Risk Analysis, Vol. 32, No. 6, 2012 DOI: 10.1111/j.1539-6924.2012.01800.x

The Interplay Between Knowledge, Perceived Efficacy, and Concern About Global Warming and Climate Change: A One-Year Longitudinal Study

Taciano L. Milfont*

If the long-term goal of limiting warming to less than 2°C is to be achieved, rapid and sustained reductions of greenhouse gas emissions are required. These reductions will demand political leadership and widespread public support for action on global warming and climate change. Public knowledge, level of concern, and perceived personal efficacy, in positively affecting these issues are key variables in understanding public support for mitigation action. Previous research has documented some contradictory associations between knowledge, personal efficacy, and concern about global warming and climate change, but these cross-sectional findings limit inferences about temporal stability and direction of influence. This study examines the relationships between these three variables over a one-year period and three waves with national data from New Zealand. Results showed a positive association between the variables, and the pattern of findings was stable and consistent across the three data points. More importantly, results indicate that concern mediates the influence of knowledge on personal efficacy. Knowing more about global warming and climate change increases overall concern about the risks of these issues, and this increased concern leads to greater perceived efficacy and responsibility to help solving them. Implications for risk communication are discussed.

KEY WORDS: Concern; efficacy; global warming and climate change; knowledge; longitudinal

1. INTRODUCTION

A large body of scientific evidence points to the current existence and future worsening of global warming and climate change. Besides the prevalence of independent lines of evidence and scientific consensus on the causes and consequences of global warming and climate change,[1–6] there are also other important social markers that indicate that nonscientists have begun to listen and take the message seriously. To illustrate: more than 100 Nobel laureates have mentioned global warming as a danger to world peace in the coming years,[7] and more recently Prince Charles hosted a symposium with 20 Nobel laureates to discuss a path towards a low-carbon economy;[8] almost all member states of the United Nations have now agreed that the long-term goal of climate policies should be limiting warming to 2°C or below;[9] in September 2009 the U.N. Secretary General, Ban Ki-Moon, stated that climate change is the greatest issue of the 21st century; U.S. President Barack Obama, addressed the 2009 Copenhagen Climate Change Conference by stating that his country recognizes its responsibility to address climate change as the world's largest economy and the world's second largest emitter; survey results indicate that global warming and/or climate change (hereafter referred to GWCC) are frequently in people's minds;[10–12] and many civic society movements and

*Address correspondence to Taciano L. Milfont, School of Psychology, Victoria University of Wellington, PO Box 600, Wellington, 6140, New Zealand; taciano.milfont@vuw.ac.nz.

demonstrations have taken place in recent years, including the 350.org and the Earth Hour movements.[1]

Social markers, survey results, and social demonstrations regarding the significance of GWCC should not be taken lightly. It is remarkable to have such global consensus and willingness to tackle (at least at a discourse level) a particular issue when addressing it is likely to have negative short-term effects on the *modus vivendi* of the most powerful groups worldwide. Indeed, if the long-term goal of limiting warming to less than 2°C is to be achieved, rapid and sustained reductions of greenhouse gas emissions are required. These reductions would require stringent policy interventions, which in democratic societies would only be possible by widespread public support for at least the broad and long-term goals of such interventions.[13]

Understanding the level, motivators, and limits of public support for action on GWCC is, therefore, a crucial prerequisite for successful policy interventions. The research reported here contributes to this task by investigating the interplay between knowledge, perceived personal efficacy, and level of concern. The importance of these variables comes from studies showing that each of them predict environmental intention and engagement,[14–21] which suggests they are key variables in understanding public support for action on GWCC. Given this, it is relevant to examine their associations further. By using a one-year longitudinal design, this study provides a more robust examination of their associations by allowing a better test of the strength and direction of the relationships.

2. ASSOCIATIONS BETWEEN KNOWLEDGE, EFFICACY, AND CONCERN

The issue of the relationship between knowledge, efficacy, and concern has received increasing scholarly interest in recent years. The extant literature suggests that individuals are concerned and feel personal efficacy to solve environmental issues to the extent that they are informed about these issues. This is in line with the knowledge-deficit approach in which mass media campaigns are used with the expectation that the dissemination of appropriate information will lead to greater awareness and concern for GWCC, and that this increased awareness and concern will in turn lead to meaningful action.[22,23]

There are also other reasons to believe information is important in influencing concern and efficacy. First, it can help bypass "environmental numbness,"[24] or the idea that "most people, most of the time, simply are not thinking at all about climate change. Instead, they are (understandably) thinking about their work, their friends and family, or the big game" (p. 277). Similarly, risks associated with GWCC are examples of "hidden hazards," or risks that are unnoticed or unattended until they reach disaster proportions, despite their serious consequences for society.[25] Information can thus help people begin to think about GWCC and make the risks salient.

Another reason why information is important is because it taps into the human need for understanding.[26] Individuals have a fundamental need to comprehend their physical and social environments, and uncertainty rises when understanding is inaccessible or constrained. Information can be used in interventions designed to reduce environmental and social uncertainty related to GWCC by tapping into this core human motive. And it follows that increased information would not only lead to reduced uncertainty and increased understanding but would also lead to higher levels of concern and greater demand for remedial action.

Information is also important because there is now a recognition that effective climate policies should use a combination of top-down approaches (regulatory approaches that force or motivate emissions reductions) and bottom-up approaches (fostering voluntary action to increase pro-environmental behavior) to facilitate public acceptance of action on climate change as well as to stimulate grassroots action.[27] This view suggests that, in order to tackle GWCC effectively, we cannot rely only on individuals to take collective action; it will be necessary to make action normative and subject to social sanctions through incentives and regulations. Clearly, information has a crucial role in both types of interventions.

2.1. Specific Empirical Examinations of the Associations

Studies examining the associations between knowledge, efficacy, and concern can be grouped

[1] Another sociomarker indicator of the relevance of these issues in people's minds is how often they appear in Google. Searching Google for ["global warming" OR "climate change"] yields 756,000,000 web hits that represent about 7% and 18% of the number of the hits for ["love"] and ["sex"], respectively, 10,960,000,000 and 4,240,000,000, which arguably are among the most popular searched words on the Internet (search conducted February 28, 2012).

according to the relationships they have focused on: knowledge-concern, knowledge-efficacy, or efficacy-concern relationships. Studies exploring the knowledge-concern relationship have shown that greater knowledge of environmental issues is associated with higher concern and willingness to act.[14–20] Exploring this relationship in the climate change domain, studies have examined whether respondents who report being more knowledgeable about GWCC are also more concerned about these issues. Although studies vary in their conceptualization and measurement of knowledge and concern, self-report knowledge has been found to be positively correlated with concern.[28–33] A person who has more knowledge about GWCC is more likely to feel concerned about the harmful effects of these issues.

Other studies have examined the knowledge-efficacy relationship. Self-efficacy refers to a person's evaluation of whether he or she has the necessary resources and/or skills to attain a goal or perform a particular behavior.[34,35] Studies have shown a positive association between environmental knowledge and self-efficacy,[19] and also an association between self-efficacy and environmental engagement and willingness to help tackle climate change.[15,21] Tackling GWCC requires human agency and significant changes in beliefs and behavior, so people's evaluation that they have the ability to positively influence these issues is paramount. Hence, it is reasonable to expect that an increase in knowledge would also lead to a related increase in perceived efficacy.

Other studies have focused on the efficacy-concern relationship, showing that greater perceived personal efficacy is associated with higher concern for GWCC.[30,36] People's evaluation of their ability to positively influence GWCC issues should increase their concern for these issues.

Overall, a positive association between knowledge, efficacy, and concern has been shown, such that greater self-reported knowledge about GWCC is associated with both higher concern about the harmful effects of these issues and feelings of personal efficacy to help solve these issues. Despite the empirical support for these associations, there is also evidence that the association, between knowledge, efficacy, and concern can be moderated by other factors.

For example, Kellstedt *et al*. conducted a national telephone survey of randomly selected adults in the United States ($n = 1{,}093$) and found the expected positive association between knowledge and concern (footnote 7, p. 120).[37] But when concern was regressed on knowledge after controlling for a number of variables (demographics, party identification, conservative ideological identification, general pro-environmental orientation, feelings of efficacy related to GWCC, trust in media and climate change experts, and confidence in scientists), they observed a small and negative partial association between knowledge and concern. This negative partial association indicates that being more informed about GWCC is associated with *lower* levels of concern for these issues. Besides assessing the associations between knowledge and concern, Kellstedt *et al*. also explored the knowledge-efficacy relationship. They found a negative partial association between self-reported knowledge and efficacy, indicating that being more informed about GWCC is associated with *lower* levels of perceived ability to influence GWCC outcomes. These findings sharply contrast with expectations from the knowledge-deficit model and also go against related findings reviewed above.

