

# Spiritual skepticism? Heterogeneous science skepticism in the Netherlands

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## Abstract

Recent work points to the heterogeneous nature of science skepticism. However, most research on science skepticism has been conducted in the United States. The current work addresses the generalizability of the knowledge acquired so far by investigating individuals from a Western European country (The Netherlands). Results indicate that various previously reported findings hold up: Mirroring North American patterns, climate change skepticism is associated with political conservatism (but only modestly), and scientific literacy does not contribute to skepticism, except about genetic modification (Study 1 only) and vaccine skepticism (Study 2 only). Results also reveal a crucial difference: Religiosity does not consistently contribute to science skepticism, except about evolution. Instead, spirituality is found to most consistently predict vaccine skepticism and low general faith in science—which in turn predicts willingness to support science. Concerns about societal impact play an additional role. These findings speak to the generalizability of previous findings, improving our understanding of science skepticism.

## Keywords

conservatism, environment, generalizability, health, religion, science skepticism, spirituality

## 1. Introduction

The systematic and unwarranted rejection of science is a growing societal problem that affects people and their environments across the globe. Many scientific findings and conclusions—particularly when these contradict people’s ideological or moral convictions—are increasingly dismissed by substantial segments of the public, and sometimes also on an institutional level (Eilperin et al., 2019; Nature Editorial, 2017a). Scientific associations and institutions have expressed their

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concerns about the current “crisis of trust” in science (Nature Editorial, 2017a, 2017b). It is evident that science skepticism represents a major contemporary challenge, one that can have far-reaching societal and environmental consequences. Consider as an example recent measles outbreaks (e.g. in the United States and in the Netherlands; Pierik, 2017) due to insufficient herd immunity, which is a direct consequence of vaccine skepticism (Amin et al., 2017; Wenner Moyer, 2018), or consider the personal lifestyle and political choices that people make—partially as a result of their skepticism about anthropogenic global warming—that degrade the environment (Schleussner et al., 2016). Vaccine hesitancy and climate change have been listed by the World Health Organization (WHO, 2019) as one of the top 10 health threats facing the world in 2019. Mapping the antecedents of science skepticism is thus an important task, which has been taken up by various researchers in the last decade or so (Hornsey and Fielding, 2017; Lewandowsky and Oberauer, 2016; Rutjens et al., 2018a).

However, two important limitations of the growing body of work on science skepticism are (1) that various domains of science are mostly investigated in isolation, with disproportional emphasis being placed on understanding *climate change* skepticism specifically and (2) that most of the conclusions so far are based on *North American* samples. Regarding the first limitation, the consequence of mostly focusing on this specific topic is that the conclusions that are based on this body of research have been somewhat generalized, so that political ideology (i.e. conservatism) has been appointed as one of the main culprits of science skepticism generally (Rutjens et al., 2018a, 2018b). Consequentially, research has mostly overlooked other—potentially more potent—antecedents of science skepticism beyond climate science, even when it was pointed out relatively early (e.g. Kahan, 2015; Lewandowsky et al., 2013; Scott et al., 2016) that political conservatism falls short in predicting skepticism about vaccination and genetic modification (GM).

The second limitation is that very little is known about the nature and scope of science skepticism beyond the cultural context of the United States. This is a problem that plagues social science research in general (Henrich et al., 2010), and one that could have severe consequences for our understanding of the ideological underpinnings of science skepticism. As one illustration of the importance of broadening the narrow cultural scope of most previous research, a recent cross-national study found that the all-too-familiar association between political conservatism and climate change skepticism was stronger in the United States than in any of the other nations that were investigated (Hornsey et al., 2018a). In addition, the United States is an outlier among Western countries in terms of religiosity (Gao, 2015; Pew Research Center, 2018). Given that previous work on science skepticism has found that religiosity is overall a robust predictor of skepticism across various domains (e.g. McPhetres and Zuckerman, 2018; Rutjens et al., 2018b), the important question arises whether this association holds up among a more secular population (which is—at least in terms of religiosity—more representative of other countries in the Western world; Pew Research Center, 2018). Moreover, if this is not the case, a second question is what would predict science skepticism of not religiosity. As we will argue later, we expect *spirituality* to replace religion as an important predictor of various manifestations of science skepticism.

Recent work has started to address the first limitation and found that science skepticism is indeed more heterogeneous than previously assumed, with political conservatism driving climate change skepticism, religiosity driving vaccine skepticism as well as general (low) faith in science, and GM skepticism being associated with non-ideological factors (Rutjens et al., 2018b). Other recent work that investigated skepticism toward various science topics points to a similar conclusion (Drummond and Fischhoff, 2017). Importantly, however, systematic investigations of the relative impact of various potential predictors of skepticism across various topics are still scarce. A first step in addressing the second limitation (low generalizability) has recently been taken in a

cross-national comparison of climate science skepticism (Hornsey et al., 2018a) and vaccine skepticism (Hornsey et al., 2018b), respectively, but systematic tests of the heterogeneity of science skepticism conducted outside of the US context are still lacking.

The current work is a first step in filling this gap by *simultaneously addressing both limitations*. Utilizing two community samples of Dutch participants—one collected in 2018 and the other collected in 2019—we systematically scrutinized science skepticism in four domains: climate change, vaccination, GM, and evolution. We also included measures of general faith in science and willingness to support science, and incorporated the most relevant previously identified predictors of science skepticism: Political ideology, moral purity concerns,<sup>1</sup> religiosity, and scientific literacy (see Rutjens et al., 2018b). We also included a novel predictor, spirituality, which we will briefly elaborate in the next section. In addition, to be as complete as possible in determining the antecedents of science skepticism across domains, we incorporated measures that have previously been shown or argued to inform science skepticism: Conspiracy thinking (Hornsey et al., 2018a, 2018b; Rutjens et al., 2018a; Sutton et al., 2018), perceived corruption of science (Pechar et al., 2018), concerns about the societal impact of accepting scientific conclusions (Sutton et al., 2018), alongside various demographic variables. Although we took an in principle exploratory approach in the current work, we formulated four general predictions based on various literatures and earlier work (bearing in mind the caveat that most of the work discussed is based on data collected among US samples).

