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Do autistic traits predict pro-environmental attitudes and behaviors, and climate change belief?

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ABSTRACT

The climate agenda has gathered extraordinary pace due to Greta Thunberg and other autistic environmentalists. Thunberg's autism is widely used to explain and celebrate, but also diminish and denigrate, her activism. However, despite speculation linking autism, pro-environmental action, and climate change belief, there is neither psychological theory nor empirical evidence on this topic. We therefore considered theoretical reasons for and against this potential association, and examined whether autistic traits were positively, if at all, linked to pro-environmental attitudes and behaviors, and climate change belief. In three preregistered studies ($N = 2288$), including nationally representative samples and well-powered frequentist and Bayesian analyses, we found substantial evidence that autistic traits were associated with engagement in *fewer* pro-environmental behaviors. Further, autistic traits were neither predictive of pro-environmental attitudes nor climate change belief. We conclude that, irrespective of environmental attitudes or climate change belief, autism and mental health conditions may present barriers for pro-environmental action. Suggestions for understanding the psychological factors underlying climate action and a more inclusive environmental agenda are discussed.

1. Introduction

Autism is a lifelong condition characterized by social-communication difficulties and restricted behaviors and interests (American Psychiatric Association [APA], 2013). Despite such difficulties, many people with autistic characteristics make vital contributions to environmental science and wider society (Silberman, 2015). Autistic environmentalists are increasingly prominent, including Chris Packham (Packham, 2019), Temple Grandin (Wolfe, 2013), Dara McAnulty (McAnulty, 2020) and, most notably, Greta Thunberg (Thunberg, 2019). Thunberg, for example, reports that their autism is a psychological "gift" and "superpower" that underpins their climate change activism (Rourke, 2019; Thunberg, 2019). Autistic environmentalists have prompted a critical shift in the climate agenda, inspiring a surge in public awareness of climate science and encouraging pro-environmental attitudes, behaviors, and activism across the world (Fisher, 2019; Sabherwal et al., 2021; Silberman, 2019). This has fueled speculation that autistic personality traits are linked to pro-environmental attitudes and behaviors, as well as climate change belief (Hook, 2019; Silberman, 2019) and staff members in the UK's *National Autistic Society* are even being asked whether autistic people might help to advance psychological science concerning the environment. Hence, a scientifically grounded approach is urgently required to shift from *ad hominem* discourse, often focusing on Thunberg, towards evidence-based policy and practice.

Many factors have been identified as key predictors of pro-environmental attitudes, behaviors, and climate change belief. This has ranged from personal factors, such as socio-demographics (Hornsey et al., 2016) and values (Gatersleben et al., 2014), to social psychological factors, such as social identities (Schulte et al., 2020) and norms (Farrow et al., 2017). However, despite the range of predictors explored to date, the role of neurodevelopmental and mental health conditions has not been considered. Such clinical conditions, including autism, are associated with atypical cognitive functioning known to influence behavior more generally. However, whether these conditions are associated with differences in pro-environmental attitudes and behaviors,

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and climate change beliefs is yet to be explored. There are increasing calls for a more inclusive environmental agenda (Human Rights Council, 2019), especially given that climate change is thought to have a negative impact on mental wellbeing and disproportionately affects people with pre-existing mental health conditions (Lawrance et al., 2021). Investigating clinical populations with atypical cognitive function may help identify populations that could contribute to pro-environmental action and/or those that need more support (see also, Berry et al., 2018). Equally, such research has potential to elucidate the psychological processes that underlie environmentalism in non-clinical populations just as it has contributed to other areas of psychological research. The study of autism, in particular, has had a major influence on psychological theories (e.g., Happé et al., 2017) and empirical work (e.g., Shah et al., 2013) on socially relevant cognition and behaviors. It may therefore have untapped potential to advance understanding of environmental psychology.

1.1. Autistic traits

Traits and behaviors associated with an autism diagnosis (e.g., social-communication difficulties), henceforth 'autistic traits', are continuously distributed in the population. People with a clinical autism diagnosis are at the extreme end of this distribution (Ruzich et al., 2015). In autism research, examining autistic traits rather than clinically diagnosed autism is considered a powerful approach to investigate cognitions and behaviors associated with autism. This approach has led to valuable developments in psychological and autism-related theories (see Happé & Frith, 2020) and the identification of small but important associations between autism and (a)typical cognitive processing (e.g., Gollwitzer et al., 2019; Taylor et al., 2019). This trait-wise approach to autism research helps to overcome existing difficulties in conducting large and well-powered studies, which are otherwise lacking when selectively sampling people with a clinical diagnosis of autism. Additionally, measuring and examining autistic traits is a more inclusive approach. It includes individuals who have high levels of autistic traits but may not have access to diagnostic services, as well as those who self-identify as autistic but do not seek a clinical diagnostic label. Equally, it is inclusive of people who may fall below diagnostic thresholds by their engaging in psychological strategies to limit their observable autistic traits (Livingston & Happé, 2017). Given these benefits of using autistic trait measures to study features of human cognition and behavior, when combined with the recent speculation that autistic personality traits are linked to environmentalism, it is a timely opportunity to advance this line of research. To this end, it is important to ground this topical issue in contemporary autism-related research. As there is no direct empirical research investigating associations between autistic traits and environmentalism, we start by considering several theoretically grounded reasons for and against the idea that autistic traits positively predict pro-environmental attitudes and behavior, and climate change belief.