In another related study, Malka *et al.* explored whether the knowledge-concern relationship could be moderated by political party affiliation and trust in scientists in the United States.[38] In a first cross-sectional study, results from two surveys (both with $n = 1{,}002$) showed that the positive relationship between knowledge and concern was only evident for people who trusted scientists and among those who identify themselves to be a Democrat or an Independent; knowledge and concern were uncorrelated for those who were skeptical of scientists and were Republicans. The panel data in the second study ($n = 497$) confirmed a pattern of higher knowledge being associated with greater concern for global warming, but this relationship was again moderated by party identification. The causal impact of knowledge on concern was only evident for people who identified themselves to be a Democrat.

Despite the fact that the associations between knowledge, efficacy, and concern can be moderated by other factors, the extant literature assumes that the association flows from knowledge to efficacy and then to concern. But this assumed direction of influence could be erroneous. It is possible that interested and/or concerned individuals are more likely to look for information and as a result feel more able to change their behavior. It is also possible that the influence flows from concern to efficacy, indicating that as the overall concern about the risks of GWCC increases, the perceived ability to affect GWCC outcomes also increases.[21] Because most past research has used cross-sectional data, the direction of the influence in the associations between knowledge,

efficacy, and concern could not be specifically examined. To fill this important gap, this study examines these associations longitudinally.

3. THE PRESENT STUDY

Considering that knowledge, efficacy, and concern are important in the environmental domain, that not many studies have systematically assessed their associations and the flow of influence between them, and that the literature in this area is still young, this study contributes to the field by examining their associations over time. It contributes to the literature in two considerable ways.

First, this study uses one-year panel data to provide a more robust examination of the associations between the variables. Also, there is no current evidence about the stability or instability of attitudes towards GWCC over a period of time. By assessing the specific direction of the associations between knowledge, efficacy, and concern and their stability over time, the findings will provide a stronger case for the interplay between them. Based on the literature reviewed above, three models defining the flow of influence in the associations can be identified. The first model posits that greater knowledge is associated with higher concern; the second model posits that greater knowledge is associated with higher perceived efficacy; and the third model posits that greater perceived efficacy is associated with higher concern. Besides these models, there exists other possible directions, of influence that will also be explored in this study. For instance, it is possible that the influence of self-reported knowledge on perceived efficacy is mediated by concern about GWCC.

Second, studies outside the United States that have examined these associations in the GWCC domain are scarce. By relying on New Zealand data, this study also expands the cultural validity of the interplay between knowledge, efficacy, and concern. A brief overview of the New Zealand context and the methodological framework used are presented below.

3.1. The New Zealand Context

The data for this study were gathered in 2008 and 2009 when New Zealand experienced a transition from a government led by the Labor Party (a center-left party), which had three terms and nine years in power, to a government led by the National Party (a center-right party). The then Labor-led government had a vision to have New Zealand championing the world on environmental sustainability,[39] and had introduced a carbon emissions trading scheme. The now National-led government focuses more on economic rather than environmental interests. Although the current government has announced a commitment to a 50% reduction in greenhouse gas emission from 1990 levels by 2050,[40] it has weakened the emissions trading scheme and other climate policies.[41]

New Zealand research has also shown that support for climate change actions is positively and moderately related to support for the Labor Party and the Green Party, which is a strongly environmentally-oriented party and currently is the third main party in the country, while it is negatively related to support for the National Party.[42,43] These findings are in line with findings from the United States, where Democrats are more likely to be concerned about climate change than Republicans.[32,37,38,44]

More broadly, New Zealand surveys on public attitudes to GWCC show similarities with public surveys in other countries. One nationally representative survey ($n = 1{,}003$) found that 33% of the New Zealand general public strongly believes that climate change is happening, and a higher proportion (38%) strongly believes that humans or animals have a direct impact on this issue.[43] Nearly 31% of respondents of another national survey ($n = 752$) identified "global warming/climate change/ozone layer" as the single biggest issue facing the world.[45] Another national survey ($n = 500$) found that 80% of the respondents agreed that the world is experiencing climate change and that it is a problem, of which 44% agreed that there seems to be clear proof that climate change is caused by human activity.[46] The same survey also found a positive and strong correlation between respondents' feelings of the seriousness of climate change and human impact, with those who rate climate change as extremely serious also rating human behavior as having a very direct impact on climate change. Finally, respondents in another large national survey ($n = 2{,}851$) believed climate change is a problem (76%) and that its effects have already begun to happen (65%).[47]

3.2. The Methodological Framework

Panel data from a national survey of New Zealand adults conducted at three time-points from

2008 and 2009 are used to address the research questions. Four main sets of analyses are reported. In the first set, ordinary least squares (OLS) regressions were computed to assess the three models outlined above. The baseline model includes the demographic variables, the political-related variables, and the New Environmental Paradigm (NEP) Scale in predicting concern for GWCC.[2] The second model includes these variables, plus the effects of knowledge, personal efficacy, trust, and confidence in scientists. These regression models followed procedure used by Kellstedt *et al.*,[37] and demographic and other variables were included in the models to examine the association between knowledge and concern after controlling for those variables. After these initial analyses at time 1, the analyses are repeated for time 2 and time 3 to examine the stability of the findings.

In the second set of analyses, the moderation hypothesis proposed by Malka *et al.* is tested.[38] They found that the knowledge-concern relationship was moderated by party identification and trust in scientists, with knowledge and concern being positively related only for people who trusted scientists and among those who identify themselves to be a Democrat or an Independent. The moderation hypothesis was tested in this study using the available variables. Specifically, the knowledge-concern relationship was tested for moderation by support for the National Party and confidence in scientists for each data point.

Although important for assessing the stability of the relationships between the variables over time, the regression analyses do not allow for a proper investigation of possible change over time. Mass political attitudes are famously unstable,[48] and to date there is no evidence about the stability or instability of attitudes towards GWCC over time. Moreover, the increase in awareness of GWCC in recent years suggests it is a result of increased information available to the general public, which also suggests that change may be observed over time. In the third set of analyses, latent growth curve (LGC) modeling was performed to explore whether the levels of knowledge, efficacy, and concern related to GWCC changed over the one-year period. In brief, LGC is a method of longitudinal data analysis that focuses on both initial levels and rate of change over time by estimating individual regression parameters and modeling individual variation in growth of the measured variable; a second goal of LGC is to identify potential factors that explain this variation.[49–51]

Two types of LGC models can be estimated. Unconditional growth models assess the respondents' average initial level of the variable of interest at time 1 (the "intercept") and how the respondents' average level of the variable changed over the time period (the "slope"). Detailed descriptions of the unconditional LGC models tested in this study is given in the Appendix. The unconditional growth models only model the initial levels and any rate of change observed, excluding any predictions of variables causing the initial levels and rate of change. It is also possible to add one or more variables that could explain the change observed. In this conditional growth model, it is possible to examine whether one particular variable is responsible for changes in respondents' average levels of the variable of interest. Examples of conditional growth models can be obtained elsewhere.[52,53]

Finally, structural equation modeling (SEM) was used to estimate latent path models on the associations between the variables. In these models, the observed indicators for the latent variables were the averaged scores at the three time-points. The latent path models were used to test the three specific models detailed above that imply that the influence flows from information to efficacy and then to concern. Alternative and mediational models were also examined.

4. METHOD

4.1. Sample and Measures

A total of 3,000 names were collected at random from the 2007 New Zealand Electoral Roll held in hard copy at public libraries. The Electoral Roll is split across 69 electorates, and each roll-book has a different number of pages. To increase proportionality, the sample was split across 69 electorates and each subsample was proportional to the size of the electorate. A random number generator was used to select page numbers in each electoral roll. The list of numbers was sorted in ascending order and the

[2] Malka *et al.* have criticized the inclusion of the NEP Scale in the regression models reported by Kellstedt *et al.* because of content overlap between the items of this scale and the measure of concern about GWCC.[38] The NEP Scale was kept in the regression models reported in this study for both theoretical and methodological reasons. First, broad environmental values measured by scales such as the NEP Scale are likely to cause concern about more specific matters like GWCC so its inclusion is theoretically motivated. Second, the NEP Scale is well established in the literature and its exclusion could thus lead to omitted-variable bias.

second name on the page matched by the random number was recorded. From the original 3,000 names recorded, five addresses were invalid, resulting in an initial sample of 2,995 households. The survey was mailed with a consent form and covering letter describing the aims of the survey, and invited the named person or another member of the household to participate. A postage-paid return envelope and an entry form for a draw to win $NZ500 worth of grocery vouchers were included to encourage participation.

