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Research article

The (non)effect of personalization in climate texts on the credibility of climate scientists: a case study on sustainable travel

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Abstract. How we communicate about climate change affects how others think, feel, and act. Therefore, the way that climate scientists formulate messages is important. In this study, we assess the effect of personalization (operationalized as writing in a conversational style), as previously done by Ginns and Fraser (2010), and the perceived credibility of climate scientists. We exposed 100 participants aged between 18 and 35 to three versions of a text on the climate impact of train versus plane travel with varying degrees of personalization and assessed the outcome with respect to (1) their attitude (specifically interest and opinion) towards sustainable travel and (2) the perceived credibility of the climate scientist who wrote the text. Results show that there is a small effect on the degree of happiness after reading the different texts, but there are few other effects. Our main conclusion is that, although personalization may be well received by readers, it may not be the best mode to influence the attitudes of readers towards sustainable travel or to impact how readers come to perceive climate scientists' credibility.

1 Introduction

Climate change, due to anthropogenic carbon emissions, is a major environmental problem. One critical driver of climate action is the public's attitude (specifically interest and opinion): prior study has suggested that positive attitudes towards climate-related topics lead to higher support for climate action (Cerf et al., 2023). Attitudes can be affected by many factors, including the perceived credibility of the information providers, when reading climate information (Bouman et al., 2021; Dong et al., 2018; Scott and Willits, 1994). In their study, Dong et al. (2018) found that there is a positive relationship between climate information and action and that it can be strengthened by the perceived credibility of the information provider. When it is understood how specific textual elements affect the perceived credibility of information providers, this information can be used to optimally strengthen the relationship between climate information and climate action.

One way of appealing to the emotional involvement and happiness of the reader via text is by implementing certain textual elements that have emotional appeal (Glaser et al., 2009). Indeed, previous research has shown that highlighting sadness or hope or using gain or loss frames can affect readers' responses (Lu, 2016). There have been numerous studies on how narrative elements (specifically written in a manipulative way, such as done by lobbyists) affect people's responses as well as how these elements can improve knowledge acquisition (Dahlstrom, 2014; Glaser et al., 2009; Norris et al., 2005; Yang and Hobbs, 2020). A combination between expository – purely scientific – and narrative elements is often used to popularize science and stimulate interest (Avraamidou and Osborne, 2009). One such element is personalization, which is defined here as a way of communicating abstract scientific concepts within a frame of reference, focusing on a particular individual or smaller groups of people and exploring their actions as well as the consequences that these actions entail (Schiffer and Guerra, 2015; Vonk et al., 2024).

Personalization of expository texts can affect the reading experience, by creating a protagonist that "explains" the science (Glaser et al., 2009). This protagonist decreases the distance between the reader and the content of the text and can, thus, urge readers to actively participate in reading, which leads to a feeling of closer proximity (Sangers et al., 2020). Additionally, such elements are likely to make the content more interesting on an emotional level. One way to include personalization in a text is to use direct address, where the writer addresses the reader in the second-person voice with "you". Another way is for the writer to explicitly expose themselves as the protagonist, writing in the first-person voice and including opinions in the text. Multiple studies have shown that personalization enhances learning outcomes and understanding (Ginns and Fraser, 2010; Mayer, 2014; Sangers et al., 2020).

However, whether personalization also results in an attitude change on climate change is understudied (Cerf et al., 2023). Understanding the effect of personalization on the public's attitude can, thus, provide information on the usefulness of personalization in climate mitigation and adaptation. Such insights may help climate communicators decide on their mode of communication and the formulation of their message. This, for example, can help climate communicators write popular scientific translations of highly scientific – expository – research, including the Intergovernmental Panel on Climate Change (IPCC) reports. Therefore, our first research question is as follows:

> *RQ1. How does the personalization of popular scientific climate texts affect the interest and opinion of participants with respect to climate change?*

Scientists' roles in public dialogues have been persistently discussed by the scientific community (Pielke, 2007). Especially in climate communication, knowing which role to take can be hard (Fischhoff, 2007). Considerations for scientists conducting climate communication can, for example, be the wish to remain neutral or to reflect objectivity, resulting in a specific type of text that will be very different from that written by scientists considering it their role to convince or incite the public to action and urge for change. Often, scientists choose to communicate in the role of *pure scientist*, aiming to provide neutral, unbiased, and fundamental information (Pielke, 2007). Scientists might be worried about their perceived credibility when choosing another role, such as that of *issue advocate*. However, communicating in the role of issue advocate can make information more comprehensible for a broader audience (Cologna et al., 2021). In this role, scientists inform the public of their own preference by explicitly voicing their support for one policy over others (Pielke, 2007).

By adding direct address to the reader and exposing the writer as the protagonist, the role of a scientist in climate texts may shift from pure scientist to issue advocate. It is, however, not yet known how these types of personalization affect the perceived credibility of a text or the scientist who wrote it. To find out more about this effect, our second research question is as follows:

> *RQ2. What is the effect of personalization on the perceived credibility of a popular scientific text and the climate scientist who wrote it?*

A new instrument proposed and tested by Peeters et al. (2022), and which we will be using here, can serve just that purpose. Their IMPACTLAB instrument is a toolbox, specifically designed for science communication, that provides a set of tools to measure the effect of public engagement activities. It also includes a decision tree to choose the most appropriate measurement tool for a particular activity. It is based on a theoretical framework to measure three features that help evaluate science communication interventions: science capital (what Peeters et al., 2022, term "output"), emotional memory ("outcome"), and long-term effect ("impact"). The science capital of participants is measured to find out how acquainted the public is with science in general. The emotional memory measures which emotions are aroused within the public. Emotions serve as predictors of memory retention, influencing how effectively individuals recall experiences over the long term. Additionally, the effect analysis measures a change in attitude. Within the framework, it is realized that measuring output is relatively straightforward, but measuring impact can be extremely difficult. The strength of the tool is that it is very practical and easy to adapt to a wide variety of public engagement activities.

To answer the two research questions, we conducted a randomized online survey experiment in which participants read a popular scientific text and answered questions. Based on a design with three different conditions (i.e., expository, slightly personalized, and highly personalized), both the effect of personalization on the perceived credibility of the climate scientist who wrote it and the effect of personalization on participants' attitude (specifically interest and opinion) toward sustainable travel were studied. As the basis for the three texts, we used a popular existing, published, online science article. In this original text, the carbon emissions of traveling by train are compared with those of flying, and the carbon emissions of building the required infrastructure are also included.

2 Methods

2.1 Context

The popular science article was taken from KlimaatHelpdesk (KH; https://www.klimaathelpdesk.org, last access: 15 July 2024), a Dutch online platform via which society can ask academic experts questions about climate change. These questions are published along with the academic peer-reviewed answers, which include references. Questions that are sent to KH are taken up by an editor,

who then asks an expert to write an accessible answer to that specific question. The experts are contacted based on their scientific expertise. They are generally not trained specifically in science communication but are supplied with a one-page guideline document regarding readability. After this writing procedure, the text is anonymously peer reviewed to increase the reliability of the answer prior to publication on http://KlimaatHelpdesk.org (last access: 15 July 2024). The main goal of KH is to explain climate issues to society in a trustworthy and understandable manner, by providing popularized scientific texts. By answering questions, KH hopes to start a dialogue between citizens and scientists.

The target audience of KH ranges from young secondary-school students to young adults (ages 13–35) with diverse backgrounds. Therefore, KH aims to make their answers understandable for secondary-school student ages and above.

2.2 Conditions and text conversion

One text from KH was converted into three conditions, as we aimed to separate the potential effect of the second-person voice from the first-person voice. As a basis, we chose a text on the climate impact of train versus plane travel, as it had received a large readership on the website (> 5000 visits), so we knew it was a popular topic, and it was not too technical and, therefore, relatively easy to adapt. All three texts included the same scientific information (approximately 750 words in length and a fairly technical figure) but differed with respect to the number of personalization (through direct address) elements. The three texts were checked by the original author for correctness.

For the first condition, the expository condition, no personalized elements were present, and the text was pallid and distant. Sentences in this text were factual and formal. For example, the text included the following sentence: "A single trip from the Netherlands to Milan, about 1100 km, produces about 11 kg of CO_2 per person. That is less than average for train journeys in Europe, because Nederlandse Spoorwegen and Deutsche Bahn (the Dutch and German national railway companies) operate mostly on wind energy, and the Swiss railways on hydropower."

In the second condition, the slightly personalized condition, minor changes were made compared to the first condition. A total of 23 definite articles (e.g., "the train seat") were replaced by second-person possessive pronouns (e.g., "your train seat"). Additionally, 17 indefinite pronouns were replaced by the second-person pronoun. Such changes have previously been made by Dutke et al. (2016) and Ginns and Fraser (2010). For example, the sentence above was changed to "With a single trip from the Netherlands to Milan, about 1100 km, you generate about 11 kg of CO_2 per person. That is less than average for train journeys in Europe, because Nederlandse Spoorwegen and Deutsche Bahn (the Dutch and German national railway companies) operate mostly on wind energy, and the Swiss railways on hydropower."