1.2. A positive relationship with autistic traits

There are several potential reasons to expect a positive association between autistic traits and pro-environmental attitudes and behaviors. First, resistance to change and intolerance of uncertainty, both in the short and long-term, are core features of autism (e.g., Bishop et al., 2013; Vasa et al., 2018). While typically these core features can result in several daily difficulties for people with many autistic traits (e.g., in coping with unexpected changes to daily routines), we speculate that they may serve as important psychological factors underlying and motivating conservation efforts. For example, a rapidly changing environment with an uncertain future may concern individuals with high levels of autistic traits. This phenomenon may be enhanced due to heightened levels of attention to detail and weather salience in autistic populations (Bolton et al., 2020), resulting in a greater perceptual awareness of ongoing environmental changes, which is known to shape climate change belief (Taylor et al., 2014).

Second, special interests in non-human animals, nature, and the environment, are widely self-reported by autistic individuals and are a positive predictor of their subjective wellbeing and life satisfaction (e.g., Grove et al., 2018). Further, people with many autistic traits demonstrate an affinity for non-human animals, with preferences for interacting with non-human animals over humans and inanimate objects (e.g., Celani, 2002; Prothmann et al., 2009). Accordingly, there is a greater level of pet ownership in families with an autistic person (e.g., Carlisle, 2014) and personal accounts of autistic people suggest they identify more closely with non-human animals than humans (Atherton & Cross, 2018). This may be underpinned by a greater tendency for people with many autistic traits, compared to those low in autistic traits, to anthropomorphize – attributing human mental states to non-human animals (Atherton & Cross, 2018; White & Remington, 2019). At the same time, it has been theorized that autistic traits are predictive of atypical motivation to engage with human agents, resulting in potentially lower adherence to social norms compared to those with fewer autistic traits (Chevallier et al., 2012; but see Livingston et al., 2019). This might explain why autistic traits may be associated with a greater ability to act against normative social influences that are otherwise currently harming non-human agents and the environment.

Taken together, people with many autistic traits may have special interests and a particularly unique set of motivations to protect non-human animals and environmental interests that are threatened by climate change. In non-autistic populations, contact with and appreciation of nature (Alcock et al., 2020; Martin et al., 2020), as well as the ability to act against social norms in human society (Keizer & Schultz, 2018), is highly predictive of pro-environmental attitudes and behavior. Therefore, it follows that increased interest and connectedness with nature and non-human animals may increase pro-environmental attitudes and behaviors in those with high autistic traits. This may in part be driven by greater moral reasoning regarding protecting the environment and non-human animals from physical harm (Dempsey et al., 2020).

Third, autistic traits have been theoretically and empirically linked to an increased engagement in rational, deliberative thinking (Brosnan et al., 2016; Farmer et al., 2017; Shah et al., 2016) and accordingly, a *reduced susceptibility* to certain cognitive biases (e.g., the framing effect; Morsanyi & Byrne, 2019). In non-autistic populations, a deliberative mindset is predictive of reduced climate change skepticism (Trémolière & Djeriouat, 2020). Further, cognitive biases are known to impede rational thinking about the existence, risks, and consequences of climate change (Zaval & Cornwell, 2016). Therefore, it seems possible that the more rational, deliberative thinking style associated with autistic traits, may contribute to a stronger climate change belief and resulting pro-environmental attitudes and behaviors.

Fourth, autistic environmentalists, such as Thunberg, Packham, and Grandin, have highlighted autism as a key part of their identity. This has raised awareness and increased public interest of autism (e.g., Hartwell et al., 2020), while they have also become positive role models for autistic people. Indeed, role models play an important role in identity formation (Sealy & Singh, 2010). Autism identity is increasingly regarded to be a key positive social identity that can integrate into an individual's self-concept (Cooper et al., 2017). Recently, following the Social Identity Model of Pro-Environmental Action (see Fritsche et al., 2018), it has been suggested that Thunberg may serve as a 'prototypical leader' for young liberals, shaping group norms and intentions to take collective action on climate change (Sabherwal et al., 2021). We therefore speculate that Thunberg, and other autistic environmentalists, may equally serve as prototypical leaders for autistic people, potentially engendering even stronger pro-environmental views in people who consider autism as a salient aspect of their social identity. As such, in addition to promoting collective action among group members, those with high autistic traits may also be more likely to hold pro-environmental attitudes and engage more generally in

pro-environmental behaviors, by drawing on behavioral cues from prominent autistic environmentalists. Similarly, society has long marginalized people with autistic traits and other minoritized social identities (Silberman, 2015). Therefore, people with many autistic traits may be more willing to attribute the changing climate to humans, i.e., have strong belief in anthropogenic climate change, partly in response to their historically negative treatment from non-autistic groups in society.

1.3. A negative relationship with autistic traits

Despite convincing reasons for why autistic traits may be associated with pro-environmental attitudes and behaviors, there is an equally and arguably even stronger reason to expect no such relationship or even a negative link. Autistic traits are well-known to be associated with several psychological and socio-demographic barriers, which may also limit pro-environmental attitudes and behaviors. First, cognitive flexibility, the ability to shift thinking between two separate concepts or perspectives, positively predicts climate change belief and long-term oriented pro-environmental behaviors in the general population (Chen & Unsworth, 2019; Lange & Dewitte, 2019). Hence autism-related cognitive inflexibility (Morsanyi & Byrne, 2019), sometimes known as 'black and white thinking', might have the opposite effect.

Second, several psychological factors may limit the translation of pro-environmental attitudes to pro-environmental behaviors. For instance, autistic sensory sensitivities can result in intolerance to various sounds and foods (Ben-Sasson et al., 2019; Chistol et al., 2018). When this is combined with the aforementioned resistance to change in autism, it may constrain behavioral change to more pro-environmental options, such as using public transport and dietary changes to reduce meat consumption. Indeed, people with many autistic traits have reported sensory sensitivities, intolerance of uncertainty, and anxiety as key factors that limit their use of public transport (Haas et al., 2020). Similarly, working memory capacity is required for pro-environmental attitude and behavior alignment in non-autistic populations (Langenbach et al., 2020). Thus, reduced working memory capacities associated with autism (Habib et al., 2019), may result in a larger attitude-behavior gap in those with high levels of autistic traits.