Five hundred eighty-one questionnaires were returned in time 1, with a total of 551 valid surveys, giving a response rate 1 of 18% according to the American Association for Public Research (AAPOR). The questionnaire was mailed again to respondents who agreed to participate in the panel study six months after the first survey (November 2008) and then again one year after the first survey (June 2009). The group of 269 respondents who took part in all three surveys comprised the panel for the present analysis, which represents a response rate 1 of 9% from the initial total of surveys mailed. Table I displays distributions of unweighted demographics for the panel sample alongside national demographics based on the 2006 Census from Statistics New Zealand. The panel data overrepresented respondents from the majority ethnic group, females, older adults, and people with relatively higher education and income, which is common in survey research.[37,38] The study was approved by the School of Psychology Human Ethics Committee under deligated authority of the Human Ethics Committee of the Victoria University of Wellington. The questionnaire included the same set of measures used by Kellstedt *et al*.,[37] which are described in Table II. The measures were included in all three surveys (excepted when noted), and higher numbers indicate more of the construct measured.

5. RESULTS

5.1. Regression Analyses

5.1.1. Concern

Examining the baseline model in time 1 first (Column 1 of Table III), the only variables significantly related to concern for GWCC were age and the NEP Scale. The associations for these variables were in the direction predicted by the literature. Younger respondents and those who endorse environmental values exhibit significantly greater concern for GWCC than their counterparts. After controlling for the new variables in the model (Column 2 of Table III), age and the NEP Scale remained statistically significant, and attendance at religious service became significant, with those who attended a religious service showing higher concern for GWCC.

Despite the change observed for religious-service attendance, the inclusion of the new variables did not substantially alter the initial findings. The stronger effect was observed for perceived efficacy. Respondents who feel they have the ability to influence GWCC outcomes show greater concern for the effects of these environmental issues. Importantly, both information level and confidence in scientists were positively and marginally significantly related to concern. This suggests a trend for respondents with perceived higher knowledge volume about GWCC and with greater confidence in scientists' understanding of these issues to show more concern than those who have lower knowledge volume and lower confidence in scientists.

To access the stability of these findings across time, the models were also examined at time 2 and time 3. Because some questions were only included in the first survey, the same time 1 scores for these questions were added in these additional models.[3] The results in Columns 2 and 3 of Table III show that the NEP Scale and perceived efficacy remained significant predictors, while the significant effect of age was diminished. Another difference was observed for the variable assessing support for the National Party, which became significantly related to concern, indicating that those who place higher support for this center-right party are considerably less concerned about GWCC. This result is similar to previous findings,[37] and the change across time might indicate the modification of the political environment in New Zealand between the survey points (see discussion below). Also noteworthy is the effect of information level on concern, which is consistently positive across time (albeit nonsignificantly) and also similar in size to the effect of −0.018 reported by Kellstedt *et al*.

5.1.2. Efficacy

Because of the strong effect of efficacy on concern, another set of models was tested at each

[3] Variables included in the model based on time 1 response were: ethnicity, gender, education, income, age, religious-service attendance, ideology, and the NEP Scale. Some small variability across time can be expected for these variables, but here they are assumed to be stable across the surveys and thus treated as time-invariant covariates.

Table I. Comparison of Survey Respondents' Demographic Characteristics with the New Zealand Population

Characteristic	Panel Data (%)	2006 Census (%)
Ethnicity (New Zealanders of European descent)	85.9	59.0
Sex (male)	33.8	48.8
Personal income ($NZ)*		
<$10,000	18.6	15.8
$10,001–$20,000	16.4	21.7
$20,001–$40,000	18.6	29.5
$40,001–$100,000	28.3	23.5
>$100,001	8.6	3.7
Age (median)	54.0	35.9
Respondents from Auckland (biggest city)	23.0	32.4
Education (post high school)	55.0	40.0

Note: The panel data included 269 respondents and the 2006 Census data are based on a population of 4,143,279. (*) The way personal income was measured in the panel study differs from the standard New Zealand Census question, but the brackets are relatively similar. New brackets were created based on the panel data and the 2006 Census and are presented here to aid comparison. Median personal income in the 2006 Census was $NZ24,400.

time-point assessing the predictors of efficacy following the study by Kellstedt *et al*. Taken in conjunction, there is some consistency in the pattern of findings (see Columns 1–3 of Table IV). Age is a negative predictor of efficacy, indicating that older respondents feel less personally efficacious on issues related to GWCC than younger respondents. The other consistent significant predictors were the NEP Scale, trust in experts, and confidence in scientists, with respondents who endorse environmental values, trust experts and are confident in scientists feeling they have the ability to influence GWCC outcomes. There is also some consistency in the pattern of findings for nonsignificant variables. Younger respondents, those who tend to oppose a mainstream center-right party, and those who trust the media feel they have the ability to influence GWCC outcomes. Some of these findings are in contrast to those observed by Kellstedt *et al*., for example, the negative effect observed for age and the positive effects for trust and confidence in scientists. Perhaps more importantly was the effect of information level on perceived efficacy, which in the Kellstedt *et al*. study was negative, while in this study had a positive (albeit nonsignificant) pattern.

5.1.3. Moderation by Confidence in Scientists and Support for National Party

To test the moderation hypothesis, the variables for information level, National Party support, and confidence in scientists were first mean centered and then product terms were created by multiplying the centered scores.[57] Thus, two moderating variables were added to the regression models presented in Table II for each of the data points: knowledge × National Party support, and knowledge × confidence in scientists. If the moderating variables significantly predict additional variation in concern for GWCC not explained by the sum of the separate effects of all other variables then this would support the moderation hypothesis.

The only moderating variable achieving marginal significance level was the interaction between information level and National Party support in time 2 (Beta $= -0.015$, $p = 0.11$).[4] This result indicates a trend for National Party support to moderate the knowledge-concern relationship in the wave of December 2008. The positive correlation between knowledge and concern is strongest in the case of low support for the National Party and weakest in the case of high support for this political party. That is, greater self-perceived knowledge about GWCC is associated with higher concern, but only for those with low support for the National Party, which is in line with the results reported by Malka *et al*. for those who identified as Democrats or Independents.[38] That this moderation trend only appeared in time 2 is also relevant as the survey was conducted only weeks after the general election that resulted in the transition from a Labor-led government to a National-led government. It can be speculated that the marginally significant moderation emerged in this time-point because support or opposition to the

[4] Results from the moderated multiple regressions are not reported in text but are available upon request.

Table II. Description of the Measures

Variable	Measure Description and Reliability
Level of information/self-reported knowledge	A single question asked respondents to indicate on a 11-point scale "how well-informed do you consider yourself to be on global warming and climate change?" anchored by 0 = not at all informed, to 5 = somewhat informed and 10 = very well informed. This information-level question was taken as a measure of respondents' knowledge volume about GWCC.[38]
Perceived efficacy	Personal efficacy for GWCC was measured with three items that asked respondents to indicate their level of agreement with statements referring to the respondent's perceived ability to influence GWCC outcomes, whether the actions of the respondent will influence others to behave in ways that mitigate the effects of global warming, and whether the respondents accept climate change as a human responsibility. Respondents indicated their level of agreement on a 4-point scale, anchored by 1 = strongly disagree and 4 = strongly agree (Cronbach's alphas: time 1 = 0.703, time 2 = 0.729, and time 3 = 0.778).
Public concern for global warming and climate change	Respondents indicated their level of agreement with items on future negative effects of GWCC on their own health, financial, and environmental welfare (anchored by 1 = strongly disagree and 4 = strongly agree), as well as their level of perceived risks on negative effects to public health, ecomony, and environmental integrity (anchored by 1 = no risk and 4 = extreme risk). The average of the six items was used (Cronbach's alphas were: time 1 = 0.856, time 2 = 0.873, and time 3 = 0.885). This 6-item measure of future negative effects of GWCC is taken as a proxy of public concern regarding these environmental issues.[38]
Environmental values	The New Environmental Paradigm (NEP) Scale was used as an indicator of environmental values.[54] Kellstedt *et al*. used an abbreviated version of the NEP Scale, which included only pro-environmental items. This could have made the scale biased in terms of wording-effect and research has also shown that abbreviated versions of the NEP Scale often lead to unreliable findings.[55] For these reasons, the full 15 items were included. The NEP Scale was only included in time 1 (Cronbach's alpha = 0.844).
Trust in media and experts	Trust in media was measured with a 3-item index asking respondents to evaluate the trustworthiness of information on GWCC provided by newspapers, television news, and radio (Cronbach's alphas: time 1 = 0.934, time 2 = 0.936, and time 3 = 0.949). Trust in experts was measured with a 4-item index asking respondents to evaluate the trustworthiness of information provided by government agencies, nonprofit organizations, environmental interest groups, and other interest groups (Cronbach's alphas: time 1 = 0.877, time 2 = 0.867, and time 3 = 0.864). Respondents indicated their level of trust on an 11-point scale, ranging from 0 (not at all trustworthy) to 10 (very trustworthy).
Confidence in scientists	A single item asked respondents to indicate "how clearly do you think scientists understand global warming and climate change?" on a 4-point scale, ranging from 1 = very unclear understanding to 4 = very unclear understanding.
Political ideology and political party support	Political ideology was measured in time 1 on a 7-point scale ranging from 1 = extremely liberal to 7 = extremely conservative. Because partisan identity is less strong in the New Zealand context than in the United States, political party support was measured and taken as a proxy of party identification.[46,56] Respondents were asked to indicate how strongly they support/oppose the main New Zealand political parties. In order to aid comparison with the Kellstedt *et al*. study, only support/opposition to the National Party (a right-centre party) was included in the models. Respondents indicated how strongly they support/oppose this political party on a 7-point scale (anchored by 1 = strongly oppose and 7 = strongly support). For respondents in time 1 this question asked them to indicate their party support/opposition for the upcoming New Zealand election (November 2008). Respondents in time 2 answered the questionnaire

