The Moderating Role of Environmental Identity on the Relationship Between Political Ideology and Public Acceptability of Direct Air Carbon Capture with Storage (DACCS)

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2324_2a_27 EN Lee Public acceptability of negative emission technology

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July 7th, 2024

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Abstract

Negative Emission Technologies have been introduced as means to decarbonize the atmosphere by filtering carbon directly out of the air and storing it over a long period. Previous literature suggests that a lack of public acceptability is one of the major roadblocks to the implementation of these technologies. Therefore, the present study aims to investigate which variables can predict public acceptability by focusing on a single negative emission technology, called direct air carbon capture with storage (DACCS). We were specifically interested in whether and how people's political ideology and environmental identity play a role in the public acceptability of DACCS. A moderation model is proposed that considers a person's political ideology from left to right as the independent variable and environmental identity as the moderating variable. In a convenience sample of 150 participants, no main effect of political ideology on the public acceptability of DACCS was found to be significant. However, environmental identity held significant negative predictive power over an individual's acceptability of DACCS. This means that a stronger environmental identity led to less acceptance of the technology. No moderation effect could be observed. The present study added to the extremely scarce body of literature on the public acceptability of DACCS by showing that environmental identity is an important determinant. Further research could validate these findings, place environmental identity in different theoretical frameworks, and test it in the general population. Especially environmental values should be integrated into future research to understand how they influence political ideology and the acceptability of DACCS.

Keywords: environmental identity, political ideology, public acceptability, negative emission technologies, DACCS,

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Climate change has severe implications for both human well-being and the environmental system, posing a major change for society and demanding immediate solutions (IPCC, 2023). The emission of greenhouse gasses (GHG), specifically carbon dioxide, is known to be among the main determinants of global warming (IPCC, 2023). Carbon dioxide (CO_2) emissions have increased by approximately 50% since the Industrial Revolution, mainly due to unsustainable energy consumption lifestyles (Allen et al., 2009). Continuing at this rapid pace leaves the global climate system with substantial long-term repercussions. Recent research suggests that solely minimizing the emission of greenhouse gasses would not suffice to counteract the effects of global warming (Pires, 2021). Meeting the objectives of the Paris Agreement of limiting the global average temperature levels below 2°C above pre-industrial levels calls for increased decarbonization efforts (Rockström et al., 2017). Achieving these targets poses an expensive and profoundly challenging task, which will require the implementation of greenhouse gas removal strategies in addition to continuous reductions of emissions (Royal Society, 2018).

Negative Emission Technologies

To combat the detrimental and severe consequences that climate change inflicts on the vitality of the earth, negative emission technologies (NETs) have been introduced to reduce atmospheric GHG concentrations (Rueda et al., 2021). The conceptual idea behind NETs involves the removal of already emitted CO_2 from the atmosphere and its long-term subterranean storage (Wenger et al., 2021). NETs are often referred to as "any anthropogenic activities that deliberately extract CO_2 from the atmosphere" (Fuss et al., 2016). They significantly differ in

pricing, methodology, readiness for implementation, and CO_2 removal capacity. Due to this variety, NETs have often been categorized and clustered according to the way they operate. One of the most prominent categorizations, which is of high importance to the present study, has been to either refer to them as nature- or technology-based methods (Motlaghzadeh et al., 2023). Direct Air Capture with Carbon Storage (DACCS) has been proposed as not only an optional but necessary negative emission technology to meet the Paris Agreement goals (Marcucci et al., 2017). This study aims to focus solely on DACCS, as it is considered one of the most effective and promising NETs for atmospheric carbon reduction in the near future (Erans et al., 2022; Rueda et al., 2021).

However, DACCS does have its drawbacks, which may hinder its successful implementation (e.g., costs and high energy requirements) (Smith et al., 2016). If this energy is derived from non-renewable sources, it poses further complications and significantly decreases the alternatives of possible deployment locations (EASAC, 2018). Additionally, the storage phase of DACCS has been found to hinder deployment in earlier CCS projects, raising concerns about seismic disturbances, explosive gas releases, and toxic hazards possibly contaminating nearby freshwater deposits or ecosystems (Dowd & James, 2014; Wallquist et al., 2010).
It is important to keep these downsides in mind when predicting how acceptable these technologies may be viewed as by the public. Although the carbon capture roadmap set by the International Energy Agency (IEA) in 2009 projected significant growth in the implementation of carbon capture and storage (CCS) technologies by 2020 and 2050 to achieve substantial CO_2 capture, the current deployment of these technologies has not been able to meet the initial expectations, further highlighting a discrepancy between expected and actual deployment (Viebahn & Chappin, 2018). Despite being presented as a technology of high potential and

necessity to tackle climate change, carbon capture technologies including DACCS are often viewed ambiguously in emissions mitigation literature. This is due to concerns about their public acceptability which has been found to be among the major roadblocks to the deployment of new technologies (Thomas et al., 2018; Wennersten et al., 2015).