The main prediction was that religiosity plays a more minor role in predicting science skepticism, given that the Netherlands—as are other Western European countries—is relatively secular (Halman and Draulans, 2006; Houtman and Aupers, 2007; Versteeg and Roeland, 2011; Wojtkowiak et al., 2010), as compared with the United States. Instead, we expected contemporary *spirituality* (i.e. spiritual identity, meaning self-identifying as a spiritual person) to play a more prominent role—similar to religiosity in previous research conducted in the United States. We based this prediction on two observations. First, a large body of survey research indicates that a substantial part of the Dutch population consists of individuals who are referred to as post-Christian spirituals, or more generally as individuals who “believe-without-belonging” (Houtman and Aupers, 2007; Van Mulukom et al., in press; Versteeg and Roeland, 2011). In 2012, a substantial part of the Dutch population indicates to view themselves as either somewhat (31%) or very (12%) spiritual, while the percentage of frequent churchgoers was 19% (De Hart, 2014). Such contemporary spirituality has replaced more traditional religiosity not only in the Netherlands, but in various other Western countries as well (Houtman and Aupers, 2007). Second, contemporary spirituality is characterized by an *experiential* approach to truth (Hanegraaff, 1996), which reflects the idea that truth—from both an epistemological and an existentialist perspective—can only be found through personal experience, as opposed to reason (i.e. science) or faith (i.e. religion). Indeed, recent research has shown that, in comparison with other groups, spiritual-but-not-religious individuals strongly rely on intuitions (Lindeman et al., 2019). The notion of an experiential approach to truth, which can be used as a definition of contemporary spirituality and New Age belief (Hanegraaff, 1996), reflects a radically different epistemology than that of science, and also different than that of traditional religion, both of which locate truth in the external world. Put differently, the *intuitive epistemology* of contemporary spirituality will likely be hard to reconcile with (faith in) science, especially in the context of contentious topics such as those central to the current study.

In sum, given that the Netherlands is characterized by relatively low levels of traditional religiosity and relatively high levels of contemporary spirituality—which is characterized by an intuitive epistemology—we expected spirituality to play a more prominent role than religiosity in shaping skepticism about vaccination as well as low faith in science and willingness to support science.

Our second prediction was that political ideology is associated with climate change skepticism, but not with skepticism about vaccination, GM, and evolution (Drummond and Fischhoff, 2017; Hornsey et al., 2018a; Rutjens et al., 2018b). Our third prediction was that scientific literacy is the main predictor of GM skepticism and contributes to vaccination skepticism but does not predict the other forms of skepticism (McPhetres et al., 2019; Rutjens et al., 2018b). Finally, we predicted that evolution skepticism is primarily associated with religiosity (Drummond and Fischhoff, 2017; Rutjens et al., 2018a). Predictions 2–4 were based on separate strands of previous work and theorizing, that—as mentioned previously—has mostly been conducted in the United States.

## 2. Method

### *Study population recruitment*

After approval of the study protocol by the Ethics Committee of the first author's institution (#2018-SP-8701), we started recruiting respondents online with the assistance of undergraduate students as part of their coursework. In Study 1 (2018), 329 individuals took part, of which 26 did not complete the survey, 34 failed to correctly respond to an attention check (described below), and one respondent was deleted for detailing her age as 12 years old. This left a final sample of 268 participants. In Study 2 (2019), 245 individuals participated, of which 14 participants failed the attention check and 13 did not complete the study. These participants were not included in the analyses.

Demographics of the remaining participants can be found in Table 1. An attention check was included to make sure participants were paying attention to the wording of the questions. The item read, "We would like to make sure that you are paying attention to the wording of the questions. Please fill in the number that corresponds to 'somewhat disagree'." Participants agreed on a voluntarily basis through advertisements on various (social) media platforms. To avoid self-selection bias, the survey was advertised using neutral terminology.<sup>2</sup>

**Table 1.** Participant demographics Studies 1 and 2.

	Study 1	Study 2
N	268	218
Data collection period	April 2018	April 2019
Mean age	32.11 ( <i>SD</i> = 11.62)	36.53 ( <i>SD</i> = 17.34)
Gender	59% female, 38% male, 3% other	58% female, 41% male, 1% other
Country of residence	94.4% The Netherlands 5.6% other	97% The Netherlands 3% other
Political conservatism (1–10)	3.59 ( <i>SD</i> = 1.61)	4.01 ( <i>SD</i> = 1.77)
Religious: yes or no?	Yes: 43 (16%) No: 225 (84%)	n/a
Religious orthodoxy (1–10)	2.20 ( <i>SD</i> = 1.40)	2.10 ( <i>SD</i> = 1.24)
Spirituality (1–7)	2.82 ( <i>SD</i> = 1.60)	2.92 ( <i>SD</i> = 1.73)
Subjective SES (1–10)	6.81 ( <i>SD</i> = 1.79)	7.45 ( <i>SD</i> = 1.25)
Scientific training	None: 49.2% Yes, university degree: 50.8% Working in science: 3.0%	None: 37.6% Yes, university degree: 62.4% Working in science: 4.1%
Scientific literacy (0–8)	6.10 (1.46)	6.12 (1.44)

SES: socioeconomic status.

