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# Applying an attitude network approach to consumer behaviour towards plastic

Maria V. Zwicker[a,*], Hannah U. Nohlen[a], Jonas Dalege[a], Gert-Jan M. Gruter[b], Frenk van Harreveld[a,c]

[a] Department of Social Psychology, University of Amsterdam, Nieuwe Achtergracht 129-B, 1018 WT, Amsterdam, the Netherlands
[b] Industrial Sustainable Chemistry, University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, the Netherlands
[c] National Institute for Public Health and the Environment (RIVM), Antonie van Leeuwenhoeklaan 9, 3721 MA, Bilthoven, the Netherlands

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ABSTRACT

In a time of rapid climate change, understanding what may encourage sustainable consumer behaviour is a vital but difficult challenge. Using an attitude network approach, we investigated which associations people have towards conventional and bio-based plastic in order to develop an empirically-based approach to initiate attitude- and behaviour change. With a qualitative study ($N$ = 97), we distilled 25 evaluative reactions (i.e. beliefs, emotions, and behaviours) that encompass people's attitudes towards using (bio-based) plastic. These reactions were used to create a new scale, which was subsequently tested among 508 online participants. The resulting data was then used to build a network displaying relationships between participants' evaluative reactions regarding plastic use. Analyses of this network indicated that guilt was most strongly connected to people's willingness to pay more for bio-based plastic products. Based on this, we conducted another study ($N$ = 285) in which we experimentally manipulated guilt (general guilt, personal guilt, and control condition) to determine its effects on people's willingness to pay for a sustainable cause. Results indicate that manipulating guilt can lead participants to donate more to a sustainable cause. This effect was fully mediated by self-reported guilt. Determining which factors influence consumers to change their buying behaviour towards sustainability is the first step in creating a demand for more sustainable products amongst the public and investors.

## 1. Introduction

Climate change is one of the most important societal challenges of the 21st century and while some fluctuation of the planet's temperature is natural, the rapid increase in average global temperature over the last 50 years can only be explained if we include the effects of greenhouse gases such as carbon dioxide ($CO_2$) emitted through human activity. One contributor to $CO_2$ emissions that is often overlooked is plastic. Plastic's carbon footprint can be traced to its production and the $CO_2$ that is released at the end of its life cycle. About half of plastic's $CO_2$ emission (1.43 Gt or 3% of total global annual $CO_2$ emissions; Hertwich, 2019) stems from the production process, the remaining carbon is captured in the plastic products themselves and is released as $CO_2$ later, for example when they are incinerated at the end of their life cycle (World Economic Forum, 2016). Annual global plastic production has increased to twenty times what it was 50 years ago (from 15 million tons in 1964 to 311 million tons in 2014), and is expected to almost quadruple by 2050 (Ellen McArthur Foundation, 2016; World Economic Forum, 2016). More than 90% of the over 1000 different types of plastic are currently manufactured from fossil feedstock (Bourguignon, 2017; Ellen McArthur Foundation, 2016; PlasticsEurope, 2018). Plastic production alone makes up about 6% of global oil consumption, about the same amount as used by the entire global aviation sector. The opposing trends of global $CO_2$ emission reduction targets (to below 10 Gt in 2050) (Paris agreement) and the tripling of plastic volumes to more than a billion tons in 2050 are not widely recognised and require global action.

One of the options to reduce the large carbon footprint of plastic, while still retaining its versatility and properties, is bio-based plastic. Rather than being made from fossil feedstocks (such as oil, coal, or natural gas), bio-based materials are wholly or partially derived from renewable material of biological origin, or biomass (Bourguignon, 2017; European Commission, 2011; van den Oever, Molenveld, van der Zee, & Bos, 2017). While often not biodegradable (van den Oever et al., 2017) bio-based plastic's main benefit is that no additional $CO_2$ is released at the end of their life cycle (i.e. during incineration or

* Corresponding author. University of Amsterdam, Departement of Social Psychology, Nieuwe Achtergracht 129-B, Amsterdam, the Netherlands.
*E-mail address:* m.zwicker@uva.nl (M.V. Zwicker).

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degradation).

Before new technologies such as bio-based plastics can be effective, they need to be adopted by the public (and investors), something that is notoriously difficult to achieve. Public reluctance can be observed towards many types of new technologies, for example nuclear energy in Germany (Wittneben, 2012), or underground carbon dioxide storage in the Netherlands (de Best-Waldhober, Daamen, & Faaij, 2009). This reluctance can also manifest itself in conspiracy theories, for example towards vaccinations (Jolley & Douglas, 2014), or the low trust in the safety of genetically modified foods (GMOs) seen throughout Europe (Fresco, 2013).

The literature identifies several reasons for why people do not act against global issues such as climate change: for example, they do not have the right attitude (e.g., they do not believe that climate change is happening, that it is man-made, or are unaware of the size of plastic's $CO_2$ footprint), the attitude is not strong enough to translate into behaviour (e.g., Armitage & Christian, 2003), or they are not able or do not *feel* able to effectively translate their attitudes into behaviour (e.g., they do not know what they can do to combat climate change). This relates to attitude behaviour models, such as the theory of planned behaviour (TPB; Ajzen, 1991), which makes a similar distinction between people's attitude and their perceived behavioural control in driving behavioural intention and actual behaviour. The TPB for example argues that behaviour is predicted by attitudes (and social norms) and intentions, but it also stresses the importance of people's perceived behavioural control of being able (or knowing how) to enact a behaviour successfully. In this research we focus specifically on people's attitudes. In particular, we are interested in the structure of people's attitudes towards the use of plastic and how these attitudes drive behaviour. We do so by using attitude networks, a novel approach designed to provide insights into when and how attitudes might influence behaviours.

### 1.1. A network approach

A network is a system of variables (i.e., nodes) that share connections with each other (i.e., edges). In psychological networks these nodes represent observed variables (e.g., questionnaire items) and the edges represent the correlational or partial-correlational structure of the data (Dalege, Borsboom, van Harreveld, Waldorp, et al., 2017; Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012). For the network approach in the current paper we built on the Causal Attitude Network (CAN) model (Dalege et al., 2016), which was specifically developed to link research on attitudes to network theory by conceptualising attitudes as networks of causally interacting evaluative reactions (e.g., beliefs, emotions, and behaviours). The causal interactions between evaluative reactions lead to a coherent representation of the attitude object, in this case, people's attitudes towards conventional and bio-based plastics and their uses. This approach allows for the integration of the structural and dynamic properties of attitudes and how they relate to behaviours (Dalege et al., 2016; Dalege et al., 2017). Unlike previous network models, the CAN model incorporates the interrelatedness of the evaluative reactions. This is important because attitudes can be formed by and also in turn influence affect, behaviour, and cognition (Dalege et al., 2016).

Within the CAN model, the evaluative reactions are represented as ‘nodes’, and the causal influences between them as ‘edges’. As an example of a simple attitude network, let's take Charlie's attitude towards eating meat. Say Charlie thinks that eating meat is bad for the environment and also thinks the current meat production is cruel. These two evaluative reactions lead Charlie to stop eating meat (behavioural node). These three nodes already represent a small network (Fig. 1) in which the different nodes hold each other in check, such that changing one of them without inflicting some change on the others is difficult. Within a given network, some nodes are more central than others (e.g., some nodes have more connections than other nodes). The centrality of a node provides information about its structural importance and can tell which evaluative reactions most likely influence decision-making and make the best targets for persuasion attempts (Dalege, Borsboom, van Harreveld, & van der Maas, 2017; Dalege et al., 2017).

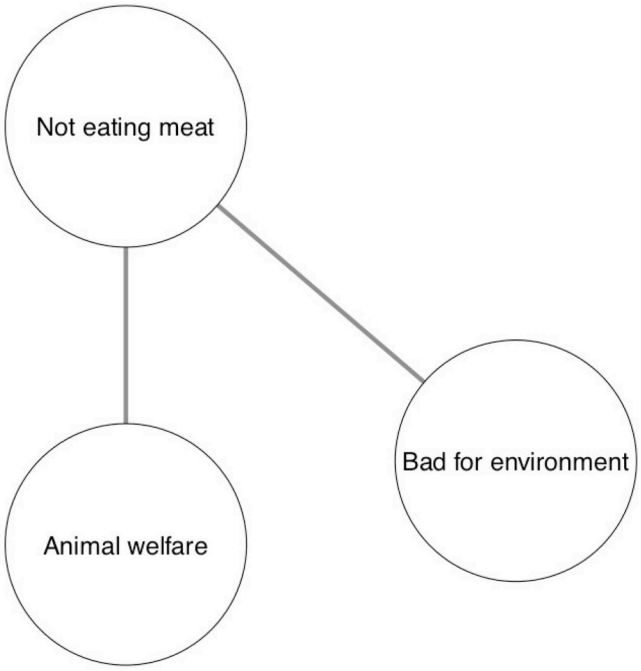



**Fig. 1.** Hypothetical attitude network towards meat consumption. The different circles (nodes) represent evaluative reactions and the connecting lines (edges) represent the conditional independence between them.

