Does nuclear energy produce neodymium? Negative perception of nuclear energy drives the assumption that it is polluting

Electronic supplementary materials

This document includes

- 1. Link to the pre-registration documents
- 2. Consent form
- 3. Attention check
- 4. ESM for Experiment 1
- 5. ESM for Experiment 2
- 6. ESM for Pilots 1 and 2
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1. Pre registrations links

We pre-registered the experiments' sample size, exclusion criterion, hypotheses, research questions, and statistical analyses, which can be consulted on the following link: https://osf.io/4ujbw/?view_only=5b6fcb3d5a384ad297755d24a1fd8f49.

2. Consent form

Each experiment started with the following consent form:

We invite you to participate in a scientific experiment. Participation requires that you give your informed consent. Before proceeding, please consider the following information:

You will be asked to answer a few questions.

The survey will take about [X] minutes to complete.

There are no risks involved in this study, but some of the items bear on topics likely to elicit disgust.

You will be paid for your participation at the posted rate (provided that you complete the whole study, including demographic questions).

Your individual privacy will be maintained in all published and written data resulting from the study.

Participation in this research study is voluntary. You may choose not to participate.

By ticking the box below, and proceeding to the study task you certify that you have read this form, and agreed to participate in accordance with the above conditions.

3. Attention check

Each experiment included an attention check, participants being excluded if they failed the check by not answering “I pay attention” at the following question:

Imagine that you are playing video games with a friend and that at some point your friend says to you: "I don't want to play this game anymore! To make sure you have read the instructions, please write the following three words "I pay attention" in the box below. I really don't like this game, it's the most overrated game of all".

Do you agree with your friend?

4. ESM for Experiment 1

Additional research questions

We pre-registered three research questions:

- RQ1: whether claimed knowledge would decrease if the question asking to declare participants’ perceived knowledge on energy source was asked at the end of the survey, in comparison with a group that was asked the question at the beginning of the survey;
- RQ2: whether claimed knowledge would correlate with actual knowledge;
- RQ3: whether real pollutants produced by solar and wind energy sources would be more associated with nuclear energy than with natural gas.

Materials specific to the research questions

Half of the participants were asked to evaluate their perceived knowledge about energy sources with the question: “In general, how knowledgeable would you say you are about energy sources?“(1[Extremely knowledgeable], 2[Very knowledgeable], 3[Knowledgeable], 4[Moderately knowledgeable], 5[Not very knowledgeable], 6[Not knowledgeable at all]). The other half was presented with the question at the end of the survey.

Results of the research questions

Participants who were asked to report their knowledgeability on energy sources at the end of the survey reported being less knowledgeable than those who answered first (ß=-1.00, CI [-1.09, -0.9], t(1285)= -20.51, p<.001).

More knowledgeable participants on energy sources reported being more knowledgeable than those who were less knowledgeable (ß=0.29, CI [0.10, 0.48], t(97) = 2.97, p=0.003).

Participants associated the real products (tritium, neodymium, and nitrogen trifluoride) more with nuclear energy than with natural gas (ß=0.81, CI [0.63, 0.99], t(394) = 8.81, p<.001).

5. ESM for Experiment 2

Additional research questions

Additionally to the main hypothesis, we measured participants' environmental concern in order to better understand the link between perceived CO2 emissions, and perceived dangers of climate change, and pre registered eight research questions, regarding the following questions:

- RQ1: whether claimed knowledge would decrease if the question asking to declare participants' perceived knowledge on energy source was asked at the end of the survey, in comparison with a group that was asked the question at the beginning of the survey.
- RQ2: whether claimed knowledge would correlate with actual knowledge.
- RQ3:, whether participants associated neodymium, nitrogen trifluoride and tritium more with nuclear than with natural gas.
- RQ4: whether the participants who expressed more concern about the environment thought that nuclear power emitted more CO2 in general and more CO2 than renewables in particular.
- RQ5: whether participants who expressed more concern about the environment thought that nuclear power is more toxic than renewables.
- RQ6: whether participants who expressed more concern about the environment thought that smoke from nuclear power plants contained more pollutants.
- RQ7: whether participants considered that nuclear power plants emitted more CO2 than natural gas.
- RQ8: whether participants considered nuclear power plants to be more dangerous to the environment than natural gas.

