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Perceptions of behaviors that cause and mitigate global warming and intentions to perform these behaviors

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ABSTRACT

Individual household and travel behaviors represent a sizeable contribution to U.S. greenhouse gas emissions. This paper investigates people's knowledge of these behaviors and perceptions of these behaviors' impact in causing and mitigating climate change. In the present study, a sample of college students were asked to list the behaviors they perform that cause global warming (GW) and the behaviors they could perform to mitigate GW, to rate the impact of the behaviors in terms of their effect on causing or mitigating GW, and to rate their intention to perform each of the behaviors. Results revealed that this sample was well aware of the effect of driving on GW. However, participants underestimated the relative impact of adjusting the thermostat and eating meat on GW and overestimated the impact of littering on causing GW. Although knowledge about GW-mitigating behaviors was not consistently related to behavioral intention, belief that a behavior mitigated GW (whether accurate or not) was strongly related to intention to perform that behavior. Specifically, correlations between belief in the mitigating potential of a behavior and intention were relatively high for adjusting the thermostat, reducing meat consumption, and several behaviors that do not mitigate GW, but were relatively low for reducing driving and not littering. Practical implications and comparisons with previous literature are discussed.

1. Introduction

The U.S., home to 4.5% of the world population, is responsible for approximately 18% of global greenhouse gas emissions, per 2005 calculations (World Resources Institute, 2011). This translates to a per capita emissions amount of 23.4 metric tons of carbon dioxide equivalent for the average American citizen compared to a world average of 5.8 metric tons (World Resources Institute, 2011). This disproportionate impact on climate change has resulted in national and international calls for the U.S. to reduce its greenhouse gas emissions. In light of the repeated failure of passing federal climate change legislation, those interested in reducing emissions in the U.S. have begun to look for other avenues. Several scholars have recommended a focus on individual actions which, if performed in aggregate across the American public, can have a sizeable effect on reducing U.S. greenhouse gas emissions (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009; Vandenbergh, Gilligan, & Barkenbus, 2008). As such, attempting to reduce emissions by changing individual household and travel behaviors is a promising strategy. However, it is unclear how much knowledge the U.S. public has about these climate change-related behaviors. To what extent do laypeople recognize the behaviors they perform that cause global warming (GW), the behaviors they can perform to mitigate GW, and the relative impact and effectiveness of undertaking these behaviors to mitigate GW[1]? Additionally, what influence do beliefs and knowledge about the effectiveness of undertaking a behavior to mitigate GW have on intention to take that behavior?

Although knowledge plays only a background role in the major psychological theories that have been applied to proenvironmental

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[1] Although *climate change* has become the preferred phrase among scientists, the public and media often use the term *global warming* when referring to changes in climate that result from natural causes and human activities. As such, although *climate change* technically includes all changes to the climate system (including global warming) that result from changes in greenhouse gas concentrations, the terms *climate change* and *global warming* are used interchangeably in the present paper and are both meant to refer to "an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere" (U.S. EPA, 2009 April 22). All questions included in this survey used the term *global warming*, as Read et al. (1994) used this terminology and recent research has found that the lay public more often associates *global warming* (versus *climate change*) with concern, human causes, and individual mitigating actions (Whitmarsh, 2009a).

behavior (e.g., the Theory of Planned Behavior (Ajzen, 1991; Ajzen & Fishbein, 2005), and the Value-Belief-Norm Theory (Stern, 2000)), a recent group of scholars has successfully forwarded a new theory that postulates that declarative knowledge may be a more important predictor of proenvironmental behavior than previously recognized (Frick, Kaiser, & Wilson, 2004; Kaiser & Fuhrer, 2003). According to the Knowledge Structure Model (Frick et al., 2004), declarative knowledge is multi-dimensional and consists of system knowledge (e.g., how does the greenhouse effect work?), action knowledge (e.g., what behaviors mitigate GW?), and effectiveness knowledge (e.g., how effective are behaviors in mitigating GW?). Action knowledge and effectiveness knowledge have been found to mediate the effect of system knowledge on general conservation behavior and are thus considered more directly related to behavior (Frick et al., 2004). In the climate change literature, participants have frequently cited lack of knowledge on how to change behavior to reduce climate change (i.e., action knowledge) as a major barrier to engaging in GW-mitigating behavior (Aitken, Chapman, & McClure, 2011; Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; Semenza et al., 2008). Less research has focused on effectiveness knowledge in the climate change domain (see Downing & Ballantyne, 2007). As such, the present paper focuses on action and effectiveness knowledge and beliefs related to behaviors that cause and mitigate GW. We begin with a review of the literature on perceptions of behaviors that cause and mitigate climate change with a focus on identifying key misperceptions. Then we forward new hypotheses about the effect of these perceptions on behavior intention.

1.1. Perceptions of GW causes

Several studies have assessed the public's knowledge of the activities that cause GW. In initial studies, Bostrom, Morgan, Fishhoff, and Read (1994) and Read, Bostrom, Morgan, Fischhoff, and Smuts (1994) interviewed Pittsburgh residents to determine their thoughts about the causes of GW and asked them to rate their degree of agreement that each activity caused GW. Results from these studies showed that participants' beliefs about broad GW contributors were often flawed. In Read et al.'s (1994) study, participants agreed more strongly that clearing tropical rainforests, deforestation, and aerosol spray cans[2] are causes of GW than burning fossil fuels. Similarly, in Bostrom et al. (1994) study, most participants mentioned ozone depletion, pollution and air pollution, aerosol cans, automobile use, and industrial emissions as causes of global warming, while fossil fuels and energy use in buildings were much less frequently mentioned.

More recent studies have used large-scale surveys or polls to assess Americans' perceptions of GW causes. Stamm, Clark, and Eblancas's (2000) investigation into Washingtonians' beliefs about the importance of various causes of GW (in which household energy use was not an option) found that more participants believed that deforestation was a very important cause of GW than believed that use of fossil fuels was a very important cause. Additionally, use of chlorofluorocarbons (CFCs) was judged to be a very important cause of GW by more participants than industrialization, overpopulation, and agriculture (Stamm, Clark, & Eblancas, 2000). O'Connor, Bord, Yarnal, and Wiefek (2002) found that almost three quarters of their participants thought that heating and cooling their homes was not a major cause of GW and over half thought that the use of coal and oil by utilities or electric companies was not a major cause. Strikingly, 35% rated people driving cars as not a major cause (O'Connor et al., 2002). In a cross-national poll conducted in 2001, Brechin (2003) found that more Americans rated depletion of the ozone layer and air pollution as the main cause of the greenhouse effect than burning of fossil fuels (15%). Finally, in a replication of the Read et al. (1994) study, Reynolds, Bostrom, Read, and Morgan (2010) found that Seattle and Pittsburgh residents interviewed at a public street fair and public park showed some important improvements in knowledge compared to the 1994 sample, but also some continued misperceptions. For example, participants' in the 2009 sample (Reynolds et al., 2010) were more likely than participants in the 1992 sample (Read et al., 1994) to correctly mention burning fossil fuels and methane-related activities, such as landfills and agriculture, as causes of GW. However, the same percentage of participants in each sample mentioned automobiles, industry, and pollution as causes of GW in open-ended questions. Further, when rating their agreement that a list of activities cause GW, participants in 2009 (Reynolds et al., 2010) showed the same level of agreement that burning fossil fuels causes GW and showed lower degrees of agreement that clearing tropical rainforests and deforestation cause GW than participants in the 1992 sample (Read et al., 1994). It is clear from this work that misperceptions still exist and that additional research is needed to further investigate these misperceptions.