The attitude networks created with the CAN model conform to a small-world structure, which means that evaluative reactions that are similar to each other form tight clusters, are connected by “shortcuts”, and influence each other more strongly than other nodes in the network (Dalege et al., 2016). Clusters are formed to balance the need for consistency and accuracy in people's attitudes, which clustering enables by allowing different sets of highly interconnected evaluative reactions while permitting inconsistency to allow for higher accuracy (Dalege et al., 2017; Dalege et al., 2016). With regards to an attitude network about plastic, clustering means that one can have positive evaluative reactions towards plastic (e.g., that it is convenient, lightweight, and good for packaging) while at the same time also harbouring negative evaluative reactions (e.g., that plastic is a source of waste and pollution, and the use of it invokes feelings of guilt).

Another structural feature of the network that provides insights into the effectiveness of persuasion attempts is node centrality. The most central evaluative reactions of a network tend to have the strongest impact. For example, Dalege et al. (2017a) analysed voting data and attitudes towards presidential candidates in past US elections and found that central nodes are the most predictive of voting decisions. Additionally, the higher the connectivity of the whole network, the more predictive the attitudes are of actual behaviour (Dalege et al., 2017; Dalege et al., 2016) and the more stable and resistant to change or persuasion (Dalege et al., 2016; Howe & Krosnick, 2017; van Borkulo et al., 2014).

The main reason why we are interested in studying attitudes and evaluative reactions is because they are important drivers of human behaviour. We therefore also add a behavioural node (willingness to pay) to the attitude network to investigate which of the evaluative reactions relate(s) most strongly to participants’ behaviour. Because of this, we focus on the centrality of a node (rather than connectedness of the whole network) to inform us which persuasion attempts are more likely to successfully convince people to use and pay for more

sustainable plastics, rather than being interested in changing the entire attitude towards (bio-based) plastic all together.

### 1.2. The present research

Psychological research on plastic-related behaviour is scarce (with the exception of recycling behaviour) and even more so with regard to new types of plastics, for example those that are bio-based. However, for products based on new technologies like bio-based plastic to be adopted and widely made available, people need to be willing to pay more for them, as the adaption of new technologies tends to be more expensive than continued use of current technologies. Only when consumers *want* products created by these new technologies, can they be produced on a large scale, at which point they will become cheaper. However, so far, we do not know whether people would be willing to pay more (and if so how much) for similar products made from bio-based plastic. The fact that this is largely unknown may make large companies hesitant to switch to these new technologies in fear of suffering a financial deficit compared to their competitors. For example, as long as brand owners are able to say that 'the consumer is not willing to pay more for sustainable packaging', a switch to bio-based packaging is unlikely. Therefore, the specific behaviour we focus on in the present research is consumers' willingness to pay. More specifically, we are interested in how much people are willing to pay for a bio-based product compared to one made from conventional plastic, how this relates to the evaluative reactions people have about (bio-based) plastic and its use, and whether we can effectively target specific evaluative reactions to increase people's willingness to pay.

Moreover, we are trying to gain insight into what encourages people to behave more sustainably using a cutting edge methodology, namely an attitude network approach (in addition to qualitative and experimental studies). Before the emergence of the CAN model, network analysis has mostly been used in clinical and cognitive psychology (e.g., Cramer, Waldorp, van der Maas, & Borsboom, 2010; Van der Maas et al., 2006). Recently, environmental psychologists have started to use graphical models to evaluate and understand the effects of intervention programmes on sustainable behaviour (e.g., using causal directed acyclic graphs; Bhushan, Steg, & Albers, 2018) and to visualise and explain relationships between large sets of variables (e.g., using the Gaussian graphical model; Bhushan et al., 2019). However, the use of these types of models is still in its infancy. To our knowledge, the network approach has not yet been applied to attitudes about plastic or how they relate to people's willingness to pay, with previous research mainly focussing on sustainable energy behaviour (Bhushan et al., 2018; 2019).

The first study employed a qualitative approach, asking participants to list any thoughts, emotions, and associations they have regarding (bio-based) plastic. The results from Study 1 were then used to create a scale measuring evaluative reactions towards (bio-based) plastic, which was the basis for the network analysis in Study 2. The evaluative reactions indicated by the network analysis to have the highest connection with willingness to pay were then manipulated in the third study to determine whether the results of the network analysis can indeed be used to develop effective tools to influence people's actual behaviour. The experimental procedures of all studies were approved by the Ethics Review Board of the Faculty of Social and Behavioral Sciences, University of Amsterdam, The Netherlands.

## 2. Study 1

To our knowledge, no questionnaire exists that assesses people's attitudes specifically about plastic and its use, let alone one that assesses their attitudes about bio-based plastics. We therefore designed a new measure. We did so by asking participants directly (rather than assuming or guessing) which thoughts, emotions, and associations they have with (bio-based) plastic. We included questions about participants' feelings, rather than just asking about cognitions, because research suggests that affect, negative affect in particular, can be a strong predictor of different types of adaptive behaviour in response to climate change news (van Valkengoed & Steg, 2019).

### 2.1. Method

#### 2.1.1. Participants

Using the online research platform Prolific Academic, 97 participants[1] were recruited to complete the online survey created using the survey software Qualtrics. Of these, 61 (62.9%) were female and 36 (37.1%) male with ages ranging from 18 to 64 years ($M$ = 33.94, $SD$ = 12.05). The majority of the participants either completed secondary education (30.9%) or an undergraduate degree (50.5%), while 9.3% finished trade/technical/vocational training, 8.4% completed graduate education, and one person (1.0%) did not complete secondary education. Most of the participants resided in or were nationals of the United Kingdom (58% and 52%, respectively), others lived in North America (14% and 13%), or the rest of Europe (30% and 32%). Participants received £1.50 for taking part in this approximately 18-minute survey.

#### 2.1.2. Measures

*2.1.2.1. Demographic information.* Participants indicated their age, gender, highest completed level of education, country of residence, and nationality.

*2.1.2.2. Thoughts about using plastic.* Items for this new scale were collected by way of a qualitative thought-listing survey (see also Cacioppo, von Hippel, & Ernst, 1997; Heimberg, Nyman, & O'Brien, 1987). This open-response method has previously been used as a basis for the development of self-report scales (e.g., Glass, Merluzzi, Biever, & Larsen, 1982), and is particularly useful if one has few or no predetermined ideas about relevant cognitive dimensions (Cacioppo et al., 1997). During thought-listing, participants are instructed to write down any thoughts that come to mind in response to a question. We asked participants five questions: "What do you think are reasons for (against) using plastics?", "What feelings do you associate with plastic use?", "What do you think 'bio-based' plastic is?", and "Do you have any concerns that come to mind when you think about using bio-based plastics or buying products made from bio-based plastic?". Participants were given 3 minutes to write down a minimum of four thoughts per question into the 10 provided answer boxes. They were prevented from advancing in the survey for the first 60 seconds of each question (30 seconds in the case of the feelings and 'what is bio-based plastic' questions, because we did not want to have them try to come up with more feelings than they were experiencing and they were less likely to have knowledge and thoughts about bio-based plastic). There were no requirements for complete sentences, spelling, grammar, or punctuation.

#### 2.1.3. Procedure

After reading information about the study and consenting to take part, participants filled out demographic information. The format of the thought-listing questions was then explained to them (including an example). In the first part of the study, participants answered the thought-listing questions concerning reasons for and against the use of plastic products, and the feelings they associate with plastic. The second part of the study included the two thought-listing questions about 'bio-based' plastic. Afterwards, the participants were debriefed and paid.

[1] As this is a qualitative study, no a priori power analysis was conducted to determine the sample size. The authors decided that recruiting 100 participants (after exclusions, $N$ = 97) would be sufficient for this type of analysis.

### 2.2. Results

#### 2.2.1. Thoughts about using plastic

Responses were coded and combined to distill concrete evaluative reactions (see supplementary material). Items that would best give a meaningful indication of a person's attitude were favoured in the selection process to create 25 concrete evaluative reactions for and against plastic use that were mentioned with regard to both conventional and bio-based plastic: convenient, lightweight, cheap, available, useful, durable, hygienic, safe, good for storage/packaging, recyclable, takes a long time to decompose, pollutes bodies of water (e.g., oceans), causes waste, pollutes the air, harmful to people's health (e.g., by entering the food chain or drinking water), harmful to animals, depletes natural resources, and often being of poor quality (e.g., breaks easily), as well as feeling worried, joyful, guilty, sad, angry, uncertain, and excited. The frequent mention of feelings (negative ones in particular) illustrates that affect also plays a role in the formation of complex attitudes. The scale constructed using these 25 items can be seen in Appendix A.

### 2.3. Discussion

This qualitative thought-listing study helped to identify the evaluative reactions people most commonly have towards (bio-based) plastic products, and to create a 25-item scale with two parts (Appendix A). Part 1 consists of 18 cognitive evaluative reaction items, and Part 2 consists of 7 items inquiring about participants' emotions. The items of this scale will represent the nodes in the network analysis.

Next, we conducted a pilot study ($N = 52$) to test the reliability of the newly developed evaluative reactions scale, as well as the presentation order of the items (e.g., whether it made a difference whether participants saw the conventional or bio-based plastic items first). Details of the measures and results of this pilot study can be found in the supplementary materials.

