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Chen, L and Hardin, K orcid.org/0000-0002-0826-7565 (2019) Cognitive Complexity Increases Climate Change Belief. Journal of Environmental Psychology, 65. 101316. ISSN 0272-4944

https://doi.org/10.1016/j.jenvp.2019.101316

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Cognitive Complexity Increases Climate Change Belief

Abstract

The present research bridged the relationship between cognitive complexity and belief in anthropogenic climate change and tested the differential effectiveness of two argument types. In the first two studies (with 817 and 226 participants, respectively) we found that participants with lower levels of cognitive complexity were less likely to believe in anthropogenic climate change than those with higher levels. In Study 3 we used an experimental design with 304 participants to examine the reactions to different types of arguments across people with differing cognitive complexity. We compared the two most common types of arguments in discussions of climate change: 1) Presenting facts about climate change on their own (one-sided); 2) Presenting opposing arguments (i.e., misinformation) together with the correct climate change facts (two-sided). Participants with lower cognitive complexity were more likely to believe in climate change when exposed to facts of climate change on their own compared to the two-sided, refutational combination of misinformation and facts; but those with higher cognitive complexity were more likely to believe in climate change when exposed to the refutational combination rather than facts alone. Media and scientists need to consider the cognitive complexity of their audience when dealing with climate change.

Keywords: climate change belief, cognitive complexity, arguments for climate change

1. Introduction

It is clear that the world is undergoing climate change predominantly due to human actions (IPCC 2013; Van der Linden, Leiserowitz, & Maibach, 2019). To deal with this impending crisis, it is imperative that people recognize and acknowledge this fact (Hornsey, Harris, & Bain, et al., 2016), however considerable numbers of people are still skeptical that anthropogenic climate change is happening (e.g., Carmichael & Brulle, 2017). How can we sway these people and increase belief in anthropogenic climate change? Previous research has suggested that the framing of the message is important (e.g., Hurlstone, Lewandowsky, & Newell, et al., 2014;O'Neill, Williams, & Kurz, et al., 2015; Unsworth & McNeill, 2017), as is highlighting the connection of the individual to nature (Wang, Geng, & Schultz, et al., 2019) and the scientific consensus (e.g., Lewandowsky, 2011). But how should these arguments be presented? Should they be one-sided arguments that just address these issues, or should they be two-sided arguments that identify the skeptic's reasoning and presents the case against this? We argue that although one-sided arguments generally work well (e.g., Hurlstone et al., 2014), they will do so only for those people with low cognitive complexity and that for people with high cognitive complexity a two-sided, refutational argument will be more strongly associated with belief in anthropogenic climate change.

There is clear evidence that supports the use of one-sided positive arguments (e.g., Hurlstone, Lewandowsky, Newell, & Sewell, 2014; Myers, Nisbet, Maibach, & Leiserowitz, 2012; O'Neill, Williams, Kurz, Wiersma, & Boykoff, 2015; Stevenson, King, & Selm, 2018) and shows that misinformation about climate change undermines people's acceptance of anthropogenic global warming (e.g., Cook, Lewandowsky, & Ecker, 2017; McCright, Charters, Dentzman, & Dietz, 2016; Van der Linden, Leiserowitz, Rosenthal, & Maibach, 2017). Despite this, there is cause to revisit the encouragement of the one-sided approach. Contradictory arguments about climate change coexist across the media spectrum and reports, not only comments by climate change sponsors, but also views by climate change denialists (Boykoff, 2013; Koehler, 2016; Lewandowsky, 2011). As a result, people can still receive arguments against anthropogenic climate change from other sources. For some people, this may not cause a problem as they will focus on only one thing at a time; and, as such, a one-sided message about climate change will be received positively. However, for other people who will take all these different angles into account a one-sided argument may be perceived as false or shallow because it does not acknowledge the extant complexity of messaging.

Given this, we propose that a more sophisticated approach is required that takes the audience into consideration. We suggest that the best form of argument will depend on the individual's level of cognitive complexity, which refers to the degree of differentiation of the construct system such that individuals with high levels of cognitive complexity can think about a concept through different perspectives (Bartunek, Gordon, & Weathersby, 1983; Bieri, 1955). For example, when considering anthropogenic climate change, a person with low cognitive complexity might explain climate change in terms of a single factor (i.e., human activities or natural factors), whereas a person with high cognitive complexity might explain it as an interaction of several factors (i.e., both human activities and natural factors).

Although previous research has investigated the effect of cognitive complexity across various topics (e.g., Miron-Spektor, Efrat-Treister, Rafaeli, & Schwarz-Cohen, 2011; Bowler, Bowler, & Cope, 2012; Youngvorst & Jones, 2017), to our knowledge, cognitive complexity has not been applied to the literature of climate change belief. We believe that rectifying this neglect is important as it can help us to not only understand which people are more likely to believe in anthropogenic climate change but also how best to frame the arguments around it. Thus, the present study bridges the link between cognitive complexity and climate change belief. First, we suggest that the inherent complexity involved in anthropogenic climate change means that there will be a relationship between cognitive complexity and anthropogenic climate change. Second, we argue that those with lower cognitive complexity who are exposed to one-sided arguments will believe in anthropogenic climate change more than those with lower cognitive complexity who are exposed to two-sided arguments; but that those with higher cognitive complexity exposed to one-sided arguments will believe in anthropogenic climate change less than those exposed to two-sided arguments.

We test our theorizing using three studies. Study 1 is a large-scale cross-sectional survey study examining the relationship between anthropogenic climate change and cognitive complexity. Study 2 replicates this with a more rigorous approach, namely a temporally-lagged survey study controlling for other demographic variables known to influence belief in climate change. Study 3 is an experimental study that examines the interactive effect of cognitive complexity and exposure to arguments about climate change on anthropogenic climate change beliefs.

2. Theory and Hypothesis

2.1. Cognitive Complexity and Climate Change Belief

The importance of belief in anthropogenic climate change can be seen in the wide variety of research that has examined its antecedents. This work has found correlations with demographic variables, knowledge, values and political ideologies, situational cues and psychological factors (e.g., Hornsey, Harris, & Bain, et al., 2016; Lewandowsky, Gignac, & Oberauer, 2015; Unsworth & Fielding, 2014; Wang, Geng, & Schultz, et al., 2019). We take a different approach by considering the capacity that people have for understanding anthropogenic climate change. Cognitive complexity was originally developed from personal construct theory (Kelly, 1955) and refers to the degree to which an individual differentiates and integrates multiple constructs in describing a particular domain of phenomena (Bieri, 1955; Kelly, 1955; Scott, 1962). Individuals with high levels of cognitive complexity are able to employ multiple complementary and incompatible constructs to understand surrounding phenomena (Bartunek, Gordon, & Weathersby, 1983). For example, when talking about climate change, a cognitively simple person would describe it with a unitary view (e.g., Climate changes have happened before due to natural causes), whereas a cognitively complex person would illustrate it using multidimensional constructs (e.g., Even though climate changes have happened before, the increase in CO2 levels due to human activities is exacerbating natural causes).

Since cognitive complexity was first proposed, it has been applied in multiple fields. Due to the fact that it is positively related with abstract reasoning and an ability to handle complex information, cognitive complexity has been shown to have a beneficial effect on creativity

(Miron-Spektor, Efrat-Treister, Rafaeli, & Schwarz-Cohen, 2011), decision-making accuracy (Tripathi & Nath Srivastava, 2016), project leadership performance (Green, 2004) and making an appropriate vocational choice (Bodden, 1970). Moreover, cognitive complexity can shape an individual's values. For example, a highly complex cognitive system is positively related with confident self-evaluation (Adams-Webber, 2003), political extremism (Van Hiel & Mervielde, 2003), perception of subtle racism (Reid & Foels, 2010), endorsing group inequality (Foels & Reid, 2010), making an open trade policy (Crichlow, 2002) and communication processes (Bodie, Burleson, & Holmstrom, et al., 2011; Youngvorst & Jones, 2017). Finally, cognitive complexity has shown a curvilinear relationship with making ethical decisions such that only moderate levels of cognitive complexity impair moral choices (Moore & Tenbrunsel, 2014).

Although none of this previous research has been in the environmental domain, some clues exist that indicate that low cognitive complexity could be a psychological barrier to climate change belief due to a lack of climate change experience (Hornsey, Harris, & Bain, et al., 2016). As climate is changing gradually (IPCC, 2013), people do not notice a change and because direct climate change experience has a stronger effect on attitudes than second-hand information (Tversky & Kahneman, 1974), there is greater likelihood of being unconcerned about climate change. However, cognitive complexity can help people to overcome this barrier. Cognitive complexity leads people to understand the phenomena of climate change using diverse pieces of information (Bartunek, Gordon, & Weathersby, 1983). As a result, they would not make judgments about climate change only relying on personal experience. Cognitive complexity reflects the individual's ability to construct the "objective" world (Bartunek, Gordon, &

Weathersby, 1983). Therefore, people with a complex cognitive system have enough ability to explain climate change more accurately based on both personal experience and other information (e.g., scientific reports published by the public media). Consequently, cognitive complexity can reduce the bias caused by the lack of climate change experience and enable people to realize the fact that climate is changing and that humans contribute to such changes.

Further, cognitive complexity contributes to removing the barrier in terms of cognitive separating of humans from nature, which refers to individual's belief that she/he is out of the nature (Schultz, 2001; Schultz, Shriver, Tabanico, & Khazian, 2004). Evidence has shown that bridging connectedness with nature can cultivate a belief in climate change (Wang, Geng, Schultz, & Zhou, 2019). Compared with people whose cognitive style is simple, people with a complex cognitive style have more independent concepts that can be used to describe a phenomenon (Scott, 1962). Hence, it is more likely for people with high levels of cognitive complexity to hold more concepts which can demonstrate the connectedness between humans and nature than people with low cognitive complexity. In a nutshell, cognitive complexity may result in constructing a strong association between humans and the environment, thereby strengthening anthropogenic climate change belief. According to the theoretical logic abovementioned, we make the following hypothesis:

Hypothesis 1: Cognitive complexity is positively associated with anthropogenic climate change belief.

