The (non)effect of personalization in climate texts on credibility of climate scientists

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Abstract. How we communicate about climate change affects how others think, feel and act. Therefore, the way 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 perceived credibility of climate scientists. We

10   exposed hundred participants aged between 18 and 35 to three conditions of a text on the climate impact of train versus plane travel, with varying degree of personalization, and assessed the outcome in their attitude (specifically interest and opinion) towards sustainable travel, as well as the perceived credibility of the climate scientist who wrote the text. Results show that there is a small effect in the degree of happiness after reading the different texts, but little 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

15   readers towards sustainable travel, nor 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 for climate action is the public's attitude: a study suggests 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 information

20   providers when reading climate information [Scott and Willits 1994, Dong *et al* 2018, Bouman *et al* 2021]. In their study, Dong *et al* [2018] found that the positive relationship between climate information and action was 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.

25   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 provides both a theoretical framework and a practical set of tools 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 with the

30   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.

1.2 Personalization

One way of appealing to the emotional involvement and happiness with the text is implementing certain textual elements that have emotional appeal [Glaser *et al* 2009]. Indeed, previous research showed that highlighting sadness or hope, or using gain
35   or loss frames, can affect readers' responses [Lu 2016]. There have been numerous studies on how writing (and specifically manipulating) narrative elements affects people's responses, and how these elements can improve knowledge acquisition [Norris *et al* 2005, Glaser *et al* 2009, Dahlstrom 2014, 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]. An often-used element is personalization, which creates a way of communicating abstract scientific concepts within a
40   frame of reference, focusing on a particular individual or smaller group of people and exploring their actions and the consequences these uphold [Schiffer and Guerra 2015].

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,
45   such elements are likely to make the content emotionally more interesting. 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 showed that personalization enhances learning outcomes and understanding [Ginns and Fraser 2010, Mayer 2014, Sangers *et al* 2020].

50   However, whether personalization also results in an attitude change on climate change is understudied. This is important, since attitudes affect climate action [Cerf *et al* 2023]. Understanding the effect of personalization on the public's attitude can thus inform about the usefulness of personalization in the fight against climate change. Such insights may help climate communicators decide on their mode of communication and formulation of their message. This, for example, can help climate communicators write popular scientific translations of highly scientific – expository – research, including the
55   Intergovernmental Panel on Climate Change (IPCC) reports. Therefore, our first research question is:

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

Scientists' roles in public dialogues have been discussed by the scientific community persistently [Pielke Jr 2007]. Especially in climate communication, knowing what role to take can be hard [Fischhoff 2007]. Considerations for scientists
60   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 one written by scientists considering it is 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 Jr 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*

65   *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 Jr 2007].

By adding direct address to the reader and by 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 portrayed in the text. To find out more about this effect, our second research

70   question is:

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

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

75   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 an existing and published online popular science article. In this original text, the carbon emissions of travelling by train are compared to those of flying, while also taking the building of infrastructure into account.

80   **2. Methods**

2.1 Context

The popular science article was taken from the Klimaathelpdesk.org (KH), a Dutch online platform where society can ask questions about climate change to academic experts. These questions are published along with academic peer-reviewed answers, which include references. Questions that are sent to the KH are taken up by an editor, who then asks an expert to

85   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 a one-pager with guidelines on readability. After this writing procedure, the text is anonymously peer reviewed to increase the reliability of that answer, before being published on KlimaatHelpdesk.org. The main goal of the KH is to explain climate issues to society in a trustworthy and understandable manner, by providing popularized scientific texts. By answering questions, the KH hopes to start a dialogue

90   between citizens and scientists.

The target audience of the KH ranges from young secondary school students to adults with diverse backgrounds. Therefore, the KH aims to make their answers understandable for secondary school students and up.

2.2 Conditions and text conversion

One text from the KH was converted into three conditions. All three texts included the same scientific information but
95 differed in the number of personalization (through direct address) elements in the text. The three texts were checked by the
original author for correctness.

