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The Impact of Hypocrisy on biased Nuclear Energy Risk Perceptions

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Abstract

Substantial research has been developed within the field of nuclear energy. Most of it deals with nuclear energy’s arguable impact on society and near future and its recent developments. Some of it is concerned with monitoring the development of risk perceptions over the years, following catastrophic events. However, little to no research has studied the mechanisms behind risk perceptions and what psychological processes are at the root of the former. Nonetheless, there is evidence that documents how people, like in most situations, resort to heuristics, or biases, when judging certain situations and problems regarding nuclear energy’s risks. Namely, the two biases that are determinant in skewing nuclear energy’s risk perceptions are availability and small probability overweighting. With the aid of a survey experiment designed to arouse cognitive dissonance through hypocrisy, this study finds that hypocrisy can significantly reduce the use of availability bias in anti-nuclear subjects. After having declared and justified their stance on nuclear energy, the anti-nuclear subjects are presented with three positive facts about nuclear energy. According to our results, this hypocritical feeling is determinant in lowering availability bias. These results can be of use to any government looking to invest in a pro-nuclear energy information campaign in the near future, in an attempt to kick-start a decarbonisation process. In fact, the results show that anti-nuclear people would respond positively to it, inhibiting their availability bias when considering the risks of such a project, and thus being more prone to be favourable to it.

Key words: *Nuclear energy, Hypocrisy, Availability, Small probability overweighting*

Introduction

The topic of nuclear energy has always been met with controversy. Nuclear energy was first theorized in 1934 and by 1942 the first self-sustaining nuclear reactor had been created. However, the first demonstration of the potential of nuclear energy that the world witnessed, saw thousands of Japanese civilians die, in the Hiroshima bombing. Later in the century, two more nuclear disasters filled the newspaper's headlines. This time no bomb was dropped, but the Three Mile Island and especially the Chernobyl accident put a stain on the otherwise improving reputation of nuclear energy. In 2011, in Fukushima, amidst a violent earthquake and subsequent tsunami, another nuclear power plant reactor was damaged and released radioactive waste, leaving the city inhabitable.

Yet, countries such as France obtain approximately 70% of their supply of electricity from nuclear power (Wiegman, Gutteling and Cadet, 1995). The reasons behind such a choice are quite straightforward. Despite it making the news for all the negative reasons, nuclear energy has many theoretical advantages to it. Simply put, it is one of the most efficient and clean sources of energy that are available to us. Other sources, such as renewables, are clean but less efficient. More efficient energy sources, such as coal, have driven Earth's atmosphere and climate on the brink of collapse. The combination of high efficiency and low pollution is therefore attractive in a time where the climate change, caused by the energy sources used thus far, poses much uncertainty for the near future.

Clearly, there is a discrepancy between theory and practice, which can explain the different opinions surrounding the issue. On one hand, most theory provides extensive justifications as to why nuclear power is beneficial and convenient. On the other, the practical side of it sheds a negative light on the safety risks that come with adopting more nuclear energy. Arguably, the latter draws more of the public attention and consequently weighs heavier on society's judgement. In fact, it is difficult for governments to ensure a substantial amount of trust in nuclear energy from their citizens, while events such as Fukushima or Chernobyl prove that it is much easier to destroy that fragile trust (Whitfield et al., 2009).

The possible implementation of a plan that would see the expansion of nuclear energy as a source of electricity in a certain country is an intricate issue to evaluate, more so for regular citizens. Often, the questions that arise around such topics are complicated to say the least, and the answers to them should be matched in complexity. Nevertheless, as the founding fathers of Behavioural Economics address, people suffer from bounded rationality and, as a result, they tend to assess cognitively challenging problems by resorting to heuristics (Tversky and Kahneman, 1974). There exist two heuristics that people make use of when analysing nuclear energy risks: availability bias and small probabilities overweighting.

Availability bias concerns the propensity of humans to think about actuality based on the more striking and readily available examples that come to mind (Tversky and Kahneman, 1973). Chernobyl and Fukushima can be examples of how this bias gets accentuated when people are posed with a problem that requires thinking about the risks associated with nuclear energy. Small probability overweighting is a bias that falls under the umbrella of Prospect Theory, a pillar in the field of Behavioural Economics (Tversky and Kahneman, 1974). It argues that when people think about small probabilities, they overestimate them and believe that a certain event is more likely to happen. When considering the risks of nuclear energy, this heuristic can affect perceptions about the safety of nuclear power plants. Overall, these heuristics bridge the gap between theory and practice, which seems to be the tougher challenge to overcome for governments willing to take into consideration nuclear energy as a sustainably viable option for battling climate change and providing households with cheaper electricity. The question remains as to what internal psychological mechanism can alter these biases in people.

When thinking of questions about matters that have many facets and that lead you to encounter contradicting answers, one might encounter a level of psychological discomfort in trying to chose one side of the argument while understanding that both options are valid. This discomfort is known as cognitive dissonance in the psychological literature, but it has been at the core of many economics related studies. Arguably, cognitive dissonance adds difficulty in analysing the already complex issue of nuclear energy adoption. Thus, it can be a direct link to the formation of heuristics that people make use of when judging nuclear energy risks. Hence, the following research question;

What impact does arousing cognitive dissonance on the nuclear energy topic have on the perception of its risks?

The relevance for governmental institutions lies in the deeper understanding on a potential driver of the main biases surrounding nuclear energy. As the use of biases dictates one's risk perceptions, the answer to this question can ultimately indicate the extent of the effect, if any effect is found, of cognitive dissonance on nuclear energy risk perceptions. The results will concern governments looking to consider nuclear energy as an increasingly dominant electricity supplier, in the attempt to cut CO_2 emissions by the 2050 mark, as targeted by the European Union. Moreover, it is more probable that, generally speaking, a certain government would be more interested in looking at findings regarding a possible expansion of the nuclear power plant network rather than a reduction. The latter would be quite easy to achieve and the amount of nuclear power plants is too low to have a serious debate about reducing it, while the former can pose a tougher challenge for governments. Hence, it is more valuable to look in the direction of factors affecting a possible expansion.

The following sections of the paper will be organized in the following way; section 2 will provide an overview of the existing literature surrounding the relevant concepts discussed. Section 3 will lay out the methods of research and data analysis employed to answer this paper's research question. Section 4 is meant to focus on the key results with respect to the hypotheses formulated in section 3. Section 5 will be dedicated to the elaboration of the key results, and their interpretation as well as the limitations of this paper and some suggestions for any possible future research connected to this one. Section 6's purpose will be to outline the concluding remarks.

Literature Review

Nuclear Energy's potential; climate change and efficiency

As Bill Gates (2021) points out, nuclear energy is "the only carbon-free energy source that can reliably deliver power day and night, through every season, almost anywhere on earth, that has been proven to work on a large scale." The main aspects that policy-makers would focus on when planning a pro-nuclear campaign, are efficiency and climate change. While the former might sound like a less noble reason than the latter, it is undeniable that many people would welcome lower electricity bills.

In fact, people seem to give more weight to this aspect, instead of climate change, when considering the benefits of nuclear energy (Bisconti, 2018). Households that depend more on electricity tend to be more favourable about nuclear energy (Nkosi and Dikgang, 2018; Arikawa, Cao and Matsumoto, 2014; Renn and Rohrmann, 2000). While the former is an undeniable advantage, there exists the notion that climate change is the most compelling reason for a wider adoption of nuclear energy (Whitfield et al., 2009). Its employment can lead to the mitigation of climate change effects, such as reducing the amount of CO_2 released in the atmosphere (Socolow and Glaser, 2009; Pravalie and Bandoc, 2018; Buongiorno, 2018; Baek, 2015; Lee, Kim and Lee, 2017).

One argument against nuclear energy is based on the theoretical concept of the Kuznets curve which theorizes that income inequality first rises and subsequently falls as the economy grows (Stern, 2003; Kuznets, 1955). Kuznets' theory was later fitted to predict that environmental quality first decreases with GDP growth while it improves in a second instance as GDP continues its rise (Stern, 2003). Some authors have reason to believe that nuclear energy does not need to be a protagonist of the world's future energy production, as the current trend of economic growth will prove to be enough to improve the climate change situation (Manejuuk et al., 2020; Jebli, Youssef and Ozturn, 2016; Bento and Moutinho, 2016). However, this view was met with substantial criticism as it only holds for a few OECD countries (Iwata, Okada and Samreth, 2011; Manejuuk et al., 2020).

