Knowledge & Attitudes on Nuclear Energy

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Abstract

With recent elections in the Netherlands, the topic of nuclear energy was rekindled by many political parties. Some see it as the solution to prevent carbon dioxide emissions, and some think nuclear energy is a dangerous way to generate energy. No researchers have looked for attitude differences on nuclear energy in the Netherlands, and what could cause this. This research aims to fill this gap by testing whether providing information on nuclear energy improves how people perceive it. This is done through an online survey which had 111 respondents from the Dutch adult population. After providing the treatment group with information, attitudes were compared with help of seven attitude statements. The results were analysed with help of Mann-Whitney U tests and linear regressions.

Results show that there is a knowledge gap about nuclear energy. However, filling this gap with information did not improve one's attitude. Regressions showed that females and people with left-wing political affiliation showed a more negative attitude towards the use of nuclear energy. In addition, people with either conservative or progressive affiliations showed a more positive attitude. Mann-Whitney U tests showed that females from the control group showed more negative attitudes towards the use of nuclear energy, while the political affiliations right and conservative showed a more positive attitude. Other tested demographics did not show significant differences.

Due to little significant results, a small, and not representative sample, no policy implications should be made based on these results. Follow-up research is necessary to draw more precise conclusions.

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Introduction

Energy is one of the main factors considered in discussions of sustainable development. Sustainable development is the idea to meet the needs of the present without compromising the ability of future generations to meet their own needs (Dincer, 1999). Generally, energy sources are marked as either fossil-based energy or green energy. The difference between these two is that fossil-based energy, for example coal, petroleum or gas, are not renewable. Green energy sources like wind, solar, tidal or biomass are renewable and therefore often chosen for sustainable energy strategies (Midilli et al., 2006).

One of the most controversial energy sources is nuclear energy. Nuclear energy is energy which is taken out of the core of an atom. In the process of nuclear fission of the element uranium, atoms are forced to break apart. The fission products cause other uranium atoms to split, starting a chain reaction. The energy released from this process creates heat, which is used to create steam. The steam turns turbines, and these turbines drive generators to create electricity (Ramroop et al., 2011). Nuclear energy is known for very low carbon emission, which is the main driver of worldwide greenhouse gas emissions (about 66%). Therefore nuclear energy is considered an important resource in managing atmospheric greenhouse gases and therefore climate change.

Public attitudes towards nuclear energy are formed by news regarding it. Two very well-known news items about nuclear energy are the two nuclear disasters in Chernobyl (1986) and in Fukushima (2011). Although nuclear accidents are rare, they produce severe damage and therefore generate a strong signal that there is an unusual risk in nuclear power generation (Slovic, 1987). A research by Kim et al. (2013) stated that the Fukushima disaster, caused by a tsunami, had an indirect effect on public acceptance of nuclear energy because of the stigma it creates. Stigma is an illuminating excursion into the situation of persons who are unable to conform to standards that society calls normal. Disqualified from full social acceptance, they are stigmatized individuals (Goffman, 2009). A specific type of stigma is technological stigma, which refers to the negative public perception of potential hazards of new technology or technology-based activities such as the construction of a power plant (Gregory et al., 1995). The stigma can result from actual or perceived hazards fuelled by negative imagery from mass media.

As of 2011, 435 nuclear reactors are in operation worldwide, with an additional 108 under construction or on order. Worldwide, nuclear energy provides about 13% of electrical demand. The USA is the largest producer with more than 30% of worldwide nuclear generating capacity

(Zinkle & Was, 2013). Looking at the Netherlands, there is currently one active nuclear power plant located in Borssele, Zeeland. This plant accounts for approximately 3% of Dutch energy demand (NOS, 2021). The share of nuclear energy is very small compared to the European averages. In neighbouring countries like Belgium and France, nuclear energy is already the main energy source with 47.6% and 69.9% of total energy production. The European average is 26.7% (NOS, 2021).

For the Netherlands specifically, there has been an ongoing debate about nuclear energy. GroenLinks, one of the biggest political parties in The Netherlands, has been trying to hold a national referendum since 2011 regarding the build of new nuclear power plants (RTLnieuws, 2011). It is estimated that building a new nuclear power plant would take at least till 2035, and would therefore not contribute to reaching the set climate goals for 2030.

It is not yet known whether a negative attitude or stigma surrounding nuclear power plants exists, and if this might influence Dutch citizens towards wanting these power plants as an energy source. In addition to that, it is also important to know whether this is caused by having too little knowledge on the topic. This information is important for the Dutch government to take into consideration before deciding on building a new nuclear power plant.

This research will aim to fill this gap by answering the following research question:

Does providing information about nuclear energy improve how people perceive it?

The research question will be answered with help of the following hypotheses:

Hypothesis 1: People have a knowledge gap about nuclear energy

Hypothesis 2: Filling the knowledge gap with information will improve the attitude towards the use of nuclear energy.

This research will commence by researching the existing literature. The theoretical background will consist of three parts. First, literature regarding advantages and disadvantages of nuclear energy and nuclear power plants will be analysed. This will be followed by a theoretical analysis about stigma, public attitudes and imaging. In the final part of the theoretical background, literature regarding stigma and public attitudes on nuclear power will be analysed and discussed. After analysing the existing literature, the experimental design will be explained in the methodology section, supplemented by a description of the data and the process of collecting it. When the data is obtained, the results will be discussed and conclusions will be drawn from it. The discussion will give insights into the limitations and possibilities for follow-up research.

Theoretical background

Nuclear energy: advantages & disadvantages

The increase of energy consumption worldwide is driven by population increase and economic development that tend to increase energy usage per capita (Dincer, 1998). This increased demand for energy paired with recent elections flared up the debate about nuclear energy in the Netherlands again.

As explained in the introduction, nuclear energy is energy which is taken out of the core of an uranium atom in the process of nuclear fission. The final product of this process is electricity, which can be distributed to the homes of citizens.

To gain a better understanding of the current ongoing debate about why or why not nuclear energy should be used, it is important to know the advantages and disadvantages about using nuclear energy.

Advantages

Supporters of nuclear energy state that building nuclear power plants reduces the heavy dependence on fossil fuels like oil and gas. These fossil fuels are not renewable and emit significant amounts of carbon dioxide when using them (Midilli et al., 2006). Carbon dioxide (CO_2) is one of the key greenhouse gases which atmospheric concentration increased a lot over the 20th century. This is mainly due to human activities like using fossil fuels as energy sources. Higher levels of atmospheric concentration of greenhouse gases result in a higher average temperature on earth (Solomon et al., 2009). This proves that nuclear energy can be an attractive alternative to using fossil fuels as a main energy source. Countries like France already started this transition from fossil fuels to nuclear energy some time ago. 69.9% of all energy in France is nuclear energy, and they are already scaling down their nuclear energy production to transition to green energy (NOS, 2021). In The Netherlands, the only nuclear power plant available provides 3.2% of Dutch energy consumption, while over 80% of energy consumption is still being provided by fossil fuels (NOS, 2011).

A second advantage of nuclear energy exists compared to previously mentioned green energy alternatives like wind, solar and tidal (Midilli et al., 2006). Green energy sources have the disadvantage that they are heavily dependent on meteorological conditions. In the absence of the sun for instance, solar energy will not provide sufficient energy for a country. Nuclear energy on the other hand, is an alternative energy source which can provide energy at any time, without depending on any meteorological conditions (Coskun & Tanriover, 2016). Petrescu et al. (2006) see nuclear energy as the solution for the dependence on meteorological conditions when using green energy. They suggest nuclear power plants as an energy buffer, which are able to work to a minimum capacity when green energy is steadily produced. When the meteorological conditions are not in favour of green energy production, nuclear power plants can run at progressively increased capacities to meet the existing demand.

Disadvantages

Fritsche & Lim (2006) compared specific costs of different energy sources in Germany. This was done without external costs, which means only the generation costs were taken into account. They concluded that the generation costs of nuclear energy were between 4.5 and 6.5 €cent per kWh of electricity. This was slightly higher than the generating costs of almost all fossil fuels. Fossil fuels ranged from 1-4 € cent per kWh of electricity, with one exception which was slightly more expensive than generating nuclear energy. Nuclear energy was in general slightly cheaper than all green energy sources, except for solar energy. Solar energy is very expensive with generating costs of approximately 45 €cent per kWh of electricity. Other green energy sources have a cost varying from circa 6-8 €cent per kWh of electricity. The frequently used argument that nuclear energy generation is more cost efficient than other energy sources does therefore not hold.

Apart from the generating costs, there are also many other costs involved. Some examples are costs for building the plant, operating, maintaining and fuelling it. Hewlett (1992) showed in his paper on operating and longevity costs of nuclear power plants in the USA that the mean operating and maintenance costs of 114 nuclear power plants increased from 22 to 84 dollars per kW of capacity in the period of 1974-1989. Also post operational capital expenditures increased significantly over this period.
Earlier in the process of producing electricity, the uranium mining costs should be taken into account. Van Leeuwen & Smith (2005). predicted that extracting, mining, and milling uranium will become more and more expensive, whilst also a lot of energy is needed in the process. Uranium is an exhaustible resource, and only one of the two isotopes is fissile (Lenzen, 2008).

As previously mentioned, nuclear energy results in a very low level of carbon dioxide emission (AKYÜZ, 2017). This is however only the case for generating electricity in the nuclear power plants. Fritsche & Lim (2006) looked at carbon dioxide emission on a bigger scale in their research. They take the so-called upstream and downstream activities into account. Additional upstream or pre-plant activities include ore mining and processing, enrichment of uranium and fuel fabrication for example. Downstream or post-plant activities include process and store (nuclear) wastes. Furthermore, steel, concrete and other materials are necessary for both the construction of the plant and the facilities in the up- and downstream fuel-cycle. The energy needed for these purposes is often produced by fossil fuels, which causes greenhouse-gas emissions. Although nuclear power plants generate energy in a more environmentally friendly way, indirectly carbon dioxide as well as other greenhouse gases are still emitted.

One of the more known issues with using nuclear energy is that both the fuel used (enriched uranium) and the exhausted by-products are radioactive and dangerous (Petrescu et al., 2006). According to Sirin (2010), 99% of nuclear waste is so-called low or intermediate level waste that can be disposed of without incurring significant costs. The remaining 1% is high-level waste. To dispose of high-level waste more complex disposal techniques are required. Currently, geological disposal is proposed to be one of the best ways, but no decisive solution has been found for the final disposal of high-level waste.

Some tragic accidents have happened due to nuclear energy. For example the well-known disasters in Chernobyl (1986) and in Fukushima (2011) (Steinhauser et al., 2014). These accidents, although rare, have been very severe due to the release of radiation and can therefore be seen as an argument against building nuclear power plants.

A final argument against nuclear power plants is that investing in nuclear energy is not seen as very popular. The electricity market liberalization process is a major challenge in developing countries for nuclear energy. According to Sirin (2010), the main reason for the liberalization of the electricity market is lowering prices for consumers. In a competitive market environment however, investors' perception of risk is the main determinant of investment decisions (Joskow, 2006).

Stigmas, public attitudes and imaging

To develop a better understanding of public opinion on nuclear energy, existing literature on stigmas, public attitudes and imaging are researched. In this part, the focus will be on the theoretical concepts of these three aspects, which can be linked to nuclear energy. In the following part, existing literature of these concepts on nuclear energy specifically will be analysed.