2.2. The interactive effect of cognitive complexity and exposure to arguments about climate change

We therefore suggest that those with lower cognitive complexity will be more skeptical about anthropogenic climate change than those with higher cognitive complexity. However, we also suggest that the differences in cognitive complexity will play a role in the effectiveness of different argument types. In this study, we focus on two types of argument: one is one-sided arguments for climate change and the other one is two-sided arguments about climate change belief. Specifically, one-sided argument for climate change refers to the message only associated with the view that confirms the existence of climate change. Two-sided, refutational arguments about climate change belief present the conflicting messages (i.e., both misinformation and fact) about the existence of anthropogenic climate change. An example of a one-sided argument for climate change is: “There is long-term correlation between CO_2 and global temperature; other effects are short-term”, whereas the two-sided argument would set out both conflicting views: “There's no correlation between CO_2 and temperature” and “There is long-term correlation between CO_2 and global temperature; other effects are short-term”.

People with a simpler cognitive system prefer to process information from a single perspective (Bartunek, Gordon, & Weathersby, 1983) and therefore will be more likely to accept the fact of anthropogenic climate change when exposed to a one-sided (rather than two-sided) argument. Due to the simpler processing, they would not think more about the messages displayed to them (Reid & Foels, 2010) and thus will be less likely to evaluate the messages rigorously (Petty & Cacioppo, 1986). Therefore, they have a high tendency to make a judgment only relying on the low-effort evaluation of the available messages when asked about their belief about human-caused climate change. As such, their judgments on the anthropogenic climate change are susceptible to be influenced by the content of the messages. When the messages include only arguments in support of climate change (i.e., one-sided arguments for the existence of climate change), these people are more likely to believe in the arguments and accept that climate change is human-caused. However, when the misinformation and the fact of climate change are mixed together (i.e., two-sided refutational arguments for the existence of climate change), these people would be confused and skeptical about the existence of climate change.

In contrast, people with highly complex cognition prefer to elaborate phenomena from various perspectives (Bartunek, Gordon, & Weathersby, 1983). Even though these people are exposed to one-sided arguments in support of climate change, they would also employ knowledge that they already possess to deeply consider these messages from different perspectives. More thinking enables people to evaluate the messages including the issues whether these arguments were from a credible source (Petty & Cacioppo, 1986). As a result, their judgments on human-caused climate change would not only depend on the contents of the messages but also on their existing knowledge. Hence, the one-sided arguments will have little effect on climate change beliefs of people whose cognitive system is complex; instead, the two-sided argument will be more likely associated with anthropogenic climate change beliefs in those with high cognitive complexity.

Moreover, people with high cognitive complexity are willing to deal with messages with conflicting views (Bartunek, et al., 1983). Indeed, studies have shown that people with high levels of cognitive complexity were able to form accurate views of the world when faced with uncertainty and complicated conditions (Bieri, 1955; Hasse, Reed, & Winter, et al., 1979). Thus, people with high levels of cognitive complexity are less likely to be confused by two-sided arguments and more likely to express higher levels of climate change belief. Accordingly, we make the following hypothesis:

Hypothesis 2: People with low levels of cognitive complexity are more likely to believe in anthropogenic climate change when exposed to one-sided arguments for the existence of climate change compared to two-sided arguments; however, people with high levels of cognitive complexity are more likely to believe in anthropogenic climate change when exposed to two-sided arguments about the existence of climate change compared to one-sided arguments.

We conducted three studies to test these hypotheses. The first two studies examine the association between cognitive complexity and belief in anthropogenic climate change. These studies were designed to produce results that were generalizable, with minimal common method variance (using differing survey methods and, in study 2, separate time points), and replicable (using three separate samples). The third study was experimental and examined the effect of different styles of argument on the belief in anthropogenic climate change.

3. Study 1

3.1. Participants and Procedures

All studies reported in this paper were conducted according to the ethical rules of the 1964 Helsinki declaration and its later amendments or comparable ethical standards. In addition, all studies in this paper have been approved by Hohai University and University of Western Australia.

The first study was designed to test our first hypothesis across a generalizable sample. We used an accredited panel survey organization (Qualtrics) to access 870 participants from the Australian population and collected 817 complete responses. As indicated in Hornsey's et al. (2016) study, almost all of the studies regarding the effect of antecedent factors on climate change belief have examined at best a moderate effect size. Hence, the sample size of the following three studies should help us detect at least a moderate effect size. Further, according to Cohen's (1992) research, when the sample size is 133 and above, we can detect at least a moderate effect size (*Effect size of Chi-square = 0.3*[1]) with 0.8 statistical power[2] and a two-tailed test with α=0.05 and *df*=4[3]. Therefore, we believed that the design in study 1 has enough power to test the hypothesis. Most participants were female (61.3%) and the average age was 46.19 years (*SE =18.066 years*). Approximately 40% of the participants had a junior or high school degree (41.5%), just less than a third had vocational or trade qualifications (26.9%), and the remainder had a bachelor degree (24.5%) or higher qualification (7.1%).

3.2. Measures

Climate change belief. Belief in anthropogenic climate change was captured using the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) (Leviston & Walker, 2011) measure. Greenhill, Leviston, Leonard, and Walker (2014) found this one-item scale to be the most valid measure of climate change belief. Participants are asked to choose the

[1] The reason that we chose the effect size of Chi-square is that our dependent variable is coded as a binary variable. In study 2 and study 3, we also chose the effect size of Chi-square.
[2] 0.8 is a commonly accepted threshold of statistical power (Cohen, 1992).
[3] Four variables (i.e., gender, age, education and cognitive complexity) will be included in the logistic regression of study 1. Hence, the degree of freedom (*df*) should be 4 as showed in Table 2.

statement that best reflects their general belief about climate change. The statements are a lack of belief in climate change (I do not believe in climate change), a lack of knowledge (I do not know whether climate change is happening or not), a belief in non-anthropogenic climate change (I believe that climate change is happening but it's just a natural fluctuation in Earth's temperatures) and in anthropogenic climate change (I believe that climate change is happening and humans are contributing to it). A recent meta-analysis (Hornsey et al., 2016) indicated that the anthropogenic climate change belief had a stronger impact on climate change mitigating behavior than the general climate change belief. Also, it is true that people with a human-caused climate change belief are more likely to conduct mitigation behavior than people with the belief that climate change is only happening (Hornsey, Harris, & Bain, et al., 2016). Therefore, we focused specifically on anthropogenic climate change beliefs. We coded lack of belief in climate change, lack of knowledge and belief in non-anthropogenic climate change as "0". The fourth statement "I believe that climate change is happening and humans are contributing to it" was coded as "1".

Cognitive complexity. The Construct Repertory Test (Rep Test) developed by Bieri and colleagues (1966) was used to measure cognitive complexity. Participants rated characteristics of 10 specified role types (i.e., yourself, person you dislike, mother, person you would like to help, father, friend of same sex, friend of opposite sex, person with whom you feel most uncomfortable, person in a position of authority, person difficult to understand). Specifically, they were asked to use a seven-point Likert-type scale to rate each one of the individuals on 10 bipolar adjective pairs (i.e., outgoing/shy, maladjusted/ adjusted, decisive/indecisive, excitable/calm, interested in others/self-absorbed, ill humored/cheerful, irresponsible/responsible, considerate/inconsiderate, dependent/independent, interesting/ dull). There are 100 ratings in total. We computed the score of cognitive complexity using Johnson's (1994) procedure. It is scored by summing the number of matching ratings assigned for each role (2 points each) and the number of ratings within one scale value of each other (1 point each). Fewer matches for each role (i.e., lower scores) indicate that the participant is able to describe a role using different ratings and implies a more complex cognitive system, whereas more matches for each role (i.e., higher scores) means that the participant is describing a role using similar ratings and implies a more simple cognitive system. There are 450 comparisons in total and values of cognitive complexity range from 230 (high cognitive complexity) to 900 (low cognitive complexity). This measure has been shown to have strong test-retest reliability (Woehr, Miller, & Lane, 1998).

The original score of cognitive complexity means that low scores represent higher cognitive complexity which might cause confusion when interpreting the results. Thus, to ensure clarity, we transformed the score of cognitive complexity using 1130 minus the initial score, such that the minimum value of cognitive complexity is transformed 230 to and the maximum value of cognitive complexity is transformed to 900. In other words, high scores of cognitive complexity in our results represent more complex cognitive systems. Unless specified, all the scores of cognitive complexity in this research will use this transformed value.

Control variables. Prior research suggests that gender, age and education are related to climate change belief (Dunlap, Xiao, & McCright, 2001; Hornsey, Harris, & Bain, et al., 2016).

In this study, gender was dichotomized into "male" (coded as "0") and "female" (coded as "1") and education was coded into junior high school (coded as "1"), high school (coded as "2"), vocational or trade qualification (coded as "3"), bachelor degree (coded as "4"), master degree (coded as "5") and PhD (coded as "6"). Age was measured in years.

3.3. Results

The means, standard deviations and correlation coefficients of cognitive complexity, anthropogenic climate change belief and other potential control variables are shown in Table 1.

Table 1 The correlations between the variables in study 1

Variables	1	2	3	4	5
1. Cognitive complexity	-				
2. [a]Climate change belief	0.130***	-			
3. [b]Gender	0.096**	0.059	-		
4. Age in year	0.026	-0.068	0.007	-	
5. [c]Education	0.074*	0.094**	-0.058	-0.032	-
Mean	555.676	0.594	0.610	49.190	2.880
S.D.	120.479	0.491	0.487	18.066	1.135

Note: N=817, *p < 0.05, **p < 0.01, ***p < 0.001; [a]Climate change belief ("0" skeptical about anthropogenic climate change ; "1" accepting anthropogenic climate change); [b]Gender ("0" male; "1" female); [c]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD).

As cognitive complexity was measured on a wide-ranging scale (i.e., ranging from 230 to 900) which might make the coefficients very small and thus difficult to understand the meaning of the coefficients, we standardize the values of cognitive complexity. Then, we conducted a logistic regression to examine hypothesis 1 while using the standardized values of cognitive complexity and the results are shown in Table 2. Overall the total model was significantly related to belief in anthropogenic climate change ($\chi^2 = 26.111, df = 4, p < 0.001; Cox \& Snell R^2 = 0.031$). The effect of cognitive complexity on anthropogenic climate change belief was significant (*B=0.249, SE=0.074,OR= 1.283, 95% confidence interval for OR [1.110-1.483], Wald statistic = 11.365, p<0.001*). These results provide preliminary support for Hypothesis 1 that there is a positive relationship between cognitive complexity and climate change belief.