Contrary to the view of a nuclear-less EKC hypothesis, new evidence was found about the existence of the EK curve, while highlighting that nuclear energy plays a pivotal role in both the reduction of environmental decay and the continued economic growth, like in the case of France (Iwata, Okada and Samreth, 2011). Without it, the EKC hypothesis is not satisfied (Lau et al., 2019; Baek and Pride, 2014; Lee et al., 2017). Other studies even fail to find confirmation of said hypothesis, but still do prove that nuclear energy should be an important driver of CO_2 reduction in the future (Baek, 2015; Lee et al., 2017). At the current state of affairs, more economic growth will not bring any improvement to the environment, especially if mostly renewable energy resources, rather than nuclear, are employed (Skamp et al., 2019; Menegaki and Tsagarkis, 2015).

Others have indicated that nuclear energy does not lead to the reduction of CO_2 emissions and recommend renewable energy sources as the preferable solution (Jin and Kim, 2018; Gralla et al., 2017). Nevertheless, this does not seem to be the widely accepted view in literature concerning nuclear energy, and is often met with the criticism that the increase in energy prices could be unsustainable for the economy and that these views mainly accommodate countries with better socioeconomic statuses (Jin and Kim, 2018; Pampel, 2011).

Determinants of Risk Perceptions

If most theory does not seem to undermine the belief that nuclear energy is a valid energy supplier for the future, risk perceptions pose an obstacle in that respect, to the extent where interesting paradoxes are formed. For example, the so-called environmentalists tend to affiliate to anti-nuclear energy sentiments, while still being concerned with climate change (Spence et al., 2010; Wang and Kim, 2018; Vainio, Paloniemi and Varho, 2017). Despite nuclear energy's main by-product being water vapour, anti-nuclear people attach more value to possible public health and environmental risks (van der Pligt, van der Linden and Ester, 1982). Furthermore, for the most part, individuals seem to accept technologies that come with high benefits and low risk levels, except in the case of nuclear energy (Kim, Kim and Kim, 2020). More generally, nuclear energy tends to arouse safety concerns linked to one's own safety. Even when people recognize the potential of nuclear energy, just a minority prefers it to renewable energy sources (Pidgeon, Lorenzoni and Poortinga, 2008; Davy and Nawa, 2019; Whitfield et al., 2009).

A cause of worry is related to the disposal of nuclear waste (Siquera et al., 2019) although many efficient solutions have been found regarding both the safe transportation and its disposal, including recycling the spent fuel (Ritchie, 2021; Gates, 2021; Hejlzar et al., 2013; Lappi and Lintunen, 2020). Further concerns can be linked back to the nuclear disasters that recent generations have experienced, especially the Fukushima accident. It is these types of accidents that make it difficult for public trust in nuclear energy to be won back (Whitfield et al., 2009). The statistics surrounding the likelihood of other such events are discordant and can be hard to digest for laypersons. Some authors state that the chance of a core-melt accident in the next decade is as high as 70% (Rose and Sweeting, 2016). Others have calculated that there is a 50% chance of a Fukushima event happening in the next 50 years, a Chernobyl event happening in the next 27 years or a Three-Mile Island event happening in the next decade, even when considering as high a reactor safety level as 99.5% (Wheatley, Sovacool and Sornette, 2017; Engler, 2020). On the other hand, when taking into consideration the safety risks that a single person could face in a core-melt accident, the probability of a certain individual suffering dramatic health consequences converges to zero (Higson and Crancher, 1975). While it is true that the computations by Higson and Crancher (1975) were made before disastrous events such as Chernobyl, it is also true that, in the meantime, technological advancements in the nuclear energy sector has allowed for better safety measures. Additional support in favour of the latter arises when looking at the death toll of the Fukushima accident. According to a Japanese government's report, the number of deaths directly caused by the core-melt accident is one (Ritchie, 2021).

This evidence suggests that attention-grabbing events can create biased perceptions of the true nature of nuclear power plants, suggesting that availability bias is a determining factor in judging it. Availability bias was first introduced in Psychology by Tversky and Kahneman (1973). Their idea was that our perception of reality is shaped by examples that are readily available to us rather than an accurate consideration of all facts and variables. Nevertheless, when studying the consequences of Chernobyl's disaster, it was discovered that an adaptation effect kicked in. Years after the event, polls concerning risk perceptions in countries such as the Netherlands, Great Britain, France and Germany ascertained that the effect on risk perceptions following the Chernobyl accident were only temporary (de Boer and Catsbura, 1988). On the other hand, Fukushima's events have proved that Chernobyl's experience did not hinder the formation of the same biased perceptions, especially within the Japanese community. As a result, Japanese people lost trust in nuclear energy, and other countries followed (Poortinga, Aoyagi and Pidgeon, 2013; Kim, Kim and Kim, 2013; Siegrist, Sutterlin and Keller, 2014). In Japan, this was also a consequence of the people's relative overweighting of the negative aspects compared to the positive ones in their own cost-benefit analyses, as well as heightened risk perceptions and fear following the Fukushima accident (Siegrist et al., 2014; Iwai and Shishido, 2015). Moreover, little relevance was given to the fact that the real cause of the nuclear disaster was one of the strongest earthquakes ever recorded

(Kim et al., 2013; Siegrist et al., 2014). Clearly, availability bias partly shaped the public opinion, which failed to take into account all actors at play during the disaster. Acquiring the false belief of having enough information to reach sound conclusions about nuclear energy's risks actually leads to skewing perceptions to become more negative (Zhu, Wei and Zhao, 2016).

Additionally, lack of familiarity to nuclear power plants is another factor that affects the risk perceptions surrounding nuclear energy. This connects to a second bias: the overweighting of small probabilities, a concept born as a part of Prospect Theory (Kahneman and Tversky, 1980). In fact, laypersons amplify the risks of highly feared and misunderstood events while nuclear experts judge nuclear energy to be more secure than other professionals (Harris et al., 2018; Kasperson, 2012). Similarly, living closer to nuclear power plants also translates into more support for nuclear energy (van der Pligt, Eiser and Speares, 1986). In France, one of the largest nuclear energy producer in the world, people trust more the authorities and scientists operating the plants (Renn and Rohrmann, 2000). As Kasperson (2012) further explains, risks from other low-level radiation sources are usually played down, but the same cannot be said for nuclear energy's risk. This bias is not exclusive to less educated individuals as other professionals have equally negatively biased attitudes towards nuclear energy (Kasperson et al., 1988; Slovi, Fischoff and Lichtenstein, 1984). Of course, there is a selection bias effect at play. Arguably, this difference in risk perception is partly consequential to working at nuclear power plants because it translates into both living closer to it and being more knowledgeable about the matter (van der Pligt et al., 1986). Still, this can be taken as proof that better understanding the subject of nuclear energy leads to less biased and lower risk perceptions and that laypersons tend to overestimate the risks of nuclear energy.

Cognitive Dissonance's impact on policy-making and information acceptance

Given that risk perceptions are susceptible to availability bias and small probability overweighting, policy-makers need to carefully take the issue into consideration. Perceived risk is a crucial variable in determining the level of public acceptance and satisfaction with a policy (Jeon, Mok and Kim, 2016; Kim et al., 2020). If these risk perceptions are not well understood, policies can be ineffective and counterproductive and lead to lower trust levels (Slovic, Fischhoff and Lichtenstein, 1984). The lack of such trust, which is associated to a lack of knowledge on the topic, is detrimental to the risk perception of nuclear energy (Zhu et al., 2016; Iwai and Shishido, 2015; Wang and Kim, 2018; Whitfield et al., 2009). Moreover, trust is easier to lose than to gain in this particular scenario (Whitfield et al., 2009).

However, changing people's attitudes about nuclear energy could prove not to be enough to effectively steer risk perceptions in the desired direction. When it comes to nuclear energy, no significant relationship has been detected between attitudes and risk perceptions (Kim et al., 2020), which provides evidence for the presence of cognitive dissonance. Cognitive dissonance was first introduced in the psychology literature by Festinger (1957) and it can be defined as the feeling of psychological discomfort that the brain is subjected to when two contrasting thoughts occupy our consciousness. For instance, when thinking about nuclear energy, one might think of its efficiency as an energy source. However, when reminded of the possible risks that a city runs when building a nuclear power plant in its proximity, the subject experiences two opposing thoughts, which ultimately lead to the arousal of cognitive dissonance.

