

# Morality and Nuclear Energy: Perceptions of Risks and Benefits, Personal Norms, and Willingness to Take Action Related to Nuclear Energy

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We examined factors underlying people's willingness to take action in favor of or against nuclear energy from a moral perspective. We conducted a questionnaire study among a sample of the Dutch population ( $N = 123$ ). As expected, perceptions of risks and benefits were related to personal norms (PN), that is, feelings of moral obligation toward taking action in favor of or against nuclear energy. In turn, PN predicted willingness to take action. Furthermore, PN mediated the relationships between perceptions of risk and benefits and willingness to take action. In line with our hypothesis, beliefs about the risks and benefits of nuclear energy were less powerful in explaining PN for supporters compared to PN of opponents. Also, beliefs on risks and benefits and PN explained significantly more variance in willingness to take action of opponents than of supporters. Our results suggest that a moral framework is useful to explain willingness to take action in favor of and against nuclear energy, and that people are more likely to protest in favor of or against nuclear energy when PN are strong.

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**KEY WORDS:** Benefits; nuclear energy; personal norms; risks; willingness to take action

## 1. INTRODUCTION

In many countries, among which is the Netherlands, the use of nuclear energy is a controversial issue. The actions in favor of and against the use of nuclear energy have strongly guided political decision making throughout the years. The first commercial nuclear plant in the Netherlands, Dodewaard, was shut down in 1997 after only 28 years of service. This decision was taken against the background of political opposition to nuclear energy that manifested itself in nationwide public demonstrations and aver-

sion over a long period of time.<sup>(1)</sup> In 1993, the Dutch government also decided that the only remaining nuclear power plant (in Borssele) would be closed in 2004. Plant owners and employees protested against this decision. A new government set in and decided to delay the decommissioning until 2013, meaning the plant would exactly fulfill its intended life span of 40 years.<sup>(2)</sup>

In recent years, the nuclear debate is regaining interest because of increasing concerns about climate change, security of energy supply, and energy self-reliance.<sup>(1-3)</sup> As a result, in 2006, the Dutch government decided that the nuclear power plant in Borssele will remain operational until 2033 provided that the power plant is able to comply with the highest safety standards. Furthermore, the Social and Economic Council of the Netherlands advised the Dutch government to postpone further decisions on increasing the supply and use of nuclear energy at least until 2010.<sup>(3)</sup> It suggested that the government should

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keep an open mind about the use of nuclear energy in the Netherlands.

This brief history of nuclear energy in the Netherlands makes clear that there have been opponents and supporters of nuclear energy who both try to influence the political decision-making process. Willingness to take action among the public will strongly influence the decision-making process because politicians are reluctant to introduce policies that lack public support.<sup>(4)</sup> Therefore, it is important to understand which factors influence the public's willingness to take action in favor of or against nuclear energy. In this article, we provide a framework to understand the factors underlying people's willingness to take action in favor of or against nuclear energy.

### 1.1. Willingness to Take Action from a Moral Perspective

Both willingness to take action *in favor of* and *against* nuclear energy can be regarded as an intention to take environmental action.<sup>(5,6)</sup> Environmental activism implies that individuals are prepared to take an active involvement in actions to reduce environmental problems or risks, such as being a member of an environmental organization, participating in demonstrations, or signing petitions. Environmental activism entails that people benefit others or the environment, such as taking action to promote nuclear energy to reduce CO<sub>2</sub> emissions or taking action against nuclear energy to reduce the chance of nuclear waste accidents. Individuals may personally benefit as well, but this is generally not the main motivation for their willingness to take action.<sup>(7)</sup>

Environmental activism often does not benefit individual interests in the short term because it takes time, effort, and money to protest. Therefore, environmental activism is often associated with morality, that is, it is rooted in considerations of what is the right thing to do.<sup>(5,7)</sup> Various scholars suggest that moral considerations are of primary importance to explain willingness to take action toward nuclear energy.<sup>(8–11)</sup> Therefore, theories that focus on the role of moral considerations, such as the norm activation model (NAM),<sup>(12,13)</sup> may be a relevant framework for research in the area of risk perception<sup>(14)</sup> and, specifically, to explain activism intentions toward nuclear energy. The NAM was originally developed to explain prosocial behaviors, but has successfully been applied to examine intentions and behaviors in the environmental domain.<sup>(15–19)</sup> The NAM also

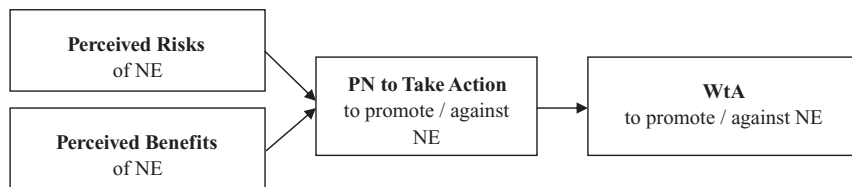
appeared to be successful in explaining activism-type intentions and behaviors, such as willingness to pay for environmental protection<sup>(20,21)</sup> and pro-environmental political behavior.<sup>(6,22)</sup> Therefore, the NAM seems relevant for explaining willingness to take action in favor of or against nuclear energy.

