

Article

# Values Influence Public Acceptability of Geoengineering Technologies Via Self-Identities

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**Abstract:** Values are important antecedents of how people view themselves, known as self-identities. Self-identities differ in their content and the importance that people attach to them. In turn, important self-identities promote attitudes that are compatible with a sense of who one is. This paper builds on existing work that highlights that self-identities explained the relationship between values and environmental judgments. This study incorporates a broader range of values (i.e., conservatism, openness to change, self-transcendence, self-enhancement) and self-identities (i.e., environmental, economic, political) and tests how they are related to acceptability of four geoengineering technologies. Whilst support was found for the overall model, the results also show that technology acceptability is context dependent. That is, which specific values and self-identities explain acceptability judgements depends on the specific technology that is evaluated. In general, an environmental self-identity related more to geothermal energy, an economic self-identity was most relevant to geotechnical engineering, and a political self-identity to nuclear power. Each self-identity seemed relevant to mining. This research contributes to the literature by applying this framework to acceptability of geoengineering technologies and discusses practical implications.

**Keywords:** values; self-identities; geosciences; acceptability; energy

## 1. Introduction

The 7th United Nations' Sustainable Development Goal focuses on clean energy and aims to ensure access to affordable, reliable, sustainable, and modern energy for all [1]. In this regard, supporting sustainable development is important to increase the use of renewable energies, to tackle environmental issues such as climate change, and also to maintain communities. Important means to achieve these goals are investments in new and the development of existing technologies that largely depend on geoengineering. However, lack of social acceptability of such technologies is often a barrier to the development of new projects and energy infrastructure and hinders countries and industries meeting internationally binding renewable energy targets [2]. As such, understanding the public's acceptability of different energy technologies is critical for two reasons [3–9]. Firstly, there is a keen interest among geoscientists and industries to understand the public's acceptability of different geological technologies to facilitate their development [10,11]. Secondly, the Psychology of Sustainability and Sustainable Development takes the standpoint that sustainability also includes an improvement of quality of life and well-being [12]. Understanding to what extent and under which conditions individuals are willing to accept and adopt different technologies is an important starting point to enhance quality of life [13] and aligns with a more user-centred approach when developing or introducing new technologies [14].

Public opinion about how acceptable specific technologies on geological activities are varies considerably, usually ranging from relatively positive to strongly negative. Yet, for many technologies, the reasons underlying these public perceptions and acceptability are poorly defined and

underinvestigated [10,13]. Hence, the aim of this paper is to understand what underlies the public acceptability of different technologies that are, arguably, needed for a sustainable development of the energy grid. The aim of this paper is to examine whether a general theoretical framework, based on values and self-identities, can explain the acceptability of very different technologies that are debated in the area of clean energy. Before the theoretical framework (Section 1.2) and aims of this research (Section 1.4) are elaborated upon, the four technologies this study focuses on are explained.

### 1.1. Geoengineering Technologies

For the purpose of this paper, the public's acceptability of four geoengineering technologies that are assumed to contribute to a sustainable energy system is investigated. These technologies potentially vary in acceptability levels or, in some cases, are heavily debated [15]. Two types of energy sources that are contested as possible options to contribute to the aim of sustainable and clean energy include geothermal energy [16] and nuclear power [17,18]. To date, research on the public's attitudes toward geothermal energy is rather scarce, given that it is an emerging technology in some countries and not widely discussed or understood by the public [2,10,16]. Of research that has been conducted, Beninghaus and Bleicher [19] found that geothermal energy is viewed by some local communities in Germany as an emerging technology that still requires further development or view it in terms of its possible environmental impact (i.e., help in national and regional renewable energy transition, relatively low CO<sub>2</sub> emissions). Specifically, their participants noted the positive contribution of geothermal energy to the supply of renewable energy and its benefits for regional development, energy security, and the environment. Other arguments, however, concerned potential damage to buildings due to uplift, subsidence or seismic events, groundwater pollution caused by radioactive elements, costs of construction, and insurance [2]. Likewise, the media image of geothermal energy varies from interpreting it as a risky technology to an innovative, progressive, and renewable energy technology [20], indicating ongoing social and political debate regarding geothermal energy.

For nuclear power, previous research found that the public is often sceptical about the viability and relevance of nuclear fusion technology due to the distant timescales they perceive for when it will eventually become operational [18]. Further, nuclear power's risks are seen more negatively than those from other energy sources [21]. Indeed, the term 'nuclear' is often linked to well-known environmental catastrophes (Chernobyl, Fukushima; [18]) and can be strongly linked with perceived risks that, in turn, lower nuclear power acceptability.

In addition, two other technological processes that typically provide important preconditions for clean energy are investigated; firstly, the mining of raw materials, which is crucial in the sense that it provides indispensable materials for the production of renewable energy and new resource streams [8,22]. An illustration is the need for lithium to produce batteries or the need for various metals (e.g., copper, silicon, and zinc) for photovoltaic cells. In this regard, substantial amounts of raw materials will be required to build new, low-carbon energy devices and infrastructure (for building wind turbines, solar cells, etc., [8,23]). There are many examples in practice, however, where mining may lead to strong public resistance [24]. For instance, although mining may have economic and communal benefits, the environmental impacts of mining for natural resources used in energy production remain a significant concern among environmental and community groups [25–29].

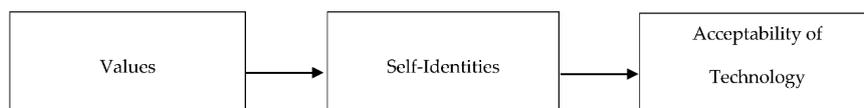
Geotechnical engineering is also included, which provides the basis for many infrastructural projects, such as the foundations for wind turbines, underground power lines, or underground structures in public transport. Research shows that the public generally recognises that geotechnical engineering can improve infrastructure and be economically beneficial [10]. However, the aesthetics and acoustics of certain infrastructure can also impede social acceptability [30].

In sum, the focus of this study lies on the public acceptability of four technological developments that heavily rely on geological processes: geothermal energy, nuclear power, mining, and geotechnical engineering. The vast majority of literature on public acceptability in the area of clean energy focuses on the acceptability of renewable energy sources, primarily solar and wind energy [15,31], and the public's

acceptability of other technologies is under-researched. The aim of this paper is to examine whether a general theoretical framework can explain the acceptability of these very different technologies in the area of sustainable energy.

## 1.2. Theoretical Framework

The theoretical framework that is adapted in this research is based on previous work that investigated the link between values, self-identities (i.e., labels that people use to describe themselves; [32,33]), and environmental judgments in a model developed by Van der Werff, Steg, and Keizer [34,35]. This research specifically focuses on their suggestion that there is an indirect relationship, at least in part, between values and acceptability of different technologies through self-identities. Van der Werff et al.'s research showed that a general environmental self-identity is related to a range of environmental judgements and intentions (e.g., energy conservation, using smart-energy systems), as well as certain types of values (e.g., biospheric), suggesting that their model is also applicable to the acceptability of geoengineering technologies [34–36]. The current research builds on this work in two ways. Firstly, Van der Werff et al.'s original mediation model is expanded by investigating different values and identities within their model (Figure 1). Specifically, a broader range of values and self-identities are included to investigate how different values (conservative values, openness-to-change values, self-transcendence values, self-enhancement values) are associated with specific self-identities (environmental, economic, political) that, in turn, relate to the overall acceptability of the four geoengineering technologies. Secondly, the aim is to test whether Van der Werff et al.'s theoretical model (i.e., values relate to attitudes via self-identities) can be replicated in another domain (acceptability of geoengineering technologies).



**Figure 1.** The relationship between values, self-identities, and acceptability of technologies in the theoretical model.

### 1.2.1. Values

Values are beliefs and refer to desirable, trans-situational goals [37,38]. Values serve as guiding principles in people's lives and in the evaluation of different behaviours and activities [39,40]. This is because values reflect what people find important in life and ideals worth striving for [33]. Values are among the most important motivational factors influencing energy behaviours [41]. For instance, people are more likely to accept energy policies and changes in energy systems when these policies and changes align with and support their important values [13]. In this regard, values can be important antecedents of people's attitudes towards geoengineering technologies [36,42–47].

The values that were investigated in this research are based on Schwartz's [39] Theory of Basic Values. In this model, four categories of values are distinguished across a bipolar, two-dimensional structure: (i) openness to change versus conservatism, and (ii) self-transcendence versus self-enhancement. Openness to change refers to independence of thought, action, and feelings, readiness for change, and openness to new ideas and experiences. These are in contrast to conservative values that emphasise order, preservation of the past, and resistance to change [39,48]. The second dimension contrasts self-transcendence versus self-enhancement values. This dimension contrasts values that emphasise concern for the welfare and interests of nature and society (self-transcendence) with those that emphasise pursuit of one's own interests, success, and dominance (self-enhancement).

However, values often do not have strong *direct* relationships with attitudes or behaviours [49–51]. Instead, there seems to be an indirect relationship between values and attitudes through other factors [52,53]. Accordingly, the processes through which values relate to attitudes have been the subject of recent research [43]. Indeed, studies by Van der Werff et al. [34,54] suggest that people's

self-identities are important mediators of the relationship between people's values and acceptability judgments of geoengineering technologies.

### 1.2.2. Values and Self-Identities

Values are an important component of people's self-concept [55], reflecting how people view themselves [56–58] and the type of person they aspire to be (i.e., their ideal self; [34,54]). Accordingly, values influence people's self-identities and the attitudes and behaviours that fulfil those identities. Gecas notes that values do not directly relate to judgments and behaviours but rather through people's self-identities. In turn, values are enacted and articulated through the intermediary role of self-identities.

People's self-identities differ in their content and the importance that people attach to different self-identities [59]. People are most committed to self-identities that best enable people to express their values [60]. In turn, people's motives and behaviours are related to the importance that they place on certain self-identities and values [61]. For example, people who care strongly for the environment are more likely to see themselves as the type of person who acts environmentally friendly and behave consistently with those beliefs [34,62]. Regarding geoengineering technologies, Mason et al. [27] found that the salience of specific identities (e.g., environmental) differentially affected people's attitudes towards the mining industry in Australia; people for whom the environment was important wanted to minimise the destructive, environmental impacts of mining [63]. This is because identities prescribe beliefs and actions that are compatible with those identities [35,56,64]. Likewise, regarding nuclear power, people with self-enhancement values tend to acknowledge the benefits of it such as affordability of energy [65] and energy security [17]. Yet, people with self-transcendence values tend to view nuclear power as an environmentally harmful and risky technology due to the possibility of accidents, health risks, and environmental threats [4,18,42,66].

### 1.2.3. Values, Self-Identities, and Acceptability

Interestingly, Van der Werff et al. [34,35] found that people's biospheric values (a component of self-transcendence values) predicted pro-environmental judgments, preferences, intentions, and behaviours via having an environmental self-identity using both correlational and experimental designs [67]. In their research, people's biospheric values were associated with having a stronger environmental self-identity that in turn related to higher intentions to reduce general energy use, increase use of green and renewable energy sources, as well as other pro-environmental behaviours (e.g., driving in a fuel-efficient way, reducing meat consumption). This pattern was replicated using a longitudinal design in which biospheric values led to a stronger environmental self-identity that in turn predicted choosing sustainably produced, but more expensive products, as well as judging environmentally unfriendly behaviours more harshly (i.e., turning up the heating instead of putting on a sweater; [68]). In conjunction, Van der Werff and Steg [69] later showed how biospheric values predicted people's personal norms to use smart energy systems via their environmental self-identity.

