		-.05	-.16, .05		<b>.28</b>	.18, .39	
Openness	<b>.35</b>	.25, .45		<b>.36</b>	.26, .46		<b>.22</b>	.11, .33		.08	-.03, .18		<b>.33</b>	.23, .43	
Intellect	<b>.24</b>	.13, .34		<b>.32</b>	.21, .42		<b>.19</b>	.08, .30		-.01	-.09, .08		<b>.28</b>	.17, .38	
Curiosity	<b>.36</b>	.26, .46		<b>.30</b>	.19, .40		<b>.19</b>	.08, .29		<b>.13</b>	.02, .24		<b>.29</b>	.18, .39	
Agreeableness	<b>.22</b>	.12, .33		<b>.27</b>	.16, .37		-.01	-.10, .08		-.01	-.10, .08		<b>.07</b>	-.03, .18	
Compassion	<b>.30</b>	.19, .40		<b>.29</b>	.18, .39		.11	.00, .21		.01	-.08, .10		<b>.22</b>	.11, .32	
Politeness	.07	-.04, .17		<b>.17</b>	.06, .28		<b>-.15</b>	-.25, -.04		-.03	-.13, .07		<b>-.13</b>	-.23, -.02	
Conscientiousness	.07	-.03, .18		<b>.27</b>	.16, .37		<b>.21</b>	.10, .31		-.04	-.14, .06		<b>.16</b>	.05, .27	
Orderliness	.03	-.07, .13		<b>.14</b>	.03, .25		.11	.00, .21		-.02	-.11, .08		<b>.09</b>	-.02, .19	
Industriousness	.10	-.01, .20		<b>.32</b>	.21, .42		<b>.25</b>	.14, .35		-.05	-.15, .05		<b>.19</b>	.08, .30	
Environmental Motives for Plant-Based Eating	<b>.64</b>	.58, .70		<b>.40</b>	.31, .47		<b>.35</b>	.27, .43		<b>.28</b>	.19, .36		<b>.47</b>	.39, .54	
Intrinsic Environmental Motives	<b>.68</b>	.61, .74		<b>.49</b>	.40, .57		<b>.40</b>	.30, .49		<b>.21</b>	.10, .32		<b>.49</b>	.40, .58	

Table 1 (continued)

	Attitudes			Behaviors							
				Goods		Food		Transportation		Engagement	
	<i>r</i>	95% CI		<i>r</i>	95% CI	<i>R</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI
Social Environmental Motives	.10	-.01, .21		.07	-.03, .18	<b>.36</b>	.25, .45	<b>.14</b>	.03, .25	<b>.36</b>	.25, .45
Extrinsic Environmental Motives	<b>-.41</b>	-.50, -.31		<b>-.35</b>	-.44, -.24	<b>-.25</b>	-.35, -.14	-.06	-.16, .05	<b>-.30</b>	-.40, -.19
Biospherism Value	<b>.59</b>	.51, .66		<b>.33</b>	.23, .43	<b>.14</b>	.03, .24	<b>.20</b>	.09, .30	<b>.25</b>	.14, .35
Faith in Growth Value	<b>-.20</b>	-.30, -.09		-.08	-.19, .03	<b>.18</b>	.07, .28	-.04	-.14, .07	<b>.12</b>	.02, .23
General Values											
Social power, authority	.06	-.04, .17		.00	-.08, .08	<b>.31</b>	.20, .41	.04	-.06, .14	<b>.32</b>	.21, .42
Achievement, success	.06	-.05, .16		.02	-.08, .12	<b>.16</b>	.05, .27	-.01	-.11, .08	<b>.15</b>	.04, .25
Pleasure, enjoying life	.05	-.05, .15		.01	-.08, .09	-.05	-.15, .06	-.06	-.17, .04	-.01	-.09, .08
Daring, exciting life	<b>.13</b>	.02, .24		.07	-.04, .18	<b>.28</b>	.18, .39	.04	-.06, .14	<b>.31</b>	.21, .41
Creativity, freedom	<b>.20</b>	.09, .30		<b>.19</b>	.08, .30	<b>.15</b>	.04, .25	<b>.12</b>	.02, .23	<b>.21</b>	.10, .31
Social justice, environmental protection	<b>.64</b>	.56, .70		<b>.38</b>	.28, .48	<b>.33</b>	.23, .43	<b>.28</b>	.17, .38	<b>.51</b>	.42, .59
Politeness, obedience	.02	-.08, .11		.09	-.02, .20	<b>.14</b>	.04, .25	.05	-.06, .15	<b>.11</b>	.01, .22
National security, social order	-.07	-.17, .04		.06	-.04, .16	<b>.13</b>	.02, .24	.01	-.08, .10	.07	-.03, .18
Environmental Knowledge	<b>.15</b>	.04, .26		<b>.15</b>	.04, .26	<b>-.17</b>	-.27, -.06	-.04	-.15, .06	<b>-.14</b>	-.24, -.03
Being Republican	<b>-.44</b>	-.54, -.33		-.09	-.21, .03	-.07	-.19, .05	<b>-.17</b>	-.29, -.05	<b>-.23</b>	-.34, -.10
Conservatism	<b>-.34</b>	-.44, -.23		-.04	-.14, .06	.06	-.05, .16	<b>-.16</b>	-.27, -.05	-.10	-.21, .01
Connectedness to Nature	<b>.57</b>	.48, .64		<b>.50</b>	.41, .58	<b>.40</b>	.30, .49	<b>.22</b>	.11, .33	<b>.51</b>	.42, .59
Satisfaction with Life	.07	-.04, .18		<b>.26</b>	.16, .37	<b>.27</b>	.16, .37	-.06	-.16, .05	<b>.22</b>	.11, .32