## 3. Study 2

Study 1 provided 25 evaluative reactions that people most frequently have towards (bio-based) plastic. These, together with an added behavioural node (willingness to pay), built the foundation of the attitude network towards plastic. We added willingness to pay because we were particularly interested in how the components of people's attitudes towards (bio-based) plastic relate to behaviour. Ideally this would inform us which aspect(s) of people's attitude towards plastic should be targeted to effectively stimulate a change in buying behaviour. Understanding what encourages people to pay more for a bio-based product compared to one made from conventional plastic is an important step in enabling the adoption of a new and more sustainable type of plastic.

In addition to creating an attitude network, we also included a measure of participants' holistic attitude towards (bio-based) plastic. This was done to ensure that the set of evaluative reactions used in the network indeed accurately represents the attitudes people have towards (bio-based) plastic and its use.

### 3.1. Method

#### 3.1.1. Participants

Epskamp (2016) suggests that for moderately sized networks (around 25 nodes) that are based on continuous data, a sample size of 250 is sufficient. We aimed to create two networks of 26 nodes (one for conventional and one for bio-based plastic), and thus recruited 508 participants via the online research platform Prolific Academic to participate in our survey. Of these, 268 (52.8%) were female and 232 (45.7%) male (five participants indicated "other" and three preferred not to say). Their ages ranged from 18 to 72 years, with a mean age of 32.41 ($SD = 10.83$). The majority of the participants either completed secondary education (24.2%), an undergraduate degree (47.4%), or postgraduate education (17.9%), while 8.7% of the participants completed trade/technical/vocational training and 1.8% completed only primary education. Most participants resided in or were nationals of the United Kingdom (35.43% and 33.07% respectively), or the rest of Europe (43.50% and 46.06%), and some lived in North America (19.49% and 17.13%). The survey took approximately 15 minutes to complete, and participants received £1.25 as compensation.

#### 3.1.2. Measures

*3.1.2.1. Demographic information.* Participants indicated their age, gender, highest completed level of education, country of residence, and nationality.

*3.1.2.2. Evaluative reactions towards (bio-based) plastic.* To assess participants' evaluative reactions towards both kinds of plastic, we used the scale we developed in Study 1 (Appendix A). The scale consists of 25 evaluative reaction statements to which participants indicate their agreement using a 7-point Likert scale (1 = *strongly disagree* to *7 = strongly agree*). The scale is divided into two parts: Part 1 consists of 18 items about evaluative reactions that are mostly cognitive in nature, while Part 2 includes the 7 remaining emotion items. The scale was divided so that the question statements for both parts could be phrased slightly differently in order to feel more natural. Part 1 of the scale includes very simple statements starting with "(Bio-based) Plastic…" followed by a random order of the 18 chosen evaluative reactions (excluding the 7 emotion items) from the qualitative study: … is convenient, is lightweight, is cheap, is readily available, is useful, is durable, is hygienic, is safe, is good for storage and packaging, is recyclable, takes a long time to decompose, pollutes bodies of water (e.g., oceans), causes waste, pollutes the air, is harmful to people's health (e.g., by entering the food chain or drinking water), is harmful to animals, depletes natural resources, is often of poor quality (e.g., breaks easily). Part 1 showed a reliability of $\alpha = 0.70$ for the conventional plastic items and $\alpha = 0.81$ for the bio-based items. In the second part of the scale, participants saw statements starting with "When I think about (bio-based) plastic use, I feel…" and were then asked to indicate how much they felt worried, joy, guilty, sad, angry, uncertain, and excited (in a random order). This emotion measure (Part 2) had reliabilities of $\alpha = 0.82$ and $\alpha = 0.80$ for conventional and bio-based plastics, respectively.[2]

*3.1.2.3. Willingness to pay.* The behavioural measure and dependent variable of this study was participants' reported willingness to pay for bio-based compared to conventional plastic products. To ascertain this, participants were shown a picture of an unlabelled 1.5 L bottle of water, and were told that it was made from 'conventional'[3] plastic and costs 1€. They were then asked to indicate how much they would be willing to pay for the same bottle if it were made from bio-based plastic using a continuous slider from 0€ to 2€ (the starting position of the slider was at 1€).

*3.1.2.4. Other measures.* In addition to the measures described above, we also assessed social norm factors, perceived behavioural control, and self-reported pro-environmental behaviour. As the main focus of this study was to determine the attitude network people have about

[2] One might judge the reliabilities of the scale as rather low. However, our aim for designing the scale was not to maximise reliability but to measure the evaluative reactions toward plastic in a comprehensive manner. This is likely to lead to a rather low reliability of the scale (Dalege et al., 2016).

[3] In survey questions, we chose to use the terms 'normal' or 'regular' plastic, rather than 'conventional' plastic, because it is more in line with language used in everyday conversation.

(bio-based) plastic, these measures and their results will not be discussed here but are available in the supplementary material.[4]

*3.1.2.5. Attitudes*. To test whether the network nodes we have chosen adequately reflect people's overall attitude, we also included a holistic attitude measure. Traditionally, when trying to assess an overall attitude (in this case the attitude towards plastics), a range of more specific beliefs is assessed (here represented by the evaluative reaction nodes) that are predictive of the holistic attitude. We therefore expected the composite score of the evaluative reactions to correlate with the holistic attitude measure.

Attitudes are not always as dichotomous as seeing something as 'positive' or 'negative', or 'good' or 'evil' (Thompson, Zanna, & Griffin, 1995). Many situations can lead one to have mixed feelings, be it about daily dietary temptations, large societal issues, or anything in between (van Harreveld, Nohlen, & Schneider, 2015). We therefore assessed both the positive and negative evaluations people hold towards plastic separately rather than in a single bipolar scale, to get a more accurate picture of people's attitudes towards plastics. This design mitigates one of the main limitations of traditional bipolar attitude scales, namely that it is impossible to determine whether participants are indifferent (*neither* positive nor negative) or ambivalent (*equally* positive and negative) when checking the midpoint of the scale (Thompson et al., 1995). Knowing this difference is important because ambivalence is known to have a wide range of consequences for affect, cognition, and behaviour (van Harreveld et al., 2015). We therefore asked participants to first consider only the positive aspects of (bio-based) plastic use and indicate on a 7-point scale (*1 = not favourable at all* to *7 = extremely favourable*) how favourably they evaluated conventional/bio-based plastic use. The same was then done for the negative aspects: "Considering only the negative aspects of using plastic products and ignoring the positive aspects, how unfavourable is your evaluation of (bio-based) plastic use?". Besides gaining a better understanding of how positively and negatively participants evaluate plastic, we were also interested in determining whether these evaluations differed with regards to conventional versus bio-based plastic.

### 3.1.2. Procedure

After reading the information letter about the study and giving consent, participants read some information about the difference between conventional and bio-based plastics. The first part of the survey concerned only conventional plastics. After responding to the newly developed evaluative reactions scale, participants were asked how positively and negatively they felt towards plastic use. The second part of the survey was identical to the first, but all the questions concerned bio-based plastic. This was followed by the willingness to pay item. After responding to demographic questions, participants were debriefed and paid.

## 3.2. Results

### 3.2.1. Network analysis

Due to the fact that most participants did not have a correct perception of what bio-based plastic is (58% of the participants thought that bio-based plastic is biodegradable), we were not able to directly and meaningfully compare the attitude networks for conventional and bio-based plastic as we originally intended. We therefore only display the results for the conventional plastic network (and provide the results for the bio-based plastic network analysis in the supplementary material). Our current goal is to pinpoint effective means to increase people's willingness to pay for bio-based plastics, but we do not want to achieve this goal by building on misconceptions people have towards bio-based plastics. As a result, we focus on how people's attitudes towards conventional plastic relate to willingness to pay for bio-based plastics.

To estimate a weighted, undirected network, we followed the method described by Dalege et al. (2017a), though we used continuous (rather than binary) data. Identical methods were used for both the conventional and bio-based plastic attitude networks. In particular, we used the *glasso* method implemented in the R package *qgraph*[5] (Epskamp et al., 2012) to create the partial correlation networks shown in Fig. 2. The *glasso* method estimates partial correlations between each pair of variables conditioning on all other variables. It also decreases the number of spurious partial correlations by making use of the LASSO technique, and selects the best fitting regression function based on extended Bayesian information criteria (see Blanken et al., 2018). We also tested the stability of the estimated network using the R package *bootnet* (Epskamp, Borsboom, & Fried, 2018), the results of which can be found in the supplementary material (Figure S4 and S5).

*3.2.1.1. Community detection*. To be able to inspect the global structure of the network and the differing interconnectedness of the nodes, we used the walktrap algorithm (Pons & Latapy, 2006) to detect communities (clusters) within the network. To do this, we used the *igraph* package implemented in R (Amestoy et al., 2015). As illustrated by Fig. 2, which shows the plastic network after community detection, all negative emotions form a community and cluster together with the behavioural node 'willingness to pay'. The positive emotions also form a cluster (together with the 'recycling' node), as do all the nodes describing the positive attributes of plastic. The evaluative reactions concerning mainly negative aspects of plastic use also form a community, together with how 'safe' participants thought plastic to be (which seems to act as a 'bridge' between multiple clusters). What is most relevant for this paper is the finding that the behavioural node clusters together with the negative emotions, suggesting that targeting those emotions might have the largest influence on changing people's willingness to pay.

