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'Yes, we care': pro-environmental social identity framing to promote acceptance of decentralized wastewater treatment systems

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ABSTRACT

Decentralized wastewater treatment systems can help mitigate the water crisis. Their successful implementation depends not only on their technological design but also on the level of public support. We aim to assess how a pro-environmental social identity framing in which we present a decentralized wastewater treatment system as an environmentally responsible neighborhood initiative may increase public support of these systems. Two experimental studies examined the impact of pro-environmental social identity framing on public acceptance of decentralized wastewater systems in Groningen (the Netherlands) ($n = 92$) and Santiago de Compostela (Spain) ($n = 208$). As expected, pro-environmental social identity framing increased public acceptance in both studies, irrespective of the extent to which people identify with their neighborhood. Specifically, participants in the pro-environmental social identity framing condition displayed more positive attitudes, more positive and less negative emotions, and higher voting intentions toward the decentralized wastewater systems compared to those in the control condition. These results suggest that connecting such systems to shared neighborhood identities can be an effective strategy for overcoming barriers to their implementation. Our study offers valuable insights for policymakers, community leaders, and environmental advocates to craft messages to promote the adoption of decentralized wastewater systems.

Key words: decentralized wastewater treatment systems, pro-environmental social identity framing, public acceptance, social influence, sustainable initiatives

HIGHLIGHTS

- The neighborhood plays a key role in influencing decentralized wastewater system acceptance.
- Pro-environmental social identity framing positively influences perceptions about these systems.
- Portraying the technology as a community initiative generates more positive and fewer negative emotions toward this technology.

1. INTRODUCTION

Many regions in the world face an uncertain future concerning their water resources (Mekonnen & Hoekstra 2016). The growing world population, improving living standards, changing consumption patterns, and the expansion of irrigated agriculture are all contributing to an increasing global demand for this essential resource (Vörösmarty *et al.* 2010). This mounting pressure on water resources is causing deterioration in freshwater supplies, both in terms of quantity due to overexploitation and drought and quality due to pollution and eutrophication (Ganoulis 2009). Thus, even in regions with abundant water and regular rainfall, water problems may exist due to the diminishing quality of available water resources. For this reason, the United Nations has issued a warning emphasizing the urgent need for countries and regions to tackle the critical problems related to water and sanitation (UN 2023).

One promising solution to this water crisis lies in the adoption of decentralized wastewater treatment systems (Rittmann 2013). These systems defy the prevailing philosophy of 'flush and forget' (Nair 2013) and challenge the convention of getting rid of the waste far from home. Decentralized wastewater systems facilitate the recovery of water and valuable nutrients for reuse, promoting the circular economy (Lens *et al.* 2005; Roefs *et al.* 2017). Furthermore, compared to current centralized water systems, decentralized systems are not only more environmentally sustainable (Poortvliet *et al.* 2018) but also cheaper

in the long run (Libralato *et al.* 2012). Decentralized wastewater systems are thus a promising alternative to address water problems.

Yet, despite the urgency of addressing the water crisis and the advantages of decentralized wastewater systems, people are resisting their implementation (Mankad & Tapsuwan 2011). Low acceptance may partly be explained by the short-term costs of decentralized wastewater systems for residents (including installation, maintenance, and location-based costs) compared to centralized systems (Mankad & Tapsuwan 2011). However, even decentralized systems, which are shared by multiple households and are therefore more cost-efficient (Lee *et al.* 2018), face low acceptance, partly because people are disgusted by sharing wastewater with others outside of their household (Contzen *et al.* 2023). A key question is therefore under which conditions people accept decentralized wastewater systems in their neighborhood.

Only a few studies have examined the acceptance of decentralized wastewater systems, with particularly few studying the acceptance of such systems in neighborhoods (for reviews, see Gómez-Román *et al.* 2020; Contzen *et al.* 2023). So far, research suggests that people who are more aware of water problems (Dolnicar *et al.* 2011), and who are more strongly motivated to protect the environment, evaluate decentralized wastewater systems as more acceptable (Gómez-Román *et al.* 2020). As such, strengthening people's problem awareness and environmental motivations, or making these more accessible, can be a successful strategy to boost acceptance (Gómez-Román *et al.* 2021). Yet, no studies have considered how others influence people's acceptance of the implementation of these systems (Contzen *et al.* 2023).

We propose that decentralized wastewater systems in neighborhoods are likely to make people aware that they share their wastewater with their neighbors. As such, this group can influence an individual's acceptance of such systems. In the present paper, we test whether stressing that if the neighborhood values protecting the environment in general and supports the decentralized wastewater system specifically it can enhance people's acceptance of such systems.

1.1. Social influence and pro-environmental behavior

Generally, there is increased recognition that social influence strategies can increase pro-environmental behaviors (e.g., Cialdini 2003). For example, a meta-analysis examining the impact of various social influence interventions (e.g., social norms information or block leader approach) to boost pro-environmental behaviors suggests that such interventions are generally effective (although not always) and slightly more effective than, for example, providing information (Abrahamse & Steg 2013). Similarly, a review suggests that social norm interventions can be effective at inducing significant changes in pro-environmental behavior (Farrow *et al.* 2017; see also Keizer & Schultz 2018). In the field of sustainable energy technology acceptance, social norms appear to predict technology acceptance (Huijts *et al.* 2012), and there is preliminary evidence that social norms play a role in the acceptance of centralized wastewater systems too (Fielding *et al.* 2018; Contzen *et al.* 2023). While the acceptance of products derived from these decentralized wastewater treatment systems, such as recycled water or nutrients, has been studied under the perspective of social influence (Schultz & Fielding 2014; Leong & Lebel 2020; Liu *et al.* 2022), the same cannot be said for the installation of these systems itself.