Table 2 Logistic regression of cognitive complexity on climate change belief in study 1

Variables	B (SE)	OR	95% Confidence Interval for OR
Constant	-0.072(0.374)	0.931	-
[a]Gender	0.229(0.149)	1.257	0.939-1.683
Age in year	-0.008(0.004)*	0.992	0.984-1.000
[b]Education	0.160(0.065)*	1.174	1.034-1.332
Cognitive complexity	0.249(0.074)***	1.283	1.110-1.483
Total Model: □χ^2 = 26.111, *df* = 4, p <0.001; Cox & Snell R^2 = 0.031			

Note: N=817, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Education (“1” Junior high school (10 years), “2” High school, “3” TAFE or trade qualification, “4” Bachelor degree, “5” Master degree, “6” PhD).

In addition, we also visualized the raw data from study 1 and drawn Figure 1. Considering that cognitive complexity is a continuous variable and anthropogenic climate change belief is coded as a binary variable, we computed the mean value of cognitive complexity for both participants who believed in anthropogenic climate change and participants who were skeptical about human-caused climate change. As showed in Figure 1, participants who believed in anthropogenic climate change had a higher cognitive complexity (*M= 568.666, SD=110.501*) than participants who were skeptical about anthropogenic climate change (*M= 536.699, SD=131.608*). Hence, the central tendency of our raw data is consistent with hypothesis 1.

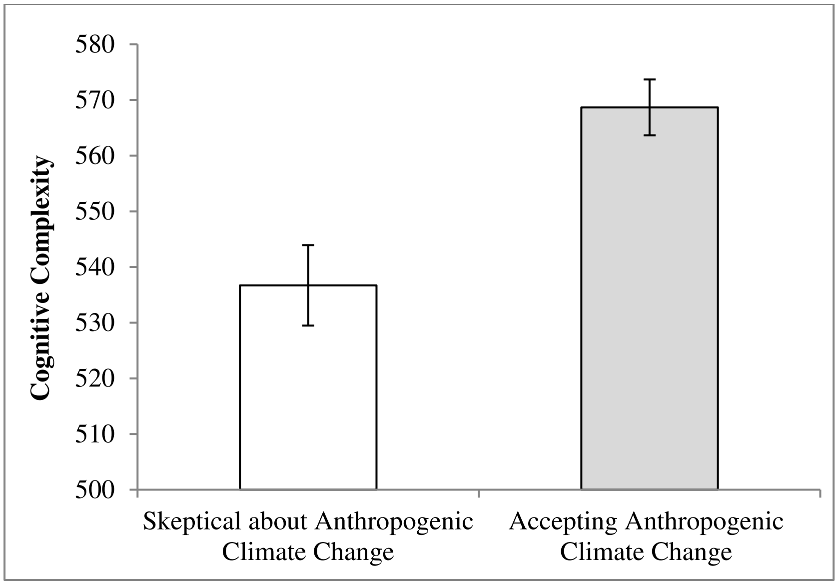

Figure 1 The difference of cognitive complexity between participants for anthropogenic climate change belief and against anthropogenic climate change belief in study 1

4. Study 2

Although study 1 offered support for hypothesis 1, it did not include political orientation which might also influence belief in anthropogenic climate change (Unsworth & Fielding, 2014). People who align themselves with relatively right-wing-oriented parties are more likely to be skeptical about the existence of climate change than people who align themselves with relatively left-wing-oriented parties (Hornsey, Harris, & Bain, et al., 2016). Besides that, previous research has indicated that low levels of cognitive complexity are associated with right-wing-oriented conservatism (Jost, Glaser, Kruglanski, & Sulloway, 2003). Hence, it is possible that the impact of cognitive complexity on climate change belief is via political orientation and it should be controlled. Further, study 1 is a cross-sectional design and the correlations are vulnerable to be inflated by common method variance (Lindell & Whitney, 2001). As a result, the examination of the hypothesis 1 in study 1 may be inaccurate. Thus, to address the alternative explanation for our finding and the drawback of cross-sectional design, we used a temporally-lagged design with cognitive complexity and control variables measured at time one and anthropogenic climate change belief measured one month later.

4.1. Participants and Procedures

For the second study, we used a pool of undergraduate students at a large research-oriented university in Australia. The first wave of data collection received 501 complete responses and the second wave of data collection received 273 complete responses with 226 matching responses across the two time periods. According to Cohen's (1992) research, when the sample size is 143 and above, we can detect at least a moderate effect size with 0.8 statistical power and a two-tailed test with $\alpha=0.05$ and $df=5$[4]. Therefore, we believe that the design in study 2 has enough power.

Among the matching responses, 54.4% of participants were male and participants had an average age of 19.159 years (*SD=2.882*). Nearly one third (31.4%) of these participants aligned with Labor Party (centre-left-wing), 54.4% with Liberal Party (conservative, right-wing), 5.3% with Nationals Party (rural conservative, right-wing) and 8.8% with Greens Party (progressive, left-wing). Participants who aligned with independents were not included in these 226 samples as they supported single-issue candidates rather than being ideologically driven (Unsworth & McNeill, 2017). An ANOVA showed that there were no significant differences between matching responses and the other responses (including the responses that did not return for time

[4] Five variables (i.e., gender, age, education, political orientation and cognitive complexity) will be included in the logistic regression of study 2. Hence, the degree of freedom should be 5 as showed in Table 4.

2 and the incomplete responses that return for both time 1 and time 2) for gender (*F(1,499)=0.012, p=0.914*), age (*F(1,499)= 2.068, p=0.151*) and political orientation (*F(1, 499)=0.843, p=0.359*). Another ANOVA also showed that there were no significant differences between matching responses and the other responses (including the incomplete responses that return for time 2) for climate change belief (*F(1, 267)=2,532, p=0.113*).

However, the average education of the participants among matching responses is lower than that among the other responses (*F(1, 499)=8.591, p=0.004, matching responses: mean= 2.593, SD=0.911, the other responses: mean=2.847 ,SD= 1.010)*. Furthermore, the average cognitive complexity of the participants among matching responses is higher than that among the non-responders (*F(1, 499)=5.002, p=0.025, matching responses: mean= 597.584, SD=67.822, the other responses: mean=581.793 ,SD= 86.255)*. We discuss the possible effect of these in the results.

4.2. Measures

Measures of climate change belief, cognitive complexity, gender, age and education were the same as study 1. For political orientation, those who aligned with the Greens and Labor parties were categorized as “left-wing-oriented” (coded as “0”) and those who aligned with Liberal party and Nationals party were categorized as “right-wing-oriented” (coded as “1”).

4.3. Results

The means, standard deviations and correlation coefficients of cognitive complexity, anthropogenic climate change belief and other potential control variables are shown in Table 3.

As in study 1, we conducted a logistic regression to examine hypothesis 1 while using the standardized values of cognitive complexity and the results are shown in Table 4. Overall the total model was significantly related to belief in anthropogenic climate change (*$\chi^2 = 18.555$, $df = 5$, $p = 0.002$; Cox & Snell $R^2 = 0.079$*). Even after controlling for gender, age, education and political orientation, the effect of cognitive complexity on anthropogenic climate change belief was still significant (*B=0.292, SE=0.145, OR=1.339, 95% confidence interval for OR [1.008-1.778], Wald statistic = 4.069, p=0.044*).

Table 3 The correlations between the variables in study 2

Variables	1	2	3	4	5	6
1. Cognitive complexity	-					
2. [a]Climate change belief	0.101	-				
3. [b]Gender	0.066	0.079	-			
4. Age in year	-0.047	0.173**	-0.001	-		
5. [c]Education	-0.001	0.108	0.107	0.303***	-	
6. [d]Political orientation	-0.123	0.100	0.100	-0.002	0.060	-
Mean	597.584	0.668	0.460	19.158	2.590	0.403
S.D.	67.822	0.472	0.499	2.882	0.911	0.492

Note: N=226, **p < 0.01, ***p < 0.001; [a]Climate change belief ("0" skeptical about anthropogenic climate change ; "1" accepting anthropogenic climate change); [b]Gender ("0" male; "1" female); [c]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [d]Political orientation ("0" right-wing-oriented; "1" left-wing -oriented). (listwise deletion).

Table 4 Logistic regression of cognitive complexity on climate change belief in study 2

Variables	B (SE)	OR	95% Confidence Interval for OR
Constant	-5.492(2.103)**	0.004	-
[a]Gender	0.337(0.304)	1.401	0.772-2.542
Age in year	0.303(0.116)**	1.354	1.079-1.700
[b]Education	0.069(0.177)	1.072	0.757-1.517
[c]Political orientation	0.456(0.309)	1.577	0.860-2.892
Cognitive complexity	0.292(0.145)*	1.339	1.008-1.778
Total Model: $\chi^2 = 18.555$, $df = 5$, p =0.002; Cox & Snell $R^2 = 0.079$			

Note: N=226, *p < 0.05, **p < 0.01; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [c]Political orientation ("0" right-wing-oriented; "1" left-wing-oriented). (listwise deletion).

Similar to study 1, we have visualized the raw data of study 2 by computing the mean value of cognitive complexity for both participants who believed in anthropogenic climate change and participants who do not. As shown in Figure 2, participants who believed in anthropogenic climate change had a higher cognitive complexity (*M= 602.417, SD=63.446*) than participants who were skeptical about anthropogenic climate change (*M= 587.853, SD=75.385*). Hence, the central tendency of our raw data is consistent with hypothesis 1.

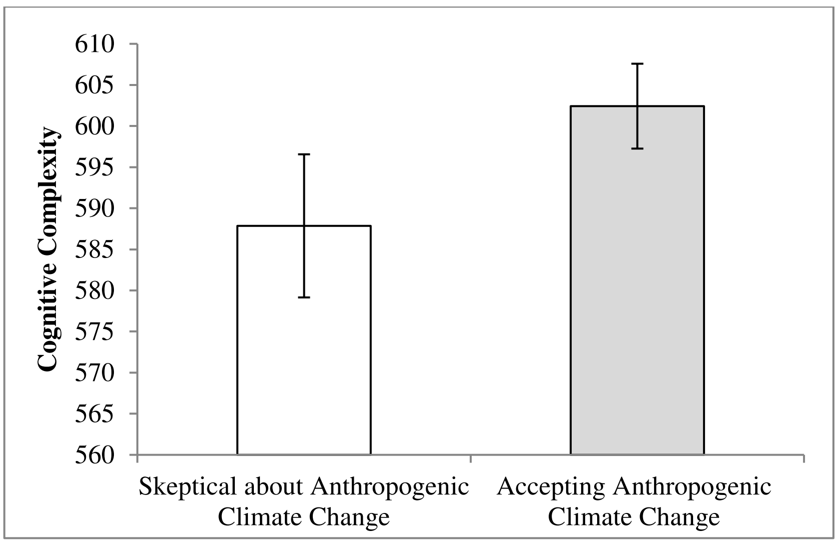

Figure 2 The difference of cognitive complexity between participants for anthropogenic climate change belief and against anthropogenic climate change belief in study 2

Despite the support for hypothesis 1, the association between cognitive complexity and climate change belief reported in study 2 was weaker than that found in study 1. This could be due to a small amount of (non-significant) shared variance between political orientation and cognitive complexity. However, we conducted a logistic regression without controlling political orientation and the regression coefficient of cognitive complexity on climate change belief did not significantly become stronger[5].