### 1.2. The Norm Activation Model and Willingness to Take Action

The NAM explicitly considers morality when explaining intentions and behaviors.<sup>(12,14)</sup> The NAM proposes that prosocial or pro-environmental behavior follows from personal norms (PN) that reflect “feelings of moral obligation to perform or refrain from specific actions” (p. 191).<sup>(13)</sup> In our case, PN reflect feelings of moral obligations to engage in actions in favor of or against nuclear energy, respectively. When actors fail to activate PN, no actions will be recognized as appropriate and willingness to take action will be low. In line with the NAM, we assume that PN to engage in actions in favor of or against nuclear energy will be the most important antecedent of willingness to take action in favor of or against nuclear energy.

According to Schwartz,<sup>(12)</sup> PN are activated when people are aware of the adverse consequences of not acting morally right. Schwartz and Howard<sup>(13)</sup> acknowledge that, besides concern about negative consequences, positive consequences may affect willingness to take action in favor of or against nuclear energy as well. However, studies based on the NAM generally do not study the influence of perceived positive consequences on PN. Also, in risk research, intentions to protest are believed to be dependent on the tradeoff between “risks” (i.e., negative or adverse consequences or costs) and “benefits” (i.e., positive consequences) of nuclear energy: the more a person believes nuclear energy has beneficial (e.g., cheap energy or less CO<sub>2</sub> emissions) rather than negative consequences or risks (e.g., increase risks of a nuclear accidents), the stronger his or her willingness to take action to promote the use of nuclear energy, while willingness to protest against the use of nuclear energy will be higher when a person believes that nuclear energy has particularly negative consequences or risks rather than positive consequences.<sup>(23–29)</sup> Hence, negative as well as positive consequences seem relevant to explain PN and willingness to take action in favor or against nuclear energy, but supporters and opponents are likely to

**Fig. 1.** Mediation model of risks, benefits, personal norms, and willingness to take action to promote/against nuclear energy.



Notes: PN = personal norms; WtA = willingness to take action; NE = nuclear energy.

differ in the way in which they emphasize the positive and negative consequences of nuclear energy.

We will examine how perceptions of risks and benefits of nuclear energy explain PN and activism intentions for both supporters and opponents of nuclear energy. We expect that supporters of nuclear energy have stronger PN and are more willing to protest in favor of nuclear energy when they perceive more benefits and less risks of nuclear energy, whereas opponents have stronger PN and are more likely to protest against nuclear energy when they perceive more risks and less benefits of nuclear energy. Furthermore, we propose that perceptions of risks and benefits of nuclear energy are mostly indirectly related to willingness to protest, through PN.<sup>(5,16,30)</sup> So, we expect that PN mediate the relationship between the perceived risks and benefits of nuclear energy and willingness to take action (Fig. 1), as suggested in the NAM.

**1.3. Beliefs About Risks and Benefits and Willingness to Take Action**

Research revealed that people consider various risks and benefits of nuclear energy.<sup>(25,26,31)</sup> In general, perceptions of risks of nuclear energy are predominantly related to collective problems. People believe that an increase in the supply of nuclear energy increases the risk of nuclear accidents, waste management problems, or environmental pollution.<sup>(25,26,31,32)</sup> Of course, reducing these risks may benefit the individual as well, but the risks are clearly related to collective interests. Nuclear energy also has potential social and environmental benefits, such as reductions in CO<sub>2</sub> emissions or climate change mitigation.<sup>(33)</sup> Besides, nuclear energy has potential individual benefits, such as getting cheap energy.<sup>(24–27,31)</sup> As explained previously, willingness to take action from a moral perspective generally implies that people are willing to take action in favor of or against nuclear energy without close attention to individual costs and benefits.<sup>(7,34)</sup> As nuclear en-

ergy has mainly collective risks and opponents tend to focus more on the risks, while the benefits are related to both collective and individual interests, we assume that taking action against nuclear energy will be more based on moral (collective) considerations than taking action in favor of nuclear energy. Thus, we expect that perceptions about risks and benefits of nuclear energy and PN toward taking action will be less powerful in explaining willingness to take action to promote nuclear energy (i.e., of supporters) than willingness to take actions against it (i.e., of opponents).