Although there is general evidence that social influence strategies can be effective in promoting pro-environmental behaviors, the literature points to a gap in understanding of what drives these effects (for example, a block leader approach appears more effective than social norms information; Abrahamse & Steg 2013; Farrow *et al.* 2017). A social identity perspective on social influence offers insights into the conditions under which and why social influence strategies are more likely to be successful (Fielding & Hornsey 2016, Fritsche *et al.* 2018; Jans & Fielding 2018; Lede *et al.* 2019). Specifically, it clarifies that the influence of others depends on shared group membership and goes against the notion of social influence as an extrinsic motivation for behavior. According to the social identity approach (Tajfel & Turner 1979; Turner *et al.* 1987), individuals derive part of their identity – their social identity – from their knowledge of and emotional attachment to group(s), such as their nationality or their neighborhood. When people think about themselves in terms of a member of a specific group, or when a group membership becomes salient, they internalize this group into their self-concept and aim to act in line with the internalized group's motivations and advance the interests of that group as a whole (Turner 1991). Furthermore, such a shared identity facilitates mutual influence, collaboration, and the sharing of resources, as group members see each other as a 'we', and thus alike. As a result, the social identity approach clarifies which 'others' are likely to influence our behavior and why norms (and other indicators of the group's motivation) can intrinsically motivate (pro-environmental) behavior. Specifically, when one strongly identifies with a group with strong pro-environmental motivations, this pro-environmental social identity is likely to motivate pro-environmental behavior (Masson *et al.* 2016; Jans 2021).

As decentralized wastewater systems make people in a neighborhood share their wastewater, we propose that the neighborhood could be a key group membership for influencing the acceptance of such systems. Specifically, we expect people to be more accepting of decentralized wastewater systems when the membership of the neighborhood is salient and when the neighborhood is perceived to be supportive of this sustainable system and of protecting the environment in general.

1.2. Using pro-environmental social identity framing to induce acceptance

Based on the previous, we reason that emphasizing the neighborhood's pro-environmental social identity in the communication about the decentralized wastewater treatment system may enhance its acceptance. Social identity framing is a communication tool that links social identity to the intended pro-environmental behavior by stressing that this new behavior is a normative part of who the group members are and what they stand for (Seyranian 2014; Seyranian *et al.* 2015). To effectively implement social identity framing, it is crucial to use inclusive language that serves two key purposes. First, it helps in clarifying and defining the social identity within the group. Second, it contributes to the construction of a shared understanding of who the group members are and how they should collectively act. In doing so, it becomes possible to convey which specific attitudes, values, or behaviors are considered typical for that group (Seyranian 2013). Some experimental studies have shown that using such a social identity frame with highly inclusive language levels promotes a positive perception of sustainable alternatives. For instance, the use of inclusive language, compared to individual language, promoted greater support for renewable energy to the extent that it was perceived as a group norm (Seyranian 2014; Seyranian *et al.* 2015; see also Lede *et al.* 2019). Hence, by using inclusive language in the messaging around decentralized wastewater systems, such as 'our neighborhood' and 'we', while also emphasizing the group's pro-environmental motivations and support of the system, a pro-environmental neighborhood identity can be made salient. Such a pro-environmental social identity may further be strengthened by emphasizing that the sustainable decentralized wastewater system was proposed by residents of the neighborhood themselves. When pro-environmental initiatives are perceived to have been formed from the bottom up, by members of the group rather than by external parties, the perceived pro-environmental motivations of the group will increase, and the level of identification with this group will be strengthened (Jans 2021). Thus, we expect that the acceptance of decentralized wastewater systems can be increased by using inclusive language, emphasizing the neighborhood's pro-environmental motivations, and the neighborhood's involvement in the plans for its implementation.

Pro-environmental social identities are generally described as fluid and context-dependent, as they are bound to the salience of a particular group membership (Fielding & Hornsey 2016; but see Postmes *et al.* 2013; Jans 2021). This raises the question of whether the effects of pro-environmental social framing in the communication about a decentralized wastewater system are limited to the acceptance of this system in the neighborhood or if they may have broader implications for how individuals perceive their own environmental self-identity. Environmental self-identity – the self-perception that one is a person who behaves pro-environmentally – has been identified to motivate a broad range of pro-environmental behaviors across situations (Van der Werff *et al.* 2013a, 2013b, 2014; Van der Werff & Steg 2016). If pro-environmental social identity framing also boosts people's environmental self-identity, the impact of such messaging is likely wider and less context-dependent.

We further argue that the influence of social identity framing may be stronger for those who are more highly identified with their neighborhood (Ellemers *et al.* 1999). Previous research suggests that group norms have a stronger influence on pro-environmental behavior the more strongly one identifies with the group (e.g., Masson *et al.* 2016). Thus, even though we assume the pro-environmental social identity framing will make the pro-environmental neighborhood identity salient, people's level of identification with their neighborhood before receiving this message may affect how attentive they are to this message and how influenced they are by it. We will, therefore, examine whether the effects of pro-environmental social identity framing depend on how much people are already identified with their neighborhood.

1.3. The present research

In the present paper, we aim to test whether a pro-environmental social identity framing can increase acceptance of a decentralized wastewater system in one's neighborhood, as well as people's pro-environmental self-perceptions (i.e., environmental self-identity). In addition, we examine whether pro-environmental social identity framing effects may be stronger among those who strongly identify with their neighborhood.

We tested the effect of pro-environmental social identity framing (vs. a control condition) on acceptance of decentralized wastewater treatment systems in two experimental studies in the Netherlands and Spain. By replicating the study in two

distinct cultural and geographical settings, we aim to mitigate the risk of context-specific biases and ensure that the observed effects are robust and not limited to a single population (Cronbach *et al.* 1972).

In both studies, participants were presented with a scenario involving the installation of a decentralized wastewater treatment system in their neighborhood and read information about the functioning of such a system, potential costs and benefits of its implementation. Given that prior research (Hegger *et al.* 2008; Domènech 2011; Gómez-Román *et al.* 2020) has consistently found that highlighting the environmental benefits of the system fosters acceptance, the text emphasized these environmental benefits in both conditions. However, in the social identity framing condition, participants also read that the decentralized system was presented as a neighborhood plan in line with their shared commitment to protect the environment, using inclusive language (see the Supplementary Materials for the complete text of both control and experimental conditions).

In the context of this paper, we consider acceptance as 'the favorable or positive reaction towards the implementation or adoption of [a proposed technology] by the members (individuals and collective actors) of a given society (country or region, community or town, and household) (Oltra *et al.* 2014, p. 7). Therefore, we assess the impact of pro-environmental social identity framing on cognitions (perceptions and beliefs about the system), affect (emotions produced by the system), and behavioral intentions (voting intentions in favor of the system) in response to a decentralized wastewater system in one's neighborhood.