Public attitudes and imaging

An attitude is an individual's disposition to respond favourably or unfavourably to an object, person, institution, or event, or to any other discriminable aspect of the individual's world (Ajzen, 1989).

According to Alberto (2009), imaging is about the impression people have of something. This can arise and be formed by own experiences as well as (un)consciously by the influence of others. Image formation consists of three elements, namely an active connotation or emotional value, the process of image formation itself and the static image that exists already (Top, 2001). Every person would, consciously and unconsciously, engage in image formation, but there is always a starting point for having a certain attitude or image. This is independent of influences, deception, propaganda and such (Top, 2001). Three actors are needed for imaging, between whom an interaction takes place. These are the producers, intermediaries and consumers of images. Ideally there is a balance between these actors, but this is rarely the case in reality (Alberto, 2009).

One of the most important factors in imaging is the media. Media imaging affects the formation of both conscious and unconscious (pre)judgments about, among other things, events, areas, and people among themselves. Wijnberg (2013) thinks that the media is most determining for the images people have of the world. The media shows certain images of the world and thus influences what its audience sees as reality. News media specifically has an influential role in knowledge and images that people have of the world around them. The core function of news media is to provide the reader with objective information and on the other hand to ensure in a narrative and visual way that the audience gains understanding and knowledge of the world around them (Wijnberg, 2013). The ways in which people think, act and respond are determined by the images and ideas they have (Jenkins, 2003). Imaging of places can show that people experience a certain place very differently, because everyone has their own view of the world. Reality can thus be seen as a social construct (Adams, 2009). In addition, mutually sharing and exchanging images and experiences can lead to a changed perception of places, events or objects (Adams, 2009; Jenkins, 2003).

Happer & Philo (2016) conclude that in spite of the potential offered by digital media, there is currently no demand for significant political or cultural change, and strong evidence for the continuing role of the mass media in shaping public understanding. When focussing on climate change specifically, they wrote that in spite of high levels of awareness and concern about climate change it is not considered an issue of high priority. A second finding was that attitudinal positions towards climate change seem to alter frequently. This can be a main factor why scaling down the use of fossil fuels is done at a very slow pace in some countries.

Citizens protest against a variety of different and unwanted land uses, for instance maximum security prisons, nuclear facilities, low income housing, garbage dumps, airports, lead plants and other instances of land uses perceived to be dangerous, noisy or generally obtrusive (Wexler, 1996). The not-in-my-backyard (NIMBY) syndrome refers to intense, often emotional and usually organized opposition to siting proposals that residents of a local community believe will result in adverse impacts (Wexler, 1996). The project's costs and risks such as effects on human health, environmental quality, property values or aesthetic detractions are geographically or spatially concentrated while the benefits accrue to a larger, more dispersed population. He continues that the NIMBY syndrome may be traced to its growing fear of dread and unknown technological risks such as hazardous waste, toxic substances, hormone experimentation and nuclear power (Slovic, 1987), as well as to a dramatic increase in publicly available information on health and environmental risks associated with the proposed facilities (Graber & Aldrich, 1993; Wexler, 1996).

Frewer et al. (1998) say that perceptions of risk are defined by individuals not necessarily in terms of actual risk magnitudes, but rather by other psychological factors of relevance. They later state that assessment of attitudes to technology assumes an inverse relationship between the extent to which an individual favours technological developments, and the extent to which that individual holds proactive attitudes to environmental conservation

Desforges et al. (1991) studied negative attitudes towards stigmatized social groups like mental patients. Their conclusion was that people generally have negative prejudices towards these groups, but people have an increased liking for members of these groups when actually interacting with them. After their experiment, the initially prejudiced students described the typical mental patient more positively and adopted more positive attitudes towards them. This research gives an indication about what having more knowledge can do for people’s attitudes towards certain groups or issues.

Stigma

One reason why it is difficult to approach the study of stigma with much confidence is that there are so many kinds. Stafford & Scott (1986) think one of the most curious features of literature concerning stigma is the variability that exists in the definition of the concept. According to Link & Phelan (2001), many researchers provide no explicit definition and seem to refer to something like the dictionary definition. When stigma is explicitly defined, many authors quote Goffman's definition of stigma as an "attribute that is deeply discrediting" and that reduces the bearer "from a whole and usual person to a tainted, discounted one" (Link & Phelan, 2001; Goffman, 1963).

Goffman (1963) notes that the ancient Greeks used the word stigma to refer to bodily marks or brands exposing the bearers as persons to be avoided (e.g., slaves, criminals, or sinners). Today, the term is used in similarly, but it is applied more to the disgrace itself than to the bodily evidence of it (Goffman, 1963).

Smith (2002) also argues in his paper on stigma that there is no generally accepted theory of stigma. He thinks that this is due to stigma being a complex interaction between social science, politics, history, psychology, medicine and anthropology. Nonetheless, there are some clear indicators of the social origins of stigmatisation and the factors that perpetuate it. A key step in generating stigma according to Smith is perception of difference. For stigmatisation to occur, such differences must be linked to undesirable traits. He gives an example of stigmatisation on mental illness. This lies in the association of illness with stereotypes of potential violence, communication problems and unpredictability. Such stigmatised out-groups are typically characterized as 'them', instead of 'us'. Smith continues by saying that the media has a big influence on attitudes and stigmatization. Typical adverse stories involve stereotypes and misunderstandings that closely reflect the ignorance and prejudices of the audience.

There exists extensive literature on the topic of stigma as it applies to people. By means of the association with risk, the concept of stigma recently has been generalized to technologies, places, and products that are perceived to be unduly dangerous (Slovic, 2013). Slovic continues by saying that stigma plays out socially in opposition to many technological activities, particularly those involving the use of chemicals and radiation.

Gregory et al. (1995) say that technological stigma has risen to prominence as a result of increasing concern about the human and ecological health risks associated with the use of technology. Stigma reminds us that technology offers two faces. One shows the potential for benefit, while the other shows the potential for risk. Stigmatized places, products and technologies share several features. The source of the stigma is a hazard with characteristics such as dread consequences and involuntary exposure, that typically contribute to high perceptions of risk. Its impacts are perceived to be inequitably distributed across groups or geographical areas. They also mention that the magnitude or persistence over time is often not well known. They finish by saying that the best response is to recognize that stigma is the outcome of widespread fears and perceptions of risk, lack of trust in the management of technological hazards and concerns about the equitable distribution of the benefits and costs of technology. Technological stigma should be seen as a rational social response to the multiple influences that produce it.

Bush et al. (2001) add on the concept of technological stigma by saying that places with stigmatised technologies may affect the identity of a place and the people who live there. These places often suffer not only from technological stigma, but also from social stigma, arising from high levels of poverty, deprivation, unemployment and crime.

Dijksterhuis et al. (2000) discovered that there is a strong link between memory and stereotyping behaviours, therefore, it has been suggested that an inability to retain or recall information may lead to stereotypes being formed. Therefore, the information an individual perceives may have an impact on stigma (Simons et al., 2017). The World Health Organization (2013) explicitly stated that negative attitudes are generated due to a lack of subject knowledge.

A final paper is about measuring stigma in an experiment. Unger et al. (2013), did research on what increasing depression knowledge can do for reducing stigma. They split their respondents in two groups, where one group would get a fotonovela, a story of someone who experienced depression and eventually obtains counselling and medication, and the other a low-literacy text pamphlet which is straightforward information about symptoms and behavioural characteristics. They compared the two groups afterwards by asking the participants' opinions on certain statements on the topic of depression. Based on the participant's score on these questions, the stigma or attitude score could be calculated.

Stigmas and public attitudes on nuclear energy

Public evaluation of advanced technologies tend to be ambiguous, are often inaccurate and can, as such, contribute to the stigmatization of the technologies (Gregory et al., 1995). They continue by saying that it is not surprising that nuclear energy, touted so highly in the 1950s for its promise of cheap and safe power, is today subject to severe stigmatization, reflecting public perception of abnormally great risk, distrust of management and the disappointment of failed promises. From previously done studies it was concluded that when people are asked what comes to mind when they hear or read the word 'chemicals', terms like dangerous, toxic, hazardous, poison or deadly were most popular (Gregory et al., 1995).

Slovic (1987) describes in his research on groups ordering perceived risks for 30 activities and technologies what activities and technologies are seen as dangerous amongst different segments. Nuclear power is one of these 30 options, ranked most risky for both women voters and college students, ranked eighth for active club members and ranked twentieth by experts. This indicates that people who generally have more knowledge on the topic (experts and active club members), see nuclear energy as less dangerous. College students and women voters see nuclear power as a riskier option than smoking, handguns, alcohol or X-rays among others. It was concluded that the chance that the general public will accept risks from voluntary activities (such as skiing) are 1000 times as great as it would tolerate from involuntary hazards (such as food preservatives) when providing the same level of benefits. Nuclear power can be seen as an involuntary hazard, this is one of the reasons why it is therefore perceived as very risky.

Horlick-Jones et al. (2012) have a more positive view on the public attitude on nuclear energy. They say that the current stigmatization surrounding nuclear technologies, in the light of concerns about issues like anthropogenic climate change, may be shifting towards a “reluctant acceptance”. In their research they state nuclear technologies as both nuclear fission and nuclear fusion technologies.

Bickerstaff et al. (2008) use the term “reluctant acceptance” to describe how, in complex ways, many focus group participants in the United Kingdom discursively re-negotiated their position on nuclear energy when it was positioned alongside climate change. They reframed nuclear energy as part of the solution to the need for low-carbon energy options, because fossil fuels have become a widely acknowledged pressing issue for the global community.

A research done by Whitfield et al. (2009) tried to answer the question if the renewed enthusiasm for nuclear power can overcome its history of public resistance that has persisted for decades. Some findings from an national survey in the United States where that increased trust in nuclear governance institutions reduces perceived risk of nuclear power. This higher trust and lower risk perceptions predicts more positive attitudes towards nuclear power. Trust in environmental institutions and perceived risks from global environmental problems do not predict attitudes toward nuclear power however. Other findings say that individuals with traditional values have greater support for, while those with altruistic values have greater opposition to nuclear power. Nuclear attitudes did not vary by gender, age, education, income, or political orientation, though non-whites are more supportive than whites (Whitfield et al., 2009).

De Groot et al. (2013) also did research on values, perceived risks, benefits and acceptability of nuclear energy. They did research among the Dutch population in early 2009. They summarized their finding in the following model:

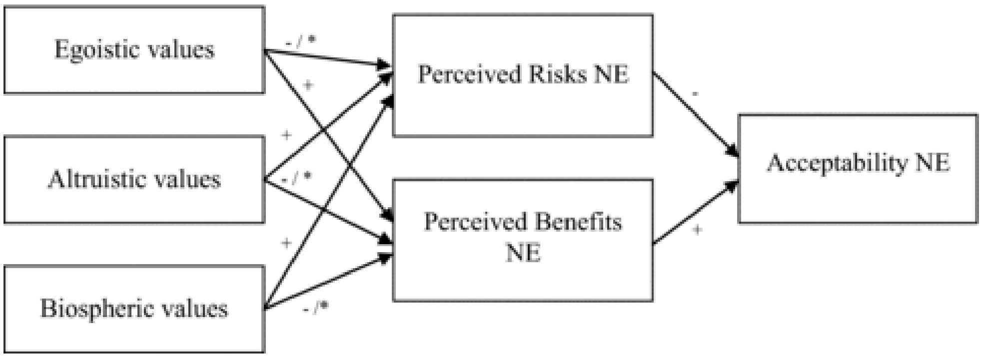

Figure 1: values, perceived risks, benefits and acceptability of nuclear energy

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

This model shows that egoistic values are positively related to the perceived benefits and acceptability of nuclear energy. In contrast, altruistic and biospheric values were positively related to the perceived risks of nuclear energy (De Groot et al., 2013).