Additional materials specific to the research questions

We measured environmental concern with the five following statements: "I would donate a portion of my income if I was certain that the money would be used to prevent environmental pollution", "It is simply too difficult for someone like me to do much for the environment", "There are more important things to do in life than to protect the environment.", "There is no point in doing what I can for the environment if others don't do the same.", and "Many claims about environmental threats are exaggerated." (1[I strongly disagree], 2[I disagree], 3[I neither agree nor disagree], 4[I agree], 5[I fully agree]).

Results of the research questions

Participants that were asked to report their knowledgeability on energy sources at the end of the survey reported being less knowledgeable than those who answered first (ß=-0.35, CI [-0.40, -0.30], t(1222) = -13.03, p<.001).

More knowledgeable participants on energy sources reported being more knowledgeable than those being less knowledgeable (ß=0.19, CI [0.13, 0.24], t(1222) = 6.63, p<.001).

Participants associated the real products (tritium, neodymium, and nitrogen trifluoride) more with nuclear energy than with natural gas (ß=0.88, CI [0.70, 1.05], t(406) = 9.85, p<.001).

We found no significant interaction between environmental concern and (i) estimated CO2 emissions emitted by nuclear energy (ß=-0.08, CI [-0.16, 0.00], t(607) = -1,93, p=0.061) and (ii) renewable energy sources (ß=0.10, CI [-0.04, 0.24], t(201) = 1,40, p=0.164). The score of environmental concern was calculated by ponderating responses to the first five questions of the survey on environmental attitudes. This score ranged from 1 (very concerned by the environment) to -19 (not concerned at all by the environment).

We found no significant interaction between environmental concern and (i) perceived dangerosity of nuclear energy (ß=0.11, CI [-0.03, 0.24], t(201) = 1,51, p=0.132) = -1,93, p=0.061) and (ii) renewable energy (ß=-0.01, CI [-0.09, 0.07], t(607) = -0,30, p=0.766).

The more participants expressed concern about the environment, the more they were likely to think that nuclear plants emitted more pollutants through their plant stacks (ß=0.06, CI [0.01, 0.12], t(1216) = 2,27, p=0.023).

Participants considered that nuclear plants emitted less CO2 than natural gas plants (ß=-0.30, CI [-0.59, -0.02], t(406) = -2,09, p=0.038).

Finally, participants considered that nuclear plants were more dangerous to the environment than natural gas power plants (ß=0.72, CI [0.48, 0.96], t(406) = 5.96, p=<0.001).

Materials in French

Echelle d'attitude environnementale (European Value Survey)

Dans quelle mesure approuvez-vous les affirmations suivantes ?

(1) Je donnerais une partie de mes revenus si j'étais certain que l'argent serait utilisé pour prévenir la pollution de l'environnement.
(2) Il est tout simplement trop difficile pour quelqu'un comme moi de faire beaucoup pour l'environnement.
(3) Il y a des choses plus importantes à faire dans la vie que de protéger l'environnement.
(4) Il ne sert à rien de faire ce que je peux pour l'environnement si d'autres ne font pas de même.
(5) De nombreuses affirmations sur les menaces environnementales sont exagérées.

1 Je ne suis pas du tout d'accord
2 Je ne suis pas d'accord
3 Je ne suis ni d'accord ni en désaccord
4 Je suis d'accord

5 Je suis tout à fait d’accord

Questions portant sur l’énergie

Q1 / Q10 : En général, dans quelle mesure diriez-vous que vous connaissez les sources d'énergie ?
Je ne connais rien sur ce sujet, je ne connais pas grand chose sur ce sujet, je connais modérément ce sujet, je connais bien ce sujet, je connais très bien ce sujet, je connais parfaitement bien ce sujet

Q2 : Selon vous, dans quelle mesure chacune des sources d'énergie suivantes est-elle nocive pour l'environnement ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q3 : Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes émet du CO2 ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q4 : Le tritium est une substance dangereuse dont dépendent certaines sources d'énergie pour produire de l'électricité. Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes dépend du tritium ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q5 : Le trifluorure d’azote est une substance dangereuse dont dépendent certaines sources d'énergie pour produire de l'électricité. Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes dépend du trifluorure d’azote ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q6 : Le néodyme est une substance dangereuse dont dépendent certaines sources d'énergie pour produire de l'électricité. Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes dépend du néodyme ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q7 : Le tranain est une substance inoffensive dont dépendent certaines sources d'énergie pour produire de l'électricité. Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes dépend du drisonium ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie : pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q8 : Le calisnon est une substance dangereuse dont dépendent certaines sources d'énergie pour produire de l'électricité. Dans quelle mesure pensez-vous que chacune des sources d'énergie suivantes dépend du calisnon ?
Liste des sources d'énergie : nucléaire, gaz naturel, charbon, éolien, solaire, hydraulique
Réponses par source d'énergie :pas du tout, très peu, peu, modérément, beaucoup, extrêmement