Alternatively it could be due to the different sample characteristics across studies. For example, the average age of the participants in study 2 is younger than that in study 1 as showed in Table 1 and Table 3 (*Study 1: mean=49.190, Study 2: mean=19.158*). A previous study also indicated that younger people tend to have stronger beliefs in climate change (Hornsey, Harris, & Bain, et al., 2016). Hence, it is possible that the positive effect of cognitive complexity on climate change belief in study 2 is suppressed by the younger sample. In order to examine whether the relationship between cognitive complexity and climate change belief was influenced by age, we ran a logistic regression with age as a moderation variable using the data of study 1 and study 2 respectively. However, we did not find the moderating role of age in either study 1 or study 2[6].

Finally, the difference of research design between study 1 and study 2 might also be responsible for the differential association. The cross-sectional design of study 1 may have inflated the relationships (Lindell & Whitney, 2001). In study 2, cognitive complexity and climate change belief were collected at different times and this research design is able to reduce the impact of common method variance thus providing a more conservative and robust estimate of the effect.

As noted above, the education level among matching responses is lower than that among the other responses. To examine whether our finding was influenced by education, we ran a logistic regression with education as a moderation variable. Before the analysis, we constructed the

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[5] Results of the logistic regression without controlling for political orientation are show in the part 5 of the online supplementary information. Using R software, we performed a parametric Bootstrap to examine the difference of the regression coefficient associated with cognitive complexity between the regression with and without political orientation. The results showed that there was no significant difference (*Mean=0.026, SD=0.207, 95% confidence interval for the difference [-0.388-0.432]*).

[6] The results of the moderation analysis were showed in the part 1 and part 2 of the online supplementary information.

interaction item using standardized cognitive complexity and standardized education. The results showed that education did not significantly influence the association between cognitive complexity and climate change belief (*B=-0.093, SE=0.122, OR=0.911, 95% confidence interval for OR [0.718-1.156], Wald statistic = 0.590, p=0.443*)[7]. Thus, we believe that the low-level education is not a serious concern for the results.

More importantly, the average cognitive complexity among matching responses was higher than that among the other responses. Thus, to examine whether our finding was influenced by a sampling bias, we ran a logistic regression with the squared item of cognitive complexity. If the effect of cognitive complexity on climate change belief is influenced by cognitive complexity, the squared item of cognitive complexity should be significantly related to climate change belief. Before the analysis, we constructed the squared item using standardized cognitive complexity. The results showed that the squared item of cognitive complexity did not significantly influence the climate change belief (*B=0.019, SE=0.054, OR=1.020, 95% confidence interval for OR [0.917-1.134], Wald statistic = 0.128, p=0.721*)[8]. Thus, we believe that the association between cognitive complexity and climate change belief was not affected by a sampling bias for cognitive complexity. Thus, we believe the support for hypothesis 1 is robust.

5. Study 3

Study 1 and study 2 have shown a relationship between cognitive complexity and an individual's belief in anthropogenic climate change. Study 3 will examine whether exposure to one-sided or two-sided arguments for climate change creates differential relationships.

5.1. Design and Material

[7] The results of the moderation analysis were showed in the part 3 of the online supplementary information.
[8] The results of the moderation analysis were showed in the part 4 of the online supplementary information.

The experiment used a one-factorial between subjects design with two conditions (one-sided argument, two-sided argument). In each condition, participants were exposed to different arguments that illustrate the existence of climate change and they were asked to read through them carefully. All the arguments about climate change are from John Cook's Skeptical Science website (https://skepticalscience.com/print.php). We randomly selected 16 paired arguments from the website listing the most popular arguments by rolling a die and selecting the next one in the list (see Table 5). In the one-sided argument condition, sentences which can all confirm the existence of climate change were presented to participants. Sample sentences were "97% of climate experts agree humans are causing global warming" and "The warming trend is the same in rural and urban areas, measured by thermometers and satellites" (see column b in Table 5). Participants in the one-sided argument condition were asked to read all 16 sentences. In the two-sided argument condition, conflicting arguments about the existence of climate change were presented to participants. Specifically, participants in this condition read sentences which deny the existence of climate change together with the sentences that were shown to the participants in one-sided argument condition. Sample sentences against the existence of climate change were "There is no consensus" and "Sea level rise is exaggerated" (see column a of Table 5). That is to say, all the sentences in Table 5 were displayed for participants in the two-sided argument condition.

Table 5 Arguments on climate change

Column a	**Column b**
ARGUMENTS AGAINST THE EXISTENCE OF CLIMATE CHANGE	ARGUMENTS FOR THE EXISTENCE OF CLIMATE CHANGE

Climate's changed before.	Climate reacts to whatever forces it to change at the time; humans are now the dominant forcing.
There is no consensus.	97% of climate experts agree humans are causing global warming.
Models are unreliable.	Models successfully reproduce temperatures since 1900 globally, by land, in the air and the ocean.
Temp record is unreliable.	The warming trend is the same in rural and urban areas, measured by thermometers and satellites.
CO2 lags temperature.	CO2 didn't initiate warming from past ice ages but it did amplify the warming.
Climategate CRU emails suggest conspiracy.	A number of investigations have cleared climate change scientists of any wrongdoing.
It's freaking cold!	A local cold day has nothing to do with the long-term trend of increasing global temperatures.
Sea level rise is exaggerated.	A variety of different measurements find steadily rising sea levels over the past century.
Medieval Warm Period was warmer.	Globally averaged temperature now is higher than global temperature in medieval times.
Arctic icemelt is a natural cycle.	Thick arctic sea ice is undergoing a rapid retreat.
It's a 1500 year cycle.	Ancient natural cycles are irrelevant for attributing recent global warming to humans.
Human CO2 is a tiny % of CO2 emissions.	The natural cycle adds and removes CO2 to keep a balance; humans add extra CO2 without removing any.
CO2 is plant food.	The effects of enhanced CO2 on terrestrial plants are variable and complex and dependent on numerous factors.
There's no correlation between CO2 and temperature.	There is long-term correlation between CO2 and global temperature; other effects are short-term.
Scientists can't even predict weather.	Weather and climate are different; climate predictions do not need weather detail.
The science isn't settled.	That human CO2 is causing global warming is known with high certainty & confirmed by observations.

Note: All these arguments are from the John Cook's Skeptical Science website (https://skepticalscience.com/print.php).

5.2. Participants and Procedures

As in study 1, an accredited panel survey organization (Qualtrics) was used to access 378 participants from the Australian population. All participants completed their demographic information and the scale of cognitive complexity first. Measures of climate change belief and cognitive complexity were the same as in study 1 and gender, age, education and political orientation were the same as that in study 2. They were then randomly allocated to either the one-sided argument condition (N = 188) or the two-sided argument condition (N = 190). In the one-sided argument condition, participants would read the following instruction: "Below are some arguments for the existence of climate change. Please read through them carefully". In the two-sided argument condition, participants would read: "Below are some arguments both for and against the existence of climate change. Please read through them carefully". Then, participants in the one-sided argument condition would see 16 arguments for the existence of climate change (i.e., all the arguments of Column b in Table 5) and participants in the two-sided argument condition would see 16 paired arguments both for and against the existence of climate change (i.e., all the arguments in Table 5 including Column a and Column b). All participants were then asked about their belief in climate change.

As in study 2, participants who aligned with independents were not included in these analyses. After removing responses with missing data, 304 complete responses were used in the following analysis. Among them, 145 participants were in the one-sided argument condition and 159 participants were in the two-sided argument condition. According to Cohen's (1992) research, when the sample size is 151 and above, we can detect at least a moderate effect size with 0.8 statistical power and a two-tailed test with α=0.05 and *df*=6[9], and when the sample size is larger than 160[10], we can also detect at least a moderate effect size with 0.8 statistical power

[9] Six variables (i.e., gender, age, education, political orientation, cognitive complexity and exposure to arguments about climate change) will be included in the logistic regression of study 3. Hence, the degree of freedom should be 6 as showed in Table 7 Model 1.

[10] Cohen's (1992) study does not list the threshold value when the degree of freedom of χ^2 is 7. Using the software of G*Power 3.1.9.4, we have obtained this threshold value after inputting effect size=0.3, α=0.05, statistical power=0.8 and *df*=7.

and a two-tailed test with α=0.05 and *df*=7[11]. Therefore, we believe that the design in study 3 has enough power.

In total, most participants were female (60.2%) and the mean age was 51.171 years (*SD=16.031*). There was a relatively equal split for the major political orientations with 41.8% of these participants aligned with Labor Party, 47.7% with Liberal Party, 3.0% with Nationals Party and 7.6% with Greens Party.

An ANOVA showed that there were no significant differences across the two conditions for cognitive complexity ($F(1,302)=1.011, p=0.315$), gender ($F(1,302)=0.004, p=0.947$), age ($F(1,302)=0.066, p=0.798$), education ($F(1,302)=0.085, p=0.770$) and political orientation ($F(1,302)=0.111, p=0.739$).

5.3. Results

The means, standard deviations and correlation coefficients of cognitive complexity, anthropogenic climate change belief and other potential control variables are shown in Table 6.

Table 6 The correlations between the variables in study 3

Variables	1	2	3	4	5	6
1. Cognitive complexity	-					
2. Climate change belief	0.175**	-				
3. [a]Gender	0.155**	0.128*	-			
4. Age in year	0.178**	-0.057	-0.135*	-		
5. [b]Education	0.105	0.073	-0.065	0.009	-	
6. [c]Political orientation	-0.001	0.360***	0.050	-0.133*	0.019	-
Descriptive statistics						
Total (N=304)						

[11] Seven variables (i.e., gender, age, education, political orientation, cognitive complexity, exposure to arguments about climate change and the interactive item of cognitive complexity and exposure to arguments about climate change) will be included in the logistic regression of study 3. Hence, the degree of freedom should be 7 as showed in Table 7 Model 2.