Earlier research by De Groot & Steg (2010) concluded that personal norms, the feeling of moral obligation towards taking action in favour or against nuclear energy, have influence on your willingness to take action. They conclude that people are more likely to protest in favour of or against nuclear energy when personal norms are strong.

Flynn (2003) describes in his research that problems confronting nuclear science and technology are clearly expressed in nuclear stigma. Flynn continues by saying that nuclear stigma functions as a composite evaluation of inherent hazards, the history of management, and the potential risks. The stigma response runs wide and deep in American society. He further explains that wide means that the concerns about nuclear facilities are shared across all segments of the population and for all forms of man-made radiation exposure. Deep includes a long history that supports public concerns.

Problems with management of nuclear programs and projects are not part of nuclear risk assessments and risk analysis except in the public's intuitive judgment. This underlies nuclear stigma (Flynn, 2003). He proposes a solution for this problem. In his opinion, society must focus on organizational performance when addressing nuclear stigma. Science and technology must be, and be seen as, the servant of human health and environmental preservation. Organizational goals must be recreated to these ends if management of inherently hazardous technologies is to achieve public acceptance and fulfil its potential contributions on behalf of mankind.

Van der Pligt, Eiser & Spears (1986) did an experiment amongst several rural communities which were selected as possible locations for new nuclear power stations in England. One of the four locations was located near one of the existing nuclear power stations. Results showed that people in this specific community had a more favourable attitude towards nuclear power stations. Results indicated marked differences in perceptions of economic benefits and health and environmental risks. Attitudinal differences were therefore most closely related to anxiety factors (van der Plicht et al., 1986).

With help of the prior literature, the following two hypotheses have been devised.
Hypothesis 1: People have a knowledge gap about nuclear energy

Hypothesis 2: Filling the knowledge gap with information will improve the attitude towards the use of nuclear energy.

Methodology

To find out if there is a negative attitude on nuclear energy in the Netherlands, and if this is caused by an existing knowledge gap, the following research will be conducted.

Experimental Design

The experiment took the form of an online survey among Dutch citizens. The experiment consists of two groups, the control and the treatment group. Using a between-subject design, respondents were randomly allocated by the online platform Qualtrics to one of these groups.

The survey started with questions about the participant's knowledge on the topic of nuclear energy. These questions gave an overview of the participants' knowledge on the topic prior to dividing the participants into the treatment and control group. This information can be used to understand whether there is an existing knowledge gap on the topic.

After answering these questions, the treatment group received more information about nuclear energy in the form of scientific sources. The current situation in the Netherlands is outlined, advantages and disadvantages are explained. The control group did not receive this information. It is assumed that the participant did not have a knowledge gap after reading the additional information. The given information included all answers to the prior asked knowledge questions. A full overview of all survey questions, including the additional information for the treatment group can be found in appendix A.

In the second part of the survey, the participant was asked to give their opinion on seven statements regarding nuclear energy. An example statement is: "I think nuclear energy is dangerous". The answers were formed with the help of a slider ranging from 0-10. All participants answered the statements in the same order, which was determined randomly beforehand.

The answers given ultimately produced a score. The statements were stated in such a way that a higher value is seen as having a more negative attitude towards nuclear energy. In addition, differences between the control and treatment group were analysed to see if providing information influences the attitudes of the participants. It is assumed that receiving information will result in having more knowledge on the topic of nuclear energy. Having prior information with the treatment is an independent variable in this research, the score is the dependent variable.

In the third and last part of the survey, people were asked about their demographics. This includes age, gender, level of education and political affiliation. These variables are covariates in this study.

Sample

Respondents were assigned randomly to either the control or treatment group by the online platform Qualtrics. However, for statistical convenience, both groups accounted for 50% of the participants to be able to perform statistical tests as optimally as possible. This means that the two groups are not perfectly randomly distributed, because with perfect randomization it is possible that the two groups differ in participant count (e.g. 70% vs 30%). However, the validity of the statistical test will improve a lot when the groups are split equally. The decision to divide the two groups equally is done with help of the statistical tool G*Power 3**.** G*Power 3 was used to perform a priori power analysis to calculate the desired sample size (Faul et al., 2007). The test indicated that with two equal groups, 122 respondents are required to reach a power of 85%, given the medium effect size d = 0.5 and using an error probability α = 0.05. The medium effect size (d = 0.5) is based on the conventional values proposed by Cohen (2013). This value is defined for Wilcoxon and Mann-Whitney U tests of a difference between two independent means. However, with a total of 111 respondents, this goal has not been met.

Distributing the survey was done through the personal connections of the author. Only Dutch citizens aged 18 and older were eligible for participation, no further restrictions were applied. The survey was accessible online from September 14th until September 30th 2021.
Prior to starting the survey, the procedure of the survey was briefly explained in the introduction. Participants were informed that participation was completely voluntary and that they could stop answering the questions at any time. In addition to that, they were told that they would be completely anonymous, and that the data would only be used for research purposes. A full description of the information provided in the survey can be found in Appendix A.

Participant removal

Out of the 150 people who recorded a response for the online survey, 120 respondents managed to fill out the whole survey. The 30 people who did not record a completed response were dropped from the sample. Out of the 30 not completed surveys, 12 respondents were part of the control group and 18 were participants from the treatment group. A possible reason that participants from the treatment group were more likely to not complete the survey is that participants from the treatment group took, on average, longer to complete the survey because of the additional information they had to read through.

According to Carver (1976), the reading rate measured in standard length words per minute is relatively constant at about 250-260 words per minute. The information provided for the treatment group consisted of 546 words, which means it is expected that people need a little over two minutes on average to finish reading the information. It has been timed how much time participants took to read through the additional information. People with a time of less than 45 seconds are excluded from the survey to ensure that all participants analysed from the treatment group read the information attentively. In total, seven respondents from the treatment group were dropped because of this.

This research also looks for gender differences. Therefore, two people who chose not to provide gender characteristics were dropped from the sample. Both respondents were part of the treatment group.

The total number of observations after dropping the selected responses equalled 111 observations. Of the 111 respondents, 50.5% identified as male, and 49.5% identified as female. The sample consists of mainly participants in the age category of 18-25 years old (61.3%). Further relevant demographic data is summarized in table 1 below.

Table 1: *Sample characteristics*

		Control Group		**Treatment group**		**Total**		**Chi-squared test**
Variable	**Category**	**N**	**%**	**N**	**%**	**N**	**%**	**P-value**
Gender	Male	36	57.1	20	41.7	56	50.5	0.106
	Female	27	42.9	28	58.3	55	49.5	
Highest completed level of education	Primary school	0	0.0	0	0.0	0	0.0	0.502
	Secondary school	11	17.5	4	8.3	15	13.5	
	Post-secondary vocational	2	3.2	3	6.3	5	4.5	
	University of applied sciences	15	23.8	11	22.9	26	23.4	

	University bachelor's	17	27.0	17	35.4	34	30.6	
	Master's degree	18	28.6	12	25.0	30	27.0	
	PhD / Doctorate	0	0.0	1	2.1	1	0.9	
Age	18-25	40	63.5	28	58.3	68	61.3	0.670
	26-35	5	7.9	6	12.5	11	10.0	
	36-45	0	0.0	0	0.0	0		
	46-55	8	12.7	7	14.6	15	13.5	
	56-65	8	12.7	7	14.6	15	13.5	
	65+	2	3.2	0	0.0	2	1.8	
Political affiliation (multiple answers possible)	Right-wing politics	12	11.9	11	15.7	23	13.5	0.486
	Conservative	6	5.9	2	2.9	8	4.7	
	Predominantly in the middle	22	21.8	8	11.4	30	17.5	
	Progressive	36	35,6	25	35.7	61	35.7	
	Left-wing politics	24	23.8	21	30.0	45	26.3	
	I do not know / I do not want to answer this question.	1	1.0	3	4.3	4	2.3	
	Total	101	100.0	70	100.0	171	100.0	
Total		63	100.0	48	100.0	111	100.0	

In order to test for correct randomisation, table 1 includes a column with the results of Chi-squared tests. Chi-squared tests are used to compare proportions of a categorical outcome according to different independent groups. The test can assess independence between two variables when the comparing groups are independent and not correlated, especially for larger groups (Kim, 2017). In this research, the test is used to check for correct randomisation between treatment and control group for the different demographics in the sample. With all p-values showing no significance on a 5% significance level, it can be concluded that there is no evidence for incorrect randomisation.

Materials

The time it took to participate in this online survey was approximately 10 minutes, depending on being in either the treatment or control group. The treatment group received additional information. Reading this information resulted in needing more time to complete the survey, this took on average an extra 133.5 seconds. This average was calculated after removing respondents with a reading time below 45 seconds.

To compensate for people's time, a monetary incentive was added to the experiment. As explained in the experimental design, the participant was asked to give their opinion on seven statements regarding nuclear energy. The answers were formed with the help of a slider ranging from 0-10. This slider represented a monetary amount between €0,- and €10,-. The participants were asked to imagine a situation where they receive €10,- at the start of each of the 7 statements. The question asked was how much of this €10,- they wanted to donate to Greenpeace to work against the use of nuclear energy in response to the given statement. Greenpeace is an organisation which focuses on preserving the environment as much as possible. In doing so, they have taken a clear stand against nuclear energy. Donating more money to Greenpeace represented a more negative attitude towards nuclear energy. The money the participant decides not to donate can be kept. In the final parts of this research, one participant will be randomly selected. His or her donated money will be donated to Greenpeace, and the undonated money will be received by the participant in the form of a gift voucher. At the end of the survey people were asked to enter their email address. Only the people who entered their email address were eligible for receiving the gift voucher. However, entering an email address came at the expense of not being completely anonymous anymore. This was another reason to make this a voluntary option for the respondent.

A description of the variables used is provided below.

Knowledge score

The knowledge score variable is implemented to determine a participant's knowledge about nuclear energy beforehand. This score consists of the number of correctly given answers out of the five knowledge questions asked. After dividing the sample into a treatment and a control group, it is assumed that the treatment group knows all answers when continuing the survey. This assumption is made because the treatment group receives additional information which includes all answers to the earlier asked questions. This variable is used to determine if there is a knowledge gap when receiving information compared to not receiving information.

Donation score

To measure attitude, participants had to answer to what extent they agreed with different statements on a scale of 0-10. The number chosen equalled the amount of money the participant wanted to donate to Greenpeace to prevent the use of nuclear energy.

There are seven different statements which form a total donation score. Dividing the total donation score by seven resulted in the average donation score per participant. This average score is used in the regression analysis. A description of the seven attitude questions is given in table 2.

Table 2: Attitude statements

Attitude variable	**Survey statement**
New plant in NL	I think the Netherlands should not build one or more new nuclear power stations.
Advantages vs disadvantages	The advantages of nuclear energy do not outweigh the disadvantages of nuclear energy.
Worry for disaster	I am concerned about a possible new nuclear disaster.
Fossil Fuels > Nuclear energy	I would rather use energy obtained from fossil fuels than from nuclear energy.
Dangerous	I think nuclear energy is dangerous.
Nuclear waste	I am concerned about (radioactive) nuclear waste.
Negative attitude	I have a negative attitude towards the use of nuclear energy in general.
Total score	This is the total donation score of all seven statements added up.