In the third condition, the highly personalized condition, the first-person voice of the writer was added. It included the same second-person (possessive) pronouns as the second condition, but it also included 6 additional first-person (plural) pronouns and 13 direct addresses from the writer. In these direct addresses, readers were spoken to in the writer's voice. These additions made the third condition conversational instead of formal. For example, the sentence above was changed to "With a single trip from the Netherlands to Milan, about 1100 km, you generate about 11 kg of CO_2 per person. I think it is important to mention that this is less than the average for train journeys in Europe, because Nederlandse Spoorwegen and Deutsche Bahn (the Dutch and German national railway companies) operate mostly on wind energy, and the Swiss railways on hydropower."

The original Dutch versions of the three conditions can be found in the Appendix (Figs. A1–A3). As Dutch is very similar to English (the languages share linguistic roots and numerous similarities with respect to vocabulary, grammar, and syntax), we expect that our results are generalizable to English too.

2.3 Participants and study design

In the period from 20 June 2023 to 4 January 2024, we used SurveySwap to recruit participants. SurveySwap is an online platform (e.g., Mouratidou et al., 2024), operating on a reciprocal basis: users can earn credits by completing other users' surveys and then use those credits to have their own surveys completed. This system is particularly used by students and academics who need to collect a significant number of data points for their research projects or dissertations; therefore, the pool of respondents may be limited with respect to diversity.

Our survey was deemed low risk by the Utrecht University Ethics and Privacy Quick Scan, and it began with a consent form (based on the default template from Utrecht University; see also the "Ethical statement" at the end of this paper) in which participants were informed that their participation was voluntary and confidential, that they could stop at any moment, and that their identity and research data would not be stored together.

A total of 169 people, who all spoke Dutch, took part in our research. Participants aged younger than 18 or older than 35 were excluded from this analysis, as our focus group was young adults (the target audience of KH). Additionally, participants were excluded when the total duration time of reading the text and filling in the survey was less than 4 min (careless readers) or more than 30 min (distracted participants). This resulted in a sample size of 100 participants. We can expect (although we have not tested) that very few of the participants had previously heard of KH and that even fewer (or none) of them had heard of the authors of the article.

Participants answered questions about their age (median of 24 years, standard deviation of 2.8 years), gender (44 men, 55 women, and 1 other), and educational level (> 50 % finished higher education). Participants were randomly assigned one of the three conditions and asked to read the text carefully and fill out a questionnaire with nine prior and five posterior questions. The first condition (expository) was read by 40 participants, the second condition (slightly personalized) was read by 30 participants, and the third condition (highly personalized) was read by 30 participants.

2.4 Measures

2.4.1 Prior intention and past conduct

Prior to exposure, participants answered four questions to determine their intention and past conduct towards flying and traveling by train (Fig. 1). These questions included statements, to which participants could respond using a five-point Likert scale, indicating how likely it would be that they would take a plane or train on a trip from the Netherlands to Milan (which was the topic of the KH text used in this study). The likelihood that they would take a plane (median of "very likely") was much higher than the likelihood that they would take a train (median of "unlikely"), with no participant answering that it would be very likely that they would take a train to Milan. Additionally, participants answered multiple choice questions (possible answers: 0, 1, 2, and 3 or more) regarding (1) how often the they went on a vacation last year (median of 2) and (2) how many of these trips were by plane (median of 1). To investigate if there was an effect of prior intention, we also separated the participants into two groups (split on the median, so that both groups were roughly equal in size): those that were very likely to travel to Milan by plane ($N = 56$) and those that filled out any of the other four options ($N = 44$). However, as we did not find any significant effects on opinion or credibility, we do not explicitly show the results below.

2.4.2 Science capital and trust

The science capital of the participant was measured using four statements assessed using a five-point Likert scale (Fig. 2), retrieved from IMPACTLAB (Peeters et al., 2022). The statements were "I am generally aware of new scientific discoveries and developments", "I am interested in the scientific process and the results it yields", "In my spare time, I participate in activities that allow me to learn something about science, such as visiting museums, looking up information online or watching science-related tv shows or videos", and "I regularly talk about science with other people, e.g., in my free time or in the context of my study or job".

Additionally, two statements assessed using a five-point Likert scale were added to test the prior perceived trustworthiness and intended purpose of scientists (Fig. 2). The two statements were "I generally find scientists to be trustworthy" and "I think it's important that scientists communicate about their research".

We combined the six statements into one construct "science capital and trust" (SCT). The Cronbach alpha score – which measures the internal consistency (e.g., Heo et al., 2015) of these six statements on science capital and trust – was acceptable ($\alpha = 0.79$). Most of the participants answered "agree" or "strongly agree" to the six questions, with the largest number of (strongly) disagree answers to the "awareness" and the "talking to others" questions (Fig. 2). To investigate if the level of science capital and trust of the participants was related to the effect of the text and the credibility of the writer, we separated the participants into two groups (split on the median, so that both groups were roughly equal in size): those that had an average score for the six science capital and trust questions of less than 4 out of 6 ($N = 53$, hereafter referred to as "SCT < 4") and those that had an average score of 4 or more ($N = 47$; hereafter referred to as "SCT ≥ 4").

2.5 Assessment of differences between conditions

To assess whether our three conditions were indeed perceived to be different with respect to personalization, we evaluated how participants experienced the text. After reading the text, participants were asked whether they found the text to be formal/informal and personal/professional; these answers were given via a 10-point semantic differential scale (Fig. 3). More than 60 % of participants experienced the texts as being relatively formal and professional (score < 6). We separated the answers by text condition and used an ANOVA to find that there was a significant difference in the extent to which the participants found the text to be personal as opposed to professional ($p = 0.003$). Post hoc tests (using the Holm correction to adjust p; Holm, 1979) indicated that both the slightly personalized and the highly personalized texts were perceived as being significantly more personal than the expository text ($p = 0.021$ and $p = 0.008$, respectively), but we found no evidence that the highly personalized text was perceived as being more personal than the slightly personalized text ($p = 0.246$). There was no significant difference when we separated the responses based on science capital and trust ($p = 0.255$).

There was also a significant difference in the extent to which participants found the text to be informal as opposed to formal (one-sided $p = 0.010$). Post hoc tests (using the Holm correction to adjust p) indicated that both the slightly personalized and the highly personalized texts were perceived as being significantly more informal than the expository text (one-sided $p = 0.035$ and $p = 0.030$, respectively), but we found no evidence that the highly personalized text was perceived as being more informal than the slightly personalized text (one-sided $p = 0.908$). Again, there was no significant

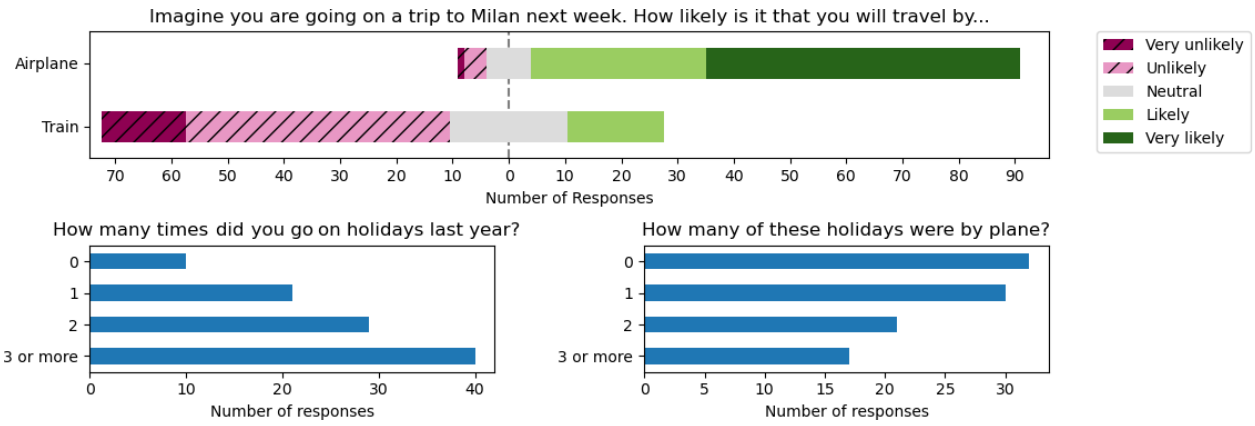


Figure 1. Plots for prior intention and past conduct towards flying and traveling by train, as answered by the 100 participants. The upper panel uses the plot-likert Python package to visualize the number of participants that have given each of the five respective answers; the plots are centered around the neutral (Likert score of 3) value.