Public Acceptability of DACCS

Technology acceptability is defined as having a positive attitude toward the technology or engaging in supportive behaviors such as advocating for, purchasing, or utilizing it (Huijts et al., 2012). Consequently, a lack of acceptability can impede the development of new projects like CCS deployment as well as energy structures, inhibiting the achievement of CO_2 mitigation goals on a national and global level (Dowd et al., 2011). Public demonstrations opposing CCS technologies have highlighted that acceptance is crucial for the policy shift toward the implementation of negative emission technologies (Arning et al., 2019). Thus, lacking public acceptance could potentially evolve into a critical roadblock in the process of successfully introducing these technologies to society (Huijts et al., 2012). Given the novelty of NETs, literature on this topic is still in its infancy, particularly for DACCS. Therefore, the main parts of existing research investigate DACCS together with analogous technologies under the umbrella terms “geoengineering” or “carbon dioxide removal” (CDR), providing valuable insights into the scholarly foundations of the present study (Kreuter & Lederer, 2021).

Although DACCS is generally less accepted by the general public than more natural NETs like afforestation, which involves planting trees, some initial results show that DACCS and CCS are often perceived as neutral to slightly positive, with neither strong support nor substantial opposition (Lee et al., 2023; L'Orange Seigo et al., 2014). However, people generally are not familiar with these technologies and have limited knowledge about them (Arning et al.,

2019; Carlisle et al., 2020; Cummings et al., 2017; L'Orange Seigo et al., 2014; Pianta et al., 2021). Thus, we assume low awareness of DACCS prior to the conductance of this study, since it is probable that most participants have never heard of the technology before. Investigating possible factors that determine why individuals would perceive DACCS as acceptable is of focal importance to the present research since it might help policymakers to enhance the effectiveness of their policies and has not received enough attention in existing literature so far (Bäckstrand et al., 2011; Klaus et al., 2020; Pianta et al., 2021). To fill this research gap, this study proposes political ideology and environmental identity as possible antecedents of public acceptance of DACCS.

Political Ideology: An Ambiguous Relationship with the Acceptability of DACCS

Political ideology, defined as an individual's preference in political values and beliefs along the spectrum from deeply conservative to strongly liberal or far-left to far-right, has emerged as one of the strongest predictors of environmental concerns and issues (Cruz, 2017; McCright & Dunlap, 2011). Political ideology shows significant predictive power over the formation of pro-environmental policy support that aims to mitigate emissions (Jagers et al., 2017). In past literature, left-leaning parties have been found to elicit a higher level of support for government intervention in the economy (Potrafke, 2017). This is crucial for large-scale energy projects since those often rely on governmental financial backing during the initial stages of deployment. Further literature suggests that individuals with left-leaning political views tend to prefer renewable energy sources over fossil fuels, which can be interpreted as an expression of environmental concern (Cadoret & Padovano, 2016). Conversely, people with right-leaning political ideologies often show less concern and belief about climate change and thus are less inclined to support renewable energy initiatives (Borick & Rabe, 2010; McCright et al., 2015).

Similarly, being conservative in the US is associated with a higher likelihood of skepticism and doubt toward climate change science (Gauchat, 2012; Leiserowitz, 2005). Since DACCS can be defined as a measure to reduce GHG emissions, acting against climate change, the probability for right-wing individuals to be less accepting than their left-wing counterparts is presumably high. Thus, individuals of the right wing would oppose DACCS since it acts against a problem (climate change) that in their perception does not exist (Pidgeon et al., 2012).

However, the influence of political ideology on the acceptability of DACCS might not be straightforward but complex instead. It is indeed possible that within the right wing, a number of people could accept the notion of DACCS due to its aforementioned technological nature. Liberals generally are more supportive of climate policies than conservatives (Pianta et al., 2021). However, conservatives are in favor of more technological solutions, which would make them more supportive of DACCS (Gardner et al., 1982). Moreover, they could view it as an "insurance policy" which allows them to keep up their high-consumption Western lifestyles. This has been referred to as the moral hazard argument, in which people's acceptance of a certain climate policy (in this case DACCS), would undermine support for other mitigation policies (especially on the individual level). This is because they see the issue of climate change as "solved" which "frees" them of personal responsibility to act against climate change (Anderson & Peters, 2016; Corner & Pidgeon, 2014a; Raimi et al., 2019). A similar line of reasoning can be found concerning so-called "self-enhancing" values. These values, such as power and wealth, have been found to correlate with the denial of climate change as well as the acceptability of geoengineering (Corner & Pidgeon, 2014b). Hence, it is presumable that people who do not believe in or are skeptical of climate change would accept geoengineering technologies as a means to feel less personally responsible for climate change. Consequently,

this would justify them to not take part in individual actions promoting emission reduction, like consuming less meat and upholding their conservative lifestyles (Corner & Pidgeon, 2014a).