*3.2.1.2. Node centrality*. A node's centrality is a reflection of its structural importance, and can help determine how changing it would affect the rest of the network (Dalege et al., 2017) and a specific node/behaviour, as was the purpose of our study. Fig. 3 displays the strength centrality measure for the plastic network. We focused on the strength measure of centrality, which represents the direct influence of a given node on the network and is calculated by summing the absolute values of all edge weights a given node has. For the plastic network, the nodes that are most central (have the highest strength) are the negative emotions 'sad', 'worried', and 'guilty'. This is because of their strong connections to each other and the other negative emotions (also see the partial correlation network, Fig. 2). While all three of these negative emotions appear to be central to the network, only the extent to which participants experienced guilt was directly connected to people's willingness to pay, the behavioural node.

### 3.2.2. Guilt and willingness to pay

Taken together, the community detection results (i.e., willingness to pay clustering with the negative emotions) and the analysis of node centrality suggest that some of the negative emotions might be good potential targets to influence people's behaviour. Looking more closely at the network displayed in Fig. 2, the 'guilt' node has the strongest connection to willingness to pay, even though some other evaluative reactions also show edges to the behavioural node (i.e., anger, sadness, and joy). When examining the partial correlations with willingness to

[4] For different research purposes, the study also measured misconceptions about bio-based plastic. The results are reported in a different article.

[5] If not stated otherwise, we used the default settings in the R-package *qgraph*. In the few cases that there was missing data (mainly concerning the bio-based network), those participants were excluded using the *na.omit* function in R. No outliers were omitted from the analysis.

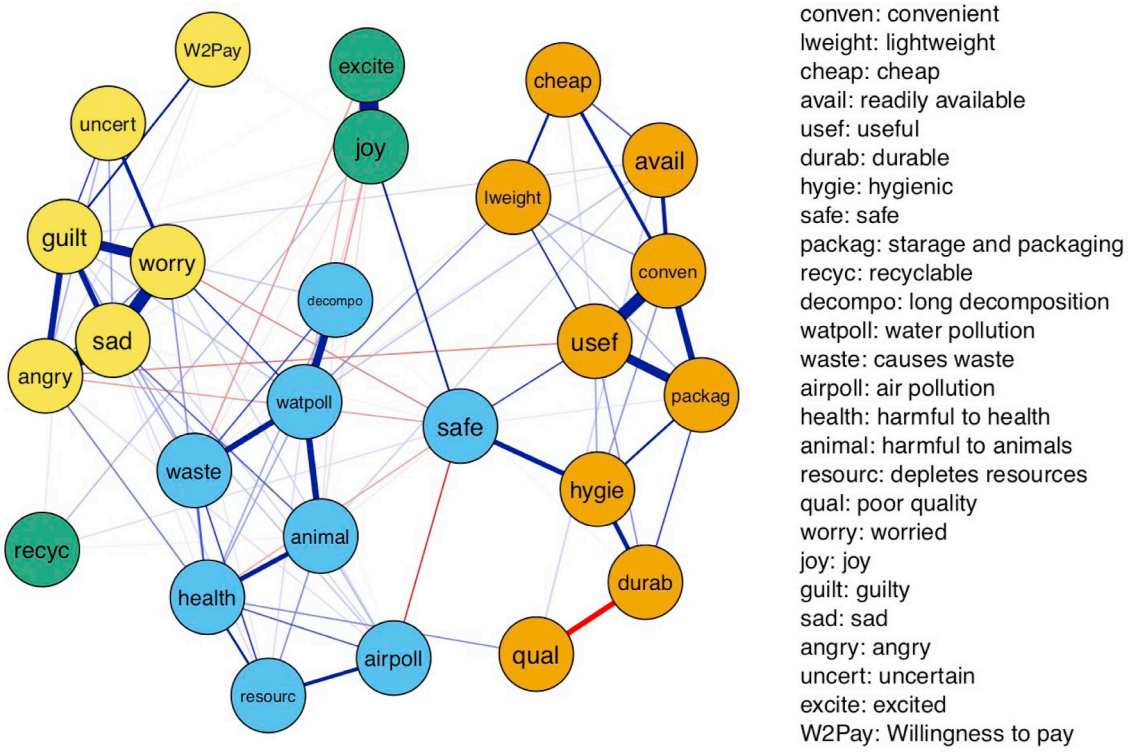



**Fig. 2.** Partial correlation attitude network of evaluative reactions towards plastic. No partial correlations under 0.1 are displayed, and edges that have higher than a 0.3 partial correlation are plotted with thickness according to their magnitude. Closely connected attitude elements are placed near to each other. The different colours represent different clusters (communities) of nodes that consist of closely connected evaluative reactions. The yellow nodes represent negative emotions (with the addition of willingness to pay), the orange nodes describe positive aspects of plastic, the blue nodes represent mainly negative aspects of plastic use, and the green represent positive emotions (and recycling).

pay, only guilt's connection to the behavioural node stays significant ($r$ (482) = 0.156, $p$ < .001); none of the other negative emotions (anger: $r$ = 0.040, $p$ = .383, sadness: $r$ = 0.015, $p$ = .737, worry: $r$ = 0.030, $p$ = .509) or joy ($r$ = −0.076, $p$ = .093) remain significant. This was also corroborated by a regression analysis in which we regressed all the evaluative reactions onto willingness to pay. The results suggest that only guilt ($b$ = 0.243, $t$(482) = 3.566, $p$ < .001, 95% $CI_B$ [0.019, 0.064]) and, to a lesser extent, uncertainty ($b$ = −0.022, $t$ (482) = −2.326, $p$ = .020, 95% $CI_B$ [-0.040, −0.003]) are significantly related to people's willingness to pay.

### 3.2.3. Other analyses

*3.2.3.1. Willingness to pay*. The majority of participants (72.83%) indicated that they would be willing to pay more for a water bottle made from bio-based plastic than for a bottle made from conventional plastic. On average, people were willing to pay €1.21 ($SD$ = 0.28) for a bio-based bottle, compared to the regular price of €1.

*3.2.3.2. Attitudes*. We conducted a paired samples $t$-test to compare people's general attitudes towards conventional plastic with their attitudes towards bio-based plastics. There was a significant difference in generally positive evaluations towards conventional and bio-based plastic, with participants responding more positively towards bio-based plastic ($M$ = 5.94, $SD$ = 1.28) than conventional plastic ($M$ = 4.72, $SD$ = 1.5), $t$(507) = −16.64, $p$ < .001, $d$ = −0.738, 95% CI [-1.36, −1.07] (Fig. 4). There was also a significant difference in negative evaluations, with participants being more unfavourable towards conventional plastic ($M$ = 5.10, $SD$ = 1.80) than towards bio-based plastic ($M$ = 3.33, $SD$ = 1.52), $t$(507) = 17.80, $p$ < .001, $d$ = 0.790, 95% CI [1.57, 1.96]. To calculate participants' ambivalence, we subtracted the absolute difference between the positive (P) and negative (N) attitude components from the average of the two components, (P + N)/2 - |P - N| (Thompson et al., 1995). We found that participants were more ambivalent about conventional plastic ($M$ = 3.01, $SD$ = 2.23) than about bio-based plastic ($M$ = 1.77, $SD$ = 2.24), $t$(507) = 9.39, $p$ < .001, $d$ = 0.417, 95% CI [0.982, 1.50].

Correlational analysis revealed that holistic attitudes indeed significantly relate to the evaluative reactions used in the network (for the complete correlation matrix see Table 1). The aggregated evaluative reaction nodes of the network (excluding willingness to pay) correlated moderately with the holistic attitude measure $r$(508) = 0.47, $p$ < .001. The cognitive nodes and the emotional nodes of the network individually also show significant positive correlations with the overall attitude with correlations of $r$(508) = 0.41, $p$ < .001 and $r$ (508) = 0.37, $p$ < .001, respectively.

## 3.3. Discussion

Overall, the network approach provided a unique and informative insight into the structure and components of people's attitudes towards plastic. It demonstrated which evaluative reactions might be worth targeting with a persuasion attempt if we want to achieve a change in people's behaviour. In particular, the main finding of the network analysis was that guilt appears to be the best predictor of people's willingness to pay more for a water bottle made of bio-based plastic instead of conventional plastic. The examination of the holistic attitudes also confirmed our choice of network nodes, as well as illustrating people's ambivalence (and negativity) towards conventional plastics and favourable evaluations of bio-based plastics.

