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# Scientific truth or debate: On the link between perceived scientific consensus and belief in anthropogenic climate change [1]

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Scientists overwhelmingly agree that climate change (CC) exists and is caused by human activity. It has been argued that communicating the consensus can counter climate scepticism, given that perceived scientific consensus (PSC) is a major factor predicting public belief that climate change is anthropogenic. However, individuals may hold different models of science, potentially affecting their interpretation of scientific consensus. Using representative surveys in the UK, France, Germany, and Norway, we assessed whether the relationship between PSC and belief in anthropogenic CC is conditioned by a person's viewing science as 'the search for truth' or as 'debate'. Results show that PSC is higher among CC believers and moreover, significantly predicts belief in anthropogenic CC. This relationship is stronger among people holding a model of science as the 'search for truth'. These results help to disentangle the effect of implicit epistemological assumptions underlying the public understanding of the CC debate.

*Keywords*: environmental communications, public understanding of science, social representations, representations of science.

The need for deep changes in our lifestyles due to climate change has highlighted the necessity to understand how science communication might affect people's belief that climate change is caused by human activity, and their subsequent behavioural choices (e.g. Pidgeon, 2012). Research has robustly shown that 97% of peer-reviewed published scientific papers on the topic agree that recent global warming is anthropogenic (cf. Cook *et al*., 2016). However, around the year 2009 opinion polls in Europe and United States started showing a substantial increase in the number of persons who appeared to question the link between climate change and human activity (Poortinga *et al.*, 2011; Smith and Leiserowitz, 2012).

The *perceived* level of scientific consensus has been found to be one of the main factors influencing public beliefs as to whether climate change is anthropogenic (Lewandowsky *et al.*, 2012; McCright *et al.*, 2013). In response to a public increasingly doubtful of about the anthropogenic origins of climate change it has been argued that communicating the scientific consensus can be used to counter climate sceptical beliefs (van der Linden et al. 2015; van der Linden et al, 2017).

These studies and suggested strategies for communication however do not consider the assumptions that underlie people's perception of scientific consensus. Indeed, individuals may hold different *models of science* (or of scientific activity), which might affect their interpretation of news about scientific consensus. These underlying models or views of science involve qualitatively different interpretations of uncertainty, data, and news.

We propose in this article that information about scientific consensus concerning anthropogenic climate change might *mean* different things when interpreted under alternative subjective epistemic models; we distinguish a model of science as a 'search for truth', or as a 'debate'. A model assuming the existence of a single universal truth, one that can be unveiled by the rigorous application of scientific methods (e.g. Bacon, 1620/1981), was defended and became widely accepted as one outcome of the Scientific Revolution. This model views science as capable of differentiating between what is true and what is not true by using codified methods (Newton, 1704/1981, p. 64). This vision of science as the 'search for truth' was challenged by the seminal work of Thomas Kuhn (1962), who showed the activity of science to embrace the co-existence, debate and possibly the substitution of conceptions of reality, or paradigms. Here research paradigms "are part of normal science, an enterprise that aims to refine, extend, and articulate a paradigm that is already in existence" (Kuhn, 1995, p. 198). This model of science acknowledges diversity in paradigms as part of the "interpretative enterprise [which] can only articulate a paradigm, not correct it" (Kuhn, 1995, p.198). In this latter approach to science as 'debate', the validity of a claim is acknowledged *within* a given paradigm, opening the possibility that differing judgments on the validity of facts or their interpretation may exist simultaneously under differing paradigms.

The fact that models of science shared among scientists appear historically to have become progressively more complex – including a diversity of proposals for the relationship between science and reality (Sorell, 2013) – does not necessarily mean that a similar transition

of models has taken place in other societal groups (Moscovici, 1988). Jaspal *et al*. (2012) suggest that it is more likely that a variety of models for interpreting scientific results coexist among the public.

Assuming the two models of science – a 'search for truth' versus 'debate' – coexist as parallel belief systems opens the possibility that members of the public differ in how they interpret information about scientific consensus on climate change depending on the epistemic model they hold. Examining the interpretation of ambiguous information regarding climate change, Rabinovich and Morton (2012) presented messages containing different degrees of uncertainty to participants adopting respectively a model of science as a 'search for truth' or 'debate'. Their results suggest that participants sharing a model of science as 'debate' (a so-called Kuhnian model) were *more* convinced by high uncertainty messages than were participants sharing a model of science as a 'search for truth'.

Our research focuses on the question of how *models of science* interact with the *interpretation of perceived scientific consensus* in shaping individuals' belief in *anthropogenic climate change*. We take these models of science as shared belief systems encompassing assumptions about the character of science, which may lead to individuals giving distinct weight to the level of scientific consensus as they perceive it. We hypothesize that under a model of science as a 'search for truth', perceived scientific consensus is central to the individual's establishing a judgment of facts as 'truth', while under a model of science as 'debate' the degree of scientific consensus perceived by the individual plays a less determinant role in assessing validity of claims – here, claims about the anthropogenic nature of climate change. In short, we will assess how *convincing* the information about scientific consensus on anthropogenic climate change is for people adopting a model of science as a 'search for truth' compared to a model of science as 'debate'.

The influence of adhering to a model of science as a 'search for truth' versus as 'debate' has been demonstrated in controlled experimental settings (Rabinovich and Morton, 2012). We propose to analyse this relationship across four representative samples (France, Germany, Norway and the UK; Steentjes *et al*., 2017). This would help demonstrate whether and how this process takes place in a wide variety of socioeconomic contexts within and across countries, through directly comparable samples.