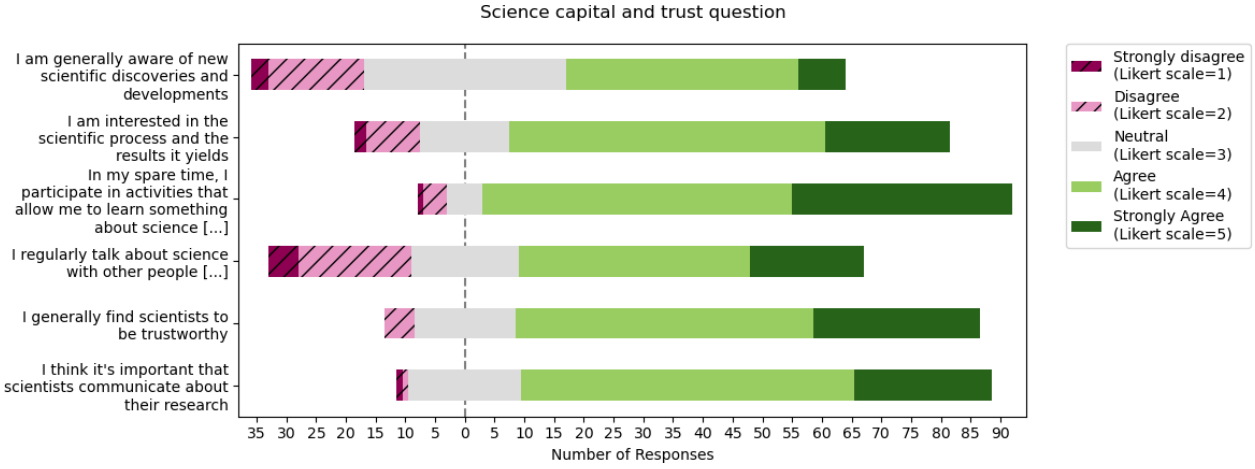


Figure 2. The responses to statements on the science capital and trust of the participants, assessed using a five-point Likert scale. The participants' responses are highly skewed towards high science capital and trust.

difference when we separated the responses based on science capital and trust ($p = 0.618$).

3 Results

3.1 Change in attitude

The effect of the texts on emotions was measured using questions derived from IMPACTLAB (Peeters et al., 2022). The first question, measuring how participants felt after reading the text, consisted of eight 10-point semantic differential statements (Fig. 4). The strongest positive response was on emotion, with $> 60\,\%$ of participants finding the texts interesting. There was a significant difference in the happy/unhappy emotion for all three conditions, although there was no trend. Additionally, there was a significant difference in the separation based on science capital and trust with respect to the unsatisfied/satisfied (with participants with higher SCT feeling more satisfied) and not interested/interested (with participants with higher SCT feeling more interested) emotions. The difference between all other emotions was not statistically significant.

Post hoc tests (using the Holm correction to adjust p) on the unhappy/happy emotion for the text condition indicated that the participants were significantly happier after reading both the expository and the highly personalized texts than the slightly personalized text ($p = 0.040$ and $p = 0.048$, respectively), but we found no evidence that participants were happier or more unhappy after reading the highly personalized text than after reading the expository text ($p = 0.662$).

For the second IMPACTLAB question, on the cognitive effect of the text, participants answered the following four statements using a five-point Likert scale (Fig. 5): "I now know more about the impact of travel on climate", "I want to know more about the impact of travel on climate", "My opinion on flying or train travel has changed", and "I want

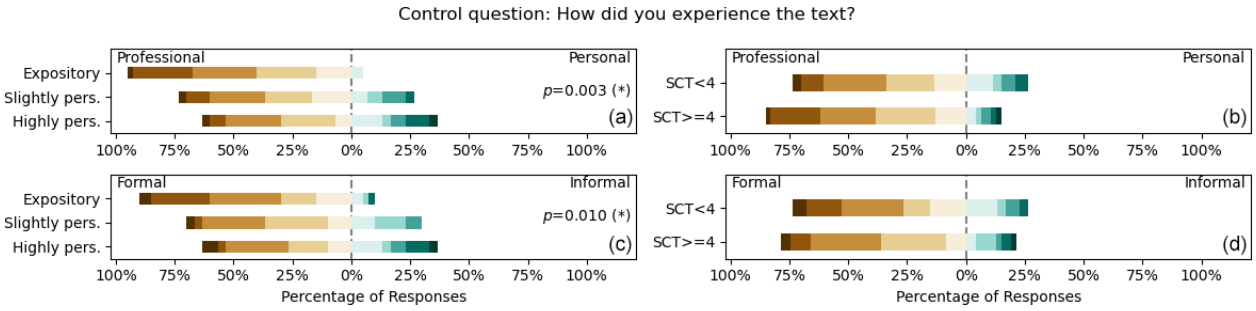


Figure 3. Responses to the two control questions, on a scale from 1 to 10, separated by **(a, c)** condition and **(b, d)** score on science capital and trust (higher or lower than 4 out of 5). ANOVA test statistics with $p < 0.05$ are indicated. The color scale is such that 1–5 are brown, whereas 6–10 are green. As expected, the expository text was experienced as being more professional and formal than the highly personalized text.

to read more of these texts – also on other scientific topics". None of these statements were answered significantly differently between the three text conditions or between the two levels of science capital and trust. The question on a change in opinion was also not answered statistically differently between those participants that were likely to take a plane to Milan and those that were not.

3.2 Perceived credibility of the writer

The perceived credibility of the writer was measured using eight different seven-point semantic differential statements (Fig. 6), as used by Kotcher et al. (2017). Randomization with respect to the order of statements was used to prevent the results falling prey to possible order effects. Averaging these eight statements in one construct and applying an ANOVA led to no significant difference between the three text conditions ($p = 0.502$); moreover, no significant difference was found between the two levels of science capital and trust ($p = 0.116$). The Cronbach alpha score for internal consistency of these eight statements on perceived credibility was acceptable ($\alpha = 0.73$).

Analyzing the statements individually, we again found that only two of these statements on the perceived credibility were answered significantly differently: the not at all intelligent/very intelligent question when separated by likelihood to take a plane ($p = 0.011$; not shown) and the not at all trustworthy/trustworthy question when separated by science capital and trust ($p = 0.019$). The groups with a higher SCT and a lower likelihood of taking a plane found the author more intelligent.

3.3 Perceived credibility of the text: goal to persuade and to inform

Based on the question by Kotcher et al. (2017), participants were then asked to specify the extent to which they agree or disagree with the following two statements: "The goal of the text was to persuade people to take action to address climate change" and "The goal of the text was to provide impartial information about traveling by airplane or train" (Fig. 7). Both statements were measured on a seven-point Likert scale (1 denotes fully disagree, whereas 7 denotes fully agree), and an ANOVA revealed that the only statistically significant result was when we separated the responses to the question on whether the writer provided impartial information by science capital and trust ($p = 0.026$).

3.4 Perceived credibility of the writer: attribution to scientific evidence and political views

Also based on the questions by Kotcher et al. (2017), participants were finally asked to specify the extent to which they agree or disagree with the following two statements: "The content of the text was shaped by the writer's evaluation of the scientific evidence about the impact of traveling by airplane or train on the environment" and "The content of the text was shaped by the writer's personal views about the impact of traveling by airplane or train on the environment" (Fig. 8). Both statements were measured on a seven-point Likert scale (1 denotes fully disagree, whereas 7 denotes fully agree). The first statement about scientific evidence was answered statistically differently between the science capital and trust groups ($p = 0.017$), while the second statement about personal views was answered statistically differently between the three text conditions ($p = 0.041$).

Post hoc tests (using the Holm correction to adjust p), however, revealed no evidence that participants found that the content was shaped by the writer's personal views after reading the expository text compared to the slightly personalized text ($p = 0.880$), after reading the expository text compared to the highly personalized text ($p = 0.071$), or after reading the slightly personalized text compared to the highly personalized text ($p = 0.071$).

4 Discussion

In this study, we set out to gain insights into the effects of personalization in writing (about traveling by train or plane) on the perceived credibility of the writer (the scientist). The