This particular state of mind has been noticed in the field of nuclear energy over the years. Supporters of nuclear energy, like French citizens, have appeared to be less stable about their general view on the topic (Midden and Verplanken, 1990; Wiegman, Gutteling and Cadet, 1995). Again, despite being more acquainted with nuclear energy, French citizens had higher risk perceptions while assessing the benefits to be greater, in comparison to Dutch citizens, and this phenomenon can be attributed to a greater exposure to nuclear energy (Midden and Verplanken, 1990; Wiegman et al., 1995). In addition, post Fukushima's events, Japanese households were recorded to have lost trust in nuclear energy despite still recognizing its benefits, mainly associated to lower electricity costs (Poortinga et al., 2013 ; Ida, Takemura and Sato, 2015).

Little research has focused on exploring the effects of cognitive dissonance on this issue. It is something that is easy to involuntarily arouse when a conversation about nuclear energy is started. By the look of things, it is practically impossible to avoid causing it when forcing people to think about nuclear energy. Hence, the problem at hand should not concern ways in which cognitive dissonance can be inhibited, but it should rather concern the effects that the latter has on how individuals shape beliefs about the risks associated to nuclear energy. Hence, cognitive dissonance should be taken as a given. It is something that humans experience by default. In fact, what this paper researches in depth, is the impact that cognitive dissonance has on the main biases that people tend to use when assessing nuclear energy's risks: availability bias and small probability overweighting.

Consequently, the expectations for this study are as follows; when experiencing an arousal of cognitive dissonance, subjects are expected to resort to a stronger use of both availability bias and small probability overweighting, which heightens their risk perceptions. Yet, there is no indication of whether they would make a stronger use of one or the other so no difference is expected there. Finally, due to the way in which the experiment is set up, subject with anti-nuclear views should be confronted with more cognitive dissonance. More detailed hypotheses are described in the following section.

Methods

Experimental Design: Stages and their Purposes

So far, we have established that the topic of nuclear energy can arouse cognitive dissonance. The literature also indicated that people involuntarily resort to the use of availability bias and small probability overweighting (SPO) when assessing the risks linked to nuclear energy. In order to draw a conclusion on what relationship links cognitive dissonance to the aforementioned biases have, we designed an experiment, in the form of online survey. Hence, the independent variable for this research is cognitive dissonance, while the dependent variables are the biases.

The experiment is divided in three stages. In stage 1, the treatment group subjects experience more cognitive dissonance compared to the control group, whose cognitive dissonance levels should not undergo any change. In stage 2, some robustness checks for Stage 1 are conducted on a sample of participants from both groups. In the final stage, all the subjects answer two questions, one for each bias, which are meant to gather data on the extent of usage of the latter. The questions' text is presented in Appendix I.

Hypocrisy is the key that allows the treatment group's subjects to experience cognitive dissonance. This approach to arouse the dissonance feeling is based on the work of Aronson, Fried and Stone (1991), who first theorized about the effectiveness of hypocrisy in the matter. Over the years, it has proven to be very effective, as it has led to the rapid development of dissonance research (Cooper, 2019; Priolo et al., 2016). For the purpose of this paper, hypocrisy is generated by requesting subjects to specify their stance on nuclear energy and justify it by writing down their reasoning. Subsequently, they are displayed with a list of facts that depict nuclear energy in a positive light. The goal is to arouse cognitive dissonance in anti-nuclear energy people, while leaving the pro-nuclear energy subjects feeling convinced of their own beliefs. This method resembles the cognitive dissonance arousal strategies that over the years saw participants write counter-attitudinal essays (Cotton and Hieser, 1980; de Vries, Bryne and Kohoe, 2015). Moreover, it is important that the dissonant behaviour takes place prior to the intervention, because it induces participants to reflect on that behaviour, thus making the intervention effective (Aronson, Fried and Stone, 1991; Dickerson et al., 1992). It is worth noting that theoretically, cognitive dissonance reduction can also been employed for the experiment, however, cognitive dissonance induction is preferred in this case, as it is more established and effective method (Elliot and Devine, 1994; Cooper, 2019).

To measure whether cognitive dissonance is aroused, three robustness checks are performed. Their purpose is to provide sufficient evidence that the treatment had an effect on participants. If that is the case, we can be confident that the feeling of hypocrisy induced in Stage 1 causes cognitive dissonance and determines the differences in results observed in Stage 3. Thus, three variables are measured based on the answers given to eight *True or False* questions. The rationale behind these checks is modelled after the works of Espinosa and Stoop (2021) and Ida, Takemura and Sato (2015). First, the accuracy of answers is taken into account. Simply put, this is the number of questions that the subject gets right, out of eight. Later, this measure is transformed into an accuracy rate that ranges from '0' to '1'. Answering *I don't know* is considered as a wrong answer. Secondly, uncertainty is measured as the rate at which subjects answer *I don't know*, ranging from '0' to '1' as well. The last of this trio, is a variable that tracks whether subjects click on a link provided in the question, namely information resistance. This link allows them to obtain key information on what the correct answer to the question is. If someone clicks on the link, the value of the variable is '1', '0' otherwise. If indeed, cognitive dissonance is aroused, the subjects of the treatment group are expected to be less accurate, more uncertain and more information resistant. In other words, their accuracy rate should be lower, they should be more prone to answering '*I don't know*' and they should click less often on the link provided.

When it comes to the final stage, the biases get measured on different units, but same scale; the ratio scale. The availability bias question asks for a number between ‘0’ and ‘500’. This indicates an estimate of the number of deaths following the Fukushima accident. Similarly, the SPO bias question asks for the expected risk of death, in percentage, associated with a fictitious Fukushima-like scenario happening in the Netherlands. The scales are provided as a way to standardize the results, over the two samples. In fact, little importance is given to the absolute numbers in the answers. The true focus is directed at the difference between the answers because that is what determines whether there exists a treatment effect.

Randomization and Survey Flow

To infer causality, it is of primary importance to ensure the random assignment of subjects to either a control group or a treatment group, thus making it a between-subject experiment. This gives us confidence that any selection bias effect is eliminated and cannot influence the results (Stoop, 2021). The survey is created in Qualtrics and the randomization process that allows us to find a causal effect is depicted in Figure 1. The share of participants destined for either group is the equal. As a result, 50% are assigned to the control group and 50% to the treatment group. Subsequently, 25% of participants in each group contribute to the robustness checks. In other words, of the total share of participants, 12.5% are randomly selected from the control group and 12.5% are randomly selected from the treatment group and they constitute the robustness checks sample.

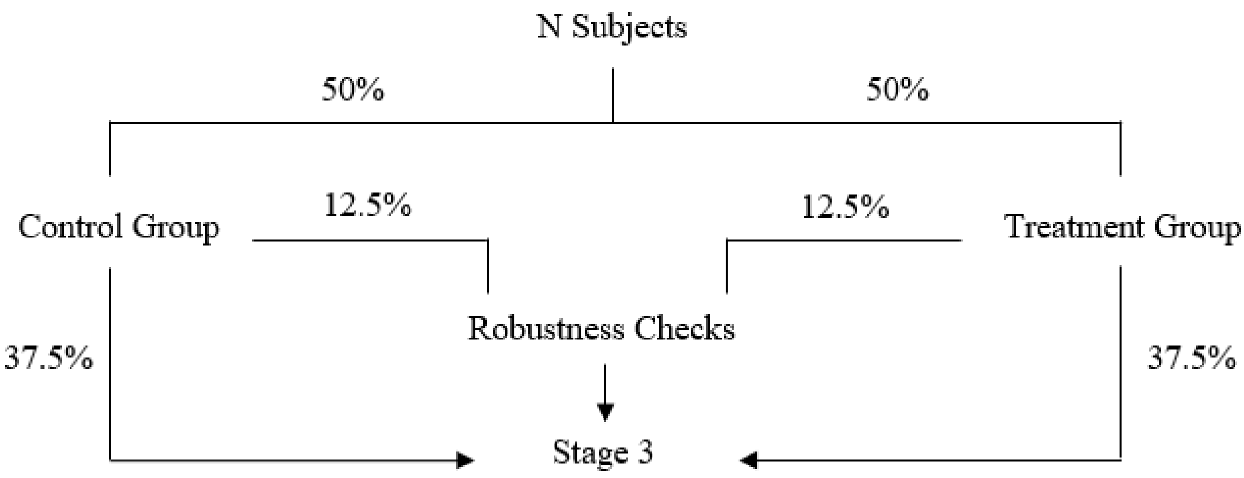

Figure 1: Survey Flow

This allocation system is partly a result of Qualtrics' lack of a feature that allows the experimenter to manually choose the share of participants destined to a certain group. Hence, the various randomization branches.