Further, a review of the causes of GW listed by and supplied to participants in the above studies reveals that they vary widely in terms of concreteness and specificity. Although some of the general causes of GW included in previous research are concrete and can easily be translated into individual behaviors (e.g., automobile use and energy use in homes), others are less tangible (e.g., deforestation and pollution) and cannot easily be equated with a behavior that an individual does on a daily basis. Only two U.S. studies could be located that specifically tap into participants' knowledge of the everyday behaviors that they perform that cause GW. Results from Read et al.'s (1994) study showed that only six behaviors were listed in the open-ended question by more than 10% of the Pittsburgh residents: driving, use of aerosol cans, air conditioning, not conserving, consuming environmentally harmful products, and generating too much waste. These same six behaviors were also listed by more than 5% of the participants in Reynolds et al.'s (2010) study with the addition of electricity use, existence beliefs, air travel, and smoking. Compared to the number of participants who mentioned each behavior in the 1992 sample (Read et al., 1994), in the 2009 sample (Reynolds et al., 2010), about the same percentage mentioned driving, consuming environmentally unfriendly products, and generating "excessive" waste; fewer mentioned using aerosol cans and A/C; and more mentioned do not conserve. Interestingly, neither study assessed perceptions of the relative impact of these behaviors in causing global warming. Additional research is needed to tease apart people's ability to list the behaviors that cause global warming and their understanding of the relative impact of these behaviors.

This literature led us to our first set of research questions.

RQ1. What behaviors do participants list when asked which behaviors they perform that cause GW and how do these compare to Reynolds et al. (2010) and Read et al. (1994)?

RQ2. What are the relative ratings of the behaviors in terms of perceived impact in causing GW?

1.2. Perceptions of GW mitigators

In addition to investigations of perceptions of the causes of GW, several studies have assessed the American public's beliefs about

[2] Laypeople often confuse ozone depletion with climate change, an example of a lack of system knowledge (Bord et al., 2000; Brechin, 2003; Kempton, 1991; Read et al., 1994; Reynolds et al., 2010; Whitmarsh, 2009a). As a result of the U.S.'s bans in 1978 and 1993 on using CFCs in aerosol spray cans, some researchers have labeled participants' belief that aerosol spray cans cause climate change as incorrect and have argued that this is another example of conflation of ozone depletion and climate change. However, we now know that the gases that have replaced CFCs in aerosol spray cans, mostly hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are also greenhouse gases regulated by the Kyoto protocol. Thus, participants who state that aerosol spray cans cause GW and that reducing aerosol spray can use would decrease GW are technically correct.

the effectiveness of general strategies that can mitigate GW. Read et al. (1994) found that most participants rated general strategies related to energy conservation and fossil fuel reductions as being effective. Additionally, participants believed that reductions in air pollution and CFC-related activities (such as banning aerosol sprays and CFCs) would slow GW (Read et al., 1994). More recently, Stamm et al. (2000) found that more than half of their respondents considered reducing industrial emissions of greenhouse gases, planting more trees, energy efficient technologies, driving less, and halting deforestation as very helpful solutions to reduce GW, while reducing home energy use was rated as very helpful by only 37%.

Just as with research on the causes of GW, most of the researchers investigating the mitigators of GW have mixed items assessing individual behaviors and societal actions, making it difficult to identify whether people are aware of the individual actions they can take. Little research has been conducted specifically on the U.S. public's knowledge of the individual behaviors that they can undertake to mitigate GW or their perceptions of the relative effectiveness of these behaviors. Read et al. (1994) found that their American participants' most frequently-mentioned behaviors that individuals could do to reduce GW were reducing driving, political actions, personal awareness and recycling. Few (only 11%) proposed cutting their household energy use (Read et al., 1994). In Reynolds et al.'s (2010) replication of Read's study, participants' most frequently mentioned GW-mitigating actions were reduce driving, recycle, save energy, green consumption, and buy a hybrid car. Several other actions (political actions, raise awareness, reduce aerosol use, use alternative energy, reduce consumption, plant trees) were listed by less than 10% of the participants (Reynolds et al., 2010). In another line of research, Semenza et al. (2008) asked their sample of Oregon and Texas residents what behaviors they have already undertaken in response to climate change and provided a list of three options. The most endorsed option was decreased energy usage at home, followed by reduced gasoline consumption, and "other" for which participants supplied their own behaviors. Recycling was the most frequently listed "other" category, although participants also listed behavior categories such as transportation, energy, food consumption, and waste reduction, among others. The percentages of people who listed each behavior category were not provided (Semenza et al., 2008).

In terms of the perceived effectiveness of various behaviors in reducing GW, a recent survey of the UK public revealed that 40% of the respondents rated recycling as the most helpful behavior that will reduce climate change (Downing & Ballantyne, 2007). Much fewer (17%) rated driving less as the most helpful behavior (Downing & Ballantyne, 2007). Overall, the research to date has found that individuals are quick to mention recycling as a behavior that can reduce climate change, but are less likely to identify cutting household energy use, with mixed results concerning driving less. More in-depth research is needed to evaluate the extent to which people recognize the important causes and mitigators of GW and the relative impact of these behaviors.

This literature led us to our second set of research questions.

RQ3. What behaviors do participants list when asked which behaviors they could perform to mitigate GW and how do these compare to Reynolds et al. (2010) and Read et al. (1994)?

RQ4. What are the relative ratings of the behaviors in terms of perceived effectiveness in mitigating GW?

1.3. Influence of effectiveness beliefs and knowledge on intention

As described above, previous research has identified various misperceptions in the public's mental models of behaviors that mitigate GW. Though identification of these misperceptions is valuable in its own right, information is needed about the effect of these misperceptions on behavior intention. In other words, we know that effectiveness-related misperceptions exist, but do these, or which of these, misperceptions matter? To investigate these questions, we draw on two theories related to conservation behavior: The Knowledge Structure Model (Frick et al., 2004; Kaiser & Fuhrer, 2003) and the Theory of Planned Behavior (Ajzen, 1991; Ajzen & Fishbein, 2005).

1.3.1. Effectiveness knowledge

Environmental knowledge has long been assumed to underlie proenvironmental behavior (Hines, Hungerford, & Tomera, 1986/87). Although most research has shown that environmental knowledge alone is not sufficient to motivate behavior (Gardner & Stern, 2002; Schultz, 2002), a recent meta-analysis has found that general environmental knowledge is one of the strongest correlates of proenvironmental intention (Bamberg & Moser, 2007). As mentioned above, the Knowledge Structure Model, posits that effectiveness knowledge (as well as action knowledge and system knowledge) influences general conservation behavior (Frick et al., 2004; Kaiser & Fuhrer, 2003). When faced with a desire to conserve energy, for example, people who know that carpooling saves more energy than maintaining correct tire pressure (Gardner & Stern, 2008) can be expected to be more likely than others to perform proenvironmental behavior (Kaiser & Fuhrer, 2003). Using multiple choice tests assessing knowledge of the effectiveness of behaviors, Frick and colleagues have found that more ecological-focused effectiveness knowledge predicts general ecological behavior (Frick et al., 2004).

