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Abstract

Climate change is a serious problem that requires people's cooperation for its solution, while it is realized that there have been perception gaps about its causes. However, little is known about what causes people to perceive that climate change is human-induced or nature-induced as well as the linkage between the perception and cooperative attitude. We empirically analyze the determinants for the human-induced or nature-induced perception as well as the impact of the perception gap on cooperative attitudes toward climate change by conducting questionnaire surveys and a climate donation game with 400 Japanese subjects. First, the analysis finds an importance of people's scientific literacy to explain the perception gap in that those with high levels of scientific literacy tend to have the perception of human-induced climate change. Second, people are identified to be cooperative toward climate change as they have prosocial value orientation, high scientific literacy and the perception of human-induced climate change, demonstrating that scientific literacy plays two important roles as not only a direct determinant but also an indirect one through affecting people's perceptions for climate change cooperation. Overall, the results suggest that enhancement of scientific literacy and prosociality through some policies, such as educational programs, shall be key to induce people to cooperate for climate change via the perception of human-induced climate change.

Key Words: Human-induced or nature-induced climate change; scientific literacy; donation game; prosociality

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1 Introduction

Climate change is a serious problem that requires people's cooperation for its solution (Pacheco et al., 2014, Bang et al., 2015). Unfortunately, people around the world seem to have failed in cooperating and coordinating their efforts each other on this issue, although human is known as an unusually cooperative species as compared with other species (Boyd and Richerson, 2009, Tattersall, 2011). There have been several researches to analyze how people become more cooperative for climate change. These studies establish that correct perception and/or knowledge toward climate change are positively associated with cooperative attitudes, whereas there have existed a wide variety of perception gaps (Rand et al., 2009, Tobler et al., 2011, Fischer and Charnley, 2012, Islam et al., 2016). Despite its importance, there have been few researches to examine how such perception gaps are related to knowledge as well as to other factors, and how the relation influences cooperative behaviors. Given this state of affairs, this research addresses people's perception gap with a focus on the cause of climate change, knowledge and cooperative attitudes within a single framework.

Past researches have examined people's perception on the cause of climate change (Bray, 2010, Cook et al., 2013, Carlton et al., 2015). By and large, there are two ideas about the cause of climate change. One is an idea of human-induced climate change in that climate change can be considered to be caused by human activities, such as burning fossil fuels, cutting down forests and farming livestock (Karl and Trenberth, 2003, Koneswaran and Nierenberg, 2008, Doran and Zimmerman, 2009, Solomon et al., 2009, Bechtel and Scheve, 2013, Höök and Tang, 2013). The other is an idea of nature-induced climate change in that climate change can be considered to have been a part of natural climate cycles and will continue to be so, being exemplified by many events in the earth's history such as the changes in solar output, the earth's orbit and volcano eruptions (Karl and Trenberth, 2003, Solomon et al., 2009, Council et al., 2011). A group of former studies show that scientists have largely accepted an idea that the cause of climate change is human-induced (Karl and Trenberth, 2003, Hegerl et al., 2007, Anderegg et al., 2010, Council et al., 2011, Lehtonen et al., 2019). Leiserowitz et al. (2010) report that only half of the American public believes in human-induced climate change, while approximately 97 % of publications by climate scientists advocate human-induced climate change (Doran and Zimmerman, 2009, Anderegg et al., 2010, Carlton et al., 2015).

Shealy et al. (2016) and Shealy (2018) find that civil engineering students in America who do not believe in human-induced climate change are less likely or never desire to take jobs associated with addressing climate change in their careers. Saleh Safi et al. (2012) examine the relationship among vulnerability, beliefs and risk perception on human-induced climate change in rural Nevada. They report that climate change-specific beliefs, in particular, whether or not people believe in the human-induced causes of climate change and/or whether they connect the locally observed impacts to the climate change, are the most prominent determinants of risk perception. In summary, an idea of human-induced climate change still remains a public controversy despite the consensus among climate scientists (Bray, 2010, Cook et al., 2013, Tol, 2014, Carlton et al., 2015). Aside from this controversy, it is likely that the actual perception and behaviors toward climate change shall be affected by the extent to which people believe in human-induced climate change.

Researchers implement surveys on people's perception and their cooperative attitudes toward climate problems by the willingness to pay (WTP) (Brechin and Bhandari, 2011, O'Connor et al., 1999, Akter and Bennett, 2011, Islam et al., 2016). Brechin and Bhandari (2011) confirm that people in some countries remain more concerned about general environmental problems than global climate change through the comparative national studies on public perception on climate change and its willingness to pay. O'Connor et al. (1999) examine the relationship between people's risk perceptions and their willingness to pay toward climate problems, and report environmental beliefs are strong predictors of behavioral intentions for voluntary actions. Akter and Bennett (2011) examine Australian households' perceptions on climate change and their preferences for mitigation action and find that people's willingness to take actions against climate problems at national and household levels is influenced by their level of mass-media exposure. Moreover, Islam et al. (2016) examine the relationship between climatic perception and flood mitigation cooperation, suggesting that accurate climatic perceptions is a key to increasing people's cooperations in managing climate change.

These studies have demonstrated that people's perception influences their cooperative attitudes toward climate change. However, few works have examined people's perception such as the cause of climate change and their cooperative attitudes in a single frame work. Moreover, little is known about what induce people to perceive that climate change is human-induced or nature-induced as well as the linkage between their perception and cooperative attitudes. To examine these issues, we empirically analyze people's human-induced or nature-induced perception and the relation to their cooperative attitudes toward climate change by conducting questionnaire surveys as well as a climate donation game with 400 Japanese subjects. In this survey, we measure and collect people's scientific literary, social preferences and actual cooperative attitudes to climate change by a climate change donation game in addition to sociodemographic information. Social psychologists and economists argue that sicientific literacy and social preferences can be keys to influence people's cooperative attitudes to natural disasters and other social events (Van Lange et al., 2007, Bogaert et al., 2008, Nakagawa, 2016, Mischkowski and Glöckner, 2016, Shahrier et al., 2016, Timilsina et al., 2019). With this data, our research addresses the following two open questions: (1) What are determinants for the human-induced or nature-induced perception on the cause of climate change and (2) How does the perception gap on the cause of climate change along with social preferences and scientific literacy affect people's cooperative attitudes?

