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Published in:
Risk Analysis

DOI:
[10.1111/j.1539-6924.2012.01845.x](https://doi.org/10.1111/j.1539-6924.2012.01845.x)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2013

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

de Groot, J. I. M., Steg, L., & Poortinga, W. (2013). Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy. *Risk Analysis*, 33(2), 307-317. <https://doi.org/10.1111/j.1539-6924.2012.01845.x>

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Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy

Judith I. M. de Groot,^{1,*} Linda Steg,² and Wouter Poortinga³

We examined how personal values and perceptions of risks and benefits are associated with the acceptability of nuclear energy (NE). A theoretical model is tested in which beliefs about the risks and benefits of NE mediate the relationship between values and acceptability. The results showed that egoistic values are positively related to the perceived benefits and acceptability of NE. In contrast, altruistic and biospheric values were positively related to the perceived risks of NE. Although it has been argued that NE may help to combat climate change through lower CO₂ emissions, these environmental benefits were not acknowledged by people with strong biospheric values. Furthermore, results confirmed that the more risks respondents perceived, the less they were inclined to accept NE. In contrast, the more a person believed that NE has beneficial consequences, the more acceptable NE was. Finally, as expected, perceived risks and benefits were found to partly mediate the relationship between personal values and acceptability. We discuss the theoretical and practical implications of these findings.

KEY WORDS: Acceptability; nuclear energy; risk perception; values

1. INTRODUCTION

In the Netherlands, nuclear energy is used to generate 4% of the total electricity supply.⁽¹⁾ Compared to, for example, the contribution of fossil fuels (85%) and renewable energy (9%), nuclear energy only plays a modest role in the Netherlands. It has been argued that an increase in the use of

nuclear energy may help to safeguard security of energy supplies and contribute to climate change mitigation through reduced CO₂ emissions.⁽²⁾ Therefore, despite the ongoing concerns about the potential risks of nuclear energy including concerns about radioactive waste management, health, and the environment^(e.g., 3–6), Dutch authorities have reopened the debate as to whether to increase the supply and use of nuclear energy by constructing a new nuclear power plant in the forthcoming years.

Public acceptability is essential for decision making regarding nuclear energy.⁽⁷⁾ Without public support, a decision to expand the use of nuclear energy may be met with public resistance, which may lead to a delay or even cancellation of the construction of new nuclear power plants.^(cf. 8,9) In this study, we aimed to examine factors that influence the acceptability of an increase in use of nuclear energy. We propose that acceptability of nuclear energy depends on the perceived risks as well as the perceived

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benefits of nuclear energy. Furthermore, we propose that the perceived risks and benefits are rooted in personal values, as we explain below.

1.1. Beliefs on Perceived Risks and Benefits of Nuclear Energy

We regard acceptability of an increase in the supply and use of nuclear energy as an attitude toward nuclear energy.^(cf. 10,11) Attitudes reflect a psychological tendency that is expressed by evaluating a particular entity, such as a policy to increase nuclear energy supply, with some degree of favor or disfavor.^(12,13) Attitudes are based on weighting the costs (or risks)⁴ and benefits of a specific object or behavior.^(14,15) Thus, the acceptability of increased use of nuclear energy is based on a trade-off between the risks and the benefits of nuclear energy: the more a person believes the use of nuclear energy has beneficial (e.g., cheap energy, security of energy supply, energy self-reliance, or less CO₂ emissions) rather than negative consequences or risks (e.g., increase in risks of a nuclear accident, health risks), the more favorable one's attitude toward nuclear energy tends to be and thus the more acceptable an increase in use of nuclear energy would be.^(10,16) Therefore, we expect that beliefs about the risks and benefits of increasing the use of nuclear energy will directly affect public support (i.e., acceptability) for nuclear energy.