Third, autistic traits are linked to being male, and lower levels of income, education, and employment (Skylark & Baron-Cohen, 2017). Indeed, recent estimates suggest just 21.7% of autistic adults are in paid employment (Putz et al., 2021). In the general population, these socio-demographic factors are associated with lower climate change belief (Hornsey et al., 2016) and limit available resources for engaging in domestic pro-environmental behaviors, particularly if adopting such behaviors is associated with an initial financial investment (e.g., purchasing a bike). Additionally, individuals with lower levels of income and education may have limited time and resources to engage as citizens (e.g., Son & Wilson, 2012), and more specifically, in collective activism and action against climate change.

Finally, high levels of autistic traits are linked with several daily challenges (APA, 2013), as well as other mental (e.g., anxiety; Hollocks et al., 2019) and physical (e.g., gastrointestinal; Weir et al., 2020) health conditions. Whilst prominent autistic environmentalists have also reported experiencing these difficulties and developed strategies to overcome them (e.g., Packham, 2019), it is arguable that they do not have the same level of difficulties experienced by most people with many autistic traits. These additional needs may, quite understandably, require prioritization, resulting in limited financial and psychological resources for consideration of the environment, climate change, and pro-environmental action.

1.4. The present research

Overall, there are theoretical and empirically based reasons for and against the hypothesis that autistic traits may positively predict pro-environmental attitudes and behaviors, and climate change belief. However, there is no direct empirical evidence on this topic. We therefore seek to address this gap in the literature and clarify public and media speculation of potential associations. Before examining any of the potential mechanisms underlying these putative associations (e.g., connectedness with nature, awareness of environmental changes), the critical starting point to addressing these gaps in the literature is to first establish whether autistic traits are linked to pro-environmental attitudes. Given the balance of the above-mentioned theory and evidence, alongside our clinical observations and co-production of this research with people with autistic traits, we, at first, tentatively predicted that autistic traits would be associated with greater pro-environmental attitudes.

2. Study 1

2.1. Methods

2.1. 1. Participants & measures

A convenience sample of 203 undergraduate students (15.3% male) was recruited at a UK university (see Table 1 for detailed participant characteristics). This sample size gave us 80% power to detect at least a 'small' to 'medium' ($f^2 = 0.04$) increase in R^2 in our regression analyses ($\alpha = 0.05$, 2-tailed).

2.1.1.1. Autistic traits. The 10-item Autism-Spectrum Quotient (AQ10; Allison et al., 2012) was administered as a measure of autistic traits as it is the recommended gold-standard by the National Institute for Health and Care Excellence (National Institute for Health and Care Excellence, 2012). Participants reported how much they agreed with statements about core characteristics associated with autism (e.g., "I find social situations easy") on a 4-point scale ("Definitely agree" to "Definitely disagree"). Total scores range on a continuous scale between 10 and 40, with higher scores indicating more autistic traits and increased likelihood of clinically significant levels of autistic traits. The AQ10 can also be used as a clinical screening tool, scored using clinical cut-offs, to categorize people who are likely to have clinically diagnosable autism.[1]

Despite potential concerns with the AQ10 (Taylor et al., 2020), this measure consistently showed adequate internal consistency and reliability in the present study (see Table S1). Nonetheless, to guard against the possibility that the AQ10 would not be sufficiently reliable, the 28-item Autism-Spectrum Quotient (AQ28; Hoekstra et al., 2011) was administered as an additional measure of autistic traits. Like the AQ10,

Table 1
Sample characteristics.

Characteristic	Study 1	Study 2	Study 3
Sampling Method	Students UK	MTurk US	Prolific UK
n	203	700[a]	1385[b]
Sex (% Male)	15.3%	46.4%[c]	49.0%
Mean Age	18.4 (1.1)	39.9 (12.1)	44.8 (15.3)
Mean Education	–	4.1 (1.8)	3.6 (1.9)
Mean Adjusted Income	–	$29.4 k ($19.6 k)	£16.8 k (£11.5 k)
Mean Political Ideology	–	3.5 (1.8)	3.5 (1.5)
LGBTQ + (% Yes)	–	8.9%	9.5%

Note. Standard deviations in parentheses.
[a] 37 additional participants were excluded as 30 failed attention checks and 7 completed the study twice. [b]56 additional participants failed attention checks and were excluded. [c]0.1% (1 participant) described their sex as 'other'.

[1] Across the present studies, we report results using the continuous scale as this provides the more sensitive measurement of autistic traits, better statistical power, and avoids ongoing confusion about clinical cut-off values (see Waldren et al., 2021). Nonetheless, the pattern of results did not differ when dichotomous scores were used as an alternative measure of autism.

participants reported how much they agreed with statements about their autistic characteristics. Total scores range between 28 and 118, with higher scores indicating more autistic traits.

2.1.1.2. Pro-environmental attitudes. The revised New Ecological Paradigm scale (Dunlap et al., 2000) was used to assess pro-environmental attitudes. Participants reported their agreement with 15 statements (e.g., "Humans are severely abusing the environment") on a 5-point scale ("Strongly agree" to "Strongly disagree"). Total scores range between 15 and 75, with higher scores indicating greater pro-environmental attitudes. It has been found to be predictive of both pro-environmental behavior and climate change belief (Dunlap et al., 2000).

2.1. 2. Procedure

The study design was co-developed in consultation with autistic adults who have high autistic traits (see Supplementary Methods for details). The order that questionnaires were administered was counterbalanced, followed by demographic questions regarding age and sex. For all studies, ethical clearance, in line with *British Psychological Society* guidelines, was granted by the local ethics committee, and participants gave informed consent prior to study completion. The statistical analysis plan was pre-registered on *aspredicted. org* (Study 1).

