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ATTITUDES TOWARDS SCIENCE

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ABSTRACT

As science continues to progress, attitudes towards science seem to become ever more polarized. Whereas some put their faith in science, others routinely reject and dismiss scientific evidence. The current chapter provides an integration of recent research on how people evaluate science. We organize our chapter along three research topics that are most relevant to this goal: ideology, motivation, and morality. We review the relations of political and religious ideologies to science attitudes, discuss the psychological functions and motivational underpinnings of belief in science, and describe work looking at the role of

morality when evaluating science and scientists. In the final part of the chapter, we apply what we know about science evaluations to the current crisis of faith in science and the open science movement. Here, we also take into account the increased accessibility and popularization of science and the (perceived) relations between science and industry. (147 words)

Keywords: science; belief in science; anti-science; motivation; ideology; religion; morality; control; order; existential meaning; popularization of science; open science

1. INTRODUCTION

As scientific knowledge continues to accumulate, attitudes towards science appear to have become increasingly negative. Although modern history is replete with examples of controversy sparked by science, it has been suggested that public distrust in science is once again on the increase (e.g., recurring contentious topics in the public debate are climate change, vaccination, and genetically modified organisms [GMO]), and that an anti-science movement is growing (e.g., Gauchat, 2013; Nature editorial, 2017a; Pittinsky, 2015). Many

organizations dedicated to the advancement of science have expressed concerns about the risks of a further decline of trust in science as an institution (e.g., KNAW, 2013; Nature editorial, 2017b). At the same time, surveys show that science is a highly respected profession (e.g., Harris Poll, 2014) and that—in the Netherlands—science as an institution is trusted more than various other institutions, including media, government, and the court of law (KNAW, 2013). Why do some people put their faith in science, whereas others flat out reject scientific evidence and distrust science and scientists? The current paper reviews and integrates our recent research into the antecedents and consequences of how science is evaluated (both positively and negatively), with the aim to foster an understanding of the polarized attitudes towards science that characterize our time. In addition, we relate these insights into the antecedents of attitudes towards science to recent changes in the ways in which science is conducted and disseminated.

1.1. Cognitive constraints to science understanding

Research in social and cognitive psychology has explored attitudes towards science from a number of different perspectives. Initially, research focused mainly on the *cognitive constraints to understanding science*, a perspective that exerts a certain educational (and sometimes perhaps even patronizing) attitude towards the public. We start with providing a brief overview of the most important insights that this research has generated.

Several theoretical and empirical accounts describe how science is hard to understand and learn, that is, that it does not come naturally to humans. Unlike religious belief, science understanding requires cognitive skills that are not easily acquired (McCauley, 2011; Shtulman, 2017). In other words, many features of science are cognitively unnatural: scientific theories can be “radically counterintuitive” (McCauley, 2011, p. 107-117), and learning about them and genuinely understanding the scientific processes involved requires substantial scientific training. Blancke, De Smedt, De Cruz, Boudry, and Braeckman (2012) reviewed some of the most prominent cognitive biases hampering the understanding and acceptance of evolutionary theory, which are essentialism, teleology, and intuitions about agency and intentionality (which is also referred to as the intentional stance; Dennett, 1989). These biases have been applied to science understanding more generally as well, and we briefly describe each below.

People intuitively perceive the natural world as emerging from invisible and immutable essences, which carve the world into homogenous and discrete categories (Gelman, 2003). This tendency, termed psychological essentialism, has been documented in diverse samples around the world (Henrich, Heine, & Norenzayan, 2010). Essentialist thinking tends to be simple, unfalsifiable, and relies on imagined and invisible forces for understanding the natural world. Importantly, it can lead people to misunderstand scientific accounts of the world (see Heine, 2017, for a review). As one example, people who engage in more essentialist thinking are more likely to misunderstand evolutionary theory, because they tend to see species as more homogeneous and discrete categories (Evans, 2001; Shtulman & Schulz, 2008). The drawbacks of psychological essentialism have been particularly evident in the ways that people make sense of genetic concepts (Dar-Nimrod & Heine, 2011). Because genes share so many features that overlap with people's understandings of essences (they are invisible, they can be transmitted across generations, they divide the social and natural world into discrete and homogeneous categories, they are natural, they exist unchanged from conception to death, they are unique to individuals, and they help make an individual who he or she is), people frequently understand genetic concepts in ways consistent with psychological essentialism (see Heine, Dar-Nimrod, Cheung, & Proulx, 2017). Indeed, whereas many surveys reveal that the lay public has a rather limited understanding of genetic concepts (Christensen, Jayaratne, Roberts Kardia, & Petty, 2010; Lanie et al., 2004), people nonetheless make attributions to genetics on a regular basis, such as companies touting that "innovation is in their DNA," to Donald Trump attributing his success to him having "a certain gene" (Heine, 2017). Moreover, much research finds that when people learn that genes are involved in a human trait, they come to think of that trait in terms that are more like an essence, regardless of whether that trait involves sexual orientation, ethnicity, mental health, violence, sex, or obesity (see Heine et al., 2017, for a review). This tendency to misunderstand concepts that are linked to genes is especially problematic because, as the first law of behavioral genetics reminds us, genes are involved in virtually *all* human traits (Turkheimer, 2000), but their impact is far more complex and involves a far more complex interplay of genes than people assume. Thus, the human tendency to seek essences to explain the natural world contributes to a general misunderstanding of science.

Teleology, or the assumption that there is purpose to the ways in which animals, plants, and natural phenomena are structured and function, is another cognitive obstacle to science understanding. Although so-called ‘promiscuous teleology’ (Kelemen, 1999) is particularly strong in children, it is also found among uneducated adults, as well as Alzheimer’s patients (e.g., “It rains so that plants and animals have water to drink and grow”; Lombrozo et al., 2007). Indeed, even schooled adults and professional scientists are prone to an *intuitive* teleological bias, that is, when under time pressure they show an automatic tendency to reason about the natural world in teleological ways (Kelemen, Rottman, & Seston, 2013).

Finally, the human mind is hardwired to detect intention and infer agency, in particular when there is a need to interpret changes in the environment (Guthrie, 1993; Newman, Keil, Kuhlmeier, & Wynn, 2010; van Elk, Rutjens, van der Pligt, & van Harreveld, 2016). This cognitive mechanism is a feature of our minds that has been argued to be biologically evolved (Haselton & Nettle, 2006) and to confer an adaptive advantage. Just like inferring purpose (i.e., teleology), inferring intention reflects a cognitive bias that can impair science understanding (consider evolutionary theory, the second law of thermodynamics, or general relativity: these perspectives all leave little room for purpose or intention, which contributes to their counterintuitiveness).

In sum, science often contradicts (flawed) human intuitions about what reality consists of and how things work, which spring from a set of evolved cognitive biases¹. Many scientific theories—including evolutionary theory, spherical earth theory, general relativity, and quantum mechanics—are highly counterintuitive, and this counterintuitive nature impairs science understanding.

1.2. Beyond cognitive constraints: ideology, motivation, and morality

It is not just that people reject science because they lack the ability to understand it; oftentimes people reject science because it runs afoul of the way they prefer to think. Most of the research reviewed in this chapter will focus on the latter. Recently, researchers, in

¹ It is interesting to note that the same cognitive biases that hamper science understanding have been argued to *facilitate* religious belief, particularly according to so-called cognitive byproduct theories of religion (Atran & Norenzayan; Barret, 2000); we will return to religion in Section 2.

particular social psychologists, have started to pay increased attention to the motivational and ideological antecedents of science understanding. These analyses closely resemble the ways in which social psychologists, alongside political scientists and psychology of religion scholars, have been investigating the intrapsychic motivational underpinnings of political ideology and religious belief. Indeed, social psychology as a field has a longstanding interest in political ideology (e.g., see the journal *Political Psychology*; also see Kay & Brandt, 2016) and religious belief (e.g., *International Journal for the Psychology of Religion*; a *Personality and Social Psychology Review* special issue on religion, Sedikides, 2010; also see Laurin and Kay, 2017). However, work on the ideological and motivational underpinnings of science acceptance and rejection is a relatively recent endeavor. This is striking, because our time is not only characterized by religious and political disagreements and conflicts, but also by a ‘politicization of science’ (Gauchat, 2012) and high levels of public ambivalence toward the scientific enterprise (e.g., Nagy, Wylie, Eschrich, & Finn, 2017; Pittinsky, 2015). This ambivalence has been argued to stem, among other things, from people’s moral objections against particular scientific findings (e.g., intuitive opposition to GMOs; denial of anthropogenic climate change; vaccine skepticism; Bain et al., 2012; Blancke et al., 2015; Lewandosky & Oberauer, 2016; Rutjens, Sutton, & van der Lee, under review; Scott et al., 2016), but also from the perceived motivations and agendas of science and scientists (e.g., Gleick et al., 2010; Rutjens & Heine, 2016).