(*Continued*)

Table II. (*Continued*)

Variable	Measure description and reliability
	soon after the general election, so they were asked to indicate how strongly they supported/opposed the National Party in the past election. The question on party support was not included in time 3, so answers for this question in time 1 and time 2 were averaged for each respondent and used in the analyses as the time 3 answer.
Demographic variables	Ethnicity was measured nominally, with those identifying themselves as New Zealanders of European decent (the majority group) receiving a score of 1, and non-New Zealand Europeans receiving a score of 0. Gender was also included as a dichotomous variable, with 0 for female and 1 for male. Education was measured on a 7-point scale, ranging from 1 (secondary school incomplete) to 7 (doctorate). Personal annual income was measure on a 9-point scale, ranging from 1 (under $NZ10,000) to 9 (more than $NZ141,000). Age was measured in years. A single question measured religious-service attendance by asking respondents to indicate whether they attended a religious service (not including funeral, wedding) in the last week (1) or not (0). These demographic questions were only included in time 1.

Note: These measures are based on the study by Kellstedt *et al.*,[37] and were used here for replication purpose. Limitations associated with these measures are discussed in text.

Table III. Sources of Public Concern for Global Warming and Climate Change

	Time 1 (Jun'08)		Time 2 (Nov'09)		Time 3 (Jun'09)	
Predictor	Baseline	Expanded	Baseline	Expanded	Baseline	Expanded
Ethnicity (New Zealand European)	0.027	−0.107	0.004	−0.195†	0.014	−0.019
Gender (male)	−0.075	−0.036	−0.138	−0.131	−0.209*	−0.097
Education	0.018	0.011	0.021	−0.003	0.030	0.022
Income	0.000	−0.009	0.023	0.037†	0.011	0.011
Age	−0.008**	−0.006*	−0.007†	−0.004	−0.002	−0.000
Religious-service attendance	0.126	0.171*	0.217*	0.161	0.179†	0.145
Support for National	−0.018	−0.003	−0.044*	−0.031	−0.068**	−0.061*
Ideology (liberal)	0.014	0.017	0.025	0.032	0.017	0.056†
Environmental values	0.425***	0.314***	0.402***	0.256**	0.312***	0.205**
Information level		0.034†		0.005		0.017
Perceived efficacy		0.332***		0.302***		0.238**
Trust media		0.005		0.007		0.035
Trust experts		0.003		0.053		0.037
Confidence in scientists		0.092†		0.053		0.102
Constant	1.359**	.379	1.430**	0.716	1.676***	0.382
R^2	0.303	0.517	0.259	0.464	0.231	0.425
Adj. R^2	0.272	0.481	0.226	0.418	0.199	0.382
N	216	203	212	175	221	203

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; $^{\dagger}p < 0.10$.
Note: The cell entries are unstandardised OLS regression coefficients. The dependent variable is concern for global warming and climate change. All variables are coded so that higher values indicate more of the construct.

political parties was more salient in the minds of the respondents.

5.2. Linear LGC Modeling

The regression results reported earlier provide evidence for the associations between knowledge, concern, and efficacy. LGC modeling was performed to better assess these variables and possible change over time. The LGC results are reported in Table V.

There are some consistent results. First, the intercept means were significant for all three concepts and represent the predicted initial mean level of knowledge (6.06, on a 10-point scale described in

Table IV. Sources of Perceived Efficacy Regarding Global Warming and Climate Change

Predictor	Time 1 (Jun'08)	Time 2 (Nov'09)	Time 3 (Jun'09)
Ethnicity (New Zealand European)	0.012	0.077	−0.154
Gender (male)	−0.135	−0.036	−0.276*
Education	0.003	0.030	0.015
Income	0.015	−0.003	0.034**
Age	−0.007***	−0.008***	−0.002
Religious-service attendance	0.023	0.182**	0.048
Support for National	−0.019	−0.028	−0.033
Ideology (liberal)	−0.038	0.038	−0.048
Environmental values	0.219*	0.284†	0.152**
Information level	0.007	0.021	−0.001
Trust media	0.038	0.031	0.082*
Trust experts	0.080	0.160†	0.108†
Confidence in scientists	0.120***	0.005	0.125***
Constant	1.491*	0.706	1.328*
R^2	0.386	0.507	0.511
Adj. R^2	0.344	0.467	0.477
N	203	175	203

*$p < 0.001$; **$p < 0.05$; ***$p < 0.010$; †$p < 0.01$.
Note: The cell entries are unstandardized OLS regression coefficients. The dependent variable is perceived personal efficacy for global warming and climate change. All variables are coded so that higher values indicate more of the construct.

Table II), efficacy (2.64, on a 4-point scale), and concern (2.53, also on a 4-point scale). These predicted initial levels are somewhat lower, but comparable to those observed by Kellstedt *et al.* for information ($M = 6.32$, $SD = 0.68$), efficacy ($M = 2.72$, $SD = 0.53$), and concern ($M = 2.73$, $SD = 0.68$).[5] This indicates that the levels of self-reported knowledge, efficacy, and concern for the New Zealand respondents are similar to those observed in the United States.

Second, there was significant variance in the intercepts, indicating that although the initial levels were on average similar to those found in a previous study, there was significant individual variability for all three variables in the initial level. This indicates that individual respondents had differing initial levels of self-reported knowledge, efficacy, and concern, and that the sample was not homogeneous regarding these variables, which was expected.

Third, the slope means were not significant. The slope means represent the estimated linear rate of change in the measured variables over time. That the slope means were not significant indicates that there was no significant average increase or decrease either in self-reported knowledge, concern, or efficacy during the one-year period. Note that the mean slope was positive for information level and concern, while negative for efficacy. This indicates a trend of positive (increase) rate of change for information and concern, and a negative (decrease) rate of change for efficacy, so that there is a trend for both information and concern to increase linearly over time (from 6.086 to 6.219 and from 2.529 to 2.533, respectively), while there is a trend for efficacy to decrease linearly (from 2.653 to 2.631).

Finally, that the slope variance for information level is significant suggests variability across respondents in the rate of change over time. Moreover, the significant and negative covariance between the intercept and slope factors for information level indicates that there was an inverse relationship between initial information level and change over time. A similar trend is also observed for concern, with an inverse relationship between initial level and change over time, while for efficacy the relationship was positive. This indicates that, as a whole, the sample is characterized by increasing levels of knowledge and concern, and by decreasing levels of efficacy, over the three time-points; and that there was large variability in the individual rates of change over time. However, because the overall rate of change was not significant these results should be interpreted with caution.

5.3. Latent Path Models

The LGC results show that there was no statistically significant increase or decrease in the levels of knowledge, efficacy, and concern over the one-year period. Considering this absence of change over time, the test of conditional LGC models in which variables are added in the models to explain the rate of change cannot be performed. However, it is possible to examine the associations between knowledge, efficacy, and concern more broadly. Table VI presents the bivariate correlations between the three variables in each of the time-points. Information level was positively (albeit nonsignificantly) related to both concern and efficacy. Perceived efficacy was positively and strongly related to concern. Results from latent path models also show a strong and positive correlation between efficacy and concern, and that information is positively associated with concern but not

[5] The author thanks Paul M. Kellstedt for providing these descriptive statistics.