Below we first review recent studies analysing public perceptions of climate change, in particular regarding beliefs (including scepticism) as to its existence, causes and impacts. Then we explore the literature on how perceived scientific consensus is associated with climate change beliefs. Then, based on our survey data, we explore simultaneously in the four national contexts: (1) how perceived scientific consensus predicts individuals' beliefs in anthropogenic climate change; and (2) whether this relation is stronger (or weaker) when the adopted model is that of science as a 'search for truth' (as opposed to science as 'debate').

## 1. Public scepticism or recognition of anthropogenic climate change

Independently of the actual existence or progression of climate change, studies reviewing public opinion on the issue found that it emerged as a public concern around the 1980s (Capstick, Whitmarsh and Poortinga, 2015). In the late 1980s and early 1990s it was common for people to associate climate change with other types of locally observed pollution, CFC and ozone depletion (Brechin, 2003). The percentage of people concerned about climate change then grew sharply in the 1990s, both in the US and Europe (Capstick *et al.*, 2015).

This trend of increasing concern was observed until around the mid-2000s. Then the public started to more clearly differentiate climate change from other environmental issues. Shared representations identified through open survey responses included for example melting ice, weather and heat (Leiserowitz, 2005; Lorenzoni *et al.*, 2006).

As of the mid-2010s the public in the US, UK, Australia and Europe also started to grow increasingly sceptical of climate change (Capstick *et al.*, 2015). In the US, Smith and Leiserowitz (2012) demonstrated this growing scepticism in four waves of representative public opinion surveys (between 2002 and 2010). Yet, not all publics evolved in the same way: starting from the late 1990s US respondents identifying as Democrats became increasingly concerned about climate change, while Republicans became more sceptical about it (Dunlap and McCright, 2008). A 2018 survey in the US shows a regain of concern over the topic independently of political affiliation (Leiserowitz *et al.*, 2018). People believing climate change exists climbed from 63% in 2015 to 73% in 2018. Similarly, belief in anthropogenic climate change reached an all-time high in 2018: 62%.

In the UK, Whitmarsh (2011) analysed the evolution of climate change public opinion between 2003 and 2008. While the percentage of people expressing scepticism about the existence of climate change (trend sceptics) remained constant over this five-year period, the percentage of participants agreeing that 'claims that human activities are changing the climate are exaggerated' (attribution scepticism) practically doubled.

A cross-national study by Tranter and Booth (2015) found that English-speaking countries in general (USA, England, Australia and New Zealand) are among the most sceptical in regard to climate change, with Northern European countries (e.g. Sweden, Finland and Norway) also displaying high climate scepticism. Lower scepticism levels, in contrast, are found among another group of western European countries – for example, Spain, France, Austria and Germany (Tranter and Booth, 2015). In a survey conducted in Germany, Engels and colleagues (2013) found climate scepticism to be overall very low (about 7%) in the country, with Germans being significantly less sceptical of anthropogenic climate change than people in the English-speaking world or people in Nordic countries such as Norway (Tranter and Booth, 2015). This result was not entirely borne out by Steentjes *et al.* (2017), who found

German respondents at 16% to be significantly more sceptical of anthropogenic climate change than were Norwegian (4%), French (6%) and UK (12%) respondents.

Studies conducted in the English-speaking world provide further information on individual contextual factors that influence climate change perceptions. Older people (Poortinga *et al.*, 2011), persons positioning themselves on the political right (Dunlap and McCright, 2008; Poortinga *et al.*, 2011; Whitmarsh, 2011), and those adopting more individualistic worldviews (Kahan *et al*., 2011) are more likely to be sceptical about the existence, causes and/or impacts of climate change. In a study of different profiles of climate scepticism in the UK, Poortinga and colleagues (2011) found a small minority of 'trend sceptics' – those who deny that the climate is undergoing change (4% in 2005 and 15% in 2010). Poortinga *et al*. (2011) showed, however, that other types of scepticism were more frequent in the 2010 sample. For example, 'impact sceptics' – identified as those who do not think climate change will lead to substantial impacts – made up 69% of respondents who agreed climate change is happening. 'Attribution sceptics' – those who question that climate change is caused by human activity – comprised 18% of the total sample.Whitmarsh (2011) found that trend scepticism was higher among older, rural respondents who were also non-adopters of pro-environmental behaviours. Moreover, political affiliation ('vote conservative') was seen to be the strongest predictor of trend scepticism in 2008. This and other studies demonstrate a strong association between climate scepticism and political orientation, especially among Anglophone societies (Engels *et al.*, 2013; Hornsey *et al.*, 2016). The same association has moreover been found worldwide by two analyses of the International Social Survey Programme data on climate change covering respectively 2005-2009 (Kvaløy, Finseraas and Listhaug, 2012) and 2010 (Tranter and Booth, 2015). However, the overall picture is far from being established and further contextual variables would appear to be relevant. Despite the lower levels of climate scepticism in most European countries, the phenomenon of scepticism across Europe seems to

be at least partially explained by the same political affiliation variables as in the English-speaking world. Both McCright *et al*. (2016)'s analysis of the May 2008 Eurobarometer data (Eurobarometer, 2017) and Hornsey *et al.* (2016)'s meta-analysis of the determinants of climate change beliefs showed that climate sceptic views are more common among right- than left-wing respondents. The same result is found by Steentjes *et al.* (2017).