The current chapter focuses on recent research that aims to uncover which ideological, motivational, and moral processes shape attitudes toward science and what it entails to believe in science. When do people embrace science and when do they reject scientific evidence, and how do they evaluate science as an enterprise and scientists as the agents that represent this enterprise? We aim to provide a comprehensive overview of the recent work on motivated evaluations of science, by reviewing and integrating three recent lines of research: 1) the relations of religious belief and political ideology to attitudes towards science, 2) the existential-motivational underpinnings and functions of belief in science; 3) the effects of morality on evaluations of science and scientists. As we will see, conservative ideology (in particular, conservative religious and political beliefs) generally is negatively related to science acceptance, and the same negative relation applies to moral concerns and science. Intrapsychic motivations, however, can both pull people towards and

push people away from science, and this depends on particular features of scientific theories and evidence, as well as on the extent to which people endorse science and scientific progress as a worldview. In the last part of the chapter, we highlight the societal relevance of science attitudes and discuss some of the ways in which public confidence in science might have recently been eroded, but also how recent developments might restore trust in science.

2. IDEOLOGY: RELATIONS OF RELIGIOUS AND POLITICAL BELIEFS TO SCIENCE ATTITUDES

Two predictors of attitudes towards science, which may help to determine to what extent certain people will accept or dismiss scientific evidence, are religious belief and political ideology. Initially, scholars particularly focused on political conservatism as a predictor of science skepticism. In addition to conservatism, these scholars have also looked at other individual difference variables, in particular conspiratorial thinking style, or conspiracist ideation (Douglas & Sutton, 2015; Lewandowsky et al., 2013a; 2013b). In recent work, we found that the predictive value of political conservatism depends on the topic that is being evaluated: Not all science skepticism is equal, whereas religion more consistently predicted science rejection and skepticism (Rutjens et al., under review). These results resonate with a long-standing research tradition that documents the tense relation between science and religion. We will first turn to research on political ideology and the science-religion relation, after which we will continue with an overview of science skepticism resulting from perceptions of agendas and conspiracies that bias scientific methods and conclusions.

2.1 Religion and politics: The heterogeneity of science skepticism

Many of the topics that have the professional interest of scientists are of relevance to people's ideological convictions. Three examples that psychologists and social scientists have particularly focused on—and that have already been mentioned earlier in this chapter—are climate science, childhood vaccination, and genetic modification of organisms (GMO). These are contentious topics—at least outside the scientific community—that many

people have strong opinions about. Other contentious topics, some of which fall in other categories than the aforementioned environmental and biomedical sciences, are evolution, nanotechnology, equality, and drugs and health (Blancke et al., 2012; Brossard, Scheufele, Kim, & Lewenstein, 2008; van der Lee & Ellemers, 2017; Sutton, Lee, & Hartley, under review).

Several authors have pointed to an increase in distrust in science that is particularly visible among conservatives (e.g., Gauchat, 2012; Pittinsky, 2015). Evidence for political conservatism as an antecedent of science skepticism, particularly pertaining to climate change denial, comes from a program of research conducted by Lewandowsky and colleagues (Lewandowsky et al., 2013a; 2013b; Lewandowsky & Oberauer, 2016). Political conservatism, alongside endorsement of free-market economics, has been found to reliably predict skepticism about anthropogenic climate change. One obvious reason for this is that potential policy implications of acknowledging climate change as problematic generally does not fit well with social and economic conservatism (also see Campbell & Kay, 2014). A recent meta-analysis confirms the association between political conservatism and climate change skepticism (Hornsey, Harris, Bain, & Fielding, 2016). However, no such robust association was obtained for anti-vaccine attitudes. On the contrary, vaccine skepticism has been reported to be slightly more pronounced among progressives (Lewandowsky et al., 2013). In a similar vein, researchers have failed to find an association between political ideology and GMO attitudes (see also Kahan, 2015; Scott, Inbar, & Rozin, 2016). Thus, when the aim is to predict science rejection more generally, just having access to an individual's political beliefs is not sufficient.

To test more systematically the ideological underpinnings of science acceptance and rejection, we recently conducted a series of online studies with US participants in which we measured political ideology and religious belief as potential antecedents of skepticism about climate change, vaccines, and GMOs (Rutjens et al., under review). Moreover, in doing so, we controlled for moral concerns, scientific literacy (see Hayes & Tarick, 2000; Kahan et al., 2012), and demographic variables, and we included measures of general faith in science (Farias et al., 2013) and a behavioral measure of willingness to support science. This measure consisted of a pie chart presented to participants that included various spending areas, one of which was science. Participants were instructed to rearrange the areas in

order of spending budget, reflecting their preferred order of prioritization. We then simply assessed how much priority participants gave to science.

One of the triggers of this work was that we observed that religious belief is given surprisingly limited attention in the bulk of the aforementioned work on science skepticism. This is striking, given the tense relation between science and religion that is the focal point of much theoretical and empirical work, a point that we will return to in the next paragraph. Another reason for us to *simultaneously* include various measures of political ideology and religious beliefs, alongside moral concerns and knowledge about science (scientific literacy), was that these variables intercorrelate and are therefore potentially confounded. Political conservatives, for example, are on average more religious than liberals (Layman, 2001; Malka et al., 2012), and conservatives and religious believers alike emphasize traditional moral values, for example those values that pertain to purity and naturalness (e.g., Graham et al., 2009; see also Piazza & Sousa, 2014).

Our findings, obtained in three studies, were largely consistent and highlighted the importance of religiosity as a predictor of science acceptance and rejection. Using hierarchical regression analyses, we found that climate change skepticism was best predicted by political conservatism. This corroborates earlier work (Lewandoswky et al., 2013b; Hornsey et al., 2016). In contrast, vaccine skepticism was best predicted by religiosity and moral purity concerns. Political conservatism did not play a meaningful role. We also observed that, among the religious participants, the more orthodox ones were skeptical about vaccines because of a low general faith in science. Furthermore, neither political nor religious ideology predicted GMO skepticism. Rather, faith in science and scientific literacy were the strongest negative predictors of GMO skepticism. General belief in science and the willingness to support science (through the allocation of monetary resources to science) were best predicted by religious orthodoxy.

Thus, the above research speaks to the heterogeneous nature of belief in science and science skepticism: We concluded from these findings that political ideology and religiosity independently predict science acceptance and rejection, depending on the topic of investigation. Of course, besides the 'ideologically contentious' topics that the above research addresses, there are many other topics of investigation in science that are less

ideologically fueled or perhaps even well aligned with political and religious convictions (e.g., imagine research yielding evidence that married people live longer and healthier lives, research on biological sex differences, or archeological evidence for the existence of Jesus Christ). However, returning to our research, we concluded that—when competing for explained variance with other potential predictors—political conservatism only reliably predicted climate change skepticism. Religious identity and religious orthodoxy were identified as the main predictors of skepticism about vaccination and of general belief in, and willingness to support, science. Over and above religious identity, concerns about moral purity and naturalness also helped predict vaccine skepticism. Next, we discuss these results in light of the complex relationship between science and religion.

2.2 Science and/or religion

It is not an exaggeration to state that the relationship between science and religion has been tense and contentious throughout history (leading to outbursts of conflict when new scientific theories clashed with conventional religious doctrine, as was the case with Galileo Galilei's heliocentric model or Darwin's theory of evolution by natural selection). Both science and religion ask the most basic of questions that surround existence: How do we explain our world, how did life evolve, and why are we here? And both formulate (often very different) answers to these questions, by providing ultimate explanations for life and the universe that can be at odds with each other, thereby invalidating each other's authority (e.g., in the case of evolution by natural selection). Another way of putting this is that science and religion both function as ultimate (and therefore incompatible) explanatory frameworks or belief systems (Blancke et al., 2012; Farias, 2013; McCauley, 2011; Preston & Epley, 2009; Thagard & Findlay, 2010), which stands in contrast to the position that science and religion cover different domains of knowledge (i.e., they should be understood as non-overlapping magisteria; Gould, 1997). Proponents of the latter position might also argue that science is based on having faith in observation, while religion is based on having faith in that which transcends observation.

The incompatibility of science and religion has also been tested in the psychology lab. For instance, Preston and Epley (2009) showed that scientific and religious explanations are automatically opposed, so that exposure to a poor (strong) explanation in one domain

enhanced (reduced) positive evaluations of explanations in the other domain. However, other research has shown that people in some cases also *synthesize* religious and scientific explanations, and that these explanations can co-exist. For example, children as well as adults have been found to combine magical thinking and science to explain AIDS (Legare, Evans, Rosengren, & Harris, 2012) and to endorse natural and supernatural explanations simultaneously for the same unusual event (Wooley, Cornelius, & Lacy, 2011). One often-quoted reason for the tense relation between scientific and religious explanation goes back to the cognitive biases described in the first part of this chapter, which tend to facilitate religious explanations (which align neatly with these biases; Atran and Norenzayan, 2004) while at the same time constraining scientific explanations (which are often counterintuitive; McCauley, 2011). Another, more motivational reason for the tension between science and religion—that we have discussed in our own research as well—is that scientific and technological breakthroughs sometimes run counter to deeply held religious values, for example, in the case of stem cell research and genome editing (Heine et al., 2016; Rutjens et al., 2016). Another example from a different science domain is paleontological evidence for the age of the earth. With all this in mind, it is not surprising that our research on the heterogeneity of science skepticism found religious orthodoxy to be the most reliable negative predictor of general faith in science and the willingness to support science.