1. In 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 this 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
100   for train journeys in Europe […]"

2. In the second condition, the slightly personalized condition, minor changes were made compared to the first
   condition. Twenty-three 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 were done previously by Dutke *et al* [2016] and Ginns and Fraser [2010]. For example, the sentence above
105   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 […]"

3. 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 also included six additional first person
   (plural) pronouns and thirteen direct addresses from the writer. In these direct addresses, readers were spoken to by
110   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 […]"

The original Dutch versions of the three conditions can be found in appendix 1-3.

115 ## 2.3 Participants and study design

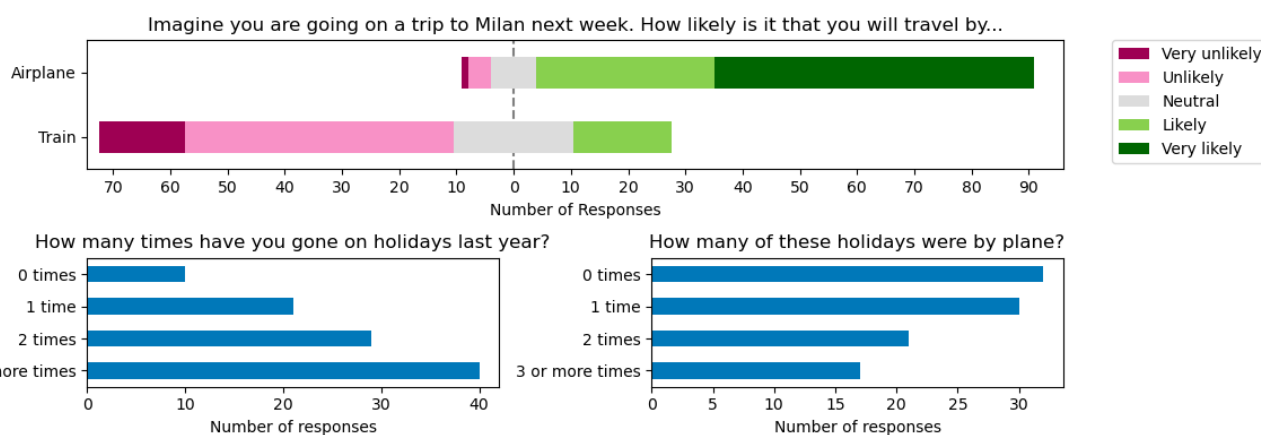
In the period of 20 June 2023 to 4 January 2024, we used *SurveySwap* to recruit participants. A total of 169 people took part
in our research. Participants aged younger than 18 or older than 35 were excluded from this analysis because our focus group
was young adults (within the target audience of the KlimaatHelpdesk). Additionally, participants were excluded when the
total duration time of reading the text and filling in the survey was less than 4 minutes (careless readers) or more than 30
120 minutes (distracted participants). This resulted in a sample size of 100 participants.

Participants filled in a consent form and answered questions about their age (M=24 years; SD=2.8 years), gender (44 men,
55 women, 1 other) and educational level. Participants were randomly assigned to one of the three conditions and asked to
read the text carefully and fill out a questionnaire with 9 prior and 5 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
125 (highly personalized) was read by 30 participants.

2.4 Measures

2.4.1 Prior intention and past behaviour

Prior to exposure, participants answered four questions to determine the intention and past behaviour towards flying and
travelling by train (Fig. 1). These questions included statements to which participants could respond on a 5-point Likert scale
130 indicating how likely it would be that they would take the plane and train on a trip from The Netherlands to Milan. The
likelihood that they would take the plane (median="very likely") was much higher than that they would take the train
(median="unlikely"), with no participant answering it would be "very likely" that they would take the train to Milan.
Additionally, participants answered multiple choice questions (possible answers: 0, 1, 2 and 3 or more) on how often the
participants went on a vacation last year (median=2), and how many of those trips were by flying (median=1). To investigate
135 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, since we did not find any significant effects on opinion or credibility, we do
not explicitly show the results below.

140 **Figure 1: Plots for prior intention and past behaviour towards flying and travelling by train.**

2.4.2 Science capital and trust

The science capital of the participant was measured using four 5-point Likert scale statements (Fig. 2), retrieved from the
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
145 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 5-point Likert scale statements 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

150   scientists communicate about their research".