While providing considerable insights into the cognitive structures underlying people's willingness to pay for bio-based plastic, the study did have its limitations. First of all, the insights were mostly limited to attitudes towards conventional plastic. As alluded to earlier, the

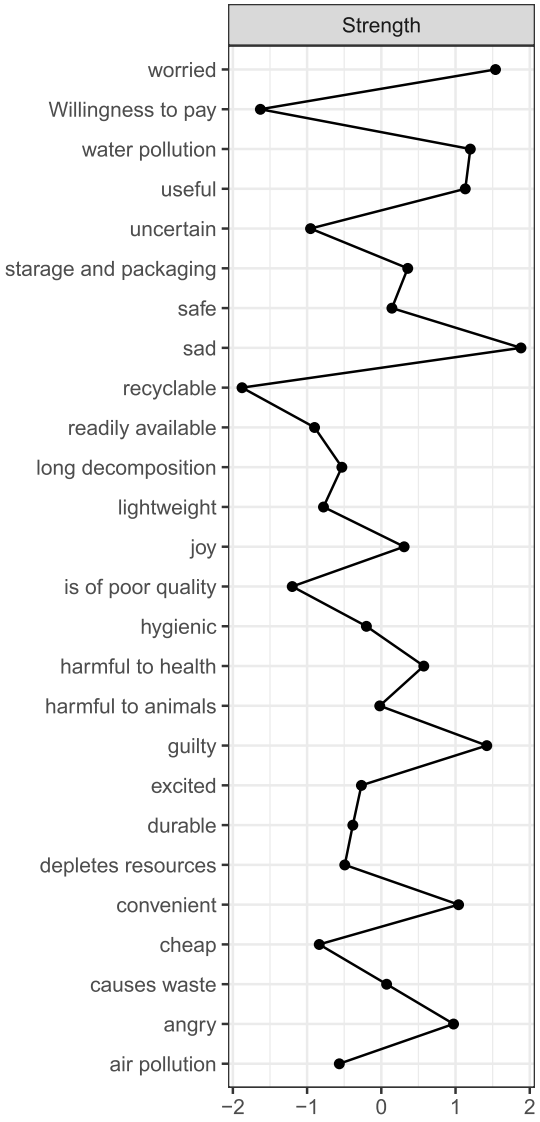
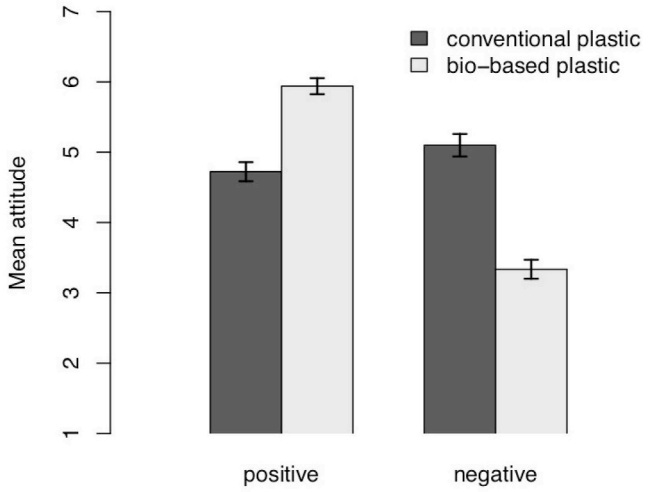



**Fig. 3.** The strength scores represent standardised *z*-scores. A score of 1, for example, means that this node has a strength score 1 *SD* higher than the mean strength score of the network.

misconceptions people hold about bio-based plastic might have distorted the bio-based attitude network. Another limitation is that the association between guilt and willingness to pay is correlational and that our measure of behaviour was hypothetical. Both of these limitations were addressed in the following study, where we manipulated participants' feelings of guilt and added a behavioural measure that asked participants to donate a portion of their earnings.

## 4. Study 3

While the previous study revealed a relation between guilt and willingness to pay, in this study we will shed light on the causality of this relation by experimentally manipulating guilt. To this end, we added a behavioural measure in which we asked participants to donate real money instead of indicating whether they would theoretically be willing to pay more. Studies on psychological distance suggest that the closer people are to a topic and the more personally responsible they feel, the more likely they are to act (e.g., Spence, Poortinga, & Pidgeon, 2012). In this study we aimed to reduce psychological distance by manipulating participants' feelings of guilt. This was done by emphasising participants' individual contributions to plastic production




*Note:* all relationships are statistically significant at $p < .001$

**Fig. 4.** Mean positive and negative evaluations (holistic attitude) towards conventional plastic and bio-based plastic with *1 = not at all (un)favourable* and *7 = extremely (un)favourable.* Error bars represent the Standard Error.

**Table 1**
Attitude towards plastic correlation matrix.

| | | Holistic Attitude | Overall Evaluative Reaction | Cognitions | Emotions |
|---|---|---|---|---|---|
| Holistic Attitude | Pearson's r | – | | | |
| | p-value | – | | | |
| Overall Evaluative Reaction | Pearson's r | 0.468*** | – | | |
| | p-value | < .001 | – | | |
| Cognitions | Pearson's r | 0.411*** | 0.877*** | – | |
| | p-value | < .001 | < .001 | – | |
| Emotions | Pearson's r | 0.371*** | 0.793*** | 0.401*** | – |
| | p-value | < .001 | < .001 | < .001 | – |

Note. *p < .05, **p < .01, ***p < .001.
The holistic attitude score was derived by subtracting the negative holistic evaluations from the positive. All other aggregate scores were computed by taking the summed mean scores of the (reverse coded) responses to (parts of) the Evaluative Reaction Scale.

related $CO_2$ emissions, and thereby to global warming. In particular, our design included three conditions (personal, general, and control) with differing levels of manipulated guilt (high, low, and none, respectively). As in the previous study, we used willingness to pay as the dependent variable. In addition to the bottle measure, in this study we also asked people whether they would be willing to donate (some of) their earnings for participating in the study to help plant a tree to reduce atmospheric $CO_2$. Because this measure concerns the donation of real money, it captures actual sustainable behaviour rather than relying on a self-report of intention.

We hypothesised that people in the personal guilt condition (i.e., the condition in which the participants' personal contributions to plastic-related $CO_2$ emissions were emphasised most) would report feeling more guilty than in the general guilt condition (where participants were simply informed about plastic-related $CO_2$ emissions), and that both these conditions would elicit more guilt than the control condition (where plastic-related $CO_2$ emissions were said to be very small). We also expected greater guilt to lead to a greater willingness to pay. We did not have any specific predictions about potential differences between the two willingness to pay measures, due to the first being more theoretical and the second being behavioural, as well as referring to a somewhat different topic (bio-based plastic bottle vs. planting a tree).

However, seeing as it was more reflective of actual behaviour, we put greater importance on the donation measure.

### 4.1. Method

#### 4.1.1. Participants and design

In total, 307 participants[6] completed the online survey (created in Qualtrics and distributed using Prolific Academic), 22 of which failed the reading comprehension check (i.e., we asked participants a multiple choice question the answer of which directly followed from the reading of an informative text about the benefits of bio-based plastic for the environment, which allowed us to check whether participants read and understood the text thoroughly). Of the remaining 285 valid participants, 155 (54.4%) were female and 128 (44.9%) male. Their age ranged from 18 to 70 years, with a mean age of 30.87 ($SD$ = 10.83). The majority of the participants either completed secondary education (25.6%), an undergraduate degree (47.7%), or postgraduate education (15.8%), while 10.2% completed trade/technical/vocational training (less than 1% completed only primary education). The majority of participants lived in Europe (89.12%), and the majority of those live in the UK (28.74%), Portugal (25.59%), Italy (16.93%), or Spain (12.20%).

The study was made available to participants residing in Western countries (see Appendix B for a complete list). Participants were randomly assigned to one of the three conditions: personal guilt ($N$ = 96), general guilt ($N$ = 89), or control ($N$ = 100). Participants were also asked to indicate the size/population of the town or city they live in; 9.1% lived in small towns (less than 2000 inhabitants), 40% in a town (2000 - 100,000), 31.2% in a city (100,000–1,000,000), and 19.6% live in a large city (more than 1 million inhabitants). Although provided by everybody, this information was only used for participants in the personal guilt condition, for whom the size/population of the town or city they lived in was inserted into the descriptive guilt manipulation text to increase the feeling of personal responsibility and guilt.

#### 4.1.2. Measures.[7]

*4.1.2.1. Guilt manipulation.* Guilt was manipulated using descriptive texts about plastic production causing $CO_2$ emissions. There were two guilt conditions: general guilt and personal guilt. In the general guilt condition, participants were informed that plastic production is a large contributor to $CO_2$ emissions and thereby to global warming, without mention of participants' personal involvement in this process. Participants in the personal guilt condition received the same text but with one added sentence that highlighted personal contribution to global warming: "The average person living in a [city size indicated by participant] in your country consumes around 100 kg of plastic each year, which accounts for the release of 600 kg of $CO_2$ per person every year. If people like yourself continue buying and using this much plastic, plastic production will have a significant effect on global warming." Participants in the control condition read that, compared to other factors, "plastic's contribution to global warming is very small". See Appendix D for complete texts.

*4.1.2.2. Emotion measure.* We measured the same seven emotions as in Study 2 (anger, excitement, guilt, joy, sadness, uncertainty, and worry, Cronbach's α = 0.78), using Part 2 of the evaluative reaction scale. In addition to being our measure of self-reported guilt, this also served as a manipulation check to test whether we indeed manipulated guilt and not negative affect in a broader sense. Participants indicated on a 7-point Likert-scale (*1 = none at all*to *7 = a great deal*) to what extent they felt these emotions when thinking about their own contribution to plastic production by buying and using plastic products.

*4.1.2.3. Willingness to pay.* As described earlier, there were two measures that assessed participants' willingness to pay. The first one was the bottle measure used in Study 2, where participants were shown a picture of an unlabelled 1.5 L plastic bottle of water and were told that it was made from 'regular' plastic and costs £1.[8] They were then asked to indicate how much they would be willing to pay for the same bottle if it had been made from bio-based plastic using a continuous slider from £0 to £2 (the starting position of the slider was at £1).