2.2. Results

Multiple linear regression indicated that autistic traits, measured using the AQ10, were *not* significantly predictive of pro-environmental attitudes ($p = .43$) after accounting for age and sex (Table 2). However, it remained unclear if the non-significant p value was indicative of a true null effect of autistic traits on pro-environmental behaviors or whether the data were not sensitive enough to identify the effect (i.e., a Type II error). This is because, while it is possible to determine if it is appropriate to reject the null hypothesis using frequentist analyses, it is difficult to find support for, and accept, the null hypothesis. Addressing this issue, we adopted a Bayesian modelling approach (see Supplementary Methods - Bayesian Analysis) to quantify the likelihood of obtaining the data under both the null and alternative hypothesis. Specifically, we conducted a Bayesian equivalent of the frequentist multiple regression to obtain a Bayes Factor (BF_{10}; see Wagenmakers et al. (2011) for recommended interpretation of values) quantifying support for the two-tailed alternative hypothesis (H_1 = autistic traits are uniquely predictive of the outcome) relative to the null hypotheses (H_0 = autistic traits are not uniquely predictive of the outcome), by comparing models with and without autistic traits included as a predictor. This Bayesian analysis showed substantially more evidence for the *absence* than existence of an association between autistic traits and environmental attitudes ($BF_{10} = 0.32$). Therefore, it was more appropriate to accept the null, rather than the alternative, hypothesis. We found that same pattern of results when AQ28 scores were used as the alternative measure of autistic traits (see Table S2).

2.3. Discussion

Study 1 provided preliminary evidence against positive associations between autistic traits and pro-environmental attitudes and behavior and climate change belief, suggesting that there is no relationship between autistic traits and pro-environmental attitudes. However, the sample was homogenous, with mainly young adult females, resulting in the variables accounting for very little variance in pro-environmental attitudes. Therefore, the findings required replication in a much larger, more representative and diverse sample of the general population. This is particularly important, given the known sex differences in environmental attitudes (e.g., Xiao & McCright, 2015). Additionally, other socio-demographic factors that predict pro-environmental attitudes, behavior, and climate change belief (Hornsey et al., 2016), such as political ideology, were not accounted for in Study 1. More fundamentally, we had examined the link between autistic traits and environmental *attitudes* but had not explored whether autistic traits were predictive of pro-environmental *behaviors*. Research indicates that environmental attitudes are not always predictive of environmental behaviors (Bain et al., 2016; Hornsey et al., 2016). Further, an individual's pro-environmental behaviors may be used to infer their own pro-environmental attitudes (Chaiken & Baldwin, 1981). Therefore, it was necessary to re-examine the associations between autistic traits and pro-environmental attitudes, as well as pro-environmental behaviors, whilst also accounting for socio-demographic factors of interest. Establishing the robustness of these associations (if any) was essential before exploring factors that may theoretically underpin an association between autistic traits and pro-environmental attitudes and behavior (e.g., connectedness with nature, awareness of environmental changes).

3. Study 2

Study 2 examined the association between autistic traits and engagement in pro-environmental behaviors. Study 2 also re-examined the relationship between autistic traits and pro-environmental attitudes using a well-powered study (i.e., replicating Study 1), whilst accounting for pro-environmental behaviors and other relevant socio-demographic variables.

3.1. Methods

3.1.1. Participants

A sample of 700 participants (46% male) was recruited via Amazon's Mechanical Turk (MTurk). This sample size was based on a power analysis suggesting that we would have 95% power to detect at least a 'small' ($f^2 = 0.02$) increase in R^2 in our regression analyses ($\alpha = 0.05$, 2-tailed). Two simple attention checks were included to identify anyone

Table 2
Descriptive statistics, intercorrelations, and multiple regression predicting pro-environmental attitudes – study 1.

Variables	***M* (*SD*)**	**1**	**2**	**3**	
1. Autistic Traits (AQ10)	20.7 (4.2)				
2. Pro-Environmental Attitudes	57.9 (6.3)	-.15[a]			
3. Age	18.4 (1.1)	.13	-.15[a]		
4. Sex (0 = Female, 1 = Male)	0.15 (0.36)	.17[a]	-.15[a]	.38[a]	
Multiple Regression (Outcome = Pro-Environmental Attitudes)					
Predictors	***B* [95% CI]**	***SE*$_B$**	***β***	***sr*^{2}**	***p***
Sex (0 = Female, 1 = Male)	−2.04 [-4.52, 0.44]	1.26	−0.12	0.013	.11
Age	−0.49 [-1.28, 0.29]	0.40	−0.09	0.008	.22
Autistic Traits (AQ10)	*−0.08 [-0.28, 0.12]*	*0.10*	*−0.06*	*0.003*	*.43*
Model fit: $F(3,198) = 2.73$, $p = .045$, $R^2 = 0.04$, $R^2_{adj.} = 0.03$					

Note. 1 multivariate outlier was excluded from the regression; the pattern of results was identical with the outlier included. The pattern of results with the secondary measure of autistic traits was almost identical and is reported in Table S1.
[a] $p < .05$.

who was not reading the questions and potentially responding at random. Participants who failed either attention check were excluded. Where some participants completed the study twice, only their first contribution was retained. Thus, 37 additional participants were recruited but excluded. See Table 1 for detailed participant characteristics.

3.1.2. Measures

3.1.2.1. Study 1 measures. Participants completed the same measures of autistic traits (Allison et al., 2012) and pro-environmental attitudes (Dunlap et al., 2000) from Study 1. As the pattern of results from Study 1 was almost identical across autistic trait measures, the AQ10 was the only measure of autistic traits used in Study 2.