Q9 : Selon vous, de quoi est faite la fumée qui s'échappe des cheminées des centrales nucléaires ? (Vous pouvez sélectionner plusieurs options)
de gaz toxique, de vapeur d'eau, de CO2, de gaz radioactif

6. ESM reporting the results of two pilot studies

Two experiments were conducted before Experiment 3, testing the same hypotheses, but with different materials. Unfortunately, both experiments proved unable to test our hypotheses, since in both cases manipulation checks were violated (i.e. the argument about CO2 emissions mostly led to an increase in the perceived CO2 emissions of renewables, instead of a decrease in the perceived CO2 emissions of nuclear energy). For transparency, we report the results here.

Pilot 1

The two arguments that participants were exposed to in this experiment relate to radiation risks and to CO2 emissions, and are in favor of nuclear energy. Participants were either presented with both arguments (Condition Radioactivity + CO2) or only the radiation argument (Condition Radioactivity).

We measured participants' opinion on nuclear energy with five questions. We controlled for the effect of reading an argument on the low level of nuclear CO2 emissions by using the scores of the participants assigned to the Condition Radioactivity as a control.

Hypothesis and research questions

Our manipulation check consisted in testing that participants who had read the argument on nuclear CO2 emissions would believe that nuclear energy emits less CO2 than those who hadn't read this argument, controlling for the prior opinions of the participants.

We hypothesized that reading the CO2 argument would cause a decrease in the belief that nuclear energy contributed to climate change and would create an improvement of the general opinion on nuclear energy, as compared to participants that didn't read the argument.

- H1: Participants in the Radioactivity + CO2 Condition will be less likely to believe that nuclear energy contributes to climate change compared to the Radioactivity Condition, controlling for participants' prior opinions.
- H2: Participants in the Radioactivity + CO2 Condition will have a better opinion of nuclear as compared to other energy sources compared to those of the Radioactivity Condition, controlling for participants' prior opinions.

Additionally, we pre-registered two research questions comparing the evolution of participants' general opinion on nuclear energy compared to renewables and fossil fuels.

Participants

Based on a pre-registered power analysis, we recruited 201 UK participants on Prolific. We removed one participant who failed the attention check, and one that didn't report his age, leaving 199 participants (121 women, M_{Age} = 35.15, *SD* = 11.86).

Materials, Design and Procedures

After completing a consent form, and an attention check, participants were asked general and specific questions on nuclear energy, were ascribed to the two subgroups defined above to read different sets of arguments, and then re-asked the same questions.

We measured general opinion on nuclear energy as compared to fossil fuels and renewables with the questions: "Do you believe that nuclear power is a good source of energy generation compared to coal, oil and gas?" and "Do you believe that nuclear power is a good source of energy generation compared to renewable sources?"(1[Strongly disagree], 2[Somewhat disagree], 3[Neither agree nor disagree], 4[Somewhat agree], 5[Strongly agree]).

We measured the specific opinion on the radioactive dangers of nuclear energy on health and on the amount of CO2 nuclear energy emitted with the questions: "Do you think that nuclear power plants emit dangerous levels of radiation that could lead to health problems?" (1[Strongly disagree], 2[Somewhat disagree], 3[Neither agree nor disagree], 4[Somewhat agree], 5[Strongly agree]) and:"How much CO2 do you think each of the following energy sources emits? " (1[None at all], 2[A little], 3[A moderate amount], 4[A lot], 5[A great deal]).

Finally, we measured the specific opinion on the contribution of different energy sources to climate change with the question: "To what extent do you consider that each of the following energy sources contributes to climate change?" (Coal, Nuclear, Natural Gas, Oil, Solar, Wind) (1[None at all], 2[A little], 3[Somewhat], 4[Very], 5[Extremely]).

To analyse the results of the two previous questions, we established a score per participant for questions on CO2 emissions and contribution to climate change per energy source.