Table V. Parameter Estimates for the Unconditional Latent Growth Models for Knowledge, Perceived Efficacy, and Concern About Global Warming and Climate Change

	Knowledge		Efficacy		Concern	
Growth Parameters	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
Mean intercept	**6.06**	**56.10**	**2.64**	**65.65**	**2.53**	**72.27**
Mean slope	0.12	1.30	−0.02	−0.46	0.00	0.15
Intercept variance	**2.59**	**7.85**	**0.29**	**6.21**	**0.25**	**6.64**
Slope variance	**1.01**	**2.07**	0.02	0.18	0.06	0.92
Intercept-slope covariance	**−0.46**	**−2.41**	0.44	0.66	−0.15	−0.49
Estimated mean (Time 1)	6.086	—	2.653	—	2.529	—
Estimated mean (Time 2)	6.037	—	2.606	—	2.532	—
Estimated mean (Time 3)	6.219	—	2.631	—	2.533	—

Note: Coefficients are standardized regression parameters and *t*-values are the ratio of the parameters to standard errors. *T*-values above 1.96 are significant at $p < 0.05$ and are presented in bold. Model fit: Information model = chi-square (1, $N = 269$) = 2.83, $p = 0.092$, RMSEA = 0.083, SRMR = 0.00, CFI = 0.99. Efficacy model = chi-square (1, $N = 269$) = 1.524, $p = 0.217$, RMSEA = 0.044, SRMR = 0.00, CFI = 0.99. Concern model = chi-square (1, $N = 269$) = 0.003, $p = 0.960$, RMSEA = 0.00, SRMR = 0.00, CFI = 1.00.

Table VI. Correlations Between Measures of Knowledge, Efficacy, and Concern at Time 1, 2, and 3

	Time 1 with Time 2			Time 1 with Time 3			Time 2 with Time 3		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
1. Knowledge	0.706	0.017	0.093	0.601	0.109†	0.130*	0.656	0.051	0.074
2. Efficacy	0.073	0.619	0.441	0.035	0.667	0.449	−0.006	0.704	0.492
3. Concern	0.071	0.492	0.659	0.041	0.451	0.648	0.103†	0.437	0.638

Note: Test-retest correlations appear on the diagonal in each of the time-point correlations. Sample size varied from 260 to 269. Correlations above 0.40 are significant at $p < 0.001$.
*$p < 0.05$; †$p < 0.10$.

Table VII. Parameter Estimates and Fit Indices of Latent Path Models

Model	Parameters	χ^2 (df)	χ^2/df	RMSEA	SRMR	CFI
Bivariate						
Knowledge ↔ Concern	0.17*	17.14 (8)	2.14	0.067	0.028	0.99
Knowledge ↔ Efficacy	0.10	23.04 (8)	2.88	0.085	0.028	0.98
Efficacy ↔ Concern	0.74*	27.94 (8)	3.49	0.098	0.029	0.98
Mediated						
Know→ Con → Eff	0.17* / 0.74*	66.30 (24)	2.76	0.083	0.034	0.97
Eff → Con → Know	0.20 / 0.74*	66.30 (24)	2.76	0.083	0.034	0.97

Note: Parameter estimates are standardized values. Starred estimates are statistically significant ($t > 1.96$, $p < 0.05$).

significantly associated with efficacy (see Column 1 in Table VII).

Given these patterns, of associations a meditational model was tested in which information influences efficacy via concern, which was supported by the data (see mediated models in Table VII). Importantly, when an alternative model was tested with efficacy influencing information via concern, the association between concern and information became nonsignificant. These findings suggest a flow of causation from information to concern and then from concern to efficacy, and sharply contrast studies assuming that the influence flows from efficacy to concern.[37] Being more informed about GWCC leads to greater concern about these issues, which in turn leads to higher perceived ability to influence GWCC outcomes.

6. DISCUSSION

The findings from these one-year panel data provide further evidence for the interplay between

self-reported knowledge about GWCC, level of concern, and perceived efficacy associated with these issues. Results showed positive associations between knowledge, efficacy, and concern, and this pattern of findings was stable and consistent across the three data points.

The model on the knowledge-concern relationship was supported. That greater knowledge is positively associated with higher concern and willingness to act is in accordance with the existing literature.[14–20] The dissemination of appropriate information can create greater awareness and concern for GWCC, and this increased awareness and concern might lead to meaningful action. Given the continued attention to and increased politicization of GWCC in recent years, it is possible that the differences between the present findings and those reported by Kellstedt *et al.*[37] are due to a change in the salience of GWCC in the intervening years since their data collection in 2004. Taking into account the evidence for the positive association between knowledge and concern, however, it seems safe to conclude that greater knowledge regarding GWCC leads to higher concern about these issues.

There is also evidence that the knowledge-concern relationship can be moderated by other factors. In line with the Malka *et al*. findings,[38] this study showed a trend for political party support to moderate the association between the knowledge and concern, with a weaker knowledge-concern relationship for those who support a center-right party. Besides party identification, there is evidence that other variables can also predispose individuals to take GWCC seriously, such as parental status and environmental values.[42,58] This is congruent with the psychological principle of confirmation or assimilation bias wherein people tend to favor evidence that supports their preconceptions, and to interpret disconfirming evidence in a biased manner that supports their own beliefs or agenda.[59,60]

For a person who already trusts scientific information on the causal connection between observed changes in the global climate and human-induced emissions of greenhouse gases, more knowledge may lead to more concern. Similarly, information is more likely to be accepted and internalized if it comes from someone who shares similar political leanings.[38] Further research should explore confirmation or assimilation biases underpinning the lack of awareness and mitigation efforts regarding GWCC.

According to the model on the knowledge-efficacy relationship, dissemination of appropriate information should increase knowledge about GWCC and induce a sense of self-efficacy and feelings that one's actions can influence others to behave in ways to mitigate the effects of GWCC. Supporting this view, there was a trend for a positive association between knowledge and efficacy. But when all three variables are examined together it seems that knowledge does not influence personal efficacy directly, but does so via concern. In line with this, path models indicate that the influence flows from concern to efficacy and not the other way round. This is a novel and important finding.

Previous studies have assumed that the influence flows from knowledge to efficacy and from efficacy to concern. The current longitudinal data suggest a major flow of causation from knowledge to concern to efficacy, such that the strongest effect is between knowledge and concern and then between concern and efficacy, with concern mediating the knowledge-efficacy relationship. That concern mediates this relationship implies that perceived knowledge leads one to feel concerned, and subsequently being concerned leads one to feel self-efficacious. Specifically, knowledge increases concern about GWCC, and it is this increased concern that induces the feeling of personal efficacy and responsibility to behave in ways to mitigate the effects of GWCC. Concern is, thus, the route by which someone who is knowledgeable becomes someone who feels personally efficacious and responsible for these issues.

This mediational model can be linked to the idea of "scaffolding" processes, which posits that incoming information is integrated with extant knowledge structures and that sociocognitive metaphors are constrained by associations between social and bodily experiences.[61,62] Extrapolating from this theorizing, the present findings suggest that perceived personal efficacy in dealing with GWCC is grounded onto one's overall concern about these issues, which in turn is grounded onto perceived knowledge. Namely, informedness serves as the foundation for the development of concern, and this contextualized concern is then scaffolded onto perceived personal efficacy in positively affecting these issues. Future research can continue to empirically delineate this mediational model and the scaffolding process.

This study was also the first to explore variation in the levels of knowledge, efficacy, and concern over time. Although change over time could be expected given the instability of mass attitude over time and increased politicization and awareness of GWCC issues in recent years, the results

show no over-time variation. That is, the levels of self-reported knowledge, efficacy and concern did not significantly change over the one-year period. However, there was a trend for both information and concern to increase over time, while there was a trend for efficacy to decrease.

The trend for reduced efficacy over time is worrying given research showing that when faced with the environmental crisis of water shortage people made more efforts to conserve water when they believed their own contribution made a difference in alleviating the crisis.[63] Reduced perceived efficacy can also reflect a sense of powerlessness regarding GWCC.[28] Because the rates of change were not statistically significant, these trends should be interpreted with caution. Moreover, this longitudinal study is only one of a few of its kind, and there is a possibility that one year is simply not long enough to expect to see statistically significant changes in the levels of knowledge, efficacy, and concern regarding GWCC. Future longitudinal studies should be extended over longer time horizons, where these variables will arguably change much more significantly and will affect each other in much stronger ways.

On the other hand, the stability shown by the over-time results might indicate that the revealed attitudes about GWCC are indeed real, and not socially desirable, made-up, random responses. Perhaps this is an indication that the general public has already formed a somewhat strong belief system regarding GWCC and that it now examines these issues more ideologically.[48] Future studies should consider this possibility.