3.1.2.2. Pro-environmental behaviors. The pro-environmental behavior scale, developed by Bain et al. (2016), assessed participants' engagement in personal, domestic pro-environmental behaviors to help prevent climate change. Participants reported their likelihood of engaging in twelve activities (e.g., "Buy environmentally-friendly products"), at present and in the next 12 months, using a 5-point scale ("Not at all likely" to "Very likely"), with the option to respond "Not applicable". Total scores were calculated by averaging scores for all items for which "Not applicable" was not selected, in line with previous research (Bain et al., 2016).

3.1.2.3. Education. Educational level was assessed using an 8-point scale from the International Standard Classification of Education (UNESCO Institute for Statistics, 2012). Scores range from 0 (No qualifications) to 7 (Doctorate). A higher score was indicative of greater educational attainment.

3.1.2.4. Income. Participants reported their annual household income before taxes. Participants selected one of eight options (less than $15,000; $15,001 to $25,000; $25,001 to $35,000; $35,001 to $50,000; $50,001 to $75,000; $75,001 to $100,000; $100,001 to $150,000; greater than $150,000). Responses were re-coded using the mid-point of each category. The value for the unbounded top category was calculated using Parker and Fenwick's (1983) median-based Pareto-curve estimator (as in Callan et al., 2017). Participants also reported the number of adults and children living in their household. Income was then adjusted by the size of the household by dividing the total household income by the number of adults and 0.5 × the number of children (as in Skylark & Baron-Cohen, 2017). This measure of adjusted income was then used in all analyses.

3.1.2.5. Political ideology. Participants reported their political ideology in response to a previously used question in climate science (e.g., Bain et al., 2016): "In political matters, people sometimes talk about 'liberals' and 'conservatives'. How would you place your views on this scale, generally speaking?" A 7-point scale was used (1 = "Very liberal" to 7 = "Very conservative").

3.1.2.6. Socio-demographic variables. As in Study 1, participants reported their age (in years) and sex (at birth). To be as inclusive as possible, participants were able to report their gender and sexual identities, and therefore an LGBTQ + identity (if appropriate). Sex and gender were highly correlated, thus sex, instead of gender, was included in all analyses and LGBTQ + identity was included as a separate variable.

3.1.3. Procedure

The procedure followed that of Study 1 with the additional measures included. The order that questionnaires were administered was counterbalanced, followed by socio-demographic questions. The statistical analysis plan was pre-registered on *aspredicted. org* (Study 2).

3.2. Results

Using the analysis procedure in Study 1, frequentist and Bayesian multiple regression analyses showed that, after accounting for socio-demographic factors (sex, age, education level, income, political ideology, and LGBTQ + identity), there was extremely strong evidence that autistic traits were predictive of engagement in fewer pro-environmental behaviors ($p < .001$, $BF_{10} = 143.84$; Table 3). Additional analysis indicated that this relationship was maintained even after accounting for pro-environmental attitudes ($p < .001$, $BF_{10} = 63.21$; Table S3). Further, replicating Study 1, there was substantial evidence for no relationship between autistic traits and environmental attitudes after accounting for socio-demographic variables ($p = .41$, $BF_{10} = 0.18$) and pro-environmental behaviors ($p = .64$, $BF_{10} = 0.13$; Table S3).

3.3. Discussion

The findings were consistent with Study 1, providing clear evidence *against* positive associations between autistic traits and pro-environmental attitudes. Study 2 revealed novel evidence of a negative association between autistic traits and pro-environmental behaviors, even after accounting for pro-environmental attitudes. This suggests that autistic traits may limit engagement in pro-environmental behaviors, irrespective of an individual's attitudes. Further, in addition to replicating the null relationship between autistic traits and pro-environmental attitudes in Study 1, Study 2 showed that this result holds even after accounting for pro-environmental behaviors and a much broader range of socio-demographic variables.

Given that we had so far found little evidence for a relationship between autistic traits and pro-environmental variables, there was little reason to consider potential mediating or moderating factors of this non-relationship. Instead, moving forward, it was important to establish if the link between autistic traits and pro-environmental behaviors was robust. And, although environmental attitudes and behaviors are typically correlated with climate change belief (e.g., Hornsey et al., 2016), a direct measure of climate change belief had not been included in Studies 1 and 2. Finally, neither Study 1 nor 2 used samples fully representative of the general population, leaving open the possibility that our findings were not generalizable. These potential limitations were addressed in Study 3.

4. Study 3

Study 3 examined if there was a link between autistic traits and climate change belief. Study 3 also examined this association whilst accounting for the association between autistic traits and pro-environmental behaviors (as in Study 2) and pro-environmental attitudes (as in Studies 1 and 2). Accordingly, this enabled well-powered replications of Studies 1 and 2 in a nationally representative sample.

4.1. Methods

4.1.1. Participants

A large sample of 1385 participants (49% male) was recruited via *Prolific*. The participants formed a representative sample of the UK, cross-stratified by age and sex, based on census data (Office for National Statistics, 2016). This sample size was, in part, based on a sensitivity (power) analysis that suggested we would have 95% power to detect at least 'very small' ($f^2 = 0.01$) increases in R^2 in regression analyses ($\alpha = 0.05$, 2-tailed). In view of the association between temperature fluctuations and belief in climate change (Li et al., 2011; Zaval et al., 2014), participants were recruited, and data collected, within a short (<18hr) period, limiting the chances of fluctuations in the weather and outdoor temperature. As in Study 2, two simple attention checks were included,

Table 3
Descriptive statistics, intercorrelations, and multiple regression predicting pro-environmental behaviors – study 2.