The CO2 score was computed as follows: for coal, natural gas and oil, if CO2 emissions and contributions to climate change are strictly higher than those of nuclear energy, one point is given per energy source, if not, zero point is given; for solar and wind, if CO2 emissions and

contributions to climate change are higher or equal to those of nuclear energy, one point is given per energy source, if not zero point is given. Therefore, four scores are calculated, Climate change pre treatment, climate change post treatment, CO2 pre treatment, CO2 post treatment, ranging from zero (no correct answer is given) to five (all responses are correct).

We used as arguments the following texts :

- Argument on radiation risk

The uranium used in nuclear plants is safely enclosed in sealed containers behind multiple, robust safety barriers. No worker is ever in direct contact with radioactive substances. Radioactivity is completely unlike a viral or bacterial disease: low doses of radiation are perfectly harmless, and radiation is not contagious. Radiation exposure can occur from natural sources, such as radioactivity in rocks and soil, or cosmic radiation. Radiation arising from human activities is not different from natural radiation. Medical procedures such as X-rays account for most non-natural radiation exposure. Less than 1% of exposure is due to the generation of electricity in nuclear power plants. You get more exposure to radiation by taking a plane or getting a dental X-ray than by living next to a nuclear power plant.

- Argument on CO2 emissions

It has been established that nuclear energy produces the same amount of CO2 as renewables (such as solar, or wind), which is around 70 times less than natural gas power plants, 120 times less than fioul power plants, and 180 times less than coal power plants. CO2 is the main driver of climate change, and most efforts aimed at slowing climate change have focused on reducing our production of CO2. To study the production of CO2 by different energy sources, scientists use Life Cycle Analysis, which is the analysis of an energy source's entire life cycle in terms of sustainability. Every part of an energy source's life cycle–the materials that are required to make it, its production, its use, and how it is disposed of–is studied to ascertain its environmental impact. One of the most important impacts that is measured in a Life Cycle Analysis is the amount of CO2 being produced.

Results

Manipulation check

Validating the manipulation check, CO2 Scores of the participants from the Condition Radioactivity + CO2 were higher than those of the Condition Radioactivity,controlling for participants' prior opinions (ß=0.28, CI [0.16, 0.39], $t(196) = 4.64$, $p<0.001$), meaning that reading the argument on nuclear low CO2 emissions decreased the belief that nuclear energy emitted more CO2 than renewables and the same amount than fossil fuels.

Main hypothesis

In support of H1, participants having read the argument on CO2 emissions had higher Climate Change Scores than those who had only read the argument on Radioactivity, controlling for

participant's prior opinions (ß=0.33, CI [0.22, 0.43], t(196) = 6.14, p<0.001), meaning that reading the argument on nuclear low CO2 emissions decreased the belief that nuclear energy contributed to climate change.

In support of H2, participants having read the argument on CO2 emissions had a better opinion of nuclear energy as compared to the other energy sources than those having only read the argument on Radioactivity, controlling for participants' prior opinions (ß=0.15, CI [0.04, 0.25], t(196) = 2.79, p=0.01).

Research Questions

We found no significant effect of the CO2 + Radioactivity Condition as compared to the Radioactivity Condition on participants' opinion on nuclear energy when compared to fossil fuels, controlling for participants' prior opinions (ß=0.06, CI [-0.05, 0.17], t(196) = 1.01, p=0.313).

Participants in the CO2 + Radioactivity Condition slightly improved their opinion on nuclear as compared to renewables more than those of the Radioactivity Condition, controlling for participants' prior opinions (ß=0.19, CI [0.08, 0.30], t(196) = 3.49, p<0.001).

Exploratory Analysis

Considering the scores specifically per energy source and not the CO2 and Climate Change scores that regrouped all the energy sources, the results are different. Concerning nuclear emissions of CO2, reading both arguments on CO2 and radioactivity does not prove to have a significant effect as compared to reading only the argument on radioactivity, controlling for pretreatment responses (ß=-0.05, CI [-0.17, 0.07], t(196) = -0.87, p=0.387). Hence the manipulation check applied to the aggregated measure (the climate change score and the CO2 score) and not to the individual measures, the argument on radioactivity having a direct effect on the opinion on CO2 emissions of nuclear energy.

Regarding nuclear contribution to climate change, reading both arguments on CO2 and radioactivity has a small and significative effect as compared to reading only the argument on radioactivity, controlling for pretreatment responses (ß=-0.11, CI [-0.22, -0.01], t(196) = -2.20, p=0.029).