With specific regard to the GW behavior domain, although some work has investigated the effect of knowledge about the general *causes* of GW on intention to perform behaviors that mitigate GW (e.g., Bord, O'Connor, & Fisher, 2000; O'Connor, Bord, & Fisher, 1999; O'Connor et al., 2002; Whitmarsh, 2009b), little empirical research has been conducted to test whether GW-based effectiveness knowledge influences intention to perform a specific behavior (c.f. Aitken et al., 2011 who found no association between self-reported effectiveness knowledge and general behavioral intention). However, several researchers have recognized the possibility that specific knowledge of behaviors that mitigate GW may lead to stronger intention to perform GW behavior (Bord et al., 2000; Gardner & Stern, 2008; Kempton, 1993; O'Connor et al., 1999; O'Connor et al., 2002). These findings, coupled with the Knowledge Structure Model (Frick et al., 2004), led us to hypothesize that higher levels of GW effectiveness knowledge would be associated with higher levels of GW behavior intention (H1).

1.3.2. Effectiveness beliefs

In the Theory of Planned Behavior, behavioral beliefs, considerations of the advantages and disadvantages of performing a behavior, influence attitude toward the behavior, which in turn influences intention and behavior (Ajzen, 1991; Ajzen & Fishbein, 2005). As such, beliefs about the effectiveness of a behavior in mitigating climate change fall into the category of behavioral beliefs in the Theory of Planned Behavior and would be expected to relate to intention to perform the behavior. If one believes that a behavior is effective in mitigating climate change then this would lead (indirectly) to stronger intention to perform the behavior. The key difference between effectiveness beliefs and effectiveness knowledge is that effectiveness beliefs are expected to influence intention regardless of whether the beliefs are accurate or not as people act in accordance with their beliefs even if they are factually incorrect.

Beliefs about the effectiveness of a behavior are also similar in concept to response efficacy beliefs, or outcome expectancy, "a person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p. 193). Heath and Gifford (2006) found that general response efficacy (which they defined as self-efficacy

of cooperation), or one's belief "that their efforts will make a difference" in mitigating GW was the strongest predictor of general GW behavioral intention above belief that climate change is occurring, belief that causes are man-made, and belief that consequences are negative (p.53). Little U.S. research could be located that investigated behavior-specific effectiveness beliefs related to GW behavior, though belief in the effectiveness of a behavior has been shown to predict behavioral intention in other environmental domains (Hall & Slothower, 2009; Lam, 2006). We hypothesized that belief that a behavior mitigates GW would be positively related to intention to perform that behavior (H2) and that this relationship would not be different for behaviors that actually mitigate GW vs. those that do not (H3).

1.4. Present study

The present study serves as a partial replication and extension of Read et al.'s (1994) and Reynolds et al.'s (2010) investigations. Those studies focused on perceptions of the scientific process of global warming, general climate change causes, consequences of climate change and responses to climate change with a sample of Pittsburgh and Seattle (in Reynolds et al.'s study) residents attending an outdoor public event. The present study adds to their work in several important ways. First, Read et al.'s (1994) and Reynolds et al.'s (2010) studies had only a limited number of questions on perceptions of the individual behaviors that cause and mitigate global warming. The present study focuses exclusively on individual behaviors and adds to the literature by investigating perceptions of the relative impact and effectiveness of these behaviors. Second, this study examines global warming perceptions among undergraduate students at a northwestern U.S. university, a very different sample than Read et al. (1994) and Reynolds et al. (2010). Understanding the perceptions of college students is vitally important as this group consists of the future leaders of our society. Identification of the accuracies and inaccuracies that characterize this sample's mental models of GW as well as the differences between this sample's perceptions and those of Read et al.'s (1994) and Reynolds et al.'s (2010) samples has important implications for applied researchers, campaign designers, and public policy. Third and most importantly, this study extends previous research by measuring intentions to perform behaviors that mitigate GW and by examining the relationships between effectiveness knowledge and intention and effectiveness beliefs and intention. No previous research could be identified that investigated these relationships in the GW domain. Examining the role of both knowledge and effectiveness beliefs in influencing intention enables us to better map out misperceptions about the effectiveness of GW behaviors and provides important insight into which misperceptions should be the focus of applied campaigns.

2. Method

2.1. Participants

Undergraduate psychology majors ($N = 112$) at a northwestern state university completed this study between April and June of 2008. The participants (69 women and 43 men) predominantly identified themselves as White, non-Latino (66.1%), with the remaining participants identifying themselves as Asian (12.5%), Latino (10.7%), African American (4.5%), and other (6.3%). The majority of the participants were between the ages of 18 and 25 (97.3%), with the sample age ranging from 18 to 52. In terms of political party affiliation, the largest segment was Democrat (42.9%), with the remainder of the sample identifying themselves as Republican (16.1%) or Independent (36.6%).

Table 1
Behavior categories and example behaviors provided by participants from open-ended questions about behaviors that cause global warming.

Behavior category	Example behaviors provided
Drive	"I drive/ride in a personal vehicle" "Drive a car"
Do not recycle	"Don't 100% recycle" "Not recycling cans sometimes"
Use electricity	"I leave electronics and lights on when not in use (computer)" "I use electricity"
Build fires	"I burn plastic in the burning barrel" "I barbeque outside"
Consume products	"Buying products that cause global warming" "I overconsume. I buy and use more than I need"
Use aerosol sprays	"I have used aerosol spray" "I use spray cans"
Leave on lights	"I do not turn off lights when not needed" "I turn on lights when they don't really need to be on"
Produce garbage	"Garbage" "Too much trash"
Fly in airplanes	"I fly home instead of drive" "Taking a flight"
Recycle[a]	"Recycling" "I recycle"
Buy goods from factories	"I purchase products made in factories that create a lot of waste and exhaust" "I but (sic) items produced in factories."
Smoke cigarettes	"I smoke" "Smoking"
Environmental inaction	"Not 'going green'" "I do not donate to Enviornmental (sic) friendly technologies"
Waste goods and resources	"I waste things" "I sometimes waste materials such as plastics"
Use or waste water	"Waste water" "I use a lot of water for shower and laundry"
Use heat & A/C	"Use air-conditional (sic)" "I use the heater in my home"
Use or waste energy	"I use energy in my home" "I don't conserve energy at times"
Ride the bus	"I ride the bus" "I sometimes ride the bus"
Use or waste paper	"I use paper cups when drinking coffee" "I use paper products"
Walk[a]	"I walk everywhere" "I walk sometimes to school"
Eat meat	"I eat cow meat" "Buy and eat animal product"
Litter	"I have littered" "Littering"
Use products that pollute	"I pollute" "I use products that pollute"
Do not carpool or use bus	"I rarely take the bus" "I don't carpool when I could easily get a ride with people"
Use inefficient light bulbs	"I do not use environment friendly bulbs" 'I use non-energy efficient lightbulbs."
Exist or breathe	"I am one more person in the population" "Breath"
Cut down trees	"Cut down trees" "I cut trees for a living"
Buy water bottles	"I buy bottled water" "Drinking bottled water"
Use no aerosol sprays[a]	"I do not use aerosol cans" "I never use aresol (sic) cans"
Miscellaneous behaviors	"I use technology" "I have an old cooling system i[n] my house" "I live in a house made of wood / contribute to forest clear cutting" "I live in America"

Note. $N = 101$.
[a] Behavior that reduces global warming.