We combined the six statements into one construct "science capital and trust" (SCT). The Cronbach-Alpha score for internal consistency of these six statements on science capital and trust was acceptable ($\alpha = 0.79$). Most of the participants answered "agree" or "strongly agree" on the six questions, with the largest number of (strongly) disagree answers on the "awareness" and the "talking to others" questions (Fig. 2). To investigate if there was an effect of science capital and trust on the effect

155   and credibility, 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 5 (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').

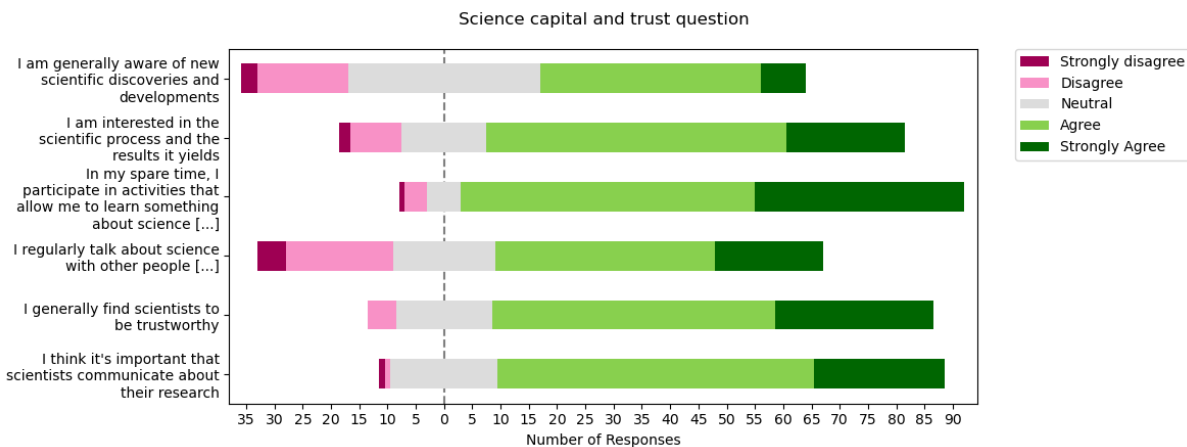



Figure 2: The responses to the 5-point Likert statements on the science capital and trust of the participants.

160   **2.5 Control**

To control whether our three conditions were indeed perceived to be different in personalization, we assessed how participants experienced the text. After reading the text, participants were asked whether they found the text formal or informal and personal or professional by filling in a 10-point semantic differential scale (Fig. 3). We separated the answers by text condition and used an ANOVA test to find that there was a significant difference in the extent to which the

165   participants found the text personal as opposed to professional (p=0.003). Post hoc tests (using the Holm correction to adjust p) indicated that both the slightly personalized and the highly personalized texts were perceived 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 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 also was a significant difference in the extent to which participants found the text 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 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 more informal than the slightly personalized text (one-sided *p*=0.908). Again, there was no significant difference when we separated the responses based on science capital and trust (*p*=0.618).

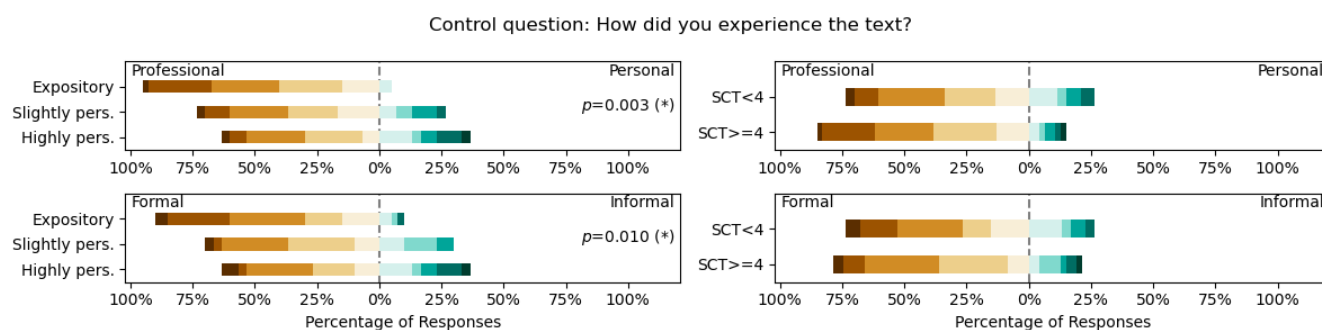



Figure 3: Responses to the two control questions, on a scale from 1 to 10, separated by condition (left column) and score on Science Capital and Trust (right column; higher or lower than 4 out of 5). ANOVA test statistics with p<0.05 are indicated. The color scale is such that 1-5 are brown, and 6-10 are green.