In the second willingness to pay measure, participants were informed about how trees can help combat global warming by absorbing $CO_2$. They were then told that for every £10 donated, a tree would be planted in real life. Participants were then asked whether they wanted to donate a portion of their earnings from taking part in this study to help plant trees to reduce $CO_2$, and if so, how much (on a slider from £0 to £0.85, with £0.85 being the maximum payout for this study). While this measure did not directly concern bio-based plastics, it did address the same issue: a pro-environmental behaviour aimed at reducing the $CO_2$ footprint. Regardless of how much they decided to donate, participants were paid in full.

#### 4.1.3. Procedure

After reading the information letter and consenting to take part in the study, participants filled in demographic information (age, gender, education, country of residence, size of their town/city). Participants then read information about how the carbon cycle works and how $CO_2$ influences global warming (see Appendix C for complete texts). Depending on their condition, participants then received information about the contribution of plastic production to $CO_2$ emissions. After this, they filled in the emotion measure. Participants were then told that one way to reduce $CO_2$ is through the use of bio-based plastics, and received an informative text about the difference between conventional plastic and bio-based plastic (see Appendix C). This was followed by the two willingness to pay measures. Participants were debriefed and told that they could keep all their money regardless of how much they decided to donate, then they were thanked and paid.

### 4.2. Results

#### 4.2.1. Willingness to pay

*4.2.1.1. Water bottle.* The majority of participants (74.04%) indicated that they would be willing to pay more for a water bottle made from bio-based plastic than for a bottle made from conventional plastic. On average, participants were willing to pay £1.18 ($SD$ = 0.32) for a bio-based bottle, compared to the regular price of £1. These results are very similar to those obtained in Study 2 ($M$ = 1.21, $SD$ = 0.28).

*4.2.1.2. Donation of earnings.* Of the 285 participants who took part in this study, 141 (49.5%) decided to donate some of their earnings in order to help plant a tree and reduce atmospheric $CO_2$. The average amount offered for donation was £0.39 ($SD$ = 0.28), which amounts to 45.27% of their earnings.

#### 4.2.2. Main analysis

*4.2.2.1. Manipulation check.* An analysis of variance showed that the main effect of condition on experienced guilt was significant $F$ (2,282) = 10.137, $p$ < .001, $\eta_p^2$ = 0.067. A Tukey post-hoc test revealed that there was no significant difference between the average

[6] As we did not have a clear idea of what the effect size would be, we aimed for 100 participants per cell.

[7] We also assessed participants' misconceptions about the recyclability and biodegradability of bio-based plastic at the beginning and the end of the survey. The results of which will be the subject of a different article.

[8] Rather than using Euros, the currency of the bottle measure was switched to GBP for Study 3, in order to keep it consistent with the currency participants were paid in.

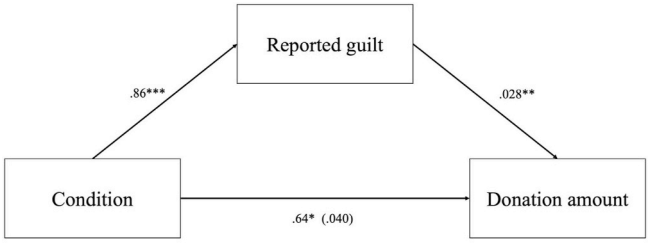
guilt participants were experiencing in the general guilt condition ($M$ = 4.89, $SD$ = 1.50) compared to the personal guilt ($M$ = 5.10, $SD$ = 1.53) condition, $t(282) = -0.94$, $p$ = .62, CI 95% [-0.76, 0.33]. Because of this, these two conditions were combined into one guilt condition in subsequent analyses. This combination was not unwarrented, as the main focus of this study was to determine whether guilt could encourage more sustainable behaviour , rather than investigating the effects of different levels of guilt). Participants in the guilt conditions reported significantly higher guilt than those in the control condition ($M$ = 4.14, $SD$ = 1.62) (the difference in experienced guilt between participants in the general guilt condition and the control group was $t(282) = 0.748$, $p$ = .004, CI 95% [0.21, 1.29], and between participants in the personal guilt condition and control $t(282) = 0.94$, $p < .001$, CI 95% [0.43, 1.49]).

*4.2.2.2. Effect of guilt on willingness to pay/donate*. We recoded the willingness to donate into a continuous 'amount' variable, noting those who chose not to donate as £0 donations. We then ran independent samples t-tests to determine the effect of the condition participants were in (guilt or control) on their willingness to pay. There did not appear to be an effect of condition on participants' self-reported willingness to pay more for a bio-based bottle, $t(283) = -0.69$, $p$ = .49, $d$ = 0.0865; however, condition did appear to influence people's willingness to donate parts of their earnings towards donating money to plant a tree, $t(230.517) = -1.97$, $p = .05$[9][10], $d$ = 0.238. To further investigate this relationship, a bootstrapping mediation analysis (5000 bootstrapped samples) was conducted using model 4 of Andrew Hayes' PROCESS v2 macro in SPSS (Hayes, 2012, 2013). While the total effect of condition on donation amount was only marginally significant, $B$ = 0.0642, $p$ = .0612 (the Levene's correction used in the $t$-test was not applied in the mediation analysis), the indirect effect was significant $B$ = 0.0241, 95% CI [0.0077, 0.0493]. Because the direct effect of condition on donation amount was not significant ($B$ = 0.0401, $p$ = .252), guilt fully mediated the effect of condition on how much of their earnings people were willing to donate (Fig. 5).

*4.2.2.3. Effect of emotions on willingness to donate*. We ran a bootstrapped (5000 bootstrap samples) stepwise regression to determine whether any of the other emotions that we measured predict the amount donated. While this was not directly indicated by the network analysis in Study 2, the network did show the other emotions (especially the negative ones) as being quite central and closely connected to guilt. Despite this, we found that only guilt emerged as a predictor for the donation amount, $R^2$ = 0.055, $F(1, 277) = 2.293$, $p$ = .028. While still only explaining 5.5% of the variance in donation amount, guilt was the only measured emotion that significantly predicted how much money people were willing to donate, $t = 2.424$, $p$ = .016, $\beta$ = 0.213, 99% $CI_B$ [0.005, 0.057]; all other emotions (anger, excitement, joy, sadness, uncertainty, worry) were excluded as predictors by the analysis.

[9] This is the corrected $p$-value suggested by the statistically significant Levene's Test for Equality of Variances. The uncorrected $p$-value was only marginally significant $t(283) = -1.800$, $p$ = .061.

[10] Because the donation measure showed a significant skew (1.411 $SE$ = 0.144) we also conducted a Mann-Whitney test, which revealed that donation amount was no longer significantly predicted by condition, $U$ = 10336, $z$ = 1.754, $p$ = .079, $r$ = 0.104. This is not surprising, as non-parametric tests have less statistical power than parametric tests. We decided to leave the complete mediation as the main analysis however, as we believe that the influence of condition on behaviour remains meaningful enough to further probe with the bootstrapping analysis, which provides the most comprehensive picture of how condition, guilt and donation relate. None of the other willingness to pay measures displayed as strong of a skew. Nevertheless, the parametric test results can be found in the supplementary material. None of the results are significantly different from what is reported in the main manuscript.




*Note.* $N$ = 285. *** $p < .001$, ** $p < .01$, * $p < .05$

**Fig. 5.** Mediation model: Unstandardised regression coefficients for the relationship between experimental condition and donation amount as mediated by self-reported guilt. Path in parentheses is the direct effect of condition on donation amount (i.e., controlling for perceived reported guilt).

### 4.3. Discussion

The aim of this study was to test whether actively manipulating guilt would lead people to behave more sustainably. We found that participants who experienced more guilt seemed to be willing to donate more than participants who experienced less guilt. The results also seem to suggest that guilt fully mediates the relationship between which condition participants were in and how much money they were willing to donate. This suggests that the effect that condition had on participants' willingness to donate seems to have been entirely caused by the reported levels of guilt. No other measured emotion influenced donation amount. Replicating the results of Study 2, we also found that people report they would be willing to pay more for bio-based products than products made from conventional plastic, though this did not appear to be due to the amount of guilt participants were experiencing. Not being able to successfully manipulate different intensities of guilt (high versus low) could be considered a limitation of this study, but the main focus of this research was whether any manipulation of guilt (rather than its intensity) could encourage more sustainable behaviour, so it is likely not a large hindrance to the findings.

Another limitation of Study 3 lies in the fact that the distribution of donations was skewed. When distributions are skewed, non-parametric tests are advised. Not surprisingly (as non-parametric tests have less statistical power) this led the effect of condition on donation amount to no longer reach a significance threshold ($p$ = .079). We decided to leave the complete (bootstrapped) mediation as the main analysis however, as we believe that even when employing the non-parametric tests, the influence of condition on behaviour remains meaningful enough to further probe with the bootstrapping analysis, which provides the most comprehensive picture of how condition, guilt, and donation relate. However, because of this and the relatively small effect sizes that were achieved in this study, we urge for caution when interpreting the results.

## 5. General discussion

Climate change is one the largest problems facing the world today, and yet many people are not aware of the impact that plastic consumption has on warming our planet. With the media often focusing on the negative effects plastic has on marine life, the $CO_2$ emissions produced during the production and life cycle of plastic products has mainly escaped the public's notice. We hardly know anything about what people's attitudes towards plastic are, how they relate to behaviour, and how they can be influenced. The research presented in this paper attempted to address this literature gap by using a multimethod and novel network approach.