Although the influence of knowledge on concern is important, there is strong evidence that interventions aimed to tackle GWCC cannot rely solely on information campaigns.[13,64–68] The existing research indicates that people's knowledge increases after receiving information about a particular environmental issue, and that those more knowledgeable are more likely to act. However, an increase in knowledge does not usually lead to behavioral change. For example, Canada created a national program to reduce greenhouse-gases emission in the residential sector by encouraging citizens to use less energy and fewer resources in their daily activities, named the One-Tonne Challenge. An evaluation of the program showed that the program achieved public awareness, as shown by 51% of respondents indicating they understood it as a program designed to reduce emissions and/or energy use, and by their support for the program and overall willingness to take personal action to reduce emissions. However, this awareness did not result in behavior change.[69]

Notwithstanding the fact that public education programs are unlikely by themselves to be effective in changing behavior, the present findings have implications for communicating risk associated with GWCC. There is evidence that some groups make deliberate efforts to challenge scientific consensus on anthropogenic climate change, and that there has been an active disinformation campaign against climate science.[70,71] This widespread campaign of doubt, coupled with the journalistic norm to present "balanced" reporting,[72,73] has increased confusion and uncertainty among the public regarding the risks of GWCC, and has led to "wait-and-see" or "go slow" policies to emissions reductions in many countries.[74] However, such policies are problematic given the time-dependency and magnitude of the issue. There is a need for urgent and immediate societal decision making, and the dissemination of appropriate mitigation-relevant information seems to be an important step to foster human agency and changes in social structure.[27]

There is also a need to explore which type of knowledge is more appropriate to target in relationship to GWCC. The literature has distinguished three forms of environmental knowledge.[18,75] *System knowledge* refers to the understanding of the natural states of ecosystems and their processes, and the understanding of environmental problems (knowing what). *Action-related knowledge* refers to the understanding of what can be done to tackle environmental problems (knowing how). *Effectiveness knowledge* refers to the understanding of the benefits of environmentally responsible actions (knowing how to get the greatest environmental benefit). Climate change communication has so far focused on system knowledge, that is, the science of climate and public understanding of the causes and consequences of the changing climate. Perhaps it is now time to shift the focus of climate change communication from system knowledge to action-related and effectiveness knowledge by communicating the mitigation actions most effective in tackling the pressing issues. Even with some remaining scientific uncertainties regarding the processes and pace of change, there is overall scientific consensus on GWCC. Thus, it is now more important that the public is informed about the actions that will advance the greatest environmental benefits, than knowing the evidence from climate science.

Similarly, climate change communication can also explore different framing and tailoring strategies that can more effectively foster mitigation actions. These strategies might include: framing the message in terms of gain or loss outcomes, local or distant impacts, and according to whether mitigation actions serve intrinsic or extrinsic goals; tailoring the message according to specific psychological processes underlying behavior change; and improving communication of uncertainty related to GWCC.[76–80] Clearly, social sciences should be taken on board in developing risk management frameworks and knowledge-based campaigns aimed to move climate change communication in this direction.[24,81]

A focus on climate communication seems warranted. But it is worth emphasizing again that while greater knowledge is necessary and valuable in its own right, knowledge by itself is not enough to engender meaningful action. As noted by Owens, "barriers to action do not lie primarily in a lack of information or understanding. More important mediating factors are the framing of problems, social and political context, and personal and institutional constraints" (p. 1143).[23] There is, therefore, a need to identify interventions that, along with information campaigns, will prompt collective action and political leadership, and at the same time recognize specific psychological barriers and contextual constraints.[82,83]

One avenue for further enquiry is the use of normative information to promote mitigation actions.[84,85] Social-norms marketing campaigns that disseminate information about mitigation behavior already conducted by others and socially approved—such as voluntary carbon offsetting schemes, car pooling and the "Transition Town" movement—can influence the public to act in the same way. Instead of emphasizing the mitigation actions people are not doing, social-norms marketing campaigns can focus on positive and successful stories of those already making a difference.

The results also suggest that contextual factors, such as the period the data are collected, can substantially affect the associations between variables related to GWCC. The time 2 data were collected weeks after the 2008 national election in New Zealand, which made support for political parties more salient. As a result, support for a center-right party marginally moderated the knowledge-concern relationship only for this survey wave. Other contextual factors, such as the global financial crisis of the late 2000s and competing perceived risks (e.g., earthquake and tsunami), can influence survey results. Fluctuating survey results regarding concern for GWCC can be argued to reflect the influence of contextual factors rather than a decrease in net concern. To argue that the fluctuation of concern indicates decrease in net concern is like arguing that because few years have been cooler the net warming of the climate is not happening.

A possible limitation of this study is sampling bias. Members of the public who already identify themselves as environmentally conscious could have decided to take part in this panel study because it covered environmental issues. Although feasible, sampling bias is challenged by the fact that the average scores for information, efficacy, and concern obtained in this panel data were comparable to those obtained in another study.[37] Consequently, respondents in this study do not in general appear to be more or less environmentally conscious than the wider public.

Another limitation refers to the measures used. The same questions originally used by Kellstedt *et al.* were employed in this study to aid replicability. However, this does not mean that the measures are without problems. The information measure is a single-item question on perceived knowledge and not on actual knowledge. People most dismissive of GWCC might self-report relatively high levels of knowledge, but have low levels of actual knowledge. There is also evidence that actual knowledge regarding GWCC varies across social groups,[33] and might equally differ in its association with other variables. The efficacy measure has an item (human beings are responsible for global warming and climate change) that measures perceived responsibility regarding GWCC rather than perceived personal efficacy. Lastly, the concern measure is only a proxy measure of public concern, asking respondents about their perceived risks and effect of GWCC and not directly asking how concerned they are about these issues.[38] Questions, wording should thus be considered when interpreting survey results on these issues.

Notwithstanding these limitations, the present research provides further support for the key role of knowledge, efficacy, and concern in understanding public support for action on GWCC. Political leadership is essential to achieve the necessary emission reductions, and it relies on widespread public support. Whether policy interventions addressing GWCC are successful will depend in part on the information available to the public and on resulting levels of concern and perceived ability to change the

situation. Understanding the interplay between levels of information, efficacy, and concern is necessary to foster collective action and political leadership regarding GWCC.

Integrating the interrelationships between the variables based upon results from a panel study across a one-year period, this article posits a mediational model in which the influence flows from knowledge to concern and then to efficacy. Knowledge is associated with higher concern about GWCC, and increased concern leads in turn to a greater sense of efficacy and responsibility to deal with these issues. Panel research such as that reported here can better inform us about the causal influence of people's knowledge on their concern and willingness to engage in mitigation actions.

ACKNOWLEDGMENTS

This study was funded by the School of Psychology Fast-Start Grant at the Victoria University of Wellington. The author thanks Sally Blackwell, Antje Döring, Jessica Hardley, and Pollyane K. C. Diniz for their help in data collection and data entry. Special thanks go to Nick Pidgeon for the invitation to contribute to this special issue; Laurel Evans and Aidan Tabor for their editing comments on an earlier draft of this article; to John McClure, Ralph Chapman, and Andy Reisinger for their ideas and valuable comments; and to the survey respondents who made this research possible.

APPENDIX: ADDITIONAL INFORMATION REGARDING THE UNCONDITIONAL LATENT GROWTH CURVE (LGC) MODELS

Fig. A.1 illustrates the unconditional LGC model performed to examine the initial level and rate of change for concern for global warming and climate change over time. By convention, the squares represent measured variables and circles represent latent variables. The squares in Fig. A.1 represent concern measured at three time-points. The circles represent two factors, an "intercept" and a "slope" latent factor. The intercept factor measures the respondents' average initial level of concern, whereas the slope factor measures whether the respondents' average level of concern increases or decreases over the time period (from time 1 to time 3). Double-headed arrows connecting the intercepts and the slopes indicate covariance among the latent factors. Positive covariance would indicate that respondents with higher/lower initial level for the variable would also have higher/lower levels of change (compared to the group's average). For example, a positive covariance between the intercept and slope of concern would indicate that a respondent who started out with a high (or low) initial level of concern will become increasingly more concerned (or less concerned) over time than others.

The loadings for the intercept factor are all fixed to 1.0 to represent the starting point of the growth curve at time 1. The loadings for the slope factor are fixed at the known values of each time-point. This pattern of loading implies that the slope (or change over time) has an increasing effect on the successive measures of the measured variable, from the start of the survey (time 1 = 0), to the second wave (six months after the first wave; time 2 = 0.5), to the final time-point (one year after the first wave; time 3 = 1). A linear trend was estimated in this study because four or more time-points are necessary to estimate quadratic trends. Arrows without origin linked to the measured variables represent measurement error.