The reliability of the scale is measured with the help of Cronbach's alpha. Cronbach's alpha is a coefficient for assessing internal consistency (Bland & Altman, 1997). The internal consistency for the seven separate attitude questions is $\alpha = .925$, which is an excellent score. When adding the total score as the eighth variable, the score lowers to $\alpha = .798$, which can still be seen as a good internal consistency score.

Information

The information variable is a dummy variable which equals 1 (or yes) when a participant is in the treatment group and 0 (or no) when a participant is in the control group of the survey.

Male

The male dummy variable takes value 1 when the participant is male, it equals 0 when the participant is female.

Age

The age variable is a dummy variable used in the regression. The value 1 represents a participant aged between 18 and 25 years old. The value 0 represents a participant aged 26 or older.

University

The dummy variable University takes on value 1 when a participant obtained a university degree (bachelor, master, PhD/doctorate), and takes on value 0 when the participant did not receive a university degree.

Right

Takes on value 1 when the participant identifies himself/herself with the “right” ideology. The value 0 represents a participant who does not support this ideology.

Conservative

Takes on value 1 when the participant identifies himself/herself with the “conservative” ideology. The value 0 represents a participant who does not support this ideology.

Middle

Takes on value 1 when the participant identifies himself/herself with the “middle” ideology. The value 0 represents a participant who does not support this ideology.

Progressive

Takes on value 1 when the participant identifies himself/herself with the “progressive” ideology. The value 0 represents a participant who does not support this ideology.

Left

Takes on value 1 when the participant identifies himself/herself with the “left” ideology. The value 0 represents a participant who does not support this ideology.

No preference

Takes on value 1 when the participant does not have any preference for ideology, or does not know what his/her preference is. The value 0 represents a participant who did not have this answer.

Analysis

Comparing the treatment and control group is done with help of Mann-Whitney U tests. The Mann-Whitney U test compares two between-subject samples and looks for significant differences between these groups. The sample of this survey includes two groups, treatment and control, and this is a between-subject design because people in the control group are compared to different people in the treatment group. The attitude questions will be compared separately as well as together after producing a total donation score.
After comparing the treatment and control group with help of the Mann-Whitney U tests, other groups are also compared for differences in donation scores. The research looks for differences between gender, age, education level, and political affiliation. To prevent treatment effects from influencing the outcome when comparing demographics, only participants from the control group are compared when testing for differences in gender, age, education level, and political affiliation. To make the analysis possible, age and education level have been transformed to dummy variables.
To be able to look for differences in donation score between different political affiliations, six separate dummy variables were generated to allow Mann-Whitney U tests to be performed. The Mann-Whitney U test is afterwards used to look for differences between the selected ideology and all five other answer options.

After conducting the Mann-Whitney U tests, a simple linear regression model has been composed to look for treatment effects on average donation scores while including control variables. In addition, several interaction terms are created and tested in the regression to test whether this increased significance. Interaction terms for being in the treatment group (Information = 1*)* with the variables Male, Age, University and all political affiliations were created and tested. The simple linear regression looked as follows:

$$Average\ donation\ score = \beta_0 + \beta_1 * Information + \beta_2 * Male + \beta_3 * Age + \beta_4 * University + \beta_5 * right + \beta_6 * conservative + \beta_7 * middle + \beta_8 * progressive + \beta_9 * left + \beta_{10} * nopreference$$

Results

All analyses were conducted using the statistical software Stata. Mann-Whitney U tests and linear regressions were conducted to test the hypotheses.

Differences between certain demographic groups have also been analysed. The sample size of this research was relatively small, and some demographic groups were overly represented. The sample contained an above average number of people who obtained a university degree, as well as people aged between 18 and 25 years old. This can be explained by the fact that the author belongs to this group and distributed the survey amongst his personal network. Inferences about differences in demographic groups should therefore be made and interpreted with care.

Knowledge gap

The first hypothesis states that there is a knowledge gap about nuclear energy. Testing this hypothesis is done with help of the five knowledge questions asked in the beginning of the online survey. Answering these questions ultimately produced a knowledge score, which equalled the amount of answers given correctly per respondent. Table 3 gives an overview of the calculated knowledge score per group. It can be seen that male respondents, on average, have a higher knowledge on the topic, as well as people who obtained a university degree. Finally, people aged older than 25 have a higher knowledge score on average compared to people being 25 or younger.

Table 3: Knowledge score per group

Variable	Category	N	Mean Knowledge Score	Standard Deviation
Treatment	Yes	48	2.08	1.16
	No	63	2.44	1.13
Gender	Male	56	2.41	1.14
	Female	55	2.16	1.16
Education Level	University Degree	65	2.48	1.08
	No University Degree	46	2.02	1.22
Age	≤ 25	68	2.13	1.26
	> 25	43	2.53	0.93
	Total	111	2.29	1.16

The scores given in table 3 are averages calculated before being in either treatment or control group. To determine whether there is an actual knowledge gap, it is important to know the difference in score between people who did and people who did not receive additional information on nuclear energy during the survey. Therefore, the difference in knowledge score between the treatment and control group before receiving information is not very relevant for this study. The table shows that people who did get information during the survey had, on average, a lower knowledge score before reading the information. It is assumed that after reading through the given information thoroughly, the respondent would be able to answer all five knowledge questions. The knowledge score would therefore be equal to 5. A Mann-Whitney U test is done to calculate the difference between the knowledge score of the treatment and control group both before and after reading through the information. On a 10% significance level, with a p-value of 0.133, the knowledge scores, on average, did not significantly differ between treatment and control group prior to receiving the information, ceteris paribus. After receiving the information and assuming that everyone in the treatment group would be able to answer all questions correctly, there is, on average, with a p-value of 0.000, a significant difference between the two groups on a 10% significance level, ceteris paribus. The full results of these Mann-Whitney U tests can be found in appendix table C1. Seeing that there is a significant difference in knowledge score after receiving information, it can be confirmed that there is a knowledge gap about nuclear energy.

Donation score

The second hypothesis states that filling the knowledge gap about nuclear energy with information will improve one's attitude on nuclear energy. Attitude was measured with the help of seven attitude questions which ultimately produced a total donation score. The total donation score was calculated by adding up all answers from the seven separate attitude questions, which were answered on a scale of 0-10. Total donation scores could therefore range from 0-70. A higher donation score represents a less favourable attitude towards nuclear energy. Table B1 (appendix) gives an overview of the sample's donation scores. The average total donation score was 24.15 out of the seven attitude questions, with given answers ranging from 0 to 67.47. This gives an average donation score of 3.45 per answer. Answers for all seven statements ranged from a minimum of 0 to a maximum of 10.

When analysing the average donation scores of both treatment and control group, the results show a higher average score for all seven attitude questions in the treatment group compared to the control group. The total donation score, on average, increases with receiving information as well (appendix table B2). The control group has a mean donation score of 22.57 (Standard Error, SE = 18.32), the treatment group has a mean donation score of 26.22 (SE = 21.23). This means that people in the treatment group, on average, had a more negative attitude towards the use of nuclear energy.

To test whether the increased average scores after filling the knowledge gap with information can be seen as significantly different, Mann-Whitney U tests were conducted. Table 4 shows the results of the Mann-Whitney U tests. On a 10% significance level, there are, on average, no significant differences in donation scores between participants from the treatment and control group for both the total donation score and the donation scores produced from the individual statements, ceteris paribus.

Table 4 : Mann-Whitney U test donation scores comparing treatment and control group

Attitude question	P-value	Z
New plant in NL	0.752	0.32
Advantages vs disadvantages	0.970	0.04
Worry for disaster	0.273	-1.10
Fossil Fuels > Nuclear energy	0.779	-0.28

Dangerous	0.169	-1.38
Nuclear waste	0.455	-0.75
Negative attitude	0.475	-0.72
Total score	0.550	-0.60

Note. Correlation value is significant at * $p < .10$, ** $p < .05$, *** $p < .01$; $N = 111$.

The results show that filling the knowledge gap about nuclear energy with information does not improve the attitude towards the use of nuclear energy. The second hypothesis is therefore rejected.

Demographics

After rejecting the second hypothesis, Mann-Whitney U tests were used to look for possible differences between donation scores based on differences in demographics of the sample. Only people in the control group are compared to each other to prevent treatment effects from altering the outcome of the Mann-Whitney U tests. The demographics used for analysis were gender, age, education level and political affiliation.

Gender

The obtained data showed large differences in donation scores when comparing both males and females. When comparing genders in the treatment group, the control group and in the whole sample, females scored on average higher on all seven attitude questions, as well as the total donation score. Females in the control group had an average total donation score of 29.19, while the mean calculated from the sample of male participants in the control group was 17.60 (Appendix table B3). Table 5 below shows the results of the Mann-Whitney U test done to look for significant differences between the donation scores for females and males in the control group. Five out of seven statements show a significant difference between answers given by females and males on a 10% significance level, ceteris paribus. The total donation scores are also, on average, significantly different on a 5% significance level, ceteris paribus.

Table 5: Mann-Whitney U test donation scores comparing genders within the control group.

Attitude question	P-value	Z
New plant in NL	0.025**	2.24
Advantages vs disadvantages	0.088*	1.71
Worry for disaster	0.014**	2.45
Fossil Fuels > Nuclear energy	0.280	1.09
Dangerous	0.084*	1.73
Nuclear waste	0.131	1.52
Negative attitude	0.010**	2.55
Total score	0.013**	2.46

Note. Correlation value is significant at * $p < .10$, ** $p < .05$, *** $p < .01$; $N = 63$.

This sample shows that gender differences can play a big part in attitudes towards the use of nuclear energy sources. It can be seen that, on average, on a 5% significance level there is a difference between total donation score between males and females in the control group, ceteris paribus. With the additional information from table B3, which shows that all mean donation scores are higher for females than for males, it can be concluded that the females in this sample showed, on average, a more negative attitude towards the use of nuclear energy.

Age

To be able to perform Mann-Whitney U tests based on differences in age, it was necessary to transform the variable age into a dummy variable. The two categories included in this new dummy variable of age are people aged between 18 and 25 years old, and people aged over 25 years old. The age category 18-25 was overly represented in this sample, therefore the line has been set at the age of 25 to separate the sample as equally as possible. The sample included 68 people aged between 18-25, and 43 people aged over 25 (table 1, methodology). Looking at the control group specifically, 40 people were aged between 18-25, and 23 people were aged over 25.

When analysing the donation score means of both groups (Appendix table B4) it can be seen that from the participants of the control group, the average donation score for the older group is higher for all statements as well as for the total donation score. The mean total donation score of the 18-25 group was 20.42, while the mean score of the older group equalled 26.31. This means that, on average, younger people have a more favourable attitude towards nuclear energy.

Afterwards Mann-Whitney U tested if these differences were significant. The results in table 6 show that no statements differ significantly between the two age categories on a 10% significance level, ceteris paribus. In addition to that, the total donation score shows no significant difference between the two age groups on a 10% significance level. This means that there is no indication of age influencing total donation score.

Table 6: Mann-Whitney U donation score comparing ages within the control group.