A third catalyst of the tension between science and religion—which likely also plays a role alongside motivation in the example of stem cell research and genome editing above—is *morality*. The argumentation goes as follows: First, religion and morality are closely intertwined in people’s minds, and resulting from this is that belief in God is seen by many as a necessary component for moral living (Gervais, 2014; McKay & Whitehouse, 2015; Norenzayan, 2014; Pew, 2014). Second, scientific explanation is often at odds with religious faith, as described above. These observations combined make it clear that science and morality might not sit well together and might in many cases be hard to reconcile. In addition, science may also be viewed as morally suspicious because advances in science and technology are frequently associated with societal pessimism, erosion of moral values, and technological disaster (Gray, 2004; Rutjens et al., 2016). Besides the earlier examples of stem cell research and genome editing, other examples that are not directly problematic in

religious terms are atomic energy, artificial intelligence, and superbugs. Here, moral concerns pertaining to harm and purity might play a more prominent role than religiosity. We will delve deeper into morality in Section 4, in which we review research that investigated the impact of moral concerns on science attitudes.

2.3 Agendas and conspiracies

In the previous sections, we have reviewed research on the political and religious antecedents of science acceptance and rejection. But science is itself a social enterprise—conducted by individuals with their own ideological values and ideas—and awareness of this notion can lead people to question the motives of the scientists. In this section, we review research looking at perceptions of biased agendas of scientists, and then at conspiracy beliefs pertaining to science. (In section 4, we will delve more directly into stereotypes about scientists.)

Science is often idealized as the pursuit of knowledge in its purist form. The sociologist Merton (1942) articulated this understanding of science as a set of norms. According to one of these norms, *disinterestedness*, scientists (and their institutions) should not act to further their own personal gain, but instead only in the interest of furthering knowledge. The *communalism* norm requires that scientists should share their methods and results openly, so that they are the property of the community rather than any particular researcher or institution. The *organized skepticism* norm requires that scientists should set aside their values and convictions in order to subject all claims of fact to detached critical scrutiny. The *universalism* norm requires that access to scientific pursuits should be free to all. This means that evaluations of scientists' work, their career progression, and the resources made available to them should depend only on their competence, and not any other characteristic (e.g., their nationality, ethnicity, political beliefs, or gender).

Any seasoned scientist reading this will immediately recognize that these norms are *ideals* that science falls short of, both regularly and systematically. Nonetheless, to varying degrees, scientists seem to internalize these norms (Anderson, Martinson, & De Vries, 2007) and present science to the world as if it were a purely value-free, dispassionate, Mertonian enterprise (Gieryn, 1999). Mandel and Tetlock (2016) argue that this characterization of science is not only an idealization but a “myth”, since science serves a range of social functions besides the production of knowledge. Nonetheless, it has a powerful effect on

how scientists and the public evaluate science. On the upside, it motivates genuine reform movements designed to improve research practices. On the downside, it fuels derogation of science on the grounds that in specific ways it falls short, or is alleged to fall short, of its ideal standards.

2.3.1. Biased agendas. One shortcoming of science is that women and ethnic majorities appear to be systematically disadvantaged in scientific education, career progression, and research funding – in violation of Merton’s (1942) universality norm (Moss-Racusin et al., 2012; van der Lee & Ellemers, 2015). This has triggered systematic efforts to redress the balance, such as the Athena SWAN Charter in the UK (Donald, Harvey, & McLean, 2011), in which universities are accountable for their efforts to promote gender equality, and more recently, other forms of diversity. However, to date, interventions to promote diversity are seldom conducted and evaluated systematically, and may provoke resentment and backlash effects (Moss-Racusin, van der Toorn, Dovidio, Breckoll, Graham, & Handelsman, 2014; van der Lee & Ellemers, in preparation). Though the predominance of particular gender and ethnic groups in science can be seen to affect its priorities and color its conclusions, it does not appear to have caused widespread questioning of the truth value of scientific research in the media or the public imagination.

This sanguinity may be starkly contrasted with reactions to another demographic bias in the scientific community. There is good evidence that the makeup of the social-scientific community is heavily biased in favor of liberals; conservatives, for example, are massively under-represented relative to the overall population. Further, there is evidence that liberals are promoted more quickly than conservatives, suggesting a further violation of the Mertonian norm of universalism. Critics both within and outside the scientific community have cast doubt on scientific research on the grounds of this bias (e.g., Duarte, Crawford, Stern, Haidt, Jussim, & Tetlock, 2015). In Mertonian parlance, this particular prima facie violation of universalism is argued to lead to violations of both organized skepticism (scientists are insufficiently critical of results that are congenial to liberal ideology) and of disinterestedness (scientists conduct research to advance liberal causes). Indeed Duarte et al. (2015, p. 1) explicitly link this to the so-called reproducibility crisis (see Section 5.1 below) when they write that “one largely overlooked cause of failure is a lack of political diversity”, which they propose “would improve the reliability and validity of social psychological science”. The liberal bias has been widely covered in the media (e.g., Huffington Post UK,

March 2015), with stories that cast doubt over the validity and integrity of research. This suggests that public awareness of a liberal bias in the scientific community can have negative effects on public acceptance of science findings.

2.3.2. Conspiracy theories. It is bad enough for scientists when they are perceived to have some kind of agenda that biases their methods and conclusions. Worse, they are sometimes seen, whether in the pursuit of this agenda or sheer self-interest, to be colluding with each other to distort, conceal, and falsify their results. In other words, they find themselves to be at the centre of conspiracy theories: beliefs that individuals, usually powerful, are acting together in secret to accomplish some selfish, usually malevolent, goal (Sutton & Douglas, 2014). Secrecy, deception, and selfishness are profoundly incompatible with idealized notions of communal science (e.g., Merton, 1972). It is therefore no surprise that exposing people to conspiracy theories about climate and vaccination science leads to disillusionment with scientists and, in turn, reluctance to act in accordance with their findings – for example, by taking measures to mitigate climate change, or by vaccinating one’s children (Jolley & Douglas, 2014a, 2014b, in press; van der Linden, 2015). Our recent research also suggests that these conspiracy theories not only cause people to reject science but also lead to support for measures to effectively shut it down – for example by defunding and censoring scientific research, surveilling and sanctioning scientists, and preventing them from offering policy advice to government (Sutton, Douglas, & Petterson, in preparation).

Conspiracy theories about science would not present a major obstacle to public acceptance of science if they were confined to the fringes of society or endorsed only by psychologically troubled individuals, as the popular, derogatory stereotype of the “conspiracy theorist” would suggest (Husting & Orr, 2007). However, over a third of Americans agree that “global warming is a hoax”, according to a recent poll (Public Policy Polling, 2013). Other conspiracy theories about science, for example on vaccination, are less widely endorsed, but feature prominently in anti-science communication. For example, Bessi et al. (2015) found that anti-science conspiracy content was shared on Facebook roughly three times as often as science content. Crucially, even conspiracy beliefs that seem unrelated to the topic of climate change, such as those concerning the assassination of JFK, are robustly associated with skepticism about climate change (Lewandowsky et al., 2013).

One reason that conspiracy thinking contributes to the rejection of science is probably that it is very unlike scientific reasoning (Barkun, 2003; Lewandowsky et al., 2015). It does

not appear to respect principles of parsimony, as illustrated by studies that show people who accept conspiracy theories are also prone to committing reasoning errors (Brotherton & French, 2014). It is also tolerant of internal contradiction: Participants who endorsed the belief that Princess Diana faked her own death also tended to endorse the belief that she was murdered, apparently because of their commitment to the higher-order belief that the official account of her death is a cover-up (Wood, Douglas, & Sutton, 2013). Swami (2013) showed that conspiracy beliefs are correlated with measures of reliance on gut-level intuition rather than logic, and are decreased by manipulations that encourage analytical thinking. It is also associated with magical and teleological thinking, and in particular the so-called intentionality bias in which inanimate objects and systems are seen as sentient and motivated (also see Section 1.1 on cognitive constraints). In our own work (Douglas, Sutton, Callan, Dawtry, & Harvey, 2016), we showed that conspiracy thinking is associated with magical thinking (belief in causation by physically impossible means) and the perception that weather systems (Waytz, Cacioppo, & Epley, 2010) and moving geometrical shapes (Heider & Simmel, 1944) have intentions. Finally, although conspiracy theories may not always be falsifiable, conspiracy thinkers tend to be resistant to falsification, because they believe that disproofs and debunks offered by up authorities are not only unconvincing but may themselves be part of the ongoing conspiracy to cover up events and mislead the public (Jolley & Douglas, in press; Lewandowsky et al., 2015).