**1.4. Aim of This Study**

The NAM appears to be successful in explaining various types of moral intentions and behaviors. However, as yet, it has not been tested to explain willingness to take action in favor of or against risky activities such as nuclear energy. In this study, we aim to examine whether the NAM is a relevant framework for explaining willingness to take action in favor of or against an increase in supply and use of nuclear energy in the Netherlands. Based on the earlier discussion, we expect that opponents of nuclear energy are more likely to have stronger PN and engage in actions against nuclear energy when they think nuclear energy has many risks and few benefits (hypothesis 1a). And, supporters have stronger PN and are more likely to engage in actions in favor of nuclear energy when they perceive many benefits and few risks of nuclear energy (hypothesis 1b).

Furthermore, we expect that the perceived risks and benefits are related to willingness to take action in favor of or against nuclear energy, but mostly indirectly, via PN. That is, we propose that PN mediate the relationship between perceived risks and benefits and willingness to take action (hypothesis 2). Finally, we evaluate the relative utility of the NAM for explaining willingness to take action to promote nuclear energy (i.e. supporters) and willingness to take action against nuclear energy (i.e. opponents). We

assume that the NAM has less explanatory power to explain willingness to take action in favor of nuclear energy compared to explaining willingness to take action against nuclear energy (hypothesis 3).

## 2. METHOD

### 2.1. Procedure and Respondents

In December 2008, we send out 1,000 questionnaires to a randomly selected sample of the Dutch population. Respondents received a letter with the request to fill in a questionnaire about nuclear energy. We included a reply paid envelope. Respondents did not receive any financial incentives for cooperation. One hundred and twenty-eight respondents returned the questionnaire (response rate of 13%), of which 123 were useful for analysis. The five respondents who were excluded from further analyses did not answer most questions, resulting in too many missing data.

The sample was not entirely representative of the Dutch population.<sup>(35,36)</sup> Men were overrepresented (76%) compared to women (24%). The average age of respondents was 53 years ( $SD = 15.5$ ). Respondents aged between 20 and 40 years were somewhat underrepresented (18.5% compared to the Dutch average of 26.0%), whereas respondents aged 40–65 (41.7% compared to 35.3%) and 65–80 (14.6% compared to 11.0%) were slightly overrepresented. Single-person households were underrepresented: 19% single households in the sample, compared to approximately 35% in the Dutch population. Forty-eight percent were two-person households (compared to 29% in the Dutch population), and 26% consisted of three persons or more (compared to 29% in the Dutch population). Income levels were representative for the Dutch population, with 25% having a net monthly household income of less than 2,000 Euros, 34% having an income between 2,000 and 3,000 Euros, 24% having an income between 3,000 and 4,000 Euros, and 17% of more than 4,000 Euros. Because of the low response rate, our sample can probably best be regarded as a convenience sample.

### 2.2. Measures

After filling in a brief questionnaire on values (not to be discussed here), respondents read a general introduction in which we explained that the Dutch government had to decide whether an in-

crease in supply and use of nuclear energy would be needed to meet the increasing energy demands in the Netherlands. After reading this introduction, respondents completed questions on beliefs about the risks and benefits of an increase in supply and use of nuclear energy in the Netherlands, followed by a general question about whether they considered themselves as “supporters” or “opponents” of an increase in supply and use of nuclear energy in the Netherlands. Respondents were also given the opportunity to be indecisive.

We developed two versions of the second part of the questionnaire: one for supporters and one for opponents of nuclear energy. The group of supporters ( $N = 72$ , 59.5%) included all participants who indicated they were in favor of nuclear energy. The group of opponents included all respondents who were either opposing nuclear energy ( $N = 29$ , 24.0%) or were indecisive about nuclear energy ( $N = 20$ , 16.5%). We made the decision to include the indecisive respondents in the group of opponents when developing the questionnaire because we assumed that this group would at least consider moral (social and environmental) risks and benefits of nuclear energy just as much as opponents of nuclear energy because otherwise they would face fewer problems to come to a decision. Because we assumed that opponents emphasize the social and environmental risks, we believed that asking specific questions related to personal norms and activism against nuclear energy would not be inappropriate. *Post hoc* exploratory descriptive analyses revealed that the indecisive group responded in the same direction toward the individual risk and benefit items as did opponents of nuclear energy. The risks and benefits of nuclear energy were measured preceding the question about whether respondents considered themselves as supporters, opponents, or indecisive. This further validated our decision to ask these respondents questions in relation to personal norms and willingness to take action *against* nuclear energy.

Finally, respondents had to indicate to what extent they felt morally obliged to take action in favor of or against nuclear energy (i.e., PN) and to what extent they were willing to take action in favor of or against an increase of supply and use of nuclear energy in the Netherlands (i.e., willingness to take action), respectively. The questions were alternated with questions irrelevant for this study. Respondents were also asked questions on sociodemographic characteristics in this part. We measured the main constructs as follows.