1.2. Values, Beliefs, and Acceptability of Nuclear Energy

People's general worldviews appeared to determine the perceived risks and benefits, and acceptability of nuclear energy.^(e.g., 16,17,18) Worldviews are defined as generalized attitudes toward the world and its social organization and function as orienting dispositions that guide people's responses in complex situations.^(19,20) Studies based on cultural theory⁽²¹⁾ suggest that risk perceptions are embedded into four distinct worldviews (i.e., egalitarian, individualistic, hierarchistic, and fatalistic). Those who endorse an egalitarian worldview perceive nuclear energy as a rather risky activity; those who endorse an individualistic worldview find nuclear energy far

less risky, whereas hierarchists and fatalists typically take a middle positions.⁽²²⁾ This conceptualization has been criticized for several reasons. First, scholars argued that worldviews are not measurable innate qualities of individuals.^(23–25) Therefore, they do not measure a psychological tendency, such as an attitude normally does. Other criticisms include that (1) the four types of worldviews can not always be reliably distinguished,⁽²⁵⁾ and (2) they only explain a limited amount of the variance in perceived risks and acceptability judgments.⁽²⁴⁾

We propose that values are an important general determinant of beliefs about risks, benefits, and acceptability of nuclear energy. Surprisingly, relationships between values and perceived risks, benefits, and acceptability of nuclear energy received little attention in research. Schwartz⁽²⁶⁾ defines a value as “a desirable transsituational goal varying in importance, which serves as a guiding principle in the life of a person or other social entity (p. 21).” Values placed on different targets direct attention toward value-congruent information which affects specific beliefs, acceptability and behaviors.^(26–30) As values are abstract and are thought to transcend situations, they may affect beliefs, attitudes, and actions in almost all contexts, including beliefs about the risks and benefits and acceptability of nuclear energy. Values are assumed to be important because they provide a stable and relatively enduring basis for the formation of beliefs.⁽³¹⁾ Indeed, the causal influence of values on beliefs, attitudes, and behaviors has been reliably documented in a number of studies.^(e.g., 32) Hence, values are a relevant starting point for explaining and changing beliefs, attitudes, and behaviors. Knowledge of how different values are related to beliefs on risks and benefits and acceptability reveals which values can best be strengthened or activated to change, for example, the acceptability of nuclear energy.⁽³³⁾ Values may be particularly relevant to understand risk perceptions as they are more predictive of behavior-specific beliefs and acceptability judgments than are other general beliefs such as environmental concerns and ecological worldviews.⁽³⁴⁾ Therefore, we will focus on values as a general determinant of beliefs on risks and benefits and acceptability in this study.

Stern⁽³⁵⁾ argues that three types of values are particularly relevant when explaining beliefs and behaviors in the environmental domain, namely egoistic, altruistic, and biospheric values.^(see also 28,29,36,37) People who strongly endorse egoistic values will especially consider the risks and benefits of nuclear

⁴The costs or negative consequences of nuclear energy include more than merely the perceived risks of nuclear energy. For example, the development and installation of nuclear energy technologies will go along with considerable financial costs. However, many of these costs are uncertain. Therefore, we will refer to perception of risks instead of costs.

energy to themselves. People with strong altruistic values are assumed to base their decision to accept nuclear energy on the perceived risks and benefits to other people, such as their family, community, or humanity in general. People who strongly endorse biospheric values are thought to most strongly base their decision to accept an increase in nuclear energy on the perceived risks and benefits to the ecosystem and biosphere.^(cf. 27,28,36) All three types of values may therefore help to explain the perceived risks and benefits, as well as the acceptability of nuclear energy. Although people may endorse all three types of values at the same time, and may be motivated to act on the basis of all three values, they tend to act upon the values that they deem to be most important. That is, when competing values are activated in a situation, choices are thought to be based on the value, that is, considered most important in that particular situation.⁽²⁶⁾

The distinction between egoistic, altruistic, and biospheric values seems relevant for the acceptability of nuclear energy as nuclear energy has egoistic, altruistic as well as biospheric risks and benefits.^(cf. 5,38,39) The perceived risks of nuclear energy are predominantly related to social or environmental problems: people believe that nuclear energy poses problems regarding waste management, environmental pollution, and risks resulting from nuclear accidents.^(5,11,38) This suggests that altruistic, but also biospheric values will be positively related to the perceived risks of nuclear energy and consequently result in a lower acceptability of nuclear energy. Indeed, Whitfield *et al.*⁽¹¹⁾ found that self-transcendent values (including altruistic and biospheric values) are directly and negatively related to the acceptability of nuclear energy, as well as indirectly, via the perceived risks of nuclear energy: people who strongly value other humans or the environment perceived higher risks and were less supportive of nuclear energy than those who endorse self-transcendent values weakly. The study of Whitfield *et al.*⁽¹¹⁾ showed no significant relationships between egoistic values, risks, and acceptability of nuclear energy. Based on the strong inverse relationship between risks and benefits,^(4,42,43) if any, we would expect a negative relationship between egoistic values and the evaluation of risks: the stronger people are egoistically oriented, the less they believe nuclear energy to be risky.