## Materials

The studies were almost identical, but Study 2 consisted of additional measures. All differences between studies are detailed below. The studies consisted of the following measures (largely following Rutjens et al., 2018b). Unless otherwise reported, all items were scored on scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Upon completion, participants were thanked for participation.

## Outcome variables

**Science skepticism.** Four items were presented: “Human CO<sub>2</sub> emissions cause climate change”; “Vaccinations cause autism”; “Genetic modification of foods is a safe and reliable technology”; and “Human beings, as we know them today, developed from earlier species of animals.” All items except for the vaccination item were reverse scored.

**Faith in science and science support.** Participants completed a five-item *Faith in Science* scale (see Farias et al., 2013; Hayes and Tariq, 2000; Rutjens et al., 2018b). An example item is “Science is the most efficient means of attaining truth” ( $\alpha = .86$ ). They subsequently completed the following science support item: “According to you, how much money should the government spend on science?”

## Predictor variables

**Moral purity concerns.** Participants completed the moral purity subscale of the moral judgments section of the Moral Foundations Questionnaire (Graham et al., 2009), consisting of three items (e.g. “I would call some acts wrong on the grounds that they are unnatural”). Reliability was insufficient (Study 1:  $\alpha = .57$ ; Study 2:  $\alpha = .52$ ); removing the item about chastity increased reliability slightly in Study 1:  $\alpha = .60$ . In Study 2, reliability remained the same, but for consistency, we here also removed the chastity item. The items were scored on 5-point scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

**Political orientation.** Participants indicated their political orientation on two scales ranging from 1 (*very left-wing*) to 10 (*very right-wing*) and 1 (*very progressive*) to 10 (*very conservative*), respectively.

**Religiosity.** Participants indicated whether they considered themselves to be a religious person (yes or no); due to an oversight this measure was only included in Study 1. After indicating their affiliation, we asked participants to indicate whether they believe in God or a higher power on a scale ranging from 1 (*not at all*) to 10 (*very much*). Next, religious orthodoxy was measured with two<sup>4</sup> items ( $r = .48$  in both studies) that were taken from the orthodoxy subscale of the post-critical belief scale (Fontaine et al., 2003).

**Spirituality.** Participants then indicated whether they considered themselves to be a spiritual person (Maij and van Elk, 2018), by answering the following two items: “To what extent do you consider yourself to be a spiritual person?” and “To what extent do others consider you to be a spiritual person?” (Study 1:  $r = .79$ ; Study 2:  $r = .89$ ).

**Demographics and scientific literacy.** After indicating demographic details (age, gender, subjective SES, educational level; see Table 1), a scientific literacy test consisting of eight true–false items

was presented (maximum score 8 points). An example test item is “Electrons are smaller than atoms.”

**Conspiracy thinking.** To measure a general tendency to belief in conspiracies, we adopted a single-item measure that was shown to have good validity (Lantian et al., 2016). The measure consisted of a short text about various well-known events, which was followed by a single item: “I think that the official version of the events given by the authorities very often hides the truth.” (1 = *completely false* to 9 = *completely true*), with a higher score reflecting more conspiracy thinking. Mean score on the conspiracy thinking measure was 4.77 ( $SD = 2.20$ ) in Study 1 and 4.79 ( $SD = 2.45$ ) in Study 2.

**Societal impact concerns.** We created two items which were designed to measure the extent to which people worry about the negative societal impact of accepting: The reality of climate change, the safety of vaccines, and the safety of eating GM foods.<sup>5</sup> The first item asked participants to indicate for which of the three topics acceptance has dangerous consequences on the short term; they could select one of the topics or select “none of the above.” The second item asked participants to do the same, but this time to consider long-term societal consequences. Subsequently, we created societal impact concerns indices for climate change, vaccination, and GM, which could range from 0 (*not selected*) to 2 (*selected twice*).

**Perceived corruption of science.** Two statements were presented for participants to indicate their agreement with: “Science is corrupted by government interference” and “Science is corrupted by corporate interference.”

### Study 2 only materials

**Cognitive reflection test.** To complement the scientific literacy measure with a general measure of cognitive ability, we included the cognitive reflection test (CRT; Frederick, 2005). The CRT consists of three items that measure individual differences in intuitive–analytic cognitive style. Intuitive scores on the test have, for example, been shown to correlate with religiosity (e.g. Shenhav et al., 2012).

**Media trust.** Finally, we measured trust in traditional media and trust in social media news sources, and let participants disclose the three sources of news they use most often. We only included trust in traditional media in the analyses, which was measured on a 10-point scale ranging from 1 (*very unreliable*) to 10 (*very reliable*).

## 3. Results

In both studies, we used multiple linear regression analyses to assess which variables best predict science skepticism across four domains, faith in science, willingness to support science, holding constant the potential influence of the other predictors, and controlling for demographic variables. Note that we also control for faith in science in predicting science skepticism and science support, that is, included it as a predictor in these analyses. Bivariate correlations are displayed in the supplemental materials section.