Values are difficult to change [37] and thereby form a stable basis of people's self-identities [34,35,54]. Therefore, the stronger people's values are, the more they see themselves as having certain self-identities, which in turn motivate people to act in line with those self-identities [61]. As a result, Van der Werff et al. argue that values relate to judgements and behaviour indirectly via self-identities and that values need to be linked to the self to be influential on people's attitudes and behaviours [54].

### 1.3. Environmental, Economic, and Political Self-Identities

People have multiple identities [70,71]. As such, a range of identities may be relevant for people's acceptability of geoengineering technologies [27,72]. In this research, three self-identities are included: environmental, economic, and political self-identity.

Environmental self-identity refers to whether people see themselves as a person who acts environmentally friendly and whether people weigh environmental considerations when

contemplating environmental issues [61,64]. Several studies suggested that an environmental self-identity is an important antecedent of pro-environmental attitudes and behaviours [36,56,63,71]. Regarding values, people with self-transcendence values (specifically biospheric values) generally have more pro-environmental attitudes [73] and emphasise people's concern with nature and the environment for their own sake [74], indicating those values' relationship to an environmental self-identity [34,35].

Economic self-identity is defined as whether people see themselves as someone who thinks in the interest of the economy and whether people consider economic issues (e.g., costs and benefits) when forming opinions on different projects. Geoengineering technologies have been recognised as significant contributors to the economy by creating employment, training opportunities, and raising tax revenues [75]. Collectively, these practices contribute to future prosperity, particularly in regions where those activities already take place or that are otherwise impoverished [27,28,47,76,77]. In this regard, self-enhancement values influence the chronic accessibility of gain goals and make a person focus on safeguarding or increasing their resources [50,74,78–80]. Therefore, self-enhancement values, guided by hedonic and gain goals, are likely positively correlated with an economic self-identity, given that people with these values are often guided by how projects can be beneficial for their own resources, interests, or status [79,81].

Finally, political self-identity, defined as an adoption of an ideological signature as a form of self-description [82–84], is strongly related to acceptability judgments [85–89]. People with liberal worldviews, for example, are more likely to oppose nuclear power [90] or believe in climate change [91] than those who are politically conservative. Previous research also showed that the four value types investigated in this research can predict a liberal versus conservative political orientation [48,92]. Specifically, conservative and self-enhancement values are related to a right-leaning political orientation, whereas openness-to-change and self-transcendence values are associated with a liberal identity. In line with the chosen theoretical framework [34,35], it was predicted that people's political self-identities would also mediate the relationship between people's values and acceptability judgments of geoengineering technologies.

#### 1.4. Aims of This Paper

The aim of this paper is to examine whether the mediating role of self-identity in the relationship between values and acceptability (Figure 1), proposed by Van der Werff et al. [34,35], is applicable to a broader context. This indirect association for geothermal energy, nuclear power, mining, and geotechnical engineering acceptability was tested since each technology may be relevant in the context of clean energy. Further, this model was expanded by including more value dimensions (conservatism, openness to change, self-transcendence, self-enhancement) and self-identities (environmental, economic, political). It was generally expected that self-identities mediate the relationship between values and public acceptability for each of the four technologies. Specifically, the following links between values and self-identities were expected based on previous literature:

1. Conservative values are associated with a stronger economic identity, a more conservative political identity, but a weaker environmental self-identity [47,72,85–87,89].
2. Openness-to-change values are associated with stronger environmental and economic identities, as well as a liberal political identity [39,74,93].
3. Likewise, self-transcendence values are related to stronger environmental and economic self-identities and also a liberal political identity [4,17,42,94].
4. Self-enhancement values are associated with a stronger economic self-identity and a conservative political identity, but with a weaker environmental self-identity [17,79,81].

Given the diverse relationships that may be expected with acceptability of geotechnical engineering technologies [17,19,27,30], specific hypotheses as to which values and self-identities

are relevant for geothermal energy, nuclear power, mining, and geotechnical engineering are not listed here. These indirect relationships will be explored in detail in Sections 3 and 4, Results and Discussion, respectively.

## 2. Method

### 2.1. Participants and Design

Five hundred and twenty-five participants were recruited using a market research company. The sample size was determined based on a review of similar studies [17,34,35,68,69,71]. All participants were resident in the Republic of Ireland. Eight participants were excluded for failing an attention check. Twelve other cases were excluded as they had duplicate IP addresses. As a further quality control check, participants who completed the study in less than one third of the median study duration during the soft launch (when the first fifty participants recruited) were excluded from the overall sample. This left a usable sample of 505 participants ( $M_{age} = 45.94$ ,  $SD = 12.87$ , age range = 18–69) (Considering the age range of the participants, the relationships between age and the key constructs were investigated in this study for exploratory purposes. Age correlated significantly and negatively with openness to change,  $r(503) = -0.23$ ,  $p < 0.001$ , and with self-enhancement,  $r(503) = -0.30$ ,  $p < 0.001$ , such that the older participants were less likely to have openness-to-change or self-enhancement values. There were also small, significant, positive correlations between age and having an environmental self-identity,  $r(503) = 0.09$ ,  $p = 0.04$ , age and having an economic self-identity,  $r(503) = 0.18$ ,  $p < 0.001$ , and age and having a right-leaning political orientation,  $r(503) = 0.14$ ,  $p = 0.002$ . Using Hayes's ([95], Model 6) PROCESS macro, a significant serial indirect relationship between age and less acceptability of geothermal energy via low openness to change and a low environmental self-identity was found,  $a_1db_2 = -0.01$ ,  $SE = 0.004$ , 95% CI [-0.01, -0.0002]  $1-\beta = 0.54$ , Direct Effect:  $B = -0.01$ ,  $SE = 0.05$ ,  $p = 0.80$ ); 230 women, 275 men). Four hundred and twenty-nine participants were Irish (85%) and the remaining 76 constituted other nationalities. Four hundred and twenty-six participants were White Irish (84.4%). The remaining 79 constituted other races. Of those participants who reported their gross annual income ( $n = 436$ ), the mode was between €30,000 and €39,999 per annum ( $n = 74$ , 14.7%). Five hundred and two participants reported the highest level of education that they had completed. The mode was an ordinary degree/diploma ( $n = 114$ , 22.6%). As remuneration, participants received points for gift vouchers through the panel company. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the institution's research ethics office.

### 2.2. Materials and Procedure

Participants were e-mailed the survey link by the panel company. Participants then gave their informed consent and reported demographics. Next, two scales were presented in a random order. One was the revised version of the portrait values questionnaire [96,97]. This instrument measures people's motivational types of values, as defined by Schwartz [39]: openness to change (e.g., "She/He looks for adventures and likes to take risks. She/He wants to have an exciting life"; 1 = *not like me at all*, 6 = *very much like me*;  $M = 3.93$ ,  $SD = 0.78$ ;  $\alpha = 0.73$ ), conservatism (e.g., "It is important to her/him to live in secure surroundings. She/He avoids doing anything that might endanger her/his safety";  $M = 3.76$ ,  $SD = 0.83$ ;  $\alpha = 0.69$ ), self-transcendence (e.g., "She/He strongly believes that people should care for nature. Looking after the environment is important to her/him";  $M = 4.82$ ,  $SD = 0.70$ ;  $\alpha = 0.71$ ), and self-enhancement (e.g., "It is important to her/him to be rich. She/He wants to have a lot of money and expensive things";  $M = 3.29$ ,  $SD = 0.91$ ;  $\alpha = 0.80$ ). (It is acknowledged that the conservatism scale had a level of internal reliability below the recommended value of  $\alpha = 0.70$  [98]. It should be noted that this scale contained 6 items. In short scales, with fewer than 10 items, it is common to find measures of internal reliability lower than  $\alpha = 0.70$ . In these circumstances, Briggs and Cheek [99] note that the mean inter-item correlation for the items in the scale may be more appropriate to assess

internal reliability. An optimal range for the inter-item correlation is between 0.20 and 0.40. In this regard, although the conservatism scale ( $\alpha = 0.69$ ) had a Cronbach's alpha level below 0.70, the mean inter-item correlation was 0.27, within the optimal range.)

Participants were presented with twenty-one sentences describing different people. For each item, participants were asked to indicate how much each person was like them. Two versions of this scale were programmed, depending on whether participants reported if they were male or female. The pronouns in each of the items were adjusted accordingly. The Schwartz [38] values framework has been used in previous environmental and resource management research as a predictor of attitudes towards the extractive industries and pro-environmental behaviours [43,48]. The revised version of the portrait values questionnaire was developed for use with national samples in large surveys, has considerable predictive validity [96,100], and demonstrates meaning equivalence across cultures [97,101].

The second scale measured self-identities. This scale consisted of three items and was adapted from Van der Werff et al. [34,35,68]. The items were worded as statements (e.g., "I see myself as a person concerned with \_\_\_\_\_"; 1 = *totally disagree*, 7 = *totally agree*). The self-identities measured using this scale were an environmental ( $M = 5.82$ ,  $SD = 1.01$ ;  $\alpha = 0.92$ ) and an economic self-identity ( $M = 5.28$ ,  $SD = 1.05$ ;  $\alpha = 0.88$ ). Participants were asked to complete these items for both identities. Similar scales have been used previously to focus on self-identities related to specific and general environmental judgments, intentions, and behaviours (related to saving energy, buying sustainably produced goods, environmental activism; [62,68]).

Afterwards, participants completed Van Tilburg and Igou's [102] political self-identity measure. This scale consists of two items (e.g., "On the political spectrum, I would consider myself to be ... "; 1 = *liberal*, 7 = *conservative*; "On the political spectrum, I would consider myself to be ... "; 1 = *left-winged*, 7 = *right-winged*;  $M = 3.46$ ,  $SD = 1.28$ ;  $\alpha = 0.78$ ). The scale was validated on Irish samples previously [99]. In the self-identities scale, an attention check item was embedded for quality control (e.g., "It's important that you pay attention to this study. Please select 'Strongly Disagree'; 1 = *strongly disagree*, 7 = *strongly agree*). Again, 8 participants answered this item incorrectly and were excluded from analysis.