Finally, all the participants respond to Stage 3's questions on biases. The latter occurs in spite of concerns regarding whether the treatment group subjects partaking in the robustness check questions experience a reduction of the cognitive dissonance aroused in Stage 1. For example, answering *I don't know* to a certain question can result in a 'backdoor exit' for that feeling of cognitive dissonance, whose effect would not be entirely observed when measuring the biases. Thus, this hinders the detection of the true magnitude and direction of the causal effect between cognitive dissonance and availability bias or SPO bias.

Nonetheless, it is interesting to explore if and how those results will differ, which is why that data is still analysed. This study primarily focuses on cognitive dissonance arousal, yet it is still worth getting a glimpse of the effect of a presumable cognitive dissonance reduction, given that some data is presumably collected on it. In fact, cognitive dissonance arousal and reduction are two different mental processes (Tryon and Misurell, 2008; de Vries, Bryne and Kehoe, 2015).

Practicalities and Prize Scheme

The survey is accessible via an online link, and subsequently shared on the survey sharing platforms like *SurveySwap* and *SurveyCircle*. In addition, it is shared via social networks and personal connections, which in turn share the link to their social networks. There are no particular requirements for someone to participate. However, similarly to what is done with the answers from the robustness check's subjects, some demographic data is collected for the purpose of noticing any further insights. For the majority of subjects, answering the survey takes up to two minutes. The time for completing the survey can take up to six minutes if a certain participant is required to complete the robustness checks questions.

The payoff scheme is rather simple, as it is a variant of the randomized lottery incentive (Baltussen, van dem Assem and Wakker, 2012; Stoop, 2021). The incentive is not task-related but rather completion-related. At random, one participant that took part in the robustness checks questions is selected to win 20 euros. The sole requirement is to complete the survey. However, participants are not aware of and cannot infer whether they are in the robustness checks group or not. Therefore, the ideal strategy is for anyone to treat the experiment as if s(he) is in the lottery to win the prize. In fact, the group that takes two minutes for completion realizes not to be eligible for the lottery only once the survey ends. On the other hand, the group that answers the robustness check questions can infer to be in the lottery group as time passes by, but should still follow through because participating in the lottery is a form of compensation for the extra time that they are required to take in order to finish the survey.

The chance of being the winner of the lottery is completely random meaning that there is no correlation with performance, which reduces the incentive to employ a considerate amount of cognitive effort on the questions. The latter can be the case when rewarding people to answer surveys, which is not what is needed in this study, because it would hinder the application of biases by the subjects. This is a key aspect of the prize scheme, geared towards partially killing off cognitive effort in order to purposely expose the usage of biases by the participants. The inclusion of the prize scheme still satisfies Smith's five precepts, thus achieving control in the experiment and ensuring that intrinsic motivation is not an influential factor as it is eliminated. As a result, the main focus of all participants is directed at completing the survey, which is the only aspect that gives the subjects a chance at being picked to win the sum of money.

All the information regarding the eligibility to win the prize is explained in the introductory message. At no point of the experiment is any information willingly precluded from the participants in order to deceive them. Every participant has an equal chance to win the prize and all the information is made available to them, avoiding deception.

One final aspect of the survey that serves the purpose of encouraging the use of biases, is time pressure which has been shown to favour the use of heuristics, rather that rational reason (Facione and Gittens, 2016; Fraser-Mackenzie and Dror, 2011; Glovitch, Griffin and Kahneman, 2002). As a result, the questions on biases have a thirty seconds timer. Arguably, cheating in the form of looking up answers online is also discouraged by the lack of time available to do so.

Analysis Approach

This section gives a clear outline of what this paper tests and how. First, we distinguish between robustness checks results and core results. The former serve the purpose of proving that cognitive dissonance was successfully induced in the treatment group anti-nuclear energy subjects. On the other hand, the core results aim to answer the research question in depth, along with providing any other useful insights on the subject, still based on the data collected. Table 1 provides an overview of the variables used in this research and what they measure

View	A dummy variable that takes on value '1' for pro-nuclear subjects and '0' for anti-nuclear subjects
Group	A dummy variable that takes on value '1' for treatment group subjects and '0' for control group subjects
Accuracy	The rate of correct answers given when answering the eight True or False questions in Stage 2
Uncertainty	The rate of time that *I don't know* is selected when answering the eight True or False questions in Stage 2
Information Resistance	The rate of clicking on the link that provides the subject with the necessary information to answer the True or False questions in Stage 2
Availability Bias	The estimated number of deaths due to the nuclear reactor failure, not the tsunami, in Fukushima
SPO Bias	The estimated chance of dying form a Fukushima like event happening in the Netherlands (only applicable to residents in the Netherlands)
AB time	The time taken, in seconds, to answer the Availability Bias question
SPO time	The time taken, in seconds, to answer the SPO Bias question

Table 1: Salient Variables' description

The robustness checks results follow from a simple mean comparison analysis, using the Mann-Whitney U Test and the Chi-Squared Test, which are a nonparametric test. In fact, at first, the data retrieved from the *True or False* questions is not normally distributed. Moreover, it is at the nominal scale, but can be converted to ordinal data too. For example, given the frequency of correct answers one can compute the rate of correct answers. The statistics that are compared are then the frequencies and average rates of the anti-nuclear energy participants in the treatment group and the anti-nuclear energy participants from the control group. Conducting a total of six tests can provide us with strong evidence on whether the intervention in Stage 1 worked. The procedure is the same for all three robustness checks. Hence the following hypotheses;

H_1: Anti-nuclear energy subjects in the treatment group, compared to the anti-nuclear energy subjects in the control group, are less accurate in the True or False questions

H_2: Anti-nuclear energy subjects in the treatment group, compared to the anti-nuclear energy subjects in the control group, are more prone to answering 'I don't know' to a certain True or False question

H_3: Anti-nuclear energy subjects in the treatment group, compared to the anti-nuclear energy subjects in the control group, are more information resistant and therefore less likely to click the link provided in the True or False question

The core results seek to get a more thorough understanding of the data concerning the causal relationship between cognitive dissonance and the biases. As a result, on top of the standard Mann-Whitney U and Chi^2 Tests, an OLS regression is run. This allows us to include various control variables in the analysis. For example, it can be of great interest to detect the extent of bias usage for pro-nuclear energy people in the treatment group. That is, the effect that seeing that your opinion on nuclear energy is justified has on the biases. It might be that these subjects use them even less than control group subjects. However, the main results primarily regard how the treatment group's cognitive dissonance impacts their judgement of nuclear energy risk compared to a unsolicited control group. Therefore, the hypotheses for the core results are the following;

H_4: There is no significant difference in how cognitive dissonance impacts availability bias usage compared to SPO bias usage, both in anti-nuclear and pro-nuclear subjects

H_5: A higher level of induced cognitive dissonance leads to a higher usage of availability bias, within anti-nuclear subjects

H_6: A higher level of induced cognitive dissonance leads to a higher usage of SPO bias, within anti-nuclear subjects

Power Calculations

Before tackling the results section, it is crucial to compute the ideal number of participants for this study (Stoop, 2021). According to formula (1), the number of subjects should be spread equally across control and treatment groups, as the payoff scheme is perceived to be the same for all subjects and there is no reason to believe that the composition of the two groups varies significantly. Consequently, we can infer an optimal number of participants as a target for this study. A few things are to be taken into consideration for this, which include the target power for the study, the significance level that we want to achieve for a given result and the effect size we are interested in. These factors are included in the formula (2). For the purpose of this study, we are interested in detecting an effect size of 0.1, while considering a conventional value of 0.5 for the standard deviation, an alpha value of 0.05 and a beta value of 0.20. The Stata software comes to our aid for the computation of n*, which results to be 394. Hence, the target amount of participants for this study is 788.