3 Results

3.1 Effect

The effect of the texts on emotions was measured using questions were derived from the *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) There was a significant difference in the happy/unhappy emotion for all three separations. Additionally, there was a significant difference for the separation based on science capital and trust in the unsatisfied/satisfied and not interesting/interesting 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).

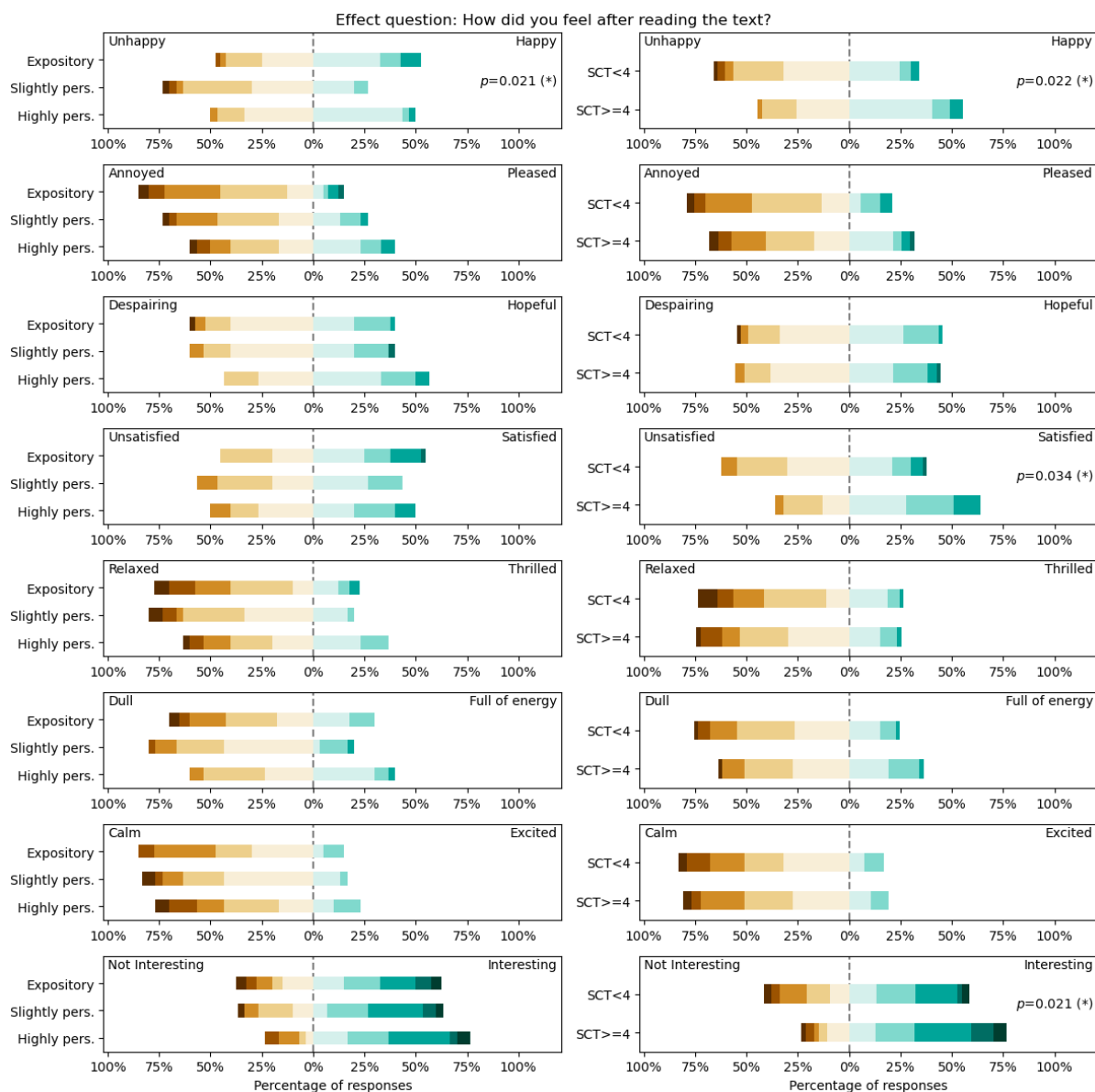



Figure 4: Responses to the eight statements on emotions of the participants after reading the texts, on a scale from 1 to 10, separated by condition (left column), score on Science Capital and Trust (right column; higher or lower than 4 out of 5). ANOVA test statistics with p<0.05 are indicated. The color scale is such that 1-5 are brown, and 6-10 are green.