Attitude question	**P-value**	**Z**
New plant in NL	0.301	1.04
Advantages vs disadvantages	0.768	0.30
Worry for disaster	0.929	-0.09
Fossil Fuels > Nuclear energy	0.119	1.57
Dangerous	0.421	0.81
Nuclear waste	0.525	0.643
Negative attitude	0.223	1.23
Total score	0.336	0.971

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 63.

Education

Like the age variable, the variable for level of education needed to be transformed into a dummy variable to be able to perform the Mann-Whitney U test. The separation made is based on whether the respondent did or did not achieve a university degree. A university degree included obtaining either a bachelor, masters and/or a PhD/doctorate degree. This group contains 65 people from the sample, while 43 people did not obtain a university degree (table 1, methodology). Looking specifically at the control group, 35 participants obtained a university degree and 29 participants did not. The group of university graduates from the control group had a mean total donation score of 22.59, while the participants who do not have a university degree had a mean total donation score of 22.55 (table B5, appendix). Even though the donation scores did not avoid each other much, Mann-Whitney U tests are again done to look for significant differences between answers of the two groups. The results in table 7 show, looking only at participants from the control group, that on a 10% significance level there are no significant differences in donation scores when comparing education level, ceteris paribus. This is true for all separate attitude questions as well as for the total donation score. Having a higher education level can therefore not be seen as an indicator for having a more favourable or negative attitude towards nuclear energy.

Table 7: Mann-Whitney U donation scores comparing levels of education within the control group.

Attitude question	**P-value**	**Z**
New plant in NL	0.881	0.15
Advantages vs disadvantages	0.785	-0.28
Worry for disaster	0.249	-1.16
Fossil Fuels > Nuclear energy	0.167	1.39
Dangerous	0.578	-0.56
Nuclear waste	0.427	-0.80
Negative attitude	0.401	0.85
Total score	0.899	-0.13

Note. Correlation value is significant at * $p < .10$, ** $p < .05$, *** $p < .01$; *N* = 63.

Political affiliation

Participants were asked to give their political preference in the survey. They were allowed to give multiple answers to this question. The 111 participants gave 171 answers in total (table 1, methodology). Looking at the control group specifically, 63 participants gave 101 answers (table 1, methodology). No participant gave more than three answers to the question.

All political preferences were transformed to dummy variables to compare people who feel affiliated to a certain political preference to people who do not feel affiliated with that political preference. Only total donation scores are compared. Appendix table B6 shows the mean total donation scores of the different political affiliation. The means for the whole sample are shown, as well as the means per political affiliation for the treatment and control group. Participants in the control group who feel affiliated with right, conservative, middle or progressive ideologies, on average, have a lower total donation score than people who do not belong to this group. On the other hand, people who feel affiliated with the left ideology, on average, have a higher total donation score than people who do not belong to this group. One participant did not state any political preference in the control group, or did not know what his/her preference was. The result had a higher total donation score on average, but due to this group only consisting of one participant, the results should be interpreted with care.

Again, Mann-Whitney U tests are used to look for significant differences between a selected affiliation and the other options for participants in the control group. The results are presented in table 8 below. People who feel affiliated to right or conservative ideologies have, on average, significantly different total donation scores on a 5% significance level compared to the other groups, ceteris paribus. Based on the results of both table 8 and appendix table B6 it can be concluded that participants from the control group who feel affiliated with the right or conservative ideologies have a significantly lower total donation score when comparing them to the other ideologies. All other political affiliations do not show a significant difference in total donation score on a 10% significance level.

Table 8: Mann-Whitney U comparing total donation score per political affiliation within the control group.

Political affiliation	**N**	**P-value**	**Z**
Right	12	0.045**	2.00
Conservative	6	0.039**	2.05
Middle	22	0.878	0.16
Progressive	36	0.622	0.50

Left	24	0.219	-1.24
No preference	1	0.476	-0.935

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 101.

Regression analysis

To test for significant differences while including control variables a simple linear regression was conducted. Table 9 shows that only the variables male, conservative, progressive and left show significant effects on average donation score on a 10% significance level, ceteris paribus.

Table 9 : Regression treatment on average donation score

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	-.0207517	.5084805	-0.04	0.968	-1.029563	.9880591
Male	-1.423491	.4935951	-2.88	0.005***	-2.40277	-.4442127
Age	-.7057345	.50468	-1.40	0.165	-1.707005	.2955363
University	.2490511	.5027806	0.50	0.621	-.7484513	1.246553
Right	-.4450733	.8009714	-0.56	0.580	-2.034178	1.144031
Conservative	-2.076073	1.076475	-1.93	0.057*	-4.21177	.0596235
Middle	.3313479	.6160922	0.54	0.592	-.8909615	1.553657
Progressive	-1.115573	.5894515	-1.89	0.061*	-2.285028	.053882
Left	1.257912	.594351	2.12	0.037**	.0787363	2.437087
No preference	2.296043	1.441065	1.59	0.114	-.5629898	5.155075
_cons	4.636042	.7951249	5.83	0.000***	3.058537	6.213547

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

The results in table 9 show that being male or having a political affiliation with the conservative and/or progressive ideology, on average, significantly decreases the average donation score on a 10% significance level, ceteris paribus. However, when choosing left as preferred political affiliation resulted, on average, in having a significantly higher average donation score on a 5% significance level, ceteris paribus. The Mann-Whitney U tests done before showed significant effects for gender, and the political affiliations right and conservative, while the regression show significant effects for gender, conservative, progressive and left on donation scores. This difference can be explained by the fact that the Mann-Whitney u tests by demographic group are only comparing people in the control group, while the linear regression shows the effects for participants of both treatment and control group.

The regression results including interaction terms are listed in Appendix tables D1-D9. No interaction terms were significant on a 10% significance level, or resulted in more significant results with one exception. Table D4 shows the regression which includes an interaction term between the variables right and information. This interaction resulted in the no preference variable falling just below the 10% significance level threshold, while still the interaction term was insignificant. However, due to the low number of participants choosing the option “I do not know / I do not want to answer this question”, this should be interpreted with care.

Discussion

Results and expectations

Nuclear energy is one of the most controversial energy sources. Public discussions on the topic result in a lot of different opinions and attitudes on the topic. This research aimed to determine if providing additional information on nuclear energy improves the attitude one has on nuclear energy. After testing for an existing knowledge gap about nuclear energy, Mann-Whitney U tests and linear regressions were used to determine if there were significant differences in attitude when people did or did not receive additional information on the topic of nuclear energy. In addition, differences in gender, age, level of education and political affiliation were tested.

The results show that people who received information did not significantly differ in attitude on nuclear energy compared to people who did not receive additional information on the topic. However, a significant difference between males and females was found. Females had a significantly higher donation score for five out of seven proposed statements as well as for the total donation score. This means that females, on average, have a more negative attitude towards the use of nuclear energy.

Based on the regression in table 9, three political affiliations showed a significant effect on donation score as well. Participants supporting the conservative or progressive ideology showed a significantly lower donation score and participants supporting the left ideology showed a significantly higher donation score compared to people who do not support this ideology. The Mann-Whitney U tests which compared political affiliations for participants from the control group showed significant differences in donation score for participants supporting the right and conservative ideology. Both the conservative and right ideology had significantly lower donation scores compared to other affiliations.

Other tested demographics such as age, level of education and remaining political affiliation did not provide evidence for differences in attitude on nuclear energy.

Lastly, the first hypothesis tested for an existing knowledge gap on the topic. Results show that there is in fact a knowledge gap on the topic.

Based on the research of Van der Plicht et al. (1986), it was expected that people with more knowledge on nuclear energy or more experience with nuclear energy expressed a more favourable attitude towards it. In addition, with the recent focus on the pressing issue of climate change, the attitude towards nuclear energy was shifting from negative to a “reluctant acceptance" (Bickerstaff et al., 2008 ; Horlick-Jones et al., 2012). The information provided in the survey also focussed on the benefits of lower CO_2 emissions, it was therefore expected that receiving information would improve one's attitude.

Erwin & Bettinghaus (1986) stated in their research that correlations between information level and overt behaviour or between attitude and over behaviour are generally positive but low. This means that even though an effect might be expected, it could be so small that no significant differences can be found. This is a possible explanation for the non-significant differences in this research.

Limitations and suggestions for future research

The sample used in this research is relatively small and not representative for the Dutch population. 111 respondents is not enough to be able to represent the Dutch population. On top of that, university graduates and people of the age category 18-25 are overly represented. This is a small and specific group within the population, and does therefore not represent the total Dutch population. Without budget restrictions it should be easier to find a big representative sample for the Dutch population. This would give the opportunity to repeat this research, as well as be helpful for other possibilities for future research.

The choice for a Mann-Whitney U test meant that a between-subject design with two groups was used. The choice for a between-subject design was deliberate. The authors budget for testing was low, therefore it was difficult to compensate participants for their time. To be able to have as many respondents as possible, it was necessary to make the questionnaire short and concise. This was done to prevent people from stopping halfway thinking the survey took too long. The survey took approximately 10 minutes to complete. If a within-subject design would have been chosen, participants would have to be compared to themselves. The questionnaire would take a lot more time to complete to be able to create control and treatment effects for each participant. A Wilcoxon rank sum test could be used to test the mentioned within-subject research. More budget would be needed to make this a feasible option for future research.

A second choice was to split the respondents in only two groups, treatment and control. A third group could have been used to look for even more differences. For example, a group without information and without any knowledge questions beforehand. This could have improved statistical significance with a large enough sample size. However, due to budget limitations and limited personal connections it was expected that the sample size would not be very large. Instead of adding a third group and conducting for example a Kruskal-Wallis test it was therefore decided to stay with the Mann-Whitney U test. In the future it would be interesting to compare multiple treatments over a bigger sample size. This could be helpful while looking for differences in attitude.

Lastly, attitude was measured through the donation of money to Greenpeace. Greenpeace was used as charity because it is a well-known organization which has a clear opinion on the topic of nuclear energy. It is however not an organisation which focuses solely on preventing the use of nuclear energy. It would be interesting to see if people donate differently when an organisation which solely focuses on preventing the use of nuclear energy is used. This was however not feasible for this research because the author did not have the means to donate money to overseas organisations. Future research could look for differences in behaviour when other organisations are used.

Conclusion

This research aimed to find out if providing information about nuclear energy improves how people perceive it. This was done with help of an online survey, spread to personal connections of the author. Two hypotheses were tested. The first hypothesis stated that there is an existing knowledge gap about nuclear energy. Five knowledge questions were used to look for this knowledge gap. The results show an average score of 2.08 out of 5 for participants in the treatment group (before information was given), and an average score of 2.44 for the control group. These scores did not differ significantly on a 10% significance level, ceteris paribus. After receiving information including answers to the knowledge questions, it is assumed that participants in the treatment group have enough knowledge to be able to answer all questions correctly. This means they will have a knowledge score of 5, with the control group average still at 2.44. With help of a Mann-Whitney U test, it is concluded that this resulted in a significant difference on a 1% significance level, ceteris paribus. This significant difference means that there is in fact a knowledge gap on the topic of nuclear energy.