We aimed to replicate the study in two European cities with distinctive water problems to test the robustness of our findings: Groningen (Study 1) and Santiago de Compostela (Study 2). These are two medium-sized cities in the north of the Netherlands and the Northwest of Spain, respectively. Both cities are University cities and students who moved to study there is a large part of these populations, making them a relevant sample for studying community-based interventions. In Groningen, approximately 56,000 students constitute almost 25% of the city's total population of 238,000 inhabitants (Municipality of Groningen 2024). Similarly, in Santiago de Compostela, about 33,000 students make up approximately 28.45% of the city's 116,000 inhabitants (Galician Seminar of Nonparametric Statistical Inference 2016). The University of Groningen ethics committee and Santiago de Compostela bioethics committee approved the study (PSY-1819-S-0218). All data and materials used in this research are publicly accessible (Open Science Framework 2023).

2. STUDY 1

Study 1 was conducted in Groningen, a city in the North of the Netherlands. The Netherlands is confronted with both drought and prolonged wet periods. According to a recent report by the Rijksinstituut voor Volksgezondheid en Milieu (RIVM; Dutch National Institute for Public Health and the Environment), the Dutch National Institute for Public Health and the Environment (Leerdam *et al.* 2023), water availability was sufficient to produce drinking water for the whole of the Netherlands (approximately 1.4 billion m^3) in 2020. Nevertheless, the report notes that Groningen is one of the Dutch provinces where there are already shortages in drinking water, which are assumed to increase if no measures are taken. As such, the context of Groningen is a relevant case to examine the acceptance of decentralized wastewater systems to address water problems.

2.1. Method

2.1.1. Participants and design

We aimed to obtain a sample size of 102 to detect a medium-sized effect ($d = 0.5$) with a one-tailed t-test comparing two independent groups with a power of 0.80, $\alpha = 0.05$ (Rosenthal & Rosnow 1985; Erdfelder *et al.* 1996). A total of 230 students from the University of Groningen were invited to participate in the research. Forty percent accepted to complete the questionnaire ($N = 92$ participants, 56.5% women, $M_{age} = 20.50$; Standard Deviation (SD) = 2.44). The sample size was thus only slightly lower than intended. Participants were randomly assigned to either the social identity framing condition ($n = 45$) or the control condition (Groningen $n = 47$).

2.1.2. Procedure and manipulation

Participants were recruited through convenience sampling by asking students in front of the university library to participate in research on students' perceptions about different issues across countries. Those who agreed to participate received a link to an online questionnaire (in Qualtrics). The questionnaire was designed in English, as the university has many international

students and many study programs are offered in English. Before starting the survey, participants received information about the study's objectives and were asked for informed consent.

The questionnaire started with some demographic questions and assessed participants' identification with the neighborhood. Next, participants were asked to carefully read a text about decentralized wastewater systems, with information about the technology (see the Supplementary Materials for the complete text). Specifically, the text stressed the environmental benefits of the system, as well as some other advantages (e.g., saving water and recovering phosphorus) and disadvantages (e.g., unpleasant odors and installation and maintenance costs). After having read the text, participants were asked to imagine that there was a plan to install a decentralized wastewater treatment system in their neighborhood block. In the pro-environmental social identity framing condition, it was explicitly stated to imagine that the plan came from their neighborhood because the neighborhood is very committed to environmental sustainability, using inclusive language (see the Supplementary Material for the full texts in both conditions). The pro-environmental social identity of the community was further emphasized in the title of the text: 'Your neighborhood cares: A sustainable decentralized wastewater treatment system.' In contrast, this was not highlighted in the control condition: 'A sustainable decentralized wastewater treatment system.' After reading the text, we asked participants about their acceptance of the system, as well as their environmental self-identity, followed by some manipulation checks.

2.2. Measures

In this section, we outline the variables under investigation and the methods employed to measure them. All descriptive statistics, reliability coefficients, and correlation coefficients are displayed in Table 1.

2.2.1. Identification with the neighborhood

Identification with the neighborhood with whom they would share the system was measured using four items as recommended by Postmes *et al.* (2013), on a 7-point Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*): 'I identify with the inhabitants of my neighborhood', 'I feel committed to the inhabitants of my neighbourhood', 'I am glad to be an inhabitant of my neighbourhood', 'Being an inhabitant of my neighbourhood is an important part of how I see myself'. To make sure that people would have the neighborhood block in mind in which a decentralized wastewater system could be installed, we introduced the neighborhood as follows: 'People usually share several facilities with their neighbors, such as garbage containers, water systems and the public lighting system. The following questions are about the neighbors living nearest to you, with whom you may share such facilities. We refer to this as your 'neighborhood', and to the people as 'the inhabitants in my neighborhood'.

2.2.2. Cognitive acceptability

We assessed the cognitive component of acceptance with the four-item acceptability scale proposed by Liu *et al.* (2019). Participants had to indicate on a 7-point scale to what extent they thought the decentralized plant project in their neighborhood was: (a) *very unacceptable–very acceptable*, (b) *very bad–very good*, (c) *very negative–very positive* and (d) *very unnecessary–very necessary*. We computed the mean scores on these four items on a 7-point scale, reflecting participants' cognitive acceptability of the system.

Table 1 | Descriptive statistics for the Groningen sample

Variables	α	*M*	*SD*	1	2	3	4	5
1. Neighborhood identification	0.80	4.20	1.22					
2. Cognitive acceptability	0.92	5.15	1.29	0.127				
3. Positive affect	0.91	4.37	1.18	0.064	0.738***			
4. Negative affect	0.90	2.44	1.23	0.007	− 0.640***	− 0.675***		
5. Voting intention	–	5.21	1.19	0.177	0.743***	0.725***	− 0.639***	
6. Environmental self-identity	0.94	5.27	0.99	0.141	0.168	0.138	− 0.132	0.098

* for $p < .05$, ** for $p < .01$, and *** for $p < .001$.

2.2.3. Affective acceptance

We asked participants to what extent they experience different positive and negative emotions (Contzen *et al.* 2021) toward the decentralized system project in their neighborhood (scores ranging from 1 = *Not at all* to 7 = *A lot*). We computed the mean scores on the items reflecting positive affect (excited, relieved, happy, satisfied, comfortable, optimistic, and proud) and negative affect (afraid, upset, disappointed, worried, angry, disgusted, and powerless), respectively.