2 Materials and methods

We conduct the survey with 400 subjects sourced from the registered participant pool of a web-based survey company, Cross Marketing Inc. The subjects' mean age is 49.61 years with the standard deviation $= 17.32$, ranging between 20 and 89 years. The area the survey covers is divided into the urban and non-urban ones according to the population density of 500 people km^{-2}. If the population density in the residence area where a subject lives is above or equal 500 people km^{-2}, it is urban, otherwise non-urban. This survey collects a sample of 200 subjects in each of urban and non-urban areas with information about (i) sociodemographic factors, such as age, gender, marital status, employment status, educational background, family characteristics and household income, (ii) perceptions on the cause of climate change, (iii) scientific literacy, (iv) cooperation to climate change and (v) social value orientation.

Subjects are asked about which perception they have with respect to the cause of climate change: human-induced, nature-induced climate change or others. Subjects read the explanatory notes 1 and 2, each of which corresponds to the description of what it stands for by saying "human-induced" and "nature-induced" climate change associated with figures 1(a) and 1(b), respectively. After subjects understand these explanations, they are asked to choose one option that is the closest to their current perception among the five options. (1) "I choose explanatory note 1 of human-induced climate change," (2) "I choose explanatory note 2 of nature-induced climate change," (3) "Explanatory notes 1 and 2 are somewhat persuasive, but I cannot choose which one to support," (4) "None of explanatory notes 1 and 2 are persuasive," (5) "I cannot judge it because I do not or cannot understand the explanation."

Explanatory note 1: Some researches on climate change suggest that greenhouse gases and carbon dioxide released by human production activities are changing the patterns and cycles of climate around the world as described in figure 1(a). Now, challenges posed by climate change are well recognized. Greenhouse gases and carbon dioxide released from various human activities have an adverse effect on societies.

Explanatory note 2: Human impacts on climate change may neither be significant nor be relevant. In the long term of thousands or tens of thousands of years, it is said that climate, the pattern and cycles are changing naturally as demonstrated in figure 1(b). Some researches suggest that the cause of climate change cannot be verified to be human-induced, claiming that human-induced climate change is exaggerated too much. It is appropriate to understand that climate change is a part of natural cycles in the long term dynamics of the earth.

[Figure 1 about here.]

Scientific literacy is measured by the NISTEP scientific literacy scale adopted from a national questionnaire survey about people's attitudes on general science and technology (NISTEP, 2001). The National Institute of Science and Technology Policy of Japan (NISTEP) has organized the scale consisting of 15 questions regarding general scientific knowledge and literarcy and it is employed in some recent researches (Nakagawa, 2016, Jingchao et al., 2018). A subject is asked to answer "true," "false" or "no idea" in each question where either of "true" or "false" is usually set to be a correct answer. When she chooses a correct answer in a question, she scores 1, otherwise 0. The answer "no idea" in each question is counted as 0. The scale is defined as the number of questions for which a subject answers correctly, being ranging from 0 to 15.

Questions 1-13 pose scientific propositions such as (1) "the center of the Earth is very hot," (2) "all radioactivity is man-made," (3) "the oxygen we breathe comes from plants," (4) "it is the father's gene that decides whether the baby is a boy or a girl" and so on, each of which shall be answered by choosing "true," "false" or "no idea." Questions 14 and 15 are posed in a different manner. Question 14 is posed as "which travels faster - light or sound?" Each respondent is asked to choose one of the four alternatives: "light," "sound," "the speeds are nearly the same" and "I have no idea." Question 15 comprises two subquestions where the first subqestion is "does the Earth go around the sun or does the sun go around the Earth?" When a subject answers correctly in the first subquestion, the next subquestion is posed as "if the Earth goes around the Sun, how long does it take?" The NISTEP scientific scale is established as a reliable measurement to influence people's behaviors and cooperative attidues in disaster management and energy issues (Nakagawa, 2016, Jingchao et al., 2018).

We institute a climate donation game to approximate the degree of people's cooperation toward climate change. This game is considered to be a variant of a dictator game in a two-player setting where one person (the other person) is assigned to be a dictator (a receiver), and the dictator can decide how to split a fixed amount of money between herself and the receiver (See, e.g., Bolton et al., 1998, Engel, 2011). In most cases, a dictator and a reciever play the game under an anonymous setting so that each player never knows the identity of the other. The climate donation game is distinct from a typical dictator game in two points. First, each subject becomes a dictator, knowing who is a reciever. Second, the reciever is not a human but a well-known organization called "The Green Climate Fund" (GCF) in Japan that runs a series of nonprofit activities to fight against climate change.

In the climate donation game, each subject is given 1000 JPY as an initial endowment and asked to distribute the money between herself and GCF as she wishes. If she takes everything (nothing) for herself, the money donated to GCF is 0 JPY (1000 JPY). If she takes 400 JPY for herself, the money donated to GCF is 600 JPY. When we instruct subjects about the climate donation game, we are very careful to state "how to split between yourself and GCF is totally up to you, and nobody can know how you split, because everything is recorded by an ID, not by your name." Economists use the amount of money the dictator gives to the receiver in dictator games as a good proxy of altruism, i.e., how much one person cares about the general unknown other(Diekmann, 2004, Bekkers, 2007, List, 2007, Andreoni et al., 2017). In a similar fashion, we consider that the amount of money the dictator gives to GCF is a good proxy for how much one person cares about climate change, wanting to coooperate for its solution.

We use social value orientations (SVOs) in the triple-dominance game developed by Van Lange et al. (1997, 2007) to characterize subjects' social preferences. It is known to be reliable and to reflect a stable personality trait of how people evaluate interdependent outcomes for themselves and others in social environments (Van Lange et al., 1997). This method categorizes individual value orientations into four types of the "competitive," "individualistic," "prosocial" and "unidentified," depending on their choices in nine questions. In one question, a subject chooses one option among three options, option (1): you get 480 and other gets 80, option (2) you get 480 and other gets 480 and option (3) you get 540 and other gets 280. In this example, option (1) represents a competitive orientation that maximizes the point gap between herself and the other ($480 - 80 = 400$); option (2) is a prosocial orientation that maximizes the joint outcome ($480 + 480 = 960$). Option (3) is an individualistic orientation that maximizes her own outcome of 540, being indifferent to the outcome of the other. This SVO game contains nine questions, each of which consists of three options for herself and the other. In each question, one option among the three corresponds to one of the following orientations, i.e., the "competitive," "individualistic" and "prosocial." Each subject is asked to choose one option as the most preferred in each item, finally generating nine choices of options. Each subject is classified as the prosocial (the individualistic or competitive) if she makes six or more choices of options with that orientation. Otherwise, she is categorized as the "unidentified."