Our aim was to be as complete as possible and thus to incorporate as many of the relevant predictors that we identified in the literature as we deemed feasible in the survey. We report

**Table 2.** Multiple linear regression analyses of science skepticism, faith in science, and science support—Study 1.

	Climate skepticism	Vaccine skepticism	GM skepticism	Evolution skepticism	Faith in science	Science support
	M = 2.38 (SD = 1.70) .15**	M = 1.83 (SD = 1.21) .25**	M = 4.25 (SD = 1.68) .33**	M = 2.05 (SD = 1.73) .38**	M = 4.24 (SD = 1.46) .23**	M = 7.41 (SD = 1.54) .20**
Descriptives						
Adjusted R <sup>2</sup>						
Age	.21** (.01, .05)	.05 (-.01, .02)	.17** (.01, .04)	-.03 (-.02, .01)	-.08 (-.03, .00)	.04 (-.01, .02)
Gender	-.05 (-.47, .19)	-.06 (-.33, .11)	.04 (-.17, .41)	-.04 (-.39, .18)	-.04 (-.36, .17)	.06 (-.13, .45)
Moral purity	-.04 (-.27, .15)	.08 (-.05, .23)	.08 (-.06, .31)	.05 (-.10, .27)	-.10 (-.31, .03)	-.02 (-.21, .16)
Political conservatism	.13* (.01, .27)	.08 (-.03, .15)	.03 (-.06, .31)	.13* (.03, .26)	.02 (-.09, .13)	-.04 (-.15, .08)
Religiosity (1 = yes; 2 = no)	-.10 (-.17, .24)	-.08 (-.73, .20)	.10 (-.18, 1.03)	-.42** (-2.55, -1.35)	.17* (.14, 1.24)	-.01 (-.65, .56)
Religious orthodoxy	.05 (-.11, .24)	.06 (-.06, .17)	.11 (-.02, .28)	.08 (-.05, .25)	-.03 (-.17, .11)	-.04 (-.20, .11)
Spirituality	-.02 (-.16, .12)	.16** (.03, .22)	.16** (.07, .33)	-.06 (-.18, .06)	-.26** (-.34, -.13)	-.05 (-.17, .07)
Faith in science	-.18** (-.36, -.06)	-.11 (-.20, .01)	-.09 (-.24, .03)	-.20** (-.37, -.11)	-.07 (-.05, .19)	.40** (.29, .56)
Scientific literacy	-.03 (-.18, .11)	-.02 (-.12, .08)	-.16** (-.31, -.05)	-.01 (-.14, .11)	.07 (-.05, .19)	.09 (-.03, .22)
Conspiracy thinking	.07 (-.05, .15)	.18** (.04, .17)	.14* (.02, .19)	.12* (.01, .18)	-.17** (-.19, -.04)	-.06 (-.13, .04)
Impact concerns	.12* (.01, .62)	.14* (.07, .64)	.26** (.41, .99)	-.03 (-.16, .08)	-.05 (-.07, .16)	.01 (-.12, .13)
Perceived corruption gov.	.04 (-.10, .19)	.12 (-.04, .19)	.10 (-.02, .24)	.05 (-.08, .18)	-.12 (-.23, .01)	-.01 (-.14, .12)
Perceived corruption corp.	-.05 (-.20, .10)	.03 (-.07, .13)	.06 (-.06, .20)			

GM; genetic modification.

Standardized beta coefficients and 95% confidence intervals are reported. All dependent variables were measured on 7-point scales, except science support which was measured on a 10-point scale.

Impact concerns reflect the topic at hand and were measured with regards to the topics of climate change, vaccination, and GM.

\*p < .05; \*\*p < .01.

**Table 3.** Multiple linear regression analyses of science skepticism, faith in science, and science support—Study 2.

	Climate skepticism	Vaccine skepticism	GM skepticism	Evolution skepticism	Faith in science	Science support
Descriptives	M = 2.32 (SD = 1.65)	M = 1.72 (SD = 1.14)	M = 392 (SD = 1.55)	M = 2.25 (SD = 1.66)	M = 4.12 (SD = 1.25)	M = 7.30 (SD = 1.55)
Adjusted R <sup>2</sup>	.29**	.40**	.32**	.19**	.24**	.12**
Age	.39** (.03, .05)	.02 (-.01, .01)	-.08 (-.02, .00)	.03 (-.01, .02)	-.04 (-.01, .01)	.06 (-.01, .02)
Gender	.08 (-.16, .68)	-.06 (-.41, .11)	.15* (.08, .86)	.06 (-.23, .65)	-.18** (-.77, -.14)	-.00 (-.45, .42)
Moral purity	-.02 (-.24, .18)	.03 (-.10, .17)	.12* (.00, .39)	.09 (-.06, .39)	-.03 (-.20, .13)	.06 (-.11, .33)
Political conservatism	.12 (.00, .24)	-.13* (-.16, -.01)	.05 (-.07, .15)	.11 (-.02, .23)	-.04 (-.12, .07)	-.16* (-.27, -.02)
Religious orthodoxy	.11 (.03, .33)	.11 (-.02, .21)	-.05 (-.22, .11)	.24** (.13, .51)	-.04 (-.18, .10)	.16* (.02, .39)
Spirituality	-.18* (-.31, -.04)	.05 (-.05, .12)	.12 (-.02, .23)	-.00 (-.15, .14)	-.30** (-.32, -.11)	.07 (-.09, .20)
Faith in science	-.18** (-.42, -.06)	-.28** (-.36, -.14)	-.22** (-.44, -.11)	-.25** (-.51, .13)	-	.33** (.23, .60)
Scientific literacy	-.00 (-.15, .15)	-.23** (-.27, -.09)	-.05 (-.19, .09)	-.01 (-.16, .15)	.06 (-.06, .17)	.04 (-.12, .19)
Conspiracy thinking	.04 (-.06, .12)	.05 (-.04, .08)	.10 (-.02, .15)	.00 (-.09, .09)	-.17* (-.16, -.02)	.02 (-.08, .11)
Impact concerns	.07 (-.14, .59)	.30** (.50, 1.11)	.32** (.44, .96)	-	-	-
Perceived corruption gov.	.09 (-.07, .27)	.04 (.02, .19)	.09 (-.05, .25)	-.02 (-.19, .16)	-.02 (-.15, .11)	-.14 (-.32, .02)
Perceived corruption corp.	-.16* (-.37, -.01)	.03 (-.09, .14)	.05 (-.12, .22)	.07 (-.12, .27)	.16* (.00, .28)	.09 (-.09, .29)
CRT score	-.05 (-.25, .11)	-.01 (-.12, .10)	.02 (-.14, .19)	-.10 (-.32, .05)	-.05 (-.19, .08)	-.11 (-.33, .03)
Media trust	-.15* (-.30, -.02)	-.12* (-.18, -.00)	-.05 (-.18, .08)	-.03 (-.18, .12)	.13* (.00, .22)	.05 (-.09, .20)