The qualitative first study revealed which evaluative reactions are most commonly related to people's perceptions of (bio-based) plastics and Study 2 visualised how they relate to one another. The key takeaway message from this research is its demonstration of how useful

attitude networks can be in designing persuasion attempts or behavioural interventions. In this case, we found that guilt was the evaluative reaction that was most strongly connected to participants' willingness to pay more for a water bottle made from bio-based plastic rather than conventional plastic, our behavioural measure. When we then actively manipulated participants' feelings of guilt, guilt appeared to fully mediate the relationship between the experimental condition participants were in and their willingness to donate to a sustainable cause. Upon further investigation, we found that no other emotion we measured was significantly related to behaviour. This confirms the results of the network analysis.

Examining holistic attitudes in Study 2 supported the selection of nodes derived from the qualitative first study, and indicated that people generally have more positive, less negative, and less ambivalent evaluations of bio-based plastic than conventional plastic. Although this research cannot make claims as to the reasons behind these differences in evaluations, these results are still encouraging. Positive evaluations of more sustainable products might indicate a certain willingness of the consumer to accept and even demand more sustainable choices. Also encouraging are our findings that people seem to be (at least theoretically) consistently willing to pay more for a bio-based product than for one made from coventional plastic (an average of €1.21 in Study 2 and £1.18 in Study 3 compared to the 1 €/£ regular bottle) even without any active manipulation of guilt or other factors. A possible next step would be to further investigate which specific aspects of conventional and bio-based plastic people evaluate positively and negatively and how best to target these aspects to encourage more sustainable behaviour. This could be achieved by using a similar attitude network approach to the one that was used in this paper. Understanding what drives people's behaviour, in this case their buying behaviour and willingness to pay, and being able to effectively change this behaviour (e.g., by targeting its antecedents), is an important first step in facilitating the adoption of new and more sustainable technologies such as bio-based plastics. This does not only have to relate to a financial willingness to pay, but to any kind of effort or discomfort related to choosing the more environmentally friendly option.

Our finding that guilt can encourage pro-environmental behaviour is not in itself a novel one. There is previous research that suggests that negative moral emotions may have the potential to motivate pro-environmental behaviour (e.g., Täuber, van Zomeren, & Kutlaca, 2015). Guilt (whether group-based, individual, or simply anticipated) is the emotion that is most often studied when it comes to encouraging prosocial or pro-environmental behaviour (Elgaaied, 2012; Ferguson & Branscombe, 2010; Harth, Leach, & Kessler, 2013; Mallett, Melchiori, & Strickroth, 2013; Onwezen, Antonides, & Bartels, 2013; Rees, Klug, & Bamberg, 2015; Schneider, Zaval, Weber, & Markowitz, 2017; Täuber et al., 2015). The added value of this research lies in the fact that we reach the same conclusions as other research on this topic using a network approach that is agnostic about which factors relate to behaviour and which do not. Such an approach is novel to social and environmental psychology and applicable to many different behavioural domains.

At present, there is very little research in social or environmental psychology that uses network analysis to better understand attitudes, and none that looks into people's attitudes towards (bio-based) plastic. This is where the second valuable and more applied aspect of this research lies; it is the first systematic investigation into people's attitudes and behaviours regarding plastic. Moreover, we believe that it illustrates the value of using a network analysis, especially with regards to understanding the relationship between attitudes and behavioural decisions (Dalege et al., 2017). It provides a novel perspective and understanding of the structure of attitudes people have regarding plastic and its use, and it was successful in determining which evaluative reactions to target for persuasion attempts. In our research we focused mainly on the centrality of specific nodes, because more central nodes tend to have a stronger impact on other nodes (especially those in the same cluster), as well as on behavioural decisions (Dalege et al., 2016; Dalege et al., 2017). However, network analysis also provides other informative indices. The connectivity of a network, for example, illustrates the strength of a given attitude (stronger attitudes are represented by more strongly connected networks). Greater connectivity usually indicates a tendency of the attitude to be more resistant to change and persuasion (Dalege et al., 2016; Howe & Krosnick, 2017; van Borkulo et al., 2014). Network analysis also allows one to directly compare different attitude networks.

Our original plan for this research was to compare the conventional and bio-based plastic attitude networks to each other using the Network Comparison Test (NCT; van Borkulo, Epskamp, Jones, Halsbeck, & Millner, 2016). With the help of these types of network comparisons, it is possible to determine whether two networks significantly differ in structure, global strength, and the weight of specific edges. Edge weights can inform about the different roles the same node can play in the different networks (Dalege et al., 2017). For example, comparing the connectivity of the attitude networks of two different groups might reveal which group would more easily be persuaded to change its behaviour. Knowing one's audience is crucial when trying to communicate issues such as climate change and sustainability (Clayton & Manning, 2018), so being aware of which target audience will be most susceptible and likely adopt more sustainable behaviour can save a lot of resources and time.

The fact that we were not able to compare people's attitude networks regarding conventional and bio-based plastic due to the majority of participants believing bio-based plastic to be biodegradable might be considered a limitation (future research should make the properties and benefits of bio-based plastic very clear before measuring participants' evaluative reactions towards it). However, it also raises an interesting question and opportunity. Attitude networks develop over time, with more nodes being added when new judgements, emotions, and beliefs about the attitude object emerge, for example through acquiring more information. With bio-based plastic being a relatively new and unknown technology, and with the public mostly unaware of its properties and benefits, most people do not yet have an attitude (and therefore also no attitude network) concerning bio-based plastic. It might therefore be an interesting case study to investigate the way in which attitude networks towards new technologies, such as bio-based plastic, emerge and develop. One could for example use network simulations to help make inferences on the dynamics of the newly forming network, to aid in the generation of hypotheses, and in devising behaviour predictions (Dalege et al., 2017).

### 5.1. Limitations

A possible limitation of the present research is the lack of a difference between the two guilt conditions in Study 3. Against our expectations, participants in the personal guilt condition (in which the participants' personal contributions to plastic-related $CO_2$ emissions were emphasised) did not report feeling more guilty than those in the general guilt condition (where participants were simply informed about plastic-related $CO_2$ emissions). It is possible that participants experienced more guilt than expected in the general guilt condition when hearing about the large amount of $CO_2$ that plastic production emits into the atmosphere, for example because it reminded them of their personal use, making this condition more similar to the personal condition than anticipated. Alternatively, mentioning the size of the town/city the participants live in and including the phrase "If people like yourself" might not have had the desired effect of making participants feel more personally responsible. While combining both the guilt conditions was deemed acceptable for the present study, as the central question was whether guilt in general has an effect on willingness to pay, this limitation can be easily overcome in future studies through thorough pilot testing of the manipulations.

As already mentioned in the discussion of Study 3, the skew of the

donation data and the small effect sizes achieved in that study urge for caution when interpreting the results of that final study. We do, however, still believe that these limitations do not lessen the potential value of network analyses to better understand and predict people's attitudes and encourage behavioural change.

Additionally, Study 3 only focused on guilt and not on any of the other evaluative reactions that the network analysis showed to be connected to willingness to pay (i.e. anger, sadness, and joy). We focused solely on guilt because it had the strongest connection with the behavioural node out of all the other evaluative reactions (see Fig. 2). However, this also means that, while we know that network analysis is able to identify relevant nodes connected to behaviour, we *do not know* whether these nodes are also more effective persuasion targets than the other nodes. Future research could investigate whether experimentally manipulating anger, sadness, or joy would also lead to higher willingness to pay, and if so, whether they are effective to the same or a lesser extent.

### 5.2. Implications

We hope that this research has implications for how social and environmental psychologists approach attitude and behaviour change studies, and encourages researchers to make more use of network approaches. It also supports previous research suggesting that guilt can encourage pro-environmental behaviour. Being the first research to specifically look at perceptions of plastic and bio-based plastic and create a scale designed to measure these, it might also prove useful in further reducing people's use of plastic, encouraging the switch to more sustainable plastic alternatives, and investigating people's relationship with plastics in greater detail. As previously mentioned, before new sustainable technologies can be adopted on a large scale, understanding how people can be encouraged to accept and be willing to pay more for it is an important step as new technologies are likely to be more expensive in the short term.

### 5.3. Future directions

While frequently being used in climate change intervention campaigns and found to be effective in changing people's pro-environmental intention and behaviour, using guilt to encourage behaviour change also has its drawbacks. In short, people do not like feeling bad about themselves and may try to deny, deflect, or avoid anything that might make them feel this way, especially if they feel that they are being manipulated to feel guilty (Rees et al., 2015; Täuber et al., 2015). Additionally, with increased awareness of climate change and sustainability, many people have developed coping strategies to deal with guilt they might feel about the discrepancy between their actual behaviour and the more sustainable behaviour they could ideally adopt. It might therefore be interesting to investigate the effect of positive affect on pro-environmental behaviour. Positive emotions did not seem to play a large role in the attitude network we created; however, the type of questions the attitude network was based upon might not have been the most conducive to the expression of positive emotions. Positive emotions (e.g., pride or awe; Bissing-Olson, Fielding, & Iyer, 2016; Harth et al., 2013; Onwezen et al., 2013; Piff, Dietze, Feinberg, Stancato, & Keltner, 2015) might be as effective, if not more so, than guilt in encouraging pro-environmental behaviour.