Bold values indicate significance at  $p < .01$  after using Holm-correction for multiple testing

**Table 2** Correlates of costly vs. costless sustainable behaviors

	Costly		Costless	
	<i>r</i>	95% CI	<i>r</i>	95% CI
Intrinsic motivation	<b>.45</b>	.37, .52	<b>.43</b>	.36, .50
Assertiveness	<b>.41</b>	.33, .48	<b>.17</b>	.10, .24
Intellect	<b>.28</b>	.20, .36	<b>.26</b>	.18, .34
Compassion	<b>.20</b>	.12, .27	<b>.25</b>	.17, .33
Politeness	<b>-.13</b>	-.20, -.07	<b>.18</b>	.11, .26
Industriousness	<b>.28</b>	.20, .36	<b>.6</b>	.18, .34

Bold values indicate significance at  $p < .01$  after using Holm-correction for multiple testing

Compassion, assertiveness, Industriousness, and Intellect and negatively related to Extrinsic Motivations. The only pattern in which there were different associations was that Politeness was positively associated with costless but negatively associated with costly SBs. Overall, these results do not support a consistently differential pattern between costly and costless SBs with personality traits or environmental motivations, although they do suggest a more specific effect in that polite people tend to engage in SBs only to the extent that they are costless.

### 3.4 Specificity of sustainable food behavior associations with eating motives

Several measures related to eating motives were used to provide a more focused test of the discriminant validity of SB dimensions (Table 3). We reasoned that people who behave sustainably in terms of food might do so in part because of other food-related motives, such as social justice or animal rights. We therefore predicted that Speciesism and vegetarian motives would be more strongly related to sustainable behaviors involving food, as well as the overall amount of meat eating, than other kinds of sustainable behaviors.

As predicted, Speciesism was positively and vegetarian motives were negatively related with eating animals, whereas meat eating motives were positively related with eating animals. However, the Food SB factor was the only dimension that Speciesism was not negatively related to. Health, Environmental, and Animal Rights motives to be vegetarian were all positively associated with all four SBs, with the exception of the Health Motive and the Transportation factor. The Health Motive was also unrelated to eating meat (see also Hopwood et al., 2021). There were a few non-hypothesized associations between motivations to eat meat and SBs. Overall, there was no support for the specificity of food-related SBs to measures of vegetarian dietary motivation.

## 4 Discussion

The overall goal of this study was to generate a model of individual differences in sustainable behaviors with three features. First, it should be relatively comprehensive in covering the wide range of behaviors on which people vary in ways that can impact climate change. Second, it should be structured around underlying dimensions that meaningfully cluster these behaviors together. Results supported a preregistered structure with four dimensions

**Table 3** Specificity of sustainable food behavior associations with eating motives

	Attitudes		Behaviors						Meat Eating			
			Goods		Food		Transportation		Engagement			
	<i>r</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI
Speciesism	<b>-.37</b>	-.45, -.29	<b>-.24</b>	-.32, -.15	-.07	-.15, .02	<b>-.13</b>	-.21, -.04	<b>-.16</b>	-.25, -.07	<b>.34</b>	.25, .42
MEMI												
Natural	<b>-.21</b>	-.29, -.12	-.10	-.19, -.01	.06	-.03, .14	-.05	-.13, .03	.02	-.05, .09	<b>.39</b>	.31, .47
Normal	.01	-.06, .09	.03	-.04, .11	<b>.33</b>	.24, .41	<b>.13</b>	.04, .21	<b>.30</b>	.21, .39	<b>.26</b>	.18, .35
Necessary	<b>-.12</b>	-.21, -.03	.00	-.06, .05	.05	-.03, .13	-.07	-.15, .02	.07	-.02, .15	<b>.38</b>	.29, .46
Nice	<b>-.21</b>	-.29, -.12	<b>-.16</b>	-.24, -.07	-.10	-.18, -.01	<b>-.14</b>	-.23, -.05	-.07	-.15, .02	<b>.42</b>	.34, .50
VEMI												
Health	<b>.28</b>	.19, .37	<b>.24</b>	.15, .32	<b>.24</b>	.15, .32	.04	-.04, .12	<b>.26</b>	.17, .34	-.05	-.13, .03
Environment	<b>.64</b>	.58, .70	<b>.40</b>	.31, .47	<b>.35</b>	.27, .43	<b>.28</b>	.19, .36	<b>.47</b>	.39, .54	<b>-.27</b>	-.35, -.18
Animal Rights	<b>.50</b>	.42, .57	<b>.31</b>	.23, .40	<b>.30</b>	.21, .39	<b>.22</b>	.13, .31	<b>.43</b>	.34, .50	<b>-.26</b>	-.34, -.17



reflecting goods, food, transportation, and engagement. Third, it should generate psychological profiles linking different demographic, personality, motivational, and attitudinal features to each dimension, specifically. Correlations with a range of criterion behaviors helped us articulate the psychological profile of each of the sustainable behavior dimensions. This study provides an organizational foundation for future research on sustainable behavior, while also highlighting the need for further work in this area.