2.2. Procedure and instruments

Participants completed several surveys on the computer individually on the internet from their residences. The survey items included in this study were part of a larger study on attitudes and behavior related to climate change and only survey items relevant to this study are discussed here. First, participants completed several questionnaires originally asked in Read et al. (1994) or adapted from that study. In open-ended questions, participants listed all behaviors that they do that contribute to GW and the most effective behaviors that they could perform to reduce GW (from Read et al., 1994; Reynolds et al., 2010).

Next participants completed measures developed by the author to assess beliefs about the extent to which specific behaviors cause and mitigate GW. Behaviors were drawn from existing popular lists of activities people can do to reduce GW as well as from previous research in this area. Behaviors were chosen that result in direct greenhouse gas emissions, such as energy use from household electricity use and travel behavior (Gardner & Stern, 2008), as well as meat consumption, a behavior that increases emissions indirectly (Weber & Matthews, 2008). In total, participants rated 16 behaviors on the extent to which they contribute to GW on a scale from 1 (Negligible impact) to 11 (Very major impact). The measure was developed such that some proenvironmental behaviors that do not have a discernible impact on GW (i.e., skiing, littering, purchasing items that are tested on animals, and riding your bike) were included because such behaviors have been identified by previous researchers (e.g., Read et al., 1994) as sources of potential misperceptions. All items are listed in Table 2. Participants also rated 20 behaviors on the extent to which they are effective in reducing GW on a scale from 1 (Extremely ineffective) to 11 (Extremely effective). To allow for the identification of misperceptions, the measure was developed such that some pro-environmental behaviors that do not have a discernible impact on GW (e.g., turn off the sink while brushing teeth, throw away garbage instead of littering) were included. Additionally, behaviors about which emissions are unpublished (e.g., use reusable containers and grocery bags) or about which emissions are currently under debate (e.g., recycling, buy locally grown foods) were also included (Lave, Hendrickson, Conway-Schempf, & McMichael, 1999; Saunders, Barber, & Taylor, 2006). All items are listed in Table 4. Considering the characteristics of the sample in that the targeted population was made up of predominately non-

Table 2
Mean impact ratings of behaviors that contribute to global warming in closed ended questions.

Behavior	Mean	SD
Driving your car	7.79	2.25
Throwing away recyclable materials	6.83	2.57
Flying in airplanes	6.47	2.46
Heating and cooling your house	5.97	2.41
Littering[a]	5.83	2.84
Using aerosol cans	5.75	2.57
Lighting in your house	5.51	2.48
Using paper	5.43	2.53
Heating water for the shower and laundry	5.29	2.62
Using the dishwasher	5.27	2.64
Using electronic devices	5.14	2.54
Having children	4.55	2.74
Eating meat	3.83	2.52
Purchasing items that are tested on animals[a]	3.70	2.86
Riding your bike[a]	2.61	3.05
Skiing[a]	2.54	2.06

Note. Response scale for impact was 1 (Negligible impact) to 11 (Very major impact). *N*s ranged from 109 to110.

[a] Behaviors that do not have a discernable impact on global warming.

Table 3
Behavior categories and example behaviors provided by participants from open-ended questions about behaviors that prevent global warming.

Behavior category	Example behaviors provided
Drive less; use alternate transportation	"I would stop driving my car" "Carpool as often as possible"
Recycle	"I would recycle" "Recycle"
Use eco-friendly products	"I would only buy biodegradable materials" "Using environment friendly products"
Drive fuel-efficient car	"I could drive a more efficient car" "Buy a more fuel effic[i]ent car"
Encourage others	"I would promote recycling" "I could encourage others to walk to class rather than driving"
Conserve electricity	"I would reduce my use of electricity" "I could attempt to use less electricity"
Political actions	"I would start a strike at local factories to have them control emissions" "I would help with an organization"
Conserve	"Use both sides of a sheet of paper" "I could conserve more"
Replace light bulbs with efficient ones	"I could replace lightbulbs with energy saving bulbs" "I would change my light bulbs to lower watts"
Avoid aerosol sprays	"I would stop using spray cans" "I would not buy things in aerosol cans"
Do not litter	"Not littering" "Picking up trash"
Turn off lights	"Turning the lights off" "Turn off lights"
Do not pollute	"I could try to prevent excessive pollution" "I would not pol[l]ute the environment"
Learn	"I would become informed as to how to reduce global warming" "I could read up on the subject and learn more about it"
Reduce energy	"I could use less energy in my house" "I would conserve energy"
Plant trees	"Plant trees" "I could plant more trees and protect our forests"
Adjust thermostat	"I could use less heat and less air conditioning" "I can turn down my thermostat a few degrees in the winter and up a few degrees in the summer"
Stop smoking	"I could quit smoking" "I can stop smoking"
Alternatives to fuel/cars	"I could create a new way of energy that is clean" "I would reduce pollutants by finding alternative fuel"
Make fewer fires	"I would not use trees for fire wood" "I could quit having bon fires"
Reduce fossil fuel use	"I can manage my use of fossil fuels" "I would reduce burning of fossil fuels"
Do not buy bottled water	"I could buy a water purifier and stop buying bottled water" "I would not buy bottled water anymore"
Produce less garbage	"I could produce less waste" "I could reduce waste"
Fly less	"I would drive, instead of flying every[ ]where" "I[ ]could[ ]stop[ ]flying"
Insulate house	"I could insulate/weatherize home more efficiently" "I can make sure my next home is better insulated so that I can use less heat"
Reduce meat consumption	"Stop buying and eating animal products" "Consuming less meat (hamburger one time in a week)"
Purchase energy efficient appliances	"I could buy more energy efficient appliances" "I could buy energy efficient appliances"
Miscellaneous behaviors	"Farm all own food sources" "I would maintain my car" "I would properly dispose of potentially toxic wastes (batteries, etc.)" "Double paned windows"

Note. $N = 104$.

Table 4
Mean effectiveness ratings of behaviors that reduce global warming from closed ended questions and intention to perform these behaviors.

Behavior	Effectiveness ratings		Behavioral intention	
	Mean	SD	Mean	SD
Throw away garbage instead of littering[a]	8.34*	2.63	6.25	1.12
When it is time for a new car, choose a more fuel-efficient vehicle	8.26*	3.04	5.46	1.74
Reduce the number of miles you drive by walking, biking, carpooling or taking mass transit	8.00**	2.96	5.18	1.75
Recycle paper, glass, and plastic	7.98**	2.7	5.68	1.51
Only run your dishwasher when there's a full load	7.94**	2.94	5.76	1.45
Turn off electronic devices when you're not using them	7.81*	2.82	5.49	1.45
Use environmentally friendly cleaning products[a]	7.65**	2.91	4.88	1.67
Turn off the sink while brushing teeth[a]	7.09	3.24	5.34	1.67
Avoid using aerosol spray cans	7.05	3.22	4.73	1.95
Print double-sided	6.65***	3.4	4.58	2.00
Do not purchase individual size water or soda bottles, instead use a reusable container for drinks	6.59*	3.33	3.75	2.10
Refuse plastic and paper bags at the grocery and use cloth bags or carry groceries by hand	6.45***	3.49	3.66	2.04
Buy locally grown and produced foods	6.34	3.18	4.96	1.69
Reduce the number of miles you fly	6.33	3.42	4.23	1.95
Make sure your tire pressure is correct	6.06	3.29	4.68	1.77
Keep your water heater thermostat no higher than 120°	6.04**	3.07	4.42	1.55
Move your thermostat down 2° in winter and up 2° in summer	5.95	3.13	3.99	1.89
Stop receiving junk mail	5.95	3.58	3.86	1.96
Avoid buying products that are tested on animals[a]	5.58***	3.5	4.28	1.96
Reduce your meat consumption	4.35**	2.96	2.99	2.07