Mean	557.609	0.566	0.600	51.171	2.930	0.493
S.D.	108.748	0.496	0.490	16.031	1.171	0.501
One-sided arguments for climate change (N=145)						
Mean	551.041	0.566	0.600	50.924	2.910	0.503
S.D.	114.924	0.497	0.492	16.572	1.142	0.502
Two-sided arguments for climate change (N=159)						
Mean	563.598	0.566	0.600	51.396	2.950	0.484
S.D.	102.793	0.497	0.491	15.569	1.200	0.501

Note: *p < 0.05, **p < 0.01; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [c]Political orientation ("0" right-wing-oriented; "1" left-wing-oriented). (listwise deletion).

After standardizing cognitive complexity, we constructed the interactive item of cognitive complexity and exposure to arguments about climate change. As in study 1, we conducted a logistic regression to examine hypothesis 1 while using the standardized values of cognitive complexity and the results are shown in Table 7. Model 1 was significantly related to anthropogenic climate change belief ($\chi^2 = 55.123$, *df = 6*, $p < 0.001$; *Cox & Snell* $R^2 = 0.166$). Replicating the findings of study 1 and study 2, cognitive complexity was positively related to anthropogenic climate change belief (*B= 0.392, SE=0.140, OR= 1.480, 95% confidence interval for OR [1.124-1.948], Wald statistic = 7.817, p=0.005*). Model 2 with the interactive item was also significantly related to anthropogenic climate change belief ($\chi^2 = 61.468$, *df = 7*, $p < 0.001$; *Cox & Snell* $R^2 = 0.183$). As expected, cognitive complexity and exposure to arguments about the existence of climate change had an interactive effect on belief in anthropogenic climate change (*B=0.734, SE=0.306, OR=2.083, 95% confidence interval for OR [1.143-3.797], Wald statistic = 5.737, p=0.017*).

Table 7 Logistic regression of cognitive complexity on climate change belief in study 3

Variables	Model 1	Model 2

	B (SE)	OR	95% Confidence Interval for OR	B (SE)	OR	95% Confidence Interval for OR
Constant	-1.233(0.791)	0.291	-	-1.229(0.803)	0.293	-
[a]Gender	0.419(0.266)	1.521	0.903-2.562	0.396(0.270)	1.486	0.876-2.521
Age in year	-0.004(0.008)	0.996	0.980-1.012	-0.005(0.009)	0.995	0.978-1.011
[b]Education	0.111(0.109)	1.117	0.902-1.384	0.141(0.112)	1.151	0.925-1.433
[c]Political orientation	1.568(0.260)***	4.796	2.878-7.990	1.556(0.264)***	4.742	2.829-7.948
Cognitive complexity	0.392(0.140)**	1.480	1.124-1.948	0.121(0.174)	1.129	0.803-1.586
[d]Exposure to arguments about climate change	-0.023(0.256)	0.978	0.592-1.613	-0.063(0.261)	0.939	0.563-1.565
Cognitive complexity × Exposure to arguments about climate change				0.734(0.306)*	2.083	1.143-3.797
Total Model: □	$\chi^2 = 55.123$, $df = 6$, p <0.001; Cox & Snell $R^2 = 0.166$			$\chi^2 = 61.468$, $df = 7$, p <0.001; Cox & Snell $R^2 = 0.183$		

Note: N=304, *p < 0.05,**p < 0.01, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Education (“1” Junior high school (10 years), “2” High school, “3” TAFE or trade qualification, “4” Bachelor degree, “5” Master degree, “6” PhD); [c]Political orientation (“0” right-wing-oriented; “1” left-wing-oriented). (listwise deletion). [d]Exposure to arguments about climate change (“0”, one-sided arguments for climate change, “1”, two-sided arguments for climate change).

To further examine hypothesis 2, we ran a simple slope analysis using Hayes and Matthes’ (2009) MODPROBE SPSS Procedure. This procedure can select logistic regression automatically when the dependent variable is binary. Simple slope analysis can help us to examine the significance of the association between the independent variable and the dependent variable when the value of the moderation variable is high or low (Aiken & West, 1991). In order to test our assumption in hypothesis 2, we regarded exposure to arguments about climate change, cognitive complexity and climate change belief as the independent variable, moderation variable and dependent variable respectively. In the simple slope analysis, we aimed to understand the effect of exposure to arguments about climate change on climate change belief when cognitive complexity is low and high. Therefore, the impact of cognitive complexity is not our concern and cognitive complexity was not standardized in the simple slope analysis.

Most simple slope analysis, generally, it is recommended to initially choose a high value at 1 SD above the mean of the moderation variable and a low value at 1 SD below the mean of the moderation variable, because most of the data lie between those two values (Cohen & Cohen, 1983). Thus, we first distinguished low and high cognitive complexity based on Cohen and Cohen's (1983) suggestion. As shown in Figure 3, for those with low cognitive complexity, exposure to one-sided arguments for climate change was marginally associated with greater anthropogenic climate change belief than two-sided arguments (*B=-0.797, SE= 0.4228, p=0.059, 95% confidence interval [-1.625, 0.032]*). At high levels of cognitive complexity, exposure to one-sided arguments was marginally associated with lower anthropogenic climate change belief than exposure to two-sided arguments (*B= 0.670, SE= 0.381, p =0.078, 95% confidence interval [-0.076, 1.417]*).

Statisticians recommend using theoretically relevant values of the moderation variable rather than relying on the more simplistic mean plus and minus 1 SD alternative (Hayes & Matthes, 2009). In present study, the theoretical high value of cognitive complexity should demonstrate that people are able to describe a role using different ratings and imply a more complex cognitive system, while the theoretical high value of cognitive complexity should demonstrate that people can only describe a role using similar ratings and imply a more complex cognitive system (Bieri, Atkins, & Briar, et al., 1966). Hence, the theoretical high and low value of cognitive complexity should refer to the absolutely low and high values of cognitive complexity. However, using the mean minus and plus 1 SD only describes the relatively high and low values of the moderator and the reference point is the mean value (Hayes & Matthes, 2009). For example, assumed there is a sample with a mean and SD of 700 and 100 for cognitive complexity, the relatively high and low values of cognitive complexity are 800 (i.e., 700+100) and 600 (i.e., 700-100). There is no concern about regarding the relatively high value of 800 as the theoretical high level of cognitive complexity, because people whose cognitive complexity is 800 can indeed describe a role using different ratings. Nonetheless, it is problematic to consider the relatively low value of 600 as the theoretical low level of cognitive complexity. It is because people who obtain a 600 score of cognitive complexity are able to describe a role using at least half of the different ratings, which indicates at least a moderately complex system. Hence, Cohen and Cohen's (1983) method might be inappropriate in examining our hypothesis 2.

Considering that values of cognitive complexity range from 230 (low cognitive complexity) to 900 (high cognitive complexity), it is irrefutable that individual with a cognitive complexity score of 230 can hardly describe a role using different ratings and individual with a cognitive complexity score of 900 is absolutely able to describe a role using different ratings. As such, we selected the absolute low value of 230 as the theoretical low and the absolute high value of 900 as the theoretical high.

As shown in Figure 3, for those with low cognitive complexity, exposure to one-sided arguments for climate change was associated with greater anthropogenic climate change belief than exposure to two-sided arguments (*B=-2.274, SE= 0.9852, p=0.021, 95% confidence interval [-4.205, -0.343]*). At high levels of cognitive complexity, exposure to one-sided arguments was associated with lower anthropogenic climate change belief than exposure to two-sided arguments (*B= 2.247, SE= 0.972, p =0.021, 95% confidence interval [0.342, 4.152]*). Thus, hypothesis 2 was supported.

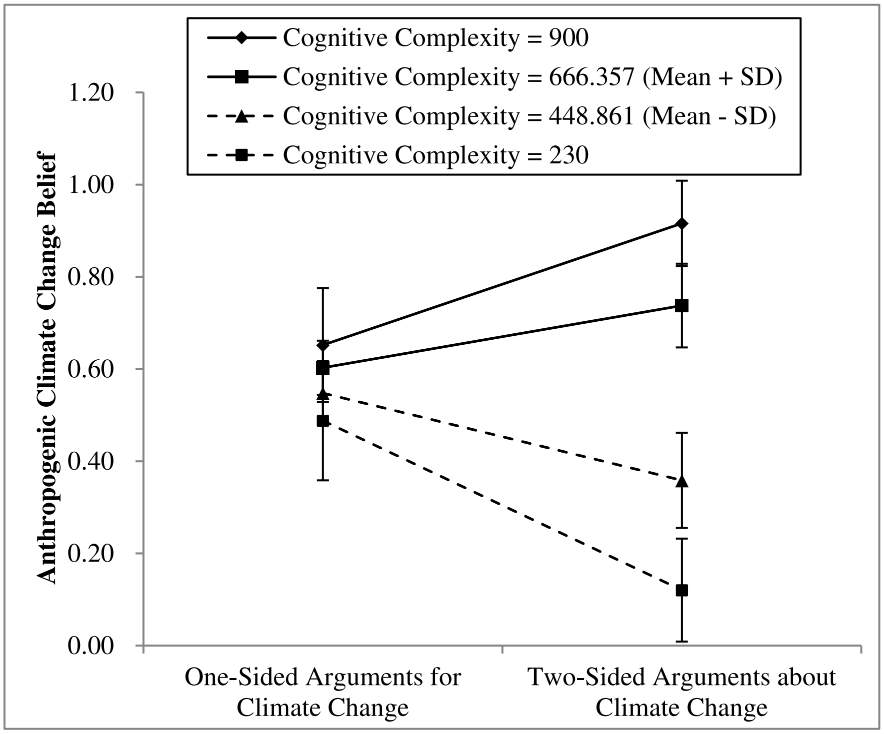

Figure 3 The interactive effect of cognitive complexity and exposure to arguments on climate change belief in study 3

Furthermore, we also visualized the raw data of study 3 in Figure 4. Because cognitive complexity is a continuous variable and both anthropogenic climate change belief and exposure to arguments about climate change are binary variables, we computed the mean value of cognitive complexity for both participants who believed in anthropogenic climate change and participants who were skeptical about human-caused climate change in each of the two conditions (one-sided argument, two-sided argument). As shown in Figure 4, for participants exposed to the one-sided argument, there was little difference in cognitive complexity between those who believed in anthropogenic climate change (*M=553.342, SD=97.623*) and those who did not (*M= 545.444, SD=134.790*). On the other hand, for participants exposed to the two-sided argument, those who believed in anthropogenic climate change (*M= 591.433, SD=61.217*) had substantially higher cognitive complexity than those who did not (*M= 527.290, SD=131.466*). These central tendencies of our raw data are consistent with hypothesis 1. In addition, for participants who believed in anthropogenic climate change, exposed to two-sided arguments about climate change is associated with higher cognitive complexity (*M= 591.433, SD=61.217*) than exposed to one-sided arguments for climate change (*M= 553.342, SD=97.623*). For participants who were skeptical about anthropogenic climate change, exposed to two-sided arguments about climate change is associated with lower cognitive complexity (*M= 527.290, SD=131.466*) than exposed to one-sided arguments for climate change (*M= 545.444, SD=134.790*). These central tendencies of our raw data are consistent hypothesis 2.