#### 4.1 Potential benefits of a generalizable structure of sustainable behaviors

As predicted, four underlying dimensions were identified from among sustainable behaviors (SBs), indicating that variation in sustainable behaviors can be organized into goods, food, transportation, and engagement factors (Fig. 1, Table S1). Goods involves 29 behaviors related to purchasing, reusing, and recycling a variety of goods, such as household items or clothes. Food includes 6 behaviors including purchasing and eating plant-based, local, and organic food. Transportation has 6 behaviors involving making tradeoffs, such as public or low-carbon transportation rather than fuel-based cars or avoiding flights. Finally, the 31 engagement behaviors include voting for green policies or candidates, volunteering or donating to proenvironmental causes, or promoting such causes publicly.

Understanding how SBs covary with one another has a variety of potential benefits for future research. First, knowledge of the underlying structure of SBs can be used as a basis for constructing tools to measure proenvironmental behavior in different contexts. A complexity of work in this area is that different kinds of behaviors will tend to be most important for the environment in different settings. For instance, whereas mode of transportation might be a particularly important indicator in an urban setting where there are options for different choices, in rural settings where automobiles are essential for daily living, and thus, nearly all people own an automobile, this might not be an effective indicator of one's disposition toward the environment given that specific indicators are not necessarily transferable from one setting to another. Identifying underlying latent dimensions allows researchers to focus on the latent psychological features that give rise to contextualized behaviors, and thus provides an evidence-based conceptual model with which to identify and organize the kinds of behaviors that may be relevant for a certain context. For instance, in urban settings, it may be more relevant to ask questions about mode of transportation (e.g., public vs. personal), whereas in rural settings, it may be more relevant to ask about type (fuel efficient vs. inefficient automobile).

Such a model also permits comparisons of results across existing studies by abstracting away from how specific behaviors relate, toward these underlying dimensions. Rather than examining how specific behaviors vary across contexts, it may be more useful to compare levels of the latent traits identified in this study. Future work should test whether levels of latent traits, which may be organized around the four dimensions in the current data but have different specific indicators appropriate to their context, are better predictors of other environment-relevant behaviors than manifest indicators that are common across contexts. Using the example above, it may be that information is lost when people in very different environments are compared using specific behaviors like whether or not they own an automobile, whereas more reliable information is gained when they are compared on a latent factor that measures the ways in which they choose means of transportation that are suited to their specific environment but limit climate impact.

Such a tool could be used to understand the covariation of SBs with one another, harmonize previous studies examining SBs, generate content-valid measurement instruments

for studying SBs, examine differences in the nature of SBs across cultures and contexts, establish the psychological correlates of different types of SBs, evaluate the sensitivity of different types of SBs to different types of interventions, and test hypotheses about personalized approaches to encourage proenvironmental behavior. Importantly, given that different kinds of behaviors may be relevant in different settings, a model focusing on latent variables diminishes the importance of any specific set of manifest indicators. Thus, different combinations of indicators that are most relevant for a given context can be used, rather than the specific indicators identified here. In other words, the overall take home of this study is that four latent dimensions likely explain covariation in comprehensive models of sustainable behaviors, not that all of the specific indicators identified here should be expected to generalize across all settings.

Finally, this four-dimensional model could be useful for understanding the specific impacts of interventions and policy designed to curb climate change. For instance, interventions could be organized around the generalizable dimensions identified here but tailored to target certain kinds of SBs that are relevant to the local context. These dimensions could also be used to identify people who are more likely to engage in certain kinds of SBs, and thus to test moderators of interventions. Finally, this four-dimensional organization of behaviors could be used to generate measures of the outcomes of interventions.

## 4.2 Complexity in the structure of sustainable behaviors

Although this study provides a strong foundation for these kinds of applications, there was notable complexity in our findings. First, many more items were identified for the goods and engagement factors than for the food or transportation factors. This may be due to the fact that sustainable food-related behavior and transportation-related behavior are relatively narrower constructs, and thus, fewer behaviors fall within those rubrics. However, it may also be the case that food-related sustainable behavior can be considered a specific facet of goods. Although this was not supported by the low correlation between the food and goods factors, this could have been due in part to our selection of items, in which several items that loaded on both of these factors were systematically removed.