The final four items measured participants' acceptability of the geoengineering technologies: geothermal energy, nuclear power, mining, and geotechnical engineering. Prior to completing the items, participants were presented with an image relevant to the technology in question and provided with a short explanation of it (Appendix A). Participants were then asked how acceptable each of the technologies were to them (e.g., "Overall, considering its risks and benefits, how acceptable do you think nuclear power is?"; 1 = *not at all*, 7 = *very much*; [28,29]). (Five outliers were detected among scores for self-transcendence values,  $S-W = 0.97$ ,  $df = 505$ ,  $p < 0.001$ . Scores for the construct were transformed using the inverse ( $S-W = 0.91$ ,  $df = 505$ ,  $p < 0.001$ ) and square root formulas ( $S-W = 0.95$ ,  $df = 505$ ,  $p < 0.001$ ), reducing the number of outliers to 0. Nine outliers were detected among scores for environmental self-identity,  $S-W = 0.89$ ,  $df = 505$ ,  $p < 0.001$ . Transforming the construct using the inverse ( $S-W = 0.88$ ,  $df = 505$ ,  $p < 0.001$ ) and square root formulas ( $S-W = 0.92$ ,  $df = 505$ ,  $p < 0.001$ ) reduced the number of outliers to 0. Nine outliers were also detected among scores for economic self-identity,  $S-W = 0.94$ ,  $df = 505$ ,  $p < 0.001$ . The number of outliers was reduced to 0 after transforming the construct using the inverse ( $S-W = 0.85$ ,  $df = 505$ ,  $p < 0.001$ ) and logarithmic formulas ( $S-W = 0.97$ ,  $df = 505$ ,  $p < 0.001$ ). The items measuring acceptability of geothermal energy ( $S-W = 0.85$ ,  $df = 505$ ,  $p < 0.001$ ) and geotechnical engineering ( $S-W = 0.86$ ,  $df = 505$ ,  $p < 0.001$ ) were significantly negatively skewed. One and 10 outliers were detected among scores for these constructs, respectively. Scores for acceptability of geothermal energy were transformed using the inverse ( $S-W = 0.79$ ,  $df = 505$ ,  $p < 0.001$ ) and square root formulas ( $S-W = 0.83$ ,  $df = 505$ ,  $p < 0.001$ ) that reduced the number of outliers to 0. Similarly, scores for acceptability of geotechnical engineering were transformed using the inverse ( $S-W = 0.79$ ,  $df = 505$ ,  $p < 0.001$ ) and ARTAN ( $S-W = 0.84$ ,  $df = 505$ ,  $p < 0.001$ ) formulas, reducing the number of outliers to 4. The raw scores were used for the remaining constructs. These scores were either not significantly different from normality, the distribution of scores differed significantly from

normality when transformed, or the number of outliers (if any) in the constructs did not decrease when transformed. All scores were converted to z-scores for all analyses. A one-way repeated-measures ANOVA was conducted on the raw scores of acceptability of the different geoenvironmental technologies. A significant effect of the different technologies on acceptability was found, Wilk's Lambda = 0.49,  $F(3,502) = 172.71$ ,  $p < 0.001$ ,  $\eta^2 = 0.51$ . Pairwise comparisons using the Bonferroni adjustment test showed that acceptability of geothermal energy ( $M = 5.77$ ,  $SE = 1.19$ ) was significantly higher than acceptability of mining ( $M = 4.49$ ,  $SE = 1.45$ ; mean difference = 1.29,  $SE = 0.08$ ,  $p < 0.001$ ), geotechnical engineering ( $M = 5.55$ ,  $SE = 1.15$ ; mean difference = 0.22,  $SE = 0.06$ ,  $p = 0.002$ ), and nuclear power ( $M = 3.82$ ,  $SE = 1.96$ ; mean difference = 1.94,  $SE = 0.10$ ,  $p < 0.001$ ). Similarly, acceptability of mining differed significantly from acceptability of geotechnical engineering such that mining was rated as less acceptable (mean difference = 1.07,  $SE = 0.07$ ,  $p < 0.001$ ). Yet, mining was rated as significantly more acceptable than nuclear power (mean difference = 0.67,  $SE = 0.09$ ,  $p < 0.001$ ). There was also a significant difference between acceptability of geotechnical engineering and nuclear power such that geotechnical engineering was rated as more acceptable (mean difference = 1.74,  $SE = 0.09$ ,  $p < 0.001$ .) Note that the acceptability items were single-item measures. Thus, no measures of internal reliability were computed. The four activities were presented to participants in a randomised order. Afterwards, participants were debriefed, thanked, and rewarded. Descriptive statistics are reported in Table 1.

**Table 1.** Descriptive Statistics.

Descriptive Statistics	N	M	SD	Max	Min	$\alpha$
Variables						
Openness to Change	505	3.93	0.78	6.00	1.83	0.73
Conservatism	505	3.76	0.83	5.83	1.33	0.69
Self-Transcendence	505	4.82	0.70	6.00	2.40	0.71
Self-Enhancement	505	3.29	0.91	6.00	1.00	0.80
Environmental Self-Identity	505	5.82	1.01	7.00	1.00	0.92
Economic Self-Identity	505	5.28	1.05	7.00	1.00	0.88
Political Self-Identity	505	3.46	1.28	7.00	1.00	0.78
Geothermal Acceptability	505	5.77	1.19	7.00	1.00	-
Nuclear Acceptability	505	3.82	1.96	7.00	1.00	-
Mining Acceptability	505	4.49	1.45	7.00	1.00	-
Geotechnical Acceptability	505	5.55	1.15	7.00	1.00	-

Note. N = Sample Size, M = Mean, SD = Standard Deviation, Max = Maximum Score, Min = Minimum Score,  $\alpha$  = Cronbach's alpha coefficient.

### 3. Results

#### 3.1. Zero-Order Correlations

Data were analysed using IBM SPSS Statistics Version 25. In the analyses, scores were standardised for each variable. First, the zero-order correlations between the different value types and self-identities were examined (Table 2). As expected, conservative values correlated positively and significantly with having an economic self-identity,  $r(503) = 0.33$ ,  $p < 0.001$ , and a right-leaning political self-identity,  $r(503) = 0.39$ ,  $p < 0.001$ . In contrast to what was expected, there was no significant correlation between conservatism and having an environmental self-identity,  $r(503) = 0.07$ ,  $p = 0.12$ . As expected, openness to change was associated with having an environmental self-identity,  $r(503) = 0.26$ ,  $p < 0.001$ , as well as an economic self-identity,  $r(503) = 0.19$ ,  $p < 0.001$ , and a left-leaning political self-identity,  $r(503) = -0.11$ ,  $p = 0.01$ . Self-transcendence values also correlated positively and significantly with having an environmental self-identity,  $r(503) = 0.52$ ,  $p < 0.001$ , an economic self-identity,  $r(503) = 0.22$ ,  $p < 0.001$ , and a left-leaning political self-identity,  $r(503) = -0.20$ ,  $p < 0.001$ . Finally, self-enhancement values correlated positively and significantly with having an economic self-identity,  $r(503) = 0.16$ ,  $p < 0.001$ . However, contrary to expectations, self-enhancement values were not significantly correlated with having an environmental self-identity,  $r(503) = -0.004$ ,  $p = 0.93$ , or a particular political self-identity,  $r(503) = 0.06$ ,  $p = 0.19$ .

Table 2. Zero-Order Correlation Matrix.

	Open	Conser	Self-Trans	Self-Enhance	Env	Econ	Pol	GthA	NucA	MinA	GtechA
Open	-	0.11 *	0.36 **	0.69 **	0.26 **	0.19 **	-0.11 *	0.12 **	0.05	0.01	0.09 *
Conser	-	-	0.17 **	0.30 **	0.07	0.33 **	0.39 **	-0.08	0.02	0.12 **	0.00
Self-Trans	-	-	-	0.09 *	0.52 **	0.22 **	-0.20 **	0.11 *	-0.09 *	-0.22 **	0.02
Self-Enhance	-	-	-	-	-0.004	0.16 **	0.06	0.04	0.09 *	0.10 *	0.06
Env	-	-	-	-	-	0.43 **	-0.13 **	0.12 **	-0.04	-0.20 **	-0.01
Econ	-	-	-	-	-	-	0.13 **	0.02	0.07	0.07	0.16 **
Pol	-	-	-	-	-	-	-	-0.03	0.10 *	0.19 **	0.02
GthA	-	-	-	-	-	-	-	-	0.06	0.05	0.33 **
NucA	-	-	-	-	-	-	-	-	-	0.26 **	0.16 **
MinA	-	-	-	-	-	-	-	-	-	-	0.22 **

Note. Open = Openness-to-Change Values; Conser = Conservative Values; Self-Trans = Self-Transcendence Values; Self-Enhance = Self Enhancement Values; Env = Environmental Self-Identity; Econ = Economic Self-Identity; Pol = Political Self-Identity; GthA = Geothermal Acceptability; NucA = Nuclear Acceptability; MinA = Mining Acceptability; GtechA = Geotechnical Engineering Acceptability. \*  $p \leq 0.05$ . \*\*  $p \leq 0.01$ .

In summary, these results showed that openness-to-change and self-transcendence values were associated with having an environmental self-identity, constituting small and large effect sizes, respectively. Conservatism, openness-to-change, self-transcendence, and self-enhancement values were each associated with having an economic self-identity, constituting a medium effect size with regards to conservatism and small effect sizes regarding the other value types. Finally, openness-to-change and self-transcendence values were associated with having a left-leaning political self-identity, whereas conservatism was associated with having a right-leaning political self-identity, constituting small and medium effect sizes, respectively [103]. These findings were largely consistent with the predictions.

### 3.2. Geothermal Energy

#### 3.2.1. Zero-Order Correlations

Next, the zero-order correlations between the value types, self-identities, and acceptability of geothermal energy were examined (Table 2). Openness-to-change,  $r(503) = 0.12$ ,  $p = 0.01$ , and self-transcendence values,  $r(503) = 0.11$ ,  $p = 0.01$ , correlated positively and significantly with acceptability of geothermal energy. That is, greater acceptability of geothermal energy was associated with having stronger openness-to-change or self-transcendence values. However, there were no significant correlations between conservative,  $r(503) = -0.08$ ,  $p = 0.07$ , or self-enhancement values,  $r(503) = 0.04$ ,  $p = 0.40$ , with geothermal acceptability.

Acceptability of geothermal energy correlated positively and significantly with having an environmental self-identity,  $r(503) = 0.12$ ,  $p = 0.01$ . However, there were no significant correlations between geothermal acceptability with an economic self-identity,  $r(503) = 0.02$ ,  $p = 0.70$ , or with a certain political self-identity,  $r(503) = -0.03$ ,  $p = 0.52$ .

#### 3.2.2. Indirect Relationships

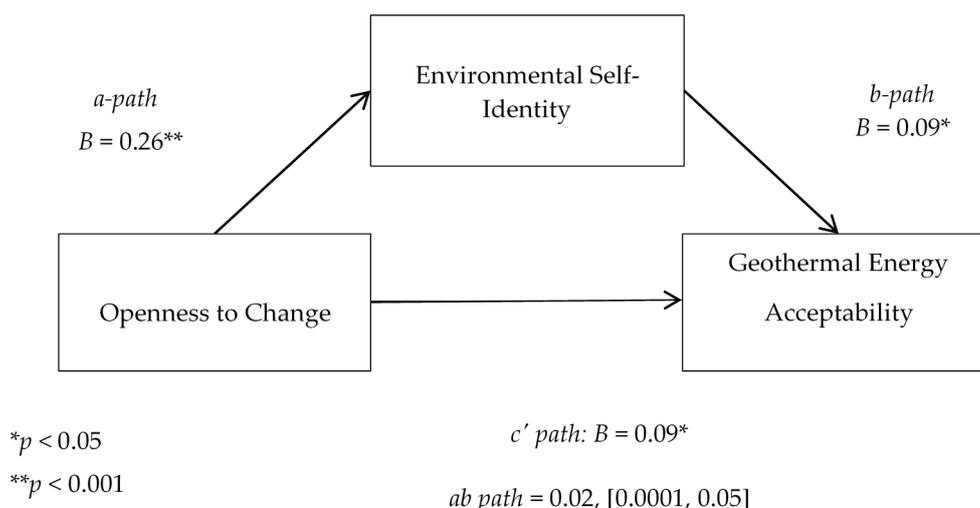
Next, it was tested whether there was a significant indirect relationship between self-transcendence values and geothermal energy acceptability via an environmental self-identity. All mediation analyses reported were conducted using Hayes's ([95], Model 4) PROCESS macro, using 10,000 bias-corrected bootstraps. For all indirect relationships reported, post hoc power analyses were conducted using an app developed by Schoemann, Boulton, and Short ([104], 10,000 replications with 20,000 Monte Carlo draws, assuming a type-I error of  $\alpha = 0.05$ , two-tailed). The indirect relationship between self-transcendence values and increased acceptability of geothermal energy via an environmental self-identity was marginally significant,  $ab = 0.04$ ,  $SE = 0.03$ , 95% CI  $[-0.01, 0.10]$ ,  $1-\beta = 0.34$ , Direct Effect:  $B = 0.07$ ,  $SE = 0.05$ ,  $p = 0.17$ .