195 In the second IMPACTLAB question, on the cognitive effect of the text, participants answered four statements in a 5-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 to read more of these texts - also on other scientific topics". None of these statements were answered significantly different between the three text conditions, nor between the two levels of science capital and trust.

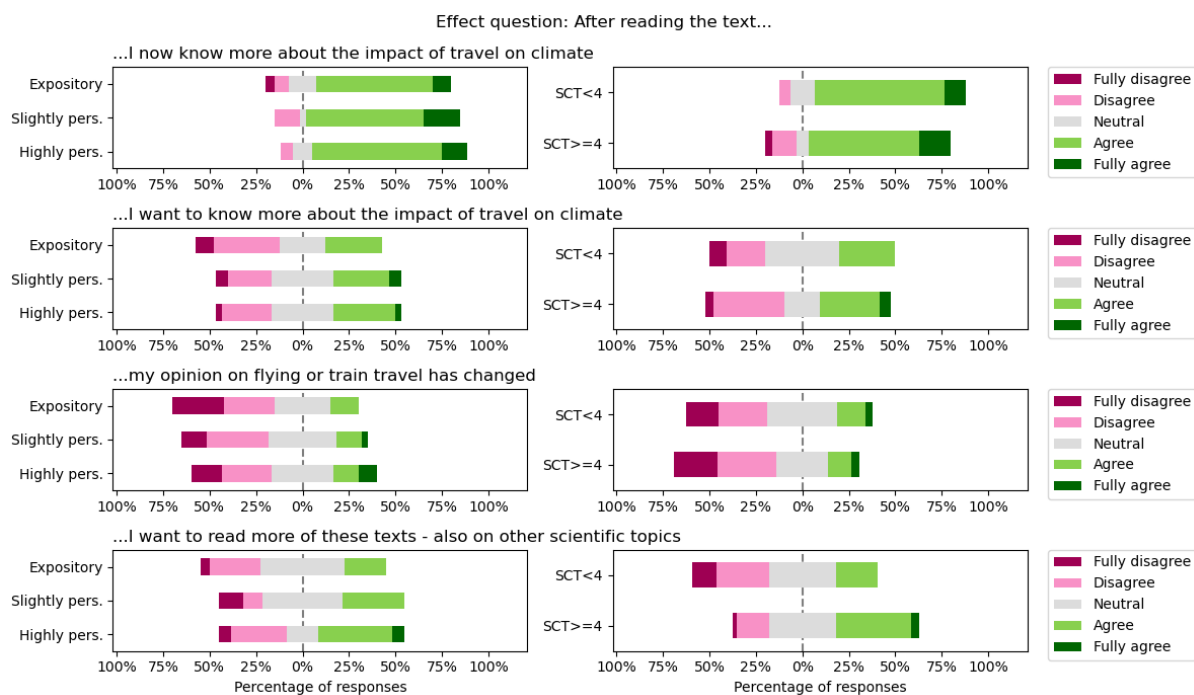



Figure 5: Responses to the four statements on effects on the participants after reading the texts on a five-point Likert scale, separated by condition (left column), score on Science Capital and Trust (right column; higher or lower than 4 out of 5). None of the ANOVA test statistics were lower than p=0.05.