Another reason why conspiracy theories may have gained such purchase in the rejection of science is that, although it is possible to entertain conspiracy theories about any agents, they tend to focus on the alleged wrongdoings of institutions, elites, and authorities, including journalists, government officials, politicians, and, of course, scientists. Uscinski and Parent (2014) argue that “conspiracy theories are for losers” and provide historical data to suggest that conspiracy theories point the finger at incumbent more often than opposition groups and thrive among political groups that find themselves out of power. Sociologists have argued that conspiracy theories offer a way for disempowered groups to make sense of their situation and gain from that a compensatory sense of control. In keeping with these arguments, social psychologists have shown that people in disadvantaged minority groups (Crocker, Luhtanen, Broadnax, & Blaine, 1999) and those experimentally reminded of times in which they lacked personal control (Whitson & Galinsky, 2008) are more prone to adopt conspiracy theories. In the same vein, people whose worldviews are threatened by

consensually accepted scientific findings may turn to conspiracy theories that cast doubt on those findings and so provide compensatory validation of their beliefs.

Research has yet to offer a clear answer to how the attritional effect of conspiracy belief on acceptance of science may be countered. Studies indicate that attempting to debunk anti-science conspiracy theories yields mixed results. Recent research by Jolley and Douglas (in press) suggests that it is better to psychologically inoculate people by providing anti-conspiracy information before, rather than after, they are exposed to conspiracy theories – a result in keeping with the idea that conspiracy beliefs are resistant to falsification (also see van der Linden et al., 2017). Given that various studies have linked conspiracy theories to lower levels of education and analytical thinking, it is possible that education, especially educational interventions that focus on the development of analytical thinking skills, may ultimately prove effective (Douglas et al., 2016; Swami et al., 2013).

It is important to note that not all conspiracy theories are anti-science, just as not all are false (Douglas et al., in press). For example, we have drawn attention to the fact that conspiracy theories are used as ammunition by both sides of the so-called climate war (Sutton & Douglas, 2015). Whereas one side accuses scientists and governments of colluding to sow fear in the public imagination, the other accuses the oil industry, maverick scientists, and right-wing political stooges of colluding to sow doubt. The latter conspiracy theories have a meta-conspiracy character, suggesting that the claim that global warming is a hoax is itself being propagated as part of a broader conspiracy to discredit science. These conspiracy theories are, unsurprisingly, linked not to doubt but to belief in climate change, even after adjusting for the political polarization of belief in different conspiracy theories (conservatives favor anti-science conspiracies, whereas liberals favor anti-oil lobby conspiracies; Sutton, Douglas, & Petterson, in preparation).

3. MOTIVATION: PSYCHOLOGICAL NEEDS UNDERLYING BELIEF IN SCIENCE

Ideologies and worldviews, such as the religious and political beliefs—and indeed also the conspiracy beliefs—described in section 2, are shaped importantly by the psychological functions they fulfill: people want to adhere to certain political ideologies or maintain their religious beliefs because these help them to perceive the world in which they live as controllable, orderly, and (existentially) meaningful (e.g., Greenberg, Solomon &

Pyszczynski, 2009; Kay et al., 2010; Laurin & Kay, 2017; Proulx & Heine, 2006). These motivations can be classified as either leaning toward the epistemological (i.e., the need to learn about the world and be able to predict future outcomes) or as leaning toward the existential (i.e., the need to perceive the world and one's place in it as having purpose and significance). However, one should probably view the aforementioned motivations not as mutually exclusive dichotomous categories (that are either purely epistemological or purely existential) but rather as existing somewhere along a continuum; we would argue that the need to maintain perceptions of the world as orderly, under control, and meaningful all have both epistemological and existential aspects to them (also see Laurin & Kay, 2017; Rutjens et al., 2016).

As we mentioned in section 1.2, ample social psychological work has focused on the intrapsychic motivational underpinnings of religious belief and political ideology, and we refer the interested reader to a recent review of this work (Laurin & Kay, 2017). Importantly, in our own and others' research, results have shown that some of the same psychological needs for order, control, and meaning that shape religious and political beliefs *also shape evaluations of—and belief in—science*. Thus far in the chapter, we have seen that there are various ideological reasons why people are *negative* about science, but science can also function as a belief system in its own right that may fulfill important psychological motivations. We review this work below.

3.1. Psychological functions of science

Several important human motivations have been studied in the context of religiosity, including identity, belonging and attachment needs, self-esteem, control and order, uncertainty reduction, and (existential) meaning (Sedikides, 2010). Research on the motivational underpinnings of political ideology has mainly focused on how political beliefs relate to control and order needs and—to a lesser extent—existential meaning motives (Greenberg et al., 2009; Kay et al., 2010; Kay & Brandt, 2016).

Research on the motivational underpinnings and psychological functions of belief in *science* so far has predominantly focused on the order and control conferring qualities of science. Also, some work has focused on the viability of science as a source of existential

meaning. In the following section, we start with reviewing the main research results from our lab on science as a source of compensatory order and control.

3.1.1 Can science provide order and control?

We conducted the first test of the hypothesis that science can be used as a source of compensation when personal control is threatened, in a similar way as religious belief. We investigated whether compensation for low control could be conferred from both religious and scientific views on the origins of life (Rutjens, van der Pligt, & van Harreveld, 2010). Perceptions of control were manipulated using a recall task, in which participants were asked to remember a negative situation over which they had no (full) control and subsequently summarize the situation. After the recall task, they were also asked to provide three reasons that support the notion that the future is uncontrollable (controllable). Next, participants were presented with two of three different accounts on the origins of life: intelligent design, Darwin's Theory of Evolution, and a more contemporary (albeit contested) variation on evolutionary theory, which offers a view on evolution as an orderly and predictable process. The gist of the latter perspective was that processes of natural selection are bound by various laws, meaning that if evolution were to be replayed the results would be more or less the same. In contrast, the Darwinian perspective emphasized the randomness and unpredictability of evolutionary processes. The intelligent design perspective focused on the existence of a supernatural agent who to some extent controls the outcomes of human evolution. We asked participants to choose from pairs of the aforementioned theoretical accounts. The results indicated that a control-threat led to a preference shift in favor of intelligent design, but only when the alternative was Darwin's Theory of Evolution. When the alternative was an orderly view on evolution, this preference shift was not found. In addition, control-threat led to a preference shift in favor of an orderly view on evolution when the alternative was Darwin's Theory of Evolution. Thus, control-threat not only sparked a motivational push towards a religious view on evolution, but it also pushed participants to a scientific explanation, provided that this explanation was orderly. Thus, when lacking control, people seek order and prevention of (further) randomness, and they search for this both in religious and in scientific explanations about the world.

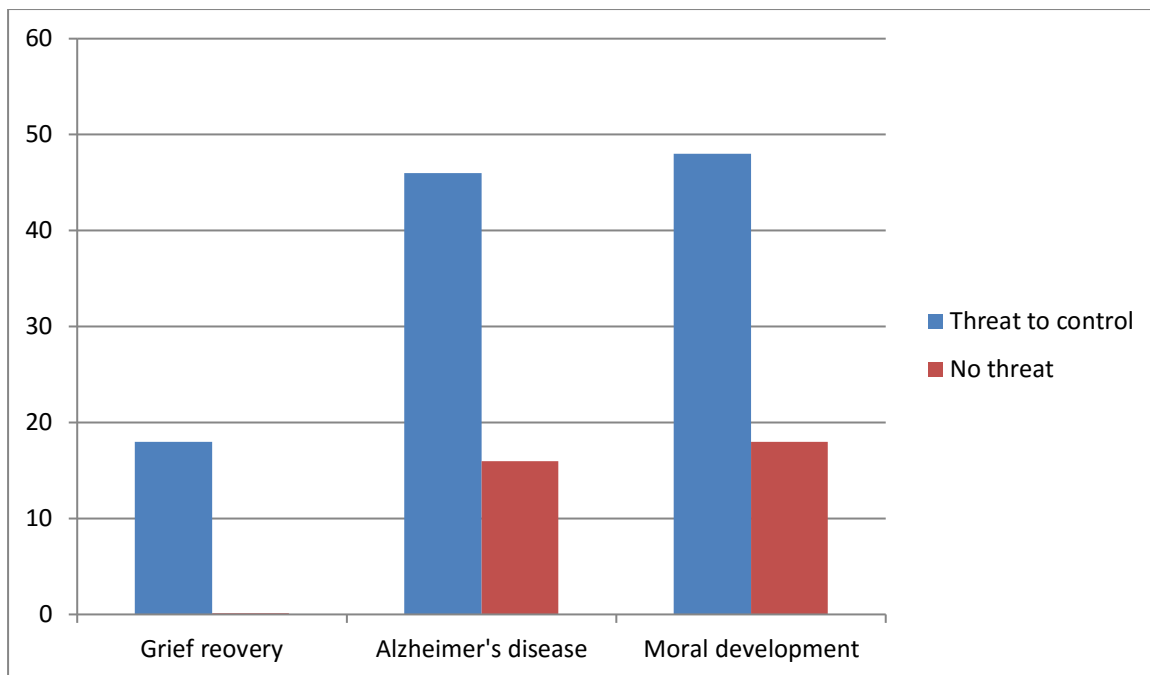
In a different set of studies (Rutjens, van Harreveld, van der Pligt, Kreemers, & Noordewier, 2013), we examined whether comparable preference shifts result from threats to personal control when participants are asked to choose between different, competing scientific theories about the same processes or phenomena, depending on the extent to which these theories provided order and predictability. To do so, we used short descriptions of stage theories and continuum theories within the domains of grief recovery, Alzheimer’s disease, and moral development. We hypothesized that when participants’ personal control was threatened, they would show an increased endorsement of scientific stage theories. Why would stage theories become more attractive as a result of control-threat? We built on the idea that stage theories help to structure reality, by molding a complex interplay of behavioral and environmental variables into a predictable and orderly sequence of discrete stages. Continuum theories do not confer that psychological advantage to the same degree, because these theories tend to describe processes and phenomena as gradual transitions without abrupt changes or discrete steps. The process is more fluid and lacks qualitatively different stages. Results of five studies supported our hypotheses, showing that a threat to personal control (using the same manipulation as described above; Rutjens et al., 2010) increased preference for stage theories of grief recovery, Alzheimer’s disease, and moral development (see Figure 1). We also found that a more direct threat to order perceptions (which we established by priming participants with randomness related words; see also Kay, Moscovitch, & Laurin, 2010) increased stage theory preference, and, in one study, we found that a motivated search for order underlay the preference shift. Here, participants were presented with an illusory pattern perception task; a set of grainy pictures of which some contained images and some did not. Consistent with previous work (Whitson & Galinsky, 2008), control-threat increased the number of reported patterns for pictures in which none existed. Moreover, illusory pattern perception mediated the effects of control-threat on stage theory preference: Participants in the control-threat condition were more motivated to impose order—resulting in the reporting of more illusory patterns—which in turn led to an increased preference for scientific stage theories.