## 2. Perceived scientific consensus on anthropogenic climate change

The influence of perceived scientific consensus regarding anthropogenic climate change on the public's climate beliefs has been studied under two main perspectives: either as a precursor to other climate attitudes, or as a consequence of motivated reasoning. Under the first perspective, perceived scientific consensus is seen as a 'gateway' belief. It is understood as an indicator of a group norm: The degree of consensus perceived by a given individual is aligned with a 'socially valid version' of climate change facts as defined by the individual's reference group (Lewandowsky *et al*., 2012; van der Linden *et al*., 2017). Van der Linden *et al.* (2015) affirm that perceived scientific consensus – taken as a socially valid version of reality – is central to public climate change beliefs. The predictive power of perceived scientific consensus in relation to climate change beliefs has been demonstrated both experimentally (Lewandowsky *et al*., 2012; van der Linden *et al.*, 2015) and through survey studies. For example, McCright *et al*. (2013) showed how perceived scientific consensus predicts climate change beliefs and support for public policies in the US. That said, perceived scientific consensus was seen in the same study to be itself influenced by other value-based beliefs such as respondents' political orientation and environmental identity.

In the same vein, perceived scientific consensus has been analysed in explicit juxtaposition with value-based beliefs including worldviews and political orientations. Lewandowsky *et al*. (2012) found that information about perceived scientific consensus is capable of 'neutralizing' the expected influence of hierarchical-individualistic worldviews on

individuals' climate change beliefs. More recently, van der Linden *et al*. (2017) claimed that "correcting people's perception of the scientific norm can help depolarize ideological worldviews and neutralize motivated cognition" (p. 2) and bridge the conservative-liberal divide[2].

From another research perspective, perceived scientific consensus as a belief is considered to *follow* - not shape - pre-existing climate change beliefs and worldviews. Kahan *et al*. (2011) take this perspective and claim that the perception of scientific consensus (or of issues such as how credible, trustworthy and/or competent scientists are) is itself determined by pre-existing individual beliefs shaped by culture. The theory of the cultural cognition of risk proposes that scientific information and claims of consensus are overall more readily recalled when they fit the individuals' own beliefs on the matter, and "[help] to explain public disagreement about the significance of empirical evidence generally" (Kahan *et al*., 2011, p. 148). Kahan and colleagues have demonstrated that respondents holding hierarchical-individualistic worldviews perceive significantly lower scientific consensus on anthropogenic climate change than those holding egalitarian-communitarian worldviews (Kahan *et al*., 2011, Study 1). Moreover, higher levels of trust and competence are attributed to experts whose positions are aligned (versus non-aligned) with those of the participants (Study 2). The same dynamic was described by Kahan *et al*. (2012) in a study questioning the association commonly found between climate change beliefs and scientific literacy. That study shows that education, which can be assumed to be related to scientific literacy, is positively rather than negatively related to the degree of polarization concerning climate change beliefs between people holding different worldviews, which Kahan *et al*. (2012) interpreted to be a result of identity concerns. In this regard, Kahan *et al*. (2012) propose that "what guides individual risk perception is not

[2] Conceptual and methodological critiques of this study were voiced by Kahan (2017).

the truth of those beliefs [perceptions] but rather their congruence with individuals' cultural commitments" (p. 734).

## 3. Models of science

Few studies have sought to analyse explicitly how scientific consensus may be interpreted by differing populations, and the consequences their interpretation may have for beliefs about anthropogenic climate change. In an attempt to fill this gap, Rabinovich and Morton (2012) propose that an individual's interpretation of scientific debate may influence, or be influenced by, the model of science – as a 'search for truth' or 'debate' – held by that individual. Their study compared interpretations of messages communicating a high versus a low degree of consensus. Subjects were presented with messages indicating varying degrees of consensus, such as: "six out of ten experts agree that…" (low consensus[3]) or "nine out of ten experts agree that global warming may make more than a quarter of all species extinct" (high consensus) (p. 996). Then they asked participants to report "how likely they were to perform a number of environmental behaviours during the following month" and "how willing they were to support the introduction of household carbon budgets". The latter variables were intended to assess whether, and to what degree, participants had been convinced by the consensus-related information that they had received. The authors found that messages indicating lower consensus led to messages being seen as less convincing to those holding a model of science as 'truth', compared to people holding a model of science as 'debate' (Rabinovich and Morton, 2012).

This finding – that signs of low consensus produced less loss of persuasive power among individuals holding what the authors call a Kuhnian model of science as 'debate' – may be discussed or interpreted as follows. Within a model of science as 'debate', dissensus and diversity of scientific opinion would be accepted as part and parcel of scientific activity. In

[3] Note that, as presented later in this paper, our own survey identified such a condition (60% agreement) as indicating that "*most scientists agree*".

contrast, under a classical model of science as 'the search for truth', the presence of debate and diversity of positions would be taken as showing that scientists have not been able to reveal the truth. Thus, low scientific consensus would give respondents holding the classical model a justification to reject the scientific result under discussion.

The assumptions implicit in each of these models of science thus provide frames for the interpretation of discourse indicating degrees of scientific consensus. Depending on the model of science solicited, perceived scientific consensus can be adapted to contribute to either a climate sceptical position or to one endorsing conventional climate science.

**This Study**

Our study aims to disentangle the influence of models of science as an interpretative frame for perceived scientific consensus using a survey conducted simultaneously in four European countries (France, Germany, Norway and UK). We examine the role of perceived scientific consensus in anthropogenic climate change beliefs (cf. van der Linden *et al.*, 2015). We furthermore test whether the subjective interpretation of science as a 'search for truth' versus a 'debate' moderates this role. To our knowledge, this is the first time that such an effect of model of science is analysed in a large, comparative international survey with nationally representative and simultaneously drawn samples across countries.