The benefits of nuclear energy are generally related to self-interests,^(cf. 6,34) such as getting affordable energy.^(e.g., 5,38–40) Therefore, we propose that egoistic values will mainly be positively related to

the benefits of nuclear energy and will consequently result in a higher acceptability of nuclear energy. One could also argue that nuclear energy provides benefits for the environment by mitigating climate change as a result of lower CO₂ emissions.^(e.g., 41) Indeed, proponents of nuclear energy specifically use statements such as “real environmentalists support nuclear power” (e.g., <http://www.ecolo.org>; <http://pronucleardemocrats.blogspot.com>). Based on this, it can be argued that biospheric and altruistic values should be positively related to some of the benefits of nuclear energy as well, notably, possible environmental benefits. However, nuclear energy has been a center cause for environmental organizations for decades, suggesting that those with strong biospheric values are particularly concerned about the risks associated with nuclear energy. Also, many studies have reported strong and negative correlations between perceived risks and benefits of nuclear energy,^(e.g., 4,42,43) probably because people tend to base their evaluations of specific risks and benefits on an initial overall (affective) evaluation of risky activities, the so-called “affect heuristic.”^(42–44) That is, if the initial overall evaluation of an activity is positive, people will focus on the benefits and ignore any risks associated with this activity. If the initial overall evaluation is negative, the reverse will happen. People will then mainly focus on the risks and downplay the benefits of the activities. Based on the above, we propose that it is unlikely that people with strong biospheric values believe that nuclear energy has important environmental benefits, but that these environmental benefits are probably only relevant to those who already believe that nuclear energy has mainly benefits: those who strongly endorse egoistic values.

Although many scholars stress the importance of personal values for the acceptability of nuclear energy,^(e.g., 5,7,10,25) very few studies have explicitly examined the relationships between values, perceived risks and benefits, and acceptability of nuclear energy. This study aimed to examine these relationships. Our study builds on the work of Whitfield *et al.*⁽¹¹⁾ However, we will distinguish biospheric and altruistic values as two separate clusters of self-transcendence values. The distinction of biospheric and altruistic values may be useful, because, as explained above, risks but especially benefits of nuclear energy may be differently associated with altruistic and biospheric values, particularly because recent discussions have stressed the possible environmental benefits of nuclear energy. Moreover, we will not only study relationships between values and the

perceived risks of nuclear energy, but also study how values affect its perceived benefits, and how both perceived risks and benefits in turn affect the acceptability of nuclear energy. So, we aimed to examine the relationships between egoistic, altruistic, and biospheric values, beliefs about the risks and benefits of nuclear energy, and the acceptability of nuclear energy.

1.3. Mediation Model of Values, Perceived Risks and Benefits, and Acceptability

Various psychological models, such as the theory of planned behavior⁽¹⁴⁾ and the value-belief-norm theory,^(35,45) assume that general determinants (such as values and worldviews) influence behavior-specific beliefs, such as beliefs about the likelihood of risks and benefits of nuclear energy, which in turn influence acceptability judgments. In other words, specific beliefs about risks and benefits of nuclear energy are rooted in more generic determinants, such as values.^(7,10,37) Following this, we assume that beliefs about the risks and benefits of nuclear energy mediate the relationship between values and acceptability (see Fig. 1). The study of Whitfield *et al.*⁽¹¹⁾ provided some initial support for such a model. They found that values were directly and indirectly related to acceptability via the perceived risks of nuclear energy. This suggests that values may be directly associated with acceptability of nuclear energy, but that this influence will be weaker when specific beliefs about the perceived risks and benefits of nuclear behavior are controlled for. In this study, we will test whether beliefs on risks and benefits mediate the relationship between different types of values and acceptability.