Note. *N*s ranged from 108 to 112.
*women scored higher than men at $p < .05$; ** women scored higher than men at $p < .01$; ***women scored higher than men at $p < .001$.
[a] Behaviors that do not discernibly reduce global warming.

homeowners, neither the knowledge of contributors measure nor the knowledge of mitigators measure included items relating to efficiency investments (e.g., major household appliance purchases and weatherization actions). Finally, participants completed a behavioral intention measure, which assessed their intention to perform proenvironmental behaviors (of which 20 items corresponded to the items in the effectiveness scale) in the coming month on a scale from 1 (Strongly unlikely) to 7 (Strongly likely).

3. Results

3.1. Behaviors that cause GW

The participants' free response answers to the behaviors that they perform that contribute to GW were coded such that any behavior listed by more than one participant was assigned to a category, with a total of 30 categories emerging from the data. Although participants were asked to list all the behaviors that they do that contribute to GW and were given 10 spaces to list their behaviors; few participants (<10%) listed more than 7 behavioral causes of GW. Participants' responses were coded such that each participant could only list each category once. If a participant listed more than one behavior that fell in the same category, only the first response was calculated in the totals. After removing participants who did not list any causes ($n = 4$), participants who listed only very broad or general responses ($n = 7$), and duplicate categories of responses within participants, 343 behavior categories in total were listed by 101 participants. The behavior categories and example behavior items from each category are listed in Table 1.

The percentages of participants who listed each category were calculated (Fig. 1). Only 7 behaviors were listed by more than 10% of the sample. Driving a car was by far the most frequently listed behavior. Not recycling was listed next frequently followed by using electricity, but both behaviors were listed by 65% fewer participants than driving a car. Interestingly, some behaviors that are relatively major contributors to GW were not listed by many participants. Less than 10% of the sample recognized that leaving on lights, using heat and A/C, and eating meat contribute to GW. Finally, Fig. 1 shows that one quarter of the participants actually listed pro-environmental behaviors as causes of GW. It is not clear whether these represent misinterpreting of the question or misunderstanding of the behavioral causes of GW, although the same issue was present in both Read et al.'s (1994) and Reynolds et al.'s (2010) investigations. The most frequently listed proenvironmental behavior was recycling.

Fig. 1 allows for a direct comparison of the percentage of participants who listed each behavior in the current sample to those of Read et al. (1994) and Reynolds et al. (2010). Most interestingly, far more participants in this study listed driving compared to the previous samples. Additionally, consistent with Reynolds et al.'s (2010) findings, fewer participants in this study listed aerosol sprays than in Read et al. (1994) and fewer participants listed use heat and A/C as a cause of GW even compared to Read et al.'s (1994) code which only included use A/C. Although more than 20% of the current sample listed their lack of recycling as a cause of GW and more than 10% listed building fires as a cause of GW, neither Read et al. (1994) nor Reynolds et al. (2010) reported these findings. Finally, several new categories emerged from the current data set and Reynolds et al.'s (2010) data that were not present in Read et al.'s (1994) data. Roughly the same percentage of participants in this sample and the Reynolds et al. sample mentioned use electricity, smoke cigarettes, fly in airplanes, and existence beliefs as causes of GW.

After participants completed the free response question about contributors to GW, they were asked to rate the impact of 16 behaviors in contributing to GW. As described above in the method section, the behaviors were chosen to represent actual behaviors that cause GW as well as behaviors that have been commonly incorrectly associated with GW in previous research. Participants' mean ratings of each behavior's impact in contributing to GW are shown in Table 2.

The contributor rated as having the highest impact was driving a car. Participants also rated throwing away recyclable materials and flying in airplanes above the midpoint of the scale. All other