### 2.2.1. Beliefs on Risks and Benefits

Beliefs about the potential risks and benefits of an increase in the supply and use of nuclear energy in the Netherlands were based on a selection of the most relevant beliefs considered in the Eurobarometer 2008<sup>(37)</sup> combined with information from the Dutch media, Internet sites, and research articles.<sup>(2,3,38)</sup> We informed respondents that an increase in supply and use of nuclear energy may result in different consequences. Next, we asked how likely they believed 13 positive and negative consequences were when more nuclear energy would be supplied and used in the Netherlands. Respondents rated the likelihood of the following six potential risks of an increase in supply and use of nuclear energy on a 7-point Likert scale ranging from 1 (*very unlikely*) to 7 (*very likely*): (1) increase in risks of accidents for future generations; (2) increase in environmental problems; (3) increase in health risks for people in the Netherlands; (4) increase in risks of accidents related to nuclear waste; (5) increase in risks of accidents related to the transport of nuclear waste; and (6) increase in the likelihood of proliferation of nuclear weapons. Respondents also indicated the likelihood of seven potential benefits: (1) economic growth; (2) decrease in climate change; (3) increase in employment; (4) more affordable energy; (5) decrease in CO<sub>2</sub> emissions; (6) decrease in dependency of energy supply from other countries; and (7) decrease in the use of fossil fuels. Beliefs about the risks and benefits items were put in random order. We computed mean scores for items that were included on the risks ( $M = 4.1$ ,  $SD = 1.5$ ,  $\alpha = 0.89$ ) and benefits ( $M = 4.4$ ,  $SD = 1.3$ ,  $\alpha = 0.87$ ) scale. These scores revealed that respondents believed that the benefits of nuclear energy were slightly more likely than the risks.

### 2.2.2. Personal Norms

Respondents rated to what extent they agreed with four items reflecting the extent to which they felt morally obliged to take action in favor of or against an increase in the supply and use of nuclear energy in the Netherlands. An example is “I feel morally obliged to sign a petition *in favor of* the implementation of a new power plant in the Netherlands” or “I feel guilty when I don’t take action *in favor of* the use of nuclear energy” (i.e., for supporters). Opponents of nuclear energy evaluated the same items but this time the items focused on taking action against nuclear energy (e.g., “I feel morally obliged to sign a

petition *against* the implementation of a new power plant in the Netherlands” or “I feel guilty when I don’t take action *against* the use of nuclear energy”). Respondents scored all items on a 7-point Likert scale ranging from 1 (*fully disagree*) to 7 (*fully agree*). Mean scores were computed on items included in the PN scale for supporters ( $M = 2.8$ ,  $SD = 1.2$ ) and opponents ( $M = 3.8$ ,  $SD = 1.7$ ) of nuclear energy. Supporters had weaker personal norms than opponents. The internal consistency of this scale was 0.79 for supporters and 0.91 for opponents.

### 2.2.3. Willingness to Take Action

Supporters of nuclear energy were asked how likely it would be that they would take six actions to *increase* the supply and use of nuclear energy in the Netherlands. Opponents were asked to what extent they were likely to take these same actions to *prevent an increase* in the supply and use of nuclear energy in the Netherlands. We included the following actions: (1) participate in a demonstration *in favor of/against* the implementation of a new nuclear power plant; (2) sign a petition *in favor of/against* an increase in the supply and use of nuclear energy; (3) donate to an organization that aims to *support/oppose* nuclear energy use in the Netherlands; (4) put a protest poster on your window to *support/oppose* the construction of a nuclear power plant in the Netherlands; (5) participate in a public meeting to convince authorities to *increase/decrease* the supply and use of nuclear energy; and (6) vote for a political party that *supports/opposes* nuclear energy in the Netherlands. Responses on the 7-point Likert scale could range from 1 (*not likely to take the action*) to 7 (*very likely to take the action*). We computed the mean score, standard deviation, and Cronbach’s alpha on these six items for supporters ( $M = 3.1$ ,  $SD = 1.2$ ,  $\alpha = 0.83$ ) and opponents of nuclear energy ( $M = 4.2$ ,  $SD = 1.6$ ,  $\alpha = 0.90$ ). Supporters of nuclear energy were less willing to take action than opponents.

## 2.3. Analyses

We first computed Pearson’s bivariate correlations between the different constructs for the group of supporters and opponents separately. Next, we further examined the relationships between perceived risks and benefits, PN, and willingness to take action by means of a series of regression analyses for both groups. We followed the procedure suggested by Baron and Kenny<sup>(39)</sup> to test the mediation model.