Variables	*M* (*SD*)	1	2	3	4	5	6	7	8
1. Autistic Traits	20.6 (3.7)								
2. Pro-Environmental Attitudes	55.9 (11.8)	-.04							
3. Pro-Environmental Behaviors	4.0 (0.7)	-.14[a]	.45[a]						
4. Age	39.9 (12.1)	-.11[a]	-.04	.05					
5. Education	4.1 (1.8)	-.07	-.01	-.01	-.02				
6. Adjusted Income	$29.4 k ($19.6 k)	-.16[a]	-.05	-.05	.07	.32[a]			
7. Political Ideology	3.5 (1.8)	-.01	-.49[a]	-.30[a]	.19[a]	-.06	.05		
8. Sex (0 = Female, 1 = Male)	0.47 (0.50)	.13[a]	-.15[a]	-.08[a]	-.07	.00	.12[a]	.00	
9. LGBTQ+ (0 = No, 1 = Yes)	0.09 (0.28)	.12[a]	.15[a]	.07	-.15[a]	-.07	-.12[a]	-.26[a]	-.08[a]

Multiple Regression (Outcome = Pro-Environmental Behaviors)

Predictors	*B* [95% CI]	SE_B	*β*	sr^2	*p*
Sex (0 = Female, 1 = Male)	−0.03 [-0.13, 0.06]	0.05	−0.02	0.001	.52
Age	0.01 [0.00, 0.01]	0.00	0.10	0.009	.008
Education	0.00 [-0.03, 0.03]	0.01	−0.00	0.000	.94
Adjusted Income	0.00 [0.00, 0.00]	0.00	−0.06	0.003	.13
Political Ideology	−0.11 [-0.13, −0.08]	0.01	−0.30	0.080	<.001
LGBTQ+ (0 = No, 1 = Yes)	0.02 [-0.15, 0.20]	0.09	0.01	0.000	.78
Autistic Traits	*−0.02 [-0.04, -0.01]*	*0.01*	*−0.14*	*0.018*	*< .001*

Model fit: $F(7,685) = 12.60$, $p < .001$, $R^2 = 0.11$, $R^2_{adj.} = 0.11$

Note. 6 multivariate outliers were excluded from the regression; the pattern of results was identical with the outliers included. 1 participant could not be included in the regression as they did not report their sex; their inclusion by excluding Sex as a predictor did not change the pattern of results.
[a] $p < .05$.

hence 56 additional participants were recruited but excluded for failing these checks. See Table 1 for detailed participant characteristics.

4.1.2. Measures

4.1.2.1. Study 2 measures. Participants completed all Study 2 measures of autistic traits (Allison et al., 2012), pro-environmental attitudes (Dunlap et al., 2000), pro-environmental behaviors (Bain et al., 2016), sex, age, education level, income, political ideology, and LGBTQ + identity. In Study 3, the measure of income was in GBP. Therefore, participants selected one of 18 options to indicate their household income (less than £5000; £5001 to £10,000; £10,001 to £15,000 etc. Increasing by intervals of £5000 until £80,001 to £85,000; £85,001 and above).

4.1.2.2. Climate change belief. Participants reported their belief in anthropogenic climate change by selecting one of three options widely used in previous research (Bain et al., 2012, 2016): "I believe climate change is occurring, and human activities are having significant effects on climate change"; "I believe climate change is occurring, but human activities are not having significant effects on climate change"; "I do not believe climate change is occurring". Participants scored 1 point when choosing the first option and 0 for the latter two. Participants additionally answered two questions (from Wang et al., 2019; Zaval et al., 2014) to measure the extent of their general belief in climate change ("How convinced are you that climate change is happening?") and anthropogenic climate change ("How convinced are you that climate change is caused mostly by human activities?"). Participants responded to each question on a 4-point scale (1 = "Not at all convinced" to 4 = "Completely convinced"). Climate change belief was computed as a composite measure by averaging z-scores from these questions.

4.1.3. Procedure

The procedure followed that of Study 2, with the additional measure of climate change belief. The order that questionnaires were administered was counterbalanced, followed by demographic questions. The statistical analysis plan was pre-registered on *aspredicted. org* (Study 3).

Table 4
Descriptive statistics, intercorrelations, and multiple regression predicting climate change belief – study 3.

Variables	*M* (*SD*)	1	2	3	4	5	6	7	8	9
1. Autistic Traits	21.2 (4.0)									
2. Pro-Environmental Attitudes	57.4 (8.8)	-.02								
3. Pro-Environmental Behaviors	4.1 (0.6)	-.08[a]	.45[a]							
4. Climate Change Belief	0.0 (0.9)	.01	.56[a]	.43[a]						
5. Age	44.8 (15.3)	-.16[a]	.01	−0.2	-.19[a]					
6. Education	3.6 (1.9)	-.03	.04	.11[a]	.11[a]	-.06[a]				
7. Adjusted Income	£16.8 k (£11.5 k)	-.09[a]	-.04	-.01	.02	.04	.28[a]			
8. Political Ideology	3.5 (1.5)	-.02	-.25[a]	-.22[a]	-.39[a]	.16[a]	-.20[a]	.06[a]		
9. Sex (0 = Female, 1 = Male)	0.49 (0.50)	.18[a]	-.10[a]	-.16[a]	-.05	-.01	.02	.04	.00	
10. LGBTQ + (0 = No, 1 = Yes)	0.10 (0.29)	.15[a]	.07[a]	-.01	.11[a]	-.16[a]	.05[a]	-.05	−.16[a]	.01

Multiple Regression Analysis (Outcome = Climate Change Belief)