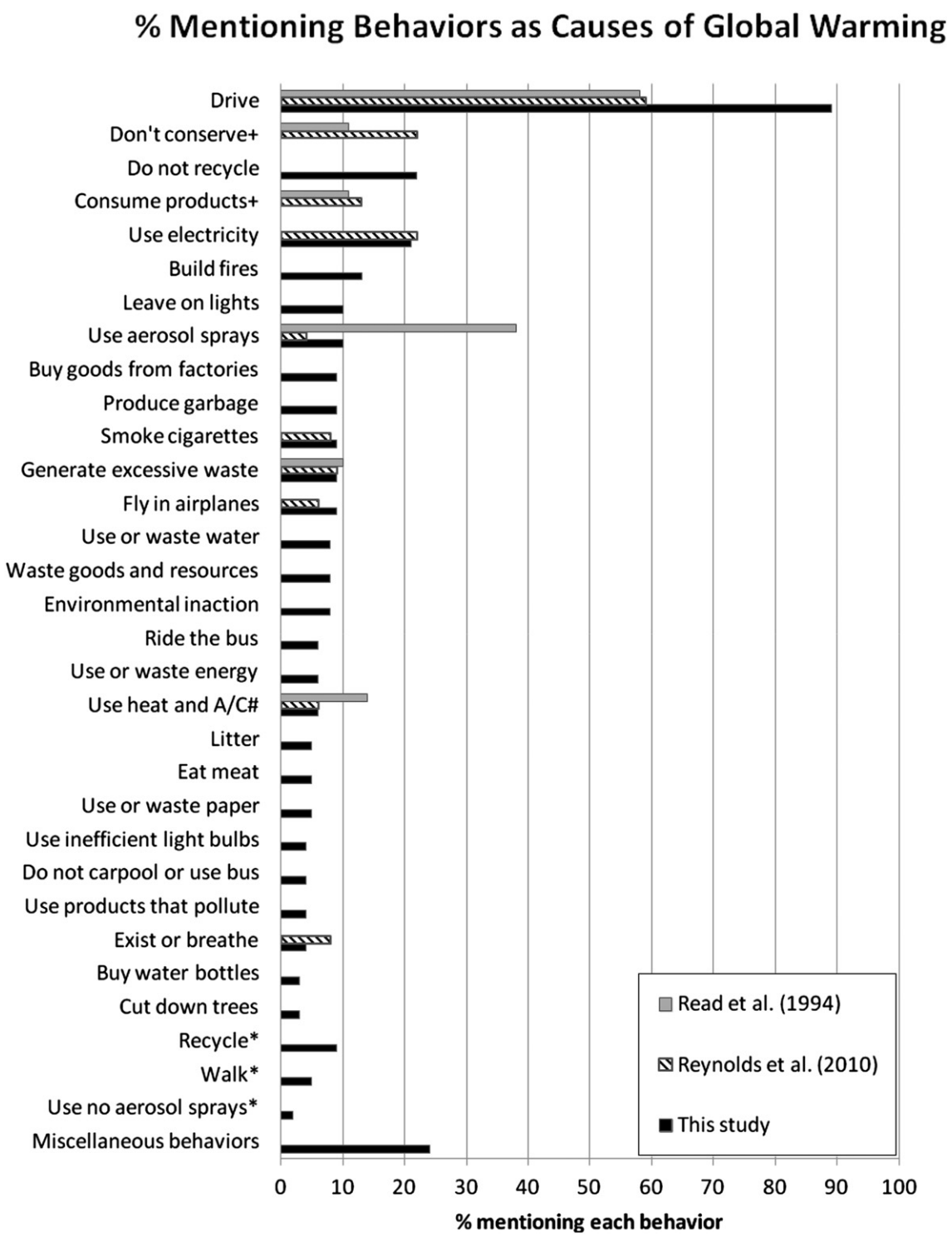

Fig. 1. Percentage of participants who listed each behavior as a behavior they perform that causes global warming in this study compared to Read et al. (1994) and Reynolds et al. (2010). Notes. For Read et al. (1994), only behaviors listed by at least 10% of participants were included and for Reynolds et al. (2010), only behaviors listed by at least 5% of participants were included. # Previous research coded only behaviors that use A/C. Behaviors that use A/C and heat were included in the current study. + Behavior that was coded with more specificity in this study compared to previous studies. * Behaviors that do not have a discernable impact on global warming.

behaviors were rated as having an impact on causing GW below the midpoint of the scale, although heating and cooling the house was rated as having an impact just below the midpoint of the scale. Littering, a non cause, was rated as being a stronger contributor to GW than lighting in the home. Eating meat was rated low on the scale in terms of impact.

3.2. Behaviors that reduce GW

Participants were given 10 spaces to list the most effective actions they could take to prevent GW; few participants (<10%) listed more than 7 behaviors. The participants' responses were coded such that any behavior listed by more than one participant

was assigned to a category. Although it could be argued that certain categories should be combined (e.g., replace light bulbs and turn off lights; conserve electricity and adjust thermostat), an effort was made to maintain the specificity of responses as much as possible to provide an in-depth picture of the participants' specific perceptions. As such, participants' behaviors were coded into one of 28 categories. If participants listed the same category twice, only the first response was calculated in the totals. After removing participants who did not list any behaviors ($n = 8$), as well as participant responses that were very broad actions or indecipherable responses and duplicate categories of responses within participants, 361 behavior categories in total were listed by 104 participants. The behavior categories and example behavior items are listed in Table 3.

The percentages of participants who listed each category of behaviors that prevent GW in the current study and those of Reynolds et al. (2010) and Read et al. (1994) are shown in Fig. 2. In the present study, driving less or using alternate transportation besides driving was listed by more than three quarters of the participants. Recycling was listed second most frequently, by almost half of the present sample. Use of eco-friendly products was listed by almost one quarter of the current participants and was listed by more participants than driving a more fuel-efficient car. Rounding out the top five, encouraging others was listed by almost 20% of the present sample. Conservation behaviors were also recognized in that more than 10% of the present sample listed conserving electricity and conserving resources in general, although adjusting the thermostat was recognized by less than 6% of the participants. Over 10% of the present sample also recognized political actions as effective behaviors they could undertake. Flying less, reducing meat consumption, purchasing energy efficient appliances, and installing insulation were listed by few participants in the current sample.

Compared to Read et al. (1994) and Reynolds et al. (2010), a far greater proportion of participants in this study listed reducing driving, recycling, and purchasing or using green products as

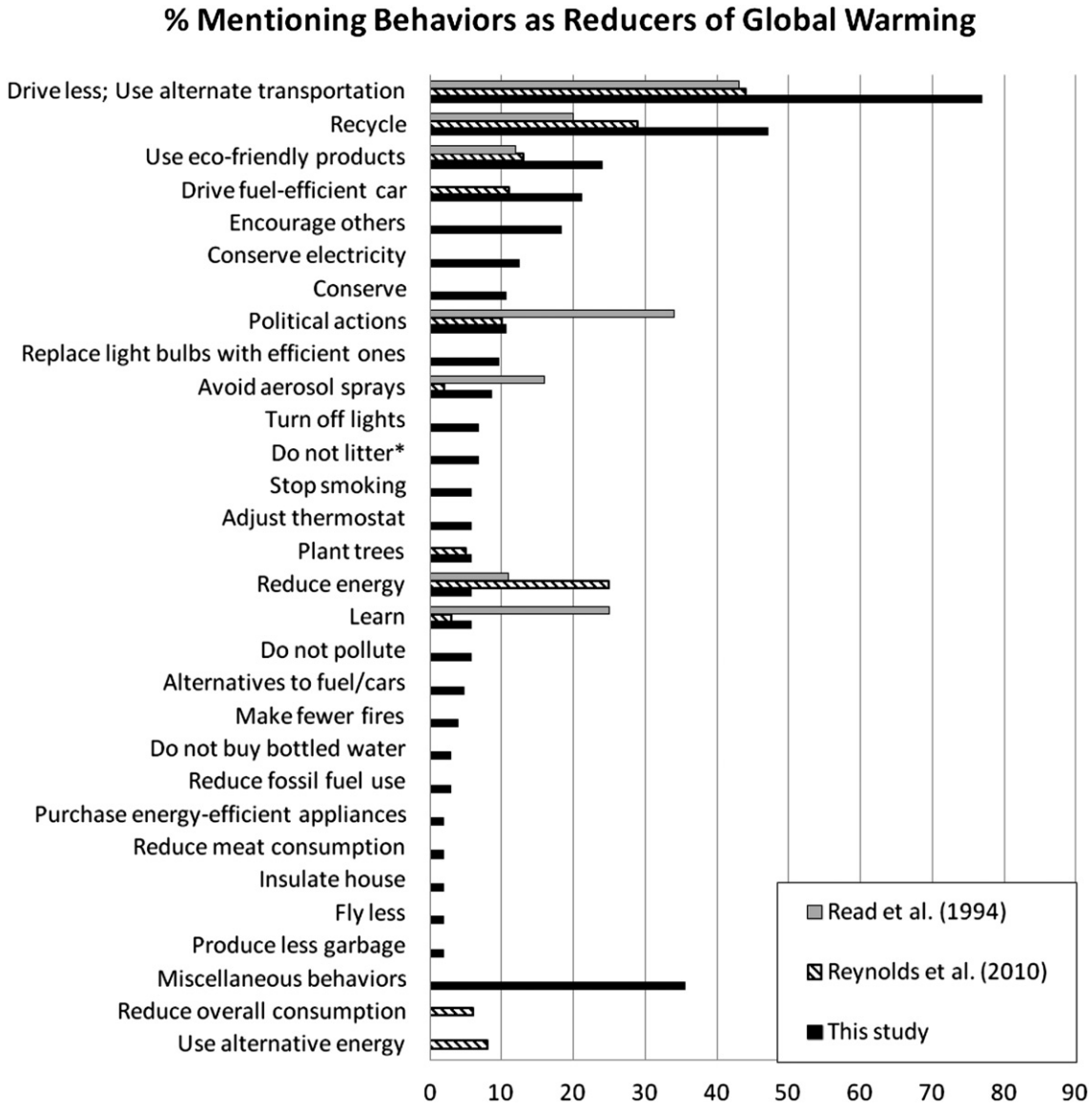

Fig. 2. Percentage of participants who listed each behavior as a behavior they could perform to reduce global warming in this study compared to Read et al. (1994) and Reynolds et al. (2010). Notes. For Read et al. (1994), only behaviors listed by at least 10% of participants were included and for Reynolds et al. (2010), only behaviors listed by at least 5% of participants were included. * Behavior that does not discernibly reduce global warming.