Our survey experiments have been conducted with real monetary payments in the climate donation and SVO games. This is made for motivating subjects to seriously participate in the games, considering their opportunity costs of time as well as their true revelation of social preferences and cooperative behaviors toward climate change. In the SVO games, subjects are informed that we randomly match two subjects as a pair, and the more experimental points one subject gets, the more real money she will earn with some exchange rate (20 points are converted to 1 JPY), which is 226 JPY $\approx$ 2.05 USD on the average. In the climate donation game, subjects are informed that the amount of money they keep is theirs.

3 Results

The description of all variables is presented in Table 1. Table 2 presents the summary statistics of the major dependent and independent variables for the urban and non-urban areas. The percentage of female's subjects to the survey is similar in both urban areas (38 %) and non-urban areas (36 %). Subjects in both of the urban and non-urban areas possess high school graduate as the median. The median household income range in urban areas is 1 million JPY higher than in non-urban areas in Table 2. With respect to occupations, only 2 % of the subjects in non-urban areas are employed in Agriculture or Fishing. This implies that even in non-urban areas people depend on industries other than Agriculture and Fishing in Japan. As predicted by our initial expectation, a high proportion (200 out of 200) of people in urban areas report that they are salaried workers, such as company owners, office workers and civil servants. However, even in non-urban areas, 173 people out of 200 subjects reports that they receive a regular salary. The statistics of the sociodemographic information in Table 2 are in the accordance with our initial expectation, which is that subjects from the urban area have higher values for education level and household income. Therefor, these results indicate that nowadays, in Japan, there is little difference between urban and non-urban areas.

Regarding the result of climate donation game, the average donation (JPY) in urban areas (455.53) is higher than in non-urban areas (419.90). The average total of donation both areas is 437.71. With respect to perception of the cause of climate change, 30 % of subjects in urban areas and 33 % of subjects in non-urban areas answer that climate change is caused by human-induced factors. On the other hand, 12 % of subjects in urban areas and 14% in non-urban areas answer that climate change is caused by nature-induced factors, respectively. Table 2 also shows subject's SVOs to be a prosocial or proself between the urban and the non-urban. This exhibits that 56 % of subjects in urban areas and 60 % of subjects in non-urban areas of subjects are categorized into "prosocial". The number of prosocial subjects in non-urban areas is only 4 % higher than those in urban areas. This implies the prosociality among people is not so different between the urban and non-urban areas, now a day, in Japan.

Furthermore, Table 2 presents subject's scientific literacy. The Cronbach's alpha of this scale is 0.76, showing that this scientific literacy scale has acceptable internal consistency. The median scores of scientific literacy is 9.00 point in both urban and non-urban areas. The average scores of scientific literacy is 8.53 point in urban areas and 8.24 point in non-urban areas. This implies that subject's scientific literacy level among people is not so different between urban and non-urban areas in this survey.

[Table 1 about here.]

[Table 2 about here.]

[Table 3 about here.]

Table 3 presents the summary of statistics of subject's perception on the cause of climate change and donation (JPY) toward the prevention of climate change. An interesting feature can be found in the donation by subjects who chose the nature-induced climate change between urban and non-urban areas. With respect to human-induced climate change, the average donation is 590.25 in urban area, and 525.00 in non-urban area, respectively in Table 3. Regarding a perception of nature-induced climate change, the average donation in urban area is 535.22 in Table 3 and, the average donation in non-urban area is 272.50. The median of donation from subjects who have the perception of human-induced climate change in urban area (500) is relativery higher than that in non-urban area (100). Subjects who favoured the perception on nature-induced climate change tends to pay less donation toward the prevention of climate change, and especially those subjects in non-urban area donate less than that in the urban area. It implies that the perception of man-induced climate change has something positive relationship with people's cooperation toward the prevention of climate change.

Table 3 summarizes the statistics of the subject's Social Value Orientation (SVO) and donation toward the prevention of climate change. The median donation by the prosocial is 500 in each area of urban and non-urban. The average of total donation by the prosocial in both areas is 475.85, and compared with proself of 386.83, the prosocial tends to pay more donation toward the prevention of climate change. This trend is found both in urban and non-urban areas, but donation itself is higher in urban area both prosocial and proself. The average donation by prosocial is 493.43 in urban area and 459.58 in non-urban area. The Median donation of proself is 300 in urban area and 200 in non-urban area. The average donation by the proself is 412.84 in urban area, 352.69 in non-urban area. There seems to be some factors that the donation toward the prevention of climate change increases in urban area.

Regarding a marital status, the average donation by the marriage experienced is 520.31, 476.34 in order of urban and non-urban areas. The average donation by the marriage non-experienced is 314.67, 312.73 in order of urban and non-urban areas. This implies that donation among people is not so different between urban and non-urban areas in this survey. The average donation in urban area is 520.31 (median = 500), 314.67 (median = 200) in order of marital status experienced and marital status non-experienced. Furthermore, the average donation in non-urban area is 476.34 (median = 500), 312.73 (median = 198) in order of marital status experienced and marital status non-experienced. According to these results, the marriage experienced have a tendency to make more donation to climate change than the marriage non-experienced. With respect to scientific literacy in Table 3, the average donation in urban area is 382.51, 462.40, 538.53 in order of low, medium and high. The average donation in non-urban area is 386.59, 509.48, 376.22 in order of low, medium and high. The average total donation both urban and non-urban areas is 384.72, 487.69, 473.89 in order of low, medium and high. The Median donation of low scientific literacy (300 in urban areas and 200 in non-urban areas) is lower than that of high scientific literacy (500 in urban areas and 500 in non-urban areas). Overall, from these results, the scientific literacy is likely to bring positive impacts on people's attitudes toward climate change.