This is applicable to every hypotheses that this paper formulates, which translates to taking the same effect size into consideration for all tests. Nevertheless, gathering such a large number of participants is outside the scope of this study, which aims at settling at circa 150 responses, a number realistically feasible to reach.

$$\frac{n_0}{n_1} = \frac{\sigma_0}{\sigma_1} \times \sqrt{\frac{p_1}{p_0}} \qquad (1)$$

$$n^* \approx 2(t_{\alpha/2} + t_{\beta/2})^2 \times \left(\frac{\sigma}{\delta}\right)^2 \qquad (2)$$

Sample Description

Table 2 summarizes the composition of the sample of subjects for this study. About 60% are pro-nuclear energy while the rest is anti-nuclear energy. Approximately 56% are females and 51 are reside in the Netherlands. 10 subjects have completed high school, 62 have completed a Bachelor programme, 67 are Master graduates and only 5 have obtained a PhD. Most participants can be classified as young adults as the average age across participants is relatively low, sitting at 24.9 years old. Moreover, 81.3% of participants are in their 20s, further ascertaining that the participants are mostly young. Additionally, we notice that the randomization process of subjects into control and treatment group produced the expected results as the split was practically even. Finally, a total of 46.5% entered Stage 2 of the experiment. Initially, this figure was designed to be 25%, but some late updates to the randomization process were made, allowing enough data to be collected for the robustness checks.

Variable	Mean	Frequencies	
View	0.597	PN = 86	AN = 56
Gender	0.563	Female = 81	Male = 63
NL	0.514	NL citizen = 74	Other = 70
Group	0.493	Treatment = 71	Control = 73
Stage 2	0.465	Stage 2 = 67	Core = 77
Education	omitted	High-school = 10 Bachelor = 62 Master = 67 PhD = 5	
Age	24.917	% of subjects in their 20s = 81.25%	

Table 2: Sample Composition and Demographics

A few adjustments are done to the datasets before the data analysis can initiate. In fact, some responses are deleted based on some factors. Namely, these include having completed the survey, having taken enough time to answer the timed questions and not having the same IP address as other responses.

Results

Robustness Checks for Induced Cognitive Dissonance

Prior to interpreting the core results, we look for evidence of an arousal of cognitive dissonance in the treatment group's anti-nuclear subjects. Once again, cognitive dissonance cannot be directly observed, as there is no measurement scale for it. Therefore, what enables us to draw any conclusions on the matter, are three indicators: accuracy, uncertainty and information resistance. The latter are all measured by means of eight True or False questions, containing an '*I don't know*' option as well.

Table 3 contains a summary of the most important statistics that aid us in answering the first three hypotheses. We have previously hypothesized that within the anti-nuclear subjects' sample, those that are exposed to the treatment should be less accurate, more uncertain and more resistant to information. Unfortunately, no evidence was found to prove that the treatment had the desired effect. In fact, the p-values of the MWU and Chi^2 Tests are not significant because they are all above the 10% alpha significance level. This leads us to reject the hypotheses that a higher level of cognitive dissonance is experienced by the anti-nuclear subjects within the treatment group. In fact, the latter are not less accurate, they are not more uncertain and, finally, they are not more information resistant.

	Averages		Observations		Test statistic's p-value	
	AN (hypocrisy)	AN (no hypocrisy)	AN (hypocrisy)	AN (no hypocrisy)	MWU	Chi^2
Accuracy	0.484	0.466	16	11	0.880	0.952
IDK	0.211	0.227	16	11	0.781	0.581
Link	0.125	0.125	16	11	0.587	0.970

Table 3: Anti-Nuclear people that experienced hypocrisy vs. Anti-Nuclear people that did not experience hypocrisy for Robustness Checks

Despite so, no real conclusions on the effectiveness of the treatment can be drawn, as we cannot be certain of whether these outcomes are a result of a poor induction of the treatment or a lack of sufficient data to detect its efficacy. Yet, following the above results, we are interested in knowing whether an effect is perhaps solicited in pro-nuclear subjects. This can give us an additional indication on whether the hypocrisy treatment triggers something or not. In this case, compared to before, the opposite would be true. In other words, the treatment would not induce cognitive dissonance but it should rather reduce it. Similarly to Table 3, Table 4 summarizes the p-values of the MWU and Chi^2 Tests. Once more, the results are not significant, as none of the p values are below 10% alpha significance level.

	Averages		Observations		Test statistic's p-value	
	PN (hypocrisy)	PN (no hypocrisy)	PN (hypocrisy)	PN (no hypocrisy)	MWU	Chi^2
Accuracy	0.588	0.556	20	20	0.590	0.752
IDK	0.169	0.181	20	20	0.780	0.337
Link	0.100	0.163	20	20	0.391	0.256

Table 4: Pro-Nuclear people that experienced hypocrisy vs. Pro-Nuclear people that did not experience hypocrisy for Robustness Checks

This additional evidence on the lack of efficacy of the treatment is confirmed when looking at Table 5. As expected, no significant effect is detected across the whole sample of subjects that took part in Stage 2's robustness checks' questions. We can conclude that, to the best of our knowledge, no cognitive dissonance was aroused by hypocrisy.

	Averages		Observations		Test statistic's p-value	
	N (hypocrisy)	N (no hypocrisy)	N (hypocrisy)	N (no hypocrisy)	MWU	Chi^2
Accuracy	0.542	0.524	36	31	0.773	0.866
IDK	0.188	0.198	36	31	0.732	0.296
Link	0.111	0.149	36	31	0.325	0.359

Table 5: Subjects that experienced hypocrisy vs. Subjects that did not experience hypocrisy for Robustness Checks

Nevertheless, we are still interested in assessing the impact of being in the treatment group on the usage of availability bias and SPO bias. The lack of proof of a cognitive dissonance arousal does not imply that the treatment does not have an effect. However, if an effect is indeed found, cognitive dissonance cannot be the reason for it, according to the evidence found so far. The hypotheses that are meant to be tested assume that cognitive dissonance was indeed aroused. We have just concluded that that is not something we can infer, given the data collected. Yet, we still test those hypotheses, predicting that, there is no significant difference in which bias is most used, and expecting that treatment subjects do not use more bias than their control group counterparts. For the following results, we use data from the entire sample since there is no evidence of a difference between participants than took part in Stage 2 and not, contrary to what initially theorized. Instead, what we still aim to find, is a difference between treatment group and control group.

Tables 6 and 7 show yet more unexpected results, as we find evidence to reject the first two core hypotheses, as it seems that the treatment and control groups differ in their bias usage. As a matter of fact, anti-nuclear subjects exposed to the treatment, do differ in their usage of availability bias as both p-values of the MWU and Chi^2 Tests are significant, the former at the 5% alpha significance level and the latter at the 10% alpha significance level. On the contrary, the same cannot be concluded about SPO bias, whose p-values from the MWU and Chi^2 Tests are not significant. Similar assessments derive from looking at the pro-nuclear sample, with treatment group's subjects not scoring significantly different in bias usage, compared to pro-nuclear people in the control group. Hence, treatment group subjects significantly differ in availability bias scores, when being anti-nuclear, compared to the control group's anti-nuclear sample. Additionally, this difference is not present when looking at SPO bias, indicating that there exists a treatment effect for availability bias, but not for SPO bias. Instead, within the pro-nuclear sample, no differences are detected, meaning that pro-nuclear people tend to be unaffected by the treatment and less prone to the use of one bias over the other.

	Averages		Observations		Test statistic's p-value	
	AN (hypocrisy)	AN (no hypocrisy)	AN (hypocrisy)	AN (no hypocrisy)	MWU	Chi^2
Av. Bias	275.063	356.077	32	26	0.014	0.099
SPO	28.344	21.346	17	15	0.623	0.388

Table 6: Anti-Nuclear people that experienced hypocrisy vs. Anti-Nuclear people that did not experience hypocrisy for bias usage

	Averages		Observations		Test statistic's p-value	
	PN (hypocrisy)	PN (no hypocrisy)	PN (hypocrisy)	PN (no hypocrisy)	MWU	Chi^2
Av. Bias	207.410	220.149	39	47	0.715	0.144
SPO	15.974	13.574	16	26	0.969	0.776

Table 7: Pro-Nuclear people that experienced hypocrisy vs. Pro-Nuclear people that did not experience hypocrisy for bias usage

Core Results

Considering that we detect a treatment effect, it is worth analysing the magnitude and direction of that effect. To achieve this, Table 8 presents the coefficients of OLS regressions (1) and (2). The same approach as before is taken, as different samples based on subjects' view of nuclear energy are considered. Furthermore, following the Robustness Checks results, we assume that the sample of participants that took part in Stage 2 is fundamentally equal to the sample that did not. Appendix II contains results for the same set of regressions while only taking into account the participants that did not take part in Stage 2, as originally planned. The interpretation of the data does not change drastically, giving us additional confidence on the reliability of this study's findings, using the whole sample. Thus, we incorporate their data in our data analysis for the core hypotheses, which at the same time increases the power of our results.