1.4. Present Study

As yet, no known study has examined relationships between egoistic, altruistic and biospheric values, perceived risks and benefits of nuclear energy, and the acceptability of nuclear energy. This study aims to investigate these relationships. On the basis of the proposed theoretical model (see Fig. 1), we tested five hypotheses. First, we expected that egoistic values are positively related to the perceived benefits (Hypothesis 1a) and negatively or not significantly to the perceived risks of nuclear energy (Hypothesis 1b). Because of this, we expected that egoistic values are positively related to the acceptability of an increase in the supply and use of nuclear energy (Hypothesis 1c). Second, we hypothesized

that altruistic values are positively related to the perceived risks of nuclear energy (Hypothesis 2a), and negatively or not significantly to the perceived benefits of nuclear energy (Hypothesis 2b). As a consequence, we assumed that altruistic values are negatively related to the acceptability of nuclear energy (Hypothesis 2c). Third, we expected that biospheric values are positively related to the perceived risks of nuclear energy (Hypothesis 3a), and negatively or not significantly to the perceived benefits of nuclear energy (Hypothesis 3b), and consequently, that biospheric values are negatively related to the acceptability of nuclear energy (Hypothesis 3c). Given recent discussions on the possible environmental benefits of nuclear energy, we further explored how egoistic, altruistic, and biospheric values are related to *specific* beliefs about the risks and benefits of nuclear energy in more depth. As explained above, we expected that biospheric values are negatively or not significantly related to all specific benefits of nuclear energy, including specific environmental benefits of nuclear energy (such as reduced CO₂ emissions; Hypothesis 3d).

Fourth, we assumed that perceptions of risks and benefits of nuclear energy predict acceptability judgments. More specifically, we expected that people who perceive mainly risks related to nuclear energy and hardly benefits are less likely to accept nuclear energy (Hypothesis 4a), whereas people who believe that nuclear energy has many benefits and few risks will more likely accept an increase in nuclear energy (Hypothesis 4b). Finally, we hypothesized that egoistic, altruistic, and biospheric values are mainly indirectly related to acceptability, via the perceived risks and benefits of nuclear energy. In other words, we expected that perceived risks and benefits will mediate the relationship between values and acceptability (Hypothesis 5).

2. METHOD

2.1. Procedure and Respondents

Questionnaires and a prepaid envelope to return the questionnaire were sent out to a randomly selected sample from the Dutch population ($N = 1000$) early 2009. In total, 128 respondents returned the questionnaire (response rate of 13%) of which 123 were useful for analysis (76% male). Full details of the sample are reported by De Groot and Steg.⁽⁴⁾ Because of the low response rate we treat our sample as an opportunity sample. Our sample was not fully

Fig. 1. Relationships between values, perceived risks and benefits, and acceptability of an increase in the supply and use of nuclear energy.

Notes: NE = Nuclear energy; + = assumed positive relationship; -/* = assumed negative or weak relationship; - = assumed negative relationship.

representative of the Dutch population. To examine whether this affected our results, we explored how sociodemographics affected perceived risks, benefits, and acceptability. In line with previous studies,⁽⁴⁶⁾ we found that only gender correlated moderately but significantly with perceived risks, benefits, and acceptability [Spearman's rho (ρ) of 0.27, -0.30, and -0.33 respectively]. To check whether gender affected our results, we conducted a path analyses (see Section 3.2) with and without correcting for gender. Because both analyses produced similar results, we only report the unadjusted path model. In line with previous studies, the other sociodemographic variables were only weakly correlated with the perceived risks, benefits, and acceptability of nuclear energy.^(see e.g., 46) Therefore, we did not adjust for these variables in further analyses.

2.2. Measures

Respondents first completed questions on egoistic, altruistic, and biospheric values. Next, they evaluated the perceived risks and benefits associated with nuclear energy, followed by questions about the acceptability of an increase in the use of nuclear energy in the Netherlands. Measures of the main variables are described below.

2.2.1. Values

We assessed egoistic, altruistic, and biospheric values by means of a value instrument developed by De Groot and Steg.^(27,36) Respondents rated the importance of 13 items as “a guiding principle in their lives” on a nine-point scale, ranging from -1 (*opposed to the values*), 0 (*not at all important*) to 7 (*of supreme importance*). The values were placed in a randomized order. The values reflected egoistic (i.e., social power, wealth, authority, influential, ambitious), altruistic (i.e., equality, a world of peace,

social justice, helpful), and biospheric (i.e., preventing pollution, respecting the earth, unity with nature, and protecting the environment) values. Respondents were instructed to vary the scores and to rate no more than two values as extremely important. Mean scores were computed on items included in each scale. Cronbach's alpha was 0.79 for the egoistic values ($M = 2.5$; $SD = 1.3$), 0.74 ($M = 5.3$; $SD = 1.1$) for the altruistic values, and 0.80 for the biospheric values ($M = 5.0$; $SD = 1.2$).