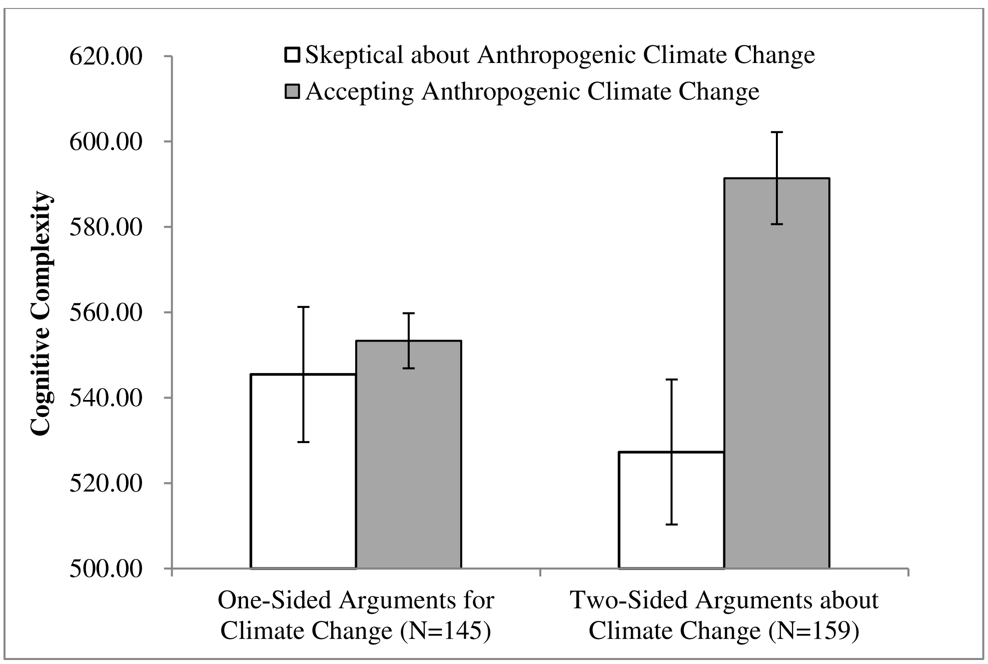

Figure 4 The difference of cognitive complexity between participants for anthropogenic climate change belief and against anthropogenic climate change belief in the one-sided argument and two-sided argument condition

As in study 2, we also ran a logistic regression without controlling for political orientation to see whether our findings were robust. Results of this logistic regression are shown in the part 7 of the online supplementary information. Using R software, we performed a parametric Bootstrap to examine the difference of the regression coefficient associated with cognitive complexity between the regression with and without political orientation. The results showed that there was no significant difference (*Mean=0.123, SD=0.384, 95% confidence interval for the difference [-0.636-0.885]*). Similarly, we did not find a significant difference for the interactive effect of cognitive complexity and exposure to arguments about climate change (*Mean=-0.011, SD=0.418, 95% confidence interval for the difference [-0.807-0.8112]*).

For these analyses, we had deleted 78 responses with missing data. To test whether our results were influenced by these participants, we reexamined our hypothesis without controlling for gender, age, education and political orientation thus enabling them to be included. Results indicated that our findings were robust[12].

6. Discussion

The present study links cognitive complexity to belief in anthropogenic climate change and examines its role in determining the effect of exposure to different types of climate change arguments. All three studies have offered support for the hypothesis that cognitive complexity is positively associated with anthropogenic climate change belief. Furthermore, we found that, for those with low cognitive complexity, presenting only the facts of climate change was associated with greater belief in climate change compared to presenting both misinformation and the facts. In contrast, for people whose cognitive complexity is at high levels, the presentation of the conflicting misinformation and facts (that is, a two-sided, refutational argument) was associated

[12] Please see the logistic regression in the part 9 of the online supplementary information.

with greater belief in climate change compared to the one-sided argument. Our findings have significant societal implications for crafting arguments for climate change as well as the literatures of cognitive complexity and pro-environmental behavior.

6.1. Theoretical Implications

For cognitive complexity research, this study extended the function of cognitive complexity into strengthening individual's belief in human-caused climate change. Considerable evidence has shown that individuals whose cognitive structures are complex have advantages in dealing with complicated and uncertain issues (e.g., Bartunek, Gordon, & Weathersby, 1983). As complex cognition enables individuals to use multiple constructs in illustrating surrounding phenomena, cognitive complexity creates benefits in cultivating diverse and creative thinking (Miron-Spektor, Efrat-Treister, Rafaeli, & Schwarz-Cohen, 2011). Thus, exploring its role in addressing "wicked problems" in society is an obvious step now that we have demonstrated its relationship to belief in climate change.

For pro-environmental research, this study gave a new cognitive explanation for why people are skeptical about anthropogenic climate change. Previous research has indicated that a lack of extreme weather experience, cognitive separation from nature, status quo biases (i.e., regarding climate change as gradual change from current to future values) and skepticism about science lead people to be skeptical about climate change (Carmichael & Brulle, 2017; Hornsey, Harris, & Bain, et al., 2016). Our findings show that perhaps at base this might be because of low levels of cognitive complexity.

On a more pessimistic note, our findings demonstrate why framing positive arguments in messages about climate change has limited general impact on persuading people to accept the reality of anthropogenic climate change. Our study revealed that one-sided arguments were more convincing than two-sided arguments for those whose cognitive structure is simplicity. But for individuals with high levels of cognitive complexity, two-sided arguments were more effective. This suggests that different forms are required depending upon the audience and that a one-size-fits-all approach will not work. When the audience is likely to have high cognitive complexity then a two-sided approach should be used but when the audience is likely to have low cognitive complexity then a one-sided approach should be used.

Finally, the present study provides a way of deterring the damaging impact of conflicting arguments on belief in anthropogenic climate change. Prior scholars have proposed that conflicting information created a confusion between people's agreement with scientific consensus and government policy (e,g, Aklin & Urpelainen, 2013; Kobayashi, 2018). One approach of protecting the public from the spread of conflicting information about climate change is "inoculation" against conflicting arguments (Van der Linden, Leiserowitz, & Rosenthal, et al, 2017). However, there is no prior research addressing the positive role of cognitive complexity. Findings of our study indicated that people with high levels of cognitive complexity can still have strong anthropogenic climate change belief even when exposed to the two-sided conflicting arguments. Therefore, our study offers a cognitive approach to prevent the confounding effect of the conflicting arguments about human-caused climate change belief.

6.2. Limitations and Future Study

It should be noted that our study has some limitations. The first limitation is the measure of climate change belief. On the one hand, climate change belief was measured using just one item which may cause mono-operation bias; however this scale was shown to outperform multi-item scales on climate change belief (Greenhill, Leviston, & Leonard, et al., 2014). On the other hand, climate change belief in our study was measured using self-report and as such is dependent on a controllable cognitive process (Evans, 2008). Future studies can address this by measuring implicit belief in climate change (see e.g., Wang, Geng, & Schultz, et al., 2019).

Second, although we clearly demonstrated the relationship between cognitive complexity and climate change belief, we have not captured the mechanism behind this relationship. We propose that this mechanism might involve the inclusion of diverse perspectives (Wendler & Nilsson, 2009), the connectedness between humans and nature (Scott, 1962), or a simple capacity issue; future studies that delineate the underlying mechanisms are required.

Third, in study 2, we measured cognitive complexity at time 1 and measured anthropogenic climate change belief at time 2. This temporally-lagged design has an advantage in reducing common method variance however a cross-lagged panel design would be a better way to infer the causal effect of cognitive complexity at time 1 on anthropogenic climate change belief at time 2 (Kearney, 2017). Nonetheless, participants must generate 100 ratings to complete cognitive complexity scale. This process is tedious and needs participants to spend more than 30 minutes to complete the scale (Carraher & Buckley, 1996). Therefore, measuring cognitive complexity at both time 1 and time 2 is very demanding so that participants might fill the questionnaires with some careless responses. Furthermore, repeated measuring cognitive complexity and climate change belief might cause participants to guess the hypotheses and ingratiate to support those hypotheses (Zizzo, 2010). Finally, given that cognitive complexity is assumed to be a trait-like measure (Reid & Foels, 2010) and unlikely to be affected by beliefs we suggest that our study is a solid first step in our understanding of this relationship. Hence, we did not measure cognitive complexity and climate change belief at both time 1 and time 2.

Fourth, our design precludes a conclusion of full causality because climate change belief was measured only once in study 3 and thus we cannot determine actual change in beliefs. Nonetheless, because the groups were randomly allocated and there were no other differences between them, we believe our findings are robust and that exposure to arguments has a differential relationship with belief in anthropogenic climate change. Moreover, we also examined whether the interactive effect of cognitive complexity and exposure to arguments about climate change was still established when controlling for the interactive items of exposure to arguments about climate change and other constructs correlated with cognitive complexity (i.e., age, gender, education and political orientation). Results showed that the interactive effect of hypothesis 2 was not changed[13].