Moreover, reading the argument on CO2 had the effect of increasing estimated emissions of renewable energy sources (ß=0.30, CI [0.21, 0.40], t(196) = 6.20, p<0.001), and increasing the belief that they contributed to climate change (ß=0.21, CI [0.13, 0.30], t(196)= 4.89, p<0.001), in both cases controlling for pretreatment answers.

Discussion of Pilot 1

Reading the argument relative to CO2 emissions in addition to the argument about radioactivity, by contrast with only the argument about radioactivity, did not lead participants to believe that nuclear energy emitted less CO2 (but it led them to believe that renewables emitted more CO2, which is why the manipulation check misleadingly appeared to be positive). As a result, even

though the hypothesized results in terms of the general attitude regarding nuclear energy and climate change were obtained, they cannot be attributed to a correction of the specific misconception by the argument about CO2 emissions.

Pilot 2

Pilot 2 is an adaptation of Pilot 1. In comparison to Pilot 1, we introduced a third argument on the economic benefits of nuclear energy to use it as a baseline, given that the argument on radioactivity used as a baseline in Pilot 1 proved to have had an impact on the belief that nuclear energy produced CO2.

Moreover, we rephrased the content of the CO2 argument to explicitly indicate that CO2 emissions from renewable and nuclear sources are significatively lower than those of fossil fuels.

Finally, in contrast with the method used in the first pilot, we directly measured the evolution of participants' opinion without using a scoring system to analyse the responses.

Hypothesis and research questions

Our manipulation check consisted in testing the four following effects:

- MC1: Post-treatment responses for nuclear CO2 emissions are lower for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions.
- MC2 : Post-treatment responses for fossil fuels CO2 emissions are not lower for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions.
- MC3 : Post-treatment responses for renewables CO2 emissions are not higher for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions.
- MC4 : Post-treatment responses for Nuclear CO2 emissions are not significatively lower than the pre-treatment responses for participants reading only the Economy Argument.

As in Pilot 1, we hypothesized that reading the CO2 argument would cause a decrease in the belief that nuclear energy contributed to climate change and would create an amelioration of the general opinion on nuclear energy, as compared to participants that didn't read the argument. Formally, we pre-registered these hypothesis in the following wording :

- H1: Post-treatment opinions on the contribution of nuclear energy to climate change are lower for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions.
- H2: Post treatment opinions on the general use of nuclear energy as an energy source are higher for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions.

Additionally, we pre-registered the four following research questions, regarding whether participant's general opinion evolved or not as compared to renewables and fossil fuels when reading the CO2 argument, and whether reading the Radioactivity Argument along with the Economy argument was more effective than reading the CO2 Argument along with the Economy Argument.

- RQ1: whether the post-treatment opinion on the use of nuclear energy compared to renewables is higher in the CO2 experimental condition than in the control condition, controlling for baseline levels;
- RQ2: whether the post-treatment opinion on the use of nuclear energy compared to fossil fuels is higher in the CO2 experimental condition than in the control condition, controlling for baseline levels;
- RQ3: whether the CO2 condition is more effective than the Radiation condition into reducing the belief that nuclear energy contributes to climate change;
- RQ4: whether the CO2 condition is more effective than the Radiation condition in improving general opinion on nuclear energy as an energy source.

Participants

Based on a pre-registered power analysis, we recruited 303 UK participants on Prolific. We removed eight participants who failed the attention check, leaving 295 participants (202 women, M_{Age} = 39.79, *SD* = 13,99).

Materials, Design and Procedures

After completing a consent form, participants were asked for their opinion on nuclear energy. Afterwards, participants were ascribed to one of three conditions, and received different arguments concerning nuclear risks and benefits:

- a first group was only given an argument on the economic benefit of nuclear energy production (Condition Economy)
- a second group was given the same argument on the economic risks, and an argument on the limited CO2 emissions of nuclear energy production (Condition Economy+CO2)
- a third group was given the same argument on the economic risks, and an argument on the limited effect of nuclear radiation (Condition Economy+Radioactivity)

Opinions on nuclear energy were measured again, in the same wording as at the beginning.

The questions are the same as in Experiment 3, and a sixth one is added to measure the specific opinion on the economic benefits of the use of nuclear energy, with the following wording: "Do you think that the use of nuclear power has a positive impact on economic activity?" (1[Strongly disagree], 2[Somewhat disagree], 3[Neither agree nor disagree], 4[Somewhat agree], 5[Strongly agree]).