2.2.2. Perceived Risks and Benefits

Participants rated the likelihood of a diversity of possible risk and benefit of nuclear energy on a seven-point Likert scale ranging from 1 (*very unlikely*) to 7 (*very likely*). We included six risks (e.g., related to nuclear accidents, health risks, proliferation, and environmental threats) and seven benefits (i.e., economic growth, increase in employment, less dependency of energy supply, affordable energy, reduction of CO₂ emissions, reduction in climate change, reduction in fossil fuel use).⁵ Mean scores were computed of items included in the risk and benefit scale, respectively. Evaluations of the likelihood of risks ($M = 4.1$; $SD = 1.5$) and benefits ($M = 4.4$; $SD = 1.3$) were average.

2.2.3. Acceptability

Respondents judged the acceptability of nuclear energy in the Netherlands on a seven-point Likert

⁵A full description of the risks and benefits included in our study can be found in De Groot and Steg.⁽⁴⁾ This article is based on the same data set as reported in the article by De Groot and Steg (2010).⁽⁴⁾ However, in this article we focus on relationships between values, perceived risks and benefits, and acceptability of nuclear energy. In contrast, the article of De Groot and Steg (2010)⁽⁴⁾ focused on how perceived risks and benefits affect personal norms to protest in favor or against nuclear energy, and how this in turn affects intentions to protest.

scale ranging from 1 (*totally disagree*) to 7 (*totally agree*). Four items were included: “Nuclear energy use is acceptable”; “It is acceptable that we are establishing new nuclear power plants in the Netherlands”; “It is acceptable that parts of the Dutch energy comes from nuclear sources”; “It is acceptable that we will use more nuclear energy in the Netherlands in the future” ($\alpha = 0.98$). Respondents evaluated an increase of the use of nuclear energy in the Netherlands as moderately acceptable ($M = 4.7$; $SD = 2.1$).⁶

2.3. Analyses

We first present bivariate correlations between values, the perceived risks and benefits, and acceptability of nuclear energy. To explore how the three types of values were related to beliefs on specific risks and benefits in more depth (Hypothesis 3d), we computed Pearson’s bivariate correlations between egoistic, altruistic, and biospheric values on the one hand, and on the other hand specific beliefs about the perceived risks and benefits of nuclear energy. Finally, we tested our full theoretical model on the relationships between the three types of values, perceived risks and benefits, and acceptability of nuclear energy via path analysis.

3. RESULTS

3.1. Bivariate Correlations between Values, Perceived Risks and Benefits, and Acceptability

The results in Table I show that the acceptability of nuclear energy is most strongly related to the perceived risks and benefits of nuclear energy, and somewhat weaker to the egoistic, altruistic, and biospheric values. Of the three values, egoistic values correlated strongest with perceived benefits of nuclear energy ($r = 0.28$; $p < 0.01$), whereas both altruistic ($r = -0.04$) and the biospheric ($r = -0.16$) values were not significantly related to the perceived benefits of nuclear energy, supporting hypotheses 1(a), 2(a), and 3(a). In contrast, in line with hypothesis 1(b), 2(b), and 3(b), altruistic and biospheric values were both positively associated with the perceived risks of nuclear energy. The more respondents valued other people ($r = 0.31$; $p < 0.01$) or the envi-

Table I. Bivariate Correlations between Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy ($N = 123$)

	Ego Values	Alt Values	Bio Values	Risks NE	Benefits NE
Alt values	0.12				
Bio values	0.12	0.61**			
Risks NE	-0.13	0.31**	0.28**		
Benefits NE	0.28**	-0.04	-0.13	-0.57**	
Acceptability NE	0.30**	-0.16	-0.23*	-0.73**	0.80**

Notes: Ego = Egoistic; Alt = Altruistic; Bio = Biospheric; NE = Nuclear energy.

* $p < 0.05$; ** $p < 0.01$.

ronment ($r = 0.28$; $p < 0.01$), the more they believed that an increase in nuclear energy would have potential risks. Egoistic values were not significantly related to the perceived risks of nuclear energy ($r = -0.13$). As expected, nuclear energy was evaluated as more acceptable when people more strongly endorsed egoistic values ($r = 0.30$; $p < 0.01$), and when they had weaker biospheric values ($r = -0.23$; $p < 0.05$), supporting hypotheses 1(c), and 3(c). Altruistic values were also negatively related to acceptability, but this relationship was not statistically significant ($r = -0.16$; ns), so hypothesis 2(c) was not supported.