The second hypothesis stated that filling the knowledge gap with information will improve the attitude towards the use of nuclear energy. Mann-Whitney U tests and simple linear regressions have been used to see if this was true. Results show for both tests that both average and total donation score did not change significantly when people obtained additional information on nuclear energy. However, there was evidence for gender differences. Females showed, on average, significantly higher donation scores compared to males. This means that females had a more negative attitude towards nuclear energy usage than males. According to the linear regressions three political affiliations showed, on average, a significant effect on donation score as well. Participants supporting the conservative or progressive ideology showed a significantly lower donation score compared to people who did not support this ideology. In addition, participants supporting the left ideology showed a significantly higher donation score on average. The Mann-Whitney U tests tested for differences between demographic groups within the participants of the control group. Mann-Whitney U test showed significant results for gender differences and for the political affiliations right and conservative. People supporting these political affiliations have, on average, a significantly lower total donation score when comparing them to the other political affiliations.

Other demographics tested were age, level of education and other political ideologies (middle and having no political preference). These demographics did not show any significant differences on donation scores.

Due to the small, not representative sample and the absence of a significant effect between receiving information and improved attitude on nuclear energy, this research does not have policy implications. There is no evidence that awareness should be increased amongst citizens to improve their attitude on nuclear energy.

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Appendix

Appendix A: Survey

Introduction:

Dear participant,

Thank you very much for participating in the research for my master thesis in behavioural economics at the Erasmus University in Rotterdam. With my thesis I am conducting research on nuclear energy in the Netherlands.

The first part of the survey asks a number of questions about the topic to find out how much knowledge you already have about the topic. Then, in the second part, you will be asked for your opinion on various statements about the subject. Finally, you will be asked for some demographic information such as your age. It takes approximately 10 minutes to complete the survey.

I would like to remind you that participating in this survey is completely voluntary and you can decide at any time before the end of the survey to stop. The survey is also completely anonymous and the data is only used for research purposes. For any questions you can contact me personally via the email address 455445tt@student.eur.nl in the name of Tim van Tol.

Thank you for your time.

Tim

Dutch translation:

Beste deelnemer,

Hartelijk dank voor het deelnemen aan het onderzoek voor mijn masterscriptie gedragseconomie aan de Erasmus Universiteit in Rotterdam. Met mijn scriptie doe ik onderzoek naar kernenergie in Nederland.

In het eerste deel van de enquête worden er een aantal vragen gesteld over het onderwerp om te achterhalen hoeveel kennis u al bezit over het onderwerp. Vervolgens zal in het tweede deel uw mening gevraagd worden over verschillende stellingen omtrent het onderwerp. Tot slot word u gevraagd voor wat demografische informatie zoals bijvoorbeeld uw leeftijd. Het invullen van de enquête bedraagt ongeveer 10 minuten.

Ik wil u er graag aan herinneren dat het deelnemen aan deze enquête geheel vrijwillig is en u ten alle tijden kan besluiten om niet meer deel te nemen voor het einde van de vragenlijst. De enquête is daarbovenop ook geheel anoniem en de gegevens worden alleen gebruikt voor onderzoeksdoeleinden. Voor eventuele vragen kunt u persoonlijk contact op nemen met mij via het email adres 455445tt@student.eur.nl ten name van Tim van Tol.

Wederom hartelijk bedankt voor uw medewerking,

Tim

Knowledge questions

Introduction:

This is the first part of the survey. Five questions are asked to find out how much knowledge you already have on the topic of nuclear energy. I would like to ask you to rely on your own knowledge and therefore not to use any aids to answer the questions.

- How many nuclear power plants are located in the Netherlands?
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5 or more
  - I do not know / I do not want to answer this question

- What percentage of energy consumption in the Netherlands is from nuclear energy?
  - 0-15%
  - 16-30%
  - 31-45%
  - 46-60%
  - 61-75%
  - More than 75%

- I do not know / I do not want to answer this question

- How is energy generated in a nuclear power plant?
  - Nuclear fusion
  - Nuclear fission
  - Heating response
  - Chemical decomposition
  - I do not know / I do not want to answer this question

- What happens to the leftover radioactive waste?
  - This is dumped in seas and rivers
  - This is transmuted from radioactive to non-radioactive waste
  - This is reused in the power station
  - This is stored underground until it is not or less radioactive
  - I do not know / I do not want to answer this question

- Which country is the largest producer of nuclear energy?
  - Australia
  - Brazil
  - Canada
  - China
  - Germany
  - Japan
  - Russia
  - South-Korea
  - Ukraine
  - USA
  - I do not know / I do not want to answer this question

Dutch translation:

Introductie:

Dit is het eerste deel van de enquête. Er worden hier vijf vragen gesteld om te achterhalen hoeveel kennis u al bezit over het onderwerp kernenergie. Ik wil u vragen hierbij geen hulpmiddelen te gebruiken en echt uit te gaan van uw eigen kennis.

- Hoeveel kerncentrales zijn er in Nederland?
    - 0
    - 1
    - 2
    - 3
    - 4
    - 5 of meer
    - Ik weet het niet / ik wil deze vraag niet beantwoorden

- Hoeveel procent van het energiegebruik in Nederland is geproduceerd als kernenergie?
    - 0-15%
    - 16-30%
    - 31-45%
    - 46-60%
    - 61-75%
    - Meer dan 75%
    - Ik weet het niet / ik wil deze vraag niet beantwoorden

- Op welke manier wordt de energie opgewekt in een kerncentrale?
    - Door kernfusie
    - Door kernsplijting
    - Door een verwarmingsreactie
    - Door een ontledingsreactie
    - Ik weet het niet / ik wil deze vraag niet beantwoorden

- Wat gebeurd er met het overgebleven radioactieve afval?
    - Dit wordt gedumpt in zeeën en rivieren
    - Dit wordt getransmuteerd van radioactief niet niet-radioactief afval
    - Dit wordt hergebruikt in de centrale
    - Dit wordt ondergronds opgeslagen tot het niet of minder radioactief is
    - Ik weet het niet / ik wil deze vraag niet beantwoorden

- Welk land is de grootste producent van kernenergie?
    - Australië
    - Brazilië
    - Canada

- China
- Duitsland
- Japan
- Rusland
- Zuid-Korea
- Oekraïne
- Amerika (USA)
- Ik weet het niet / ik wil deze vraag niet beantwoorden

The information given to 50% of participants:
Please read the information carefully.

Nuclear energy is energy extracted from the core of an atom. In the process of nuclear fission of the element uranium, atoms are forced to break apart. The fission products cause other uranium atoms to split, causing a chain reaction. The energy released in this process creates heat, which is used to create steam. The steam turns turbines and these turbines drive generators to generate electricity (Ramroop et al., 2011).

Advantages:

- Low CO2 emissions
    - CO2 emissions are the main cause of global greenhouse gas emissions (approximately 66%). Therefore, nuclear energy is considered an important resource in controlling atmospheric greenhouse gases and thus climate change (Ramroop et al., 2011).
- Fossil fuel consumption is decreasing
    - In addition to the high CO2 emissions, fossil fuels are exhaustible. When producing nuclear energy, raw materials will run out at a slower pace compared to when fossil fuels are produced. (Midilli et al., 2006).
- Independent of weather conditions
    - Green energy sources such as wind, solar and tidal energy depend on the weather conditions in a country. Nuclear energy can be supplied at any time, regardless of weather conditions (Coskun & Tanriover, 2016). Nuclear power stations can therefore also function as an energy buffer, which can operate to a minimum when there is a steady production of green electricity. When the weather conditions are not favourable for green energy production, nuclear power plants can run with increasing capacities to meet existing demand (Petrescu et al., 2006).

Disadvantages:

- Nuclear energy is expensive
  - Compared to the use of fossil fuels, it is a more expensive alternative. Both the generation costs and the initial investment are much higher (Fritsche & Lim, 2006; Hewlett, 1992).
  - Due to the fact that there is more financial risk for the investor in the construction and use of nuclear power plants than with the use of existing energy systems for fossil fuels on a freely operating energy market, investing in nuclear energy is unpopular. (Sirin, 2010).
- High-level waste
  - About 1% of the nuclear waste that remains is high-level (or radioactive) waste. Landfilling the high-level waste requires more complex disposal techniques. Geological disposal is currently proposed as one of the best ways, but an optimal solution for the final disposal of the high-level waste has not yet been found (Sirin, 2010).
- Nuclear Disasters
  - Nuclear energy is known worldwide for various disasters. The disasters in Chernobyl (1986) and in Fukushima (2011) are most well-known examples. The two incidents were caused by completely different reasons. The Chernobyl nuclear accident happened during a technical test, while the Fukushima disaster was the result of a tsunami. These accidents, although rare, were very serious due to the release of radiation and can therefore be seen as an argument against the construction of nuclear power plants (Steinhauser et al., 2014).

An overview:

- The Netherlands currently has one nuclear power plant in Borssele, Zeeland.
  - This nuclear power plant accounts for approximately 3% of the Dutch energy demand.
  - More than 80% of energy consumption is still provided by fossil fuels in the Netherlands.
- The Netherlands is lagging behind in the use of nuclear energy.
  - Belgium uses 47.6% nuclear energy
  - France uses 69.9% nuclear energy
  - European average: 26.7%
- Americas is the largest producer worldwide

- 30% of all nuclear energy is produced in America.

I confirm that I have carefully read the information provided above.

- Yes

Dutch translation:
Lees de informatie alstublieft aandachtig door.

Kernenergie is energie die uit de kern van een atoom wordt gehaald. Bij de kernsplijting van het element uranium worden atomen gedwongen uiteen te vallen. De splijtingsproducten zorgen ervoor dat andere uraniumatomen splijten, waardoor een kettingreactie ontstaat. De energie die vrijkomt bij dit proces creëert warmte, die wordt gebruikt om stoom te creëren. De stoom zet turbines aan en deze turbines drijven generatoren aan om elektriciteit op te wekken (Ramroop et al., 2011).

Voordelen:

- Lage CO2 uitstoot
  - CO2-uitstoot is de belangrijkste oorzaak van de wereldwijde uitstoot van broeikasgassen (ongeveer 66%). Daarom wordt kernenergie beschouwd als een belangrijke hulpbron bij het beheersen van atmosferische broeikasgassen en dus klimaatverandering (Ramroop et al., 2011).
- Fossiele brandstof gebruik neemt af
  - Naast de hoge CO2-uitstoot, zijn fossiele brandstoffen uitputbaar. Bij de productie van kernenergie raken grondstoffen een stuk minder snel op dan bij de productie van energie uit fossiele brandstoffen (Midilli et al., 2006).
- Onafhankelijk van weersomstandigheden
  - Groene energiebronnen zoals wind, zon en getijdenenergie zijn afhankelijk van de weersomstandigheden in een land. Kernenergie kan op elk moment geleverd worden, ongeacht de weersomstandigheden (Coskun & Tanriover, 2016). Kerncentrales kunnen daarom ook nog fungeren als energiebuffer, die bij een gestage productie van groene stroom tot een minimum kunnen werken. Wanneer de weersomstandigheden niet gunstig zijn voor de productie van groene energie, kunnen kerncentrales met steeds grotere capaciteiten draaien om aan de bestaande vraag te voldoen (Petrescu et al., 2006).