On the other hand, left-wing individuals could oppose DACCS because they see it as an "unnatural" solution to climate change that will interfere with nature. This is inherently related to the framing of geoengineering technologies, such as DACCS, which has been found to play a major role in acceptability ratings. As DACCS represents a rather technological approach to extracting CO_2 from the atmosphere, it has been compared to "massive vacuum cleaners" (Keith, 2009). Research showed that framing DACCS as "artificial trees" increases acceptance and support (Corner & Pidgeon, 2014b). Moreover, the concept of "messing with nature" has been found to play a significant role in whether the public perceives direct air capture as acceptable. This concept is rooted in a broader cultural and moral framework that values the preservation of natural processes and views large-scale technological interventions like DACCS with suspicion (Corner et al., 2013). Fittingly, findings suggest that among other geoengineering technologies such as afforestation, direct air capture has received less support since it is seen to tamper with nature (Wolske et al., 2019). In a recent study, DACCS similarly was found to be the least favorable CDR strategy due to its unnatural characteristics in comparison to other decarbonization strategies (Bellamy, 2022). Therefore, left-wing individuals may be less likely to accept DACCS than right-wing individuals. Based on the previously analyzed literature, this study aims to test the following two competing hypotheses.

H1A: People with a right-wing political ideology are less accepting of DACCS than people on the left side of the political spectrum.

H1B: People with a left-wing political ideology are less accepting of DACCS than people on the right side of the political spectrum.

Environmental Identity as a Moderator: Is DACCS "tampering" with nature?

The ambivalent relationship between political ideology and public acceptability of DACCS calls for extended alternative approaches to clarify how acceptability is influenced and shaped. It is indeed possible that individuals with economic perspectives, aligning with the right side of the political spectrum, adopt leftist socio-cultural opinions making them increasingly concerned about the environment (Hillen & Steiner, 2019). This is taken as a starting point to propose the construct of environmental identity as a moderating variable on the relationship between political ideology and public acceptance of DACCS. Environmental identity describes how individuals incorporate their sense of self in relation to nature and attach themselves to the non-human world around them. It plays a crucial role in determining perceptions and actions towards the environment (Clayton, 2003; van der Werff et al., 2013). This personal connection of an individual with nature influences various pro-environmental attitudes and behaviors. A strong environmental identity is a negative predictor of climate change denial and a positive predictor of environmental activism, pro-environmental behavior, and policy preferences (Brick & Lai, 2018; Nartova-Bochaver et al., 2022; Schmitt et al., 2019). This is in line with recent literature revealing that a strong environmental identity positively influenced the acceptance of energy consumption reduction targets (Faure et al., 2022). Given the aforementioned pivotal role that environmental identity plays in shaping attitudes towards environmental issues, this study hypothesizes that individuals with a strong environmental identity will perceive DACCS more favorably than people with weaker environmental identities. They are likely to support it as part of a broader strategy to address climate change, feeling a personal sense of accountability towards environmental conservation (Poortinga et al., 2012).

However, coming back to framing effects and naturalness of technologies addressed earlier, those with strong environmental identities might also prefer natural solutions over technological fixes like DACCS, complicating the relationship between environmental identity, political ideology, and public acceptability of DACCS. Again, it would be extremely crucial whether people perceive DACCS as "messing with nature" (Corner et al., 2013). In Corner's study, the public revealed significant concerns about geoengineering representing an unnatural interference with the environment, which could influence the acceptability of DACCS similarly. Moreover, focus-group studies of geoengineering showed even more extreme examples of naturalness. While most of the individuals displayed the belief that natural processes are inherently good, some of them additionally shared the perception that any human intervention in nature is inherently negative (Wibeck et al. 2015). Thus, individuals with strong environmental identities may prioritize natural solutions over technological ones like DACCS, aligning with their deep connection to nature. Consequently, they might express skepticism towards DACCS. Therefore, this study sets out to explore in which direction the relationship between environmental identity and acceptability of DACCS develops.

H2A: Individuals with a high environmental identity are going to be more accepting of DACCS than people with low environmental identities.

H2B: Individuals with a high environmental identity are going to be less accepting of DACCS than people with high environmental identities.

Since both previously discussed hypotheses are competitive in nature, the moderation pathway proposed in this study will not be of any less complexity. The interplay between political ideology and environmental identity has been under-investigated in the literature so far. Yet, several scholars argue that environmentalism should not be attributed solely to the left side