GM: genetic modification; CRT: cognitive reflection test. Standardized beta coefficients and 95% confidence intervals are reported. All dependent variables were measured on 7-point scales, except science support which was measured on a 10-point scale. Impact concerns reflect the topic at hand and were measured with regards to the topics of climate change, vaccination, and GM. \*p < .05; \*\*p < .01.

**Table 4.** Multiple linear regression analyses of vaccine skepticism—Studies 1 and 2.

	MMR vaccine skepticism		HPV vaccine skepticism		Vaccines cause autism	
	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2
	M = 2.08 (SD = 1.51)	M = 1.91 (SD = 1.39)	M = 3.01 (SD = 1.74)	M = 2.54 (SD = 1.56)	M = 1.83 (SD = 1.21)	M = 1.72 (SD = 1.14)
Adjusted R <sup>2</sup>	.26**	.33**	.23**	.20**	.25**	.40**
Age	.14* (.00, .03)	.08 (-.00, .02)	.04 (-.01, .02)	-.02 (-.01, .01)	.05 (-.01, .02)	.02 (-.01, .01)
Gender	.00 (-.27, .27)	-.02 (-.41, .28)	-.01 (-.34, .31)	-.06 (-.90, -.08)	-.06 (-.35, .11)	-.06 (-.41, .11)
Moral purity	.06 (-.10, .25)	.09 (-.04, .31)	.11 (-.02, .39)	.08 (-.07, .35)	.10 (-.05, .23)	.03 (-.09, .17)
Conservatism	.13* (.01, .23)	-.12 (-.19, .01)	.05 (-.08, .18)	-.02 (-.13, .10)	.08 (-.03, .15)	-.13* (-.16, -.01)
Religiosity (1 = yes; 2 = no)	.06 (-.31, .83)	-	-.05 (-.91, .43)	-	-.08 (-.73, .20)	-
Religious orthodoxy	.05 (-.09, .20)	.25** (.12, .42)	-.02 (-.19, .15)	.13 (-.01, .02)	.06 (-.06, .17)	.11 (-.02, .21)
Spirituality	.19** (.06, .29)	.13 (-.02, .22)	.11 (-.01, .26)	.23** (.07, .34)	.16** (.03, .22)	.05 (-.05, .12)
Faith in science	-.15* (-.28, -.03)	-.14* (-.30, -.01)	-.21** (-.40, -.10)	-10 (-.29, .05)	-.11 (-.20, .01)	-.28** (-.36, -.14)
Scientific literacy	-.12* (-.24, -.00)	-.22** (-.33, -.10)	-.05 (-.21, .08)	-.21** (-.37, -.09)	-.02 (-.12, .08)	-.23** (-.27, -.09)
Conspiracy thinking	.09 (-.02, .14)	.14* (.00, .15)	.16** (.03, .22)	.12 (-.01, .17)	.18** (.04, .17)	.05 (-.04, .08)
Impact concerns	.20** (.28, .99)	.20** (.28, 1.03)	.10 (-.03, .80)	.11 (-.07, .86)	.14* (.07, .64)	.30** (.50, 1.11)
Perceived corruption gov.	.02 (-.10, .14)	-.09 (-.21, .05)	.05 (-.08, .20)	-.03 (-.20, .13)	.12 (-.04, .19)	.04 (.02, .19)
Perceived corruption corp.	.11 (-.02, .23)	.08 (-.07, .22)	.09 (-.04, .25)	.10 (-.07, .29)	.03 (-.07, .13)	.03 (-.09, .14)
CRT score	-	.08 (-.05, .23)	-	-.02 (-.20, .15)	-	-.01 (-.12, .10)
Media trust	-	-.20** (-.30, -.07)	-	-.15* (-.29, -.02)	-	-.12* (-.18, -.00)

CRT: cognitive reflection test.

Standardized beta coefficients and 95% confidence intervals are reported. All dependent variables were measured on 7-point scales, except science support which was measured on a 10-point scale.

Religiosity (dichotomous) was only measured in Study 1. CRT and media trust were only included in Study 2.

\*p < .05; \*\*p < .01.

the results of a regression model which includes age and gender, moral purity values, political ideology, religiosity, orthodoxy, and spirituality, faith in science, scientific literacy, conspiracy thinking, perceived corruption of science, societal impact concerns, and—in Study 2—CRT scores and media trust. Results are displayed in Tables 2 to 4. We tested and found no evidence for multicollinearity in all analyses (all variance inflation factors < 1.3 in Study 1 and < 1.8 in Study 2).

## Study 1

See Table 2 for main results.

**Climate change.** The final regression model explained 15% of the variance. Age, political conservatism, and (low) faith in science were predictors of climate change skepticism, which mirrors<sup>6</sup> previous results obtained with US participants and is line with our second prediction. Note, however, that the association with conservatism is modest. Concerns about the societal impact of accepting the reality of climate change was an additional contributor to skepticism.