3.2 Perceived credibility of the writer

The perceived credibility of the writer was measured using eight different 7-point semantic differential statements (Fig. 6), as used by Kotcher *et al* [2017]. Randomization in the order of statements was used to prevent the results from possible order effects. Averaging these eight statements in one construct and applying an ANOVA test led to no significant difference between the three text conditions ($p=0.502$), nor a significant difference 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 different: the not at all intelligent/intelligent question when separated by likelihood to take the plane ($p=0.011$) and the not at all trustworthy/trustworthy question when separated by science capital and trust ($p=0.019$).

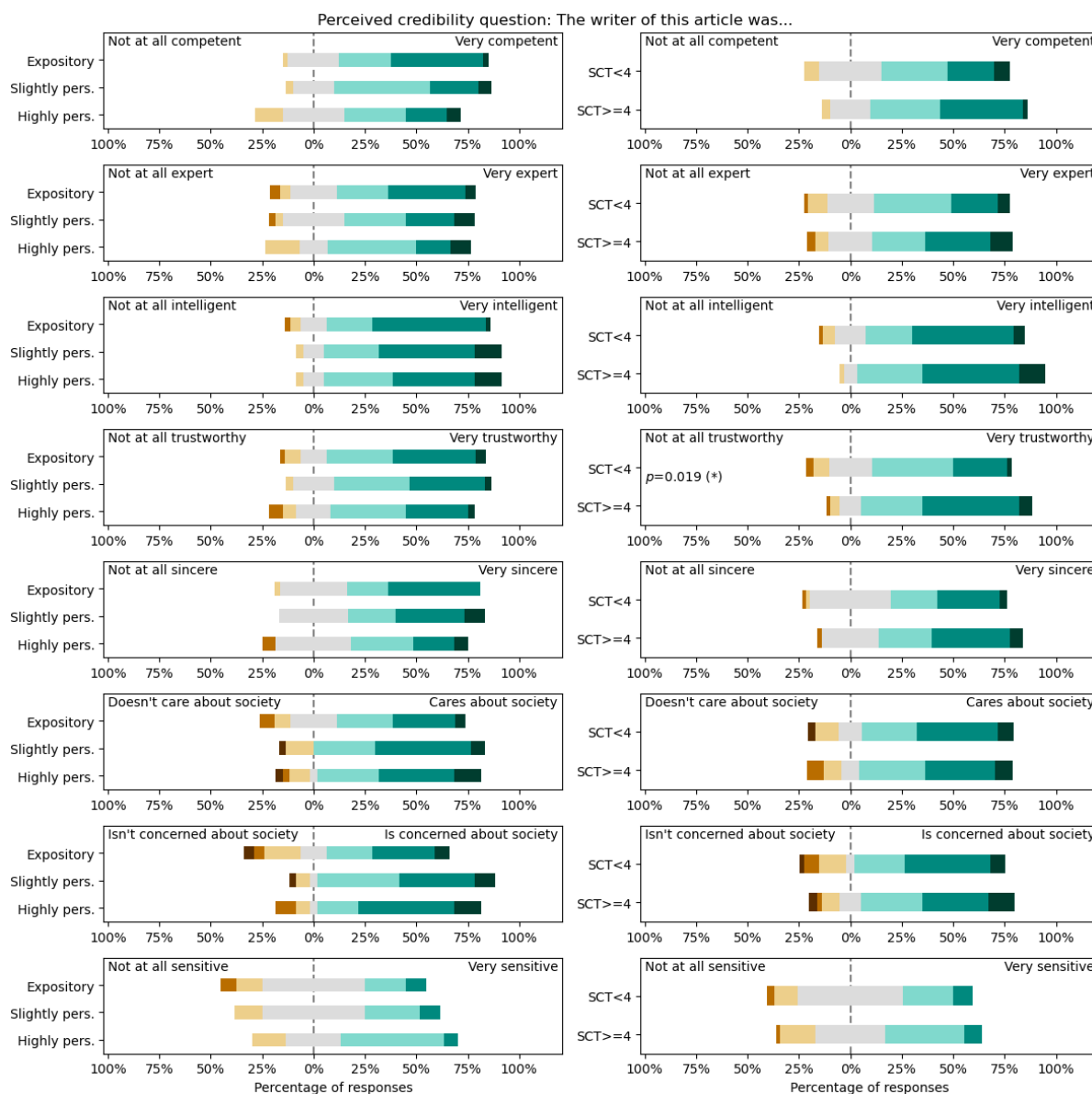



Figure 6: Responses to the eight statements on perceived credibility of the writer, on a scale from 1 to 7, separated by condition (left column), score on Science Capital and Trust (right column; higher or lower than 4 out of 5). ANOVA test statistics with p<0.05 are indicated. The color scale is such that 1-3 are brown, 4 is grey, and 5-7 are green.