of the political spectrum. John R.E. Bliese (1997), for instance, considers the assumption that environmentalism is more inherent in liberal individuals a misconception, or in his words "historical accident". According to him, concern about the environment aligns well with the philosophical underpinnings of conservatism, meaning that environmental concern can be observed in conservatives (Bliese, 1997). More recently, Hess and Renner (2019) have cautioned against the assumption that individuals on the right, especially the far-right, are inevitably opposed to policies aimed at energy transition and emission mitigation (Hess & Renner, 2019). Their review advises against oversimplifying the energy politics of far-right parties, since some aspects of renewable energy and energy efficiency policies may be more acceptable to them. For instance, while wind energy often faces harsh criticism, distributed solar energy and energy efficiency tend to receive more support (Hess & Renner, 2019). Further, research in Nebraska, a predominantly conservative state, showed that liberals and conservatives are not as far apart in their opinions on environmental issues as often assumed (Blankenau et al., 2007). Although there is a tendency for leftists to value the environment more highly than the economy, a notable proportion of right-wingers (55.7%) indicated that they would rather protect the environment than pursue economic growth (Blankenau et al., 2007). To pursue a more extreme route, research on right-wing populist parties is especially insightful. Although individuals of these populist parties have been consistently found to be skeptical about climate change and particularly its underlying scientific basis, they increasingly support national environmental policies that preserve and protect the environment of their own countryside (Buzogány & Mohamad-Klotzbach, 2021; Forchtner et al., 2018). This has been attributed to their emphasis on nationalism and their stance against multiculturalism. In other words, nature, at least on a national level, seems to have an important historical value for individuals of the right wing,

while the issue of climate change is often opposed or ignored due to its global character, underlying complexity, and threat to conservative lifestyles (Tosun & Debus, 2020; Vihma et al., 2021). Accordingly, individuals of the far right have been found to support "green patriotism" and environmental protection if it concerns the "homeland" (Forchtner, 2020; François & Nonjon, 2021). Motivation to adopt green politics by right-wing parties has often been found in the need to gain younger voters or, more generally, when it potentially increases overall electoral success (Spoon et al., 2013). Political ideology can also influence an individual's perceptions of naturalness. Right-leaning individuals, often less supportive of environmental interventions, may be more inclined to view DACCS favorably as a technical solution in comparison to left-leaning individuals, regardless of its perceived naturalness. Thus, understanding how environmental identity interacts with political ideology is crucial for predicting the public acceptability of DACCS. Examining this interaction could allow for greater insights into how individuals with different ideological beliefs and environmental identities perceive and accept climate change mitigation policies in the form of DACCS. Hence, this study highlights environmental identity as a potential moderator of the relationship between political ideology and the acceptability of DACCS. Given the ambiguous roles both variables might play in this theoretical framework, this study proposes an explorative approach to the moderation pathway.

H3: Environmental identity moderates the relationship between an individual's political ideology and their acceptability of DACCS.

Methods

Participants

A priori power analysis was conducted in two different ways, depending on the study design. The current paper used the software G-Power, based on Linear Multiple Regression,

which indicated that a minimum of 133 participants were required to achieve a small to medium effect size (f_2 =.06) and power of .80%. In total, 203 people consented to participate and completed the questionnaire. Of those 203 participants, 53 were excluded due to failing the attention and/or manipulation checks. This led to a final sample size of 150 for the analysis in this study (66.7% women, 30.7% men, 2.7% others). The age range of participants was between 18 and 87 years old (M = 31.39, SD = 16.13). Among them, 14.7% of participants were Dutch, 40.7% were German, and 19.3% were British. Other nationalities included Spanish, Bosnian, Norwegian, Russian, Luxembourgish, and many more, with 38 participants identifying as one of these nationalities.

Research Design and Procedure

This cross-sectional study was approved by the Ethical Committee of the Faculty of Behavioural and Social Sciences at the University of Groningen (EC-BSS). Participants were recruited from various demographics through convenience sampling, which involves inviting individuals from the researchers' social networks and social media circles to participate in an online survey administered through Qualtrics survey software. This was done by sharing the link to the survey. Furthermore, participation in the study was completely voluntary for every participant. The data collection was conducted over a week beginning on the 19th of May 2024 and ending on the 26th of May 2024.

The information was retrieved using a single survey, which was available in English, Dutch, or German. The survey was available online and took between 10 and 15 minutes to complete.

At the beginning of the questionnaire, participants gave their consent to participate in the study and stated their age, gender, and nationality. After that, participants were randomly

assigned to two different conditions. The experimental conditions were differentiated by introducing DACCS either in a basic manner, providing an infographic about the workings of the technology (low knowledge condition) or providing the infographic and additionally providing a list of pros and cons of the technology (high knowledge). To check the effectiveness of the manipulation, a timer was included in the questionnaire measuring the time spent by participants engaging with the provided information. After that, participants were asked a single question about their political orientation. The survey continued with questions regarding the environmental identity of the participants. Finally, there were questions about the acceptability of DACCS. At the end of the questionnaire a debriefing was provided, informing the participants that they had been assigned to one of the two knowledge conditions, either having received only basic knowledge or basic knowledge and a list of pros and cons. Lastly, contact details of the research team and a box for general comments were provided, allowing the participant to contact the research team for any further questions or concerns. The survey also contained questions assessing a participant's perceived climate change severity, familiarity with DACCS, environmental values of their political group, perceived risk, and benefits of DACCS. However, these variables were not used for this analysis and are out of the scope of this study.

Measures

The questionnaire consisted of eight subscales, starting with a section outlining the purpose of the study and explaining important information to participants. This subsection included an explanation that the study participation is voluntary, information about data privacy, and contact information of the research team. Next to the informed consent, background information was collected, such as age, gender, and nationality.