behaviors that could prevent GW (See Fig. 2). Some of the categories that were not present in Read et al. (1994), but emerged in Reynolds et al. (2010) also emerged in this data set. For example, participants mentioned drive a fuel-efficient car (although twice as many participants listed this in the current study), and planting trees (about the same percentage listed this in both). However, the themes of reduce overall consumption and use alternative energy did not emerge in the current study, although more specific aspects of these behaviors were mentioned (e.g., conserve, do not buy bottled water, reduce fossil fuel use). In line with Reynolds et al.'s finding, many fewer participants mentioned political actions and increase personal awareness of GW through learning in the current study than in Read et al. (1994). On the other hand, the percentage who listed avoid using aerosol sprays in the current study fell between the percentages found in Reynolds et al. (2010) and Read et al. (1994). Finally, reduce energy was mentioned much more frequently in Reynolds et al.'s (2010) study, which could reflect coding differences as many more specific actions that reduce energy (e.g., replace light bulbs, turn off lights, adjust thermostat) were coded as separate behaviors in the current study.

After participants completed the free response question about behaviors that prevent GW, they were asked to rate the effectiveness of 20 behaviors in reducing GW. As described above in the method section, the behaviors were chosen to represent actual behaviors that prevent GW as well as behaviors that are commonly mistakenly associated with GW (Read et al., 1994). Table 4 shows the mean effectiveness ratings for each of the GW-reducing behaviors that participants rated in the closed-ended questions. Interestingly, throwing away garbage instead of littering, a behavior that does not mitigate GW, was seen as the most effective behavior. Behaviors related to driving (i.e., choosing a fuel-efficient car and reducing driving) were rated as relatively highly effective in mitigating GW. Recycling was also rated high. Besides throwing away garbage, two other behaviors that do not mitigate GW were rated above the midpoint of the scale: using environmentally friendly cleaning products and turning off the sink while brushing teeth. On the other hand, some more major mitigators of GW were listed below the midpoint of the scale: adjusting thermostats and reducing meat consumption. *T*-tests revealed that women rated several behaviors as more effective than men. Some of these behaviors are major GW mitigators (e.g., fuel-efficient car, reduce driving, and reduce meat consumption), although some non-mitigators (i.e., throw away garbage, use eco-friendly cleaning products, avoid animal tested products) were also rated higher by women.

Table 4 also shows participants' mean intention ratings for each of the behaviors. Although throwing away garbage instead of littering was rated as the highest mean intention, several important GW-mitigating behaviors were rated relatively highly: choose a fuel-efficient car and reduce miles driven. Two key GW-mitigating behaviors—adjusting the thermostat and reducing meat consumption—were among the behaviors rated below the midpoint of the scale.

3.3. Influence of effectiveness knowledge on intention

To test the influence of effectiveness knowledge on intention, a measure of effectiveness knowledge was created. In line with O'Connor et al.'s (1999) method for assessing knowledge related to GW causes, the mean effectiveness ratings of behaviors that do not discernibly reduce GW (incorrect behaviors) was subtracted from the mean effectiveness ratings of behaviors that do reduce GW (correct behaviors) as identified by Gardner and Stern's (2008) list of effective actions to curb climate change. Although, several other behaviors likely reduce GW (though often indirectly, which makes an estimate of their GHG emissions and in turn savings potential very difficult), only those behaviors listed in Gardner and Stern (2008) were included here so as to have a common frame of reference for effective GW-mitigating behaviors. The only exception is reducing meat consumption, which has repeatedly been shown to be an effective strategy to reduce GW (Weber & Matthews, 2008). Higher scores on the effectiveness knowledge measure mean more accurate ability to discriminate between actions that are effective at mitigating GW and those that are not.

To test H1 that greater knowledge about the effectiveness of behaviors that mitigate GW influences intention to take action, two analyses were run. First, the effectiveness knowledge score was correlated with the mean intention score of the effective GW behavior intention items (Cronbach's $\alpha = .76$). Effectiveness knowledge did not significantly correlate with intention to perform behaviors that mitigate GW, $r\,(110) = .10$, $p = .30$. Second, the effectiveness knowledge score was correlated with intention to perform individual effective GW behaviors. As shown in Table 5, only one of the correlations reached statistical significance: the correlation between effectiveness knowledge and intention to choose a more fuel-efficient vehicle. As levels of knowledge about the effectiveness of behaviors to mitigate GW increased, intention to choose a more fuel-efficient vehicle also increased $r\,(110) = .19$, $p = .03$. In general, the correlations for the seven other effective behaviors were low, ranging from −.07 to .14. Thus, accurate

Table 5
Correlations between effectiveness knowledge and intention to perform behaviors that mitigate global warming and between belief in the mitigating potential of behavior and intention to perform that behavior.

Behavior	Effectiveness knowledge-intention *r*	Effectiveness beliefs-intention *r*
Avoid buying products that are tested on animals[a]	N/A	.70***
Move your thermostat down 2° in winter and up 2° in summer	.12	.66***
Turn off the sink while brushing teeth[a]	N/A	.65***
Reduce your meat consumption	.01	.63***
Use environmentally friendly cleaning products[a]	N/A	.61***
When it is time for a new car, choose a more fuel-efficient vehicle	.19*	.60***
Only run your dishwasher when there's a full load	−.07	.59***
Reduce the number of miles you fly	.10	.58***
Keep your water heater thermostat no higher than 120°	.04	.48***
Make sure your tire pressure is correct	.02	.43***
Reduce the number of miles you drive by walking, biking, carpooling or taking mass transit	.14	.35***
Throw away garbage instead of littering[a]	N/A	.20*

*$p < .05$.
***$p < .001$.
Note. *N*s ranged from 108 to 112.
[a] Behaviors that do not discernibly reduce global warming.

effectiveness knowledge was not a significant predictor of intention.

3.4. Influence of effectiveness beliefs on intention

To test H2 that effectiveness beliefs positively influence intention to perform behaviors that mitigate GW, correlations were run between belief that a behavior is effective in mitigating GW and intention to perform that behavior for the each of the eight effective behaviors. Correlations ranged from .35 to .66, with all correlations being statistically significant at $p < .001$. The strongest correlations were for adjusting the thermostat and reducing meat consumption while the lowest correlations were for making sure tire pressure is correct and reducing the number of miles driven. The overall correlation between the mean effectiveness beliefs score (for the eight effective GW-mitigating behaviors) and the mean behavior intention scale for these items was also quite high, $r\,(110) = .67$, $p < .001$.

To test H3 that the effectiveness beliefs–intention relationship is not dependent on whether the behavior is actually a mitigator of GW, we visually compared the correlations for actual mitigators and non-mitigators. As can be seen from Table 5, three of the five highest belief-intention correlations were for behaviors that do not discernibly influence GW (i.e., avoid products tested on animals, turn off sink while brushing teeth, and use eco-friendly cleaning products). However, the lowest belief-intention correlation was found for throw away garbage instead of littering, another non-mitigator. To further explore H3, we calculated the mean belief-intention correlation for mitigators and non-mitigators. The mean belief-intention correlation for mitigators (Mean $r = .48$) was actually lower than the mean correlation for non-mitigators (Mean $r = .55$). Thus, the relationship between effectiveness beliefs and intention is not higher for behaviors that mitigate GW and may actually be lower.