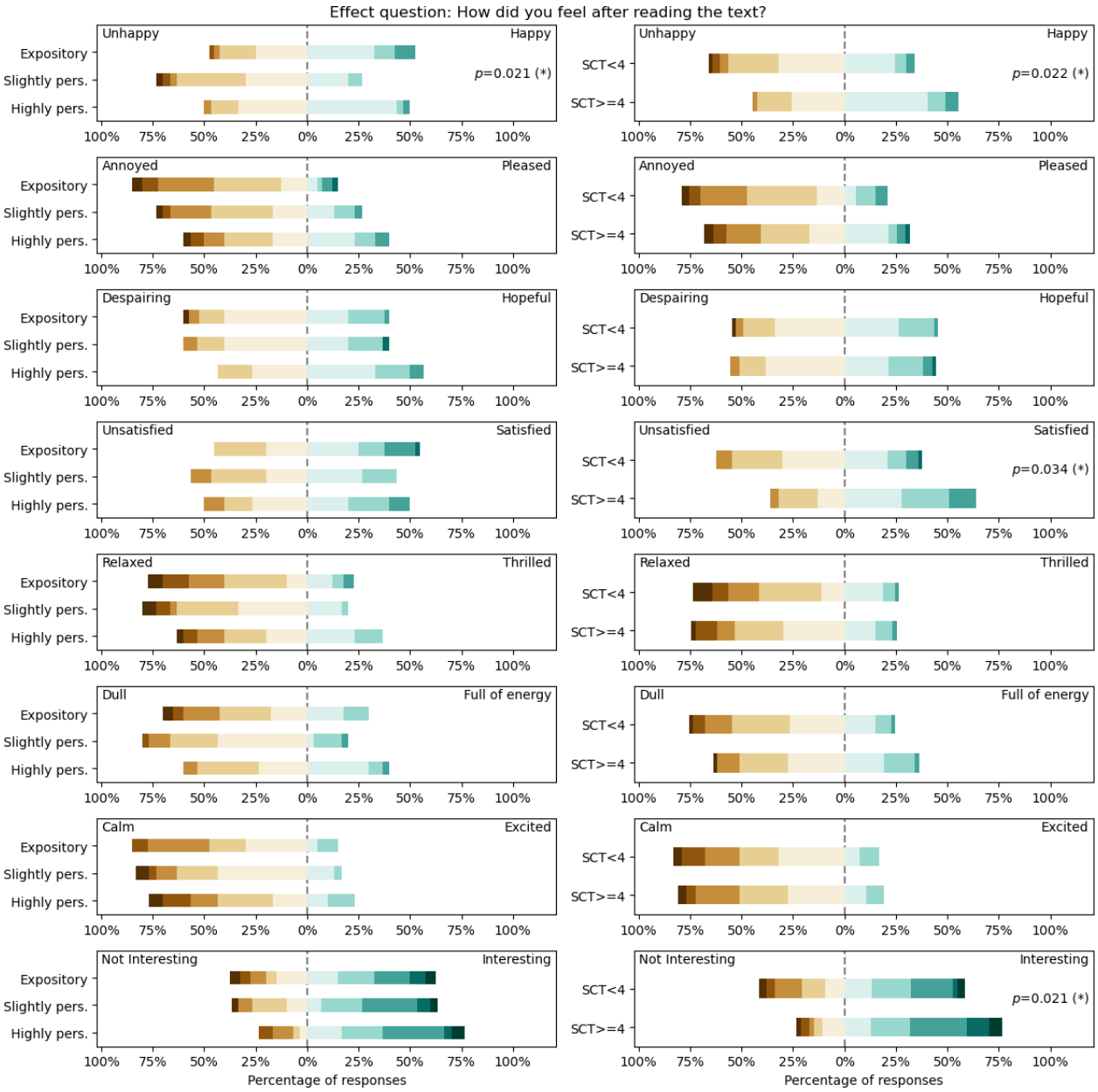


Figure 4. Responses to the eight statements on the emotions of the participants after reading the texts, on a scale from 1 to 10, separated by (left column) condition and (right column) score on science capital and trust (higher or lower than 4 out of 5). ANOVA test statistics with $p < 0.05$ are indicated. The color scale is such that 1–5 are brown, whereas 6–10 are green. There was hardly any difference between the three texts or between the two levels of science capital and trust.

variation in the amount of personalization in the texts was recognized by readers (e.g., using second-person pronouns in the "slightly personalized" condition and adding the first-person voice of the author in the "highly personalized" condition), as was apparent from the result that the highly personalized version of the text was perceived as being much more personal and informal than the base (expository) version (Fig. 3). In that sense, our textual changes worked as intended, although it should be noted that most participants (> 60 %) still experienced the highly personalized text as relatively formal and professional (score < 6). Thus, we did not manage to rewrite the expository text to such an extent that we could alter it from primarily formal to primarily informal while keeping the content the same. It may be that our manipulation, in our attempt to keep the text as similar as possible, was too subtle and that, in reality, when scientists write more personalized texts, changes in the tone and content affect the text more than we have operationalized in this study. Addi-

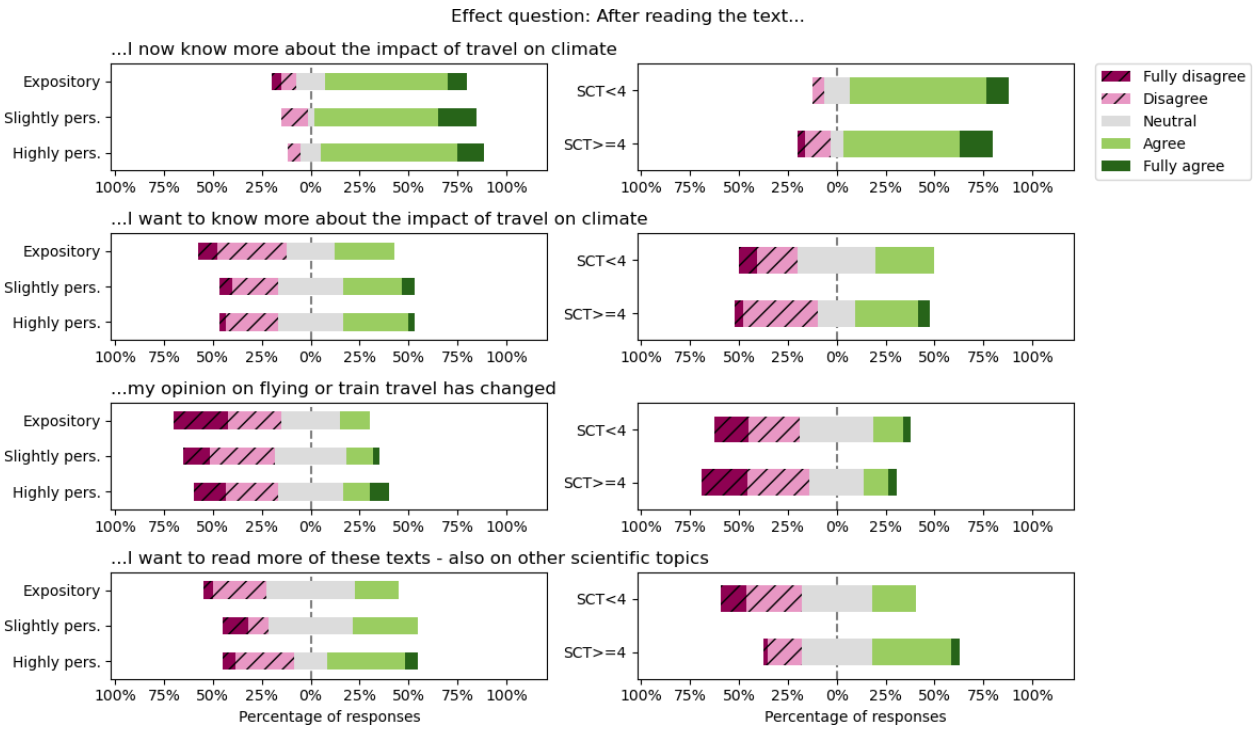


Figure 5. Responses to the four statements on the effects on the participants after reading the texts, on a five-point Likert scale, separated by (left column) condition and (right column) score on science capital and trust (higher or lower than 4 out of 5). None of the ANOVA test statistics were lower than $p = 0.05$. There was no difference between the three texts or between the two levels of science capital and trust.

tionally, readers may be likely to perceive a text as formal if it contains scientific information.

The answer to our first research question ("How does personalization of popular scientific climate texts affect the interest and opinion to climate change of participants?") is that we see a limited effect (Fig. 5). Most participants indicated that they knew more about the impact of travel on climate after reading the text, independent of the text version that they read and of their science capital. On the other hand, reading the texts did not change most of the participant's opinions on flying or train travel, again with no difference between the texts or science capital. It could be that some of the participant's attitudes to, for example, the need for better rail infrastructure has changed; however, as we only asked about their opinion on flying or train travel, we could not evaluate that effect.

Of course, in real life, people will be exposed to various sources of information about this issue, and previous research has shown that peer pressure can be particularly effective in changing behaviors. As KH is essentially an interactive question–answer-based website, future research may investigate if adding simulated responses from other readers (indicating that, based on what they just learned, they would take the train) would have more effect. This concept of communicated actions of peers (even anonymously) having a positive effect on behavior has previously been shown in various contexts, such as preventive health behavior (Saran et al., 2018).

The questions on the effects of the texts on emotions (Fig. 4) did not vary significantly when we separated them by text condition or by science capital and trust, except for the emotion of happiness, which was significant for both types of separation. This confirms the findings of Peeters et al. (2022), who found that happiness is one of the strongest predicting emotions with respect to effect. Most participants found the text interesting ($> 60\,\%$ for all three conditions), but they felt calm, dull, and relaxed (i.e., not excited) after reading. Additionally, they also felt annoyed. We conclude that the participants did not enjoy reading any of the three conditions, and this may also indicate that a more extreme shift between conditions is necessary to better simulate personalized science texts aiming to entice.