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 what extent 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 travelling by airplane or train" (Fig. 7). Both statements were measured on a 7-point Likert scale (1 = Strongly disagree, 7 = Strongly agree), and an ANOVA test revealed that the only

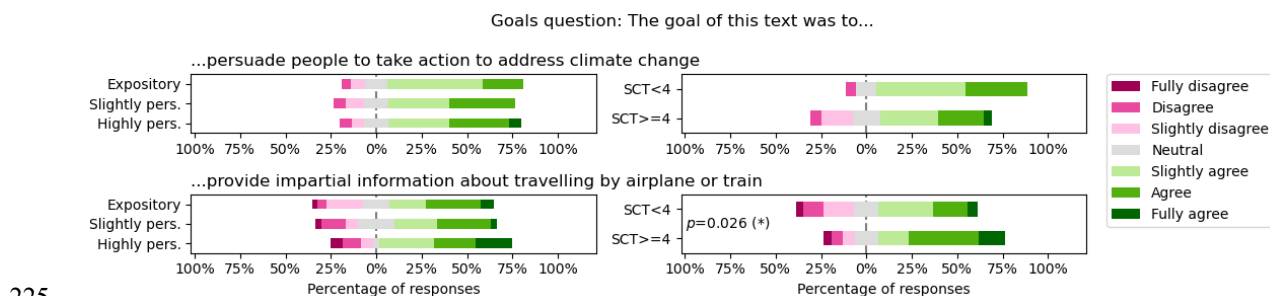
statistically significant result was when we separated the responses to the question on whether the writer provided impartial information by science capital and trust ($p=0.026$).

225

Figure 7: Responses to the two statements on the perceived goals to persuade on a seven-point Likert scale, separated by condition (left column), score on Science Capital and Trust (right column; higher or lower than 4 out of 5). ANOVA test statistics with p<0.05 are indicated.

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

230   Also based on the questions by Kotcher *et al* [2017], participants were finally asked to what extent 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 travelling 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 travelling by airplane or train on the environment" (Fig. 8). Both statements were measured on a 7-point Likert scale (1 = Strongly disagree, 7 = Strongly agree). The first statement about scientific evidence

235   was answered statistically differently between the science capital and trust groups ($p=0.017$) and the second statement about personal views was answered statistically different 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

240   personalized text compared to the highly personalized text ($p=0.071$).

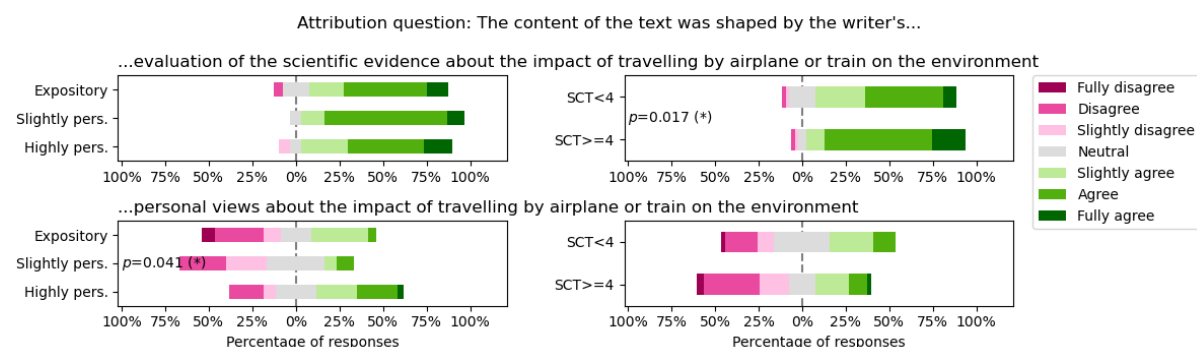



Figure 8: Responses to the two statements on the perceived goals to persuade on a seven-point Likert scale, separated by condition (left column), score on Science Capital and Trust (right column; higher or lower than 4 out of 5). ANOVA test statistics with p<0.05 are indicated.