$$\text{Availability} = \beta_0 + \beta_1(\text{Group}) + \beta_2(\text{View}) + \beta_3(\text{Stage 2}) + \beta_4(\text{AB time}) + \beta_5(\text{Gender}) + \beta_6(\text{Age}) + \beta_7(\text{NL}) + \beta_8(\text{Education}) + \varepsilon \quad (1)$$

$$SPO = \beta_0 + \beta_1(\text{Group}) + \beta_2(\text{View}) + \beta_3(\text{Stage 2}) + \beta_4(\text{SPO time}) + \beta_5(\text{Gender}) + \beta_6(\text{Age}) + \beta_7(\text{NL}) + \beta_8(\text{Education}) + \varepsilon \qquad (2)$$

The table below demonstrates the validity of our previous verdicts. Namely, availability is the only bias that is significantly impacted and the treatment effect is observed over the entire sample even though it gets more accentuated within anti-nuclear subjects. However, the interesting take-away from these results is that the treatment effect reduces the use of bias, rather than increasing it as initially thought. The hypocrisy treatment is meant to arouse cognitive dissonance, which was theorized to enhance the employment of biases. This is clearly not the case, as hypocrisy seems to produce the opposite effect. On average, when looking at the entire sample, being in the treatment group leads to the subject estimating that in the Fukushima accident, 48.5 less people have died, compared to the estimates of control group subjects, ceteris paribus. This effect is significant at the 10% alpha significance level. For anti-nuclear people, this number rises to 90.7 less, while also being more significant, as p is lower than the 5% alpha significance level.

Moreover, the aforementioned effect is not reflected onto pro-nuclear people. In other words, if getting shown facts that contradict your nuclear energy stance leads to a decrease in availability bias, getting shown facts that support your stance does not have a significantly positive impact on someone's availability bias usage. In fact, the OLS regressions derived from the pro-nuclear sample do not produce a significant coefficient for the *Group* variable. Similarly, no effect is registered in the OLS regressions with SPO bias as dependent variable. This shows that, on average, being in the treatment group does not result in an overestimation of the risk of death associated with a potential Fukushima like event happening in the Netherlands, compared to the control group, across all samples.

	Availability			SPO		
	N	AN	PN	N	AN	PN
Group	-47.684*	-97.461**	-17.454	3.211	2.658	3.301
	(26.679)	(37.679)	(37.189)	(3.790)	(6.235)	(4.646)
View	-85.431***	0	0	-7.526*	0	0
	(27.575)	(omitted)	(omitted)	(3.908)	(omitted)	(omitted)
Stage 2	33.366	50.821	20.209	3.829	6.073	5.299
	(26.568	(39.891)	(35.333)	(3.566)	(6.065)	(4.423)
Resp. time	-0.458	-1.412	0.039	-0.121***	0.956	-0.126***
	(1.649)	(2.135)	(2.496)	(0.028)	(0.588)	(0.033)
Gender	56.289**	24.043	80.492**	10.323***	20.449***	5.723
	(28.270)	(46.310)	(38.407)	(3.919)	(6.975)	(5.075)
Age	-1.338	1.875	-1.801	0.229	2.027***	-0.221
	(2.529)	(5.613)	(2.902)	(0.408)	(0.732)	(0.415)
NL	-26.177	14.236	-37.718	-8.994**	-8.678	-6.113
	(31.559)	(57.035)	(38.538)	(4.460)	(7.788)	(4.867)
Education						
Bachelor	-26.778	-108.976	-0.297	-0.996	3.045	-6.458
	(60.757)	(77.550)	(99.845)	(7.773)	(12.329)	(8.844)
Master	-17.948	-63.413	-18.908	-3.885	-1.728	-12.629
	(63.318)	(87.573)	(102.834)	(7.700)	(12.973)	(8.829)
PhD	23.510	41.745	1.420	-3.831	16.275	-18.524**
	(82.919)	(98.881)	(138.104)	(9.366)	(11.786)	(8.255)
Constant	354.871***	370.486**	249.664**	16.963	-50.236**	27.826**
	(83.588)	(147.036)	(111.272)	(12.299)	(21.059)	(13.366)
n	144	58	86	144	58	86
R^2	0.164	0.180	0.101	0.188	0.351	0.156

*Standard errors appear in parentheses. *** indicates p<0.01, ** indicates p<0.05, * indicates p<0.10*

Table 8: Core Results: Treatment effect on Availability and SPO bias

Among the control variables, gender's effect certainly grabs one's attention. Despite no hypotheses being formulated with regards to gender, its results in Table 8 are worth to speculate about. In four out of the six models, being a female has a significantly positive effect. With respect to availability bias, we notice that this is the case for the entire sample as well as when looking at pro-nuclear people only. On average, being a female leads to the subject estimating that the Fukushima accident caused 56.3 more deaths, compared to males, ceteris paribus. For the pro-nuclear sample, this number escalates to 80.5. These coefficients are significant at the 5% alpha significance level.

On the other hand, the opposite can be said for SPO bias. In this case, being a female also increases the bias over the whole sample, even though it is accentuated within anti-nuclear people instead. On average, being a female increases your perceived death risk from a Fukushima like accident happening in the Netherlands by 10.3%, compared to males, ceteris paribus. Within Anti-nuclear subjects, this perceived risk is 20.4% more for females, compared to males, ceteris paribus. These coefficients are significant at the 1% alpha significance level.

For other control variables, a few significant effects are detected even though these do not offer us more interesting cues. For example, education does not play a fundamental role in determining bias usage on the nuclear energy issue even though it has a negative significant effect at the 5% alpha significance level for pro-nuclear people using SPO bias. Response time also leads to a highly significant drop for the question on SPO bias, even though the economic significance is irrelevant, given that an additional second in response time lowers the bias by just 0.12% across the whole sample and 0.13% across the pro-nuclear sample. Instead, age has a positive effect for anti-nuclear subjects answering the question for SPO bias. However, the latter do not necessitate of further discussion and interpretation, while the previous results do.

Discussion

Thus far, we attempted to investigate the intricacies of cognitive dissonance's effects on nuclear energy's risk perceptions. However, no evidence was found in support of a cognitive dissonance arousal. As previously discussed, a lower everyday exposure to nuclear energy power plants can inhibit the formation of cognitive dissonance in people, the Netherlands being a prime example of that (Midden and Verplanken, 1990; Wiegman et al., 1995). Since our sample of respondents is composed of 51% Dutch residents, the result should not be extremely surprising. Nevertheless, we cannot assume that the observed effects are a direct consequence of cognitive dissonance. However, we know that hypocrisy is what was made felt to anti-nuclear treatment subjects. As a result, we can establish that any difference in nuclear energy risk perceptions outcomes is a reaction to that feeling, since it is the only aspect that distinguishes anti-nuclear people in the treatment group, compared to the control group, on average. In other words, what is tested in this paper, is the effect of hypocrisy, rather than cognitive dissonance induced through hypocrisy, on nuclear energy risk perceptions.

Indeed, the results section highlighted the effectiveness of hypocrisy, especially in anti-nuclear subjects dealing with availability bias. When feeling hypocritical about their nuclear energy stance, anti-nuclear people tend to reduce their usage of availability when estimating the number of deaths that the Fukushima accident caused. On the contrary, this conclusion cannot be drawn for SPO bias. Pro-nuclear people, instead, are seemingly not affected by the treatment, and do not exhibit variation in their bias usage. It is worth noting that for this subsample, the feeling experienced following the treatment is not hypocrisy but rather of confirmation regarding their stance, and a decrease in bias usage was expected. Yet, the difference, or the lack of it per say, in bias usage does not imply that subjects do not make use of them.