Nadelen:

- Kernenergie is duur

    - In vergelijking tot het gebruik van fossiele brandstoffen een duurder alternatief is. Zowel de opwekkingskosten als de initiële investeringen zijn een stuk hoger (Fritsche & Lim, 2006; Hewlett, 1992).
    - Doordat er voor de investeerder meer financieel risico verbonden is aan de aanleg en het gebruik van kerncentrales, dan bij het gebruik van bestaande fossiele energiesystemen op een vrij werkende energiemarkt, is het investeren in kernenergie ook niet populair (Sirin, 2010).
- Hoogactief afval
    - Ongeveer 1% van het kernafval wat over blijft is hoogactief (of radioactief) afval. Om het hoogactief afval te storten zijn complexere verwijderingstechnieken nodig. Momenteel wordt geologische berging voorgesteld als een van de beste manieren, maar er is nog geen optimale oplossing gevonden voor de definitieve berging van het hoogactief afval (Sirin, 2010).
- Kernrampen
    - Kernenergie staat wereldwijd bekend door verschillende rampen. De rampen in Tsjernobyl (1986) en in Fukushima (2011) zijn de bekendste voorbeelden. De twee incidenten werden veroorzaakt door totaal verschillende redenen. Het kernongeval in Tsjernobyl gebeurde tijdens een technische test, terwijl de ramp in Fukushima het gevolg was van een Tsunami. Deze ongevallen, hoewel zeldzaam, waren zeer ernstig vanwege het vrijkomen van radioactieve straling en kunnen daarom worden gezien als een argument tegen de bouw van kerncentrales (Steinhauser et al., 2014).

Een overzicht:

- Nederland heeft momenteel één kerncentrale in Borssele, Zeeland.
    - Deze centrale is goed voor ongeveer 3% van de Nederlandse energievraag.
    - Meer dan 80% van het energieverbruik nog steeds wordt geleverd door fossiele brandstoffen.
- Nederland loopt achter in het gebruik van kernenergie.
    - België gebruikt 47,6% kernenergie
    - Frankrijk gebruikt 69,9% kernenergie
    - Europees gemiddelde: 26,7%
- Amerika grootste producent wereldwijd
    - 30% van alle kernenergie wordt geproduceerd in Amerika.

Ik bevestig dat ik de hierboven gegeven informatie aandachtig heb doorgelezen.

- Ja

Attitude questions

Introduction:

In this part of the survey, I would like you to imagine a situation where you get €10,- at the start of each of the 7 upcoming statements. The question asked will be how much of this €10,- you would like to donate to Greenpeace to work against the use of nuclear energy in response to the given statement. Greenpeace is an organization committed to a green and sustainable world to prevent further climate change as much as possible. In doing so, they have taken a clear stand against nuclear energy.

It is assumed that when more money is donated, you agree more with the given statement. All statements are formulated in such a way that donating more money to Greenpeace is equivalent to having a more negative attitude towards nuclear energy. You can keep the money you decide not to donate. At the end of the survey, one participant will be randomly selected. His or her donated money will go to Greenpeace, and the undonated money will be received by the participant in the form of a gift voucher. At the end of the survey you will be asked to enter your email address. Only if you want to have a chance to receive the gift voucher you should fill in your email address.

The following statements will be answered with the help of a slider from 0-10.

- I think the Netherlands should not build one or more new nuclear power stations.
- The advantages of nuclear energy do not outweigh the disadvantages of nuclear energy.
- I am concerned about a possible new nuclear disaster.
- I would rather use energy obtained from fossil fuels than from nuclear energy.
- I think nuclear energy is dangerous.
- I am concerned about (radioactive) nuclear waste.
- I have a negative attitude towards the use of nuclear energy in general.

The questions were presented in this order.

Dutch translation:

Introductie:

In dit deel van de enquête vraag ik u om de situatie voor te stellen dat u €10,- krijgt aan het begin van elk van de 7 stellingen. De vraag hierbij zal zijn hoeveel van deze €10,- u zou willen doneren aan Greenpeace om zich naar aanleiding van de gegeven stelling tegen kernenergie in te zetten. Greenpeace is een organisatie die zich inzet voor een groene en duurzame wereld

om verdere klimaatveranderingen zoveel mogelijk tegen te gaan. Hierbij hebben ze een duidelijk standpunt tegen kernenergie ingenomen.
Er wordt bij de stellingen aangenomen dat naar mate er meer geld gedoneerd wordt, u het meer eens bent met de gegeven stelling. Alle stellingen zijn zo geformuleerd dat het doneren van meer geld aan Greenpeace overeenkomt met het hebben van een negatievere houding naar kernenergie. Het geld dat u besluit niet te doneren mag u zelf houden. Aan het einde van het onderzoek zal willekeurig één deelnemer geselecteerd worden waarbij het gedoneerde geld naar Greenpeace gaat, en het niet gedoneerde geld ontvangen wordt door de deelnemer in de vorm van een cadeaubon. Aan het einde van de enquête zal gevraagd worden om uw e-mailadres in te vullen. Dit veld hoeft u alleen in te vullen indien u kans wilt maken op de cadeaubon.

- Ik vind dat Nederland geen nieuwe kerncentrale(s) moet bouwen.
- De voordelen van kernenergie wegen niet op tegen de nadelen van kernenergie.
- Ik maak mij zorgen om een mogelijke nieuwe kernramp.
- Ik zou liever energie gebruiken dat wordt opgewekt met behulp van fossiele brandstoffen dan kernenergie.
- Ik vind kernenergie gevaarlijk.
- Ik maak mij zorgen om (radioactief) kernafval.
- Ik heb een negatieve houding naar het gebruik van kernenergie.

Demographics:

- Gender
    - Male
    - Female
    - Non-binary / Third gender
    - I would rather not say

- Age
    - 18-25
    - 26-35
    - 36-45
    - 46-55
    - 56-65
    - 65+

- What is your highest completed level of education?
    - PhD / Doctorate
    - Master's degree
    - University bachelor's degree
    - HBO bachelor / University of applied sciences
    - MBO / Post-secondary vocational education
    - Secondary school
    - Primary school

- What is your political affiliation? (possible to select multiple answers)
    - Right-wing politics
    - Conservative
    - Predominantly in the middle
    - Progressive
    - Left-wing politics
    - I do not know / I do not want to answer this question

The picture given below represents the Dutch political spectrum in 2021 according to kieskompas.nl. This picture was included for the participants to answer the question about their political affiliation more accurately.

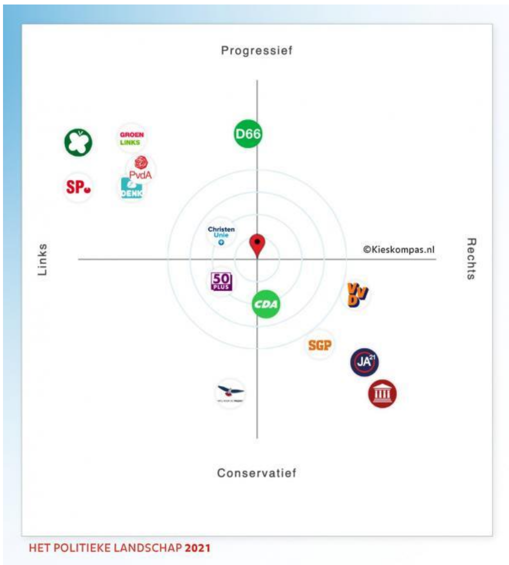

Figure 2: The Dutch political spectrum in the year 2021.

Appendix B: Average donation scores

Table B1: Sample donation scores

Group	Attitude questions	N	Mean	SE	Minimum	Maximum
	New plant in NL		4.11	3.91	0	10
	Advantages vs disadvantages		3.68	3.37	0	10
	Worry for disaster		2.88	3.07	0	10
Entire sample	Fossil Fuels > Nuclear energy	111	2.34	3.10	0	10
	Dangerous		3.34	3.21	0	10
	Nuclear waste		4.60	3.44	0	10
	Negative attitude		3.20	3.47	0	10
	Total score		24.15	19.63	0	67.47

Table B2: Donation scores by experimental group

Group	Attitude questions	N	Mean	SE
Control	New plant in NL		4.11	3.91
	Advantages vs disadvantages		3.63	3.27
	Worry for disaster		2.52	2.80
	Fossil Fuels > Nuclear energy	63	2.16	2.94
	Dangerous		2.91	2.95
	Nuclear waste		4.33	3.25
	Negative attitude		2.90	3.31
	Total score		22.57	18.32
Treatment	New plant in NL		4.12	3.94
	Advantages vs disadvantages		3.74	3.54
	Worry for disaster		3.35	3.37
	Fossil Fuels > Nuclear energy	48	2.58	3.31
	Dangerous		3.90	3.48
	Nuclear waste		4.95	3.67

Negative attitude		3.59	3.68
Total score		26.22	21.23

Table B3: Donation scores by gender

Group	Attitude questions	N	Mean	SE	Mean control group	Mean treatment group
Male	New plant in NL	56	3.04	3.73	3.20	2.75
	Advantages vs disadvantages		3.10	3.41	3.10	3.11
	Worry for disaster		2.04	2.80	1.76	2.54
	Fossil Fuels > Nuclear energy		1.71	2.47	1.58	1.94
	Dangerous		2.18	2.81	2.24	2.08
	Nuclear waste		3.55	3.15	3.75	3.17
	Negative attitude		2.13	2.92	1.97	2.41
	Total score		17.75	17.56	17.60	18.01
Female	New plant in NL	55	5.21	3.81	5.33	5.09
	Advantages vs disadvantages		4.26	3.26	4.34	4.19
	Worry for disaster		3.73	3.13	3.52	3.93
	Fossil Fuels > Nuclear energy		2.99	3.53	2.94	3.04
	Dangerous		4.52	3.18	3.81	5.20
	Nuclear waste		5.68	3.40	5.12	6.21
	Negative attitude		4.28	3.68	4.14	4.42

Total score	30.67	19.62	29.19	32.09	

Table B4: Donation scores by age

Group	Attitude questions	N	Mean	SE	Mean control group	Mean treatment group
≤ 25	New plant in NL	68	3.66	3.74	3.67	3.64
	Advantages vs disadvantages		3.47	3.19	3.41	3.56
	Worry for disaster		2.62	2.64	2.45	2.86
	Fossil Fuels > Nuclear energy		2.00	2.99	1.70	2.42
	Dangerous		2.89	2.96	2.56	3.37
	Nuclear waste		4.26	3.30	4.15	4.42
	Negative attitude		2.70	3.17	2.47	3.03
	Total score		21.60	17.89	20.42	23.30
> 25	New plant in NL	43	4.83	4.10	4.87	4.78
	Advantages vs disadvantages		4.00	3.66	4.01	4.00
	Worry for disaster		3.29	3.65	2.63	4.04
	Fossil Fuels > Nuclear energy		2.89	3.22	2.96	2.80
	Dangerous		4.05	3.49	3.53	4.64
	Nuclear waste		5.13	3.61	4.66	5.68
	Negative attitude		3.98	3.82	3.65	4.36
	Total score		28.17	21.70	26.31	30.31

Table B5: Donation scores by education level

Group	Attitude questions	N	Mean	SE	Mean control group	Mean treatment group
University Degree	New plant in NL	65	4.06	3.98	3.91	4.24
	Advantages vs disadvantages		3.68	3.45	3.66	3.71
	Worry for disaster		3.40	3.40	3.05	3.80
	Fossil Fuels > Nuclear energy		1.94	2.86	1.57	2.37
	Dangerous		3.46	3.24	2.98	4.02
	Nuclear waste		4.77	3.60	4.63	4.93
	Negative attitude		3.41	3.75	2.80	4.12
	Total score		24.72	20.88	22.59	27.20
No University Degree	New plant in NL	46	4.18	3.84	4.36	3.91
	Advantages vs disadvantages		3.67	3.30	3.60	3.79
	Worry for disaster		2.14	2.38	1.85	2.60
	Fossil Fuels > Nuclear energy		2.91	3.36	2.90	2.92
	Dangerous		3.17	3.20	2.84	3.70
	Nuclear waste		4.37	3.21	3.97	4.97
	Negative attitude		2.90	3.05	3.03	2.70
	Total score		23.34	17.90	22.55	24.59

Table B6: Total donation scores by political affiliation

Political affiliation	N	Mean in group	SE	Mean not in group	SE	Mean control in group	Mean control not in group	Mean treatment group	Mean treatment not in group
Right	23	16.1	13.9	26.3	20.4	12.77	24.87	19.65	28.17
Conservative	8	8.5	11.2	25.4	19.6	10.21	23.87	3.24	27.22
Middle	30	24.3	29.6	24.1	19.7	21.92	22.92	30.96	25.27
Progressive	61	21.4	18.8	27.5	20.2	20.94	24.74	21.96	30.85
Left	45	29.6	21.0	20.5	17.8	27.40	19.60	32.01	21.72
No preference	4	40.6	26.4	23.5	19.2	39	22.31	41.13	25.23

Appendix C: Knowledge scores

Table C1: Mann-Whitney U knowledge score on receiving information

Compared Groups	Time of Comparison	P-value	Z
Treatment vs Control Group	Before Information	0.134	1.50
	After Information	0.000***	-9.20

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Appendix D: Regressions

Table D1 : Regression treatment on average donation score with interaction between information and Male.