**Vaccination.** The final model explained 25% of the variance. Supporting our first prediction—and in contrast to previous work with US respondents—religiosity did not play a meaningful role in predicting vaccine skepticism, but spirituality did. Our third prediction—that literacy would negatively contribute to vaccine skepticism—was not supported. Conspiracy thinking and concerns about the societal impact of vaccination were additional significant predictors.

Because the main vaccine skepticism measure targeted one specific belief about vaccination (i.e. that vaccines cause autism), we also ran regression analyses on two additional items that assessed more general negative beliefs about two types of vaccination (MMR—measles, mumps, and rubella and hPV—human papilloma virus). The results for MMR vaccine skepticism were almost identical to the results for the initial “vaccines cause autism” statement (see Table 4), which is not surprising given that the vaccines–autism link belief usually refers specifically to MMR vaccination. Spirituality was the strongest predictor, alongside (low) faith in science, as well as social impact concerns. In addition, scientific literacy was a significant predictor, which supports our third prediction. Together, these variables explained 26% of the variance. Results for hPV skepticism were quite similar, although spirituality was a weaker predictor while (low) faith in science and conspiracy thinking were significant predictors.

**Genetic modification.** The final model explained 33% of the variance. Supporting our third prediction and replicating earlier work among US participants (Rutjens et al., 2018b), scientific literacy was a significant negative predictor. Age, spirituality, conspiracy thinking, and concerns about the societal impact of GM were additional significant predictors.

**Evolution.** The final model yielded 38% explained variance. This is the only topic where skepticism is most strongly predicted by religiosity, supporting our fourth prediction. In addition, (low) faith in science, political conservatism, and conspiracy thinking contributed to the explained variance.

**Faith in science and science support.** Although we also included general faith in science as a predictor in the other analyses, we were interested in assessing which variables would contribute to faith in science. Our prediction was that spirituality would play a prominent role. The final regression model explained 23% of the variance. The strongest predictor of (low) faith in science indeed were spirituality and conspiracy thinking; religiosity was a weaker but significant predictor.

The final regression model explained 20% of the variance for science support. The only significant predictor was faith in science. In contrast to previous work among US participants (Rutjens et al., 2018b), religiosity was not associated with science support. Interestingly, before entering faith in science and scientific literacy in the final model, spirituality was a reasonably strong negative predictor of science support,  $\beta = -.20$ ,  $p < .01$ , 95% CI =  $(-.32, -.07)$ . Adding faith in science strongly reduced the effect of spirituality, suggesting mediation. A bootstrapping analysis of 5000 samples (Preacher and Hayes, 2004; Process Macro Model 4) confirmed that the negative effect of spirituality on the willingness to support science was fully mediated by (low) faith in science, with an indirect effect of  $-.17$  ( $SE = .03$ ), 95% CI =  $(-.24, -.11)$ . Thus, although we had not predicted this mediation effect, the results support our main prediction that spirituality plays a larger role than religiosity in predicting general faith in science and willingness to support science.

## Study 2

See Table 3 for main results.

*Climate change.* The final regression model explained 29% variance. In contrast to the results of Study 1 and our second prediction, political conservatism was not a significant predictor ( $\beta = .12$ ,  $p = .074$ ) of skepticism. Age, low faith in science, and low trust in traditional media were significant predictors. There was also an unexpected small negative effect of perceived corporate corruption of science. Interestingly, unlike in Study 1, spirituality was a negative predictor, so that more spiritual respondents were less skeptical about anthropogenic climate change. We return to this finding in the discussion.

*Vaccination.* The final model explained 40% of the variance. As can be seen in Table 3, there were some differences compared with Study 1. First, low faith in science was a significant predictor, while the coefficient of spirituality in the final model was not significant. However, upon closer inspection, we found that spirituality was a significant predictor before faith in science and scientific literacy were added to the model,  $\beta = .25$ ,  $p < .01$ , 95% CI =  $(.06, .26)$ . A bootstrapping analysis of 5000 samples (Preacher and Hayes, 2004; Process Macro Model 4) confirmed that the initial effect of spirituality was fully mediated by (low) faith in science, with an indirect effect of  $.09$  ( $SE = .03$ ), 95% CI =  $(.05, .15)$ . There was no effect of religious orthodoxy on vaccine skepticism. Taken together, our main prediction was supported, but the indirect effect of spirituality via faith in science was not predicted and should therefore be interpreted with caution. Second, corroborating previous research conducted with US participants (Rutjens et al., 2018b) and supporting our third prediction, scientific literacy contributed significantly to vaccine skepticism. In addition, there were small negative effects of political conservatism and trust in traditional media, and a substantial effect of concerns about the societal impact of accepting vaccination (which was also observed in Study 1).

We next assessed the effects on negative MMR and hPV vaccine attitudes. As can be seen in Table 4, there were some differences with Study 1. Similar to the results above, the results for MMR skepticism showed a (small) effect of faith in science, and no effect of spirituality. However, we again observed that there was an initial effect of spirituality,  $\beta = .20$ ,  $p < .01$ , 95% CI =  $(.04, .27)$ , which became nonsignificant upon adding faith in science and scientific literacy to the model. A bootstrapping analysis of 5000 samples (Preacher and Hayes, 2004; Process Macro Model 4) confirmed that the negative effect of spirituality was fully mediated by (low) faith in science, with an indirect effect of  $.06$  ( $SE = .02$ ), 95% CI =  $(.02, .12)$ . Scientific literacy was again a significant predictor and there was an additional effect of religious orthodoxy. As in Study 1, societal impact

concerns explained additional variance. For hPV skepticism, the effect of spirituality was significant, while faith in science was not. Scientific literacy was a significant predictor, and there was a negative effect of trust in traditional media.