2.2.4. Voting intention

The voting intention was measured using a single item on a scale from 1 (*definitely against*) to 7 (*definitely in favor*): 'If you were asked to vote for the implementation of a decentralized wastewater treatment system in the neighborhood where you live, how would you vote?'.

2.2.5. Environmental self-identity

Environmental self-identity was assessed with three items (Van der Werff *et al.* 2013a) on a 7-point Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*): 'I am the type of person who acts environmentally friendly', 'Acting environmentally friendly is an important part of who I am', and 'I see myself as an environmentally friendly person'.

2.2.6. Manipulation checks

We included two checks to assess whether our social identity framing manipulation worked as intended. First, we assessed participants' perceptions regarding their neighbors' acceptance of the decentralized wastewater treatment system, with two statements on a 7-point Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*): 'Inhabitants of my neighborhood would like to have a decentralized wastewater treatment system' and 'Inhabitants of my neighborhood would be very much against a decentralized wastewater treatment system' (reversed coded) ($M = 4.56$, $SD = 1.14$, $r = 0.48$, $p < .001$). Second, we assessed the perceived environmental group identity at the neighborhood level (Wang *et al.* 2021) on a 7-point Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*). These three items mimic those of environmental self-identity, yet referring to 'My neighbors', rather than 'I' (i.e., 'My neighbors are the type of people who act environmentally friendly' ($M = 3.89$, $SD = 1.08$, $\alpha = 0.84$).

Besides these manipulation checks, we also checked whether decentralized wastewater systems make participants more aware of with whom they are sharing their wastewater on a 7-point Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*), with the following statement: 'The installation of this decentralized system makes me more aware of who I am sharing wastewater with.' ($M = 4.72$, $SD = 1.42$).

2.3. Results and discussion

2.3.1. Manipulation check

Our manipulation worked as intended. Participants in the social identity framing condition indicated that their neighbors evaluate the decentralized wastewater system as more acceptable ($M = 4.96$, $SD = 1.26$) than participants in the control condition ($M = 4.22$, $SD = 1.11$); $t_{(90)} = 3.44$, $p = .001$, Cohen's $d = 0.72$. Similarly, participants in the experimental condition considered their neighbors to have a stronger environmental group identity ($M = 4.22$, $SD = 0.12$) than those in the control condition ($M = 3.58$, $SD = 0.95$); $t_{(90)} = 2.96$, $p = 0.004$, Cohen's $d = 0.62$.

Next, in line with what was expected, participants in both conditions indicated that decentralized wastewater systems made them more aware of whom they were sharing their wastewater with. With scores slightly higher than the midpoint, with no significant difference between the experimental ($M = 4.67$, $SD = 1.48$) and the control group ($M = 4.77$, $SD = 1.39$); $t_{(90)} = 0.33$, $p = 0.740$, Cohen's $d = 0.07$.

2.3.2. Effects of pro-environmental social identity framing on acceptance and environmental self-identity

We used Student's *t*-test to test our hypotheses.[1] The results showed that, as expected, the social identity framing significantly increased the cognitive, affective, and behavioral acceptance of a decentralized wastewater system (see Table 2), with large

[1] In addition to studying the effects separately for the two countries, we also conducted analyses with the variable 'country' as a covariate. These analyses showed very similar results to what we report in the paper and thus yielded the same conclusions. As our aim was to replicate the study in different countries, rather than performing a comprehensive cross-country comparison, we report the results separately for the two countries. Detailed results of these Analysis of Covariance (ANCOVA) analyses are provided in the Supplementary Materials.

Table 2 | Differences between conditions in acceptance of decentralized wastewater treatment systems and environmental self-identity

	Experimental		Control				
Measure	***M***	***SD***	***M***	***SD***	***t***	***p***	**Cohen's *d***
Cognitive acceptability	5.99	0.81	4.35	1.16	7.84	<0.001	1.63
Positive affective component	5.23	0.73	3.56	0.92	9.57	<0.001	1.99
Negative affective component	1.68	0.82	3.17	1.12	−7.26	<0.001	−1.51
Voting intention	5.87	0.87	4.57	1.12	6.17	<0.001	1.29
Environmental self-identity	5.40	0.94	5.14	1.05	1.25	0.216	0.26

effect sizes (i.e., $d > 0.80$; Cohen 1992). When the decentralized wastewater system was presented as endorsed by the neighborhood, participants ascribed more positive qualities to the system, experienced more positive and less negative emotions toward the system, and were more likely to vote in favor of this system compared to when no pro-environmental social identity framing was used.

However, we did not find a significant difference between participants in the control and social identity framing conditions on environmental self-identity, indicating that impact may be contextually bounded to acceptance of the system (see Table 2). Furthermore, as shown in Table 1, correlations between environmental self-identity and acceptance indicators were not statistically significant, suggesting that the pro-environmental social identity framing has a stronger influence on acceptance of decentralized wastewater systems than environmental self-identity.

Next, we explored whether neighborhood identification moderated the effects of social identity framing on the outcome variables. We found no differences between conditions in neighborhood identification before the manipulation ($M_{exp} = 4.23$, $SD_{exp} = 1.33$; $M_{ctrl} = 4.18$, $SD_{ctrl} = 1.12$; $t_{(90)} = 0.18$, $p = 0.85$, Cohen's $d = 0.04$). We conducted moderation analyses using the PROCESS macro model 1, 10,000 bootstrapping samples (Hayes 2013), and found that the effect of pro-environmental social identity framing manipulation on different indicators of acceptance did not differ depending on the previous level of identification with the neighbors (see the Supplementary Materials for all test statistics for these analyses).

The results of Study 1 show that a decentralized wastewater treatment system makes people aware of whom they are sharing their water with. When the initiative for a decentralized wastewater treatment system is presented as coming from the neighborhood, because the neighborhood cares about environmental sustainability, people accept the system more. This is reflected by higher levels of cognitive acceptability, more positive and less negative affect, and stronger intentions to vote in favor of the system compared to when the information about such a system is provided without reference to the neighborhood's support for this system. This effect does not depend on the level of identification with the neighborhood. These results suggest that emphasizing that the neighborhood cares about sustainability and proposes the implementation of a decentralized wastewater treatment system may be an effective strategy to overcome barriers to implementing such a system. The influence of the pro-environmental social identity frame did not affect the extent to which individuals perceived themselves as a pro-environmental person, and as such, effects might be limited to the acceptance of this specific system. Interestingly, we found that environmental self-identity was not significantly related to acceptance, suggesting that in the context of decentralized wastewater systems that are shared with other neighbors, acceptance particularly depends on social influence.