Although threats to order and control can lead to a heightened embrace of science, learning about particular scientific findings can also lead people to *feel threatened*, which, in turn, can lead to a motivated rejection of these findings as facts. For example, Feinberg and

Willer (2010) found that particularly gloomy messages about global warming pose a threat to people's perceptions of order and control, which leads to less acceptance of the notion of anthropogenic climate change. Also, we know from other lines of work that threat can lead to conspiratorial thinking (e.g., Whitson & Galinsky, 2008), a thinking style which contributes to science denial (see Section 2.1; Lewandowsky, Oberauer, & Ginac, 2013a; Lewandowsky & Oberauer, 2016). Thus, when the aim is to understand the polarization of science attitudes, it is important to take into account the notion that both the acceptance of science (e.g., belief in a certain theory; a general faith in science) *and* the rejection of science (e.g., perceiving science as a conspiracy or certain findings as a 'hoax') can fulfill psychological needs related to order and control.

Taken together, the studies described in this section show that the motivation to perceive order and experience control shapes science evaluations and endorsement of scientific theories. It is important to note that it is not the case that all scientific perspectives and theories equally provide order or feelings of control. Many key scientific theories, such as evolutionary theory, general relativity, or quantum mechanics, are highly complex and counterintuitive and likely do not provide most people with a sense of order and structure. If anything, the opposite might be more likely. However, science and technology can also simplify people's lives and impose structure on a complex world; GPS helps us to navigate the world, cellphones help us to communicate over distance, and meteorology helps us—at least to some degree—to predict tomorrow's weather (Mesoudi et al., 2013; Rutjens, van Harreveld, & van der Pligt, 2013). In sum, for science to serve this important motivational function, it needs to provide theories that paint a picture of the world as orderly and structured.

Figure 1. Percentage of participants preferring stage theories of grief recovery, dementia, and moral development over continuum theories of the same processes (Rutjens et al., 2013).



3.1.2 Can science provide existential meaning?

Tracy, Hart, and Martens (2011) were the first to examine if science is able to provide a sense of existential meaning. Similar to Rutjens et al. (2010), these authors looked at religious and scientific views on the origin of life. They investigated whether people's acceptance of intelligent design or Darwin's theory of evolution would be affected by a reminder of mortality (which is the most commonly used method to induce a threat to existential meaning²). The results of four studies indicated that acceptance of intelligent design increased, and acceptance of Darwin's theory of evolution *decreased*, in the aftermath of an existential meaning threat. Moreover, although controlling for religiosity did not alter these effects, it was also found that natural-science students showed the opposite pattern of results. This suggests that evolutionary theory can provide existential meaning for these students, likely because evolution is a critical part of their understanding of the world. More recently, Farias and colleagues showed that a similar mortality salience induction increased faith in the scientific method (Farias, Newheiser, Kahane, & Toledo, 2013). These studies provide some empirical support for the claim that science can provide an alternative

² See terror management theory (TMT; Greenberg, Solomon, & Pyszczynski, 1997; Pyszczynski, Solomon, & Greenberg, 2015).

to religion as a source of existential meaning (e.g., Preston, 2011; Sagan, 2006; also see Farias, 2015).

However, recently we investigated more directly if belief in science is related to perceptions of existential meaning (Rutjens & Van Elk, in preparation). Using various measures of meaning and various measures of belief in science and religious belief, we observed a consistent positive relation between *religious* belief and meaning, but crucially, we observed negative (in two studies) and null (in one study) correlations between belief in science and perceptions of meaning in life, even when controlling for religious belief and other relevant variables. Thus, in contrast to the mortality salience effects reported above, we found no evidence that belief in science is related to perceptions of meaning.

Another way that science connects to existential meaning is that it has been related to efforts to strive for human immortality (e.g., life extension technologies, cryonics; De Grey & Rae, 2007); indeed, various scholars have long suggested that science can be considered an ‘immortality project’ (see Gray, 2011, for an overview of the intellectual history of this idea). In addition, recent empirical work has focused on the notion of indefinite life extension, a concept that non-religious participants support more when reminded of their own mortality (Lifshin et al., 2017; see also Rutjens, van Harreveld, van der Pligt, van Elk, & Pyszczynski, 2016). The notion that science can harbor a non-religious promise of literal immortality (see also Dechesne et al., 2003) particularly pertains to hopes for scientific and technological *progress*, a topic to which we turn next.

3.2. Psychological functions of belief in progress

A key aspect of belief and faith in science is the belief in scientific progress. Building on the politico-philosophical observations of Gray (2004, 2007; see also Burdett, 2015) that belief in progress as a worldview shares many similarities with religious belief (particularly the concepts of providence and utopia), we experimentally tested the motivational underpinnings and compensatory functions of belief in progress.

First, in two different lines of research, we investigated whether belief in scientific and technological progress can provide order and control. The conceptual idea behind this research was that belief in progress entails an acceptance of the view that human history is

linearly progressive and therefore to some extent predictable and orderly (Bury, 1920/1955; Gray 2004). A first set of studies approached this question by threatening people's perceptions of personal control and subsequently measuring beliefs in social, moral, scientific, and technological progress in various ways (Rutjens, van Harreveld, & van der Pligt, 2010). Experimentally lowered personal control—as well as a real life instance of lowered control, in this particular case being a passenger in an airborne plane—led to stronger beliefs in social-moral and scientific-technological progress, more defensive responses to an essay questioning the reality of progress, and an increased willingness to invest in strongly future-oriented areas of scientific research, such as nanotechnology and stem cell research. A second set of studies reversed the casual order of the variables and manipulated the strength of scientific progress, using a fake newspaper article, after which perceptions of order were measured. Participants who read an article that bolstered the idea of scientific progress reported perceiving the world as more orderly and structured than those who read an article that emphasized the limited rate of meaningful progress (Meijers & Rutjens, 2014). Similar findings were later obtained by Hornsey and Fielding (2016) and Stavrova, Ehlebracht, and Fetchenhauer (2016). The latter authors, in particular, build on and extend our initial findings by showing that belief in scientific progress is associated with an enhanced sense of personal control, and additionally showing that this enhanced sense of control in turn enhanced wellbeing. Moreover, Stavrova and colleagues showed that the intrapsychic motivational functions of belief in scientific progress were especially pronounced in cultures in which belief in science is widely shared.

“Theories of progress are myths answering to the human need for meaning”. This quote by John Gray (2007, p.3) was the starting point of a related line of research in which we addressed the question of whether belief in progress can provide existential meaning. In an initial paper, we reported three studies in which we employed a terror management theory perspective and showed that reminders of mortality led participants to more strongly defend the notion of progress; moreover, we found that questioning the notion of progress increased the accessibility of death-related cognitions³ (Rutjens, van der Pligt, & van Harreveld, 2009). More recently, we followed up on these findings by teasing apart belief in

³ For an elaborate perspective on the concept of death-thought accessibility, we refer to Arndt, Greenberg, Solomon, Pyszczynski, & Simon, 1997.

social-moral progress and belief in scientific-technological progress (Rutjens et al., 2016). Because it could be argued that belief in social-moral progress is quite subjective and open to interpretation, whereas belief in scientific-technological progress is more objectively observable, it could be that they serve different psychological functions. Scientific and technological progress, evidence of which is all around us, could make the future seem more controllable (e.g., the promise of solutions to current problems), but seems unlikely to provide a sense of existential meaning. Social-moral progress, where humanity and human relations advance in some way or another, requires a certain level of faith (Gray, 2007) and has been argued to have replaced religious belief in secular societies (Brunner, 1954/1972; Norenzayan, 2013). Based on the idea that belief in social-moral progress functions as a secular meaning-provider⁴, we hypothesized that 1) a mortality reminder would increase this belief, as compared to a control condition, and 2) a mortality reminder would increase this belief in particular among non-religious individuals. Employing a representative sample of the Dutch population, we indeed found that a reminder of mortality led to increased belief in social-moral—but not in scientific-technological—progress, and, as expected, this effect was moderated by strength of religious belief.