The extent of Biases

Overall, the results confirm that availability bias and SPO bias are very much present in people's evaluation of nuclear energy risks. The Japanese government's official death toll from the Fukushima nuclear power plant failure amounts to one (Ritchie, 2021). Yet, our study subjects, on average, regardless of their view or group allocation, showed significant evidence of both availability and SPO bias usage, as per Tables 3-7's sample means. As expected, anti-nuclear people are more biased than pro-nuclear people are. Still, pro-nuclear subjects recorded an average of 214.4 estimated deaths in Fukushima and an average of 11.3% chance of dying from such an event happening in the Netherlands. These are overestimations of 213.4 deaths and 11.3% respectively. In doing so, the subjects probably failed to take into consideration that most deaths were caused by the tsunami and subsequent evacuation attempts (Kim et al., 2013; Siegrist et al., 2014). Moreover, as Zhu, Wei and Zhao (2016) mention, these unexpectedly negative perceptions can be a result of having little familiarity with the subject, which applies to the Dutch context since there is only one nuclear reactor present in the Netherlands. Furthermore, such high figures imply that the true mechanisms behind nuclear power plants' operations are not well understood, just as Harris et al. (2018) and Kasperson (2012) suggest.

While the availability bias question might be considered trickier to properly evaluate, it is surprising to see such a high estimate for the SPO bias question. Logically, an 11.3% estimated chance of dying would mean that every one hundred residents in the Netherlands, 11.3 die as a result of a Fukushima-like event happening in the country. Undoubtedly, that is far too much, considering that the population of Fukushima in 2011 was approximately 450,000 and the total death toll was 473, meaning that the chance of a Fukushima resident dying was 0.12%, just below a hundred times lower than even pro-nuclear people's more conservative estimates.

Attitudes and Risk Perceptions

Contradictory evidence has emerged with respect to the relationship between attitudes and risk perceptions found by Kim et al. (2020). They theorized that such relationship is inexistent while, in Table 8, the OLS regressions that take the entire sample into consideration demonstrate that one's view is a significant predictor of risk perception. Namely, being pro-nuclear decreases their risk perceptions as bias usage is less extreme, for both availability and SPO. This is a first indication that cognitive dissonance cannot be easily triggered. Subjects fail to experience it intrinsically. That would be the case if there was some dissonance between their view and risk perception (Kim et al., 2020). However, our sample is quite firm in their belief and that reflects onto their risk perceptions. It is true that the latter are still high, even though this can be attributed to the complexity of the question and the scenario that they had to (re)create in their heads while answering them. Still, it is worth reminding that this study did not rely on the participants' accuracy in answering the bias questions, but rather in the extent of the bias usage by the two groups. Indeed, the difference in the latter is the focus of this study's research question.

Hypocrisy and Risk Perceptions

On average, the main difference that distinguishes control and treatment group, is that the treatment group was presented with three positive nuclear energy facts that shed a positive light on it. This treatment was designed to target anti-nuclear subjects' psychic into making them feel hypocritical about their view, right after motivating it. Again, the purpose of this step was to arouse cognitive dissonance, whose presence was not detected. Actually, cognitive dissonance was neither aroused in anti-nuclear participants nor reduced in pro-nuclear ones, as one could assume that by getting shown facts that confirm one's own views, those views can become more extreme, leaving less room for doubt, and therefore cognitive dissonance. However, hypocrisy is still a factor that we controlled and actively triggered in anti-nuclear people, thus making it the sole driver of any treatment effect recorded.

This effect was found to be negative for anti-nuclear people. This goes against what hypothesized for cognitive dissonance. It was believed that greater hypocrisy would lead to this sentiment of dissonance, thus having an increasing effect on bias usage. This comes to our surprise, given that Whitfield et al., (2009) mention the difficulties of gaining the trust of the public when it comes to this topic. Based on our results, a simple hypocrisy treatment, composed of showing three positive nuclear energy facts, served the purpose quite well. Risk perceptions were significantly lower as reflected by the lower employment of bias. This might not be the ideal proxy for trust but it does show that nuclear energy was not considered as risky after feeling hypocritical.

Pro-nuclear subjects did not experience the same effects. They did not show any signs of bias reduction or increment, despite their level of both availability and SPO bias being high, on average. This finding can be reconnected to what Midden and Verplanken, (1990)'s and Wiegman, Gutteling and Cadet (1995)'s insight that pro-nuclear people are less stable in their stance. Hence, this can have steered their bias usage to be objectively high, even when considering the pro-nuclear subjects that were shown positive facts about nuclear energy. However, a different interpretation can follow from the OLS regressions' results of pro-nuclear participants. The indications from the latter are that, regardless of the group the pro-nuclear subject was assigned to, his/her bias usage does not suffer a significant impact. Therefore, it rather appears as if their views are stable, and robust to heterogeneous influence from the experimenter's hypocrisy treatment. Still, those views are quite negative, in comparison to the reality of events even though, as previously mentioned, some of this outcome can be attributed to the difficulties in interpreting the scenarios depicted in the bias questions.

Furthermore, the results give a verdict on which bias is more affected. To our knowledge, this is a new addition to this branch of research dealing with nuclear energy's risk perceptions. The availability bias of anti-nuclear participants is reduced when they feel hypocrisy for their stance, while SPO bias does not undergo significant change. This is perhaps the most relevant aspect of this study's findings since it shows that information campaigns that aim to inform citizens on the benefits of a possible nuclear energy expansion have the potential to reduce availability bias but not SPO bias. Therefore, the true potential of such information campaigns is yet to be fully revealed as that would depend on which bias is of greater importance. Ultimately, it is challenging to predict which bias has the bigger impact on a person's risk perception and consequent acceptance of nuclear energy. Lastly, it is somewhat reassuring that the treatment does not have negative spill overs on pro-nuclear people. Getting confirmation that one's own view is justified by facts does not alter their risk perceptions. As a result, an information campaign is not predicted to do more damage than benefit, in terms of public support because it improves anti-nuclear people's perception of nuclear energy, while leaving pro-nuclear people's perceptions untouched.

Secondary Relationships

Aside from hypocrisy, gender is determining in defining bias utilization. Females recorded more biased answers, for both biases. As a measure of comparison, the effect on availability bias of being a female, compared to a male, is approximately as big as the effect that one's own view on nuclear energy has. Thus, being a female has approximately the same effect of being anti-nuclear. Similarly, the effect of being a female on SPO bias, compared to being a male, is circa two and a half times bigger than the effect of being anti-nuclear, compared to nuclear. Intuitively, one would expect that a person's view on nuclear energy would have a much bigger effect than gender but that is not the case. Once more, no literature in the field of nuclear energy risk perceptions was devoted to this kind of research. Nonetheless, some assumptions can be made as it seems odd that something as irrelevant as gender plays a role. For example, competitiveness can provide an explanation. Lots of research is currently being conducted on the issue, and evidence has emerged in support of the theory that males are more competitive (Gneezy, Niederle and Rustichini, 2003; Kleinjans, 2009; Buser, Niederle and Oosterbeek, 2014). This translates into more cognitive effort being applied in the biases questions, from which more accurate answers should logically derive. Yet, despite the surprising outcome, further analysing it is not part of this research's scope. Instead, what checks out with the literature, is the role of education. In fact, education mostly does not have an effect, which is what previous research already concluded (Kasperson et al., 1988; Slovi, Fischoff and Lichtenstein, 1984). A significant relationship is only detected for pro-nuclear subjects in their SPO bias usage. Still, anti-nuclear subjects' risk perceptions, which are arguably the one's of interest for policy-makers, seem unaffected by education level.

Limitations

The treatment was supposed to induce cognitive dissonance, but no evidence was found for it. This generates some doubts on the source of the treatment effect. While it is true that hypocrisy was the only aspect that supposedly differed between control and treatment group, no robustness checks are done to certify that treatment subjects experience hypocrisy. That is just an assumption that this paper makes. On the other hand, maybe cognitive dissonance was aroused, and not enough observations were recorded for its presence to be detected. Similarly, perhaps the robustness checks were not fit for this purpose. However, given that the robustness checks' method is based on existing literature, we take the former explanation as more realistic.

Moreover, the prize scheme can be challenging to grasp for participants, and this can have impacted the answers given by them. Realistically, with this prize scheme, Smith's five precepts might not be met for some participants. If that is the case, some data can mostly be a result of intrinsic motivation, which Smith's five precepts are meant to kill off. Consequently, for some observations, control could be an issue. Additionally, participants' focus was deliberately directed to the completion of the survey, in order to accentuate the use of bias, possibly though a snap judgement of the problem. Nonetheless, despite ruling out participants that took too little time to answer the questions, and therefore could have not possibly read the question properly, we cannot have the certainty that all questions were not randomly answered.

Furthermore, by taking into consideration the resources that were available to us, participants' experimental conditions were out of our control. In other words, the setting in which the survey was answered most likely varied between participants, and that was not taken into account.