As for the answer to our second research question ("What is the effect of personalization on the perceived credibility of a popular scientific text and the climate scientist that wrote it?"), the writer of the article was perceived very positively (Fig. 6), with readers assessing them as being competent, an expert, very intelligent, very trustworthy, etc. The only statement for which the writer did not score more than $60\,\%$ positive responses was on the element of sensitivity, although most responses there were close to neutral. This seems to indicate that participants' attitudes toward the writer were gen-

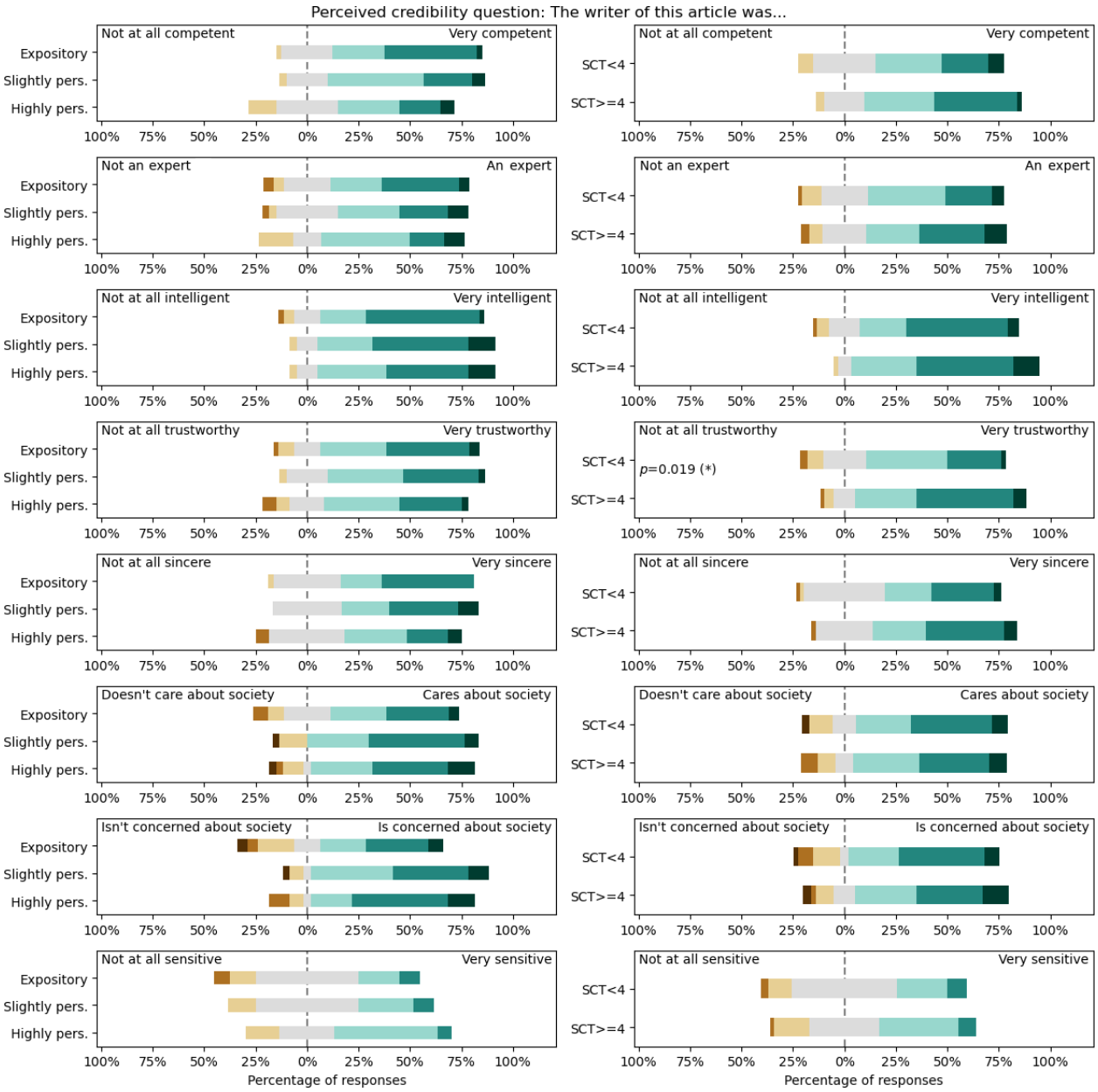


Figure 6. Responses to the eight statements on the perceived credibility of the writer, on a scale from 1 to 7, separated by (left column) condition and (right column) score on science capital and trust (higher or lower than 4 out of 5). ANOVA test statistics with $p < 0.05$ are indicated. The color scale is such that 1–3 are brown, 4 is gray, and 5–7 are green. Again, there was no difference between the three texts or between the two levels of science capital and trust.

erally positive, even though most participants did perceive that the goal of the text was to persuade people to take climate action. The positive attitude towards the writer (Fig. 2) might reflect the general trust in scientists as a source of information (Edelman Trust Institute, 2024). Participants with a high SCT more strongly perceived the goal of the writer as being to provide impartial information, compared with participants with a lower SCT. Perhaps surprisingly, participants did not perceive the text to be more shaped by the writer's personal views in the highly personalized condition (Fig. 8), despite it being perceived as being more personal (Fig. 3). This may indicate that our manipulation of the text was weak, although we would argue that this might instead suggest that a more personal text does not influence the credibility of the writer. This is also in line with past research which has shown that this mode of communication, in a more activistic tone, does not necessarily hamper public perceptions of

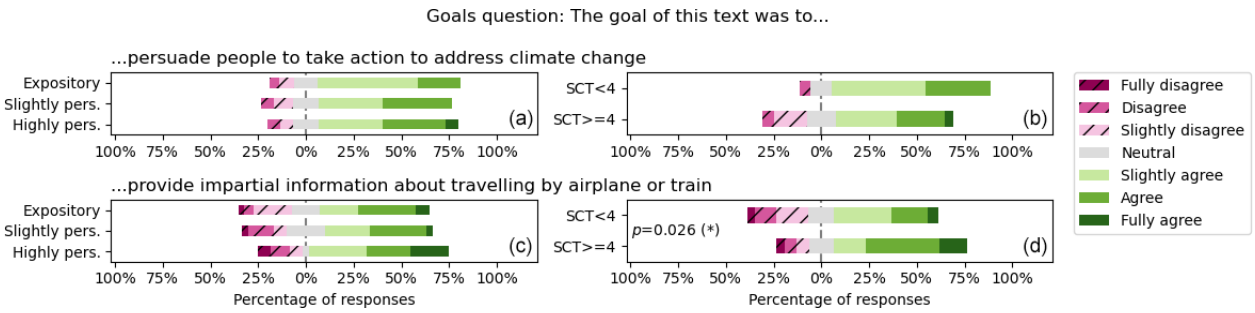


Figure 7. Responses to the two statements on the perceived goals of the text, on a seven-point Likert scale, separated by **(a, c)** condition and **(b, d)** score on science capital and trust (higher or lower than 4 out of 5). ANOVA test statistics with $p < 0.05$ are indicated. There was no difference between the three texts; however, there was a significant result for impartial information between the two levels of science capital and trust.

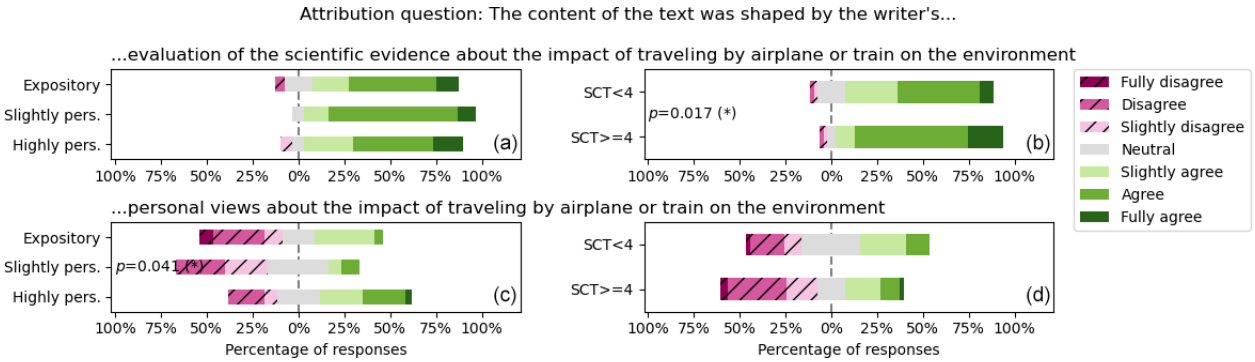


Figure 8. Responses to the two statements on the perceived goals of the text, on a seven-point Likert scale, separated by (left column) condition and (right column) score on science capital and trust (higher or lower than 4 out of 5). ANOVA test statistics with $p < 0.05$ are indicated. There was hardly any difference between the three texts or between the two levels of science capital and trust.

scientific integrity or scientists' credibility (Cologna et al., 2021; Kotcher et al., 2017).

Previous research has shown that scientists tend to stick to the facts and create messages with too much detail and a lack of personal connection (Somerville and Hassol, 2011). Therefore, an important recommendation is to make personally relevant messages by communicating on the level of values (Clarke et al., 2020; Fage-Butler et al., 2022; Seethaler et al., 2019). Given the fact that our base text was purposefully expository, it may be that the operationalization of these values was quite weak and that adding a more explicit incorporation of the writer's personal values would have had a larger effect on the readers.