In sum, the above research suggests that whereas scientific and technological progress provides psychological compensation for threats to personal control and perceptions of order, it must be accompanied by a sense of social-moral progress in order to provide existential meaning (and, even then, only to individuals who score low on measures of religious faith).

4. MORALITY: THE (PERCEIVED) RIGHT AND WRONG OF SCIENCE AND SCIENTISTS

In the previous section, we have described how threats to important intrapsychic motivations can lead to increased acceptance of, and faith in, some kinds of science, provided that these kinds of science help people perceive the world as more orderly or meaningful. The findings described in section 3 suggest that science, including a belief in scientific-technological progress, can provide compensation for threats to order and control. Evidence for the existential functions of science, including belief in scientific-technological

⁴ For a more elaborate reading of these ideas, we refer to Rutjens et al., 2016.

progress, however, is less clear-cut. Although some research has found that existential threat (e.g., mortality reminders) increases faith in science (Farias et al., 2013) and support of scientific technologies (Lifshin et al., 2017), other research has found no evidence for an existential function of belief in science and scientific progress (Rutjens et al., 2016; Rutjens & Van Elk, in preparation)⁵. In Section 2, we detailed how ideology—in particular religious and political conservatism—and perceived conspiracies and agendas negatively impact on acceptance of science and science attitudes. In the present section, we will focus on moral concerns about science and scientists.

Although morality to some extent correlates with religious and political beliefs and ideology, as we have touched upon in sections 2.1 and 2.2 (see also Graham et al., 2009; Piazza & Sousa, 2014), moral concerns may also play an independent role in the shaping of science attitudes (e.g., moral purity concerns predict vaccine skepticism over and beyond religious and political beliefs; Rutjens et al., under review; or consider how moral opposition to developments in domains such as artificial intelligence or medical health might be unrelated to religious or political beliefs and convictions). We will look at morality from two different angles. First, we review recent research that measures people’s own moral outlook and examines how it might be related to evaluations of science. Second, we review our own research that investigated how people *perceive* the moral values of science and scientists.

4.1 Moral concerns about science

Many topics of scientific investigation—such as evolution or climate change—may speak to people’s deeply held religious or political beliefs. Additionally, in many cases, these topics speak to people’s *moral* views about society and the world. Sometimes these moral views are engrained in religious or political belief, and sometimes they are not. For example, moral concerns about childhood vaccination might generally be rooted in religious faith, whereas moral concerns about artificial intelligence might not. Moral views, or moral convictions, are referred to in the literature as non-negotiable, because they consist of an

⁵ The findings reported by Tracy et al. (2011) that mortality reminders generally decrease acceptance of evolution, but increase acceptance of evolution among natural-science students, might help explain these mixed findings. Future research should investigate further how science can be a repository of existential meaning, in particular for those invested in science and the scientific worldview. Additionally, such research could examine more precisely why some manifestations of science provide meaning, whereas others do not. It is likely that, besides religiosity, individual differences in science education and scientific literacy play a role.

absolute belief that something is either right or wrong (Skitka, Bauman, & Sargis, 2005). Thus, moral conviction might interfere with factual interpretations of scientific evidence.

One compelling example is work on GMO skepticism. Although, in our own research described in Section 2.1, we found that vaccine but not GMO skepticism was partially predicted by concerns about moral purity, other research finds evidence for “absolute moral opposition” against GMO products in the United States (Scott et al., 2016). This work shows that 64% of respondents in a survey of representative U.S. residents were opposed to GMOs. Moreover, among the opponents, the majority (71%) were categorized as “absolutely opposed”. What this means is that these respondents were of the opinion that GMOs should be prohibited regardless of potential risks or benefits; the mere creation of GMOs was seen as a moral violation. Interestingly, it was found that disgust played an important role in people’s judgments; “absolute” opponents were more disgust sensitive in general, and were more easily disgusted by the idea of consuming GMOs. These findings suggest that moral concerns about purity and naturalness play a role in GMO opposition. This notion is further corroborated by Blancke and colleagues (2015), who argue that moral concerns about unnaturalness are intuitively appealing to many. These authors further note that moral concerns about fairness might also play a role in GMO skepticism; for example, some people reason that large multinationals work against small farmers by outcompeting and outpricing them. One reason that we did not find evidence for moral purity concerns as predictors of GMO skepticism in our own work might be that we did not explicitly focus on disgust (Rutjens et al., under review). If we had measured disgust sensitivity as an individual difference measure reflecting moral purity concerns, for example, we might have observed a stronger relation between moral concern and skepticism about GMOs.

Other work has looked at acceptance of scientific evidence more generally, and found that acceptance was contingent upon how morally offended participants were by the evidence (Colombo et al., 2015). More specifically, participants were presented with various statements summarizing (made-up) scientific evidence across various domains, among which were statements summarizing research that found particular effects of nutrition on health and of gender on professional success. Example statements are “Being infected with the Merrosa-virus increases the chances of being homosexual in mammals”, and “Men are more successful than women because they are more motivated and they have more

cognitive capacities”. As predicted, these researchers found that the more people were morally offended by these statements, the less they were inclined to accept the evidence as true. In a related vein, other research has shown that people are more likely to cherry-pick scientific evidence that is in line with their own pre-existing moral values, and also that they are more likely to subsequently communicate about that evidence in a positive way in an online setting (Bender et al., 2016). Moreover, the more central a certain moral value was to the individual’s self-concept, the more positively (s)he evaluated the evidence that was in line with this particular value.

4.2 Concerns about the morality of scientists

In addition to the aforementioned work that honed in on the moral concerns that people might have about various types of scientific evidence, we have examined the moral associations that people have with *scientists* (Rutjens & Heine, 2016). Do people think that scientists are good or bad people? We were inspired to study this because of an interesting ambivalence; despite the fact that scientists are one of the most respected occupations (e.g., Fiske & Dupree, 2014; Harris Poll, 2014), a substantial portion of the general public seems to distrust science. Since there was, to our knowledge, virtually no research on perceptions of scientists, we devised several studies that aimed to provide some initial insight into such perceptions.

A first set of studies exploited the representativeness heuristic (or conjunction fallacy; Tversky & Kahneman, 1983) in order to gauge intuitive associations between scientists and violations of morality. This classic fallacy is a mental shortcut in which people make a judgment on the basis of how stereotypical, rather than likely, something is. As a (famous) example, participants presented with the “Linda problem” were asked to decide, based on a short personal description, whether it is more likely that Linda is either a bank teller, or a bank teller and a feminist. The description of Linda mentioned that she is deeply concerned with issues of social justice and that she has participated in anti-nuclear demonstrations. The majority of participants in the original study (Tversky & Kahneman, 1983) opted for the feminist bank teller option (which is a subset of the set of bank tellers, and therefore logically less likely), arguably because the description that they were given fit the feminist category so well. More specifically, participants do not commit this logical fallacy because

they believe that all feminists are deeply concerned about social justice issues, or have a history of participating in anti-nuclear demonstrations, but rather that a person to which this description applies fits the social category of feminists. In our research, we used a variety of descriptions depicting various moral transgression that were used in previous research on morality (e.g., Gervais, 2014; Haidt, Koller, & Dias, 1993). Consider the following example study: participants read a description about a man named John, who engages in an act of cannibalism. Subsequently, they were asked to indicate which option is more likely: John is a sports fan, or John is a sports fan and a scientist. In the control conditions, the category of scientist was replaced with one of various control targets (e.g., teacher, Muslim). The categories were manipulated between-subjects, and in the majority of the studies, we also included two more specific scientist categories (i.e., cell biologist, experimental psychologist). An overview of the percentage of participants who committed the fallacy can be found in Figure 2. When the target category was a scientist, participants were significantly more likely to make the conjunction error, suggesting that descriptions of cannibalism (and also serial murder, incest, and necrobustiality) fit the category of scientists better than a host of control categories⁶. In other words, when reading descriptions about various immoral acts, a substantial percentage of the participants intuitively assumed that the protagonist committing the act was a scientist. Interestingly, we found no association of scientists with scenarios describing violations of care and fairness. We interpreted these results in light of Moral Foundations Theory (e.g., Graham, Haidt, & Nosek, 2009), which maintains that morality can be classified along (at least) five foundations, organized into two broad categories. The category of binding moral foundations concerns intuitions that are centered on the welfare of the group or community, and binds people to roles and duties that promote group order and cohesion. These intuitions are ingroup loyalty, authority, and purity. The category of individualizing moral foundations concerns intuitions pertaining to the welfare of the individual, which function to protect the rights and freedoms of all individuals. These intuitions are fairness and care. Our results show that scientists were

⁶ The only exception was an 'atheist' target. In all studies, we also included atheist as a category. Previous work has shown a pervasive intuitive atheist-immorality association (Gervais, 2014), and we were interested in comparing the association of scientists with immorality with that of atheists. Whereas the association was more strong for atheists in some studies, in other studies, it was equally strong or even stronger for scientists. In addition, atheists were also associated with violations of care and fairness, and this was not the case for scientists.

associated with violations of the binding moral foundations of authority and—particularly—purity, but not with violations of the individualizing moral foundations of fairness and care.