It was also investigated if openness to change was associated with increased acceptability of geothermal energy via an environmental self-identity. A significant indirect relationship was found though this path,  $ab = 0.02$ ,  $SE = 0.01$ , 95% CI  $[0.0001, 0.05]$ ,  $1-\beta = 0.53$ , Direct Effect:  $B = 0.09$ ,  $SE = 0.05$ ,  $p = 0.05$ . That is, openness to change is associated with increased acceptability of geothermal energy, and this relationship is in part explained by people's pro-environmental self-identity. This model is outlined in Figure 2. Again, the relationship was also found substituting self-transcendence as the predictor variable, albeit with marginal significance. In Table 3, a summary of all indirect relationships tested regarding geothermal energy are presented. Figures of the other mediation models tested can be found in the Supplementary Materials (Figures S1–S11).

**Table 3.** Summary of Indirect Relationships: Geothermal Energy.

Predictors	Mediators	Path a	Path b	ab	95% CI of ab	R <sup>2</sup>
Conservatism	Environmental Self-Identity	0.07	0.12 *	0.01	[−0.003, 0.02]	2.15
<b>Openness to Change</b>	<b>Environmental Self-Identity</b>	<b>0.26 **</b>	<b>0.09 *</b>	<b>0.02</b>	<b>[0.0001, 0.05]</b>	<b>2.16</b>
Self-Transcendence	Environmental Self-Identity	0.52 **	0.08	0.04	[−0.01, 0.10]	1.75
Self-Enhancement	Environmental Self-Identity	−0.004	0.12 *	−0.001	[−0.01, 0.01]	1.52
Conservatism	Economic Self-Identity	0.33 **	0.05	0.02	[−0.02, 0.05]	0.85
Openness to Change	Economic Self-Identity	0.19 **	−0.01	−0.001	[−0.02, 0.02]	1.33
Self-Transcendence	Economic Self-Identity	0.22 **	−0.01	−0.002	[−0.02, 0.02]	1.28
Self-Enhancement	Economic Self-Identity	0.16 **	0.01	0.002	[−0.01, 0.02]	0.16
Conservatism	Political Self-Identity	0.39 **	0.002	0.001	[−0.04, 0.04]	0.64
Openness to Change	Political Self-Identity	−0.11 *	−0.02	0.002	[−0.01, 0.01]	1.36
Self-Transcendence	Political Self-Identity	−0.20 **	−0.01	0.001	[−0.02, 0.02]	1.28
Self-Enhancement	Political Self-Identity	0.06	−0.03	−0.002	[−0.01, 0.01]	0.24

Notes. Path *a* = relationship between value and self-identity; Path *b* = relationship between self-identity and geothermal energy acceptability; *ab* = indirect relationship; 95% CI of *ab* = confidence interval; *R*<sup>2</sup> = variance explained in outcome variable by predictor and mediator. \* *p* ≤ 0.05; \*\* *p* ≤ 0.001.



**Figure 2.** An outline of the relationship between openness to change and geothermal energy acceptability significantly mediated by an environmental self-identity.

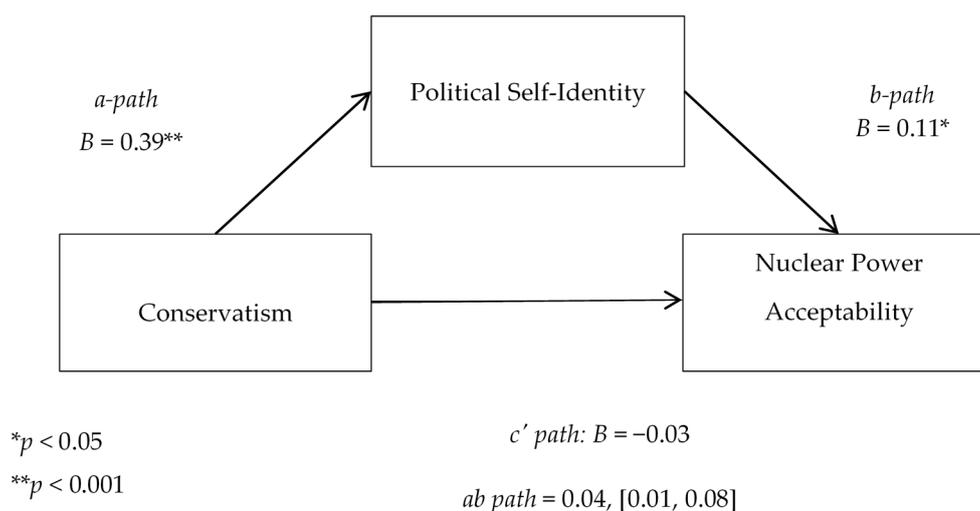
### 3.3. Nuclear Power

#### 3.3.1. Zero-Order Correlations

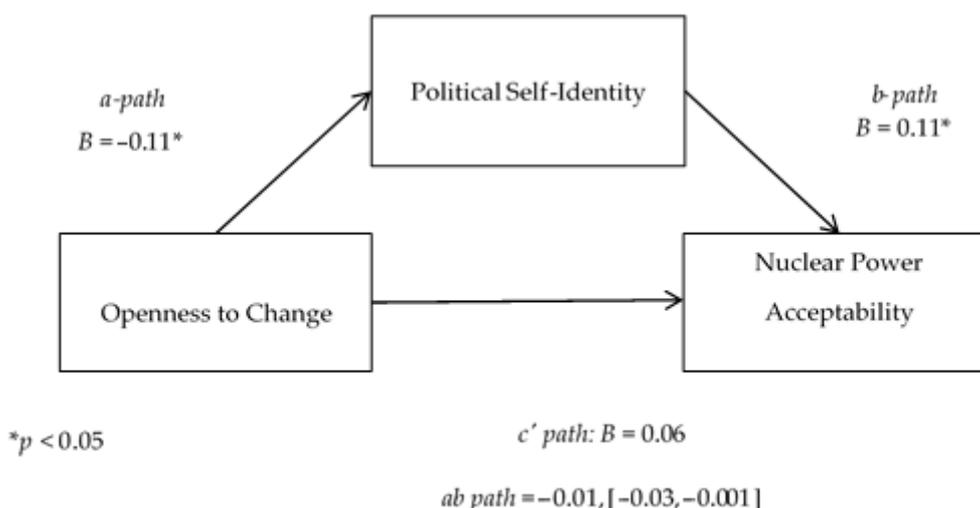
A significant, small, positive correlation was found between self-enhancement values and nuclear power acceptability,  $r(503) = 0.09, p = 0.04$ . There was also a significant, small, negative correlation between self-transcendence values and nuclear power acceptability,  $r(503) = -0.09, p = 0.05$ . The correlation between conservative values and nuclear power acceptability was not significant,  $r(503) = 0.02, p = 0.68$ , as was the correlation between openness to change and nuclear power acceptability,  $r(503) = 0.05, p = 0.30$ . Further, a right-leaning political orientation correlated positively and significantly with nuclear power acceptability,  $r(503) = 0.10, p = 0.02$ . There were no significant correlations between nuclear power acceptability with an environmental,  $r(503) = -0.04, p = 0.38$ , or economic self-identity,  $r(503) = 0.07, p = 0.11$ . In sum, these results showed that self-enhancement values and having a right-leaning political self-identity were associated with higher ratings of nuclear power acceptability, whereas self-transcendence values were associated with less.

#### 3.3.2. Indirect Relationships

A significant indirect relationship between conservative values and acceptability of nuclear power via a right-leaning political self-identity was found,  $ab = 0.04, SE = 0.02, 95\% \text{ CI } [0.01, 0.08], 1-\beta = 0.65$ , Direct Effect:  $B = -0.03, SE = 0.05, p = 0.60$  (Figure 3). That is, people with conservative values were also likely to report acceptability of nuclear power through participants' right-leaning political self-identity. Further, a significant indirect relationship between openness to change and less nuclear power acceptability via a left-leaning political identity was found,  $ab = -0.01, SE = 0.01, 95\% \text{ CI } [-0.03, -0.001], 1-\beta = 0.45$ , Direct Effect:  $B = 0.06, SE = 0.05, p = 0.19$  (Figure 4). Hence, people who are open to change are less likely to report acceptability of nuclear power through people's left-leaning political identities. A marginally significant indirect relationship between self-transcendence values and less nuclear power acceptability was also identified via a left-leaning political identity,  $ab = -0.02, SE = 0.01, 95\% \text{ CI } [-0.04, 0.001], 1-\beta = 0.50$ , Direct Effect:  $B = -0.07, SE = 0.05, p = 0.13$ . The indirect relationship between self-enhancement and nuclear power acceptability via a right-leaning political orientation, however, was not significant,  $ab = 0.01, SE = 0.01, 95\% \text{ CI } [-0.003, 0.02], 1-\beta = 0.06$ , Direct Effect:  $B = 0.08, SE = 0.04, p = 0.06$ .



**Figure 3.** An outline of the relationship between conservative values and nuclear power acceptability significantly mediated by a right-leaning political self-identity.



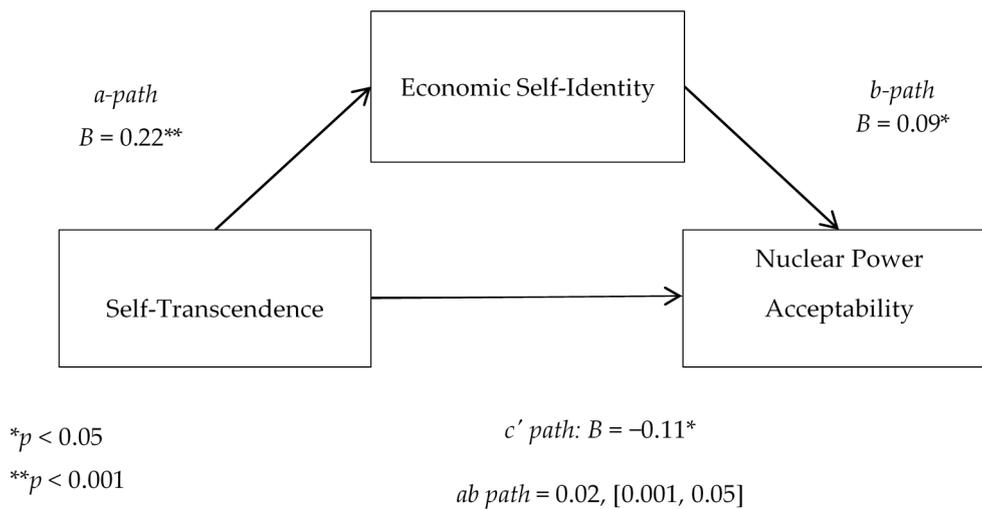
**Figure 4.** An outline of the relationship between openness to change and nuclear power acceptability significantly mediated by a left-leaning political self-identity.