The 25 items that did not survive our modeling strategy also indicate some complexity with regard to the structure of SBs. The exclusion of these items from our model had to do with our desire to identify distinct dimensions, not their relevance to proenvironmental policy. As described above, these items were largely trimmed because they loaded on multiple factors. However, an EFA of the original item pool did suggest more than four factors (see Table S4 in the supplementary material for eigenvalues, parallel analysis results, factor correlations, and pattern coefficients). Thus, it is possible that there is meaningful structure in SBs beyond the four-dimensional model identified here.

One way to try to capture this complexity would be to fit a hierarchical model, with broad dimensions at the top (e.g., a general SB factor, the four SB dimensions focused upon here), and narrower dimensions at the bottom. As an example, the goods factor was the most heterogeneous of the four identified here, in that it had the second highest number of items but the lowest internal consistency. This suggests that there is meaningful complexity within this domain that could be represented by narrower traits, such as dimensions that distinguish between purchasing, reusing, or recycling goods, or between household goods, clothing, and other products. This kind of approach has been useful in personality and psychopathology science, as alluded to in the Introduction of this paper. With such a hierarchy at hand, researchers can choose the level of analysis that best suits their research

question, without deviating from a consensual model of SBs. This kind of model can help integrate previous findings and provide a useful framework for future research. From this perspective, the four dimensions identified in this study may provide a kind of anchor to a more complex hierarchical model, in the same way that the five factors of personality traits provide a foundation for conceptualizing higher and lower order traits (Goldberg, 1993).

Another complexity is that SBs can vary in different ways. The focus in this study was on evidence-based domains as obtained via covariance analysis, and this approach clustered SBs according to the content of behaviors. However, previous researchers have distinguished SBs in terms of aspects of principled frameworks such as phases of consumption (Geiger et al., 2018). Such models introduce temporal processes into the organization of SBs, because people first buy products, then use them, and then get rid of them in a predictable order. It may be possible for future research to integrate the content-based perspective offered here with process-based perspectives such as those based on phases of consumption, toward a more complete model of individual differences in SBs.

### 4.3 Correlates of sustainable behaviors

Our second goal was to use this structure to generate profiles of different kinds of SBs. We examined correlations between the goods, food, transportation, and engagement factors with a variety of demographic and psychological variables, to test preregistered hypotheses about these associations based on the existing literature. Most of our hypotheses were supported, although there were some potentially interesting exceptions. For instance, we predicted that women would report higher rates of SBs than men, but gender differences were not observed. The strongest correlates of SBs in general were connectedness to nature, environmental values, and intrinsic environmental motives. There were some potentially interesting patterns that should be followed up in future research. Whereas we delineated these patterns one dependent variable at a time in the results, here we will describe them one SB factor at a time, to try to portraiture profiles of different SB dimensions.

*Goods.* Age was correlated positively with goods, whereas other factors were correlated negatively with age. Given that the goods factor also had more consistent associations with SES indicators than the other SB factors, it is possible that older people can afford to buy more sustainable goods. The goods dimension also had the strongest correlations with personality traits, in general. People behave more sustainably with regard to goods to the extent that they are less neurotic and more extraverted, open to experience, agreeable, and conscientious. This profile is similar to that of the generally healthy personality (Bleidorn et al., 2020), suggesting that this pattern can be summarized thus: psychologically healthy people are more likely to purchase, reuse, and recycle goods in such a way that demonstrates proactive concern about climate change. This interpretation is supported by the positive correlation between the goods factor and life satisfaction, another indicator of psychological health. Finally, engaging in more goods-related SBs was related to a variety of other proenvironmental motives, values, and knowledge, as predicted and similar to the other three dimensions.

*Food.* The food dimension was negatively related to age but was, along with engagement, the most consistent positive correlate of SES. It was negatively related to neuroticism and positively related to extraversion and conscientiousness, but in contrast with goods, it was negatively related to the politeness facet of agreeableness. People who purchase and consume sustainable foods tend to value the environment but, interestingly, got somewhat lower scores on environmental knowledge. They tend to be satisfied

with life, and are neither strongly conservative nor liberal, on average. We had expected the food dimension to show a pattern of specifically strong associations with eating motives. However, we observed similarly positive associations between all four of the sustainability dimensions and environmental motives for vegetarian diet, and negative associations with eating meat. We also observed a similar pattern of associations between the sustainability dimensions and animal rights motives, speciesism, and other variables related to vegetarian diet. This pattern suggests that vegetarians are more likely to engage in all kinds of sustainable behaviors, not just those related to food.

*Transportation.* Transportation was the only SB with a negative relation to SES variables, and which was largely unrelated to personality. This overall pattern suggests that sustainable transportation choices may be more a function of opportunity and affordability, as opposed to personal desire. In other words, people who can afford to use means of transportation that are more convenient may tend to do so, whereas people who cannot may tend not to. The fact that the transportation factor was also associated with environmental values and motives and political views suggests that personal perspectives about the environment are also an important factor, albeit perhaps less so than for the other dimensions.

*Engagement.* In contrast, engagement was related to higher SES and to several personality traits, most notably high extraversion. It also had the strongest correlation among SB dimensions with social justice and environmental motives and the strongest negative correlation with being Republican. This suggests that a blend of personal energy and progressive political values motivate people to volunteer, donate, or advocate for proenvironmental issues.