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 variation in the amount of personalization in the texts was recognized by readers, as was apparent from the result that the highly personalized version of the text was perceived 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%) experienced even the highly personalized text as relatively formal and professional (score <6). We thus did not manage to rewrite the expository text to such an extent to move it from majority-formal to majority-informal while keeping the content the same. It may be that our manipulation, in our attempt to keep the text as similar as possible, has been too subtle and that, in real life, when scientists write more personalized texts, changes in the tone and content affects the text more than we have operationalized in this study. Alternatively, readers may generally be likely to perceive a text as formal if it contains scientific information.

The answer to our first Research Question, on how personalization of the base text affects the participants' interest and opinion of climate change, is that we see a limited effect (Fig. 5). Most participants indicated they know more about the impact of travel on climate after reading the text, independent of the text version they read, and independent of their science capital. On the other hand, reading the texts did not change their opinion on flying or train travel, again with no difference between texts nor science capital. It could be that some of the participant's attitudes to e.g. the need for a better rail infrastructure has changed; but since we only asked about their opinion on flying or train travel, we can't 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 especially peer pressure can be effective in changing behaviors. Since 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 been shown in various contexts already, among which 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 by text condition, nor by science capital and trust, except for the emotion of happiness which was significant for both types of separation. This confirms the findings by Peeters *et al* [2022] that happiness is one of the strongest predicting emotions for effect. Participants in general found the text interesting (>60% for all three conditions), but 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: the writer of the article was perceived very positively (Fig. 6) as competent, expert, intelligent, trustworthy etc. The only statement where the writer did not score more than 60% positive was on the element sensitivity, although most responses there were close to neutral. This seems to indicate that participants'

attitude toward the writer was generally 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 might be reflection of the general trust in scientists as a source of information [Edelman Trust Institute 2024]. 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 more personal (Fig. 3). This may indicate a weak manipulation, although we would argue that instead, this might suggest that a more personal text does not influence the credibility of the writer. This is also in line with past research that shows that this mode of communication, in a more activistic tone, does not necessarily hamper public perceptions of scientific integrity and scientists' credibility [Kotcher *et al* 2017, Cologna *et al* 2021].

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 [Seethaler *et al* 2019, Clarke *et al* 2020, Fage-Butler *et al* 2022]. 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 bigger effect on the readers.

Of course, this study has limitations. First, the sample size and characteristics of the used conditions 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. The benefit is that the differences reported are robust, the downside is that there may be hidden effects. Also, most participants were relatively highly educated, which may also have influenced a greater acceptance of the expository condition as when the science capital of the participants would have been more diversified. Furthermore, the required time to finish the survey was quite long (8 minutes on average). This may have caused participants to be less attentive and engaged, especially toward the end of the questionnaire; and could thus explain that the last few questions showed fewer significant difference 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 can 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 (visuals) by 3 (text) design would necessitate even more respondents.

5 Conclusion

In this study, we analyzed how variation in personalization through direct address in an article about the effect of travelling by train or plane on carbon dioxide emissions affected opinion and interest toward sustainable travel and the perceived credibility of the climate scientist who wrote it specifically. We used an article that was previously published on the KlimaatHelpdesk.org platform and adapted that to increase the personalization. To measure the effect, we used a questionnaire with questions that were previously validated by Kotcher *et al* [2017] and Peeters *et al* [2022]. Our findings show that in general one text exposure cannot be expected to result in any major shifts in opinion on travel either by plane or

310 train. On the other hand, 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.

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Code/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/. In the spirit of Open Science, all data and scripts used for the manuscript are available at https://github.com/erikvansebille/KH_personalization_effect.

320 ### 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

DR is an editor at the KlimaatHelpdesk and EvS is an ambassador for the KlimaatHelpdesk.

325 ### Ethical statement

Conform Utrecht Univertity's Science-Geo Ethics Review Board protocol, an ethics and privacy QuickScan was conducted to verify if ethical considerations had to be taken during the study. Based on the study design, this study was classified low-risk and therefore no further ethical review or privacy assessment was required.

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