Based on the experimental results of Rabinovich and Morton (2012), we expect that among individuals for whom science is a 'search for truth,' the relationship between perceived scientific consensus and belief in anthropogenic climate change would be *stronger*. Conversely, we expect that among individuals for whom science is a 'debate,' the relationship between perceived scientific consensus and belief in anthropogenic climate change would be *weaker*.

The model of science variable is here assessed through a single, bi-polar item. This measure was shown to significantly discriminate how participants described science after being exposed to definitions of science as 'search for truth' or science as 'debate' (Rabinovich and

Morton, 2012, Study 2). The scale used by Rabinovich and Morton (2012) was however composed by four items presenting a good internal consistency (α = .72). Considering that major international surveys often involve limitations of space, the assessment of the model of science variable was done through a single, bi-polar item. To our knowledge this scale has been used up to now only in an experimental context. Our survey study investigates how and the degree to which different models of science, as measured by this specific item, might affect the way climate scientific consensus information is interpreted. Science beliefs however involve wider and more complex logics that are beyond the scope of this article.

Moreover, in line with cultural cognition theory (Kahan *et al*., 2011) we aim to explore whether the perceived scientific consensus is independent of climate change belief or, as predicted by Kahan et al. (2011), climate change believers perceive *more* scientific consensus than do sceptics. This hypothesis is based on Kahan's suggestion that the individual is motivated to confirm pre-existing climate change beliefs (e.g. Kahan *et al.*, 2009, 2012).

Our four nationally representative surveys, conducted concurrently (Steentjes *et al.*, 2017), provide an opportunity to explore the stated hypotheses within the national-level climate context (*cf.* Tranter and Booth, 2015) and within a common European frame (*cf.* Baker, 2007). Our study also controls for other individual-level variables that have in the past been associated with higher degrees of climate scepticism, such as gender, education and political orientation (Poortinga *et al.*, 2011; Hornsey *et al.*, 2016).

## Method

### *3.1. Project*

European Perceptions of Climate Change (EPCC; Steentjes *et al*., 2017) was a collaborative research project (2014-2017) collecting comparative data from 4,048 individuals on attitudes towards climate change, climate policy, energy, and related issues. The EPCC survey was carried out in June 2016 in France, Germany, Norway and the UK. EPCC was funded by the

Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate), a pan-European intergovernmental initiative.

### *3.2. Procedure and sample*

The EPCC collaboration involved the development of an harmonised survey in four different languages with reference to a structured socio-political analysis of the four countries[4] (Arnold *et al*., 2016). Translation, quality assurance and piloting procedures adopted by the team ensured that questions were interpreted in the same way across the different countries, allowing comparative analyses.

A first English version of the questionnaire was translated into the other three languages (French, German and Norwegian) by two independent native translators per language. These translations were then each checked by competent members of the research team and inconsistencies were discussed with the native speakers before a final translation was agreed in each country. To control and correct eventual issues in how items were understood in the different countries, the final four versions of the questionnaire were then pilot tested in May 2016 (pilot samples used by provider Ipsos MORI per country: $N_{UK}$ = 76; $N_{Fr}$ = 52; $N_{Ger}$ = 49; $N_{Nor}$ = 53).

The survey questionnaire was then administered by provider Ipsos MORI to a representative panel sample in each country between 1 and 20 June 2016 ($N_{UK}$ = 1,033; $N_{Fr}$ = 1,010; $N_{Ger}$ = 1,001; $N_{Nor}$ = 1,004). Demographic details of the samples are presented in Table 1. In France, Germany and the UK, the survey was administered face-to-face. In Norway interviews were conducted by telephone because of the high population dispersion. The total length of the interview ranged from 22 to 28 minutes (France: 28 min.; Germany: 23 min.;

[4] EPCC integrated an international stakeholder advisory panel which helped to construct socio-political country reports and the survey instrument by pointing to areas of climate change perceptions they felt merited attention. The panel furthermore provided guidance on some key dimensions of analysis.

Norway: 24 min.; UK: 22 min.). Steentjes *et al*., 2017 provide a complete report of the survey with descriptive data of other questions that are not analysed in our paper.

*****Table 1 about here*****

### *3.3. Survey context*

The survey was administered in June 2016 during a period of public debate on issues not directly associated with but having potential consequences around Europe for the political framing of climate change. The data collection for the survey had been fully completed by the time of the Brexit vote in the UK (23 June 2016). The refugee crisis in Europe had started to create national concerns such as the Calais 'jungle' in France or the German open policy for asylum-seekers. In Germany, chancellor Merkel's statement "we can do this" regarding the capacity of Germany to absorb a large number of immigrants in the summer of 2015 gained a lot of media coverage. The German government asylum policies were the dominant topic in German media outlets in 2015 and 2016. Highly politicised in 2016, these two issues deserve to be mentioned as forming part of the context of the overall survey results (see Steentjes *et al*., 2017).

### *3.4. Variables*

*Model of science*. Beliefs about science were measured by an item used by Rabinovich and Morton (2012): "There may be more than one correct answer to most scientific questions" (from 1 = *Strongly agree* to 5 = *Strongly disagree*). We inverted the variable for the analysis, resulting in a scale in which *low* values reflect endorsement of a model of science as the search for 'truth' and *high* values reflect endorsement of a model of science as 'debate'.

*Belief in the reality of climate change*. Belief in the reality of climate change was assessed through the item "As far as you know, do you think the world's climate is changing

or not?" (1 = *Yes – I think that the world's climate is changing*; 2 = *No – I do not think that the world's climate is changing;* 3 = *Don't know*). Only the two first response options were analysed in this study while '*don't know'* was treated as a missing value.