Interestingly, a significant indirect relationship between self-transcendence values and nuclear power acceptability via an economic self-identity was also identified,  $ab = 0.02$ ,  $SE = 0.01$ , 95% CI [0.001, 0.05],  $1-\beta = 0.54$ , Direct Effect:  $B = -0.11$ ,  $SE = 0.05$ ,  $p = 0.02$  (Figure 5). That is, the relationship between self-transcendence values and increased acceptability of nuclear power was explained in part by participants' economic self-identity. Further, there were a number of marginally significant indirect relationships in which an economic self-identity mediated the relationship between different values and nuclear power acceptability. These included the relationship between conservatism and increased nuclear power acceptability via an economic self-identity,  $ab = 0.02$ ,  $SE = 0.02$ , 95% CI [-0.01, 0.06],  $1-\beta = 0.33$ , Direct Effect:  $B = -0.01$ ,  $SE = 0.05$ ,  $p = 0.91$ . The relationships were also marginally significant substituting openness-to-change,  $ab = 0.01$ ,  $SE = 0.01$ , 95% CI [-0.01, 0.03],  $1-\beta = 0.28$ , Direct Effect:  $B = 0.03$ ,  $SE = 0.05$ ,  $p = 0.46$ , and self-enhancement values,  $ab = 0.01$ ,  $SE = 0.01$ , 95% CI [-0.01, 0.03],  $1-\beta = 0.22$ , Direct Effect:  $B = 0.08$ ,  $SE = 0.05$ ,  $p = 0.07$ , as predictors in the models. Figures of the other mediation models tested (Figures S12–S20) can be found in the Supplementary Materials (Table 4).

**Table 4.** Summary of Indirect Relationships: Nuclear Power.

Predictors	Mediators	Path a	Path b	ab	95% CI of ab	R <sup>2</sup>
Conservatism	Environmental Self-Identity	0.07	−0.04	−0.003	[−0.01, 0.01]	0.20
Openness to Change	Environmental Self-Identity	0.26 **	−0.06	−0.01	[−0.04, 0.01]	0.49
Self-Transcendence	Environmental Self-Identity	0.52 **	0.01	0.004	[−0.05, 0.06]	0.77
Self-Enhancement	Environmental Self-Identity	−0.004	−0.04	0.0002	[−0.01, 0.01]	0.96
Conservatism	Economic Self-Identity	0.33 **	0.07	0.02	[−0.01, 0.06]	0.50
Openness to Change	Economic Self-Identity	0.19 **	0.06	0.01	[−0.01, 0.03]	0.61
<b>Self-Transcendence</b>	<b>Economic Self-Identity</b>	<b>0.22 **</b>	<b>0.09 *</b>	<b>0.02</b>	<b>[0.001, 0.05]</b>	<b>1.61</b>
Self-Enhancement	Economic Self-Identity	0.16 **	0.06	0.01	[−0.01, 0.03]	1.14
<b>Conservatism</b>	<b>Political Self-Identity</b>	<b>0.39 **</b>	<b>0.11 *</b>	<b>0.04</b>	<b>[0.01, 0.08]</b>	<b>1.13</b>
<b>Openness to Change</b>	<b>Political Self-Identity</b>	<b>−0.11 *</b>	<b>0.11 *</b>	<b>−0.01</b>	<b>[−0.03, −0.001]</b>	<b>1.41</b>
Self-Transcendence	Political Self-Identity	−0.20 **	0.09 *	−0.02	[−0.04, 0.001]	1.53
Self-Enhancement	Political Self-Identity	0.06	0.10 *	0.01	[−0.003, 0.02]	1.78

Notes. Path *a* = relationship between value and self-identity; Path *b* = relationship between self-identity and nuclear power acceptability; *ab* = indirect relationship; 95% CI = confidence interval of *ab*; R<sup>2</sup> = variance explained in outcome variable by predictor and mediator. \*  $p \leq 0.05$ ; \*\*  $p \leq 0.001$ .



**Figure 5.** An outline of the relationship between self-transcendence values and nuclear power acceptability significantly mediated by an economic self-identity.

### 3.4. Mining

#### 3.4.1. Zero-Order Correlations

Next, the zero-order correlations between the different values and self-identities with mining acceptability were examined. Significant, positive correlations were found between conservatism and mining acceptability,  $r(503) = 0.12, p = 0.01$ , and between self-enhancement values with mining acceptability,  $r(503) = 0.10, p = 0.02$ . Additionally, a significant, negative correlation between self-transcendence values and mining acceptability was found,  $r(503) = -0.22, p < 0.001$ . Collectively, these correlations constituted small effect sizes [98]. The correlation between openness to change and mining was not significant,  $r(503) = 0.01, p = 0.79$ . In sum, higher levels of conservatism and self-enhancement were related to increased acceptability of mining, whereas stronger self-transcendence values were related to less mining acceptability.

Next, a significant, positive correlation was found between a right-leaning political self-identity and mining acceptability,  $r(503) = 0.19, p < 0.001$ . Further, there was a significant, negative correlation between having an environmental self-identity and mining acceptability,  $r(503) = -0.20, p < 0.001$ . These correlations constituted small effect sizes [98]. The correlation between having an economic self-identity and mining acceptability was not significant,  $r(503) = 0.07, p = 0.10$ . In sum, greater mining acceptability related to having a right-leaning political self-identity. Yet, scoring higher on an environmental self-identity related to lower levels of mining acceptability.

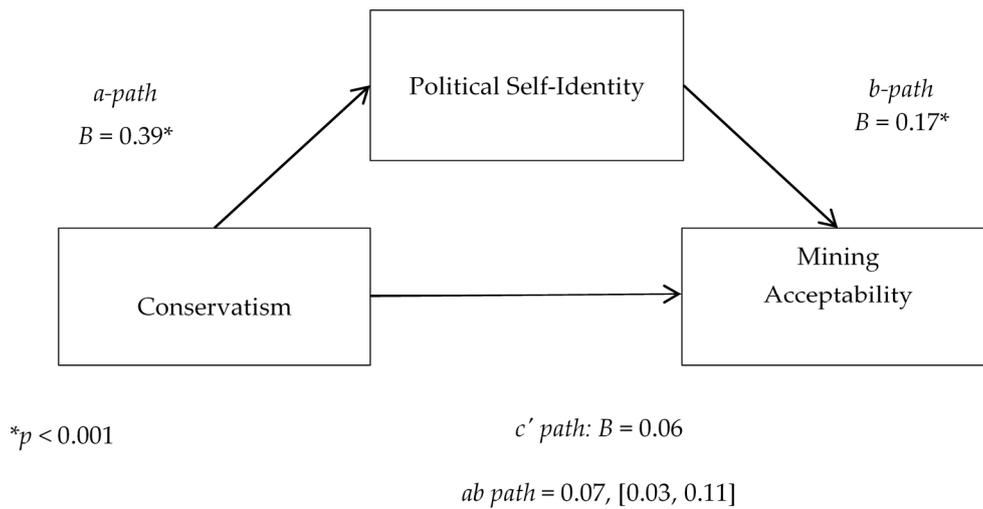
#### 3.4.2. Indirect Relationships

Next, the indirect relationships were examined (Table 5). First, a significant indirect relationship between conservative values and increased mining acceptability via a right-leaning political self-identity was found,  $ab = 0.07, SE = 0.02, 95\% \text{ CI } [0.03, 0.11], 1-\beta = 0.95$ , Direct Effect:  $B = 0.06, SE = 0.05, p = 0.25$  (Figure 6). That is, conservatism was related to higher levels of mining acceptability and this relationship was in part explained by people's right-leaning political self-identity.

**Table 5.** Summary of Indirect Relationships: Mining.

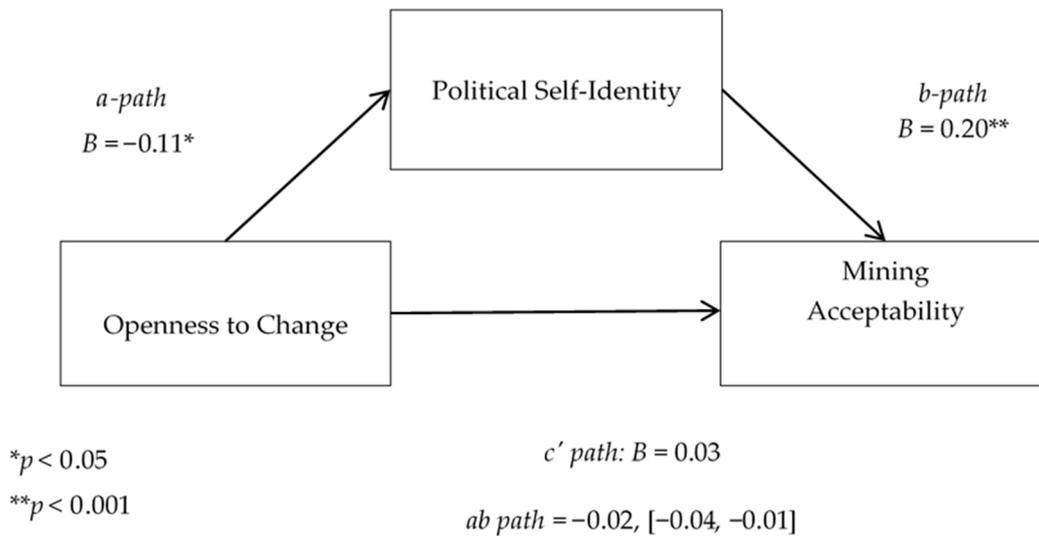
Predictors	Mediators	Path a	Path b	ab	95% CI of ab	R <sup>2</sup>
Conservatism	Environmental Self-Identity	0.07	−0.21 **	−0.01	[−0.04, 0.01]	5.80
<b>Openness to Change</b>	<b>Environmental Self-Identity</b>	<b>0.26 **</b>	<b>−0.22 **</b>	<b>−0.06</b>	<b>[−0.09, −0.03]</b>	<b>4.38</b>
<b>Self-Transcendence</b>	<b>Environmental Self-Identity</b>	<b>0.52 **</b>	<b>−0.12 *</b>	<b>−0.06</b>	<b>[−0.12, −0.01]</b>	<b>5.68</b>
Self-Enhancement	Environmental Self-Identity	−0.004	−0.20 **	0.001	[−0.02, 0.02]	5.00
Conservatism	Economic Self-Identity	0.33 **	0.04	0.01	[−0.02, 0.04]	1.61
Openness to Change	Economic Self-Identity	0.19 **	0.07	0.01	[−0.01, 0.04]	0.55
<b>Self-Transcendence</b>	<b>Economic Self-Identity</b>	<b>0.22 **</b>	<b>0.13 *</b>	<b>0.03</b>	<b>[0.01, 0.05]</b>	<b>6.18</b>
Self-Enhancement	Economic Self-Identity	0.16 **	0.06	0.01	[−0.01, 0.03]	1.39
<b>Conservatism</b>	<b>Political Self-Identity</b>	<b>0.39 **</b>	<b>0.17 **</b>	<b>0.07</b>	<b>[0.03, 0.11]</b>	<b>3.94</b>
<b>Openness to Change</b>	<b>Political Self-Identity</b>	<b>−0.11 *</b>	<b>0.20 **</b>	<b>−0.02</b>	<b>[−0.04, −0.01]</b>	<b>3.79</b>
<b>Self-Transcendence</b>	<b>Political Self-Identity</b>	<b>−0.20 **</b>	<b>0.16 **</b>	<b>−0.03</b>	<b>[−0.06, −0.01]</b>	<b>6.94</b>
Self-Enhancement	Political Self-Identity	0.06	0.19 **	0.01	[−0.01, 0.03]	4.52

Notes. Path *a* = relationship between value and self-identity; Path *b* = relationship between self-identity and mining acceptability; *ab* = indirect relationship; 95% CI = confidence interval of *ab*; R<sup>2</sup> = variance explained in outcome variable by predictor and mediator. \*  $p \leq 0.05$ ; \*\*  $p \leq 0.001$ .