Of course, this study has limitations. First, the sample size and the characteristics of the conditions used limit our options to generalize outside of this group. Especially our sample size restricts our analysis, making it impossible to show small differences across groups. A larger sample size might make some of the more subtle, nonsignificant details in the figures more pronounced. The benefit is that the differences reported are robust, whereas the downside is that there may be hidden effects. Moreover, most participants were relatively highly educated, which may have influenced a greater acceptance of the expository condition, compared with a situation in which the science capital of the participants was more diverse. Furthermore, the time required to finish the survey was quite long (8 min on average). This may have caused participants to be less attentive and engaged, especially toward the end of the questionnaire, and could thus explain the fact that the last few questions showed fewer significant differences between the conditions. Finally, we did not make changes to the visual cues in the article. All three conditions contained a figure that was fairly technical, which would be expected to minimize the personalization effects of the text, giving the overall look of the article a more expository feel. Future research could investigate this further by altering the visuals in accordance with the text-based conditions, although a 3×3 (visuals $\times$ text) design would necessitate even more respondents.

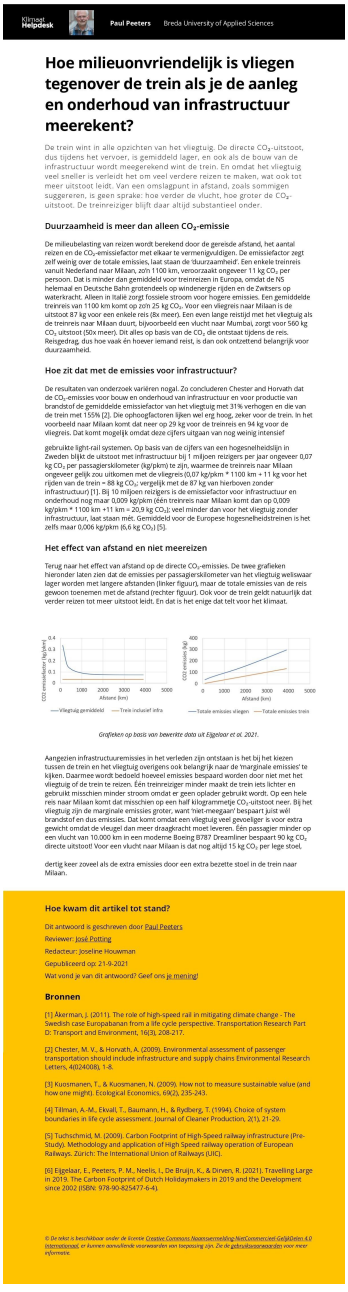
5 Conclusions

In this study, we analyzed how variation in personalization through direct address in an article about the effect of traveling by train or plane on carbon dioxide emissions affected opinion and interest toward sustainable travel and the per-

ceived credibility of the climate scientist who wrote the publication. We used an article that was previously published on the KlimaatHelpdesk (https://klimaathelpdesk.org, last access: 15 July 2024) platform and adapted it to increase personalization. To measure the effect, we used a questionnaire with questions that had previously been validated by Kotcher et al. (2017) and Peeters et al. (2022). Our findings show that a limited amount of personalization of the text was recognized and positively appreciated by the readers and did not affect the credibility of the writer.

Of course, this is only one study on one text with one type of audience (young Dutch adults). If our results hold up with respect to a wider variety of texts and audiences, this suggests that adding personalization does not harm the message of climate communication materials, which is a useful finding for communication professionals who aim to make climate texts more engaging.

Appendix A


Klimaat Helpdesk

Paul Peeters Breda University of Applied Sciences

Hoe milieuonvriendelijk is vliegen tegenover de trein als je de aanleg en onderhoud van infrastructuur meerekent?

De trein wint in alle opzichten van het vliegtuig. De directe CO_2-uitstoot, dus tijdens het vervoer, is gemiddeld lager, en ook als de bouw van de infrastructuur wordt meegerekend wint de trein. En omdat het vliegtuig veel sneller is verleidt het om veel verdere reizen te maken, wat ook tot meer uitstoot leidt. Van een omslagpunt in afstand, zoals sommigen suggereren, is geen sprake: hoe verder de vlucht, hoe groter de CO_2-uitstoot. De treinreiziger blijft daar altijd substantieel onder.

Duurzaamheid is meer dan alleen CO_2-emissie

De milieubelasting van reizen wordt berekend door de gereisde afstand, het aantal reizen en de CO_2-emissiefactor met elkaar te vermenigvuldigen. De emissiefactor zegt zelf weinig over de totale emissies, laat staan de 'duurzaamheid'. Een enkele treinreis vanuit Nederland naar Milaan, zo'n 1100 km, veroorzaakt ongeveer 11 kg CO_2 per persoon. Dat is minder dan gemiddeld voor treinreizen in Europa, omdat de NS helemaal en Deutsche Bahn grotendeels op windenergie rijden en de Zwitsers op waterkracht. Alleen in Italië zorgt fossiele stroom voor hogere emissies. Een gemiddelde treinreis van 1100 km komt op zo'n 25 kg CO_2. Voor een vliegreis naar Milaan is de uitstoot 87 kg voor een enkele reis (8x meer). Een even lange reistijd met het vliegtuig als de treinreis naar Milaan duurt, bijvoorbeeld een vlucht naar Mumbai, zorgt voor 560 kg CO_2 uitstoot (50x meer). Dit alles op basis van de CO_2 die ontstaat tijdens de reis. Reisgedrag, dus hoe vaak én hoever iemand reist, is dan ook ontzettend belangrijk voor duurzaamheid.

Hoe zit dat met de emissies voor infrastructuur?

De resultaten van onderzoek variëren nogal. Zo concluderen Chester and Horvath dat de CO_2-emissies voor bouw en onderhoud van infrastructuur en voor productie van brandstof de gemiddelde emissiefactor van het vliegtuig met 31% verhogen en die van de trein met 155% [2]. Die ophogingfactoren lijken wel erg hoog, zeker voor de trein. In het voorbeeld naar Milaan komt dat neer op 29 kg voor de treinreis en 94 kg voor de vliegreis. Dat komt mogelijk omdat deze cijfers uitgaan van nog weinig intensief

gebruikte light-rail systemen. Op basis van de cijfers van een hogesnelheidslijn in Zweden blijkt de uitstoot met infrastructuur bij 1 miljoen reizigers per jaar ongeveer 0,07 kg CO_2 per passagierskilometer (kg/pkm) te zijn, waarmee de treinreis naar Milaan ongeveer gelijk zou uitkomen met de vliegreis (0,07 kg/pkm * 1100 km + 11 kg voor het rijden van de trein = 88 kg CO_2, vergelijk met de 87 kg van hierboven zonder infrastructuur) [1]. Bij 10 miljoen reizigers is de emissiefactor voor infrastructuur en onderhoud nog maar 0,009 kg/pkm (één treinreis naar Milaan komt dan op 0,009 kg/pkm * 1100 km +11 km = 20,9 kg CO_2); veel minder dan voor het vliegtuig zonder infrastructuur, laat staan mét. Gemiddeld voor de Europese hogesnelheidstreinen is het zelfs maar 0,006 kg/pkm (6,6 kg CO_2) [5].

Het effect van afstand en niet meereizen

Terug naar het effect van afstand op de directe CO_2-emissies. De twee grafieken hieronder laten zien dat de emissies per passagierskilometer van het vliegtuig weliswaar lager worden met langere afstanden (linker figuur), maar de totale emissies van de reis gewoon toenemen met de afstand (rechter figuur). Ook voor de trein geldt natuurlijk dat verder reizen tot meer uitstoot leidt. En dat is het enige dat telt voor het klimaat.

Grafieken op basis van bewerkte data uit Elgeloar et al. 2021.

Aangezien infrastructuuremissies in het verleden zijn ontstaan is het bij het kiezen tussen de trein en het vliegtuig overigens ook belangrijk naar de 'marginale emissies' te kijken. Daarmee wordt bedoeld hoeveel emissies bespaard worden door niet met het vliegtuig of de trein te reizen. Één treinreiziger minder maakt de trein iets lichter en gebruikt misschien minder stroom omdat er geen oplader gebruikt wordt. Op een hele reis naar Milaan komt dat misschien op een half kilogrammetje CO_2-uitstoot neer. Bij het vliegtuig zijn de marginale emissies groter, want 'niet-meegaan' bespaart juist wél brandstof en dus emissies. Dat komt omdat een vliegtuig veel gevoeliger is voor extra gewicht omdat de vleugel dan meer draagkracht moet leveren. Één passagier minder op een vlucht van 10.000 km in een moderne Boeing B787 Dreamliner bespaart 90 kg CO_2 directe uitstoot! Voor een vlucht naar Milaan is dat nog altijd 15 kg CO_2 per lege stoel.

dertig keer zoveel als de extra emissies door een extra bezette stoel in de trein naar Milaan.

Hoe kwam dit artikel tot stand?