*Attitudes.* It was not surprising that sustainable attitudes had similar associations with criterion variables as sustainable behaviors, in general. It was also not surprising that these attitudes were somewhat more strongly related to environmental value and motive variables, as well as political liberalism. This speaks to interesting questions about how underlying values, thoughts, motives, and goals that are associated specific attitudes about the environment lead to sustainable behaviors, as well as ways in which such psychological attributes do not necessarily translate to more sustainable behavior.

As a general summary, these patterns of correlations show that there are some potentially interesting distinctions between different forms of SBs, even though they all largely relate to more prosocial personality characteristics and more proenvironmental values and attitudes. Evidence for specific differences helps validate the structure developed in this paper by showing that the dimensions differ not only in the content similarity, as determined by factor analysis, but also in their implications, as determined by patterns of association with external criteria. Pending validation and extension of these findings, such patterns could be used for tailored interventions or outcome assessments, as described above.

However, discriminant validity is a challenging issue in psychological assessment. Patterns of differences were interpreted based on p-values, and in some cases, those differences nevertheless had overlapping confidence intervals. This suggests that, in many applications, there may be limited benefit in distinguishing SB dimensions from one another at this level. This point highlights the value of thinking about the structure of SBs hierarchically, with a very broad dimension at the top that indicates the general tendency to behave sustainably, four dimensions indicative of goods, food, transportation, and engagement in the middle, and specific behaviors at the bottom. There are likely to be other meaningful levels in between. Delineating this kind of structure could be useful for organizing sustainability research as it has been for personality traits and mental disorders. Both internal and external validity should be brought to bear on elucidating the nature of this structure.

## 5 Limitations

There were two main limitations to this study. The first is that questionnaire data were used to assess behavior. It would be ideal to assess actual behavior. Experience sampling (Nisbet et al., 2009) or laboratory task (Lange & Dewitte, 2019; Lange et al., 2018) designs could be used to approximate actual behavior more closely, and tools such as passive sensing (Jahn et al., 2011) or behavioral observation (Wu et al., 2013) could be used to measure behavior directly. The downside of these methods is that they are more costly and labor intensive to implement, particularly when the goal is to assess a broad range of behaviors as it was in this study. However, a next step to this kind of research is to use such methods to confirm the structure and correlates identified here.

The second limitation was our use of an American sample. There are established generalizability issues with sampling from WEIRD (western, educated, industrialized, rich, democratic) populations. These are somewhat mitigated for this topic because WEIRD populations tend to contribute the most to climate change; however, results such as those of this study may not generalize to other kinds of societies. There are specific issues related to the kinds of behaviors that are likely to vary across cultures or regions. For instance, in countries in which regulations make certain kinds of recycling or sustainable purchasing more possible and cost-effective, those kinds of behaviors may vary less and may not be particularly good indicators. As such, it is likely that, to a certain degree, different specific behavioral indicators will be useful even in countries with similar living standards and cultural values. An interesting question for ongoing work is whether different kinds of behaviors across countries can still be reliably placed within the four dimensions identified here, for the purpose of cross-cultural comparison and a portable, generalizable framework of SBs. There is also considerable variability within WEIRD countries such as the USA that was not explored here (e.g., rural vs. urban settings, or states or regions that afford different opportunities for SBs). All in all, more research is needed in different cultures and regions with varying environmental policies.

## 6 Conclusion

In this study, preregistered hypotheses about the structure and correlates of a large number of sustainable behaviors were tested. As predicted, results indicated that a wide range of sustainable behaviors could be clustered into dimensions reflecting goods, food, transportation, and engagement. Those dimensions had a broadly similar pattern of criterion correlations, although some interesting differences were observed. This work provides a foundation for future research on individual differences in sustainable behavior, toward a generalizable model with important basic and applied implications.

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**Data accessibility** Preregistration and materials, data, and script can be found at [https://osf.io/5r9ac/?view\\_only=9de49cc0e5544be7ab11cafae594f653](https://osf.io/5r9ac/?view_only=9de49cc0e5544be7ab11cafae594f653)

## Declarations

**Ethical approval** The authors have no funding to report. The authors have no conflicts of interest to report. All participants were consented prior to participation.