Predictors	*B* [95% CI]	SE_B	*β*	sr^2	*p*
Sex (0 = Female, 1 = Male)	−0.09 [-0.18, −0.01]	0.04	−0.05	0.003	.030
Age	−0.01 [-0.01, 0.00]	0.00	−0.13	0.015	<.001
Education	0.01 [-0.01, 0.03]	0.01	0.02	0.000	.36
Adjusted Income	0.00 [0.00, 0.00]	0.00	0.04	0.001	.14
Political Ideology	−0.21 [-0.24, −0.18]	0.02	−0.36	0.118	<.001
LGBTQ + (0 = No, 1 = Yes)	0.09 [-0.05, 0.24]	0.07	0.03	0.001	.21
Autistic Traits	*0.00 [-0.01, 0.01]*	*0.01*	*−0.01*	*0.000*	*.82*

Model fit: $F(7,1377) = 41.06$, $p < .001$, $R^2 = 0.17$, $R^2_{adj.} = 0.17$

Note. Multivariate outliers were retained to maintain the representative sample; the pattern of results was identical with their exclusion.
[a] $p < .05$.

4.2. Results

After accounting for socio-demographic variables, multiple regression models showed strong evidence for the absence of an association between autistic traits and climate change belief ($p = .82$, $BF_{10} = 0.10$; Table 4). Additional analysis indicated this absence of a relationship even when accounting for pro-environmental attitudes and behaviors ($p = .80$, $BF_{10} = 0.08$; Table S4). Further, extending the results of Study 2, autistic traits predicted engagement in fewer pro-environmental behaviors over and above pro-environmental attitudes, climate change belief, and socio-demographic variables ($p = .031$, $BF_{10} = 1.26$; Table S4). Finally, the pattern of results from Studies 1 and 2 relating to autistic traits, pro-environmental attitudes, and pro-environmental behaviors replicated (Table S4).

4.3. Discussion

Consistent with Studies 1 and 2, this final study provided further evidence against proposed positive associations between autistic traits and pro-environmental attitudes and behaviors, and climate change beliefs. Specifically, this study added the novel finding of strong support for no relationship between autistic traits and climate change belief. Critically, the study also replicated Study 1 and 2 findings in a well-powered study and nationally representative sample. That is, autistic traits were not related to pro-environmental attitudes, but rather, were associated with engagement in fewer pro-environmental behaviors regardless of both climate change belief and pro-environmental attitudes.

5. General discussion

Contrary to speculation, we report consistent evidence *against* positive associations between autistic traits, and pro-environmental attitudes and behaviors and climate change belief. These findings represent a timely addition to the literature and will be vital to elevating the public discourse on the apparent link between autism and climate activism (Hook, 2019; Silberman, 2019). Given our results, we recommend a move away from autism-based narratives, whether positive or negative, of recent advances in climate policy. Instead, it will be more fruitful to focus on other psychological drivers, such as the age of effective climate change communicators like Thunberg, in greater depth. Although there is a tendency to disparage children's role in motivating progress in climate policies (Fisher, 2019), there is growing evidence that they may foster psychological concern and behavior change related to the changing climate in adults (e.g., Lawson et al., 2019).

The present studies are the first exploration of how traits associated with a neurodevelopmental or mental health condition may influence environmental attitudes and behavior and climate change beliefs. As autistic traits were not predictive of pro-environmental attitudes or climate change belief, such traits, including social-communication difficulties, resistance to change, and focused interests in the natural world, neither prevent nor enhance such attitudes and beliefs. This finding furthers understanding of the typical development of pro-environmental attitudes and climate change beliefs more generally, suggesting that they are less shaped by social factors and focused interests in the environment than previously thought. For instance, social cognitive difficulties in understanding and empathizing with other people is closely associated with autism (e.g., Clutterbuck et al., 2021; Shah et al., 2019). However, as autistic traits were not associated with reduced pro-environmental attitudes in the present study, it follows that our findings do not support proposals that empathy for others and the environment, and subsequent development of pro-social and pro-environmental identities, is fundamental for pro-environmental attitudes (Brown et al., 2019). Future work examining pro-environmental attitudes and climate change belief in other populations with atypical cognitive function may serve as a useful way to further understanding the psychological factors and mechanisms that facilitate the development of such attitudes and beliefs in typical populations.

Another novel finding from our research is that, regardless of pro-environmental attitudes, autistic traits were linked to a lower level of pro-environmental behaviors. An investigation into the potential mechanisms underlying this result is now required (e.g., potential difficulty reducing meat consumption on a rigid, restrictive diet) and, more generally, further investigation on understanding the *psychopathological barriers* to engaging in pro-environmental activities. It would be valuable to explore, for instance, if autism-related sensory sensitivities, resistance to change, working memory capacity, and more generally, access to resources, contribute to increased anxiety and reduced ability to adopt pro-environmental behaviors (e.g., switching to meat-free alternatives, taking public transport, preparing waste for recycling). Critically, it is important to determine if targeting these mechanisms facilitates pro-environmental behaviors, which may ultimately inform behavioral interventions in other clinical conditions and the general population. Further, re-examining the identified relationship whilst accounting for potentially confounding variables (i.e., those independently associated with both reduced pro-environmental behaviors and autistic traits; e.g., anxiety, social identity, resource availability etc.) would be of benefit to ensure the specificity of our findings.

While the present studies have revealed an association in relation to autism, many other mental health conditions are likely to be associated with barriers to personal action on climate change. For instance, those with anxiety disorders, or high levels of stress more generally, may be unable to initiate changing their behaviors to new pro-environmental behaviors (e.g., using public transport) and/or have difficulty sustaining any changes they make. Therefore, not only may these individuals initially have less available resources to engage in pro-environmental behaviors (i.e., due to coping with the challenges of managing their poor mental health), the costs and barriers of engaging in these behaviors may also be greater, thus limiting individuals' overall engagement in pro-environmental behaviors irrespective of their attitudes.