They define four criteria to establish mediation: there must be a direct relationship between (1) the independent variables (i.e., beliefs about the risks and benefits) and the mediator (i.e., PN); (2) the independent variables and the dependent variable (i.e., willingness to take action); (3) the mediator and the dependent variable; and (4) the direct effect of the independent variables on the dependent variable should weaken substantially or even disappear when the mediator is included in the model as well. We report  $F$ -values of the four regression models and  $\beta$  of predictors that significantly contributed to the regression model because multiple predictors (i.e., beliefs about the risks and beliefs about the benefits) were included in the model. The Goodman version of the Sobel test<sup>(40)</sup> was used to test the significance of the mediation effects. We first report results of mediation analysis for supporters of nuclear energy, then for the opponents.

Finally, we checked if the proposed model better explains willingness of opponents to take action against nuclear energy than willingness to take action in favor of nuclear energy of supporters. To do so, we computed the confidence interval around the difference in  $R^2$  of the different regression models for supporters and opponents of nuclear energy, following the procedure proposed by Olkin and Finn.<sup>(41)</sup> We consider the  $R^2$ -values of regression models to be significantly different with 95% certainty when the confidence interval for the difference between two squared multiple correlations excludes zero.

### 3. RESULTS

#### 3.1. Bivariate Correlations Between Perceived Risks and Benefits, Personal Norms, and Willingness to Take Action

Bivariate correlations were computed between beliefs about risks and benefits, PN, and willingness to take action for supporters and opponents of nuclear energy (Table I). Willingness to take action in favor of nuclear energy is most strongly related to PN, less strongly to beliefs on the benefits, and not significantly to beliefs about the risks of nuclear energy. When respondents felt strong moral obligations to take action to promote the supply and use of nuclear energy, they were also more willing to take action in favor of nuclear energy ( $r = 0.66$ ). And the more they believe nuclear energy has benefits, the more they are willing to take action to promote an increase in supply and use of nuclear energy ( $r =$

**Table I.** Bivariate Correlations Between Beliefs About Benefits and Risks, PN, and Willingness to Take Action for Supporters ( $N = 72$ ) and Opponents ( $N = 49$ ) of Nuclear Energy

	1	2	3	4
Opponents				
Supporters				
1. Beliefs about benefits	–	–0.35*	–0.44**	–0.47**
2. Beliefs about risks	–0.05	–	0.54**	0.62**
3. Personal norms	0.26*	.11	–	0.88**
4. WtA to promote/against NE	0.30**	–0.08	0.66**	–

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

Note: WtA = willingness to take action; NE = nuclear energy.

0.30). PN were significantly related to beliefs about the benefits of nuclear energy ( $r = 0.26$ ), indicating that the more respondents believe nuclear energy has benefits, the stronger they feel a moral obligation to take action promoting nuclear energy. PN were not significantly related to the beliefs about the risks ( $r = 0.11$ ). Finally, we found a negative relationship between perceived benefits and risks, but this relationship was nonsignificant ( $r = -0.05$ ).

Table I shows that willingness to take action against nuclear energy is more strongly related to PN than to the perceived risks and benefits of nuclear energy. Respondents were more willing to take action against an increase in the supply and use of nuclear energy when they felt a stronger moral obligation to engage in these actions ( $r = 0.88$ ), when they believed nuclear energy had more risks ( $r = 0.62$ ), and when they believed that nuclear energy had fewer benefits ( $r = -0.47$ ). PN were negatively and strongly related to beliefs about the benefits of nuclear energy, indicating that the more respondents believed nuclear energy has benefits, the less they felt morally obligations to take actions to prevent an increase in nuclear energy supply and usage ( $r = -0.44$ ). In contrast, the more respondents perceived nuclear energy as risky, the stronger they felt a moral obligation to take action ( $r = 0.54$ ). Perceptions of risks and benefits showed a negative significant relationship. The more respondents believed nuclear energy to have risks, the less they believed that nuclear energy has positive consequences ( $r = -0.35$ ).

#### 3.2. Testing the NAM for Supporters

Table II shows the results of the series of regression analyses intended to test the mediation model

**Table II.** Multiple Regression Analyses to Test Whether PN Mediate the Relationship Between Risks and Benefits, and Willingness to Take Action to Promote Nuclear Energy ( $N = 72$ )

	$R^2$	$F$	$df$	$\beta$	$t$	$p$
1. DV: personal norms	0.08	3.16	2, 69			0.049
Beliefs about risks				0.13	1.12	0.268
Beliefs about benefits				0.27	2.31	0.024
2. DV: willingness to take action	0.10	3.64	2, 69			0.032
Beliefs about risks				-0.06	-0.52	0.604
Beliefs about benefits				0.30	2.62	0.011
3. DV: willingness to take action	0.43	53.16	1, 70			0.000
Personal norms				0.66	7.29	0.000
4. DV: willingness to take action	0.47	20.12	3, 68			0.000
Personal norms				0.64	6.94	0.000
Beliefs about risks				-0.14	-1.60	0.115
Beliefs about benefits				0.13	1.41	0.163

Note: DV: dependent variable.

explaining willingness of supporters to take action in favor of nuclear energy. First, perceived risks and benefits explained 8% of the variance in PN for supporters of nuclear energy ( $F(2, 69) = 3.16, p = 0.049$ ). Only beliefs about the benefits of nuclear energy contributed significantly to the explanation of PN. The more respondents believed that nuclear energy had benefits, the stronger their feelings of moral obligation to take action to promote the use and supply of nuclear energy in the Netherlands ( $\beta = 0.27, p = 0.024$ ).