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## References

- Ackerman, F. (2000). Waste management and climate change. *Local Environment*, 5(2), 223–229.
- Ajibade, I., & Boateng, G. O. (2021). Predicting why people engage in pro-sustainable behaviors in Portland Oregon: The role of environmental self-identity, personal norm, and socio-demographics. *Journal of Environmental Management*, 289, 112538.
- Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behaviour and Human Decision Processes*, 50, 179–211.
- Allport, G. W., & Odbert, H. S. (1936). Trait-names: A psycho-lexical study. *Psychological Monographs*, 47(1).
- Avi-Yonah, R. S., & Uhlmann, D. M. (2009). Combating global climate change: Why a carbon tax is a better response to global warming than cap and trade. *Stanford Environmental Law Journal*, 28, 3.
- Balderjahn, I., Buerke, A., Kirchgeorg, M., Peyer, M., Seegebarth, B., & Wiedmann, K. P. (2013). Consciousness for sustainable consumption: Scale development and new insights in the economic dimension of consumers' sustainability. *AMS Review*, 3, 181–192.
- Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27, 14–25.
- Barr, S. (2004). What we buy, what we throw away and how we use our voice. Sustainable household waste management in the UK. *Sustainable Development*, 12(1), 32–44.
- Black, J. S., Stern, P. C., & Elworth, J. T. (1985). Personal and contextual influences on household energy adaptations. *Journal of Applied Psychology*, 70, 3–21.
- Bleidorn, W., Lenhausen, M. R., & Hopwood, C. J. (2021a). Proenvironmental attitudes predict proenvironmental consumer behaviors over time. *Journal of Environmental Psychology*, 101627.
- Bleidorn, W., Hopwood, C. J., Ackerman, R. A., Witt, E. A., Kandler, C., Riemann, R., Samuel, D. B., & Donnellan, M. B. (2020). The healthy personality from a basic trait perspective. *Journal of Personality and Social Psychology*, 118, 1207–1225.
- Bleidorn, W., Hopwood, C. J., Back, M. D., Denissen, J. J., Hennecke, M., Hill, P. L., & Zimmermann, J. (2021). Personality trait stability and change. *Personality Science*, 2, 1–20.
- Brick, C., & Lewis, G. J. (2016). Unearthing the “green” personality: Core traits predict environmentally friendly behavior. *Environment and Behavior*, 48, 635–658.
- Brick, C., Sherman, D. K., & Kim, H. S. (2017). “Green to be seen” and “brown to keep down”: Visibility moderates the effect of identity on pro-environmental behavior. *Journal of Environmental Psychology*, 51, 226–238.
- Casey, P. J., & Scott, K. (2006). Environmental concern and behaviour in an Australian sample within an ecocentric–anthropocentric framework. *Australian Journal of Psychology*, 58, 57–67.
- Clayton, S., & Brook, A. (2005). Can psychology help save the world? A model for conservation psychology. *Analyses of Social Issues and Public Policy*, 5, 87–102.
- Clayton, S., & Manning, C. (2018). Introduction: Psychology and climate change. In S. Clayton & C. Manning (Eds.), *Psychology and climate change: Human perceptions, impacts, and responses* (pp. 1–10). Elsevier.

- Cogut, G., Webster, N. J., Marans, R. W., & Callewaert, J. (2019). Links between sustainability-related awareness and behavior: The moderating role of engagement. *International Journal of Sustainability in Higher Education*, 20, 1240–1257.
- Conway, C. C., Mansolf, M., & Reise, S. P. (2019). Ecological validity of a quantitative classification system for mental illness in treatment-seeking adults. *Psychological Assessment*, 31(6), 730–740.
- Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, 52(4), 281–302.
- De Groot, J. I., & Steg, L. (2010). Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions. *Journal of Environmental Psychology*, 30(4), 368–378.
- De Neve, J. E., & Sachs, J. D. (2020). The SDGs and human well-being: A global analysis of synergies, trade-offs, and regional differences. *Scientific Reports*, 10, 1–12.
- De Young, R. (1985). Encouraging environmentally appropriate behavior: The role of intrinsic motivation. *Journal of Environmental Systems*, 15, 281–292.
- Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences*, 106, 18452–18456.
- Domingo, N. G., Balasubramanian, S., Thakrar, S. K., Clark, M. A., Adams, P. J., Marshall, J. D., & Hill, J. D. (2021). Air quality-related health damages of food. *Proceedings of the National Academy of Sciences*, 118(20).
- Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the New Ecological Paradigm: A revised NEP Scale. *Journal of Social Issues*, 56, 425–442.
- Everett, J. A. (2013). The 12 item social and economic conservatism scale (SECS). *PLoS one*, 8(12), e82131.
- Ferguson, E., Zhao, K., O’Carroll, R. E., & Smillie, L. D. (2019). Costless and costly prosociality: Correspondence among personality traits, economic preferences, and real-world prosociality. *Social Psychological and Personality Science*, 10(4), 461–471.
- Gatersleben, B., Steg, L., & Vlek, C. (2002). Measurement and determinants of environmentally significant consumer behavior. *Environment and Behavior*, 34(3), 335–362.
- Geiger, S. M., Fischer, D., & Schrader, U. (2018). Measuring what matters in sustainable consumption: An integrative framework for the selection of relevant behaviors. *Sustainable Development*, 26(1), 18–33.
- Gelissen, J. (2007). Explaining Popular Support for Environmental Protection: A Multilevel Analysis of 50 Nations. *Environment and Behavior*, 39, 392–415.
- Gilg, A., Barr, S., & Ford, N. (2005). Green consumption or sustainable lifestyles? Identifying the sustainable consumer. *Futures*, 37(6), 481–504.
- Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., & Jebb, S. A. (2018). Meat consumption, health, and the environment. *Science*, 361(6399).
- Goldberg, L. R. (1993). The structure of phenotypic personality traits. *American Psychologist*, 48(1), 26–34.
- Green-Demers, I., Pelletier, L. G., & Ménard, S. (1997). The impact of behavioural difficulty on the saliency of the association between self-determined motivation and environmental behaviours. *Canadian Journal of Behavioural Science*, 29, 157–166.
- Grob, A. (1995). A structural model of environmental attitudes and behaviour. *Journal of Environmental Psychology*, 15(3), 209–220.
- Guagnano, G. A., Stern, P. C., & Dietz, T. (1995). Influences on attitude-behaviour relationships: A natural experiment with curbside recycling. *Environment and Behaviour*, 27, 699–718.
- Hall, M. P., Lewis, N. A., Jr., & Ellsworth, P. C. (2018). Believing in climate change, but not behaving sustainably: Evidence from a one-year longitudinal study. *Journal of Environmental Psychology*, 56, 55–62.
- Harland, P., Staats, H., & Wilke, H. A. M. (1999). Explaining proenvironmental intention and behaviour by personal norms and the theory of planned behaviour. *Journal of Applied Social Psychology*, 29, 2505–2528.
- Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behaviour: A meta-analysis. *Journal of Environmental Education*, 18, 1–8.
- Hopwood, C. J., Bleidorn, W., Schwaba, T., & Chen, S. (2020). Health, environmental, and animal rights motives for vegetarian eating. *PLoS one*, 15(4), e0230609.
- Hopwood, C. J., Schwaba, T., Milfont, T. L., Sibley, C. G., & Bleidorn, W. (2021). Personality change and sustainability attitudes and behaviors. *European Journal of Personality*, 08902070211016260.
- Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., & Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters*, 15(9), 093001.