3. STUDY 2

To test the generalizability of the findings of Study 1, we aimed to replicate the findings in another city in another country: Santiago de Compostela, located in the region of Galicia, in the northwest of Spain. Galicia is well known for its abundant rainfall, gaining its reputation as the rainiest region in the country (AEMET 2023). An example of its abundance is that Santiago de Compostela collected 1,726.7 L/m^2 of precipitation in 2022 (Observatorio Astronómico Ramón María Aller 2023). The water issue in this region is therefore not a matter of quantity but rather of quality. Recent studies have highlighted the impacts of anthropogenic global warming and pollution in this region, drawing attention to the escalating water problems associated with the eutrophication of watersheds (Álvarez *et al.* 2017; García-Moreiras *et al.* 2018). This emphasizes the need for innovative water treatment technologies. However, as rainfall is abundant in this region, the local population is not very aware of the water problems, and as such is rather resistant to decentralized wastewater systems in their neighborhood (Gómez-Román *et al.* 2020).

3.1. Method

3.1.1. Participants and design

Similarly to Study 1, we aimed to obtain a sample size of 102 to detect a medium-sized effect ($d = 0.5$) with a one-tailed t-test comparing two independent groups, with a power of 0.80, $\alpha = 0.05$ (Erdfelder *et al.* 1996). We approached nearly 400 students in front of the university library, of whom 52% accepted to participate; our sample ($N = 208$) was thus higher than planned. Among them, 72% were women ($M_{age} = 20.88$; $SD = 2.44$). We randomly assigned 105 participants to the social identity framing condition and 103 to the control condition.

3.2. Procedure, manipulation and measures

The procedure and measures of Study 2 were identical to those of Study 1 (see Table 3, for the overview of descriptive statistics). For the Santiago de Compostela sample, the questionnaire was translated into Spanish and Galician by two native speakers and checked for accuracy by three additional native speakers. As manipulation checks, we again assessed participants' perception regarding their neighbors' acceptance of the decentralized wastewater treatment system ($M = 4.59$, $SD = 1.05$; $r = 0.47$, $p < 0.001$); the perceived environmental group identity at the neighborhood level ($M = 3.82$, $SD = 1.07$; $\alpha = 0.86$); and awareness of with whom they are sharing their wastewater ($M = 4.87$, $SD = 1.44$).

3.3. Results and discussion

3.3.1. Manipulation checks

The manipulation again worked as intended. As in Study 1, participants in the pro-environmental social identity framing condition perceived their neighbors' acceptability of the decentralized wastewater system to be higher ($M = 5.04$, $SD = 1.11$) than in the control condition ($M = 4.14$, $SD = 0.99$); $t_{(206)} = 6.17$, $p = 0.001$, Cohen's $d = 0.86$). Similarly, participants in the pro-environmental social identity condition considered their neighbors to have a higher environmental identity ($M = 4.11$, $SD = 0.96$) than in the control condition ($M = 3.83$, $SD = 1.19$); $t_{(206)} = 3.83$, $p = 0.001$, Cohen's $d = 0.54$.

Furthermore, participants again indicated that a decentralized wastewater treatment system made them more aware of whom they were sharing wastewater with: participants scored higher than the midpoint, with no differences between the experimental ($M = 4.76$, $SD = 1.55$) and the control group ($M = 4.98$, $SD = 1.32$); $t_{(206)} = 1.09$, $p = 0.275$, Cohen's $d = 0.15$.

3.3.2. Effects of pro-environmental social identity framing on acceptance and environmental self-identity

As in the Groningen sample (Study 1), the pro-environmental social identity framing increased acceptance of the decentralized wastewater systems compared to the control condition in which no such framing was used. Specifically, participants ascribed more positive qualities to the system and experienced more positive and less negative emotions toward the system, and were more likely to vote in favor of this system compared to when no pro-environmental social identity framing was used. Furthermore, in Study 2, participants in the pro-environmental social identity frame condition more strongly saw themselves as a pro-environmental person, compared to participants in the control group, with a small to medium effect size (see Table 4).

Given that in Spain, pro-environmental social identity framing affected environmental self-identity, and that environmental self-identity was positively related to some indicators of acceptance (Vila-Tojo *et al.* 2022), we examined whether the effects of

Table 3 | Descriptive statistics for the Santiago sample

Variables	α	*M*	*SD*	1	2	3	4	5
1.Neighborhood identification	0.82	4.51	1.10	1				
2.Cognitive acceptability	0.94	5.38	1.28	0.163*	1			
3.Positive affect	0.93	4.59	1.22	0.172*	0.732***	1		
4.Negative affect	0.90	2.25	1.13	0.045	− 0.643***	− 0.702***	1	
5.Voting intention	-	5.38	1.25	0.140*	0.797**	0.675***	− 0.600***	1
6.Environmental self-identity	0.92	5.30	1.07	0.114	0.174*	0.238***	− 0.132	0.065

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 4 | Differences between conditions in acceptance of decentralized wastewater treatment systems and environmental self-identity

	Experimental		Control				
Measure	***M***	***SD***	***M***	***SD***	***t***	***p***	**Cohen's *d***
Cognitive acceptability	6.20	0.60	4.48	1.15	14.05	<0.001	1.95
Positive affect	5.53	0.47	3.63	0.97	18.12	<0.001	2.51
Negative affect	1.55	0.35	2.97	1.20	−11.58	<0.001	−1.61
Voting intention	6.16	0.77	4.58	1.13	11.76	<0.001	1.63
Environmental self-identity	5.53	0.94	5.05	1.15	3.19	0.002	0.45

pro-environmental social identity framing are upheld when we control for environmental self-identity as a predictor of acceptance in a multiple linear regression analysis.