In addition, there are two parameters representing the means and the variances of the intercept and slopes. The means represent the group growth parameters. The mean of the intercept gives the initial level of the variable for the group, and the mean of the slope gives the rate of change. For example, the intercept mean indicates the average level of concern for global warming and climate change at time 1, and the slope mean indicates whether concern

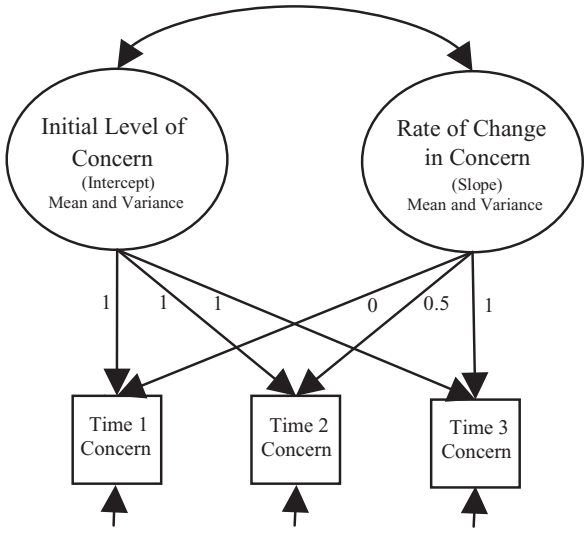

Fig. A.1. Example of unconditional two-factor latent growth model for concern for global warming and climate change.

increased over time (if positive) or decreased over time (if negative). The variances of the intercept and slope reflects the variance of each individual respondent around the overall group growth parameters, indicating how much individuals in the group vary. The variance of the intercept indicates whether the initial level of the measured variables varies significantly from respondent to respondent, and the variance of the slope indicates whether the rate of change varies significantly from respondent to respondent. For example, smaller values for the intercept and slope variances would indicate that the group is homogeneous regarding starting levels of concern for global warming and climate change, and that changes in concern happen at the same rate. Three unconditional LGC models were estimated, one for each of the discussed variables. Table V presents the model fit and parameter estimates, which are discussed in text.

REFERENCES

1. Anderegg WRL, Prall JW, Harold J, Schneider SH. Expert credibility in climate change. Proceedings of the National Academy of Sciences USA, 2010; 107:12107–121109.
2. Arndt DS, Baringer MO, Johnson MR. State of the climate in 2009. Bulletin of the American Meteorological Society, 2010; 91:S1–S224.
3. Doran PT, Kendall Zimmerman M. Examining the scientific consensus on climate change. EOS, Transactions American Geophysical Union, 2009; 90:22–23.
4. Intergovernmental Panel on Climate Change. Climate Change 2007: Synthesis Report. Cambridge: Cambridge University Press, 2007.
5. Min S-K, Zhang X, Zwiers FW, Hegerl GC. Human contribution to more-intense precipitation extremes. Nature, 2011; 470:378–381.
6. Oreskes N. The scientific consensus on climate change. Science, 2004; 306(5702):1686.
7. Nobel Laureates. The next hundred years, 2001. Available at: http://www.sciencemag.org/site/feature/data/nobel.xhtml, Accessed on March 29, 2011.
8. Vidal J. Nobel laureates compare climate crisis to threat from nuclear weapons. Guardian, May 29, 2009. Available at: http://www.guardian.co.uk/environment/2009/may/29/prince-charles-nobel-laureates, Accessed on April 13, 2011.
9. United Nations Framework Convention on Climate Change. Outcome of the work of the ad hoc working group on long-term cooperative action under the convention, 2010. Available at: http://unfccc.int/meetings/ad_hoc_working_groups/lca/items/4381.php, Accessed on March 29, 2011.
10. Eurobarometer. Europeans' attitudes towards climate change (Special Eurobarometer 313, European Parliament and European Commission), 2009. Available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_313_en.pdf, Accessed on March 29, 2011.
11. Leiserowitz A, Maibach E, Roser-Renouf C. Climate Change in the American Mind: Americans' Global Warming Beliefs and Attitudes in January 2010. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change, 2010. Available at: http://environment.yale.edu/uploads/AmericansGlobalWarmingBeliefs2010.pdf, Accessed on March 29, 2011.
12. The World Bank. Public attitudes toward climate change: Findings from a multi-country poll, 2009. Available at: http://www.worldpublicopinion.org/pipa/pdf/dec09/ClimateChange_Dec09_rpt.pdf, Accessed on April 7, 2011.
13. Intergovernmental Panel on Climate Change. Climate change 2007: Mitigation of climate change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007.
14. Grob A. A structural model of environmental attitudes and behaviour. Journal of Environmental Psychology, 1995; 15:209–220.
15. Hines JM, Hungerford HR, Tomera AN. Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. Journal of Environmental Education, 1987; 18:1–8.
16. Hornik J, Cherian J, Madansky M, Narayana C. Determinants of recycling behavior: A synthesis of research results. Journal of Socio-Economics, 1995; 24:105–127.
17. Hwang Y-H, Kim S-I, Jeng J-M. Examining the causal relationships among selected antecedents of responsible environmental behavior. Journal of Environmental Education, 2000; 31:19–25.
18. Kaiser FG, Fuhler U. Ecological behaviour's dependency on different forms of knowledge. Applied Psychology: An International Review, 2003; 52:598–613.
19. Meinhold JL, Malkus AJ. Adolescent environmental behaviors: Can knowledge, attitudes, and self-efficacy make a difference? Environment and Behavior, 2005; 37:511–532.
20. McFarlane BL, Hunt LM. Environmental activism in the forest sector: Social psychlogical, social-cultural, and contextual effects. Environment and Behavior, 2006; 38:266–285.
21. Spence A, Poortinga W, Butler C, Pidgeon NF. Perceptions of climate change and willingness to act sustainably influenced by flood experiences. Nature Climate Change, 2011; 1: 46–49.
22. Burgess J, Harrison C, Filius P. Environmental communication and the cultural politics of environmental citizenship. Environment and Planning A, 1998; 30:1445–1460.
23. Owens S. "Engaging the public": Information and deliberation in environmental policy. Environment and Planning A, 2000; 32:1141–1148.
24. Gifford R. Psychology's essential role in alleviating the impacts of climate change. Canadian Psychology, 2008; 49:273–280.
25. Kasperson RE, Kasperson JX. Hidden hazards. Pp. 9–28 in Mayo DG, Hollander RD (eds). Acceptable evidence: Science and values in risk management. New York: Oxford University Press, 1991.
26. Van Vugt M. Averting the tragedy of the commons: Using social psychological science to protect the environment. Current Directions in Psychological Science, 2009; 18:169–173.
27. Ockwell D, Whitmarsh L, O'Neill S. Reorienting climate change communication for effective mitigation: Forcing people to be green or fostering grass-roots engagement? Science Communication, 2009; 30:305–327.
28. Aitken C, Chapman R, McClure J. Climate change, powerlessness and the commons dilemma: Assessing New Zealanders' preparedness to act. Global Environmental Change, 2011; 21:752–760.
29. Bord RJ, O'Connor RE, Fisher A. In what sense does the public need to understand global climate change. Public Understanding of Science, 2000; 9:205–218.
30. Heath Y, Gifford R. Free-market ideology and environmental degradation: The case of beliefs in global climate change. Environment and Behavior, 2006; 38:48–71.