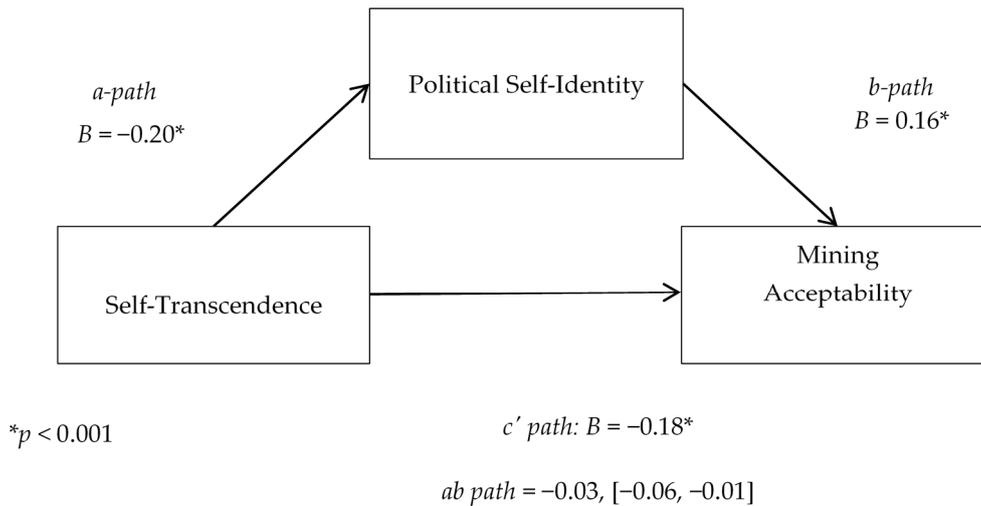


**Figure 6.** An outline of the relationship between conservative values and mining acceptability significantly mediated by a right-leaning political self-identity.

Yet, a significant indirect relationship between openness to change and less mining acceptability via a left-leaning political identity was also found,  $ab = -0.02$ ,  $SE = 0.01$ , 95% CI  $[-0.04, -0.01]$ ,  $1-\beta = 0.70$ , Direct Effect:  $B = 0.03$ ,  $SE = 0.04$ ,  $p = 0.45$  (Figure 7). Furthermore, the same pattern was found substituting self-transcendence values as the predictor variable,  $ab = -0.03$ ,  $SE = 0.01$ , 95% CI  $[-0.06, -0.01]$ ,  $1-\beta = 0.94$ , Direct Effect:  $B = -0.18$ ,  $SE = 0.04$ ,  $p < 0.001$  (Figure 8). That is, openness-to-change and self-transcendence values related to lower levels of mining acceptability and this relationship was explained in part by people’s left-leaning political self-identities.

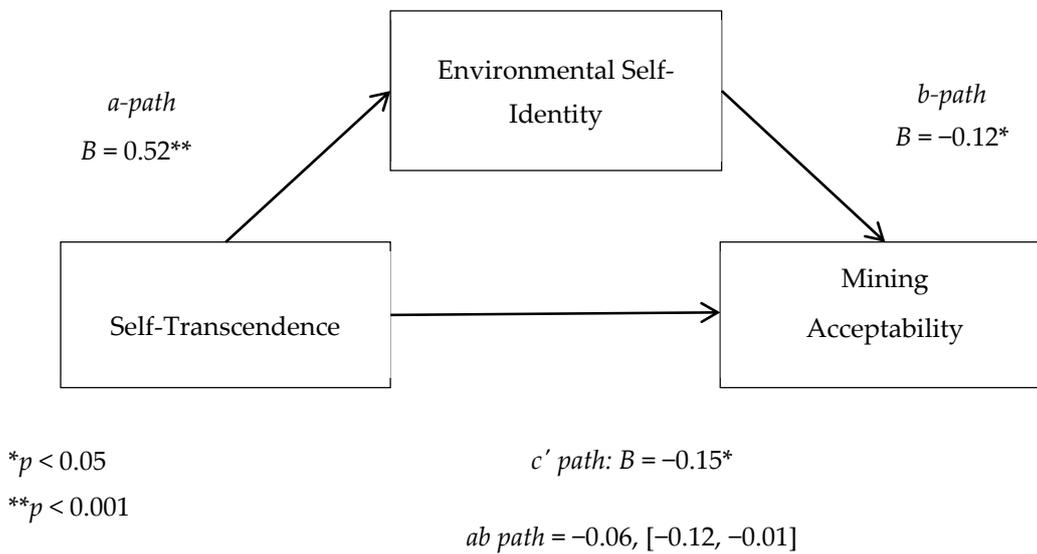


**Figure 7.** An outline of the relationship between openness to change and mining acceptability significantly mediated by a left-leaning political self-identity.

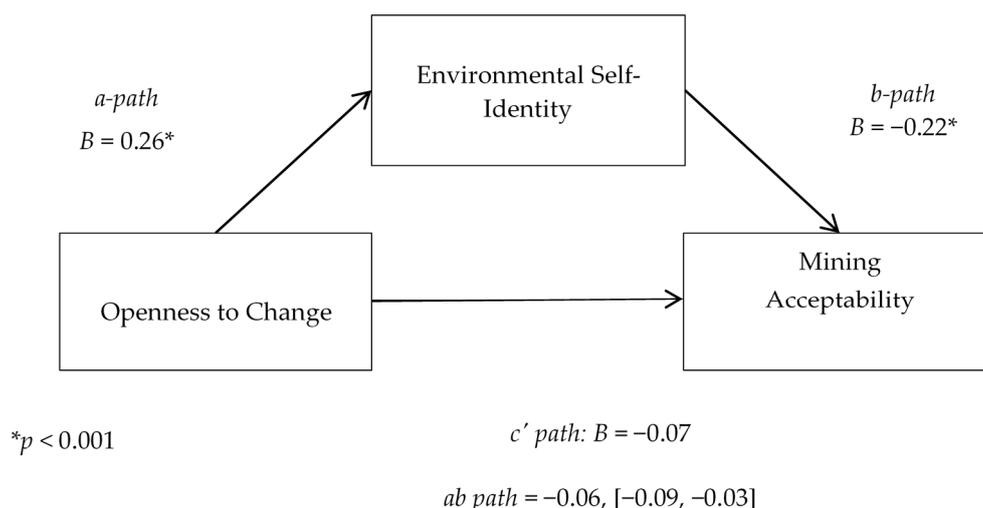


**Figure 8.** An outline of the relationship between self-transcendence values and mining acceptability significantly mediated by a left-leaning political self-identity.

Next, self-transcendence values were associated with less mining acceptability via having an environmental self-identity,  $ab = -0.06$ ,  $SE = 0.03$ , 95% CI  $[-0.12, -0.01]$ ,  $1-\beta = 0.66$ , Direct Effect:  $B = -0.15$ ,  $SE = 0.05$ ,  $p = 0.003$  (Figure 9). Similarly, the relationship between openness to change and less mining acceptability was significantly explained via an environmental self-identity,  $ab = -0.06$ ,  $SE = 0.02$ , 95% CI  $[-0.09, -0.03]$ ,  $1-\beta = 1.00$ , Direct Effect:  $B = 0.07$ ,  $SE = 0.05$ ,  $p = 0.14$  (Figure 10). In sum, openness-to-change and self-transcendence values were associated with less mining acceptability via having a pro-environmental self-identity.

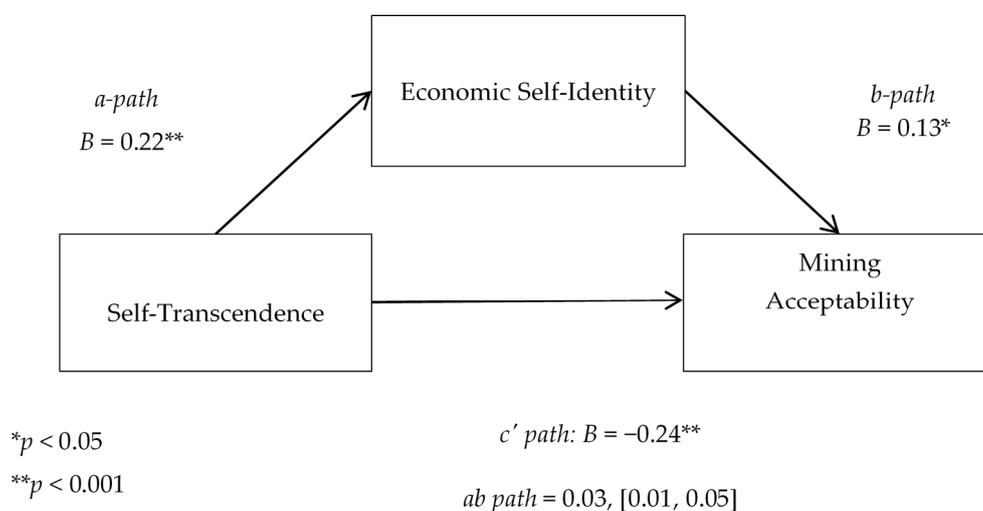


**Figure 9.** An outline of the relationship between self-transcendence values and mining acceptability significantly mediated by an environmental self-identity.



**Figure 10.** An outline of the relationship between openness to change and less mining acceptability significantly mediated by an environmental self-identity.

Finally, the relationships between values and mining acceptability were examined when an economic self-identity was included as the mediator in the model. Interestingly, self-transcendence values were associated with higher levels of mining acceptability via an economic self-identity,  $ab = 0.03$ ,  $SE = 0.01$ , 95% CI [0.01, 0.05],  $1-\beta = 0.81$ , Direct Effect:  $B = -0.24$ ,  $SE = 0.04$ ,  $p < 0.001$  (Figure 11). There was also a marginally significant indirect relationship between self-enhancement values and mining acceptability via an economic self-identity,  $ab = 0.01$ ,  $SE = 0.01$ , 95% CI [-0.01, 0.03],  $1-\beta = 0.24$ , Direct Effect:  $B = 0.09$ ,  $SE = 0.05$ ,  $p = 0.04$ . The pattern was repeated substituting openness to change as the predictor variable in the model, again with marginal significance,  $ab = 0.01$ ,  $SE = 0.01$ , 95% CI [-0.01, 0.04],  $1-\beta = 0.37$ , Direct Effect:  $B = -0.003$ ,  $SE = 0.05$ ,  $p = 0.96$ . The indirect relationship between conservative values and mining acceptability via an economic self-identity was not significant however,  $ab = 0.01$ ,  $SE = 0.02$ , 95% CI [-0.02, 0.04],  $1-\beta = 0.13$ , Direct Effect:  $B = 0.11$ ,  $SE = 0.05$ ,  $p = 0.02$ . In sum, the relationships between self-transcendence, self-enhancement values, and openness to change with higher levels of mining acceptability were explained in part by having an economic self-identity (with marginal significance regarding self-enhancement values and openness to change). Figures of the other mediation models tested (Figures S21–S26) can be found in the Supplementary Materials (Table 5).