The important constructs for the present study that were measured in the questionnaire were political orientation, environmental identity, and public acceptability of DACCS.

Political Ideology

Political ideology was measured using a six-point Likert scale, ranging from 1 (*left wing*) to 6 (*right wing*). For that, the single statement: "*Where would you place yourself on such a left-right scale?*" was used to determine the political orientation of each participant. The political ideology of the participants of this study was slightly left-skewed (M = 2.47, SD = 0.92). The single-item scale can be found in Appendix A.

Environmental Identity

Participants' environmental identity was measured by providing statements adapted from the Revised Environmental Identity Scale by Clayton (2021) and Olivos & Aragonés (2011) to which the participants indicated their level of agreement on a six-point Likert scale, ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). Examples of statements measuring environmental identity included "*I think of myself as a part of nature, not separate from it*" or "*In general, being part of the natural world is an important part of my self-image*". The environmental identity subscale consisted of 9 items which were reliable according to post-measure analysis (α = .797). The mean score for environmental identity was 4.71 (SD = 0.63). The full adapted environmental identity scale (EID) used in the present study can be found in Appendix B.

Public Acceptability of DACCS

Lastly, to measure the dependent variable public acceptability of DACCS, participants were asked how acceptable they find it to implement DACCS. The subscale consisted of four statements which were: "*I find the use of DACCS technology acceptable*", "*I find it acceptable to implement DACCS technology in my country*", "*I find it acceptable to use DACCS technology in*

order to reach global climate goals", "*I find it acceptable to use more DACCS technology in my country than is used now*". Again, participants had to indicate their level of agreement on a six-point Likert scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The acceptability subscale was comprised of four items and was highly reliable (α = .931). The mean in this sample for public acceptability of DACCS was 4.27 (*SD* = 0.85). The whole acceptability scale can be found in Appendix C.

Manipulation Checks

Two items were included as manipulation checks. The first item prompted participants to recall previously introduced knowledge on DACCS: "*Without going back to check, please answer the following question: What have you read about in previous descriptions? (selecting multiple answers is possible)*". Options included "*How DACCS works*", "*Pros of DACCS*", and "*Cons of DACCS*". In addition, a second manipulation check was added to assess participants' attention to the content: "*Please select 'disagree' as your answer*" (1 = *strongly disagree*, 6 = *strongly agree*). This is important to mention since knowledge was added as a covariate as it can be read in the data analysis section below.

Data Analysis

All of the statistical analyses were conducted by using IBM SPSS Statistics (Version 29). The hypothesized moderation model of this study was tested by running a hierarchical, moderated, multiple-regression analysis. The variables that were involved were: knowledge as a covariate (CV), political ideology as the independent variable (IV), environmental identity as the moderating variable (M), and acceptability of DACCS as the dependent variable (DV). Prior to the analysis, the IV and M were centered. These values were then used to compute the centered interaction effect between political ideology and environmental identity which is necessary to

test moderation effects. The knowledge condition was added as a categorical covariate to account for possible confounding effects.

Results

Assumption Checks for Hierarchical Regression

To test the hypothesis that the Acceptability of DACCS is a function of multiple potential predictors, and more specifically whether environmental Identity moderates the relationship between an individual's political ideology and their acceptability of DACCS, a hierarchical multiple regression analysis was conducted. Initially, all assumptions of a multiple regression analysis were checked in order to proceed with the analysis of the model. These included assumptions of linearity, normally distributed residuals, multicollinearity, and homoscedasticity. A scatterplot indicated that there was a linear relationship between the continuous predictor and the dependent variable. Moreover, the Q-Q plot and histogram of residuals verified the normality assumption. VIF values were all below 10, indicating no significant multicollinearity among the predictors. The scatterplot of studentized residuals versus predicted values showed a random pattern, indicating homoscedasticity. Lastly, Cook's Distance values were all below 1 and the studentized deleted residuals were within the ±3 range, suggesting no significant outliers or influential data points.

Main Analysis

First, the primary competing hypotheses were tested. That is, political ideology would either have a significant positive or negative effect on public acceptability of DACCS. Thus, political ideology was added as the first predictor to the first model to test its unique contribution to the explained variance of our overall model including all predictors and the interaction effect. The integration of political ideology did not account for a significant amount of variance in

acceptability scores, $\Delta R^2 = .011$, $F(2, 147) = 0.82$, $p = .443$. Therefore, the main effect of political ideology was not significant, which means that there is no difference in acceptability between left-leaning and right-leaning individuals in our sample ($B = -.076$, $p = .314$, 95% *CI* [-0.224; 0.072]). This finding led to the rejection of both hypotheses concerning the main effect of political ideology, namely H1A and H1B.