A regression analysis is conducted to verify open question (1): "What are determinants for the human-induced or nature-induced perception gap on the cause of climate change". Table 4 reports the marginal effect of choosing "Human-induced climate change"(human-induced =1, nature-induced =0) calculated from the results of logistic regressions. The distribution function of logistic regression model is as follows:

$$Prob(y_i = 1) = \frac{\exp(X_i\beta)}{1 + \exp(X_i\beta)}. \tag{1}$$

enable us to compute the probability of determinants for human-induced climate change perception.

Model1 in Table 4 contains scientific literacy. The result reveals this variable exhibit statistical significance of $p < 0.01$. We add age and gender dummy (female = 1, male = 0) in Model 2 in Table 4. Then, we find that scientific literacy remains statistically significant with the same sign, and age, and gender dummy exhibit statistical significance of $p < 0.01$ and $p < 0.05$, respectively. In addition, we add SVO (prosocial = 1, otherwise = 0) in Model 3 in Table 4. Then, we find that scientific literacy, age, and gender dummy remains statistically significant with the same sign, and prosociality exhibits statistical significance of $p < 0.10$.

To further characterize subject's perception of human-induced climate change, we add other variables such as marital status, educational background, household income, area dummy (urban = 1, non-urban = 0), and family type (nuclear family = 1, extended family = 0) in Model 4 in Table 4. We find that scientific literacy, gender dummy, and SVO remains statistically significant with the same sign, and age exhibits statistical significance of $p < 0.05$. There are no significant associations on marital status, educational background, household income, area dummy and family type in Model 4 in Table 4. Overall, these findings demonstrate the factors affect human's perception on the cause of climate change are scientific literacy level, age, gender dummy and prosociality. In particular, our result suggests that enhancement of scientific literacy level is a key to favor the perception of human-induced climate change in Figure 2.

[Figure 2 about here.]

[Table 4 about here.]

[Table 5 about here.]

A regression analysis in Table 5 is conducted to test open question (2): "Which people's characteristics is identified to be cooperative people toward climate change?". In this experiment, 106 out of 400 subjects donated 0 JPY, therefore we perform tobit regression to obtain more accurate results. Model 1 in Table 5 contains people's perception of the human-induced climate change as an independent variable. The distribution function of tobit regression model is as follows:

$$y_i^* = \beta_0 + \mathbf{P}_i\beta_1 + \mathbf{C}_i\beta_2 + \mathbf{S}_i\beta_3 + \varepsilon_i \tag{2}$$

enable us to compute which characteritics to pay more donation against climate change.

Table 5 reports the marginal effect of the estimated coefficients with statistical significance in the tobit regression of donation toward the prevention of climate change. The result reveals this exhibit the marginal effect (235.016) and statistical significance of $p < 0.01$ in Model 1 in Table 5, and is significantly associated with donation toward the prevention of climate change. Model 2 in Table 5 contains people's perception of the human-induced climate change and scientific literacy as independent variables. The result reveals these variables exhibit statistical significance of $p < 0.01$, $p < 0.01$, respectively, and are significantly associated with donation to climate change. However, the magnitude of influence by scientific literacy (T = 24.101) is rather small compared with that by the perception on the human-induced climate change (T = 190.834). Moreover, we add SVO in Model 3 in Table 5. We find that the perception of human-induced climate change, scientific literacy remains statistically significant with the same sign and magnitude, and SVO has a statistically significant positive correlation with donation toward the prevention of climate change (T = 102.251, $p < 0.05$).

To further characterize subject's donation toward the prevention of climate change, we add variables such as age, gender dummy, marital status (experienced = 1, non-experienced = 0), household income, educational background and area dummy in Model 3 in Table 5. The result reveals that the perception on human-induced climate change and age exhibit statistical significance of $p <0.01$ and $p <0.01$, respectively and are positively associated with donation toward the prevention of climate change. We find that SVO, scientific literacy and marital status have statistically significant correlations of $p < 0.05$, $p < 0.10$, and $p < 0.10$, respectively. Other variables such as household income, educational background, and area dummy show no significant associations of them in Model 4 in Table 5. Overall, these findings demonstrate the factors affect donation toward the prevention of climate change are the perception, scientific literacy, prosociality, age and marital experience. In particular, our result suggests that people who have the perception of human-induced climate change pay more donation toward the prevention of climate change in Figure 3.

[Figure 3 about here.]

There seems to be a strong relationship between scientific literacy and people's perception of the cause of climate change and donation for that's countermeasures. Threfore we will introduce the concept of mediation to confirm these three relationships. Mediation is a hypothesized causal chain in which one variable affects a second variable that, in turn, affects a third variable (Newsom, 2018). The intervening variable, M, is the mediator. It "mediates" the relationship between a predictor, X, and an outcome. Graphically, mediation can be depicted in the following way of Figure 4(a). Paths a and b are called direct effects, respectively. The mediational effect, in which X leads to Y through M, is called the indirect effect. The direct represents the portion of the relationship between X and Y that is mediated by M. Baron and Kenny (1986) proposed a four steps approach in which several regression analyses are conducted and significance of coefficient is examined at each step. Ć could also be called a direct effect in Figure 4(b).

[Figure 4 about here.]

To confirm about mediation, do the test with the following procedure.

1. Step1: Conduct a simple regression analysis with X predicting Y to test for path " ć " alone,

$$Y = B0 + B1X + e \tag{3}$$

2. Step2: Conduct a simple regression analysis with X predicting M to test for path " a ",

$$M = B0 + B1X + e \tag{4}$$

3. Step3: Conduct a simple regression analysis with M predicting Y to test the significance of path " b " alone:

$$Y = B0 + B1M + e \tag{5}$$

4. Step4: Conduct a multiple regression analysis with X and M predicting Y,

$$Y = B0 + B1X + B2M + e \tag{6}$$

1. Step1: Conduct a simple regression analysis with scientific literacy predicting donation (Y) to test for path " ć " alone, . The path " ć " is statistically significant, $P < 0.000$.
2. Step2: Conduct regression with scientific literacy predicting human-induced climate change to test for path " a " alone. The path " a " is statistically significant, $P < 0.000$.
3. Step3: Conduct regression analysis with human-induced climate change predicting donation to test the significance of path " b " alone. The path " b " is statistically significant, $P < 0.000$.
4. Step4: Conduct a multiple regression analysis with scientific literacy and human-induced climate change predicting donation. The path " ć " is statistically significant, $P < 0.005$. The path " b " is statistically significant, $P < 0.001$.