Fifth, although we have found a significant positive association between cognitive complexity and anthropogenic climate change, the effect size is small[14] and it is common in previous research on exploring the antecedent factors of climate change belief as indicated in Hornsey's, et al. (2016) meta-analysis. Future studies should do more on how to expand this

[13] Readers who are interested in these results can see all these results in the part 6 of the online supplementary information.
[14] According to Chen, Cohen and Chen's (2010) study, when the odds ratio is below 1.5, the equivalent Cohen's d is less than 0.2 which is the threshold of small effect size. As the odds ratios associated with the effect of cognitive complexity in study 1, 2 and 3 are 1.283, 1.339 and 1.478 respectively, the effect size is small.

effect size. This study has offered a way to enhance the effect size via presenting the conflict information about climate change according to the interactive effect of cognitive complexity and exposure to arguments about the existence of climate change. As for exposure to arguments about the existence of climate change, this study found that the effect size was too small to be significant. It is consistent with previous study such that framing one-sided positive messages about anthropogenic climate change have at best only moderate impact on anthropogenic climate change belief (McCright, Charters, Dentzman, & Dietz, 2016). In this study we have demonstrated the role of cognitive complexity on the effect size regarding the association between exposure to climate change arguments and anthropogenic climate change belief. However, it should be noticed that some other factors can also amplify such effect size. For example, as abovementioned, people whose initial climate change belief is high are more likely to trust the arguments that support climate change (Garrett, 2009). Hence, the effect size of exposure to arguments for climate change on climate change belief is larger for people who believe that climate is changing. As a result, future research should continue to explore this issue regarding expanding the effect size of exposure to arguments for climate change.

Finally, we want to discuss the generalizability of our findings regarding the interactive effect of cognitive complexity and exposure to arguments about climate change. We examined hypothesis 2 using the theoretically high and low values, thus potentially limiting the practical implications[15] to those at these more extreme ends of the spectrum. Hence, although hypothesis

[15] We have provided a detailed analysis about the generalizability in the part 8 of the online supplementary information.

2 was supported, our findings might be less relevant for the majority of the population that sit around the mean of cognitive complexity.

6.3. Practical Implications and Conclusion

Considering the beneficial impact of climate change belief on pro-environmental intentions and behaviors (Hornsey, Harris, & Bain, et al., 2016), our study has important implications. Cognitive complexity can be cultivated through training (Duys & Hedstrom, 2000) thus we may be able to address climate change by increasing the public's cognitive complexity. However, this will be difficult and unlikely to be practical across the population. Instead, we suggest that the media and scientists publish different forms of information to the public. To strengthen human-caused climate change belief, showing two-sided arguments about climate change to those people who are likely to have complex cognitive structure is advocated and it is better that media publishes one-sided arguments for climate change to those who are likely to have low levels of cognitive complexity.

As a conclusion, our study examines the role of cognitive complexity in belief in anthropogenic climate change. Across three studies, we find that cognitive complexity is positively associated with climate change belief and that it alters the effectiveness of the argument form. Those with absolute low cognitive complexity were more likely to believe in anthropogenic climate change after reading a one-sided argument rather than those who read a two-sided argument; but those with absolute high cognitive complexity were more likely to believe after reading a two-sided argument. It is only by taking these differential argument forms into account that we can move forward in action against climate change.

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Supplementary Information

Part 1. Age and Findings of Study 1

In order to examine whether our finding can be influenced by age in Study 1, we ran a logistic regression and age is regarded as a moderation variable. Before the analysis, we constructed the interaction item using standardized cognitive complexity and standardized age. As shown in Table 1, age cannot significantly influence the association between cognitive complexity and climate change belief (*B=-0.021, SE=0.084, OR=0.979, 95% confidence interval for OR [0.830-1.154], Wald statistic = 0.064, p=0.800*).

Table 1 logistic regression of cognitive complexity and age on climate change belief in study 1

Variables	B (SE)	OR	95% Confidence Interval for OR
Constant	-0.088(0.379)	0.915	-
[a]Gender	0.233(0.150)	1.262	0.941-1.694
[b]Education	0.162(0.065)*	1.176	1.035-1.336
Cognitive complexity	0.246(0.075)***	1.279	1.104-1.480
Age in year	-0.008(0.004)	0.992	0.984-1.000
Cognitive complexity × Age in year	-0.021(0.084)	0.979	0.830-1.154
Total Model: □χ^2 = 26.176, *df* = 5, p <0.001; Cox & Snell R^2 = 0.032			

Note: N=817, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD).

Part 2. Age and Findings of Study 2

In order to examine whether our finding can be influenced by age in Study 2, we ran a logistic regression and age is regarded as a moderation variable. Before the analysis, we constructed the interaction item using standardized cognitive complexity and standardized age. As shown in Table 2, age cannot significantly influence the association between cognitive complexity and climate change belief (*B=-0.293, SE=0.235, OR=0.746, 95% confidence interval for OR [0.471-1.182], Wald statistic = 1.588, p=0.212*).

Table 2 Logistic regression of cognitive complexity and age on climate change belief in study 2

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-5.141(2.031)*	0.006	-
[a]Gender	0.352(0.306)	1.422	0.781-2.589

[b]Political orientation	0.474(0.313)	1.606	0.870-2.965
[c]Education	0.069(0.178)	1.071	0.756-1.518
Cognitive complexity	0.358(0.158)*	1.430	1.050-1.949
Age in year	0.283(0.112)*	1.327	1.066-1.652
Cognitive complexity × Age in year	-0.293(0.235)	0.746	0.471-1.182
Total Model: □	χ^2 = 20.382, *df* = 6, p =0.002; Cox & Snell R^2 = 0.086		

Note: N=226, *p < 0.05; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Political orientation (“0” right-wing-oriented; “1” left-wing-oriented). (listwise deletion); [c]Education (“1” Junior high school (10 years), “2” High school, “3” TAFE or trade qualification, “4” Bachelor degree, “5” Master degree, “6” PhD).

Part 3. Education and Findings of Study 2

In order to examine whether our finding can be influenced by education, we ran a logistic regression and education is regarded as a moderation variable. Before the analysis, we constructed the interaction item using standardized cognitive complexity and standardized education. As shown in Table 3, education cannot significantly influence the association between cognitive complexity and climate change belief (*B=-0.093, SE=0.122, OR=0.911, 95% confidence interval for OR [0.718-1.156], Wald statistic = 0.590, p=0.443*). Thus, we believe that the low-level education is not a serious concern for the results.

Table 3 Logistic regression of cognitive complexity and education on climate change belief in study 2

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-5.396(2.096)**	0.005	-
[a]Gender	0.335(0.304)	1.398	0.770-2.538
Age in year	0.300(0.116)**	1.350	1.076-1.693
[b]Political orientation	0.485(0.313)	1.624	0.880-2.997
Cognitive complexity	0.292(0.151)	1.339	0.996-1.799
[c]Education	0.053(0.178)	1.054	0.744-1.495
Cognitive complexity × Education	-0.093(0.122)	0.911	0.718-1.156
Total Model: □	χ^2 = 19.188, *df* = 6, p =0.004; Cox & Snell R^2 = 0.081		

Note: N=226, **p < 0.01; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Political orientation (“0” right-wing-oriented; “1” left-wing-oriented). (listwise deletion); [c]Education (“1” Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD).

Part 4. Cognitive Complexity and Findings of Study 2

In order to examine whether our finding can be influenced by cognitive complexity, we ran a logistic regression with the squared item of cognitive complexity. If the effect of cognitive complexity on climate change belief is changed by cognitive complexity, the squared item of cognitive complexity should be significantly related with climate change belief. Before the analysis, we constructed the squared item using standardized cognitive complexity. As shown in Table 4, the squared item of cognitive complexity cannot significantly influence the climate change belief (*B=0.019, SE=0.054, OR=1.020, 95% confidence interval for OR [0.917-1.134], Wald statistic = 0.128, p=0.721*). Thus, we believe that the association between cognitive complexity and climate change belief will not be changed by cognitive complexity. The high-level cognitive complexity is not a serious concern for the results.

Table 4 Logistic regression of cognitive complexity and education on climate change belief in study 2

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-5.377(2.107)*	0.005	-
[a]Gender	0.340(0.304)	1.406	0.774-2.552
Age in year	0.296(0.117)*	1.344	1.069-1.690
[b]Political orientation	0.458(0.310)	1.581	0.862-2.902
[c]Education	0.072(0.178)	1.075	0.759-1.522
Cognitive complexity	0.350(0.217)	1.419	0.927-2.171
Cognitive complexity ^{2}	0.019(0.054)	1.020	0.917-1.134
Total Model: □	χ^2 = 18.683, *df* = 6, p =0.005; Cox & Snell R^2 = 0.079		

Note: N=226, *p < 0.05; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Political orientation ("0" right-wing-oriented; "1" left-wing-oriented). (listwise deletion); [c]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD).

Part 5. Findings of Study 2 without Controlling for Political Orientation

Table 5 is the results of logistic regression without controlling for political orientation in study 2. Using R software, we performed a parametric Bootstrap to examine the difference of the regression coefficient associated with cognitive complexity between the regression with and without political orientation. The results showed that there was no significant difference (*Mean=0.026, SD=0.207, 95% confidence interval for the difference [-0.388-0.432]*).

Table 5 logistic regression of cognitive complexity on climate change belief without controlling for political orientation in study 2

Variables	B (SE)	OR	95% Confidence Interval for OR
Constant	-5.410(2.087)**	0.004	-
[a]Gender	0.387(0.301)	1.472	0.816-2.656
Age in year	0.306(0.115)**	1.358	1.084-1.703
[b]Education	0.075(0.177)	1.078	0.763-1.532
Cognitive complexity	0.265(0.143)$^{+}$	1.304	0.984-1.727
Total Model: χ^2 = 16.348, *df* = 4, p =0.003; Cox & Snell R^2 = 0.070			

Note: N=226, $^{+}p < 0.1$, $^{**}p < 0.01$; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD).

Part 6. Findings of Study 3 with the Interactive Effect of Arguments and other Control Variables

Table 6-9 is the results of the logistic regression in terms of the interactive effect of cognitive complexity and exposure to arguments about climate change while controlling for the interactive items of exposure to arguments about climate change and other constructs correlated with cognitive complexity (i.e., age, gender, education and political orientation). Cognitive complexity is standardized in the logistic regression. The interactive items of exposure to arguments about climate change and age is computed by the exposure to arguments about climate change and standardized age. Similarity, The interactive items of exposure to arguments about climate change and education is computed by the exposure to arguments about climate change and standardized education. As shown in the Tables, the interactive effect of cognitive complexity and exposure to arguments about climate change was still established.