Second, beliefs about the risks and benefits were significantly related to willingness to take action to promote nuclear energy in the Netherlands ( $R^2 = 0.10, F(2, 69) = 3.64, p = 0.032$ ). Again, only beliefs about the benefits of nuclear energy contributed uniquely to the explanation of willingness to take action. As expected, the more respondents believed that nuclear energy had benefits, the higher their willingness to take action to promote the supply and use of nuclear energy ( $\beta = 0.30, p = 0.011$ ).

Third, PN were positively related to willingness to take action ( $R^2 = 0.43, F(1, 70) = 53.61, p < 0.001$ ). The stronger respondents felt morally obliged to take action in favor of nuclear energy, the more they were willing to take actions accordingly ( $\beta = 0.66, p < 0.001$ ). Fourth, when both PN and perceived risks and benefits were included in the regression model, 47% of the variance in willingness to take action was explained ( $F(3, 68) = 20.12, p < 0.001$ ). Only PN ( $\beta = 0.64, p < 0.001$ ) contributed significantly to this model, whereas the perception of the risks and benefits of nuclear energy did not contribute significantly to this model.

To test whether PN indeed carried the influence of risks and benefits on willingness to take ac-

tion, a Sobel test was conducted. As only benefits were significantly related to PN and willingness to take action, we could only test whether PN mediated the relationship between benefits and willingness to take action. The Sobel test confirmed that PN mediated the relationship between beliefs about the benefits of nuclear energy and willingness to take action ( $t(70) = 2.19, p = 0.028$ ).

### 3.3. Testing the NAM for Opponents

Table III shows the results of the series of regression analyses aimed at testing the mediation model to explain willingness of opponents to take action against nuclear energy. First, beliefs about the benefits and risks of nuclear energy explained 37% of the variance in PN ( $F(2, 46) = 13.31, p < 0.001$ ). The more respondents believed that an increase in the supply and use of nuclear energy results in risks, the more they felt morally obliged to take action against an increase in the supply and use of nuclear energy ( $\beta = 0.44, p < 0.001$ ). And, the less respondents believed that nuclear energy has benefits, the more they felt morally obliged to take actions against nuclear energy ( $\beta = -0.28, p = 0.027$ ).

Second, the perceived risks and benefits of nuclear energy explained a significant proportion in the variance of willingness to take action ( $R^2 = 0.45, F(2, 46) = 19.13, p < 0.001$ ). The less respondents believed that an increase of supply and use of nuclear energy would result in benefits, the more they were willing to take action against it ( $\beta = -0.28, p = 0.018$ ). And, the more they believed an increase in nuclear energy would involve an increase in risks, the more they were willing to take action against an

	$R^2$	$F$	$df$	$\beta$	$t$	$p$
1. DV: <i>personal norms</i>	0.37	13.31	2, 46			0.000
Beliefs about risks				0.44	3.54	0.001
Beliefs about benefits				-0.28	-2.29	0.027
2. DV: <i>willingness to take action</i>	0.45	19.13	2, 46			0.000
Beliefs about risks				0.52	4.48	0.000
Beliefs about benefits				-0.28	-2.45	0.018
3. DV: <i>willingness to take action</i>	0.77	154.10	1, 47			0.000
Personal norms				0.66	12.41	0.000
4. DV: <i>willingness to take action</i>	0.80	59.93	3, 45			0.000
Personal norms				0.74	8.82	0.000
Beliefs about risks				0.19	2.40	0.020
Beliefs about benefits				-0.07	-0.97	0.338

Note: DV: dependent variable.

increase in nuclear energy supply and usage ( $\beta = 0.52$ ,  $p < 0.001$ ). Third, PN to take action against an increase in supply and use of nuclear energy explained 77% of the variance in willingness to take action ( $F(1, 48) = 154.10$ ,  $p < 0.001$ ). The stronger respondents felt morally obliged to take action against an increase in the supply and use of nuclear energy, the more they were willing to take action accordingly ( $\beta = 0.66$ ,  $p < 0.001$ ).