Considering this fact, the perception of human-induced climate change is the mediator. It mediates the relationship between a scientific literacy and an donation action toward the prevention of climate change. The mediational effect, in which scientific literacy leads to donation behavior against climate change through perceptions, is the indirect effect. Moreover, this test shows that scientific literacy gives a direct effect to donation actions toward the prevention of climate change. Overall, there is strong relationship between scientific literacy, people's perception of the cause of climate change and donation behavior for that's countermeasures.

Now, with these results, we can answer the two open questions posed at th end of introduction section. (1) What are determinants for the human-induced or nature-induced perception on the cause of climate change? Our answer to this question is that the enhancement of scientific literacy level is a key to favor the perception of human-induced climate change, and (2) How does the perception gap on the cause of climate change along with social preferences and scientific literacy affect people's cooperative attitudes? Our answer to the question is that the perception of muman-induced climate change, scientific literacy, and prosociality affect cooperative behavior toward the prevention of climate change. In summary, our results suggest there is strong relationship between scientific literacy, people's perception of the cause of climate change and cooperative behavior for climate change countermeasures.

4 Discussion

Climate change is a serious problem that requires people's cooperation for its solution. Unfortunately, people seem to have failed in cooperating and coordinating their efforts each other on this issue. The prosocial will be good cooperators to fight against climate change. Some theoretical and experimental researches have investigated the relationship between prosociality and the prevention of climate change (e.g. Kline et al., 2018, Meyer and Liebe, 2010, Gatersleben et al., 2014). In a practical manner, the prosocial tend to find in rural areas, contrary to this, more areas in the world are urbanized. Increasing the people those who have prosociality become more difficult in the future. In order to investigate the influence of prosociality on willingness to cooperate to prevent climate change, we conduct a reserch using two games; an SVO game to measure prosociality, and a climate donation game to measure willingness to make a monetary contribution to prevent climate change. In the latter game, we also investigate the possible connection between a person's character and the amount of donation they made. Using the amount of donation as a measure of willingness to cooperate, the results indicate that the prosocial are willing to cooperative toward climate change countermeasures than the proself. The efforts to enhance prosociality can be expected to increase the people who contributes to climate change countermeasure, but that is tough and mammoth task. Brosig-Koch et al. (2011) have analyzed solidality gap between eastern and western Germany in 20 years after reunification, by demonstrating their solidarity game. Their findings indicate that people's social preferences change more slowly than political values. We need to find more better practical methods than the enhancement of people's prosociality to cooperate against climate change problems .

These results support the findings of similar research done in Nepal (Timilsina et al., 2019), in which many people in rural areas were classified as being prosocial, and many of those in urban areas were classified to as being proself. That research also proposes that one of the main factors for higher prosociality in rural communities was the higher number of interactions between members who live near each other. However, in the globalization world where urbanization and capitalism expand, a decreasing of the prosocial is a negative factor for climate change. Climate change in urban area is an important problem to be addressed (e.g. Siders, 2017). In this research, however, proportion of the prosocial is 56 % (n = 111) in urban area and 60 % (n = 120) in non-urban area, only 4 % more in non-urban area than in urban area. This is because, in advanced industrialized countries, such like Japan, even in non-urban area, people are salary workers, and their daily life is almost same as that in urban areas. More ingenuity is necessary to compare rural villages in developing countries and rural villages, not non-urban areas in Japan.

Our research focused on the gap between people's perception of the causes of climate change, and their willingness to cooperate to prevent climate change. Our results show that those who favor the perception of man-induced climate change make more monetary contribution to prevent climate change than those who favor the perception of nature-induced climate change in Figure 3. By increasing people who favor the perception on the cause of climate change induce people to cooperate toward mitigation or adaptation of climate change. Furthermore, high score of scientific literacy, becoming senior citizen, marital experience also show a positive influence on people's cooperative behaviour toward the prevention of climate change. Moreover, we need to clarify what causes people to perceive that climate change is human-induced.

Our results also show that the four main factors that affected whether of not people favor to human-induced climate change are scientific literacy scores, prosociality, age and gender. In particular, scientific literacy indicates a significant effect to the perceptional formation of human-induced climate change in Figure 2. The regressions of other variables confirm the robustness of the results in Table 3 and Table 4. Interestingly, for those who favors to human-induced climate change, scientific literacy score is positively associated with the perceptional formation, but a high-level academic background has not strongly been affected. Although Sun and Han (2018) states that more highly educated individuals have a higher probability of risk perception regarding climate change, our results suggests that a general science education attainment bring more positive effects on concern for climate change. The acquisition of scientific knowledge tends to make people think that the cause of climate change is human-induced. Contrary to focussing the prosocials, increasing the advocates of human-induced climate change by acquisition a general scientific knowledge is better practical method. Overall, we suggest that by incorporating more education about general science into adult education programs or government policies, the climate change concern would increase.

5 Conclusion

This research analyzes 400 Japanese subjects' perception as to whether the causes of climate change are primarily human-induced or nature-induced and additionally investigates the relationship between this perception and the subjects' willingness to cooperative to mitigate the effects climate change. The results suggest two main findings. First, subjects with high levels of scientific literacy tend to have the perception that climate change is human-induced. Second, people identified as being more cooperative toward climate change show strong prosocial value orientation, have high scientific literacy and perceive climate change as human-induced. From these findings, it can be seen that scientific literacy plays important roles, not only as an indirect effect but also a direct effect for willingness to cooperate to mitigate climate change. These findings represent new contributions to the literature since few studies on perceptions of the causes of climate change have included empirical data on subjects' scientific literacy, their perception of the cause of climate change and their willingness to cooperative toward mitigating climate change, as measured by the donations in a game.