Dit antwoord is geschreven door Paul Peeters

Reviewer: José Potting

Redacteur: Joseline Houwman

Gepubliceerd op: 21-9-2021

Wat vond je van dit antwoord? Geef ons je mening!

Bronnen

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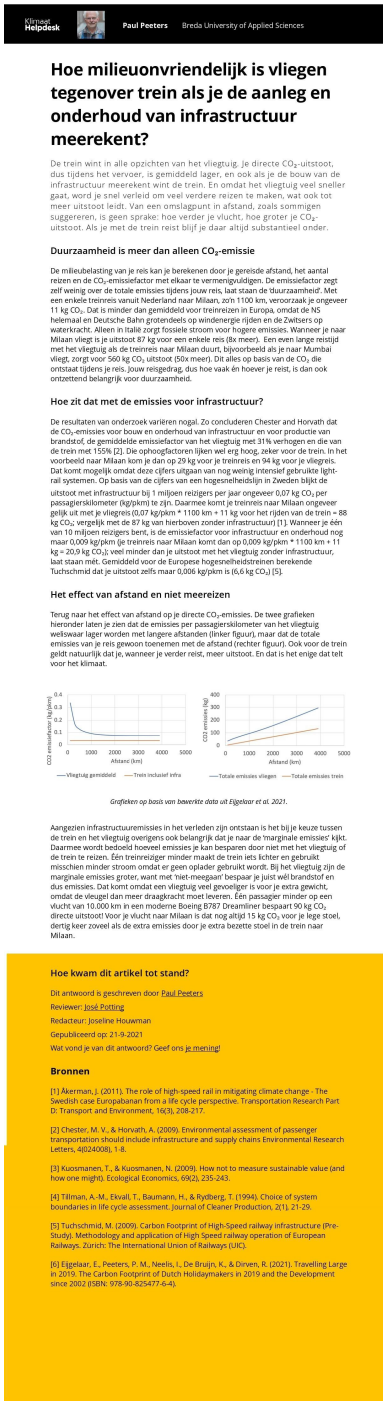
[6] Elgeloar, E., Peeters, P. M., Neelis, I., De Bruijn, K., & Dirven, R. (2021). Travelling Large in 2019. The Carbon Footprint of Dutch Holidaymakers in 2019 and the Development since 2002 (ISBN: 978-90-825477-6-4).

Figure A1. The expository condition. This image was created by the authors (and adapted with approval) based on the original version at https://www.klimaathelpdesk.org/answers/hoe-milieuonvriendelijk-is-vliegen-tegenover-trein-of-bus-met-aanleg-en-onderhoud-van-infrastructuur-meegerekend/ (last access: 15 July 2024), which was published under a CC BY-NC-SA 4.0 license.



Klimaat Helpdesk

Paul Peeters Breda University of Applied Sciences

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De trein wint in alle opzichten van het vliegtuig. Je directe CO_2-uitstoot, dus tijdens het vervoer, is gemiddeld lager, en ook als je de bouw van de infrastructuur meerekent wint de trein. En omdat het vliegtuig veel sneller gaat, word je snel verleid om veel verdere reizen te maken, wat ook tot meer uitstoot leidt. Van een omslagpunt in afstand, zoals sommigen suggereren, is geen sprake: hoe verder je vliucht, hoe groter je CO_2-uitstoot. Als je met de trein reist blijf je daar altijd substantieel onder.

Duurzaamheid is meer dan alleen CO_2-emissie

De milieubelasting van je reis kan je berekenen door je gereiste afstand, het aantal reizen en de CO_2-emissiefactor met elkaar te vermenigvuldigen. De emissiefactor zegt zelf weinig over de totale emissies tijdens jouw reis, laat staan de 'duurzaamheid'. Met een enkele treinreis vanuit Nederland naar Milaan, zo'n 1100 km, veroorzaak je ongeveer 11 kg CO_2. Dat is minder dan gemiddeld voor treinreizen in Europa, omdat de NS helemaal en Deutsche Bahn grotendeels op windenergie rijden en de Zwitsers op waterkracht. Alleen in Italië zorgt fossiele stroom voor hogere emissies. Wanneer je naar Milaan vliegt is je uitstoot 87 kg voor een enkele reis (8x meer). Een even lange reistijd met het vliegtuig als de treinreis naar Milaan duurt, bijvoorbeeld als je naar Mumbai vliegt, zorgt voor 560 kg CO_2 uitstoot (50x meer). Dit alles op basis van de CO_2 die ontstaat tijdens je reis. Jouw reisgedrag, dus hoe vaak én hoever je reist, is dan ook ontzettend belangrijk voor duurzaamheid.

Hoe zit dat met de emissies voor infrastructuur?

De resultaten van onderzoek variëren nogal. Zo concluderen Chester and Horvath dat de CO_2-emissies voor bouw en onderhoud van infrastructuur en voor productie van brandstof, de gemiddelde emissiefactor van het vliegtuig met 31% verhogen en die van de trein met 155% [2]. Die ophoogfactoren lijken wel erg hoog, zeker voor de trein. In het voorbeeld naar Milaan kom je dan op 29 kg voor je treinreis en 94 kg voor je vliegreis. Dat komt mogelijk omdat deze cijfers uitgaan van nog weinig intensief gebruikte light-rail systemen. Op basis van de cijfers van een hogesnelheidslijn in Zweden blijkt de uitstoot met infrastructuur bij 1 miljoen reizigers per jaar ongeveer 0,07 kg CO_2 per passagierskilometer (kg/pkm) te zijn. Daarmee komt je treinreis naar Milaan ongeveer gelijk uit met je vliegreis (0,07 kg/pkm * 1100 km + 11 kg voor het rijden van de trein = 88 kg CO_2; vergelijk met de 87 kg van hierboven zonder infrastructuur) [1]. Wanneer je één van 10 miljoen reizigers bent, is de emissiefactor voor infrastructuur en onderhoud nog maar 0,009 kg/pkm (je treinreis naar Milaan komt dan op 0,009 kg/pkm * 1100 km + 11 kg = 20,9 kg CO_2); veel minder dan je uitstoot met het vliegtuig zonder infrastructuur, laat staan mét. Gemiddeld voor de Europese hogesnelheidstreinen berekende Tuchschmid dat je uitstoot zelfs maar 0,006 kg/pkm is (6,6 kg CO_2) [5].

Het effect van afstand en niet meereizen

Terug naar het effect van afstand op je directe CO_2-emissies. De twee grafieken hieronder laten je zien dat de emissies per passagierskilometer van het vliegtuig wellswaar lager worden met langere afstanden (linker figuur), maar dat de totale emissies van je reis gewoon toenemen met de afstand (rechter figuur). Ook voor de trein geldt natuurlijk dat je, wanneer je verder reist, meer uitstoot. En dat is het enige dat telt voor het klimaat.

Grafieken op basis van bewerkte data uit Eijgelaar et al. 2021.

Aangezien infrastructuuremissies in het verleden zijn ontstaan is het bij je keuze tussen de trein en het vliegtuig overigens ook belangrijk dat je naar de 'marginale emissies' kijkt. Daarmee wordt bedoeld hoeveel emissies je kan besparen door niet met het vliegtuig of de trein te reizen. Één treinreiziger minder maakt de trein iets lichter en gebruikt misschien minder stroom omdat er geen oplader gebruikt wordt. Bij het vliegtuig zijn de marginale emissies groter, want met 'niet-meegaan' bespaar je juist wél brandstof en dus emissies. Dat komt omdat een vliegtuig veel gevoeliger is voor je extra gewicht, omdat de vleugel dan meer draagkracht moet leveren. Één passagier minder op een vlucht van 10.000 km in een moderne Boeing B787 Dreamliner bespaart 90 kg CO_2 directe uitstoot! Voor je vlucht naar Milaan is dat nog altijd 15 kg CO_2 voor je lege stoel, dertig keer zoveel als de extra emissies door je extra bezette stoel in de trein naar Milaan.

Hoe kwam dit artikel tot stand?