**Genetic modification.** The final model explained 32% variance. Contrary to our third prediction and the results of Study 1, scientific literacy was not a significant predictor of GM skepticism. Also contrasting the results of Study 1, spirituality was not a significant predictor ( $\beta = .12, p = .11$ ). We did observe an effect of low faith in science, as well as an additional small effect of moral purity concerns (which is in line with previous work; e.g. Scott et al., 2016) and of gender (male participants were more skeptical). Finally, concerns about the societal impact of accepting GM contributed substantially to the explained variance.

**Evolution.** As in Study 1, and supporting our fourth prediction, evolution skepticism was primarily predicted by religiosity. Since we did not have a measure of religious identity in this study, the strongest predictor in this analysis was religious orthodoxy, which together with low faith in science accounted for 19% of the explained variance. None of the additional predictors were significant.

**Faith in science and science support.** As in Study 1 and confirming our main prediction, spirituality was the strongest negative predictor of general faith in science. There was also a small effect of gender (female participants indicated a stronger faith in science). In addition, conspiracy thinking was a negative predictor and trust in traditional media was a positive predictor. There was also an unexpected small positive effect of perceived corporate corruption of science. The final model explained 24% variance.

As in Study 1, faith in science was the strongest predictor of the willingness to support science. However, contrasting our main prediction and the results of Study 1, there was no initial effect of spirituality on science support. In addition, there was a small negative effect of political conservatism and a small positive effect of religious orthodoxy. None of the additional predictors further contributed to the 12% explained variance in the final model.

## 4. Discussion

The primary goal of the current research was to investigate the heterogeneity of science skepticism beyond the US cultural context. Results of two studies partially mirror results obtained previously among US participants (Rutjens et al., 2018b), while at the same time highlighting various important—and largely predicted—cultural differences, most notably regarding the role of religiosity versus spirituality. Overall, the current studies again confirm the heterogeneous nature of science skepticism, as observed previously (Rutjens et al., 2018b). The most important similarities and differences with previous work are discussed below.

### *Hypothesized effects*

Our main prediction was that spirituality would replace religiosity as a key contributor to skepticism about vaccination, low general faith in science, and unwillingness to support science. Results largely supported this prediction. Vaccination skepticism as measured with the “vaccination causes autism” item was predicted by spirituality but not religiosity in Studies 1 (direct effect of spirituality) and 2 (indirect effect of spirituality via faith in science). The same pattern of results was found for MMR vaccine skepticism—although in Study 2 (but not in Study 1) religious orthodoxy was a

significant predictor as well—and hPV vaccine skepticism. Low general faith in science was best predicted by spirituality in both studies, although there was a small additional effect of religiosity in Study 1 as well. Unwillingness to support science was predicted by spirituality—via low faith in science—but not religiosity in Study 1. However, this was not the case in Study 2, where besides low faith in science, there was a small effect of religious orthodoxy but no effect of spirituality. In sum, results for vaccine skepticism and general faith in science provide robust evidence for our main prediction, but the evidence provided by the results for science support is inconclusive.

In Study 2, we also found that spirituality was negatively related to climate change skepticism. Although not predicted and no such relation was observed in Study 1, this is an interesting effect that fits previous work on how spirituality is related to pro-environmental attitudes (Garfield et al., 2014). Moreover, this finding also further confirms the importance of acknowledging the heterogeneity of science skepticism (i.e. spiritual individuals are not simply skeptical about science across domains; in some instances, they might even be *less* skeptical).

The second prediction was that political conservatism predicts climate change skepticism but not other manifestations of science skepticism. Although results of a recent cross-national survey indicate that political conservatism as a main antecedent of climate science skepticism (Hornsey et al., 2018a) might be an exclusively North American phenomenon, we hypothesized that political conservatism would be the main ideological antecedent of climate science skepticism.<sup>7</sup> Results provided partial support for our prediction; there was a small but significant effect in Study 1, but the effect of political conservatism in Study 2 was not significant. Thus, the association between political conservatism and climate change skepticism was weaker than that observed in previous research among US participants (Rutjens et al., 2018b; also see Hornsey et al., 2018a).

The third prediction was that low scientific literacy is the main driver of GM skepticism and contributes to vaccine skepticism. GM has been observed to be one area of science in which skepticism is primarily associated with a lack of scientific literacy, as opposed to individual differences in ideology or beliefs (McPhetres et al., 2019; Rutjens et al., 2018b). The current research provides partial support for this hypothesis: Scientific literacy was a predictor of GM skepticism in Study 1 but not in Study 2. A stronger and more consistent predictor of GM skepticism was societal impact concerns, which we will get back to shortly. Spirituality also contributed to GM skepticism in Study 1, which suggests that there might yet be a belief-component to GM skepticism. Future work should further investigate this possibility, ideally across various cultures. We had also predicted that scientific literacy contributes to vaccine skepticism, but support for this prediction was only found in Study 2.

Finally, the current work provides robust evidence for the fourth prediction that religiosity is the prime driver of evolution skepticism.

### *Additional effects*

Recent research has identified conspiracy thinking as an important precursor of vaccine skepticism in particular (e.g. Hornsey et al., 2018b; Jolley and Douglas, 2014). In the current work, we measured conspiracy thinking alongside a number of additional potential predictors of science skepticism. Although conspiracy thinking was a consistent additional predictor of low general faith in science—which is interesting and warrants future work on this relationship—its unique explanatory power in predicting domain-specific science skepticism consistently in both studies was both modest and inconclusive. It is of course possible that a domain-specific measure of conspiracy belief (e.g. exposure to conspiracy content specifically targeting vaccines; Jolley and Douglas, 2017) rather than the current measure—which tapped into a general tendency to engage in conspiracy thinking—would have been a more potent predictor of domain-specific skepticism.