## 6. Conclusion

Trying to tackle one of the largest societal challenges of the century is not an easy task. Many researchers, politicians, and activists have tried many different approaches to encourage people to behave more environmentally friendly, with varying levels of success. This paper discussed a novel approach, namely using the Causal Attitude Network model to create an attitude network to better understand the structure and components of people's attitudes towards plastic and its use. We found that, in this case, people's willingness to pay for more environmentally friendly plastic was primarily determined by their feelings of guilt about their own plastic use. However, the main value of the present research transcends that result. We believe that this approach more broadly promises the ability to determine which evaluative reactions towards an attitude object are most likely to lead to behavioural change or the change of a person's attitude.

## Declaration of competing interest

None.

## Role of the funding source

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## Research data

All data and code are made available.

## CRediT authorship contribution statement

**Maria V. Zwicker:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Visualization, Writing - original draft, Writing - review & editing. **Hannah U. Nohlen:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Jonas Dalege:** Software, Resources, Visualization, Writing - review & editing. **Gert-Jan M. Gruter:** Funding acquisition, Writing - review & editing. **Frenk van Harreveld:** Conceptualization, Methodology, Writing - review & editing, Supervision.

## Appendix E. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2020.101433.

## Appendix A

25-item evaluative reactions questionnaire constructed from the thought-listing study.

Part 1 (randomised items) You will now be presented with a number of statements. Please indicate to what extent you agree with each of the statements. (7-point Likert-scale from *1 = strongly disagree* to 7 *= strongly agree*)

Plastic/Bio-based plastic…

… is convenient.
… is lightweight.
… is cheap.
… is readily available.
… is useful.
… is durable.
… is hygienic.
… is safe.
… is good for storage and packaging.
… is recyclable.
… takes a long time to decompose.
… pollutes bodies of water (e.g., oceans).

… causes waste.
… pollutes the air.
… is harmful to people's health (e.g., by entering the food chain or drinking water).
… is harmful to animals.
… depletes natural resources.
… is often of poor quality (e.g., breaks easily).

Part 2: feelings (randomised items) We are now going to ask you about your feelings about (bio-plastic) plastic use. Please indicate how much you agree with the following statements.
(7-point Likert-scale from *1 = strongly disagree* to *7 = strongly agree*)
When I think about plastic/bio-based plastic use, I feel….
… worried.
… joy.
… guilty.
… sad.
… angry.
… uncertain.
… excited.

## Appendix B

Study 3 was made available to participants residing in the following Western countries: UK, USA, Ireland, Germany, France, Spain, Australia, Austria, Belgium, Canada, Denmark, Finland, Iceland, Italy, Lichtenstein, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland.

Within these countries, only people who had a Prolific Academic approval rate of > 99% were allowed to participate.

## Appendix C

The information texts about the Carbon Cycle, the influence of $CO_2$ on global warming, and information about bio-based plastic.

Next, you will read some information about the carbon cycle and about how carbon dioxide ($CO_2$) influences global warming. Please read the information carefully. It is important that you understand these concepts to successfully complete the rest of the survey.

*The carbon cycle*

All living things are made of carbon. Carbon is also a part of the ocean, air, and even rocks. Because the Earth is a dynamic place, carbon does not stay still. In the atmosphere, carbon is attached to oxygen in a gas called carbon dioxide ($CO_2$). Plants use carbon dioxide and sunlight to make their own food and grow, and the carbon becomes part of the plant. Animals and humans consume these plants, and thus the carbon is transferred from the plants to animals and humans, who give it back to the atmosphere through the process of respiration (breathing). Also, when plants, animals, or humans die, their remains decay and their carbon is transferred to the Earth. Over millions of years, these remains form into fossil fuels (e.g. coal, oil, and natural gases). Burning of biomass (e.g., wood) and fossil fuels transfers carbon back into the atmosphere in the form of carbon dioxide ($CO_2$).

*Information about the influence of $CO_2$ on global warming*

A fossil fuel is a material that is formed by nature and contains a high percentage of carbon (for example oil or coal). These fossil fuels produce large amounts of energy when they are burned. However, when they are burned, fossil fuels also release a lot of carbon dioxide ($CO_2$). $CO_2$ is in itself a harmless gas that can be found in our atmosphere. In the past, the amount of atmospheric $CO_2$ was more or less constant, but humans have burned so much fossil fuel that there is about 30% more carbon dioxide in the air today than there was about 150 years ago. In fact, ice cores show us that there is now more carbon dioxide in the atmosphere than there has ever been in the last 420,000 years.

$CO_2$ is called a greenhouse gas, because once emitted it helps the atmosphere to hold on to its heat. But because we emit too much $CO_2$, there are not enough plants to absorb the $CO_2$, the heat is trapped and can no longer pass through the atmosphere and the heat bounces back to the earth. That is why $CO_2$ leads to global warming.

*Information about bio-based plastic*

One way of reducing $CO_2$ is through buying and using bio-based plastics.

The difference between 'regular' plastic and 'bio-based' plastic.

*'Regular' plastic*

The 'regular' plastic that you know from your everyday life is made from fossil fuels such as petroleum and natural gas. During the production of 'regular' plastic, oil and natural gas are heated to extremely high temperatures leading to the release of large amounts of $CO_2$.

Normally, fossil fuels are 'locked up' underground and do not really influence the carbon cycle. However, many of today's factories and vehicles use fossil fuels which leads to the emission of $CO_2$. The production of 'regular' plastic is an example of a $CO_2$-emitting process, and producing plastic thus contributes to global warming. The natural carbon cycle cannot handle the vast amounts of additional $CO_2$ that is created when burning such fuels, making $CO_2$ one of the main contributors to global warming.

*'Bio-based' plastic*

The defining feature of 'bio-based' plastic is that it is made (entirely or partially) from 'biomass'. Biomass is material usually made from plants, such as wood or crops and other plants that are not eligible for food or feed production. An example of a bio-based product is paper. Nowadays, plastic can also be made from biomass.

Products made from 'regular' and 'bio-based' plastic are virtually indistinguishable. They only differ in the materials they are made from. This also means that **'bio-based' is not the same as 'biodegradable'**. There are some regular and bio-based plastics that are biodegradable, but the majority are not.

What makes bio-based plastic better for the environment than the regular plastic, is that during its production there is no additional $CO_2$ added to the carbon cycle. The $CO_2$ contained in the biomass used for the production of bio-based plastic would have been released into the earth and the atmosphere naturally when the biomass decomposed. Thus, the production of bio-based plastic does not contribute to global warming because no additional $CO_2$ is released than what would occur naturally.

## Appendix D

*Guilt manipulation texts*

*General condition (no personal involvement)*

Plastic production is a large contributor to the amount of $CO_2$ in the atmosphere, and thus to global warming. That is because plastic is made from fossil fuels, such as oil and natural gas. During the production of plastic, oil and natural gas are heated to extremely high temperatures, which releases large amounts of $CO_2$. Specifically, to produce 1 kg of plastic (roughly 33 water bottles), 2 kg of oil are burned. Burning 1 kg of oil creates about 3 kg of $CO_2$. So, in order to produce 33 plastic water bottles around 6 kg of $CO_2$ are released into the atmosphere. In 2017, the global production of plastics reached 348 million metric tons, with 64 million metric tons produced in Europe alone. If these emissions continue like this, plastic production will have a significant effect on global warming. This is because it disrupts a

delicate balance in our climate and will lead to severe floods, food shortages, animal extinction, ocean acidification, and extreme heat waves.

*Personal condition (your contribution to global warming)*

Plastic production is a large contributor to the amount of $CO_2$ in the atmosphere, and thus to global warming. That is because plastic is made from fossil fuels, such as oil and natural gas. During the production of plastic, oil and natural gas are heated to extremely high temperatures, which releases large amounts of $CO_2$. Specifically, to produce 1 kg of plastic (roughly 33 water bottles), 2 kg of oil are burned. Burning 1 kg of oil creates about 3 kg of $CO_2$. So, in order to produce 33 plastic water bottles, around 6 kg of $CO_2$ are released into the atmosphere. In 2017, the global production of plastics reached 348 million metric tons, with 64 million metric tons produced in Europe alone. The average person living in a [city size] in your country consumes around 100 kg of plastic each year, which accounts for the release of **600 kg of $CO_2$ per person every year.** If people like yourself continue buying and using this much plastic, plastic production will have a significant effect on global warming. This is because it disrupts a delicate balance in our climate and will lead to severe floods, food shortages, animal extinction, ocean acidification and extreme heat waves.

*Control condition*

There are many different factors that contribute to the production of $CO_2$, and thereby to global warming. Recently, more and more focus has been on the amount of $CO_2$ that is released during plastic production. That is because plastic is made from fossil fuels, such as oil and natural gas. During the production of plastic, oil and natural gas are heated to extremely high temperatures, releasing $CO_2$. However, compared to other processes that use fossil fuels, **plastic's contribution to global warming is very small. Only 4% of global oil production is used for plastics**. 45% is used for transport, 42% energy and heating, 4% for chemicals, and the rest is simply burnt and lost. Thus, trying to reduce plastic use has a much smaller impact on reducing $CO_2$ than using public transport rather than a car, or turning off lights and appliances when leaving the room.

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