Table 6 Interactive effect of exposure to arguments and gender on climate change belief in study 3

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-0.708(0.902)	0.493	-
[a]Gender	0.062(0.376)	1.064	0.509-2.223
Age in year	-0.005(0.009)	0.995	0.978-1.011

[b]Education	0.137(0.112)	1.146	0.920-1.428
[c]Political orientation	1.584(0.266)***	4.875	2.895-8.209
Cognitive complexity	0.138(0.173)	1.148	0.817-1.613
[d]Exposure to arguments about climate change	-1.149(0.892)	0.317	0.055-1.820
Cognitive complexity × Exposure to arguments about climate change	0.704(0.311)*	2.022	1.100-3.719
Exposure to arguments about climate change × Gender	0.678(0.532)	1.969	0.694-5.583
Total Model:	$\chi^2 = 63.100$, $df = 8$, $p < 0.001$; Cox & Snell $R^2 = 0.187$		

Note: N=304, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [c]Political orientation ("0" right-wing-oriented; "1" left-wing-oriented). (listwise deletion); [d]Exposure to arguments about climate change ("0", one-sided arguments for climate change, "1", two-sided arguments for climate change).

Table 7 Interactive effect of exposure to arguments and age on climate change belief in study 3

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-1.483(0.889)	0.227	-
[a]Gender	0.390(0.270)	1.477	0.870-2.509
Age in year	-0.001(0.011)	0.999	0.978-1.022
[b]Education	0.141(0.112)	1.151	0.924-1.433
[c]Political orientation	1.571(0.265)***	4.183	2.863-8.092
Cognitive complexity	0.111(0.174)	1.117	0.794-1.572
[d]Exposure to arguments about climate change	-0.058(0.261)	0.944	0.566-1.574
Cognitive complexity × Exposure to arguments about climate change	0.774(0.313)*	2.169	1.175-4.003
Exposure to arguments about climate change × Age	-0.182(0.271)	0.834	0.490-1.419
Total Model:	$\chi^2 = 61.921$, $df = 8$, $p < 0.001$; Cox & Snell $R^2 = 0.184$		

Note: N=304, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [c]Political orientation ("0" right-wing-oriented; "1" left-wing-oriented). (listwise deletion) ; [d]Exposure to arguments about climate change ("0", one-sided arguments for climate change, "1", two-sided arguments for climate change).

Table 8 Interactive effect of exposure to arguments and education on climate change belief in study 3

Variables	Model 2

	B (SE)	OR	95% Confidence Interval for OR
Constant	-0.133(0.894)	0.264	-
[a]Gender	0.339(0.270)	1.491	0.878-2.532
Age in year	-0.005(0.009)	0.995	0.978-1.011
[b]Education	0.172(0.165)	1.188	0.859-1.643
[c]Political orientation	1.562(0.265)***	4.769	2.839-8.011
Cognitive complexity	0.114(0.176)	1.121	0.795-1.581
[d]Exposure to arguments about climate change	-0.064(0.261)	0.938	0.563-1.564
Cognitive complexity × Exposure to arguments about climate change	0.738(0.306)*	2.091	1.148-3.807
Exposure to arguments about climate change × Education	-0.068(0.262)	0.934	0.558-1.563
Total Model:	$\chi^2 = 61.535$, $df = 8$, p <0.001; Cox & Snell $R^2 = 0.183$		

Note: N=304, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Education (“1” Junior high school (10 years), “2” High school, “3” TAFE or trade qualification, “4” Bachelor degree, “5” Master degree, “6” PhD); [c]Political orientation (“0” right-wing-oriented; “1” left-wing-oriented). (listwise deletion) ; [d]Exposure to arguments about climate change (“0”, one-sided arguments for climate change, “1”, two-sided arguments for climate change).

Table 9 Interactive effect of exposure to arguments and political orientation on climate change belief in study 3

Variables	Model 2		
	B (SE)	OR	95% Confidence Interval for OR
Constant	-1.543(0.827)	0.214	-
[a]Gender	0.384(0.271)	1.469	0.863-2.499
Age in year	-0.004(0.009)	0.996	0.979-1.013
[b]Education	0.157(0.113)***	1.170	0.938-1.460
[c]Political orientation	2.080(0.396)	8.006	3.682-17.410
Cognitive complexity	0.151(0.182)	1.163	0.813-1.633
[d]Exposure to arguments about climate change	0.376(0.352)	1.457	0.731-2.903
Cognitive complexity × Exposure to arguments about climate change	0.658(0.305)*	1.933	1.063-3.515
Exposure to arguments about climate change × political orientation	-0.994(0.533)	0.370	0.130-1.051
Total Model:	$\chi^2 = 64.989$, $df = 8$, p <0.001; Cox & Snell $R^2 = 0.192$		

Note: N=304, *p < 0.05, ***p < 0.001; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender (“0” male; “1” female); [b]Education (“1” Junior high school (10 years), “2” High school, “3” TAFE or trade qualification, “4” Bachelor degree, “5” Master degree, “6” PhD); [c]Political orientation (“0” right-wing-oriented; “1” left-wing-oriented). (listwise deletion); [d]Exposure to arguments about climate change (“0”, one-sided arguments for climate change, “1”, two-sided arguments for climate change).

Part 7. Findings of Study 3 without Controlling for Political Orientation

Table 10 is the results of logistic regression without controlling for political orientation in study 3. Using R software, we performed a parametric Bootstrap to examine the difference of the regression coefficient associated with cognitive complexity between the regression with and without political orientation. The results showed that there was no significant difference (*Mean=0.123, SD=0.384, 95% confidence interval for the difference [-0.636-0.885]*). As for the interactive effect of cognitive complexity and exposure to arguments about climate change, we neither found a significant difference (*Mean=-0.011, SD=0.418, 95% confidence interval for the difference [-0.807-0.8112]*).

Table 10 Logistic regression of cognitive complexity on climate change belief without controlling for political orientation in study 3

Variables	Model 1			Model 2		
	B (SE)	OR	95% Confidence Interval for OR	B (SE)	OR	95% Confidence Interval for OR
Constant	-0.198(0.717)	0.820	-	-1.170(0.727)	0.843	-
[a]Gender	0.411(0.248)	1.508	0.928-2.450	0.388(0.251)	1.474	0.901-2.410
Age in year	-0.010(0.008)	0.990	0.975-1.005	-0.011(0.008)	0.989	0.973-1.004
[b]Education	0.115(0.103)	1.121	0.916-1.372	0.139(0.105)	1.149	0.935-1.413
Cognitive complexity	0.359(0.132)**	1.432	1.106-1.853	0.061(0.163)	1.063	0.773-1.462
[c]Exposure to arguments about climate change	-0.040(0.238)	0.961	0.602-1.532	-0.070(0.243)	0.932	0.579-1.501
Cognitive complexity × Exposure to arguments about climate change				0.751(0.280)**	2.118	1.224-3.667
Total Model:	χ^2 = 15.630, *df* = 5, p =0.008; Cox & Snell R^2 = 0.050			χ^2 = 23.516, *df* = 6, p <0.001; Cox & Snell R^2 = 0.074		

Note: N=304, ,**p < 0.01; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio; [a]Gender ("0" male; "1" female); [b]Education ("1" Junior high school (10 years), "2" High school, "3" TAFE or trade qualification, "4" Bachelor degree, "5" Master degree, "6" PhD); [c]Exposure to arguments about climate change ("0", one-sided arguments for climate change, "1", two-sided arguments for climate change).

Part 8. Illustrating the Generalizability of Findings in Study 3

In order to demonstrate the generalizability of our findings, we will compute the proportion of people who are suitable for the findings in the whole sample size. Hayes and Matthes' (2009)

MODPROBE SPSS Procedure has offered a method named Johnson-Neyman (J-N) technique, which can help identifies the regions in the range of cognitive complexity where the effect of exposure to arguments about climate change on anthropogenic climate change belief statistically significant and not significant (Johnson & Neyman, 1936). Results showed that exposed to one-sided arguments for climate change was significantly associated with greater anthropogenic climate change belief than two-sided arguments when cognitive complexity was lower than 435. 067, and exposed to one-sided arguments was associated with lower anthropogenic climate change belief than exposure to two-sided arguments when cognitive complexity was higher than 697.180. Among all the participants in present study, 9.9 % of them have cognitive complexity scores lower than 435. 067 and only 0.3% of them have cognitive complexity scores higher than 697.180. Hence, although hypothesis 2 was supported, future study should continue to do more work on extending the effect size of exposure to arguments about climate change belief.

Part 9. Findings of Study 3 without Control Variables

Table 11 is the results of logistic regression without controlling for gender, age, education and political orientation. As shown in Table 8, our results were still established. Specifically, Model 1 was significantly related to anthropogenic climate change belief ($\chi^2 = 11.325$, *df = 2, p =0.003; Cox & Snell* $R^2 = 0.030$). Replicating the findings of Study 3, cognitive complexity was positively related to anthropogenic climate change belief (*B= 0.368, SE=0.114, OR=1.445, 95% confidence interval for OR [1.154-1.808], Wald statistic = 10.333, p<0.001*). Model 2 with the interactive item was also significantly related to anthropogenic climate change belief ($\chi^2 = 16.120$, *df = 4, p =<0.001; Cox & Snell* $R^2 = 0.043$). Consistent with study 3, cognitive complexity and exposure to arguments about the existence of climate change had an interactive effect on belief in anthropogenic climate change (*B=0.516, SE=0.242, OR=1.675, 95% confidence interval for OR [1.043-2.691], Wald statistic = 4.550, p=0.033*).

Table 11 Logistic regression of cognitive complexity on climate change belief without control variables in study 3

Variables	Model 1			Model 2		
	B (SE)	OR	95% Confidence Interval for OR	B (SE)	OR	95% Confidence Interval for OR
Constant	0.245(0.151)	1.277	-	0.237(0.149)	1.267	-
Cognitive complexity	0.368(0.114)***	1.445	1.154-1.808	0.163(0.142)	1.177	0.890-1.554
[a]Exposure to arguments about climate change	0.006(0.213)	1.006	0.663-1.527	-0.022(0.216)	0.978	0.640-1.493
Cognitive complexity × Exposure to arguments about climate change				0.516(0.242)*	1.675	1.043-2.691
Total Model:	χ^2 = 11.325, *df* = 2, p =0.003; Cox & Snell R^2 = 0.030			χ^2 = 16.120, *df* = 4, p =<0.001; Cox & Snell R^2 = 0.043		

Note: N=371,*p < 0.05, ***p < 0.01; B is the unstandardized regression weight and the values in the parentheses represent the standard error of the unstandardized regression weight; OR means odds ratio. [a]Exposure to arguments about climate change (“0”, one-sided arguments for climate change, “1”, two-sided arguments for climate change).

Reference

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