When beliefs about the risks and benefits of nuclear energy were entered in the regression analysis as well, 80% of variance in willingness to take action against nuclear energy was explained ( $R^2 = 0.80$ ,  $F(3, 45) = 59.93$ ,  $p < 0.001$ ). PN contributed most strongly to the model ( $\beta = 0.74$ ,  $p < 0.001$ ). Beliefs about the risks also contributed to this model ( $\beta = 0.19$ ,  $p < 0.020$ ), whereas beliefs about the benefits of nuclear energy did not contribute significantly to the model. Sobel tests confirmed that PN fully mediated the relationship between beliefs about the benefits of nuclear energy and willingness to take action ( $t(47) = -2.21$ ,  $p = 0.027$ ), and partly mediated the relationship between the risks of nuclear energy and willingness to take action ( $t(47) = 3.27$ ,  $p = 0.001$ ).

### 3.4. Comparing the Explanatory Power of the NAM for Opponents and Supporters

Beliefs about the risks and benefits of nuclear energy explained less variance in PN of supporters (i.e., 8%) compared to opponents (i.e., 37%) (Tables II and III); the 95% confidence interval around the difference in explained variance did not include zero (95% CI: 0.07, 0.51). Therefore, we regard this difference as significant. Beliefs about the

risks and benefits of nuclear energy and PN explained 47% of variance in willingness to take action for the supporters of an increase in nuclear energy compared to 80% of the variance in willingness to take action for the opponents of nuclear energy (Tables II and III). The difference in explained variance is 33%, and the confidence interval around the difference in explained variances excludes zero (95% CI: 0.14, 0.53). This suggests that the NAM is more successful in explaining willingness to take action of opponents than of supporters.

## 4. DISCUSSION

We examined whether a moral framework, in particular the NAM, is useful in explaining willingness to take action in favor of or against nuclear energy. The results of our study confirm that beliefs on risks and benefits of nuclear energy together with PN are powerful in explaining willingness to take action in favor of or against nuclear energy. As expected, perceptions of risks and benefits predicted PN toward taking action in favor of or against nuclear energy, while PN in turn were strong predictors of willingness to take action. Most importantly, PN mediated the relationships between perceptions of risk and benefits and willingness to take action.

Willingness to take action of supporters of nuclear energy depended on the expected likelihood of benefits of nuclear energy. Supporters felt a stronger moral obligation to promote nuclear energy and were more willing to take action to promote nuclear energy when they perceived more benefits of nuclear energy. PN to take action in favor of nuclear energy were positively related to their willingness to take

**Table III.** Multiple Regression Analyses to Test Whether PN Mediates the Relationship Between Risks and Benefits, and Willingness to Take Action Against Nuclear Energy ( $N = 49$ )



action to promote nuclear energy and mediated the relationship between perceived benefits and willingness to take action. The perceptions of risks did not contribute uniquely to the explanation of PN and willingness to take action for supporters when the other variables were controlled for.

For opponents, beliefs about both the benefits and the risks were related to PN to take action against an increase in the supply and use of nuclear energy as well as to willingness to take action against nuclear energy. The more opponents believed that an increase of nuclear energy would result in negative consequences (i.e., risks), the more they felt morally obliged to take action against nuclear energy and the more willing they were to take action accordingly. And, the other way around, when they believed that nuclear energy had less benefits, they felt a stronger moral obligation to take actions against nuclear energy and were more willing to take action against nuclear energy. Again, PN to take action opposing nuclear energy were strongly and positively related to opponents' willingness to take action against nuclear energy, and mediated the relationship between perceived risks and benefits and willingness to take action.

These results support the NAM,<sup>(12,13)</sup> that is, PN are the most important predictor of willingness to take action. Our results correspond with previous research that showed that PN mediate relationships between problem awareness (reflecting perceptions of risks) and environmental significant intentions and behaviors.<sup>(5,16,30,42)</sup> However, we found that perceptions of risks were only related to PN and willingness to take action of opponents, and not to PN and willingness to take action of supporters of nuclear energy. Importantly, we showed that, next to beliefs about the negative consequences (i.e., risks), beliefs about the positive consequences (i.e., benefits) were also directly related to PN and indirectly to willingness to take action of both supporters and opponents. Supporters of nuclear energy feel a stronger moral obligation to take action when they perceive more benefits of an increase in supply and use of nuclear energy, while opponents are less likely to protest against nuclear energy if they perceive more benefits of nuclear energy. Our findings suggest that future studies should not only focus on the awareness of negative consequences of risky technologies to explain activism intentions. Perceptions of positive consequences of risk technologies such as nuclear energy appear to be an important predictor of PN toward taking action, as well as (indirectly) of will-

ingness to take action. Future studies should investigate whether including perceptions of benefits in the NAM is also important for explaining other types of risk-related behavioral intentions and behaviors for opponents and supporters of the relevant technology.

The mediating role of PN confirms that a moral framework is useful for explaining willingness to take action in favor of or against risky technologies, such as nuclear energy. Our results convincingly showed that perceptions of risks and benefit influence willingness to take action because they elicit feelings of moral obligations. Most risk studies focus on beliefs about the risks or beliefs about the risks and benefits to explain activism-type intentions.<sup>(11,26,42)</sup> To the authors' knowledge, this is the first study that convincingly integrated perceptions of risks and benefits into a moral model. Our study clarifies via which process activism intentions toward risky technologies are elicited.