We used the same text than in the previous experiment for the argument on radiations, and used the following texts for the arguments on CO2 Emissions and on Economic benefits of nuclear energy:

- Argument on CO2 emissions

It has been established that **nuclear energy produces the same, low amount of CO2 as renewables** (such as solar power or wind power), which is around 70 times less than natural gas power plants, 120 times less than fioul power plants, and 180 times less than coal power plants. Nuclear plants and renewables thus emit a very low amount of CO2 to produce energy in comparison with other energy sources.
CO2 is the main driver of climate change, and most efforts aimed at slowing climate change have focused on reducing our production of CO2. To study the production of CO2 by different energy sources, scientists use Life Cycle Analysis, which is the analysis of an energy source's entire life cycle in terms of sustainability. Every part of an energy source's life cycle – the materials that are required to make it, its production, its use, and how it is disposed of – is studied to ascertain its environmental impact. One of the most important impacts that is measured in a Life Cycle Analysis is the amount of CO2 being produced.

- Argument on the economic benefits of nuclear energy

Nuclear power is considered one of the most economically cost-efficient ways of producing electricity: A small and inexpensive amount of uranium can fuel a plant, providing enough electricity to power a city of half a million people. The operating costs of a nuclear power plant are very low. Nuclear power plants are also economically attractive because they don't rely on fossil fuels. As a result, they are not affected by fluctuating oil and gas costs. According to the Organization for Economic Co-operation and Development, one new nuclear plant creates approximately 1000 permanent jobs, not to mention thousands of others during its construction. This is more than coal or natural gas plants. These positive effects on job creation further adds to the positive economic effects of nuclear power.

Results

Manipulation checks

Invalidating MC1, participant having read the CO2 Argument along with the Economy Argument did believe that nuclear emitted less CO2 than those reading only the Economy Argument, controlling for participant's prior opinions, but with a non statistically significant effect (ß=-0.20, CI [-0.42, 0.01], t(192) = 1.89, p=0.060).

Validating MC2, post treatment responses for fossil fuels CO2 Emissions are higher for participants reading the CO2 Argument along with the Economy Argument as compared to those reading the Economy Argument only, controlling for participant's prior opinions, meaning that reading the CO2 argument increased the perceived emissions of CO2 by fossil fuels (ß=0.16, CI [0.02, 0.31], t(192) = 2.32, p=0.022).

Invalidating MC3, post treatment responses for renewables' CO2 emissions are significantly higher for participants reading the Economy Argument along with the CO2 Argument as compared to those reading only the Economy Argument, meaning that reading the CO2 Argument has had the advert effect of increasing the perceived emissions of CO2 by renewables (ß=0.32, CI [0.18, 0.46], t (192) = 4.65, p<0.001).

Finally, invalidating MC4, post-treatment responses for nuclear CO2 emissions are significantly lower than the pre treatment responses for participants reading the Economy Argument only (t test : $M_{Post\text{-}Pre}$=-0.66, CI [-0.97, -0.32], t = -3.92, p<0.001).

Our manipulation checks being inconclusive, the results of our experiment seem to show that a general halo effect exists, and that the opinion on nuclear energy is not built through the cumulation of specific arguments. We produce here the rest of our results, for the purposes of information, and to quantify and analyse the nature of these halo effects.

Main hypothesis

In support of H1, post treatment responses on nuclear contribution to climate change for participants reading only the Economy Argument are higher than those reading also the CO2 Argument, controlling for participants' prior opinions (ß=0.32, CI [0.12, 0.51], t(192)= 3.17, p<0.001).

Related to H2, we found no significant effect of the CO2 + Economy Condition as compared to the Economy Condition on participants' opinion on nuclear CO2 emissions (ß=-0.17, CI [-0.37, 0.02], t(192) = -1.73, p=0.085).

Research Questions

We found no significant effect of the CO2 + Economy Condition as compared to the Economy Condition on participants' opinion on nuclear energy when compared to renewable energy sources, controlling for participants' prior opinions (ß=-0.18, CI [-0.44, 0.08], t(192) = -1.36, p=0.177).

We found no significant effect of the CO2 Condition on participants opinion on nuclear power compared to fossil fuels, controlling for participants' prior opinions (ß=-0.13, CI [-0.33, 0.06], t(192) = -1.37, p=0.172)

The Economy + Radioactivity Condition is not significantly less effective than the Economy + CO2 Condition in reducing the belief that nuclear energy contributes to climate change, controlling for participants' prior opinions (ß=0.03, CI [-0.18, 0.23], t(196) = 0.26, p=0.794).