The regression analyses indicate that environmental self-identity is not a significant predictor of any of the acceptance variables (cognitive acceptability: $\beta = 0.022$, $p = 0.679$; positive affect: $\beta = 0.035$, $p = 0.134$; negative affect: $\beta = 0.010$, $p = 0.862$; voting intention: $\beta = -0.079$, $p = 0.160$); whereas the effects of pro-environmental social identity condition remain significant (cognitive acceptability: $\beta = 0.686$, $p < 0.001$; positive affect: $\beta = 0.766$, $p < 0.001$; negative affect: $\beta = -0.638$, $p < 0.001$; voting intention: $\beta = 0.651$, $p < 0.001$). This underlines the critical role of social identity framing for enhancing acceptance of decentralized wastewater treatment systems that are shared with others.

Similar to Study 1, we performed a moderation analysis using model 1 of the PROCESS macro, to explore whether identification with the neighborhood moderated effects of pro-environmental social identity framing on the indicators of acceptance. As in the Groningen sample, no differences were found in the level of identification (before the manipulation) with the neighborhood between the two conditions ($M_{exp} = 4.63$, $SD_{exp} = 1.15$; $M_{ctrl} = 4.39$, $SD_{ctrl} = 1.05$; $t_{(206)} = 1.53$, $p = 0.128$, Cohen's $d = 0.02$). However, in Study 2, even though main effects of condition remain significant, identification with the neighborhood moderated the effect of pro-environmental social identity framing on positive affect ($B = 0.22$, $SE = 0.09$, $p = 0.019$) and voting intention ($B = -0.24$, $SE = 0.12$, $p = 0.047$), but identification with the neighborhood did not moderate the effect of pro-environmental social identity framing on cognitive acceptability, negative affect, and environmental self-identity (see the Supplementary Materials for all test statistics for these analyses). Specifically, for positive affect, the effect of social identity framing was stronger, the higher the participant's level of identification with the neighborhood (see Figure 1). However, for voting intention, we observe the opposite trend: the impact of social identity framing on voting intentions weakens as participants identify more strongly with their neighborhood. As depicted in Figure 2, participants who more strongly identify with their neighborhood are generally more likely to vote in favor of a decentralized wastewater system, in the control condition. Whereas, in the experimental condition, identification does not affect voting intentions.

In general, the results in Study 2 replicate those of Study 1, with some differences. In Spain, a decentralized system also raises awareness of whom people are sharing their wastewater with. Furthermore, people are more accepting of a decentralized wastewater treatment system when information about such a system is accompanied by a pro-environmental social identity frame emphasizing that it is a sustainable neighborhood initiative than without such a frame. Furthermore, in Spain, a pro-environmental social identity frame also increased environmental self-identity. This suggests that such a frame might motivate people more generally to engage in pro-environmental behavior as people are motivated to act in line with how they see themselves (Van der Werff *et al.* 2013a, 2013b, 2014). Importantly, as in Study 1, the pro-environmental social identity frame is more predictive of acceptance of a decentralized wastewater treatment system than environmental self-identity, underlining the importance of social influence for acceptance of decentralized wastewater systems at the neighbor level.

Furthermore, in Spain, the effect of pro-environmental social identity framing on positive affect and voting intentions depended on the level of neighborhood identification. The patterns of these results were inconsistent; while trends observed for positive affect coincided with expectations, those for voting intention were not. Specifically, higher identification with the neighborhood weakened the positive effect of social identity framing on voting intentions, with higher identification increasing voting intentions in the control condition. These findings need future examination (see further 'General Discussion' Section).

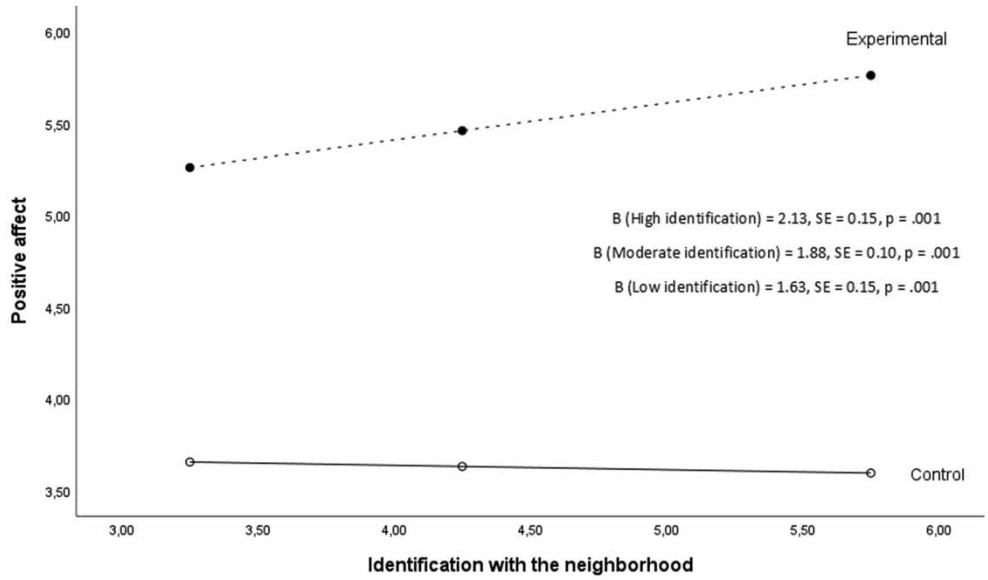

Figure 1 | Moderating effect of identification with the neighborhood on the relationship between pro-environmental social identity framing on positive affect.[2]

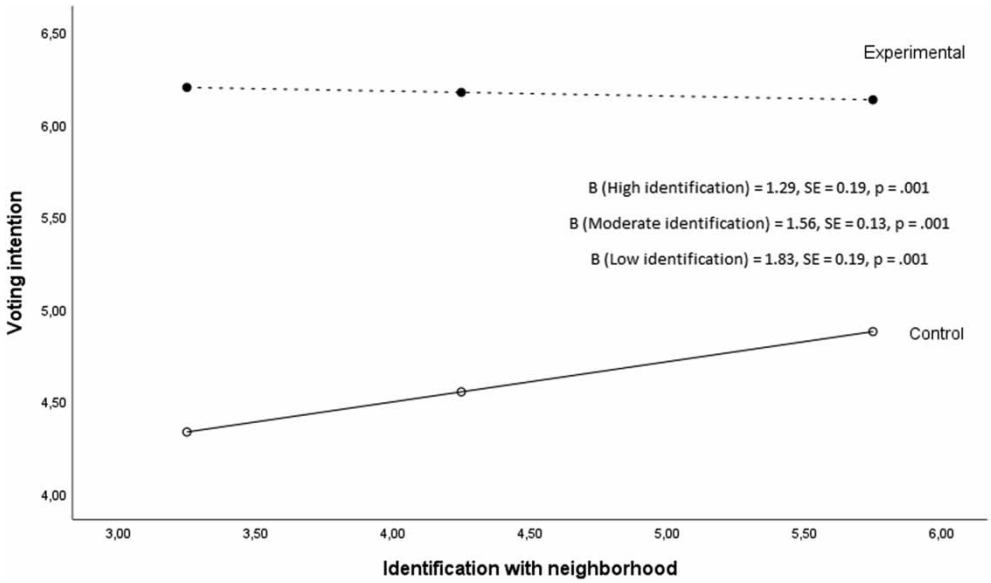

Figure 2 | Moderating effect of identification with the neighborhood on the relationship between pro-environmental social identity framing on voting intention.