Next, I added environmental identity to test the second hypothesis concerning the main effect environmental identity might have on DACCS acceptability. The addition of the scores on the EID resulted in a significant increase in the explained variance of the acceptability scores of DACCS, $\Delta R^2 = .039$, $\Delta F(1, 146) = 5.96$, $p = .016$. Thus, environmental identity was a significant negative predictor of acceptability of DACCS ($B = -0.274$, $p = .013$, 95% *CI* [-0.491; -0.058]). This finding supported H2B, stating that individuals with higher environmental identities would be less likely to accept DACCS.

Lastly, the interaction effect between environmental identity and political ideology was added in order to test the moderation hypothesis. The integration of the interaction effect did not result in a significant increase in explained variance, $\Delta R^2 = .006$, $\Delta F(1, 145) = 0.85$, $p = .359$. This led to the conclusion that no significant moderating effect of environmental identity was found during this investigation, $B = -0.11$, $p = .359$, 95% *CI* [-0.345; 0.126]. Environmental identity remained as the single significant predictor of public acceptability of DACCS, emphasizing its potential crucial role in explaining individual differences in acceptability scores. In sum, the overall model including all predictors was not significant, $R^2 = .055$, $F(4, 145) = 2.12$, $p = .081$.

Discussion

This study aimed to test a hypothetical theoretical framework that could underlie the societal perception of NETs and, in particular, to what extent people accept DACCS and the factors influencing acceptability. Keeping the possible determinants of the acceptability of DACCS in mind, which are still subject to a lack of investigation in the existing literature, this study contributed to the aforementioned gap by proposing and exploring the contribution of novel predictors, namely environmental identity and political ideology. The theoretical contribution of this study is that it emphasizes the role environmental identity could play in shaping the acceptability of DACCS and thus potentially resolving one of the major roadblocks to its implementation. Moreover, the findings add to the ambivalent relationship between political ideology and environmental policies by including DACCS.

First, political ideology was not found to be a significant predictor of public acceptability of DACCS. Consequently, both competing hypotheses proposed (H1A and H1B) were not supported. Our findings highlight the complexity and ambivalence of the construct of political ideology regarding DACCS. Especially in the case of DACCS, this study stresses that polarization has not taken place yet, particularly since public awareness is still low (Lee et al., 2023). Polarization is often reinforced through growing public debate and awareness; however, political parties have not had strong opinions on DACCS yet (Pianta et al., 2021). Therefore, people with pronounced ideological beliefs could have relied on their environmental identity rather than their political orientation to form an opinion on DACCS. This aligns with previous research suggesting that individuals across the political spectrum can hold complex and even contradictory opinions regarding environmental issues (Hess & Renner, 2019). Together with the findings of this study, this means that political ideology is a complex rather than straightforward

predictor of environmental attitudes and behaviours. While one might initially assume that liberals or left-leaning individuals are more environmentally concerned than their conservative counterparts, this dichotomy oversimplifies a more nuanced reality.

Second, the results of this study suggest that environmental identity indeed has a negative relation with the public acceptability of DACCS. Therefore, the second of the two competing hypotheses (H2B) regarding environmental identity was supported. This means that individuals with higher environmental identities were less accepting of DACCS compared to people with low environmental identities. So far, existing literature on the effect of environmental identity on individuals' acceptability of DACCS is almost non-existent. Looking at previous research, however, one thus must broaden the scope by investigating already studied links between environmental identity or values and environmental policies. Our findings align with research on public perceptions of DACCS indicating that individuals prefer it less compared to more "natural" solutions like afforestation (Lee et al., 2023). Given the negative relationship between environmental identity and acceptability found in our study, it is indeed probable that the majority of participants perceived DACCS as "tampering with nature" and "unnatural", which might have stood in conflict with their environmental identities. Moreover, studies have shown that a lot of people see CDR, including DACCS, as "non-transition" strategies because they tackle the symptoms rather than the root of climate change (Cox et al., 2020). This adds to previous research stating that a stronger environmental self-identity led to more general acceptance of CCS but decreased acceptance in the local domain, highlighting that higher acceptance of the technology itself is not equal to higher acceptance to implement this very technology (Reigstad et al., 2022). Again, this underscores the importance of environmental

identity concerning the formation of attitudes towards environmental policies, especially when it directly affects people's local communities.

Lastly, the study found no significant evidence for the moderating effect of environmental identity, which rules out the last hypothesis (H3). Thus, the effect of political ideology did not significantly differ at varying levels of environmental identity. Schwartz' Value Theory offers a framework for understanding why the moderation effect was not observed. According to Schwartz (1992), people hold values that are stable across situations and use them as overarching desirable goals that guide their behavior throughout their lives (Schwartz, 1992). Values are an important part of an individual's self-identity. Especially biospheric values (which are also categorized as self-transcendence values) are deeply engraved in a person's environmental identity and have been found to have more predictive power for pro-environmental behavior than values, while both seem to have a strong predictive influence on environmental policy acceptability (Gatersleben et al., 2012; Steg & Vlek, 2009; Whitmarsh & O'Neill, 2010). Further research has shown that environmental self-identity mediates the relationship between biospheric values and environmental preferences (e.g. intentions to save energy and willingness to pay for green energy) (van der Werff et al., 2013). An econometric analysis by Ziegler (2017) takes this view even further by demonstrating that environmental identity can overcome and bridge ideological differences concerning environmental issues. Stronger environmental values reduce the negative predictive effects conservative-non-green identification often elicits on climate change beliefs, anthropogenic climate change, and publicly financed climate policy. This leads to the conclusion that environmental values, which are antecendents of an individual's environmental identity, could play a bigger role than political ideology in the formation of acceptability ratings of DACCS. Another possible explanation for