*Belief in anthropogenic climate change*. Beliefs about the causes of climate change were assessed through the item "Thinking about the causes of climate change, which, if any, of the following best describes your opinion?" (1 = *climate change is entirely caused by natural processes*; 2 = *climate change is mainly caused by natural processes*; 3 = *climate change is partly caused by natural processes and partly caused by human activity*; 4 = *climate change is mainly caused by human activity*; 5 = *climate change is completely caused by human activity*; 6 = *There is no such thing as climate change*). The last option "*There is no such thing as climate change*" was treated as a missing value in our analyses.

*Perceived scientific consensus*. Perceived scientific consensus on anthropogenic climate change was measured by the item "To the best of your knowledge, what proportion of scientists agree that climate change is happening and that humans are largely causing it?" (1 = *The vast majority of scientists agree (80% or more);* 2 = *Most scientists agree (more than 50% but fewer than 80%);* 3 = *As many scientists agree as disagree (50%);* 4 = *Some scientists agree (more than 20% but fewer than 50%);* 5 = *A small minority of scientists agree (20% or less).* We inverted the variable for the analysis, assigning *low* values to less perceived scientific consensus and *high* values to more perceived scientific consensus.

*Demographic variables*. Other variables whose impact on perceptions has been highlighted in the literature were entered in a first block in the regression analyses in order to control for their influence on the data: gender (male / female), age (15-24 / 25-34 / 35-44 / 45-54 / 55-64 / 65 or more), education (with / without university degree), and self-reported political ideology placement (0=left to 10=right).

### *3.5. Data analysis*

Regression and analyses of variance were performed. The 'model of science' variable, which we hypothesise to moderate the relation between perceived scientific consensus and anthropogenic climate change beliefs, was treated as a continuous moderating variable.

The regression and moderation analyses were run using the PROCESS macro for SPSS (Hayes, 2013; Hayes and Matthes, 2009). The advantage of this method for testing a moderation is that it produces, in the same output model, different regression coefficients for the predictor at different levels of the moderator variable (model of science) (Hayes, 2013).

## 4. Results

### *4.1. Descriptive results*

In this section we present the descriptive results of the variables that will later be used in the regression models.

'Belief in climate change' corresponds to the belief that climate change is happening, and 'belief in anthropogenic climate change', to the belief that it is caused by human activity rather than by a natural process. Across countries, the percentages of people who believe the climate is changing (versus not changing) are: France 92.3% (versus 6.1%), Germany 83.6% (versus 15.2%), Norway 92.7% (versus 4.4%) and the UK 86.4% (versus 11.7%) [$\chi^2(3) = 86.8$, $p < .001$, Cramer's $V = .15$, $p < .001$]. These results indicate a higher percentage of trend sceptics in UK and Germany in relation to France and Norway (all *p*s < .001). Similar results were found for belief in anthropogenic climate change, also higher in UK and Germany in relation to France and Norway, as displayed in Table 2 (Steentjes *et al*., 2017). In summary, respondents from Germany and the UK believe less strongly that climate change is *real* and *anthropogenic* than their French and Norwegian counterparts.

As for perceived scientific consensus, people in the UK and Germany perceive less consensus among the scientific community than do people in France and Norway (see Table 2).

The expressed preference for a given model of science also differs across countries although the pattern is different. Means of all countries are above the midpoint of the scale. Thus, participants in all countries lean towards a model of science as 'debate'. This is most prominently the case Norway. Relatively speaking, participants from Germany are the ones who most strongly endorse a model of science as 'the search for truth'. Participants in UK and France are in an intermediary position between these two countries (see Scheffé post hoc analysis, Table 2).

*****Insert Table 2 about here *****

As for self-reported political orientation, a centrist tendency is seen in all four countries. Still, there are small but systematic differences, with a stronger leftist leaning found in France, Germany and UK in relation to Norway (Bonferroni pairwise comparisons, all *p*s < .05).

These descriptive results show some interesting differences in relation to previously reported international surveys of climate change public perception. Past research (Engels *et al.*, 2013) showed Germans displaying very low percentages of climate scepticism. Norwegians have figured in the past among the most climate-sceptical European countries (Tranter and Booth, 2015). As shown above, our results, in contrast, show the German population as the most climate sceptical among the countries surveyed, and Norway the least.

### *4.2. Perceived science consensus and climate change beliefs*

Our results above presented a pattern: Where perceived scientific consensus is lower (Germany and UK) respondents also believe less in the reality of climate change (trend scepticism) and in its anthropogenic origin (attribution scepticism). We now explore in more depth the relationship between perceived scientific consensus and belief in climate change.

We performed a 4 (country: France, Germany, Norway, UK) X 2 (trend sceptic: yes, no) between-subjects ANOVA on the perceived scientific consensus variable. In line with the data presented above, we found a significant main effect of country [$F(3,3592) = 2.61$, $p = 0.04$, $\eta^2 = .002$] and of trend scepticism [$F(1,3592) = 160.1$, $p < .001$, $\eta^2 = .04$] on the perceived scientific consensus. Their interaction was not significant [$F(3,3592) = 0.5$, $p = 0.68$]. The mean differences between countries for perceived scientific consensus are presented in Table 2. Regarding the mean difference of perceived science consensus between climate change believers and sceptics, respondents believing that climate change is *real* perceive the scientific consensus as greater ($M = 3.94$, $SD = 1.05$) compared to trend sceptics [$M = 3.02$, $SD = 1.26$; $t(3590) = 14{,}6$, $p < .001$, Cohen's $d = 0.66$]. Thus, people who believe climate change is real tend to perceive more scientific consensus than do trend sceptics.