4. GENERAL DISCUSSION

The urgency of addressing climate change and the imminent water crisis (United Nations 2023) makes it crucial to explore innovative approaches to tackle these issues. Among potential solutions, decentralized wastewater treatment systems offer a promising pro-environmental alternative. However, their successful implementation hinges on overcoming the challenge of public acceptance (Hurlimann & Dolnicar 2016). Extending previous research about acceptance of these systems (Mankad &

[2] To enhance visual clarity, the *x* and *y* axes in the figures do not commence at zero, but instead cover a broader range. This adjustment has been made to better illustrate the trends and patterns within the data.

Tapsuwan 2011; Mankad 2012; Gómez-Román *et al.* 2021), our primary aim was to assess the influence of the neighborhood's pro-environmental social identity on public acceptance of decentralized wastewater treatment systems. We reasoned that decentralized wastewater systems make people aware of whom they are sharing their wastewater with, and as such, this group may influence the acceptance of such systems. Our hypothesis was that emphasizing the neighborhood's pro-environmental identity and that the system was proposed by the neighborhood (rather than as merely an environmentally responsible system) would enhance acceptance of the system, as reflected in higher overall acceptance, more positive and less negative affect, and more likelihood of voting in favor of the system. Besides increasing acceptance, we examined whether such a frame could also increase people's environmental self-identity, creating a stronger general motivation to engage in pro-environmental behaviors in the future.

The results showed that, as expected, a pro-environmental social identity frame resulted in a higher acceptance of decentralized wastewater treatment systems in both countries compared to merely providing information, including the environmental benefits of the system. Specifically, when people see a decentralized wastewater system as a neighborhood environmental initiative that aligns with the neighborhoods' pro-environmental motivations, they: (a) find the system more acceptable, (b) experience more positive and less negative emotions toward the system, and (c) are more inclined to vote in favor of a decentralized wastewater system. By using a pro-environmental social identity frame, we found effects much larger than those generally found for social influence strategies to boost pro-environmental behaviors (Abrahamse & Steg 2013).

Previous research on social influence strategies to promote pro-environmental behavior has been criticized for not considering why they may be effective and, as such, providing little insight into how social influence strategies can be designed more effectively (Abrahamse & Steg 2013; Van Valkengoed *et al.* 2023). Our findings underscore the importance of pro-environmental social identities for promoting pro-environmental behaviors (Fritsche *et al.* 2018; Jans 2021), and extend previous research by showing it can also foster acceptance of novel sustainable alternatives, such as decentralized wastewater treatment systems. A social identity perspective can help to foster the effectiveness of strategies targeting social factors by recognizing that group members can intrinsically motivate people to engage in behaviors, as groups form an important part of our social identity. Specifically, by emphasizing shared group membership through inclusive language ('We'), highlighting the group's pro-environmental goals and norms, and stressing that the initiative came from the group themselves, people are motivated to act in line with their group's pro-environmental identity and more likely to accept a decentralized wastewater system in their neighborhood.

Such pro-environmental social identity framing may be particularly effective in promoting acceptance of novel sustainable systems where there is little preexisting knowledge, such as with decentralized wastewater treatment systems. When individuals encounter new and unfamiliar issues, they are likely to seek information to resolve uncertainty, thus activating an epistemic demand (Sabucedo *et al.* 2020; Vila-Tojo *et al.* 2024). In such situations, people are more likely to rely on social cues and the opinions of relevant others to form their attitudes and opinions (van der Linden 2015). In our study, the views and actions of neighbors provided relevant information to participants on how to think and feel about these systems. Conversely, in contexts where individuals have substantial prior knowledge or experience, the impact of social identity framing might be less pronounced (cf. Petty & Cacioppo 1986). This suggests that the effects of pro-environmental social identity framing may become less strong when decentralized wastewater systems become more common.

The pro-environmental social identity framing did not affect environmental self-identity in Study 1 conducted in the Netherlands but did strengthen environmental self-identity in Study 2 conducted in Spain (with a small-medium effect). This implies that, in Spain at least, such a framing may motivate people more generally for pro-environmental actions, as they more strongly see themselves as people who behave pro-environmentally, which motivates people to act accordingly. One explanation for the weaker effects on environmental self-identity, compared to acceptance, might be that the social identity framing focused on the specific implementation of a decentralized wastewater system. It could be that a more general pro-environmental social identity is more effective in boosting environmental self-identity as well (cf. Wang *et al.* 2023).

Importantly, environmental self-identity was not (in the Netherlands) or less (in Spain) predictive of acceptance of decentralized wastewater systems than the social identity framing. On the one hand, these findings go against previous studies on pro-environmental behavior (Steg & de Groot 2012; Van der Werff *et al.* 2013a) and initial findings on the acceptance of the products obtained from decentralized wastewater systems (Gómez-Román *et al.* 2020; Vila-Tojo *et al.* 2022), which suggest personal pro-environmental identity to be a key predictor of these outcomes. Indeed, studies suggest that environmental self-identity is generally more predictive of individual pro-environmental behavior than group pro-environmental identity

(Wang 2023). On the other hand, these findings fit with our reasoning that decentralized wastewater systems make people share their wastewater with neighbors, and as such, acceptance of these systems may be more predicted by the perceived motivations of this specific group than by their personal motivations, as reflected by their environmental self-identity. This suggests that social identities may be more influential for pro-environmental behaviors when the behaviors are group-relevant and make people interdependent on others. Understanding how personal and social identities interact and mutually influence one another (Bouman *et al.* 2021), as well as their relative importance for individual and collective pro-environmental behaviors, can help to increase the effectiveness of interventions to promote behaviors and acceptance.