External validity is also an issue. The results of this study are applicable within Dutch boundaries but once you step outside of them, the context can be much different. Among others, cultural differences, past nuclear energy policies and past experience with nuclear energy power plants can all be influences of bias usage and risk perceptions. Of course, these factors vary greatly across countries. Therefore, it is advisable to consider the conclusions of this research as valid within the Netherlands only.

A final limitation is the amount of treatment levels that were included in the experiment. This was a direct result of the expectations on the lack of data that can be collected for a Master Thesis, thus making it a measure of caution. In fact, the decision was made to collect all data for one treatment level, rather than running the risk of having either different treatment levels for hypocrisy or more treatment groups with different treatments, whilst not ending up collecting enough data to reach powerful conclusions.

Future Research

Linking back to what just argued, future research should certainly be directed at replicating this paper’s experiment while employing different treatments meant to induce cognitive dissonance. An example of the latter would be social norms. Similarly, one could attempt to alter the level of hypocrisy induced, in order to derive a more accurate relationship with bias usage. For example, too much hypocrisy can have an undesired effect, leading to an escalation of negative bias towards nuclear energy, rather than a reduction.

Secondly, the gender bias gap deserves more attention than this paper devotes to it. As previously speculated, differences in competitive nature between the genders can be worth analysing. However, other factors may provide the answers to this problem too.

Lastly, as cognitive dissonance literature mostly focuses on one's personal health, more research should follow this study's footsteps. In fact, nuclear energy is a topic that concerns societies' health and wellbeing, and one's decision on the matter does not just impact their own selves. This aspect can make respondents feel a greater sense of responsibility towards their society, which can play a role when cognitive dissonance is felt.

Conclusion

This research's analysed bias usage in nuclear energy's risk perceptions. Hypocrisy was the key factor in lowering availability bias usage in anti-nuclear subjects. When being informed about the positive aspects of nuclear energy, anti-nuclear subjects that had previously defended their stance on the matter feel hypocritical, which inhibits the extent of their usage of availability bias. As a result, their risk perceptions are lower, thus favouring a higher level of nuclear energy acceptance following an information campaign on it. Initially, hypocrisy was solely a mean to achieve the arousal of cognitive dissonance in subjects. However, the latter is not detected. Following this hick-up, hypocrisy is assumed to be the driver of the treatment effect recorded in the data analysis. Yet, no effect is discovered for SPO bias, suggesting that availability bias is the more affected of the two. The treatment has no impact on pro-nuclear participants. Following the same procedure, pro-nuclear people see their beliefs re-enforced by the nuclear energy positive facts that they read. Still, no significant difference exists between the control and treatment group of pro-nuclear people. This indicates that the intervention works for anti-nuclear people only, even though we ascertain that it does not have any counterproductive spill-overs onto pro-nuclear people.

These results come in aid of policy-makers that are attempting to expand a country's nuclear power plant network. The topic can be a sensitive one to discuss, and the main worry is that the public would not welcome a pro-nuclear information campaign that makes them feel hypocritical about their stance, thus leading to the opposite effect than what was hoped for. However, this paper shows that such pro-nuclear information is effective in lowering availability bias in anti-nuclear people. If the latter is inhibited, nuclear energy risk perceptions are lower and acceptance rates for a nuclear power plant expansion should consequently increase. The same cannot be said for SPO bias, since no effect was found. Still, the evidence found on the reduction in bias usage when feeling hypocritical is a step forward in understanding the impact of nuclear energy information campaigns on the public.

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Appendix List

Appendix I

Q1	Please select which of the two describes you the best; *Pro-nuclear energy vs. Anti-nuclear energy*
Q2 *For pro-nuclear* *For anti-nuclear*	Please list the reasons that have lead you to take this stance, over the years Hint: Imagine of trying to convince someone that is not sure of where he stands on this topic that nuclear energy is good Hint: Imagine of trying to convince someone that is not sure of where he stands on this topic that nuclear energy is bad
Treatment	Next, I will provide you with facts related to nuclear energy. Did you know that: • France produces more than 70% of its electricity supply from Nuclear reactors • There are more than 440 functioning nuclear reactors in the world which produce 10.4% of the global electricity supply • Nuclear reactors cause much less pollution than coal and are a more efficient source of electricity than renewables as they can function 24/7
Stage 2: *True vs. False*	
Q3	According to a statistical projection, there is a 50% chance that a nuclear event of the proportions of Fukushima (or worse) will happen in the next 50 years; *True* Link: https://www.technologyreview.com/2015/04/17/168600/the-chances-of-another-chernobyl-before-2050-50-say-safety-specialists/
Q4	It is estimated that, from 2011 to 2017, Germany's policies to reduce nuclear energy production caused an additional 1100 deaths each year from air pollution; *True* Link: https://ourworldindata.org/nuclear-energy?country=#how-many-people-has-nuclear-energy-saved
Q5	A nuclear explosion can have serious consequences on the surrounding natural environment; *True* Link: https://www.nap.edu/read/11282/chapter/8
Q6	Nuclear energy had considerably diminished the acceleration of global climate warming recorded in the past four decades, as its use prevented the release of over 60 billion tons CO2 after 1970; *False* Link: https://www.iaea.org/sites/default/files/16/11/np-parisagreement.pdf (page 3)
Q7	The Netherlands already produce nuclear energy; *True* Link: https://www.government.nl/topics/renewable-energy/nuclear-energy
Q8	The majority of Dutch people support nuclear energy; *True* Link: https://www.statista.com/statistics/946853/opinions-on-building-new-nuclear-power-plants-in-the-netherlands/
Q9	A nuclear reactor can explode like a nuclear bomb; *False* Link: http://nuclearconnect.org/wp-content/uploads/2015/11/Top_10_Myths_web.pdf

Q10	There is no solution for huge amounts of nuclear waste being generated; *False* Link: http://nuclearconnect.org/wp-content/uploads/2015/11/Top_10_Myths_web.pdf
Bias Questions	
Q11	Can you give an estimate of the deaths that the nuclear disaster alone in Fukushima caused? Note that some deaths were also caused by the tsunami that crashed onto the city shortly after the nuclear reactor failure. Do not take those into account, in your estimate. Drag the cursor to your best estimate. *0-500*
Q12	Currently, there is a functioning nuclear reactor in the Netherlands, what do you think is the chance for such a nuclear reactor to cause a Fukushima-like event? *0-100*

Survey Questions

Appendix II

	Availability			SPO		
	N	AN	PN	N	AN	PN
Group	-56.068*	-112.447*	-3.724	1.988	-2.772	9.005
	(26.679)	(58.294)	(49.848)	(4.471)	(8.796)	(5.534)
View	-77.899*	omitted	omitted	-4.683	omitted	omitted
	(40.921)	(0)	(0)	(5.110)	(0)	(0)
Resp. time	2.219	-2.305	5.113	-0.093	0.599	-0.944
	(2.318)	(2.837)	(3.742)	(0.473)	(0.756)	(0.640)
Gender	56.153	7.837	97.005*	17.147***	16.221	17.020***
	(39.513)	(70.075)	(53.801)	(5.097)	(11.813)	(5.838)
Age	-0.895	8.829	-2.307	0.842	1.933	0.633*
	(3.084)	(10.186)	(3.050)	(0.480)	(1.594)	(0.357)
NL	8.019	23.631	8.477	-1.657	-3.913	0.178
	(44.584)	(91.069)	(54.526)	(5.209)	(11.999)	(5.799)
Education						
Bachelor	-49.597	-33.107	-71.356	1.840	5.906	-10.063
	(96.895)	(117.239)	(185.407)	(8.814)	(16.860)	(13.085)
Master	-20.964	-13.831	-37.396	2.062	3.899	-10.913
	(95.052)	(107.256)	(186.065)	(9.321)	(17.861)	(12.983)
PhD	-43.568	-21.758	-129.092	15.399	24.428	-6.963
	(88.982)	(130.807)	(170.790)	(11.545)	(19.575)	(11.335)
Constant	283.323**	183.230	171.377	-12.671	-45.072	4.167
	(113.419)	(286.183)	(187.645)	(16.672)	(42.642)	(15.609)
n	77	31	46	77	31	46
R^2	0.181	0.227	0.155	0.266	0.273	0.334

*Standard errors appear in parentheses. *** indicates p<0.01, ** indicates p<0.05, * indicates p<0.10*