The expanding speed of urbanization is remarkable, especially in developing countries. However, this urbanization is encroaching on rural life now-a-days. Furthermore, since there are more prosocial people in rural areas than in urban areas, further urbanization will be a negative factor in increasing the number of people who are willing to cooperate toward mitigating climate change. It is a difficult task to increase the number of such cooperative and prosocial people, but the results of our research suggest more feasible method for combating . We suggest a more feasible method for combating climate change than simply increasing the number of prosocial people, namely, enhancing people's scientific literacy increase people's willingness to cooperate toward climate change countermeasures, in both urban areas and non-urban areas, was significantly depending on their scientific literacy. Thus, climate and science education has a large potential to increase the number of people who are willing to address climate problems (Lehtonen et al., 2019). Overall, the results suggest that promoting scientific literacy through policies, such as educational programs, is likely to be key to encourage more members of society to cooperate and so prevent climate change.

This research has produced useful results, but it also has limitations which suggest future avenues of this study. The results in this research were established from responses to a questionnaire on scientific literacy and behavior observed, in a SVO game, and a climate donation game. These results indicate that females believed, more than males, that climate change is human-induced phenomena. However, they did not show a corresponding tendency to make monetary donations toward mitigating climate change. Also, although marital status does not seem to affect the perception that climate change is human-induced, we found that married people were willing to make larger donations in order to mitigate climate change. Although other studies have also found that married couples are willing to join cooperative action to mitigate climate change, possibly because of their concern for family health of their future of their children, our result about women's willingness to appears to differ from findings of other studies, which indicate that women are willing make a donation, particulary a time donation for the prevention climate change (e.g. Addisu et al., 2016, Van Aelst and Holvoet, 2016, Mandleni and Anim, 2011). Therefor, we can not exclude the possibility that females prefer labor donations over money donations to combat climate change issues. As a result, future studies should consider not only behavioral data but also qualitative data, such as face to face interviews, for the purpose of detailing how and why females tend to believe climate change is human-induced. Bearing in mind these caveats, it is our perception that study is the important first step for the resolution of mechanism of perceptual impact on cooptative behaviors toward climate change, hoping that further studies will ensure to suggest something new to enhance people's cooperative attitude toward climate change.

6 References

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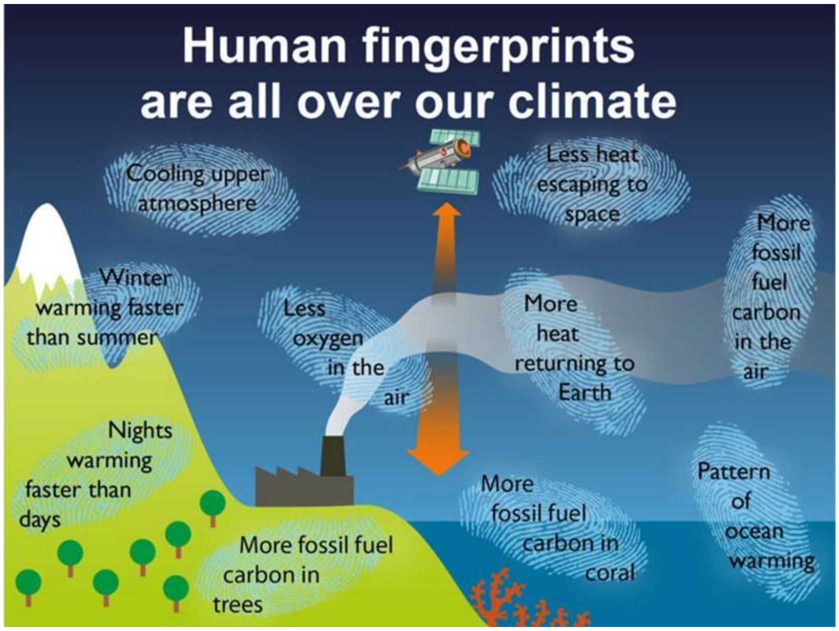
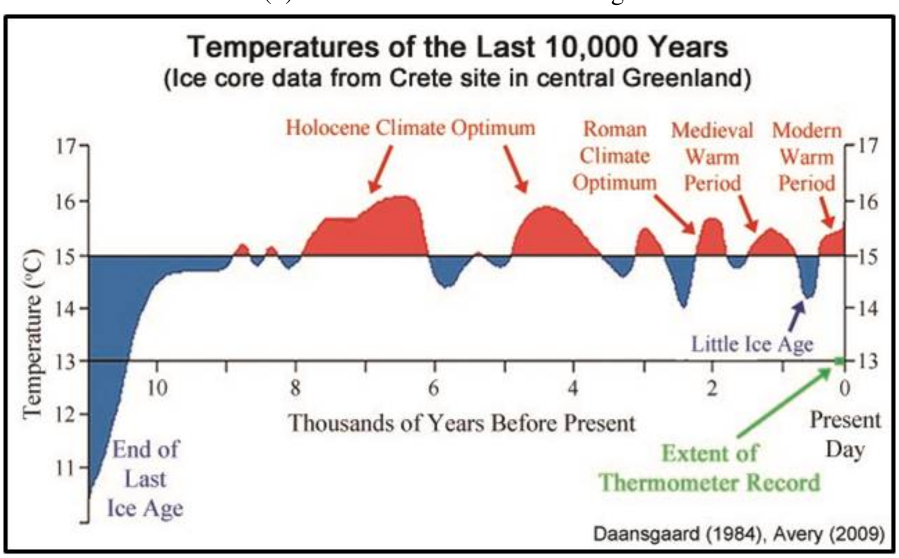
List of Figures