**Figure 11.** An outline of the relationship between self-transcendence values and mining acceptability significantly mediated by an economic self-identity.

### 3.5. Geotechnical Engineering

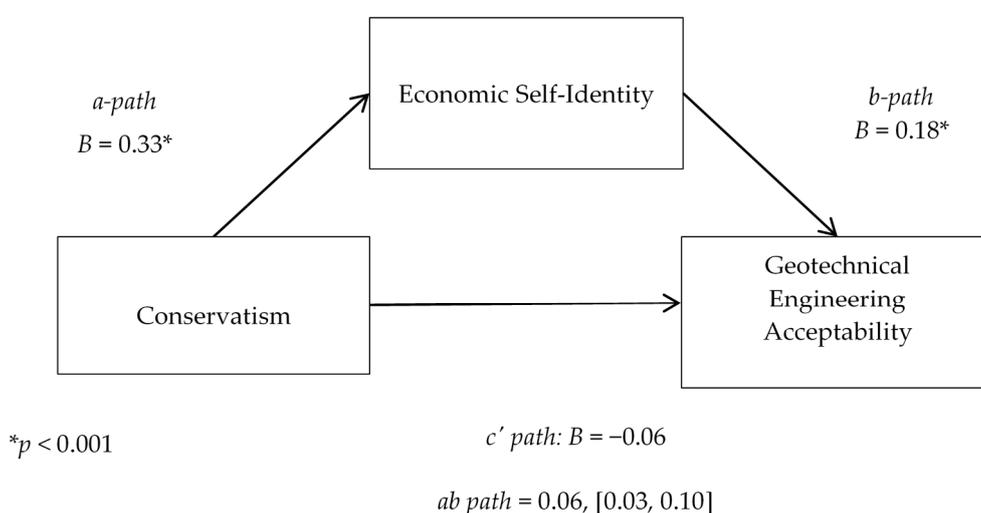
#### 3.5.1. Zero-Order Correlations

Acceptability of geotechnical engineering correlated positively and significantly with openness to change,  $r(503) = 0.09$ ,  $p = 0.04$ . However, there were no significant correlations between geotechnical engineering acceptability with conservatism,  $r(503) = 0.00$ ,  $p = 0.99$ , self-transcendence,  $r(503) = 0.02$ ,  $p = 0.63$ , or self-enhancement values,  $r(503) = 0.06$ ,  $p = 0.20$ .

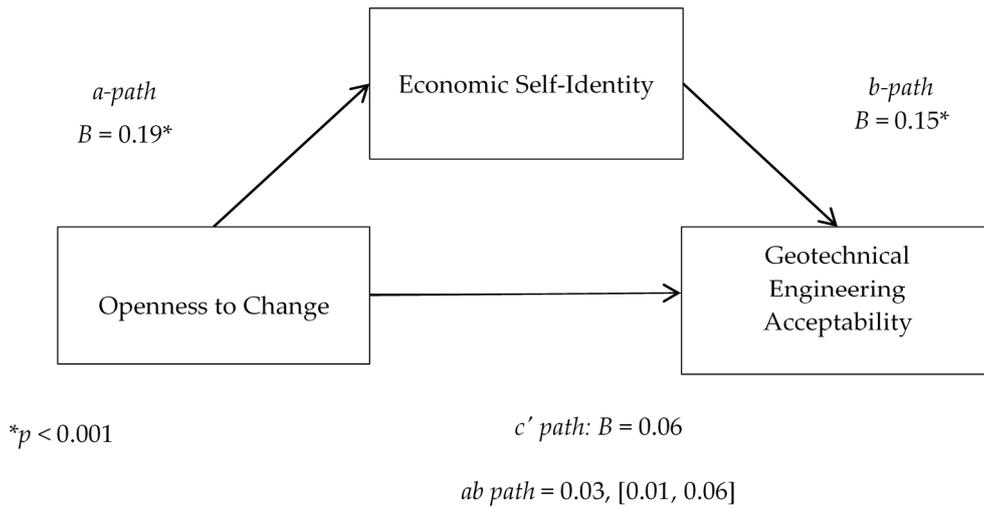
Having an economic self-identity correlated positively and significantly with acceptability of geotechnical engineering,  $r(503) = 0.16$ ,  $p < 0.001$ . However, there were no significant correlations between acceptability of geotechnical engineering with an environmental self-identity,  $r(503) = -0.01$ ,  $p = 0.90$ , or a certain political self-identity,  $r(503) = 0.02$ ,  $p = 0.70$ .

#### 3.5.2. Indirect Relationships

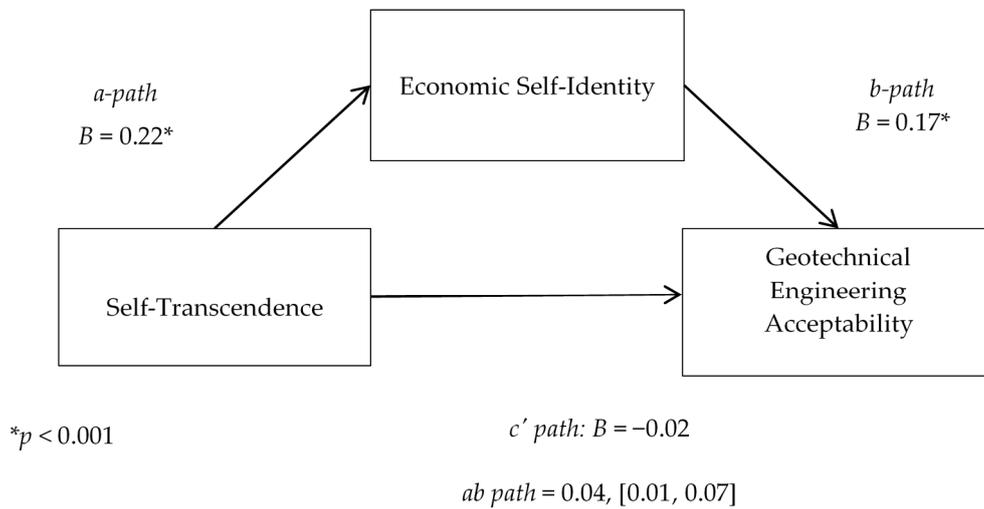
Conservative values were associated with increased geotechnical engineering acceptability via an economic self-identity,  $ab = 0.06$ ,  $SE = 0.02$ , 95% CI [0.03, 0.10],  $1-\beta = 0.98$ , Direct Effect:  $B = -0.06$ ,  $SE = 0.05$ ,  $p = 0.20$  (Figure 12). The pattern of results was repeated substituting openness to change as the predictor variable in the model,  $ab = 0.03$ ,  $SE = 0.01$ , 95% CI [0.01, 0.06],  $1-\beta = 0.91$ , Direct Effect:  $B = 0.06$ ,  $SE = 0.05$ ,  $p = 0.15$  (Figure 13). Similarly, the same patterns were found substituting self-transcendence,  $ab = 0.04$ ,  $SE = 0.01$ , 95% CI [0.01, 0.07],  $1-\beta = 0.96$ , Direct Effect:  $B = -0.02$ ,  $SE = 0.05$ ,  $p = 0.74$  (Figure 14), and self-enhancement values,  $ab = 0.03$ ,  $SE = 0.01$ , 95% CI [0.01, 0.05],  $1-\beta = 0.88$ , Direct Effect:  $B = 0.03$ ,  $SE = 0.05$ ,  $p = 0.46$  (Figure 15), as predictor variables in the models. In summary, the results showed that the relationships between acceptability of geotechnical engineering with conservative, openness-to-change, self-transcendence, or self-enhancement values were in part explained through having an economic self-identity. Figures of the other mediation models tested (Figures S27–S34) can be found in the Supplementary Materials (Table 6).



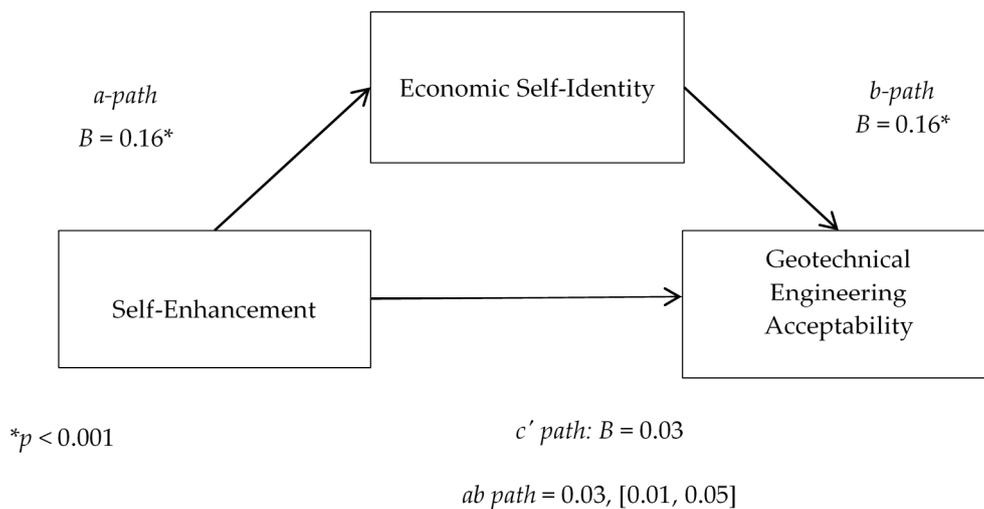
**Figure 12.** An outline of the relationship between conservative values and geotechnical engineering acceptability significantly mediated by an economic self-identity.



**Figure 13.** An outline of the relationship between openness to change and geotechnical engineering acceptability significantly mediated by an economic self-identity.



**Figure 14.** An outline of the relationship between self-transcendence values and geotechnical engineering acceptability significantly mediated by an economic self-identity.



**Figure 15.** An outline of the relationship between self-enhancement values and geotechnical engineering acceptability significantly mediated by an economic self-identity.

**Table 6.** Summary of Indirect Relationships: Geotechnical Engineering.

Predictors	Mediators	Path a	Path b	ab	95% CI of ab	R <sup>2</sup>
Conservatism	Environmental Self-Identity	0.07	−0.01	−0.0004	[−0.01, 0.01]	0.00
Openness to Change	Environmental Self-Identity	0.26 **	−0.03	−0.01	[−0.03, 0.02]	0.97
Self-Transcendence	Environmental Self-Identity	0.52 **	−0.02	−0.01	[−0.07, 0.05]	0.09
Self-Enhancement	Environmental Self-Identity	−0.004	−0.01	0.0001	[−0.01, 0.01]	0.34
<b>Conservatism</b>	<b>Economic Self-Identity</b>	<b>0.33 **</b>	<b>0.18 **</b>	<b>0.06</b>	<b>[0.03, 0.10]</b>	<b>3.02</b>
<b>Openness to Change</b>	<b>Economic Self-Identity</b>	<b>0.19 **</b>	<b>0.15 **</b>	<b>0.03</b>	<b>[0.01, 0.06]</b>	<b>3.10</b>
<b>Self-Transcendence</b>	<b>Economic Self-Identity</b>	<b>0.22 **</b>	<b>0.17 **</b>	<b>0.04</b>	<b>[0.01, 0.07]</b>	<b>2.72</b>
<b>Self-Enhancement</b>	<b>Economic Self-Identity</b>	<b>0.16 **</b>	<b>0.16 **</b>	<b>0.03</b>	<b>[0.01, 0.05]</b>	<b>2.81</b>
Conservatism	Political Self-Identity	0.39 **	0.02	0.01	[−0.03, 0.05]	0.03
Openness to Change	Political Self-Identity	−0.11 *	0.03	−0.003	[−0.02, 0.01]	0.96
Self-Transcendence	Political Self-Identity	−0.20 **	0.02	−0.01	[−0.03, 0.01]	0.09
Self-Enhancement	Political Self-Identity	0.06	0.01	0.001	[−0.01, 0.01]	0.35

Notes. Path *a* = relationship between value and self-identity; Path *b* = relationship between self-identity and geotechnical engineering acceptability; *ab* = indirect relationship; 95% CI = confidence interval of *ab*; R<sup>2</sup> = variance explained in outcome variable by predictor and mediator. \*  $p \leq 0.05$ ; \*\*  $p \leq 0.001$ .