Perceived risks and benefits and PN explained a large amount of variance in willingness to take action, especially for opponents of nuclear energy. By focusing on three variables only (i.e., perceptions of risks, perceptions of benefits, and PN), our model seems more efficient than more extensive risk perception models that explain activism-type intentions.<sup>(11,26,29,43–45)</sup> Generally speaking, in the more extensive models that include variables such as risks, benefits, self-efficacy, fairness and social norms, the amount of explained variance of willingness to take action in favor of or against nuclear energy varies between 13% and 66%.

This study also aimed to examine whether the variables included in the NAM would be more powerful in explaining willingness to take action for opponents compared to supporters. Our findings confirm this assumption. Correlations between beliefs about the benefits and risks, PN, and willingness to take action were without exceptions stronger for opponents than for supporters of nuclear energy. Regression analyses provided further support by showing that beliefs about the risks and benefits of nuclear energy were less powerful to explain PN for supporters compared to opponents. Also, beliefs on risks and benefits together with PN explained significantly more variance in willingness to take action of opponents than of supporters. As explained in Section 1, most scholars in the domain of nuclear energy emphasize that nuclear energy is associated with social and environmental risks<sup>(25,26,31,32)</sup>, whereas nuclear energy has a combination of individual and collective benefits.<sup>(27,31)</sup> Focusing on

willingness to take action from a moral perspective generally implies that you are willing to take action in favor of or against nuclear energy without close attention to personal costs and benefits.<sup>(5,7,34)</sup> Our results suggest that opponents are indeed more likely to act on the basis of moral considerations. Thus, albeit taking action to promote nuclear energy is recently injected with a “moral boost,” such as emphasizing the benefits of nuclear energy with regard to climate change issues,<sup>(33)</sup> this study suggests that willingness to take action *against* nuclear energy is still more heavily based on doing “the right thing” compared to taking action to promote nuclear energy. Therefore, a moral framework, such as the NAM, seems particularly useful to explain willingness to take action of opponents of nuclear energy.

Our sample was not fully representative of the Dutch population and relatively small. Therefore, we should be careful in generalizing our findings to the general population. However, we were especially interested in correlations between variables, and not in reporting and comparing mean scores. In such a case, a sample that is not fully representative is less problematic.<sup>(46)</sup> We have no reason to believe that correlations between key variables would differ if we had a larger sample, or a sample that is more representative of the Dutch population. Furthermore, for explaining willingness to take action the effect sizes were large for both supporters and opponents of nuclear energy.<sup>(47)</sup> Sample sizes of a minimum of only 40 respondents are required when explaining willingness to take action with only three predictors when effect sizes are large.<sup>(48)</sup> Therefore, we think that the sample was appropriate for the aim of this study. Of course, our conclusions remain tentative until our results are validated in larger and different samples and countries. For example, it would be interesting to test whether the NAM will be more predictive in countries that have showed extreme opposition toward nuclear energy in the past versus countries that have always supported nuclear energy. Based on our results, we would expect that a moral framework works better for those countries in which more opposition is present (i.e., firmer group of opponents of nuclear energy) compared to those countries that are more in favor of nuclear energy (i.e., firmer group of supporters of nuclear energy).

Schwartz<sup>(12)</sup> argued that PN are activated not only when perceptions of awareness of negative consequences (i.e., beliefs about the risks and benefits of nuclear energy) are high, but also when people feel responsible for avoiding possible negative outcomes,

when people think their actions are effective in reducing these negative outcomes, and when they think they are able in engaging in the relevant actions. We did not include these variables in our study. We decided to first study whether and how the key variables in risk research (i.e., perceptions of risks and benefits) would be related to PN and willingness to take action toward nuclear energy before working with more complicated models that include all NAM variables. Future studies should examine the role of these other variables in explaining PN and willingness to take action, next to beliefs about the risks and benefits of nuclear energy.

The approach of this study provides important insights to policy- and decisionmakers in motivations that underlie the public’s willingness to take action in favor of or against nuclear energy. Taking actions in favor of as well as against nuclear energy can be promoted by reinforcing feelings of moral obligation, which can be strengthened by changing people’s perceptions of risks and benefits of nuclear energy. People can be informed about the risks and benefits via communication and education programs. Future studies are needed to examine whether and under what specific circumstances these strategies are indeed successful to change beliefs on risks and benefits, and thus to alter PN and willingness to take action, respectively.

Our results suggest that moral models such as the NAM are important to understand risk-related behaviors. We hope to have made a first step to show the relevance of “moral” models for explaining activism intentions toward risky technologies.

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