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.1241952	.6966901	0.18	0.859	-1.258189	1.50658
Information*Male	-.3048841	.9965403	-0.31	0.760	-2.282236	1.672468
Male	-1.291688	.6568591	-1.97	0.052*	-2.595039	.0116634
Age	-.6977318	.5076572	-1.37	0.172	-1.705034	.3095702
University	.2362785	.5067972	0.47	0.642	-.7693172	1.241874
Right	-.4331708	.8055663	-0.54	0.592	-2.031589	1.165247
Conservative	-2.101025	1.084458	-1.94	0.056*	-4.252825	.0507763
Middle	.3156179	.6210354	0.51	0.612	-.9166511	1.547887
Progressive	-1.128954	.5937542	-1.90	0.060*	-2.307091	.0491834
Left	1.261112	.5971547	2.11	0.037**	.0762279	2.445997

No preference	2.258716	1.452773	1.55	0.123	-.6239011	5.141333
_cons	4.575362	.8230094	5.56	0.000***	2.942333	6.208391

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D2 : Regression treatment on average donation score with interaction between information and age

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.2448694	.7895103	0.31	0.757	-1.32169	1.811429
Information*Age	-.4505096	1.02141	-0.44	0.660	-2.477208	1.576189
Male	-1.416721	.4958327	-2.86	0.005***	-2.400561	-.4328815
Age	-.4986383	.6908207	-0.72	0.472	-1.869376	.8721
University	.2427751	.5050182	0.48	0.632	-.7592906	1.244841
Right	-.4393086	.804323	-0.55	0.586	-2.03526	1.156643
Conservative	-2.176486	1.104553	-1.97	0.052*	-4.36816	.015187
Middle	.3041989	.6216434	0.49	0.626	-.9292765	1.537674
Progressive	-1.145477	.5957107	-1.92	0.057*	-2.327497	.0365419
Left	1.242108	.597834	2.08	0.040**	.0558752	2.42834
No preference	2.256705	1.44965	1.56	0.123	-.6197159	5.133126
_cons	4.545849	.8241192	5.52	0.000***	2.910618	6.181081

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D3 : Regression treatment on average donation score with interaction between information and University degree

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	-.0365673	.8023779	-0.05	0.964	-1.628659	1.555525
Information*University	.0262792	1.027847	0.03	0.980	-2.013191	2.06575
Male	-1.422053	.4992611	-2.85	0.005***	-2.412695	-.4314105
Age	-.7049787	.5080814	-1.39	0.168	-1.713123	.303165
University	.238568	.6507357	0.37	0.715	-1.052633	1.529769
Right	-.4422561	.8125102	-0.54	0.587	-2.054453	1.16994
Conservative	-2.076756	1.082224	-1.92	0.058*	-4.224124	.0706122
Middle	.3306851	.6197364	0.53	0.595	-.8990063	1.560376
Progressive	-1.117593	.5976648	-1.87	0.064*	-2.30349	.0683035
Left	1.259823	.6020037	2.09	0.039**	.0653174	2.454329

No preference	2.293979	1.450567	1.58	0.117	-.5842603	5.172219
_cons	4.640783	.8203584	5.66	0.000***	3.013014	6.268552

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D4 : Regression treatment on average donation score with interaction between information and right ideology

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	-.1806929	.5705709	-0.32	0.752	-1.312829	.9514436
Information*Right	.7859921	1.256885	0.63	0.533	-1.70794	3.279924
Male	-1.445255	.4963265	-2.91	0.004***	-2.430074	-.4604354
Age	-.7215792	.5068574	-1.42	0.158	-1.727294	.2841357
University	.2971956	.510161	0.58	0.562	-.7150745	1.309466
Right	-.796618	.9805645	-0.81	0.419	-2.742271	1.149035
Conservative	-1.934103	1.103376	-1.75	0.083*	-4.123441	.2552355
Middle	.4030083	.6285114	0.64	0.523	-.8440947	1.650111
Progressive	-1.074016	.5949774	-1.81	0.074*	-2.25458	.1065486
Left	1.299172	.5998089	2.17	0.033**	.1090211	2.489323
No preference	2.432152	1.461768	1.66	0.099*	-.4683123	5.332617
_cons	4.618581	.7980455	5.79	0.000***	3.035086	6.202077

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D5 : Regression treatment on average donation score with interaction between information and conservative ideology

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.0548305	.5236946	0.10	0.917	-.9842932	1.093954
Information*conservative	-1.394487	2.194882	-0.64	0.527	-5.74961	2.960635
Male	-1.425735	.4950861	-2.88	0.005***	-2.408093	-.4433767
Age	-.7665708	.5151688	-1.49	0.140	-1.788777	.2556358
University	.207008	.5086098	0.41	0.685	-.8021842	1.2162
Right	-.4554317	.8035359	-0.57	0.572	-2.049821	1.138958
Conservative	-1.706934	1.226103	-1.39	0.167	-4.139789	.7259215
Middle	.2964272	.6203772	0.48	0.634	-.9345357	1.52739
Progressive	-1.093625	.5922254	-1.85	0.068*	-2.268728	.0814792

Left	1.227767	.5980164	2.05	0.043**	.0411727	2.414361
No preference	2.265422	1.446185	1.57	0.120	-.6041227	5.134966
_cons	4.677747	.8002033	5.85	0.000***	3.08997	6.265524

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D6 : Regression treatment on average donation score with interaction between information and middle ideology

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.0019386	.5766397	0.00	0.997	-1.14224	1.146117
Information*Middle	-.1031924	1.214954	-0.08	0.932	-2.513925	2.30754
Male	-1.426249	.4971247	-2.87	0.005***	-2.412652	-.4398453
Age	-.7085552	.5082901	-1.39	0.166	-1.717113	.3000026
University	.2515873	.5061766	0.50	0.620	-.752777	1.255952
Right	-.4532343	.8106914	-0.56	0.577	-2.061822	1.155353
Conservative	-2.077442	1.081979	-1.92	0.058*	-4.224323	.0694394
Middle	.3632805	.7243789	0.50	0.617	-1.074044	1.800605
Progressive	-1.117697	.5929272	-1.89	0.062*	-2.294193	.058799
Left	1.259609	.5976575	2.11	0.038**	.0737265	2.445491
No preference	2.288066	1.451314	1.58	0.118	-.5916571	5.167789
_cons	4.629227	.8031194	5.76	0.000***	3.035664	6.22279

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D7 : Regression treatment on average donation score with interaction between information and progressive ideology

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.4061396	.757354	0.54	0.593	-1.096615	1.908894
Information*Progressive	-.7651671	1.004303	-0.76	0.448	-2.757921	1.227587
Male	-1.439551	.4950827	-2.91	0.004***	-2.421902	-.4571995
Age	-.7241438	.5063189	-1.43	0.156	-1.72879	.2805027
University	.2972416	.5077933	0.59	0.560	-.7103305	1.304814
Right	-.5008698	.8059909	-0.62	0.536	-2.100131	1.098391
Conservative	-1.934626	1.0946	-1.77	0.080*	-4.106549	.2372978
Middle	.3513946	.6179491	0.57	0.571	-.8747504	1.57754
Progressive	-.7869566	.7314041	-1.08	0.285	-2.238221	.6643078

Left	1.264705	.5956684	2.12	0.036**	.0827692	2.44664
No preference	2.177859	1.452405	1.50	0.137	-.7040273	5.059746
_cons	4.431799	.8406851	5.27	0.000***	2.763697	6.0999

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D8 : Regression treatment on average donation score with interaction between information and left ideology

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	-.3048284	.6820488	-0.45	0.656	-1.658161	1.048504
Information*Left	.6358036	1.013511	0.63	0.532	-1.375222	2.646829
Male	-1.432684	.4953155	-2.89	0.005***	-2.415497	-.4498703
Age	-.690502	.5067994	-1.36	0.176	-1.696102	.3150979
University	.2772134	.5063063	0.55	0.585	-.7274081	1.281835
Right	-.4215354	.804287	-0.52	0.601	-2.017415	1.174344
Conservative	-2.103993	1.080671	-1.95	0.054*	-4.248279	.0402936
Middle	.2636207	.6273287	0.42	0.675	-.9811354	1.508377
Progressive	-1.143907	.5929697	-1.93	0.057*	-2.320488	.0326735
Left	.9745749	.7479322	1.30	0.196	-.5094849	2.458635
No preference	2.363369	1.449434	1.63	0.106	-.5126223	5.23936
_cons	4.760864	.8219927	5.79	0.000***	3.129852	6.391876

Note. Correlation value is significant at * p < .10, ** p < .05, *** p < .01; *N* = 111.

Table D9 : Regression treatment on average donation score with interaction between information and no political preference

Variable	Coefficient	Standard Error	T	P-value	95% Confidence Interval	
Information	.0071987	.5165552	0.01	0.989	-1.017759	1.032156
Information*No Preference	-1.077921	2.989199	-0.36	0.719	-7.00914	4.853298
Male	-1.438252	.4974432	-2.89	0.005***	-2.425287	-.4512165
Age	-.7151546	.5075624	-1.41	0.162	-1.722268	.2919593
University	.2673971	.5075383	0.53	0.599	-.739669	1.274463
Right	-.4482831	.8045277	-0.56	0.579	-2.044641	1.148074
Conservative	-2.062136	1.081879	-1.91	0.060*	-4.208819	.084547

Middle	.3361279	.6189317	0.54	0.588	-.8919668	1.564223
Progressive	-1.112557	.5920915	-1.88	0.063*	-2.287395	.062281
Left	1.254118	.5970461	2.10	0.038**	.0694491	2.438787
No preference	3.099994	2.658071	1.17	0.246	-2.174195	8.374183
_cons	4.624841	.7992102	5.79	0.000***	3.039034	6.210647

Note. Correlation value is significant at * $p < .10$, ** $p < .05$, *** $p < .01$; $N = 111$.