Finally, the Economy + Radioactivity Condition is not significantly less effective than the Economy + CO2 Condition in improving the general opinion on nuclear energy (ß=-0.17, CI [-0.37, 0.03], t(196)= -1.65, p=0.100).

Discussion of Pilot 2

Pilot 2 faced the same issue as Pilot 1, with the argument not bearing on CO2 also having the effect of lowering the perceived CO2 emissions of nuclear energy. In both cases, this might have been caused by information present in the radioactivity argument (Pilot 1), or the economics arguments (Pilot 2) suggesting that nuclear energy had a lower footprint in other areas (for instance by mentioning that it uses very small amounts of uranium, or that it doesn't rely on fossil fuels).

7. Experiment 4

Materials in french

Questions

Pensez-vous que les centrales nucléaires émettent des niveaux dangereux de radiations qui pourraient entraîner des problèmes de santé ? Pas du tout d'accord (1), Plutôt pas d'accord 2), Ni d'accord ni pas d'accord (3), Plutôt d'accord (4), Tout à fait d'accord (5)

Pensez-vous que l'utilisation de l'énergie nucléaire soit nécessaire pour garantir l'approvisionnement en énergie ? Pas du tout d'accord (1), Plutôt pas d'accord (2), Ni d'accord ni pas d'accord (3), Plutôt d'accord (4), Tout à fait d'accord (5).

D'après vous, quelle quantité de CO2 émet chacune des sources d'énergie suivantes ? Pas du tout (1), Une très petite quantité (2), Une petite quantité (3), Une quantité moyenne (4), Une grande quantité (5), Une très grande quantité (6); sources d'énergie : Charbon, Éolien, Hydroélectricité, Gaz Naturel, Nucléaire, Pétrole, Solaire.

Dans quelle mesure considérez-vous que chacune des sources d'énergie suivantes contribue au changement climatique ? Pas du tout (1), Une très petite quantité (2), Une petite quantité (3), Une quantité moyenne (4), Une grande quantité (5), Une très grande quantité (6); sources d'énergie : Charbon, Éolien, Hydroélectricité, Gaz Naturel, Nucléaire, Pétrole, Solaire.

Argument radioactivité

La radioactivité n'a rien à voir avec une maladie virale ou bactériologique : de faibles doses de rayonnement radioactif sont parfaitement inoffensives, et ces rayonnements ne sont pas contagieux.

L'exposition aux rayonnements radioactifs peut provenir de sources naturelles, comme la radioactivité des roches et du sol, ou celle du rayonnement cosmique. La radioactivité provenant des activités humaines n'est pas différente de la radioactivité naturelle.

Moins de 1 % de l'exposition à la radioactivité est due à la production d'électricité dans les centrales nucléaires. Vous êtes davantage exposé aux rayonnements radioactifs en prenant l'avion ou en passant une radiographie dentaire qu'en vivant à proximité d'une centrale nucléaire.

Argument approvisionnement énergétique

Nous devons construire de nouvelles centrales nucléaires car même si nous développons autant que possible l'énergie éolienne, solaire, la biomasse et l'énergie hydraulique existante, il ne sera pas possible de fournir toute l'électricité dont nous avons besoin, surtout avec l'utilisation croissante des nouvelles technologies et des véhicules électriques.

Lorsqu'il n'y a pas de vent ou de soleil, les centrales nucléaires sont capables de prendre le relais de la production d'électricité.

L'énergie nucléaire est également source d'activité économique. Selon l'Organisation de Coopération et de Développement Économique, une nouvelle centrale nucléaire crée environ 1000 emplois permanents, sans compter les milliers d'autres pendant sa construction.

Argument CO2

Les émissions de CO2 sont le principal moteur du changement climatique, et la plupart des efforts visant à ralentir le changement climatique ont porté sur la réduction de notre production de CO2.

Il a été établi que l'énergie nucléaire produit la même faible quantité de CO2 que les énergies renouvelables (telles que l'énergie solaire ou éolienne), soit environ 70 fois moins que les centrales au gaz naturel, 120 fois moins que les centrales au fioul et 180 fois moins que les centrales au charbon.

Les centrales nucléaires et les énergies renouvelables émettent donc une très faible quantité de CO2 pour produire de l'énergie par rapport aux autres sources d'énergie.