A more robust predictor of vaccine and GM skepticism is the extent to which participants were concerned about the societal impact of accepting the mainstream scientific conclusions that these are safe technologies (Sutton et al., 2018). In other words, perceptions of how dangerous acceptance is uniquely contributed to skepticism. This is a promising observation, given that such perceptions are likely malleable (unlike ideology and belief; see Rutjens et al., 2018a) and as such might be used to inform possible interventions to reduce skepticism beyond merely addressing information deficits or increasing literacy (which is with the exception of GM often not a successful strategy; e.g. Brossard and Lewenstein, 2010; Drummond and Fischhoff, 2017; McPhetres and Zuckerman, 2018; Rutjens et al., 2018b).

### *Spiritual and/or heterogeneous skepticism*

Previous work conducted in the United States has highlighted religiosity as a consistent predictor of vaccine skepticism as well as of general trust in science and attitudes to science (Rutjens et al., 2018b, also see McPhetres and Zuckerman, 2018). The current studies find that religiosity does not play a major role, except in predicting skepticism about evolution. Instead, spirituality was the most consistent predictor of vaccine skepticism and general faith in science, and there was some evidence for an association of spirituality with GM skepticism and willingness to support science (Study 1). Importantly, this does not imply that all science skepticism as investigated in the current work is related to spirituality. First, the findings for evolution skepticism show that it is possible to meaningfully distinguish spirituality from religiosity (spirituality did not contribute to evolution skepticism). Second, spirituality did not contribute to climate change skepticism. As mentioned earlier, in Study 2, we even observed a negative relation between spirituality and climate change skepticism. An additional point about spirituality is that it could mean different things to different people (e.g. Lindeman et al., 2019); future research should look more closely at the various ways in which individuals define their spirituality and how these relate to attitudes toward science.

Thus, corroborating previous work among American samples and confirming the heterogeneity of science skepticism, climate change skepticism is found to be—somewhat—political, while evolution skepticism is primarily fueled by religiosity. In addition, the added explanatory power of the other predictors that were included—such as scientific literacy, societal impact concerns, and also demographics such as age—vary considerably per domain. Moreover, the fact that various factors contributed—to various degrees—to vaccine skepticism, GM skepticism, and general faith in science, further speaks to this heterogeneity and points to the complexity and multi-faceted nature of these beliefs. These observations notwithstanding, however, only one variable was found to contribute most consistently and substantially to general faith in science and skepticism about vaccines; that variable is spirituality.

### *Limitations and considerations*

One important limitation of the current work is its correlational nature. We therefore need to be careful in inferring any causal relations. However, it is worth considering the likely direction of causality that underlies the observed associations; it is unlikely that relatively stable individual differences in political conservatism, religiosity, or spiritual beliefs will change because of fluctuations in skepticism about science. In other words, we cautiously interpret the current results as showing that relatively stable differences in ideologies and beliefs underlie various manifestations of science skepticism. Another limitation concerns the use of convenience samples that are not

necessarily representative of the entire Dutch population, although it should be noted that the current samples are demographically more diverse than student samples (see Table 1).

The current research demonstrates that the notion of heterogeneous science skepticism extends beyond the US cultural context and thus speaks to the external validity and generalizability of previous work (Rutjens et al., 2018b). Given the well-documented problems with generalizability in the social sciences (Henrich et al., 2010), the current corroboration and extension of previous work on science skepticism among Dutch individuals is an important first step. Here, it needs to be considered that the Dutch score relatively high on various indices of spirituality as compared with inhabitants of other secularized countries (De Hart, 2014; Van Mulukom et al., in press). Future studies should therefore extend this work by systematically testing the antecedents of science skepticism in samples drawn from a variety of other cultural contexts.

## 5. Conclusion

We show that in two community samples drawn from a secular Western European population, the Netherlands, climate science skepticism is modestly related to political conservatism, evolution skepticism is grounded in religiosity, and skepticism about vaccines—as well as low general faith in science—is predominantly grounded in spirituality. Thus, in the secularized cultural context of the Netherlands, contemporary spirituality is a key contributor to science skepticism. Given that science skepticism is on the rise in secularized countries in particular—with the recent decline in vaccine uptake in various non-US Western countries as a prominent example of its consequences (e.g. Hornsey et al., 2018b; Pierik, 2017); only 59% of the public in Western Europe believe that vaccines are safe (Wellcome Global Monitor, 2018)—it is important to further scrutinize the relation between spirituality and science skepticism.

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## Supplemental material

Supplemental material for this article is available online.

## Notes

1. Most research that has looked at morality has focused particularly on moral purity concerns and how these relate to skepticism about vaccines and GM (e.g. Amin et al., 2017; Rutjens et al., 2018b; Scott et al., 2016).
2. Terms related to science (skepticism), climate change, and so on were avoided. The survey was advertised as being about “various societal issues.”
3. Because of the specificity of the vaccines–autism item, we included two additional items: “I believe that the MMR vaccination has negative side effects that outweigh the benefits” and “I believe that the HPV vaccination has negative side effects that outweigh the benefits” (based on items used in previous research; Rutjens et al., 2018b). Results for all three items were quite similar, see the “Results” section for details.
4. In the interest of brevity, we selected the two highest loading items from previous work (Rutjens et al., 2018b).

5. Concerns about the societal impact of accepting evolution were not measured.
6. Except for the effect of age, which indicates that older participants were more skeptical. Although this seems unsurprising, this relation was not consistently observed in previous work (i.e. only in one out of four studies; Rutjens et al., 2018b).
7. Note that the Netherlands was not included in the aforementioned cross-national survey (Hornsey et al., 2018a).

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