- Jahn, M., Schwartz, T., Simon, J., & Jentsch, M. (2011). Energypulse: Tracking sustainable behavior in office environments. *Proceedings of the 2nd international conference on energy-efficient computing and networking*, pp. 87–96.
- 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.
- Kaiser, F. G. (1998). A general measure of ecological behavior. *Journal of Applied Social Psychology*, 28, 395–422.
- Kaiser, F. G., & Wilson, M. (2004). Goal-directed conservation behavior: The specific composition of a general performance. *Personality and Individual Differences*, 36(7), 1531–1544.
- Karp, D. G. (1996). Values and their effect on pro-environmental behavior. *Environment and Behavior*, 28, 111–133.
- Koop, S. H., & van Leeuwen, C. J. (2017). The challenges of water, waste and climate change in cities. *Environment, Development and Sustainability*, 19(2), 385–418.
- Krueger, R. F., Kotov, R., Watson, D., Forbes, M. K., Eaton, N. R., Ruggero, C. J., et al. (2018). Progress in achieving quantitative classification of psychopathology. *World Psychiatry*, 17(3), 282–293.
- Lamb, W. F., & Steinberger, J. K. (2017). Human well-being and climate change mitigation. *Wiley Interdisciplinary Reviews: Climate Change*, 8(6), e485.
- Lange, F., & Dewitte, S. (2019). Measuring pro-environmental behavior: Review and recommendations. *Journal of Environmental Psychology*, 63, 92–100.
- Lange, F., Steinke, A., & Dewitte, S. (2018). The Pro-Environmental Behavior Task: A laboratory measure of actual pro-environmental behavior. *Journal of Environmental Psychology*, 56, 46–54.
- Larson, L. R., Stedman, R. C., Cooper, C. B., & Decker, D. J. (2015). Understanding the multi-dimensional structure of pro-environmental behavior. *Journal of Environmental Psychology*, 43, 112–124.
- Loevinger, J. (1957). Objective tests as instruments of psychological theory. *Psychological Reports*, 3(3), 635–694.
- Maibach, E., Steg, L., & Anable, J. (2009). Promoting physical activity and reducing climate change: Opportunities to replace short car trips with active transportation. *Preventive Medicine*, 49(4), 326–327.
- Marjanovic, Z., Struthers, C. W., Cribbie, R., & Greenglass, E. R. (2014). The conscientious responders scale: A new tool for discriminating between conscientious and random responders. *SAGE Open*, 4(3), 2158244014545964.
- Markle, G. L. (2013). Pro-environmental behavior: Does it matter how it's measured? Development and validation of the pro-environmental behavior scale (PEBS). *Human Ecology*, 41(6), 905–914.
- Markowitz, E. M., Goldberg, L. R., Ashton, M. C., & Lee, K. (2012). Profiling the “pro-environmental individual”: A personality perspective. *Journal of Personality*, 80(1), 81–111.
- Marquart-Pyatt, S. T. (2008). Are there similar sources of environmental concern? Comparing industrialized countries. *Social Science Quarterly*, 89, 1312–1335.
- Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), 503–515.
- Meyer, A. (2016). Heterogeneity in the preferences and pro-environmental behavior of college students: The effects of years on campus, demographics, and external factors. *Journal of Cleaner Production*, 112, 3451–3463.
- Milfont, T. L. (2021). The differential psychology of environmental protection/exploitation. Psyarxiv.
- Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, 30(1), 80–94.
- Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research*, 25(6), 791–812.
- Muthén, B., & Muthén, L. (2017). Mplus. In *Handbook of item response theory* (pp. 507–518). Chapman and Hall/CRC.
- Narksompong, J., & Limjirakan, S. (2015). Youth participation in climate change for sustainable engagement. *Review of European, Comparative & International Environmental Law*, 24(2), 171–181.
- Nielsen, K. S. (2017). From prediction to process: A self-regulation account of environmental behavior change. *Journal of Environmental Psychology*, 51, 189–198.
- Nielsen, K. S., Clayton, S., Stern, P. C., Dietz, T., Capstick, S., & Whitmarsh, L. (2021). How psychology can help limit climate change. *American Psychologist*, 76(1), 130–144.
- Nisa, C. F., Bélanger, J. J., Schumpe, B. M., & Faller, D. G. (2019). Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change. *Nature Communications*, 10(1), 1–13.



- Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The nature relatedness scale: Linking individuals' connection with nature to environmental concern and behavior. *Environment and Behavior*, *41*, 715–740.
- Obradovich, N., Migliorini, R., Paulus, M. P., & Rahwan, I. (2018). Empirical evidence of mental health risks posed by climate change. *Proceedings of the National Academy of Sciences*, *115*, 10953–10958.
- Olino, T. M., Bufferd, S. J., Dougherty, L. R., Dyson, M. W., Carlson, G. A., & Klein, D. N. (2018). The development of latent dimensions of psychopathology across early childhood: Stability of dimensions and moderators of change. *Journal of Abnormal Child Psychology*, *46*(7), 1373–1383.
- Patel, J., Modi, A., & Paul, J. (2017). Pro-environmental behavior and socio-demographic factors in an emerging market. *Asian Journal of Business Ethics*, *6*, 189–214.
- Pelletier, L. G., Tuson, K. M., Green-Demers, L., Noels, K., & Beaton, A. M. (1998). Why are you doing things for the environment? The motivation toward the environment scale (MTES) 1. *Journal of Applied Social Psychology*, *28*(5), 437–468.
- Pepper, M., Jackson, T., & Uzzell, D. (2009). An examination of the values that motivate socially conscious and frugal consumer behaviours. *International Journal of Consumer Studies*, *33*(2), 126–136.
- Saunders, C. (2003). The emerging field of conservation psychology. *Human Ecology Review*, *10*, 137–153.
- Schwartz, S. H. (1977). Normative influence on altruism. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 10, pp. 221–279). Academic Press.
- Shepon, A., Eshel, G., Noor, E., & Milo, R. (2018). The opportunity cost of animal based diets exceeds all food losses. *Proceedings of the National Academy of Sciences*, *115*, 3804–3809.
- Soto, C. J. (2019). How replicable are links between personality traits and consequential life outcomes? The life outcomes of personality replication project. *Psychological Science*, *30*(5), 711–727.
- Soutter, A. R. B., Bates, T. C., & Möttus, R. (2020). Big Five and HEXACO personality traits, pro-environmental attitudes, and behaviors: A meta-analysis. *Perspectives on Psychological Science*, *15*(4), 913–941.
- Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human Ecology Review*, pp. 81–97.
- Swim, J. K., Clayton, S., & Howard, G. S. (2011). Human behavioral contributions to climate change: Psychological and contextual drivers. *American Psychologist*, *66*(4), 251–264.
- Thøgersen, J., & Olander, F. (2006). The dynamic interaction of personal norms and environment-friendly buying behaviour: A panel study. *Journal of Applied Social Psychology*, *36*, 1758–1780.
- Verain, M. C., Snoek, H. M., Onwezen, M. C., Reinders, M. J., & Bouwman, E. P. (2021). Sustainable food choice motives: The development and cross-country validation of the Sustainable Food Choice Questionnaire (SUS-FCQ). *Food Quality and Preference*, *93*, 104267.
- Wagner, J., Orth, U., Bleidorn, W., Hopwood, C. J., & Kandler, C. (2020). Toward an integrative model of sources of personality stability and change. *Current Directions in Psychological Science*, *29*(5), 438–444.
- Wiernik, B., Ones, D., & Dilchert, S. (2013). Age and environmental sustainability: A meta-analysis. *Journal of Managerial Psychology*, *28*, 826–856.
- Wu, D. W. L., DiGiacomo, A., & Kingstone, A. (2013). A sustainable building promotes pro-environmental behavior: An observational study on food disposal. *PLoS ONE*, *8*(1), e53856.
- Wynes, S., & Nicholas, K. A. (2017). The climate mitigation gap: Education and government recommendations miss the most effective individual actions. *Environmental Research Letters*, *12*(7), 074024.
- Zsóka, Á., Szerényi, Z. M., Széchy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production*, *48*, 126–138.
- Zwickle, A., Koontz, T. M., Slagle, K. M., & Bruskotter, J. T. (2014). Assessing sustainability knowledge of a student population: Developing a tool to measure knowledge in the environmental, economic and social domains. *International Journal of Sustainability in Higher Education*.