The United Nations recently called for a 'disability-inclusive' approach to climate action (Human Rights Council, 2019). There is some knowledge of how 'physical' health impairments are linked to reduced engagement in pro-environmental behaviors despite pro-environmental attitudes (Lovelock, 2010). However, there is strikingly little understanding of how 'mental' health impairments, also known as 'hidden disabilities', may be associated with climate action. Following recent thinking (Berry et al., 2018; Human Rights Council, 2019) and our findings, we speculate that the psychological support required to enable individuals with autistic traits and other mental health conditions to engage in pro-environmental activities is grossly underestimated. In future, it could be investigated whether cognitive behavioral therapies, commonly used to facilitate behavior change in people with mental health conditions (e.g., Wang et al., 2021), could be adapted to support pro-environmental behaviors. For instance, teaching individuals coping strategies to alleviate anxiety surrounding behavior change. Early environmental education and support for families of children with neurodevelopmental and mental health conditions may also be valuable, encouraging early integration of pro-environmental behaviors to alleviate later difficulties with adapting and changing behaviors. This may ultimately enhance pro-environmental behaviors in these populations, with pro-environmental actions becoming an integrated part of their daily routines rather than a barrier causing further distress.

Arguably, individuals with mental health conditions make negligible contributions to climate change, so it could also be suggested they should not be prioritized in future research and policy. However, they represent a relatively large and growing percentage of the population (around 17%; McManus et al., 2016) and poorly conceived climate policy could have a harmful impact on minority groups in society and reduce the efficacy of behavioral climate change interventions (Berry et al., 2018, Human Rights Council, 2019; Pearson et al., 2018). It is also critical to consider this research within the context of emerging evidence

that environmental pollution, a key contributor to climate change, may be associated with higher levels of mental health conditions (e.g., Ventriglio et al., 2021). Thus, unless addressed, it could be speculated that a bidirectional relationship between mental health conditions and climate change could occur, whereby reduced engagement in pro-environmental behaviors by those with mental health conditions could enhance climate change, which in turn may contribute to the development of poorer mental health of themselves and others.

One limitation of the present research is that we have primarily investigated individual's consumer and domestic-based pro-environmental behaviors, such as buying environmentally friendly products and taking public transport. We did not measure individuals' environmental citizenship and involvement in activism and behaviors aimed to bring about public and political action. Therefore, whether engagement in such collective action is different in individuals with high autistic traits remains unknown. Given our finding that autistic traits were associated with lower levels of domestic-based pro-environmental behaviors, it would be expected that autistic people may have similar, if not greater, difficulties engaging in collective action, following the additional social-cognitive demands of such action. One approach to increase collective pro-environmental behaviors of people with autistic traits could be through placing a stronger emphasis on their social identity (cf. Fritsche et al., 2018). For example, this could be achieved by further highlighting the autistic traits among prominent environmentalists (i.e., Thunberg, Packham), since priming people with a shared social identity can impact their behavior (e.g., McLeish & Oxoby, 2011). This is important to explore further and is critical to enhance inclusion, such that more people with high levels of autistic traits have access to the opportunities and resources to engage in environmental citizenship (see also, Dobson, 2007). Such research may also speak to whether providing support (e.g., social, financial etc.) may facilitate autistic people to engage in collective action and activism, fostering collective efficacy, and enhance pro-environmental action in this population.

It is to be emphasized that, despite the results of our studies, we do not wish to undermine autistic environmentalists' lived experiences or downplay the importance of people with autism and mental health conditions in discussions on climate policy. On the contrary, Thunberg has shown that "*no one is too small to make a difference*" (Thunberg, 2019, p. 10) and that individuals, regardless of their psychological difficulties and/or minority group memberships, can make revolutionary contributions to the climate agenda. Although we found no link between autistic traits and pro-environmental attitudes and climate change beliefs *per se*, that is not to say that lessons cannot be learnt from minorities, such as those with autism, to help overcome normative social influences that are currently having a negative impact on the environment and climate. Altogether, therefore, we propose that a more inclusive climate science – investigating environmentalism in underrepresented groups and consideration for barriers to their participation in environmental decision-making – is required. In addition, more interdisciplinary environmental psychology research with clinical relevance, such as the present studies, will be useful in the future (e.g., to inform supportive adaptations/interventions). Encouragingly, there is growing appreciation of these issues and, moving forward, such research will benefit from co-development with minority groups and the charity sector, as in the present study (see also, Berry et al., 2018).

In summary, autistic traits do not predict pro-environmental attitudes and climate change belief, however they are associated with engagement in fewer pro-environmental behaviors. Accordingly, we caution against autism-based explanations for the recent 'Thunberg-driven' advances in the climate agenda. Nonetheless, our findings highlight the importance of including people with autism, mental health conditions, and other minority groups, in psychological research on environmentalism and climate change. Moving forward, this approach will be crucial for understanding the interplay between biophysical, socio-demographic, and psycho (patho)logical factors pertaining to climate action, towards an inclusive and more effective climate agenda.

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Author contributions

ECT, LAL, and PS designed the studies and collected the data. ECT and PS analyzed the data. ECT, LAL, and PS drafted the article. PHPH and MJC provided critical revisions. All authors approved the final manuscript;

Data and materials availability

All data are available in the supplementary materials.

CRediT authorship contribution statement

Emily C. Taylor: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Lucy A. Livingston:** Conceptualization, Investigation, Writing – original draft. **Mitchell J. Callan:** Investigation, Writing – review & editing. **Paul H.P. Hanel:** Methodology, Writing – review & editing. **Punit Shah:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft.

Declaration of competing interest

Authors declare no competing interests;

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Appendix A. Supplementary data

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