### *4.3. Interpreting perceived scientific consensus under different models of science*

We have hypothesized that models of science influence individuals' interpretation of perceived scientific consensus. We thus assume that perceived scientific consensus is a more or less convincing argument in support of anthropogenic climate change depending on a person's view on science. We therefore treat the model of science ('search for truth' versus 'debate') as a moderator of the relationship between perceived scientific consensus and belief in anthropogenic climate change.

Our outcome variable, belief in anthropogenic climate change, was entered in a regression analysis to test the degree to which it can be explained by (1) control variables: gender, age, education, political orientation, plus our focal predictor variables perceived scientific consensus and science model, and (2) an interaction term where perceived scientific consensus is multiplied by model of science (Figure 1); the interaction term reflects the hypothesized moderation effect. This model was entered as Model 1 in the PROCESS macro (Preacher and Hayes, 2008).

*****Include Figure 1 about here*****

Among the variables entered in the first block, educational level was found to be positively associated with anthropogenic climate change belief (see Table 3): People with a university degree tend to have stronger belief in anthropogenic climate change than people without such a degree. Age and political orientation are negatively associated with belief in anthropogenic climate change: older people and people of right-leaning political orientation tend to believe less in anthropogenic climate change. When these variables are controlled, participants in France were seen overall to have stronger belief in anthropogenic climate change than participants in other countries (see also Table 2).

*****Insert table 3 about here*****

To analyse the relation of perceived scientific consensus with the belief in anthropogenic climate change under different models of science, perceived scientific consensus and model of science were initially entered as individual variables in the first block. Then in a second block they were entered in an interaction. Results presented in Table 3 show that both perceived scientific consensus ($B = .37$, $p < .001$) and holding a model of science as 'debate' ($B = .14$, $p < .01$) are independently and positively associated with belief in anthropogenic climate change.

Moreover, the interaction term whereby the joint effect of perceived scientific consensus under model of science is tested is significant. This result suggests that the power of perceived scientific consensus to predict belief in anthropogenic climate change varies with the degree to which one or another model of science is endorsed. In Table 3 these relationships are tested at three values: at the mean, and -1 and +1 standard deviation. Results show that in lower values for model of science (closer to a model of science as 'search for truth'), the relationship

between perceived scientific consensus and belief in anthropogenic climate change is *stronger* ($B$ = .28, $p$ < .001). At higher values of the model of science variable (closer to science as 'debate'), the relationship between perceived scientific consensus and belief in anthropogenic climate change is *weaker* ($B$ = .21, $p$ < .001). This result suggests that, over and above the control demographic variables entered in block 1, and the individual effects of perceived scientific consensus and of the model of science variable, model of science significantly moderates the relationship between perceived scientific consensus and belief in anthropogenic climate change.

It is possible however that a more complex model including variables associated with emotions, social norms and environmental values would increase the variance explained (*Adj* $R^2$ = .14). However, we have chosen for this study to exclusively focus on the predictive power of science-related variables.

## 5. Discussion

The goal of this paper was to analyse how epistemological beliefs and the interpretation of relevant information influence beliefs about climate change. More specifically, we examined the strength of the relationship between perceived scientific consensus and anthropogenic climate change beliefs under two models of science: as a 'search for truth' or as 'debate'. In light of previous experimental studies (Rabinovich and Morton, 2012), we anticipated that when individuals hold a model of science as seeking the 'truth', those who perceive a high degree of scientific consensus are more likely to believe that climate change is caused by humans.

Our results from a four-country survey indeed support this hypothesis. Even though the people sharing a model of science as 'debate' also tended to believe more in anthropogenic climate change as their perceived scientific consensus increased (Table 3), we found that for

people sharing a model of science as ‘search for truth,’ perceived scientific consensus is a stronger predictor of anthropogenic climate change beliefs. Furthermore, besides the effects of perceived scientific consensus and of model of science taken individually, the interaction between these two variables also contributes to significantly explaining individuals' belief in anthropogenic climate change.

Given the small percentages of people bluntly denying climate change in our survey, creating a ceiling effect, it was not possible to run the same regression model using the ‘belief in the reality of climate change’ item.

These results demonstrate how assumptions implicit in different understandings of how science works may affect the way information about scientific consensus is interpreted. The small but significant effect that we found suggests that the degree to which a person agrees that “There may be more than one correct answer to most scientific questions” reveals qualitatively different interpretations of the uncertainty behind climate science, in particular those interpretations of the level of scientific consensus on anthropogenic climate change (Jaspal, Nerlich and Koteyko, 2012; Callaghan and Augoustinos, 2013). That said, we cannot rule out the influence of broader social representations (Moscovici, 2001) of scientific knowledge and of science itself. It would seem likely that the different interpretative frames defining each of the models of science are associated with the communication systems described by Moscovici (2001): diffusion, propagation and propaganda. An empirical study of how models of science are associated with broader psychosocial representations remains to be done.