Using a different method, we tested this notion in another study. Here, we employed the moral stereotypes method (Graham et al., 2009), in which participants fill out the moral judgments section of the moral foundations questionnaire in the third person. In one condition, they were asked to reply to the statements “as John, who is a scientist” (e.g., John believes that people should not do things that are disgusting, even if no one is harmed). Compared to the control condition, participants in the scientist condition indicated that John cares less about the binding moral foundations of loyalty, authority, and purity than those in the control condition. There were no differences in perceived importance of care and fairness (see Figure 3). It is worth noting that the associations and stereotypes were found to be largely independent of participants’ own religious and political beliefs and moral foundations scores, with the exception that religious participants were somewhat more extreme in their moral stereotypes of scientists than non-religious participants.

The above studies suggest that people perceive scientists as caring less about the binding moral foundations than various other categories of people. Given this, what do people believe that scientists *do* care about. Two additional studies indicated that—compared to various other categories—people believe that scientists place relatively more value on knowledge gain and satisfying their curiosity than on acting morally. They were also seen as potentially dangerous. At the same time, scientists were found to be relatively well-liked and trusted. Thus, we concluded that scientists are perceived as capable of immoral behavior, but not as immoral per se. Potential immoral conduct might be preceded by amoral motives.

Figure 2. Intuitive associations between various morality violations and scientists. The Y-axis indicates the percentage of participants committing a logical fallacy that reflects this

association (Rutjens & Heine, 2016).

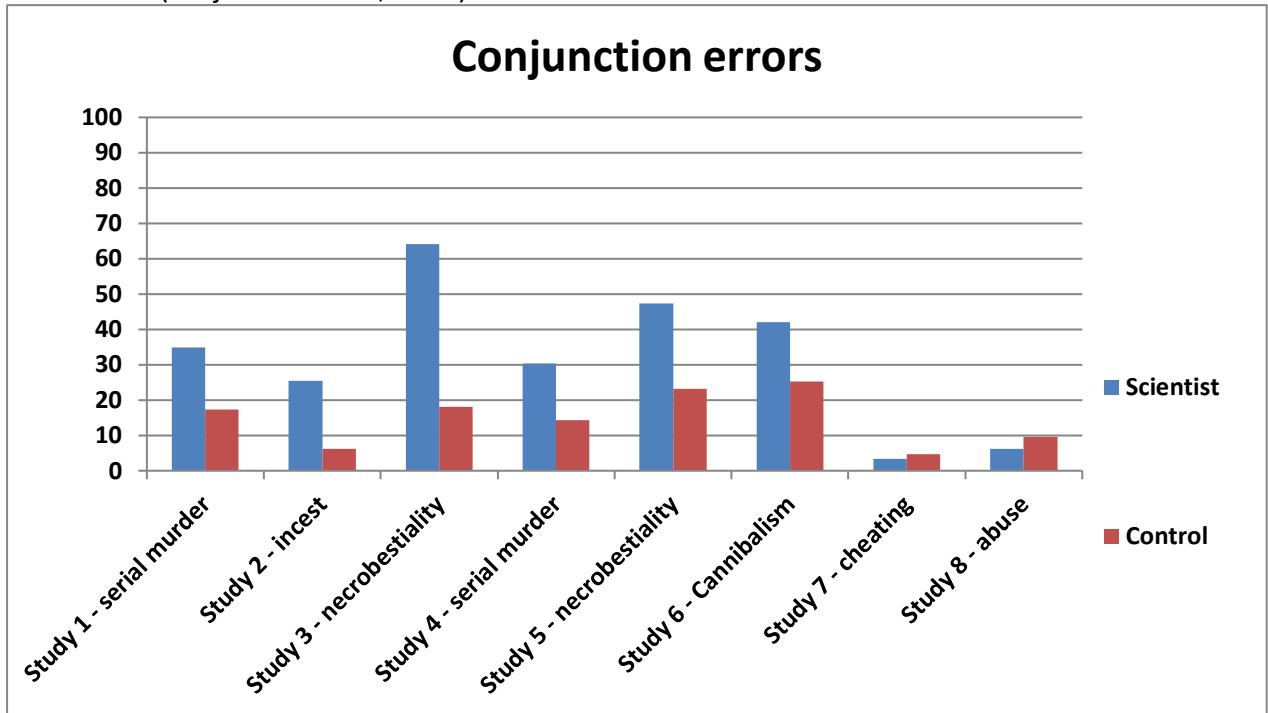
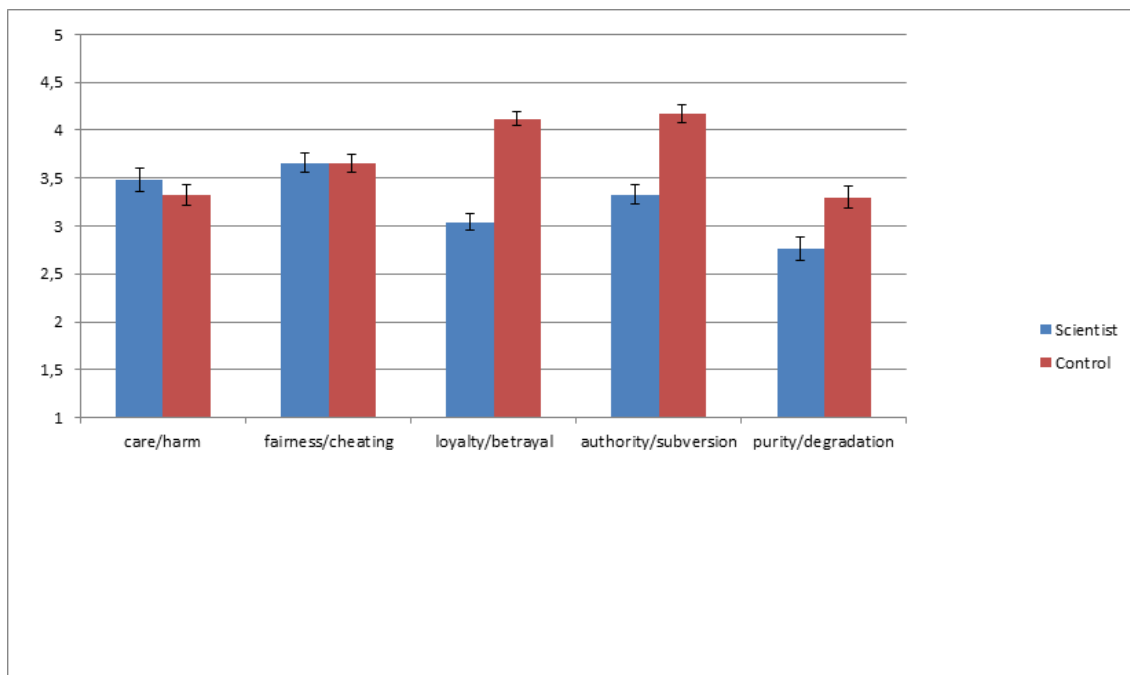


Figure 3. Moral stereotypes about scientists: scientists are seen as caring less about loyalty, authority, and purity (Rutjens & Heine, 2016).



5. MOVING FORWARD: OPEN SCIENCE AND REACHING OUT TO THE PUBLIC

While our research on perceptions of scientists (see Section 4.2) suggests that people generally like and trust *scientists* (while at the same time viewing them as capable of immoral conduct and as potentially dangerous), it is clear that (public) distrust in *science* is a major contemporary challenge (Gilbert et al., 2016; Gleick et al., 2010; Open Science Collaboration, 2015; Pittinsky, 2015; Nature editorial, 2017a). In addition, recent high-profile cases of scientific misconduct have further eroded the public's faith in scientists. In this last part of the chapter, we focus on science and scientists' own crisis of faith and the resulting recent movements toward a more open science, and review how popularization and accessibility of science might impact on the public's attitudes towards science. In doing so, we also identify links between open and accessible science and the previous sections on ideology, motivation, and morality.

5.1 Crisis of faith and open science

Although much of this chapter concerns the attitudes of the public toward science, they are not the only ones who can experience lack of faith in scientific knowledge and progress. Indeed, scientists themselves experience collective crises of faith in their endeavours. Different disciplines have experienced their own, indigenous crises from time to time, often triggered by objective shortcomings including a disciplinary lack of statistical expertise, or the pre-eminence of degenerating research programs in which established ideas are unable to generate novel and verifiable conclusions (Lakatos, 1976). These are relatively technical problems in scientific disciplines of which the public is not likely to be aware. However, scientists' faith in science can also be shaken by concerns that are strikingly similar to those of the public. These concerns revolve around the perception that science is falling short of idealized standards (see Section 2.3) of openness, disinterestedness, or skepticism, as well as worries that scientific institutions are essentially corrupt in rewarding scientists on grounds other than scientific merit.