#### 4. Discussion

The aim of this study was to investigate the underlying motives for the public's acceptability of different geoengineering technologies. A model developed by Van der Werff et al. [34,35] was adapted for this research to a distinct, yet related area from earlier literature (acceptability of geoengineering technologies). Also, this model was broadened by incorporating a more diverse range of values (conservatism, openness to change, self-enhancement, self-transcendence) and self-identities (environmental, economic, political) regarding acceptability of these technologies.

Overall, it was found that acceptability of geoengineering technologies is indeed indirectly related to values via different self-identities. This is consistent with previous findings in environmental research [17,34,35,68,71] and provides support for Van der Werff et al.'s model. The theoretical contribution of this paper is that it investigated in more detail which values and self-identities predict the acceptability of different geoengineering technologies. An important conclusion is that technology acceptability is context dependent; that is, which specific values and self-identities explain acceptability judgements depends on the specific technology that is evaluated.

The acceptability of geothermal energy was influenced by openness-to-change values via an environmental self-identity: people who are open to change tend to have a stronger environmental self-identity, which is associated with higher acceptability levels of geothermal energy. Thus, acceptability of geothermal energy is primarily based on environmental considerations. This pattern is consistent with earlier research on people's views on geothermal energy as an emerging technology [2,19] and sustainable energy production [41]. For example, the results are consistent with those of Beninghaus and Bleicher [19], who found that geothermal energy is viewed by some local communities in Germany as a developing technology requiring further investigation but also having a good environmental impact (i.e., help in national and regional renewable energy transition, relatively low CO<sub>2</sub> emissions). Accordingly, environmental self-identities and related values (i.e., openness to change) are important to consider when assessing acceptability of geothermal energy. However, the results must be interpreted with care. The data was collected in Ireland, where geothermal energy is not widely developed [10]. In contrast to other countries [105], it is not likely to find much opposition to this technology, but rather openness, in Ireland. Hence, psychological distance, as noted in research on geothermal technologies in other countries [20], may have contributed to a lack of other significant results here [106].

For nuclear power, political self-identity was the most relevant mediating self-identity, highlighting that nuclear energy is a highly political and controversial topic [107]. There were two significant indirect effects regarding political self-identities. People with conservative values reported higher acceptability levels of nuclear power via their right-leaning political orientation. This finding aligns with earlier literature showing that conservative values and right-wing identities are linked to greater acceptability of controversial geoengineering technologies such as nuclear power [42,108,109], as well as acknowledgement of its benefits [78]. Yet, those with openness-to-change values had a more left-leaning political self-identity, which was associated with finding nuclear power less acceptable. These results are also consistent with previous research indicating that nuclear power is seen as less environmentally friendly, in particular by people with openness-to-change values [4].

Values influenced the acceptability of geotechnical engineering merely via people's economic self-identities, revealing how the acceptability of geotechnical engineering is mainly seen as an economic issue [10,110]. Indeed, endorsement of all four values (conservatism, openness to change, self-transcendence, and self-enhancement) increased the acceptability of geotechnical engineering via people's economic self-identities. Perhaps surprisingly, there is a consistent pattern that all values were positively correlated with an economic self-identity. These results indicate that economic outcomes are generally important for people, irrespective of their value orientation [47,111]. To understand these relationships, it is important to note that people's values orient their attention toward value-congruent information, affecting acceptability [45,112]. Self-transcendence values reflect a key concern with collective interests [74], and people with those values may accept geotechnical engineering based on how it is economically beneficial to society at large [113,114]. People with self-enhancement values,

guided by hedonic and gain goals, may endorse geotechnical engineering for their own interests, to secure resources, or for status [80,82]. Regarding openness to change, people with these values display a readiness for change and may embrace the development of new infrastructure for economic benefits [93]. Conservative values incorporate security [39] and may relate to geotechnical engineering acceptability due to it being an established and economically beneficial technology [28,29,72,77].

Finally, the acceptability of mining showed a very mixed picture as environmental, economic, and political self-identities all mediated the relationships between different values and mining acceptability. The stronger one's environmental self-identity, the less acceptable mining was, whereas stronger economic and right-leaning political self-identities were associated with more positive acceptability judgments of mining. Openness-to-change, conservative, and self-transcendence values were the main values that indirectly related to mining acceptability. These results illustrate that many different interests are at stake when evaluating the acceptability of mining processes and that people seem to be considering these interests when evaluating mining processes in light of different values and self-identities [27,43]. Indeed, mining is associated with a negative environmental impact [28], strong economic benefits [29], and has been heavily politicised [44]. The results imply that the acceptability of mining is a rather complex issue and are consistent with results on mining acceptability found in other countries that in some cases involve lax and controversial mining installation policies [115]. Moreover, locations of the mining activity were not specified in this survey, meaning that it cannot be known how the large differences in mining practices between countries may have influenced the acceptability judgements of the respondents. Further research in this specific domain is highly recommended.

In sum, the results of this study highlight that people are more likely to accept different geoenvironmental technologies when they align with their important values but critically via related self-identities [13]. A specific value can relate to a specific self-identity, which in turn is linked with the acceptability of a specific technology. This is in line with earlier literature, which suggests that context can encourage individuals to focus on particular self-identities by reminding people of their values and the relationship between those values, specific self-identities, and particular beliefs [62,114]. This is because the connection between values and self-identities derives from people's self-reflection on their judgments and behaviours [33]. For example, nuclear power may particularly trigger people to focus on their political self-identity, while geothermal energy triggers environmental self-identities. However, for the acceptability of mining, various self-identities are important, which illustrates how complex the evaluation of mining in particular is and how various interests are contemplated. Possibly, mining and other geoenvironmental technologies trigger different cues and associations in the contexts in which attitudes to those technologies are expressed [57,116]. Overall, this study demonstrates how public acceptability of technologies varies in complexity and can depend on multiple layers of values and self-identities.

#### *Limitations and Future Directions*

Regarding the study's design, cross-sectional data limits what path models can tell about the causal and long-term relationships between constructs (although values are a stable trait; [37]). Accordingly, experimental and longitudinal replications of the study [47] that examines (latent) cross-lagged mediation models will provide greater support for the conclusions. Further, some indirect relationships found were underpowered and need to be replicated in higher-powered studies. Nevertheless, continuous variables are acceptable to include in mediation analyses when the proposed model and indirect relationships(s) are informed by theory [95,117]. Previous research on the relationship between values, self-identities, and judgments on energy and the environment have also used cross-sectional data [34,69]. In addition, the order of the variables in the models were theoretically informed and causal relationships between the variables in the models were identified in previous experimental literature [35,54,55].

## 5. Conclusions

Future energy systems will likely strongly rely on renewable energy sources, including geothermal energy. For a sustainable energy transition, the public's attitudes towards a range of sustainable energy technologies needs to be investigated. From our research, key to understanding acceptability towards geoengineering technologies is an increased understanding of the public's values and self-identities. Since social rather than technical factors influence public attitudes towards geoengineering technologies, geoscientists need to acknowledge these new, psychological insights to understand the public's concerns. In order to achieve sustainable development, authorities should integrate these psychological processes in geoengineering management strategies.

Accordingly, the results of this study can inform politicians, industries, and scientists on how to communicate effectively with the public. The most prominent finding is that which values and self-identities are relevant depends on the context, that is, which technologies are being evaluated. This has important policy implications, as it suggests that depending on which technology is being evaluated, different values and self-identities are activated to evaluate how acceptable they are. Moreover, the results show that the public acceptability of technologies varies in complexity and multidimensionality. Therefore, public acceptability is context dependent and there are no "one-size-fits-all" solutions to unacceptable technologies. Communicating with the public and finding effective ways to address multiple concerns is a process that takes time and needs to start in the early stages of a development plan that includes in-depth research as to which values and self-identities are relevant in the context.

In addition, public acceptability levels are not static. They tend to change over time, depending, for example, on personal experiences, policy measures, institutional contexts, and the media [18,105,118–120]. It may well be that the values and self-identities and other factors that impact acceptability levels also change over time [120], although no conclusions can be drawn on the basis of this paper. Future research should shed light on how the dynamics of the relationships between technology acceptability, values, and self-identities evolve over time.

This research recognises and promotes the worth of psychological insights for sustainable development. Psychological processes are often involved in environmental decisions and behaviour [36,56,63,71,121]. This research is consistent with decisional and behavioural processes, corroborated by internal psychological processes within the individual (e.g., values, self-identities, acceptability judgments). This research advances psychological contributions to achieving the UN Sustainable Development Goals, including affordable and clean energy, economic growth, industry, innovation, infrastructure, sustainable communities, responsible consumption and production, and climate action. In this regard, the Psychology of Sustainability and Sustainable Development includes aspects of reflexivity, meaning, purpose, and flourishing for the sustainability of projects in different environments, as in our research on differences in acceptability of geoengineering technologies. In this research, contributions are offered to promote effective and sustainable well-being for individuals and environments from a psychological research perspective by highlighting how people's values and self-identities need to be taken into consideration when engaging with the public about technological changes needed for a sustainable future.

**Supplementary Materials:** The following are available online at <http://www.mdpi.com/2071-1050/12/11/4591/s1>, Figures S1–S34: Conceptual Representations of Mediation Models.

**Author Contributions:** Conceptualisation, A.B.M. and G.S.; methodology, A.B.M. and G.S.; validation, A.B.M. and G.S.; formal analysis, A.B.M.; investigation, A.B.M.; resources, A.B.M.; data curation, A.B.M.; writing—original draft preparation, A.B.M. and G.S.; supervision, G.S.; project administration, A.B.M. All authors have read and agreed to the published version of the manuscript.

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## Appendix A

### Geothermal Energy Description



**Figure A1.** Geothermal energy is energy generated naturally by the earth due to the heating up of the underlying molten rock.

### Nuclear Power Description



**Figure A2.** Nuclear power uses nuclear reactions to generate heat which is then used in steam turbines to generate electricity.

## Mining Description



**Figure A3.** Mining is the extraction of valuable raw materials (e.g., minerals such as lead, zinc, gold, coal) from the earth. Mining can take place underground or over ground in an open-cast mine.

## Geotechnical Engineering Description



**Figure A4.** Geotechnical engineering looks at the principles of rock and soil mechanics to investigate subsurface conditions and evaluate their stability, e.g., used in infrastructural developments such as tunnels/bridges.

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