To test hypothesis 3(d), we correlated the values with the specific risk and benefit item. Egoistic values were significantly related to most specific perceived benefits of nuclear energy. Except for the items “decrease in fossil fuel use” and “decrease in CO₂-emissions,” egoistic values significantly related to all specific perceived benefits of nuclear energy ranging between 0.22 and 0.29, including potential “biospheric” beliefs, such as the positive effects on climate change ($r = 0.27$; $p < 0.01$). Egoistic values did not correlate significantly with any of the specific risks of nuclear energy. In contrast, altruistic and biospheric values were both strongly and negatively correlated with most of the specific perceived risks items (correlations ranging between 0.20 and 0.33), whereas altruistic and biospheric values were not significantly related to the specific benefit items of nuclear energy. Most importantly, we did not find significant correlations between biospheric values and the likelihood of the “biospheric” benefits of nuclear energy, such as reductions in CO₂ emissions and reductions in climate change. These results provide support for hypothesis 3(d).

In line with our fourth hypothesis, respondents found nuclear energy more acceptable when they thought that nuclear energy has more benefits

⁶Due to space restrictions, we were not able to provide a full overview of relationships between values and each of the specific beliefs and benefits. These results are available upon request from the first author.

($r = 0.80$; $p < 0.01$) and fewer risks ($r = -0.73$; $p < 0.01$). The perceived risks and benefits of nuclear energy were negatively related ($r = -0.57$). When respondents thought that nuclear energy has more risks, they were less likely to think that nuclear energy has benefits.

3.2. Test of the Theoretical Model: Relationships between Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy

To test our full theoretical model (see Fig. 1) and the proposed mediation effect (hypothesis 5), we constructed a path model. We removed all nonsignificant pathways between values on the one hand and acceptability on the other (thereby assuming that the regression coefficients are “0”) to be able to evaluate the path model. The resulting model (see Fig. 2) has an excellent fit ($\chi^2(8) = 10.190$; $p = 0.252$; CFI = 0.991; TLI = 0.985; RMSEA = 0.048). In line with our hypotheses, the path analysis showed that perceived risks and benefits explained 73% of the variance in acceptability judgments: nuclear energy was more acceptable when people perceived many benefits and little risks. Values explained 7% of the variance in perceived benefits, and 6% of the variance in perceived risks. Stronger egoistic values were associated with perceiving more benefits, whereas stronger altruistic values were associated with perceiving more risks of nuclear energy. Biospheric values did not significantly affect the perception of risks and benefits when the other values were controlled for, probably because of the strong correlation between altruistic and biospheric values (see also Fig. 2). More importantly, as expected, the effect of values on acceptability of nuclear energy was partly mediated by perceived risks and benefits, providing support for hypothesis 5. To formally test the significance of the mediation effects, we used the Goodman version of the Sobel test.⁽⁴⁷⁾ Results showed that perceived risks partly mediated the relationship between egoistic values and acceptability [$t(122) = 1.98$; $p = 0.048$] and altruistic values and acceptability [$t(122) = -2.15$; $p = 0.032$], whereas perceived benefits partly mediated the relationship between egoistic values and acceptability [$t(122) = 3.31$; $p < 0.001$].⁷

⁷Following Baron and Kenny,⁽⁴⁸⁾ we could only establish mediation effects for the relationships between (1) egoistic values, perceived risks, and acceptability; (2) altruistic values, perceived risks, and acceptability; and (3) egoistic values, perceived benefits, and acceptability. Due to space restrictions, we were not able

4. CONCLUSION AND DISCUSSION

We aimed to examine how egoistic, altruistic, and biospheric values and the perceived risks and benefits of nuclear energy are related to the acceptability of nuclear energy in the Netherlands, and, how perceived risks and benefits mediate the relationships between values and acceptability. We found that egoistic values were negatively and nonsignificantly related to the perceived risks of nuclear energy. As expected, egoistic values were significantly and positively related to the perceived benefits and the acceptability of nuclear energy. Thus, people who endorsed egoistic values perceived more benefits, fewer risks, and they evaluated an increase in supply and use of nuclear energy as more acceptable (supporting Hypotheses 1a, 1b, and 1c).