31. O'Connor RE, Bord RJ, Fisher A. Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Analysis, 1999; 19:461–471.
32. O'Connor RE, Bord RJ, Yarnal B, Wiefek N. Who wants to reduce greenhouse gas emissions? Social Science Quarterly, 2002; 83:1–17.
33. Sundblad E-L, Biel A, Gärling T. Knowledge and confidence in knowledge about climate change among experts, journalists, politicians, and laypersons. Environment and Behavior, 2009; 41:281–302.
34. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes, 1991; 50:179–211.
35. Bandura A. Self-Efficacy: The Exercise of Control. New York: Worth Publishers, 1997.
36. Brody SD, Zahran S, Vedlitz A, Grover H. Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. Environment and Behavior, 2008; 40:72–95.
37. Kellstedt PM, Zahran S, Vedlitz A. Personal efficacy, the information environment, and attitudes toward global warming and climate change in the United States. Risk Analysis, 2008; 28:113–126.
38. Malka A, Krosnick JA, Langer G. The association of knowledge with concern about global warming: Trusted information sources shape public thinking. Risk Analysis, 2009; 29:633–647.
39. Harré N, Atkinson Q. (eds). Carbon Neutral by 2020. Nelson: Craig Potton Publishing, 2007.
40. Ministry for the Environment. Gazetting New Zealand's 2050 emissions target, 2011. Available at: http://www.mfe.govt.nz/publications/climate/nz-2050-emissions-target/gazetting-nz-2050-emissions-target.pdf, Accessed on April 6, 2011.
41. Wilson N, Chapman R, Howden-Chapman P. New Zealand Government response to climate change: Largely fogged up? New Zealand Medical Journal, 2009; 122:111–113.
42. Milfont TL, Harré N, Sibley CG, Duckitt J. The climate change dilemma: Examining the association between parental status and political party support. Journal of Applied Social Psychology, in press.
43. New Zealand Institute of Economic Research. Emissions trading scheme (ETS) research: A summary of quantitative research amongst the general public, 2008. Available at: http://nzier.org.nz/sites/nzier.live.egressive.com/files/ETS_TNS_Conversa_08.07.07–1.pdf, Accessed on April 5, 2011.
44. Zahran S, Brody S, Grover H, Vedlitz A. Climate change vulnerability and policy support. Society and Natural Resources, 2006; 19:1–19.
45. Hughey KFD, Kerr GN, Cullen R. Public Perceptions of New Zealand's Environment: 2008. Christchurch, New Zealand: EOS Ecology, 2008.
46. Stuart D. Survey on public attitudes to climate change and the emissions trading scheme. Report for the Greenhouse Policy Coalition, Wellington, 2009. Available at: http://www.gpcnz.co.nz/includes/download.aspx?ID=106201, Accessed on April 5, 2011.
47. New Zealand Business Council for Sustainable Development. ShapeNZ: New Zealanders' attitudes to climate change, Auckland, 2009. Available at: http://www.nzbcsd.org.nz/_attachments/New_Zealanders%27_Attitudes_to_Climate_Change_ShapeNZ_Survey_Report_March%2C_2009.pdf, Accessed on March 29, 2011.
48. Converse PE. The nature of belief systems in mass publics. Pp. 206–261 in Apter DE (ed). Ideology and Discontent. London: Free Press of Glencoe, 1964.
49. Little TD, Schnabel KU, Baumert J (eds). Modeling Longitudinal and Multilevel Data: Practical Issues, Applied Approaches, and Specific Examples. Mahwah, NJ: Lawrence Erlbaum, 2000.
50. McArdle JJ, Aber MS. Patterns of change within latent variable structural equation models. Pp. 151–224 in von Eye A (ed). Statistical Methods in Longitudinal Research: Principles and Methods of Structuring Change. New York: Academic Press, 1990.
51. Willet JB, Sayer AG. Using covariance structure analysis to detect correlates and predictors of individual change over time. Psychological Bulletin, 1994; 116:363–381.
52. Curran PJ, Harford TC, Muthén BO. The relation between heavy alcohol use and bar patronage: A latent growth model. Journal of Studies on Alcohol, 1996; 57:410–418.
53. Walker AJ, Acock AC, Bowman SR, Li F. Amount of care given and caregiving satisfaction: A latent growth curve analysis. Journal of Gerontology: Psychological Sciences, 1996; 51B:130–142.
54. Dunlap RE, Van Liere KD, Mertig A, Jones RE. Measuring endorsement of the new ecological paradigm: A revised NEP scale. Journal of Social Issues, 2000; 56:425–442.
55. Hawcroft LJ, Milfont TL. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology, 2010; 30:143–158.
56. Sibley CG, Wilson MS. Political attitudes and the ideology of equality: Differentiating support for liberal and conservative political parties in New Zealand. New Zealand Journal of Psychology, 2007; 36:72–84.
57. Aiken LS, West SG. Multiple Regression: Testing and Interpreting Interactions. London: SAGE, 1991.
58. Whitmarsh L. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. Global Environmental Change, 2011; 21:690–700.
59. Lord CG, Ross L, Lepper MR. Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. Journal of Personality and Social Psychology, 1979; 37:2098–2109.
60. Ross L, Lepper MR, Hubbard M. Perseverance in self-perception and social perception: Biased attributional processes in the debriefing paradigm. Journal of Personality and Social Psychology, 1975; 32:880–892.
61. IJzerman H, Koole SL. From perceptual rags to metaphoric riches—Bodily, social, and cultural constraints on socio-cognitive metaphors: Comment on Landau, Meier, and Keefer (2010). Psychological Bulletin, 2011; 137:355–361.
62. Williams LE, Huang JY, Bargh JA. The scaffolded mind: Higher mental processes are grounded in early experience of the physical world. European Journal of Social Psychology, 2009; 39:1257–1267.
63. Van Vugt M, Samuelson CD. The impact of metering in a natural resource crisis: A social dilemma analysis. Personality and Social Psychology Bulletin, 1999; 25:731–745.
64. Abrahamse W, Steg L, Vlek C, Rothengatter T. A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 2005; 25:273–291.
65. Dietz T, Gardner GT, Gilligan J, Stern PC, Vandenberghe, MP. Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. Proceedings of the National Academy of Sciences USA, 2009; 106:18452–18456.
66. McKenzie-Mohr D. Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing, 3rd ed. Gabriola Island, Canada: New Society Publishers, 2011.
67. Schultz PW. Knowledge, education, and household recycling: Examining the knowledge-deficit model of behavior change. Pp. 67–82 in Dietz T, Stern P (eds). New Tools for Environmental Protection. Washington, DC: National Academy of Sciences, 2002.
68. Schultz PW, Kaiser F. Promoting proenvironmental behavior. In Clayton S (ed). Handbook of Environmental and Conservation Psychology. Oxford: Oxford University Press, in press.

69. Environment Canada. Evaluation of the One-Tonne Challenge program, 2006. Available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_313_en.pdf, Accessed on March 29, 2011.
70. Conway EM. Communicating the science of climate change: Lessons from history. Paper presented at the Climatefutures Conference, New Zealand Climate Change Research Institute. Wellington, New Zealand, 2011.
71. Oreskes N, Conway EM. Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming. New York: Bloomsbury Press, 2010.
72. Boykoff MT, Boykoff JM. Balance as bias: Global warming and the US prestige press. Global Environmental Change, 2004; 14:125–136.
73. Sterman JD. Risk communication on climate: Mental models and mass balance. Science, 2008; 322:532–533.
74. Antilla L. Self-censorship and science: A geographical review of media coverage of climate tipping points. Public Understanding of Science, 2010; 19:240–256.
75. Frick J, Kaiser FG, Wilson, M. Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. Personality and Individual Differences, 2004; 37:1597–1613.
76. Budescu DV, Broomell S, Por H-H. Improving communication of uncertainty in the reports of the Intergovernmental Panel on Climate Change. Psychological Science, 2009; 20:299–308.
77. Gattig A, Hendrickx L. Judgmental discounting and environmental risk perception: Dimensional similarities, domain differences, and implications for sustainability. Journal of Social Issues, 2007; 63:21–39.
78. Pelletier LG, Sharp E. Persuasive communication and proenvironmental behaviours: How message tailoring and message framing can improve the integration of behaviours through self-determined motivation. Canadian Psychology, 2008; 49:210–217.
79. Morton TA, Rabinovich A, Marshall D, Bretscheneider P. The future that may (or may not) come: How framing changes responses to uncertainty in climate change communications. Global Environmental Change, 2011; 21:103–109.
80. Spence A, Pidgeon NF. Framing and communicating climate change: The effects of distance and outcome frame manipulations. Global Environmental Change, 20; 2010:656–667.
81. Halpert J. Incremental? Yes. But a growing role for social sciences in climate change dialog. The Yale Forum on Climate Change and the Media, February 16, 2011. Available at: http://www.yaleclimatemediaforum.org/2011/02/incremental-yes-but-a-growing-role-for-social-sciences-in-climate-change-dialog/, Accessed on April 9, 2011.
82. Milfont TL. Global warming, climate change and human psychology. Pp. 19–42 in Corral-Verdugo V, García-Cadena CH, Frías-Arment M (eds). Psychological Approaches to Sustainability: Current Trends in Theory, Research and Practice. New York: Nova Science, 2010.
83. Swim J, Clayton S, Doherty T, Gifford R, Howard G, Reser JP, et al. Psychology and Global Climate Change: Addressing a Multi-Faceted Phenomenon and Set of Challenges (Report by the Task Force on the Interface Between Psychology and Global Climate Change). Washington, DC: American Psychological Association, 2009.
84. Cialdini RB. Crafting normative messages to protect the environment. Current Directions in Psychological Science, 2003; 12:105–109.
85. Schultz PW, Nolan JM, Cialdini RB, Goldstein NJ, Griskevicius V. The constructive, destructive, and reconstructive power of social norms. Psychological Science, 2007; 18:429–434.