A limitation of this study lies in the use of single-item measures to access our constructs, in particular regarding models of science. This reflects the limitations inherent to the conduct of a major international survey with nationally representative samples, conducted face-to-face in three countries and by telephone in the fourth country. For reasons of both cost

and quality (i.e., avoiding potential interviewee fatigue and reducing drop-out rates) only a limited number of questions could be included. Note that well-defined single-item scales are recognized as a useful solution when practical constraints justify their use (e.g. Bergkvist and Rossiter, 2007; Lantian *et al.*, 2016). In cross-national research into public perceptions of climate change, single item measures are indeed common for practical reasons and have not been seen to undermine valuable contributions to understanding how opinions about environmental issues are formed and shaped by cultural or national differences (e.g. Demski et al., 2018; Lee, Markowitz, Howe, Ko and Leiserowitz, 2015; Smith and Leiserowitz, 2014). Our single-item scale presents good internal consistency with a four-item scale that has significantly differentiated the adoption of models of science in an experimental setting (Rabinovich and Morten, 2012). While these precedents indicate that the chosen research methodology is adequate to support the findings as stated, further research using a larger set of items would be of great value to yield deeper insight into models of science and their impacts. Moreover, this epistemological inquiry could be extended to research on the perception of other risk objects such as disease protection through vaccination—given that like climate sceptics, anti-vaccination movements obtain or create a media platform for their challenges to scientific information as well as to science per se. Perceived scientific consensus has been shown to be an important predictive variable for belief in anthropogenic climate change (van der Linden *et al*., 2015). This is in accordance with another of our findings: in comparison to those who accept conventional climate science, climate sceptics – persons denying the existence (trend) of climate change or denying that climate change can be attributed to humans – tend indeed to perceive less consensus among climate scientists. Still our data indicate that we must be attentive to what individuals *infer* when they are exposed to information about scientific consensus in general, and about climate change in particular (Kahan *et al*., 2011). Our study underlines the importance of considering the effect of epistemological beliefs on individuals'

interpretation of information about the climate, and the use they make in that interpretation of a perceived consensus or lack of consensus.

## 6. Conclusion

Our results suggest that when forming climate change beliefs, assumptions made under different models of science shape the individual's interpretation of perceived consensus or lack of consensus among scientists, and that this process holds across many different social groups. Our study is the first to demonstrate this moderating effect in representative national samples from different countries (France, Germany, Norway and UK).

The overwhelmingly high percentage of published scientists who agree with the reality of anthropogenic climate change (i.e., the high degree of scientific consensus) has proven to be a strong argument against climate sceptical positions (van der Linden *et al*., 2015). However, results from our and other studies suggest that public communication highlighting high scientific consensus should be accompanied by awareness of possible unintended effects. Communicative acts that convey or assume that a single 'truth' exists may undermine the individual capacity to process ambiguous information (Rabinovich and Morton, 2012), which nonetheless continues to flow in societal debate, media presentation of climate change, and other public discourse. If the idea of a single 'truth' is implicit in public discourse and communications, people are more vulnerable to sceptical arguments than when an idea of science as 'debate' is implicit or acknowledged. Our results have shown this effect to be small, but systematic.

The way communications about climate change are understood and interpreted is influenced by a multitude of factors, of which the expression of scientific consensus and the recipient's epistemic beliefs are crucial components (Bostrom, Böhm and O'Connor, 2018). In the public debate and in the media the lines between legitimate and non-legitimate scientific discourse are blurred (Antilla, 2005). Considering the variety of information and of sources to

which people are exposed every day, societal communication of a model of science as ‘debate’ could reinforce the individual’s critical discernment of the source of information and its context. By contrast, implying the existence of single, exclusive truths shifts the debate away from assessing the validity of methods, presuppositions, and the quality of scientific arguments, to centre instead on whether or not scientists are unanimous. Instead of acting as a barrier to action ("little consensus among scientists or other sources, therefore no evidence to justify change in my behaviour"), the provision of contradictory and uncertain information would, under a model of science as ‘debate’, inspire a greater sense of being confidently informed about the different positions of a debate (Rabinovich and Morton, 2012). This manner of interpreting scientific debate is associated with a deeper question about the relativity of social knowledge (Moscovici, 2001) and how its ‘reality’ emerges from the fact that it is socially shared and validated by different social groups. In this sense, the adoption of a model of science as ‘debate’ is closer to a constructionist view of reality. For participants adopting a model of science as ‘debate’, reality – and more specifically, science – is not absolute but relative since it is socially produced and validated knowledge (e.g. Bertoldo *et al.*, 2016).

In this way, communicating a view of science as ‘debate’ would potentially buffer against forming scepticism in the face of contradictory information about climate change, instead reinforcing the motivation to critically analyse the context in which scientific information is produced. Future research could explore the potential effects of including a particular 'message within the message' communicating about the nature of science as well as about scientific findings and consensus.

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Table 1. *Demographic statistics (percentages).*

| | UK (*N* = 1,033) | France (*N* = 1,010) | Germany (*N* = 1,001) | Norway (*N* = 1,004) |
|---|---|---|---|---|
| Sex (%) Female | 45.8 | 53.1 | 53.5 | 46.9 |
| 15-24 | 15.6 | 13.4 | 10.5 | 16.4 |
| 25-34 | 12.6 | 15.9 | 12.5 | 15.2 |
| 35-44 | 13.6 | 16.1 | 15.4 | 17.3 |
| 45-54 | 15.4 | 17.4 | 22.5 | 16.9 |
| 55-64 | 16.4 | 15.8 | 15.7 | 13.2 |
| 65 + | 26.5 | 21.2 | 23.5 | 20.8 |
| Education (%) | | | | |
| Diploma under A-Level | 32.6 | 11.5 | 40.5 | 13.1 |
| A-Level | 19.3 | 17.8 | 51.5 | 34.2 |
| University (degree, master or PhD) | 31.3 | 31.9 | 7.9 | 52.7 |
| No formal qualification | 16.1 | 13.5 | ** | ** |