In recent years, these concerns have been thrown into sharp relief by Ioannidis (2005), whose analyses of scientific findings suggested that most of them are false. Ioannidis found that false findings are especially likely to emerge when powerful vested interests are at stake (e.g., industry funded research), or, paradoxically, when multiple labs are working on the same problem – suggesting that the desire to scoop other labs causes researchers to rush findings out to publication without sufficient scrutiny. Ioannidis's results and

conclusions have fuelled concerns about the replicability of scientific findings across several disciplines and may also have consequences for public perceptions about the morality of science and scientists. These concerns were not doused by major surveys which suggest that although a typically fewer than 2% of scientists admit blatant fraud, much larger numbers admit engaging in other questionable research practices that exaggerate the significance of their findings (Fanelli, 2009; Martinson, Anderson, & de Vries, 2005; but see Fiedler & Schwarz, 2016). Although 2% can be seen as a low number, it is disturbingly high given the potential that false findings have to wreak havoc on scientific progress. The impact of the behavior of these errant 2% has become all too clear in scandals that have played a dramatic role in lowering scientists' confidence in their own fields. In health science, the sugar lobby paid for and appeared to shape drafts of a review in the *New England Journal of Medicine* that systematically diminished the health risks posed by sugar and exaggerated those posed by dietary fat (Kearns, Schmidt, & Glantz, 2016). For its part, of course, social psychology was severely shaken by the emergence of several cases of data fraud, most notably by Diederik Stapel in 2010.

This so-called reproducibility crisis across science has percolated into the public sphere through extensive features written by science journalists. Some researchers have argued that the lack of public trust in science and scientists stems, at least in part, from legitimate concerns about the openness and quality of scientific research (Edwards & Roy, 2016; Vazire, 2016). To our knowledge, there is no systematic work on whether the reproducibility crisis has had an effect on public faith in science. There is clear evidence that members of the public take a dim view of data fraud and manipulation, such that the majority of respondents endorse criminal charges for such conduct - but are more tolerant of selective reporting of findings and other questionable research practices (Pickett & Roche, in press). Certainly, it can be said that the reproducibility crisis has had a profound effect on many members of the scientific community. Many scientists are now taking part in efforts to bring the practice of science into closer alignment with its ideals.

Most prominent among these efforts is the open science movement, in which researchers and gatekeepers are increasingly adopting, advocating, and requiring open research practices, including pre-registration of hypotheses and full disclosure of materials and results (e.g., Nosek et al., 2015). An allied development, at least in social psychology, is the adoption of more rigorous methodological and statistical practices. These include

principled, a priori determination of sample size, and the elimination of questionable research practices that tend to increase the risk of scientific studies producing false-positives: that is, statistically significant evidence of an effect that does not exist (e.g., Giner-Sorolla, 2016; Murayama, Pekrun, & Fiedler, 2014) These efforts can be seen as a manifestation of the self-correcting nature of science: albeit to varying degrees, scientists are willing and able to respond to crises of faith by reaffirming rather than abandoning their commitment to science. It is arguably too early to draw any firm conclusions about the effects of open science reform on public attitudes towards science. However, it could certainly be argued that open science and transparency can have beneficial effects on the perceived morality of—and thus public trust in—science. In addition, it might also increase public understanding of the scientific process, which in turn could enhance the order-conferring functions of science (understanding the process renders the process more structured and predictable).

The reproducibility crisis clearly illustrates that, despite its privileged position as a means of truth-seeking (which, in the long run, guarantees progress), science has important limitations that mean the current state of knowledge to be gleaned from the pages of its journals cannot be taken as the final word on any subject. Indeed, precisely because science is a progressive and self-correcting enterprise that relies on induction, its current findings could not be regarded as definitive, even if they were uncompromised by questionable research practices (Gigerenzer & Marewski, 2015; Gluckman, 2014). This means that not all skepticism about scientific findings or even science more generally should be judged as unwarranted or irrational.

The primary focus of this chapter (particularly the research described in Sections 2 and 4) is not reasonable skepticism, but rather what could be called cynicism about science: for example, the perception that (some) science or even the scientific method is fundamentally corrupt and unreliable, that even well-established and rigorously obtained findings cannot be trusted, or that scientific findings have about the same (or even lower) epistemic value as statements of opinion. Again, it is important to note that such fundamental rejection of science will be fuelled, at least in part, by a mixture of ideological (Section 2), motivational (Section 3), and moral (Section 4) concerns. If the evidence contradicts people's ideological views, threatens a particular psychological motive, or goes against their views on right and wrong, it is likely that they will reject it.

5.2 Accessibility and popularization of science

Open science and the crisis of faith in science can also be linked to recent developments in how science is conducted and in what is expected of scientists.

First, there has been a growing interdependence between universities and the corporate world. For example, from 1980 to 1998, industry funding of American universities increased at an annual rate of 8.1%, and, in the same period, the annual number of patents produced by universities increased from 250 to 4800 (Press & Washburn, 2000). As a consequence of the growth in corporate ties at universities, scientists have increasing opportunities to monetize their research discoveries. Such opportunities add further incentives to produce desirable results. For example, one review of clinical drug studies found that published articles that were funded by industry produced more outcomes favoring the drug's support (98%) compared with those that were not funded by industry (79%; Cho & Bero, 1996). These kinds of conflicts of interest seem likely to increase as state funding of universities continues to get displaced by industry funding.

Second, a rise in questionable research practices might also be the product of the growing popularization of science. Compared with the past, science research is being covered far more in the popular press. This can be seen in the recent increase in popular science books (Turney, 2008), which have become somewhat more sensationalist, as typified by the popular articles and books by Malcolm Gladwell (Bobo, 2009). Similarly, popular television shows, such as Neal DeGrasse Tyson's *Cosmos*, have proliferated (Johnson, Ecklund, & Matthews, in press). In addition, scientists now have more opportunities to appear in popular forums themselves, such as TED talks (Caliendo, 2012) and science blogs that can reach wide penetration (Blanchard, 2011). Psychology has also achieved wider visibility in the media in recent years; for example, since 2010, the Society of Personality and Social Psychology has offered a media award each year to promote popular coverage of social and personality psychological research. Given this trend of increasingly popularized science, we might expect that scientists would feel compelled to produce a product that is more fitting for mass consumption. With the incentives of fame and fortune, scientists may be tempted to overclaim their findings, to make them more dramatic with

broader real-life implications than those which are typically communicated to an academic audience. Another consequence of science coverage on the internet that has changed the relationship between science and society is that laypeople have more opportunity than ever to evaluate scientific research, for example, by commenting on it on social media and blogs. Bender et al. (2016) argue that, although there are positive aspects to these developments, there is also a danger that such public praise or criticism of research can enter the public domain unfiltered, which can impact on the public's trust in scientific evidence.

Of course, popularization of science through TED talks and television shows, popular science books, and blogposts may also have positive consequences, where members of the public learn more about what scientists actually do and thus become better equipped to evaluate the science. For example, some of the cognitive biases and lack of knowledge that hamper science understanding might be more easily combated thanks to these developments. In addition, more insight into the scientific process (e.g., the occurrence of type I and type II errors and the value of failed experiments, the limited life span and endless revision of theoretical perspectives every time new evidence comes in) might help to take away some of the public's distrust in science (Firestein, 2016). As with open science, it might be the case that increased accessibility through popularization has positive effects on all of the different levels that are described in this chapter. On the cognitive and motivational level (Sections 1 and 3), science understanding might increase, and with it the psychological functions of science (e.g., science as a belief system that can provide order, control, or meaning; better understanding of a particular scientific theory, so that it might provide a sense of order and predictability to the individual). On the ideological and moral level (Sections 2 and 4), accessibility of information and movements toward open science might increase trust in the scientific enterprise by making the scientists more like 'normal human beings' and their work seem more reliable.

6. CONCLUSION

The current chapter integrates various lines of recent research investigating the antecedents and consequences of how science is evaluated, with the goal of fostering a more complete understanding of attitudes towards science. Evaluations of science, scientific knowledge, and scientists are shaped not only by cognitive variables, but also by ideology,

motivation, and morality. The more conservative variety of religious and political beliefs, but also widespread and persistent perceptions of biased agendas and conspiracy thinking, can clash with science and consequentially fuel skepticism. Moral concerns about science and scientists further decrease science acceptance. However, science can also function as a lens through which people view the world, which can actually aid in meeting important psychological needs. In other words, for some, science is a belief system that shares motivational functions with religious and political ideologies. Understanding the impact of ideology, motivation, and morality thus helps to refine and advance our knowledge of how science is evaluated. In a time when science is more accessible to the public than ever before, this is an important endeavor.

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