In line with our expectation, correlations and path analysis showed that altruistic values were significantly and positively related to the perceived risks of nuclear energy (Hypothesis 2a). We found support for hypothesis 2(b) as well: altruistic values were not significantly related to the perceived benefits of nuclear energy. However, altruistic values were negatively but not significantly correlated with the acceptability of nuclear energy, disconfirming Hypotheses 2(c).

As expected, biospheric values correlated significantly and positively with the perceived risks of nuclear energy (Hypothesis 3a), but path analysis indicated that biospheric values did not uniquely contribute to the explanation of the perceived risks when the other values were controlled for. As expected, biospheric values were negatively related to the acceptability of nuclear energy (Hypothesis 3c). Interestingly, in line with our expectations (Hypothesis 3b), biospheric values were not positively correlated with beliefs on the benefits of nuclear energy.

To further test to what extent people who strongly endorse biospheric values acknowledge the environmental benefits of nuclear energy, we examined the correlations between egoistic, altruistic, and biospheric values and the specific perceived risk and benefit items. In line with our expectations, we found that both altruistic and biospheric values were most strongly and positively related to the perception of specific risks of nuclear energy, whereas they were negatively or nonsignificantly related to perceptions of specific benefits.

to fully report the formal test of mediation effects. A full description these results can be obtained from the first author.

Fig. 2. Path model of the relationships between values, perceived risks and benefits, and acceptability of an increase in the supply and use of nuclear energy after removing nonsignificant pathways.

Notably, and in line with our expectations, this was even true for the likelihood of the positive effects of nuclear energy on CO₂ reductions and climate change, suggesting that these environmental benefits are not acknowledged as such by those who strongly endorse biospheric values. In contrast, those who strongly endorse egoistic values did evaluate the environmental benefits, i.e., the reduction of climate change, as more likely. So, beliefs about the benefits of nuclear energy, including its contribution to climate change mitigation, appeared to be especially acknowledged by people who strongly endorse egoistic values who are generally in favor of nuclear energy, but not by those endorsing altruistic or biospheric values. This is an interesting finding because, intuitively, one may assume that people who value the biosphere would particularly appreciate the environmental benefits of nuclear energy, rather than those who strongly endorse egoistic values.

How can these counterintuitive findings be explained? As indicated in the Introduction, it seems that people first come up with an overall evaluation of risky activities (i.e., nuclear energy) based on their gut feelings, and base their evaluation of specific risks and benefits on this overall evaluation, thereby trying to be consistent and to come up with a coherent picture.^(42,43) If someone does not like nuclear energy, he or she is likely to say that nuclear energy has substantial risks and only few benefits, and vice versa. Because of this, people who strongly endorse biospheric (and altruistic) values who are not in favor of nuclear energy may evaluate the risks of nu-

clear energy as very likely, and the benefits as very unlikely, whereas the opposite is true for those with strong egoistic values. The above line of reasoning is further strengthened by the strong inverse relationship between the perception of risks and benefits of nuclear energy, although objectively, it is highly unlikely that an activity has either mainly benefits and no risks, or mainly risks and no benefits. This finding is consistent with other risk perception studies.^(4,42,43)

Our results are largely in line with previous research showing that egoistic values are especially positively related to the benefits of nuclear energy and acceptability of nuclear energy, whereas a high perceptions of risks and a lower acceptability of nuclear energy are especially related to social (i.e., altruistic values) and environmental values (i.e., biospheric values).^(5,11,38) So, our study reveals that values are indeed important for understanding the perceived risks, benefits, and acceptability of nuclear energy. Previous studies mostly included worldviews as a possible general determinant of perceived risks and benefits, and acceptability of nuclear energy.^(e.g.,16–18) These studies revealed that an individualistic worldview is associated with mainly seeing benefits of nuclear energy (like egoistic values), whereas an egalitarian worldview is associated with mainly perceiving risks of nuclear energy (like altruistic and biospheric values). Future research could study the role of worldviews as proposed by cultural theory⁽²¹⁾ and values simultaneously to examine how worldviews and values are related, to what extent they predict risk, benefits and acceptability

in a similar way, in which respects they differ, and whether values or worldviews are most predictive of perceived risks, benefits, and acceptability of nuclear energy.