Table 2. *Comparative descriptive statistic (Scheffe post hoc tests).*

| | France (*N* = 1,010) | | Germany (*N* = 1,001) | | Norway (*N* = 1,004) | | UK (*N* = 1,033) | | *F* | *p* | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | (3,2871) | | |
| Anthropogenic CC belief | $4.27^{b}$ | 0.83 | $4.06^{a}$ | 1.12 | $4.20^{a,b}$ | 0.69 | $4.10^{a}$ | 0.89 | 7.90 | .001 | .01 |
| Perceived scientific consensus on CC | $3.80^{b}$ | 1.06 | $3.62^{a}$ | 1.09 | $4.01^{c}$ | 1.03 | $3.75^{a,b}$ | 1.14 | 16.0 | .001 | .02 |
| Model of science | $3.80^{b}$ | 0.89 | $3.46^{a}$ | 1.06 | $4.15^{c}$ | 1.06 | $3.85^{b}$ | 0.94 | 58.50 | .001 | .06 |
| Political orientation | $4.85^{a,b}$ | 2.46 | $4.66^{a}$ | 1.85 | $5.14^{b}$ | 2.50 | $4.79^{a}$ | 2.0 | 4.12 | .01 | .004 |

*Note.* Anthropogenic climate change belief scale: 1-CC is entirely natural; 5-CC is completely caused by human activity. Other values were considered as missing.
Perceived scientific consensus on climate change: 1- A small minority of scientists agree; 5- The vast majority of scientists agree.
Model of science: 1- as truth; 5-as debate.
Political orientation: 0- left-wing; 10- right-wing.

Table 3: *Prediction of belief in anthropogenic climate change in four countries (UK, France, Germany and Norway).*

| **bloc** | **Predictors** | $R^2$ | *F* | *df* | *B* | *t* | *LLCI* | *ULCI* |
|---|---|---|---|---|---|---|---|---|
| 1 | Age | .14 | 45.6*** | 10,2861 | -.01 | -3.2** | -.004 | -.001 |
| | Female | | | | .04 | 1.5 | -.013 | .105 |
| | University degree | | | | .11 | 3.3** | .045 | .181 |
| | Right-wing political orientation | | | | -.03 | -4.1*** | -.041 | -.015 |
| | France | | | | .16 | 3.7*** | .076 | .245 |
| | Germany | | | | .05 | 1.2 | -.035 | .138 |
| | Norway | | | | .01 | .27 | -.070 | .094 |
| | Perceived scientific consensus | | | | .37 | 7.6*** | .274 | .465 |
| | Science model | | | | .14 | 2.9** | .046 | .237 |
| 2 | Perceived scientific consensus*Science model | .14 | 6.5* | 1,2861 | -.03 | -2.5* | -.055 | -.007 |
| | Perceived scientific consensus*(different levels of science model): | | | | | | | |
| | • 2.82 | | | | .28 | 15.2*** | .245 | .317 |
| | • 3.85 | | | | .25 | 17.6*** | .221 | .277 |
| | • 4.88 | | | | .21 | 11.2*** | .179 | .255 |

* $p < .05$; ** $p < .01$; ***$p < .001$

*Note*. Political orientation is a continuous variable. Higher values correspond to stronger right-wing orientations (1-left; 10-right).
Perceived scientific consensus is a continuous variable. Higher values correspond to perceptions of a larger consensus about climate change (1- A small minority of scientists agree; 5- The vast majority of scientists agree).
Model of science is a continuous, bipolar variable. Higher values reflect the adoption of a model of science as 'debate' (1- as truth; 5-as debate).

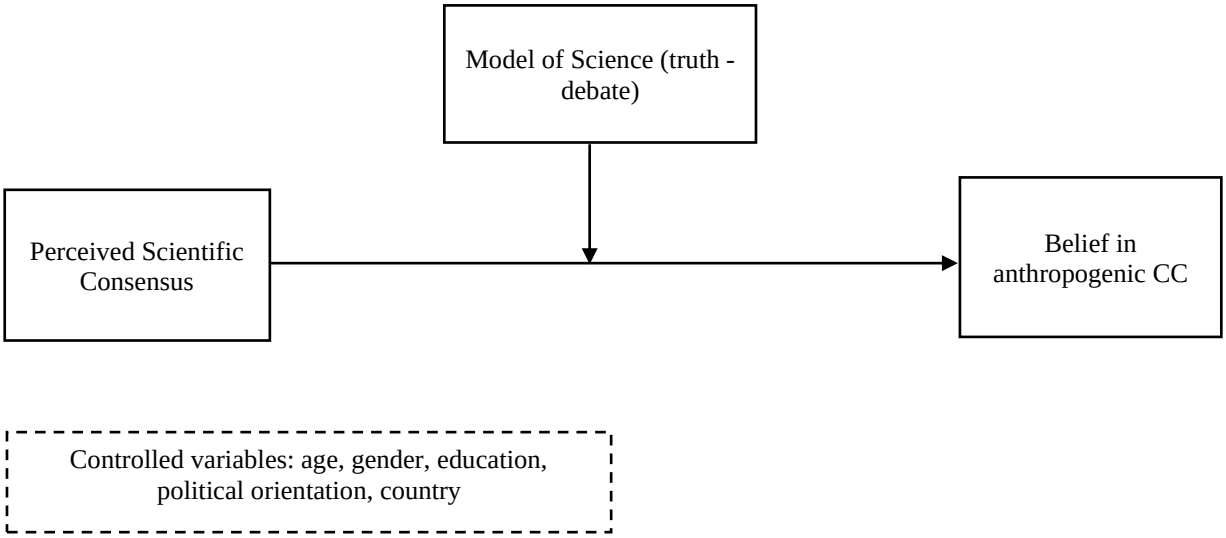


*Figure 1:* Conceptual model tested in the four countries.