Figure 1: People's perceptions of the cause of climate change

(a) Human-induced climate change



(b) Nature-induced climate change



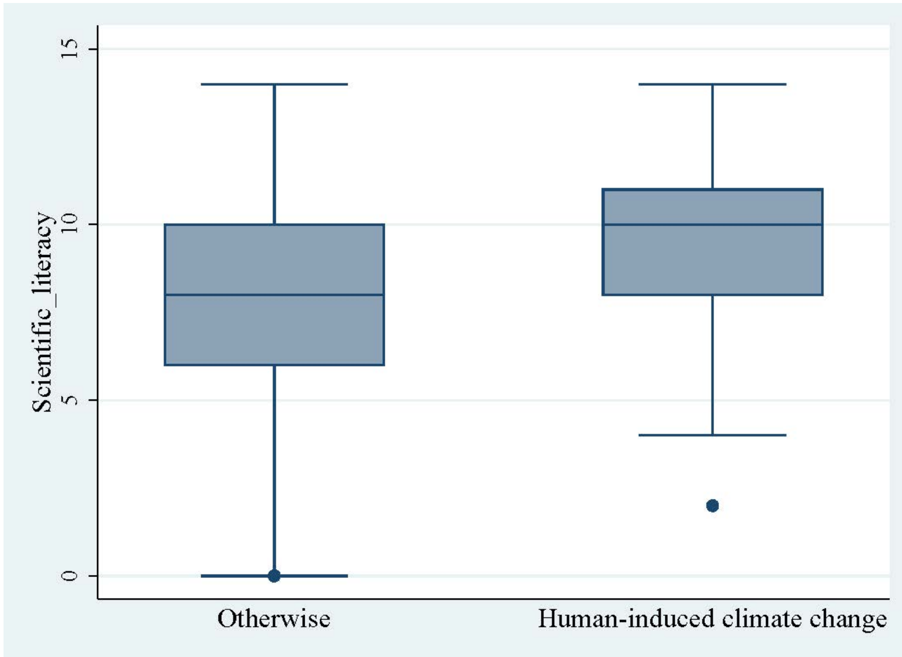


Figure 2: Scientific literacy and perception

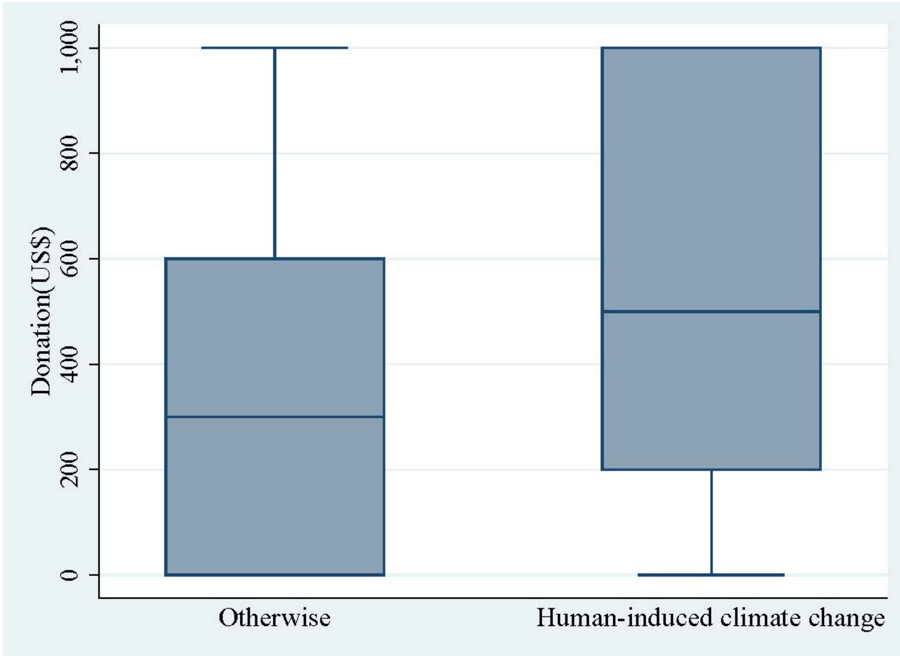
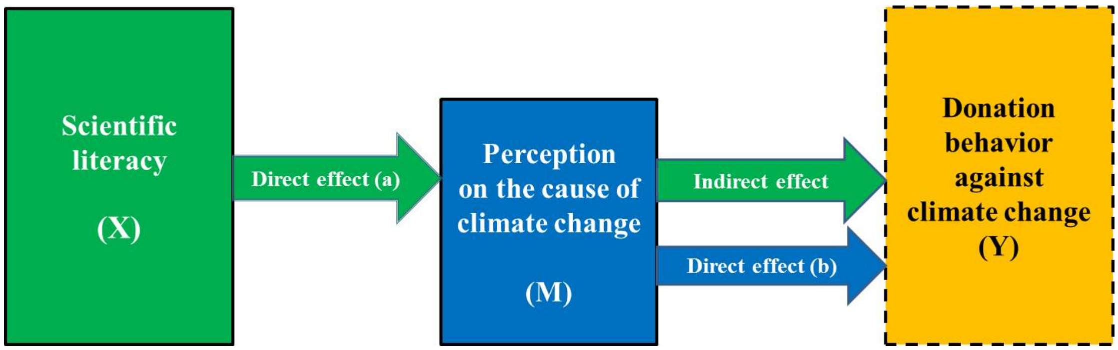


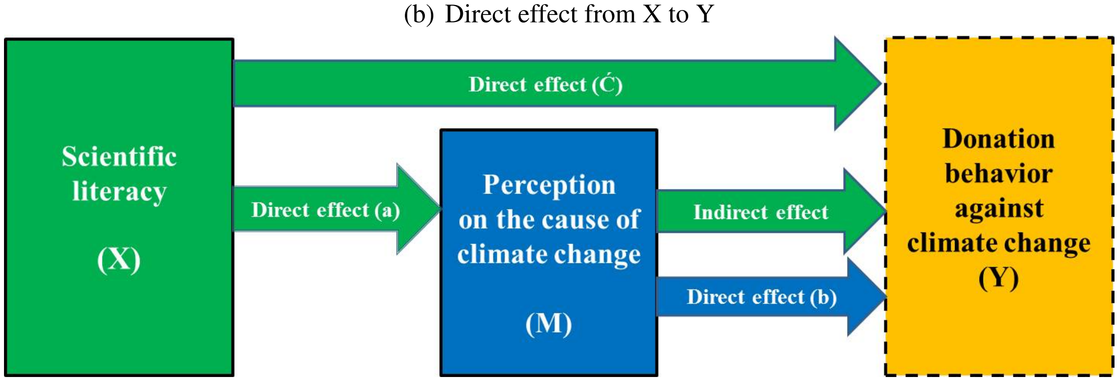
Figure 3: Donation and perception on the cause of climate change