the non-significant effect could be a high correlation between environmental values underlying a person's environmental identity and political orientation. Previous research suggests that the high correlation between environmental values (which compose an environmental identity) and political orientation can lead to omitted variable bias. For instance, Dietz and colleagues (2007) showed that the effect of a liberal orientation on support for climate policies becomes insignificant when environmental values are included in the analysis (Dietz et al., 2007). Similarly, other studies found that environmental values, opposed to political orientation, influence beliefs in anthropogenic climate change and climate protection activities when both of the predictors were included (Attari et al., 2009; Whitmarsh, 2008). This is in line with the findings of this study which demostrated that individuals with strong environmental identities might uniformly not accept DACCS. The non-significant effect of political ideology together with the significant effect of environmental identity could suggest that environmental values, lying at the base of a person's environmental identity, could have overshadowed the influence of political ideology. These values could thus have had a stronger influence than political ideology in our study and therefore nullified the expected moderation effect. Identity was found to be a stronger predictor than values alone and mediates the relationship between biospheric values and acceptance of geoengineering (Moynihan & Schuitema, 2020; van der Werff et al., 2013; Whitmarsh and O'Neill, 2010). Therefore, the findings of this study emphasize the crucial role of environmental identity in shaping the acceptability of DACCS. Future research should aim to include biospheric/environmental values next to political ideology and environmental identity to allow for a comprehensive assessment of their unique and combined effects on the acceptability of different NETs.

Limitations

Firstly, the sample used in this study was gathered through convenience sampling. This means that the way the online questionnaire was distributed and sent to the prospective participants was through social contacts. Therefore, most of the participants are younger and living in the WEIRD (western, educated, industrialized, rich, and democratic societies) countries, like the Netherlands and Germany. Therefore, this reproduces the so-called "WEIRD problem" impeding the generalizability of these findings. To add to this, Scheer & Renn (2014) state that caution is needed concerning the actual validity of attitude tests towards geoengineering technologies with low prior knowledge. Since these attitudes are most likely formed during the course of an interview and dependent on the way information about technologies was presented, opinions expressed on a scale would not be stable across time (Scheer & Renn, 2014).

Awareness of geoengineering is still extremely low amongst laypeople. This means that participants in our study might have expressed fragile opinions concerning their acceptance of DACCS that were only based on the information they received during the survey (e.g. the infographics) because this was the first and only information they ever received about DACCS. Thus, participants who deemed DACCS as acceptable in this study might not engage in the same acceptability ratings once the topic of DACCS gains popularity and they further educate themselves on this topic.

Secondly, perceptions and therefore acceptability ratings of DACCS could have been influenced by the manner the technology was presented to the participants. Our questionnaire used infographics of DACCS that made use of bright colors and simplified pros and cons, while visually oversimplifying the scale as well as the complexity of these technologies once deployed. Again, taking low prior knowledge into account, the way our questionnaire presented and

manipulated knowledge to the participants might not have been detailed enough to allow for a nuanced and informed decision in favor or against DACCS. Existing research, investigating possible effects of framing of geoengineering technologies, including DACCS, allows for explanations. It is thus likely that most of the participants in this study had heard about DACCS for the first time at the moment they opened the questionnaire. Hence, they could be prone to hold the initial depictions of these technologies as anchors for making sense of discussions revolving around these technologies (Raimi et al., 2019). If individuals were provided with more extensive information and critically engaged with it, acceptability ratings might have been more pronounced. However, previous studies conducted in a focus group setting, where people unfamiliar with geoengineering technologies should engage in discussions about them, showed that even individuals with prior low awareness engaged in critical discussion about geoengineering containing the main aspects of the scientific debates (Wibeck et al., 2015).

Thus, the general low awareness of the majority of our participants paired with a rather positive framing of DACCS might have skewed the acceptability ratings of the technology.

Practical Implications

This study contributed to the small existing body of research on DACCS acceptability by emphasizing the role of environmental identity, independent from political ideology. Therefore, future policies should aim to adress public concerns about the “unnaturalness” of DACCS, especially among individuals with strong environmental identities. By developing communication strategies emphasizing how DACCS can complement natural climate solutions and highlighting its role as a small part of a bigger solution, policymakers could increase public acceptance. Moreover, it is important to involve the public in discussions to gain a deeper insight into their perceptions of DACCS which might stand in conflict with their environmental identity

and underlying values. Understanding the determinants that shape acceptance and support of carbon capture technologies is critical to laying the foundation for addressing public concerns, designing communication strategies, fostering well-informed public debates, and grasping the political feasibility of a large-scale rollout of technologies like DACCS.