Dit antwoord is geschreven door Paul Peeters

Reviewer: José Potting

Redacteur: Joseline Houwman

Gepubliceerd op: 21-9-2021

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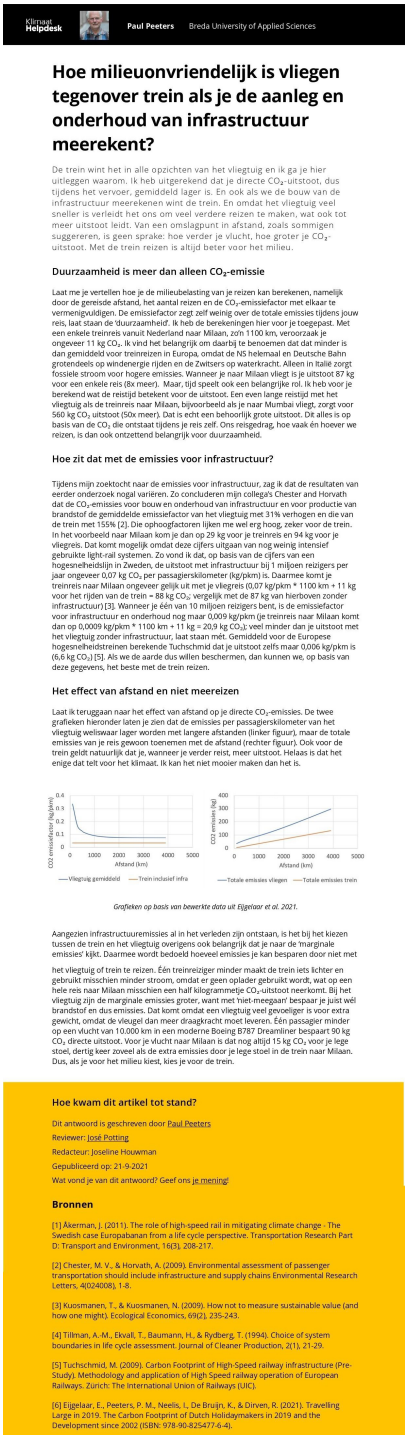
Figure A2. The slightly personalized condition. This image was created by the authors (and adapted with approval) based on the original version at https://www.klimaathelpdesk.org/answers/hoe-milieuonvriendelijk-is-vliegen-tegenover-trein-of-bus-met-aanleg-en-onderhoud-van-infrastructuur-meegerekend/ (last access: 15 July 2024), which was published under a CC BY-NC-SA 4.0 license.



Klimaat Helpdesk

Paul Peeters Breda University of Applied Sciences

Hoe milieuonvriendelijk is vliegen tegenover trein als je de aanleg en onderhoud van infrastructuur meerekent?

De trein wint het in alle opzichten van het vliegtuig en ik ga je hier uitleggen waarom. Ik heb uitgerekend dat je directe CO_2-uitstoot, dus tijdens het vervoer, gemiddeld lager is. En ook als we de bouw van de infrastructuur meerekenen wint de trein. En omdat het vliegtuig veel sneller is verleidt het ons om veel verdere reizen te maken, wat ook tot meer uitstoot leidt. Van een omslagpunt in afstand, zoals sommigen suggereren, is geen sprake: hoe verder je vliucht, hoe groter je CO_2-uitstoot. Met de trein reizen is altijd beter voor het milieu.

Duurzaamheid is meer dan alleen CO_2-emissie

Laat me je vertellen hoe je de milieubelasting van je reizen kan berekenen, namelijk door de gereiste afstand, het aantal reizen en de CO_2-emissiefactor met elkaar te vermenigvuldigen. De emissiefactor zegt zelf weinig over de totale emissies tijdens jouw reis, laat staan de 'duurzaamheid'. Ik heb de berekeningen hier voor je toegepast. Met een enkele treinreis vanuit Nederland naar Milaan, zo'n 1100 km, veroorzaak je ongeveer 11 kg CO_2. Ik vind het belangrijk om daarbij te benoemen dat dat minder is dan gemiddeld voor treinreizen in Europa, omdat de NS helemaal en Deutsche Bahn grotendeels op windenergie rijden en de Zwitsers op waterkracht. Alleen in Italië zorgt fossiele stroom voor hogere emissies. Wanneer je naar Milaan vliegt is je uitstoot 87 kg voor een enkele reis (8x meer). Maar, tijd speelt ook een belangrijke rol. Ik heb voor je berekend wat de reistijd betekent voor de uitstoot. Een even lange reistijd met het vliegtuig als de treinreis naar Milaan, bijvoorbeeld als je naar Mumbai vliegt, zorgt voor 560 kg CO_2 uitstoot (50x meer). Dat is echt een behoorlijk grote uitstoot. Dit alles is op basis van de CO_2 die ontstaat tijdens je reis zelf. Ons reisgedrag, hoe vaak én hoever we reizen, is dan ook ontzettend belangrijk voor duurzaamheid.

Hoe zit dat met de emissies voor infrastructuur?

Tijdens mijn zoektocht naar de emissies voor infrastructuur, zag ik dat de resultaten van eerder onderzoek nogal variëren. Zo concluderen mijn collega's Chester and Horvath dat de CO_2-emissies voor bouw en onderhoud van infrastructuur en voor productie van brandstof de gemiddelde emissiefactor van het vliegtuig met 31% verhogen en die van de trein met 155% [2]. Die ophoogfactoren lijken me wel erg hoog, zeker voor de trein. In het voorbeeld naar Milaan kom je dan op 29 kg voor je treinreis en 94 kg voor je vliegreis. Dat komt mogelijk omdat deze cijfers uitgaan van nog weinig intensief gebruikte light-rail systemen. Zo vond ik dat, op basis van de cijfers van een hogesnelheidslijn in Zweden, de uitstoot met infrastructuur bij 1 miljoen reizigers per jaar ongeveer 0,07 kg CO_2 per passagierskilometer (kg/pkm) is. Daarmee komt je treinreis naar Milaan ongeveer gelijk uit met je vliegreis (0,07 kg/pkm * 1100 km + 11 kg voor het rijden van de trein = 88 kg CO_2; vergelijk met de 87 kg van hierboven zonder infrastructuur) [3]. Wanneer je één van 10 miljoen reizigers bent, is de emissiefactor voor infrastructuur en onderhoud nog maar 0,009 kg/pkm (je treinreis naar Milaan komt dan op 0,0009 kg/pkm * 1100 km + 11 kg = 20,9 kg CO_2); veel minder dan je uitstoot met het vliegtuig zonder infrastructuur, laat staan mét. Gemiddeld voor de Europese hogesnelheidstreinen berekende Tuchschmid dat je uitstoot zelfs maar 0,006 kg/pkm is (6,6 kg CO_2) [5]. Als we de aarde dus willen beschermen, dan kunnen we, op basis van deze gegevens, het beste met de trein reizen.

Het effect van afstand en niet meereizen

Laat ik teruggaan naar het effect van afstand op je directe CO_2-emissies. De twee grafieken hieronder laten je zien dat de emissies per passagierskilometer van het vliegtuig wellswaar lager worden met langere afstanden (linker figuur), maar de totale emissies van je reis gewoon toenemen met de afstand (rechter figuur). Ook voor de trein geldt natuurlijk dat je, wanneer je verder reist, meer uitstoot. Helaas is dat het enige dat telt voor het klimaat. Ik kan het niet mooier maken dan het is.

Grafieken op basis van bewerkte data uit Eijgelaar et al. 2021.

Aangezien infrastructuuremissies al in het verleden zijn ontstaan, is het bij het kiezen tussen de trein en het vliegtuig overigens ook belangrijk dat je naar de 'marginale emissies' kijkt. Daarmee wordt bedoeld hoeveel emissies je kan besparen door niet met het vliegtuig of trein te reizen. Één treinreiziger minder maakt de trein iets lichter en gebruikt misschien minder stroom, omdat er geen oplader gebruikt wordt, wat op een hele reis naar Milaan misschien een half kilogrammetje CO_2-uitstoot neerkomt. Bij het vliegtuig zijn de marginale emissies groter, want met 'niet-meegaan' bespaar je juist wél brandstof en dus emissies. Dat komt omdat een vliegtuig veel gevoeliger is voor extra gewicht, omdat de vleugel dan meer draagkracht moet leveren. Één passagier minder op een vlucht van 10.000 km in een moderne Boeing B787 Dreamliner bespaart 90 kg CO_2 directe uitstoot. Voor je vlucht naar Milaan is dat nog altijd 15 kg CO_2 voor je lege stoel, dertig keer zoveel als de extra emissies door je lege stoel in de trein naar Milaan. Dus, als je voor het milieu kiest, kies je voor de trein.

Hoe kwam dit artikel tot stand?

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Figure A3. The highly personalized condition. This image was created by the authors (and adapted with approval) based on the original version at https://www.klimaathelpdesk.org/answers/hoe-milieuonvriendelijk-is-vliegen-tegenover-trein-of-bus-met-aanleg-en-onderhoud-van-infrastructuur-meegerekend/ (last access: 15 July 2024), which was published under a CC BY-NC-SA 4.0 license.

Code and data availability. The stacked bar graph plots were made using the plot-likert library, distributed under a BSD-3 license at https://github.com/nmalkin/plot-likert/ (nmalkin et al., 2024). In the spirit of open science, all data and scripts used for the paper are available at https://doi.org/10.5281/zenodo.12579018 (van Sebille, 2024).

Author contributions. AL designed the survey and wrote the first draft of the manuscript. EvS analyzed the data from the survey and wrote the second draft of the manuscript. All authors designed the study and edited the manuscript.

Competing interests. Daan Reijnders is an editor at KlimaatHelpdesk and Erik van Sebille is an ambassador for KlimaatHelpdesk.

Ethical statement. As per Utrecht University's Science-Geo Ethics Review Board protocol, an Ethics and Privacy Quick Scan was conducted to verify if ethical considerations had to be taken into account during the study. Based on the study design, this study was classified low risk; therefore, no further ethical review or privacy assessment was required.

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