Figure 4: Mediation

(a) Indirect effect from X to Y



(b) Direct effect from X to Y



List of Tables

Table 1: the definition of the variables

Variables	Descriptions
Age	Age is defined as years of age.
Gender	Gender is a dummy variable that takes 1 when the subject is female, otherwise 0.
Education	Education is categorical variables of 0, 1, 2, 3 and 4 where educational background, No scholastic, Junior high school, high school, undergraduate, graduate and otherwise are coded as 0, 1, 2, 3 and 4, respectively.
Household income	Household income per year in JPY. Categorical variable of 0 to 12 with an interval of 1 M, however where 11 presents as earning 10 M $<$ 15 M, and 12 represents as earning more than 15 M per year.
Marital status	Marital status is a dummy valuable that categorical variable of 0 and 1 where marital status experienced ,marital status non-experienced are coded as 0 and 1, respectively.
Family type	Family type is that categorical variable of 0 and 1 where family type ,nuclear family, extended family are coded as 0 and 1 respectively.
Donation	Donation is defined as a donation payment (Range is between from 1000JPY)
Perception of the cause of climate change	Perception of the cause of climate change represents a dummy variable taking 1 when the subject chooses Human-induced and otherwise (Nature-induced, Can not say, and No idea) 0.
SVO	The “SVO” represents a dummy valuable taking 1 when the subject is prosocial. and otherwise 0, based on SVO games.
Scientific literacy	This scale is defined as the number of questions for which respondents provided correct answers. The theoretical range is from 0 to 15.

Table 2: Summary statistics of subject's sociodemographic information, donation, perception of the cause of climate change, SVO and scientific literacy

	Urban areas					Non-urban areas				
	Mean	Median	SD[1]	Min	Max	Mean	Median	SD	Min	Max
Age	49.4	47	17.72	20	89	49.82	49	16.96	21	86
Gender	0.38	0	0.49	0	1	0.36	0	0.48	0	1
Education	2.71	3	0.7	0	4	2.54	3	0.67	1	4
Household income	6.21	6	3.1	0	12	5.52	5	2.97	0	12
Marital status	0.69	1	0.47	0	1	0.66	1	0.48	0	1
Family type	0.1	0	0.3	0	1	0.12	0	0.33	0	2
Occupation (Agri&Fisher)	0	0	0	0	0	0.02	0.00	0.12	0	1
Donation	455.53	500	403.88	0	1000	419.9	400	381.09	0	1000
Perception of Climate change	0.3	0	0.46	0.0	1	0.33	0	0.47	0	1
SVO	0.56	1	0.5	0	1	0.6	1	0.49	0	1
Scientific literacy	8.53	9	3.36	0	14	8.24	9	2.95	0	14
Subjects(Total n = 400)	n = 200					n = 200				

[1] SD stands for standard deviation.

Table 3: Donation to climate change across regions and variables such as perceptions of climate change, SVO, marital status and scientific literacy

	Urban areas						Non-urban areas					
	n	Mean	Median	SD[1]	Min	Max	*n*	Mean	Median	SD	Min	Max
Perception of climate change												
Human-induced	60	590.25	500	386.23	0	1000	66	525	500	365.88	0	1000
Nature-induced	23	535.22	500	444.23	0	1000	28	272.50	100	326.7	0	1000
Otherwise	117	370.78	300	385.55	0	1000	106	393.39	300	389.2	0	1000
SVO												
Prosocial	111	493.43	500	394.41	0	1000	120	459.58	500	379.70	0	1000
Proself[2]	63	412.84	300	411.48	0	1000	48	352.69	200	389.20	0	1000
Unknown	26	397	400	423.76	0	1000	32	371.88	250	365.65	0	1000
Marital status												
Marital status non-experienced	63	314.67	200	388.56	0	1000	69	312.73	198	367.72	0	1000
Marital status experienced	137	520.31	500	403.11	0	1000	131	476.34	500	377.19	0	1000
Scientific literacy												
Low	82	382.51	300	406.65	0	1000	97	386.59	200	394.66	0	1000
Middle	50	462.40	500	385.97	0	1000	58	509.48	500	363.88	0	1000
High	68	583.53	500	402.59	0	1000	45	376.22	500	361.23	0	1000
Subjects(Total n = 400)	n = 200						n = 200					

[1] SD stands for standard deviation.
[2] Proself includes individualists and competitors.

Table 4: Marginal effects after logit regression adaptation model

Variable	Marginal effect			
	Model 1	Model 2	Model 3	Model 4
Scientific literacy	0.044***	0.039***	0.039***	0.040***
	(0.007)	(0.008)	(0.008)	(0.008)
Age		0.004***	0.004***	0.003***
		(0.001)	(0.001)	(0.001)
Gender dummy (Female = 1, Male = 0)		0.096**	0.100**	0.083**
		(0.045)	(0.045)	(0.046)
SVO (Prosocial = 1, Otherwise = 0)			0.069*	0.066*
			(0.049)	(0.045)
Marital status (Experienced = 1, Non-experienced = 0)				0.069
				(0.059)
Education				–0.040
				(0.045)
Household income				0.007
				(0.008)
Area dummy (Urban = 1, Non-urban = 0)				–0.045
				(0.234)
Family type (Nuclear family = 1, Extended family = 0)				–0.004
				(0.070)

***significant at the 1 percent level, **significant at the 5 percent level,*significant at the 10 percent level

Table 5: Marginal effects of tobit regression adaptation model

Variable	Marginal effect			
	Model 1	Model 2	Model 3	Model 4
Perception (Human-induced = 1, Otherwise = 0)	235.016***	190.834***	183.948***	136.400***
	(54.566)	(56.004)	(55.835)	(55.317)
Scientific literacy		24.101***	22.996***	13.506*
		(8.490)	(8.477)	(8.881)
SVO (Prosocial = 1, Otherwise = 0)			102.251**	104.477**
			(51.441)	(50.191)
Age				4.935***
				(1.696)
Gender dummy (Female = 1, Male =0)				67.191
				(64.313)
Marital status (Experienced = 1, Non-experienced = 0)				93.457*
				(64.313)
Household income				6.037
				(8.611)
Education				−27.055
				(3.912)
Area dummy (Urban = 1, Non-urban = 0)				49.880
				(49.651)

***significant at the 1 percent level, **significant at the 5 percent level, *significant at the 10 percent level