Since DACCS is still perceived as "messing with nature", individuals with strong environmental identities are likely to oppose the technology and voice preference for more natural solutions like afforestation. Thus, the utilization of frames analogous to natural processes like "artificial trees" could help to play into people's environmental identity and increase acceptability (Corner et al., 2013). Especially, if studies aim to not decrease support and acceptance, framing DACCS as a minor step towards the solution to a major problem seems to be the most promising approach (Raimi et al., 2019). Being aware of and controlling for aforementioned framing effects could benefit future explorative research looking into the acceptability of DACCS.

Furthermore, high acceptability ratings of DACCS in this study should not be confused with the readiness of these very individuals to actually support local implementation of DACCS facilities once research advances and other roadblocks are being lifted. In previous research, this phenomenon has been framed as "Not in my Backyard-ism" (NIMBYsm) in which people are in favor of e.g. nuclear energy but oppose it once nuclear waste facilities would be implemented locally (in their backyards) (van der Horst, 2007). Although nuclear energy and DACCS are concepts differing in a multitude of aspects, people have been found to use analogies about the storage of nuclear waste to make sense of geoengineering (Cox et al., 2020). Therefore, DACCS could face similar strong resistance since people perceive both risky technologies (Nisbet, 2019). Because DACCS seeks to store CO_2 permanently in geological reservoirs, people who indicated

their acceptance in this questionnaire could switch their minds and oppose large-scale roll-outs if storage took place in their local communities (Bates et al., 2023). Thus, it can be speculated that asking for acceptance of local DACCS implementation could lead to different and more pronounced effects, especially for environmental identity.

In sum, political ideology does not seem to be a main determinant for acceptance of DACCS, at least in this theoretical framework. Rather, a person's environmental identity and how they see themselves in relation to nature takes a significant role in foreshadowing a person's opinion towards DACCS. Since environmental identity has been found to mediate the relationship between environmental values and the acceptance of geoengineering in the past, underlying values are probably more important than a person's political orientation in shaping attitudes and acceptability towards DACCS (Moynihan & Schuitema, 2020). Therefore, the findings of this study suggest that addressing an individual's environmental values through environmental identity could indeed be a policy lever that allows for bipartisan support of DACCS. However, investigation of this idea should be the subject of future research and go beyond the scope of this study.

Conclusion

This study aimed to explore whether environmental identity moderates the relationship between political ideology and public acceptability of DACCS, thereby addressing a gap in the present literature. Although the proposed moderation pathway was not supported by the findings, environmental identity stood out as a significant predictor of acceptability. Therefore, it is important to address people's environmental identity on the way to implement DACCS since it could bridge the ideological divide between left and right. Moreover, investigating which role biospheric values play in this framework could be beneficial for policymakers by engaging the

public in open discussions about their perceptions of DACCS. Future research should continue to explore the determinants of DACCS acceptability, including other predictors that constitute a person's environmental identity, such as environmental values and beliefs. Moreover, longitudinal studies could allow for valuable insights into the evolution of attitudes toward DACCS as public awareness and debate increase. Lastly, investigating the acceptability of local DACCS implementation and potential NIMBY effects would provide a deeper understanding of the possible challenges of deploying this technology.

Appendix A

Political Ideology Scale

	1 Left wing	2	3	4	5	6 Right Wing
Where would you place yourself on such a left-right scale?	o	o	o	o	o	o

Appendix B

Environmental Identity Scale

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Somewhat Agree	5 Agree	6 Strongly Agree
I like to spend time outdoors in natural settings (such as woods, mountains, rivers, fields, local parks, lake or beach, or a leafy yard or garden).	o	o	o	o	o	o
I think of myself as a part of nature, not separate from it.	o	o	o	o	o	o
If I had enough resources such as time or money, I would spend some of them to protect the natural environment.	o	o	o	o	o	o

When I am upset or stressed, I can feel better by spending some time outdoors surrounded by nature.	o	o	o	o	o	o
I feel that I have a lot in common with wild animals.	o	o	o	o	o	o
Behaving responsibly toward nature – living a sustainable lifestyle – is important to who I am.	o	o	o	o	o	o
In general, being part of the natural world is an important part of my self-image.	o	o	o	o	o	o
An important part of my life would be missing if I was not able to get outside and enjoy nature from time to time.	o	o	o	o	o	o

Being a part of the ecosystem is an important part of who I am.	o	o	o	o	o	o

Appendix C

Acceptance of DACCS Scale

	1 Strongly disagree	2 disagree	3 Somewhat disagree	4 Somewhat agree	5 agree	6 Strongly agree
I find the use of DACCS technology acceptable	o	o	o	o	o	o
I find it acceptable to implement DACCS technology in my country	o	o	o	o	o	o
I find it acceptable to use DACCS technology to reach global climate goals	o	o	o	o	o	o
I find it acceptable to use more DACCS technology in my country than is used now	o	o	o	o	o	o

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