Next, we did not consistently find that neighborhood identification moderates the effect of social identity framing on acceptance and environmental self-identity (Masson & Fritsche 2014; Comello & Farman 2016; Wang 2023). Specifically, in the Netherlands, we found no significant moderating effects for identification. In Spain, we found that the effect of social identity framing on positive affect and voting intentions depended on the extent to which participants identify with their neighborhood. The more the Spanish sample identified with their neighborhood, the more the social identity framing increased their positive emotions about the system. Yet, interestingly, the less they identified with their neighborhood, the more social identity framing affected their voting intentions, as identification with the neighborhood increased voting intentions without a social identity frame. This suggests that there is a complex interplay between identification and social identity framing (and social identity motivations, more generally), in motivating pro-environmental behavior (see also, for example, Jans 2021; Goedkoop *et al.* 2022). Future research is needed to disentangle the specific conditions that affect the impact of different aspects of pro-environmental social identity, identification, and their interplay on pro-environmental behaviors and acceptance of sustainable projects.

4.1. Limitations and future research directions

It is important to recognize certain limitations of our studies. First, the Groningen sample size was slightly smaller than required for the detection of a small-medium effect, and this might partly explain why we did not find a significant effect of social identity framing on environmental self-identity here. Also, both samples consisted of university students, who may not be representative of the other citizens in Groningen and Santiago de Compostela, despite being roughly a quarter of the population in these cities. The rest of the population likely differs from university students in matters such as having children, owning a home, having their own income, and education level (Andersen *et al.* 2010; Ashraf & Merunka 2017), which may affect acceptance of decentralized wastewater systems. For this reason, it would be interesting to replicate the study with a representative sample of citizens who have a (more) permanent residence in the neighborhood and who must make financial decisions regarding their own homes. Nevertheless, the significant positive effects of social identity framing observed in a university students' sample, who are likely temporarily residing in the neighborhood, suggest that such effects might, if anything, be even more pronounced among permanent residents with stronger neighborhood identification.

Second, it is important to consider the hypothetical nature of our studies. Participants reflected on the potential introduction of decentralized wastewater treatment systems in their neighborhood rather than on an actual proposal. This could have influenced the results, as it is often easier to feel positive about something that 'might' happen in the future rather than something that is definitely being proposed (Price *et al.* 2015). Future research can further examine the effectiveness of pro-environmental social identity framing, including in neighborhoods where there are actual plans for a decentralized wastewater system.

Third, besides the general positive effect of pro-environmental social identity framing on acceptance, we find differences between the Spanish and Dutch samples in terms of effects on, and of, environmental self-identity and of the moderating role of identification. Although this disparity may be due to differences in sample size, it also points to the potential role of cultural and (socio-)contextual factors in shaping the effects. Further exploration is needed to understand these differences and their implications for future interventions and policy implementation.

Another limitation is that we have not examined which elements of social identity framing (e.g., inclusive language, emphasizing the pro-environmental motivation of the neighborhood, a bottom-up initiative proposed by the neighbors itself) are underlying the effectiveness of our manipulation. Specifically, we cannot fully rule out that our social identity framing also made the environmental benefits of the system more salient (Osth & Farrell 2019). By comparing the relative impact of these different elements of our framing and their combinations, future research can better understand which facets of our social identity framing message are key to fostering acceptance.

Finally, an interesting avenue for future research is to study the width of the effects. Our results suggest that social identity framing can strengthen environmental self-identity, at least in Spain, which could promote pro-environmental actions more broadly. It would be interesting to examine whether results indeed spill over to other pro-environmental behaviors (Truelove *et al.* 2014). Furthermore, a longitudinal design can increase insight into the long-term impact of social identity framing.

4.2. Practical implications

The findings of this research offer valuable insights for policymakers, community leaders, and environmental advocates seeking to promote the adoption of decentralized wastewater treatment and other sustainable systems. Our study demonstrates the promising role of pro-environmental social identity framing in promoting the acceptance of decentralized wastewater treatment systems. Specifically, by emphasizing shared group membership through inclusive language ('We'), highlighting the group's pro-environmental motivations, and stressing the involvement of group members in developing the plans themselves, acceptance of decentralized wastewater systems can be increased. This approach is not only useful in fostering public acceptance of these systems but may also promote a sense of shared responsibility for sustainable practices more generally.

Moreover, our research underscores the significance of social identities in influencing pro-environmental behaviors, particularly when behaviors are group-relevant and involve interdependence among group members. As such, relevant groups could be more systematically considered in the implementation of sustainable systems. In the context of decentralized sustainable systems in a neighborhood, this neighborhood is a key social identity affecting the acceptance and adoption of such systems (see also Sloot *et al.* 2018; Goedkoop *et al.* 2022, for similar findings in the domain of energy). However, when decentralized sustainable systems are planned to be installed at another scale (e.g., a flat or a housing complex), these group memberships may be more relevant to target. Furthermore, social identity framing builds on shared group membership; as such, it is important that group members are perceived to be involved in the implementation of the system. In our framing, we emphasized this by stating that the plan for the system came from the neighborhood itself (see also Jans 2021). Yet, if this is not the case, such involvement may also be signaled in other ways, for example by including group members in important decisions around the system (cf. Liu *et al.* 2019), or by stressing collective ownership and benefits of the system (cf. Contzen *et al.* 2023).

5. CONCLUSION

The water crisis and climate change challenges are unprecedented, which makes it crucial to explore innovative sustainable approaches to tackle these issues. Decentralized wastewater treatment systems represent a promising and environmentally viable solution for water problems, although their successful implementation depends on public acceptance. Our study shows that by connecting to relevant group memberships and building a collective pro-environmental motivation, it is possible to increase public acceptance of such innovations in the socio-spatial context in which they will be implemented. Pro-environmental social identity framing not only enhances a positive view of the system but also generates more favorable emotions and an increased willingness to support it. As such, strengthening pro-environmental social identities is a key step to effectively addressing the challenges posed by the water crisis and climate change, and building an environmentally and socially sustainable future.

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DATA AVAILABILITY STATEMENT

All relevant data are available from https://osf.io/4BWKQ/.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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