Our findings suggest that altruistic and biospheric values affect perceived risks, benefits and acceptability toward nuclear energy in a similar way. This may be because of the positive correlation between altruistic and biospheric values, which is in line with previous studies and with Schwartz's⁽²⁶⁾ value theory, as both reflect self-transcendence values. This once again demonstrates that perceptions of risks and benefits are not always fully congruent with values, as in that case, we may have found that altruistic and biospheric values affect perceived risks and benefits and acceptability differently, as we included some potential environmental benefits of nuclear energy, as explained above. Future studies are needed to further examine whether altruistic and biospheric values consistently explain a variety of beliefs about risks, benefits and acceptability of nuclear energy in a similar way, and whether it is important to study both altruistic and biospheric values when studying opinions on nuclear energy.

Interestingly, we found that even though the perceived risks and benefits of nuclear energy were negatively and strongly correlated, they both contributed strongly to the explanation of the acceptability of nuclear energy, providing support for Hypothesis 4. Indeed, the perceived risks and benefits were able to predict a substantial proportion of the variance in acceptability judgments. The more risks respondents perceived of nuclear energy, the less they were inclined to accept nuclear energy, supporting Hypothesis 4(a). On the other hand, the more a person that nuclear energy provides benefits, the more acceptable nuclear energy was to them, supporting Hypothesis 4(b). These results are in line with the reasoning of Alhakami and Slovic⁽⁴²⁾ that people evaluate specific risks and benefits of nuclear energy on the basis of an initial overall evaluation of this activity.^(43,44) This finding is also consistent with the historical context of environmental organizations opposing to nuclear energy by emphasizing the risks and downplaying the possible benefits of nuclear energy.

As expected (Hypothesis 5), perceived risks as well as perceived benefits partly mediated the relationship between values and acceptability. More specifically, perceived risks partly mediated the relationship between egoistic values and acceptability as well as the relationship between altruistic values and acceptability, whereas perceived benefits partly me-

diated the relationship between egoistic values and acceptability. This result suggests that values, and especially egoistic values, are directly as well as indirectly (via beliefs on the risks and benefits) related to the acceptability of nuclear energy. These findings seem to contradict findings of Whitfield *et al.*,⁽¹¹⁾ who showed that self-enhancement values did neither directly nor indirectly contribute to the risks and acceptability of nuclear energy (perceived benefits were not included in this study). Future studies should explore why these contradictory results were found. Probably, this may be because of the cultural or country differences, or to the particular conceptualizations of the key variables of interest (e.g., the selection of values, risks and benefits included in the studies, or sample size).

Our sample was not fully representative of the Dutch population. To examine whether this may have affected our results, we examined relationships between sociodemographics (i.e., gender, age, income and household type) and the main variables of interest in our study. In line with previous studies,⁽⁴⁶⁾ sociodemographics appeared to be hardly related to values, perceived risks, perceived benefits, and acceptability. The only exception was "gender."^(see also 46) In line with past research, women were found to perceive more risks and fewer benefits than men, and they evaluated an increase of nuclear energy as less acceptable than men. Importantly, we found a similar pattern of results when correcting for the unequal distribution of gender via a weighting procedure, suggesting that our results were robust. Furthermore, because we were especially interested in relationships between variables and not in comparing absolute scores on these variables, a sample that is not fully representative is less problematic.^(e.g., 4,49) Therefore, we believe that the sample was adequate for the aim of this study.

We examined to what extent egoistic, altruistic, and biospheric values affect the perceived risks and benefits of nuclear energy, and how these in turn explain the acceptability of an increase in the supply and use of nuclear energy in the Netherlands. We showed that values are directly related to perceived risks and benefits, although they are mainly indirectly related to the acceptability of nuclear energy. Also, we found clear support for our hypotheses that those with strong egoistic values evaluated the benefits of nuclear energy as more likely and were more in favor of nuclear energy, whereas those with altruistic and biospheric evaluated the risks as more likely and were less in favor of nuclear energy. Some have

argued that nuclear energy has positive consequences for the biosphere and society as a whole, because it results in reductions in CO₂ emissions and climate change. Our results suggest that these potential environmental benefits are hardly acknowledged by people who strongly endorse biospheric or altruistic values. In fact, environmental benefits seem to be acknowledged mainly by people with strong egoistic values, who are generally more in favor of nuclear energy and perceive more benefits associated with nuclear energy. So, our results do not support the slogan that real environmentalists support nuclear power. It seems more likely that people who support such arguments try to argue in retrospect why they are in favor of nuclear energy.

ACKNOWLEDGMENT

This research was supported by the Department of Psychology at the University of Groningen, and by ESSENT, a Dutch energy company.

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