4. Discussion

Read et al. (1994) and Reynolds et al. (2010) found important flaws in their samples' perceptions of GW-related behaviors. The present study extended these findings by studying a different sample type and by evaluating participants' perceptions and knowledge of the relative impact of behaviors that cause and mitigate climate change and the influence of these beliefs on behavior intention. Identifying the misperceptions that continue to permeate people's perceptions of climate change causes and mitigators is important for campaign organizers and public policy. If targeted populations are unaware that certain actions reduce climate change then they may be unsupportive of policies aimed at changing those behaviors. Additionally, identifying the areas where beliefs and knowledge are most related to intention can help campaign organizers determine where best to focus their efforts.

This study is the first we know of to investigate the influences of effectiveness knowledge and effectiveness beliefs on intention to perform behaviors that mitigate climate change. Effectiveness knowledge was not consistently associated with intentions to perform behaviors that mitigate climate change. We found that effectiveness knowledge only significantly correlated with intention to purchase a more fuel-efficient car. Those with higher knowledge about which behaviors effectively mitigate global warming were more likely to intend to purchase a more fuel-efficient car. Although our findings do not support the effectiveness knowledge–intention relationship for GW-related behaviors, other researchers have found that Swiss residents' general pro-environmental effectiveness knowledge measured by means of a multiple choice test relates to intention to perform general ecological behaviors (Frick et al., 2004). Whether the difference between this study and their findings relates to the method of measuring knowledge, the behavior domain, or the sample remains an open question for future research. The first step could involve creating a multiple choice test of behaviors' relative effectiveness at mitigating GW. This would require close collaboration with physical scientists as several assumptions about behaviors' mitigating potential (e.g., locally grown food and recycling) have been recently challenged (Lave et al., 1999; Saunders et al., 2006).

On the other hand, the perceived effectiveness of a particular behavior had a major influence on intention to perform that behavior for all behaviors under investigation (whether actual mitigators or not). As would be expected from the Theory of Planned Behavior (Ajzen, 1991; Ajzen & Fishbein, 2005), stronger belief that a behavior effectively mitigated GW led to stronger intentions to adopt that behavior in the future. Though hypothesized from the Theory of Planned Behavior and found in previous research investigating other proenvironmental domains, this study is the first test of this hypothesis for GW-mitigating behavior and the results provide strong support for this hypothesis. Effectiveness beliefs, as conceptualized in the current study are considered as background variables in the Theory of Planned Behavior, influencing intention only indirectly through attitude. But, effectiveness beliefs are also closely related to personal response efficacy beliefs, or outcome expectancy beliefs, as identified by Bandura (1977). Bandura's theory envisions efficacy beliefs as a more proximal determinant of behavior than the Theory of Planned Behavior. Contrasting these two theories would be an interesting avenue for future research.

Besides testing the influence of effectiveness knowledge and beliefs on intention, the combination of questions asked in the present study also allows for a more in-depth picture of GW perceptions than that revealed by previous research. Specifically, our reliance on emissions estimates from recent research coupled with our measurement of behavioral intention sheds light on which misperceptions matter most for this sample.

Driving is by far the largest consumer of energy, accounting for 39% of the average person's energy use (Gardner & Stern, 2008). Previous research findings have been mixed on the extent to which people recognize driving as a major contributor to CC (O'Connor et al., 2002; Read et al., 1994). In this study, with a focus on individual behaviors and not societal actions, an overwhelming majority of the participants (much more so than Read et al.'s (1994) and Reynolds et al.'s (2010) samples) recognized that driving causes GW and that reducing driving can reduce GW. Additionally, driving was rated as one of the largest contributors to GW and driving less was rated as an effective behavior to reduce GW. Thus, participants in this sample have a good grasp on the importance of driving on GW; they believed that driving is a major contributor of GW and that reducing driving can strongly reduce an individual's impact on GW.However, the relationship between beliefs about driving and intention was not straightforward. For purchasing a fuel-efficient car, accurate knowledge about the effectiveness of GW-mitigating behaviors influenced intention to buy a fuel-efficient car and the specific belief that a fuel-efficient car reduces GW was highly related to intention to perform this behavior. As such, a focus on increasing beliefs that a fuel-efficient car can reduce GW may not be needed. Most of this sample already endorsed this belief and the strength of endorsement was related to intention to purchase a fuel-efficient car in the future. However, although most of the sample recognized the importance of driving less, this belief was not as strongly related to intention to drive less compared to the belief-intention correlations for the other behaviors measured in this study. As such, closing the belief-intention gap for reducing miles by driving less should be a focus of additional research and

future applied efforts. Campaigns would likely benefit by targeting other factors known to influence transportation intentions such as social norms (Heath & Gifford, 2002), perceptions of public transportation (Whitmarsh, 2009b), and perceived behavioral control (de Groot & Steg, 2007).

House space heating and air conditioning constitutes 25% of the average American's total energy use (Gardner & Stern, 2008). Previous research has found that participants underestimate the impact of heating and cooling their homes on causing GW (Bord, Fisher, & O'Connor, 1998; O'Connor et al., 2002). In the current study, heating and cooling the house was not listed by many participants in the free response questions and the percentage who listed air conditioning and heat was similar to the percentage who listed air conditioning in Reynolds et al. (2010), though less than that of Read et al. (1994). However, heating and cooling the house was rated relatively high in terms of impact of contributing to GW in the closed ended question. The specific behavior of adjusting the thermostat was rated low in terms of effectiveness in reducing GW compared to other household energy use behaviors, such as running the dishwasher, which accounts for less than 1% of an individual's total energy use (Gardner & Stern, 2008), and turning off electronics when not in use, which accounts for approximately 3% of an individual's total energy use (Gardner & Stern, 2008). Thus, knowledge of the mitigating potential of adjusting the thermostat remains low. However, belief that adjusting the thermostat mitigates GW was strongly related to intention to adjust the thermostat, which suggests that increasing people's beliefs about the mitigating potential of adjusting the thermostat can be an important avenue for future research and applied campaigns. Smart meters, household electricity meters that record real time energy usage information, have the potential to drastically alter knowledge of the mitigating potential of adjusting the thermostat. When coupled with on-line applications and in-home displays, smart meters have the potential to enable residents to receive visual feedback about their energy use, which has repeatedly been shown to be effective in reducing household energy use (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Seligman, Becker, & Darley, 1981). Although research is currently being conducted on the effectiveness of these and other advanced metering initiatives (e.g., Ehrhardt-Martinez, Donnelly, & Laitner, 2010), additional research is needed to more fully evaluate the effectiveness of metering programs on changing action knowledge and effectiveness knowledge and the effects of changes in knowledge on energy use behaviors.

Methane-producing activities are also important contributors to GW, as methane is almost three times more powerful in terms of climate change potential than carbon dioxide (Nickerson, 2003). Per the U.S. EPA (2009a), the largest source of methane emissions in the US comes from enteric fermentation, or emissions from ruminant animals such as cows, sheep, buffalo and goats, which account for approximately 24% of the U.S.'s total CH_4 emissions. Globally, livestock activities contribute to approximately 18% of the total GHG emissions, contributing to CO_2, CH_4, and N_2O emissions among others (Steinfeld et al., 2006). Some climatologists have argued for a shift in focus from CO_2 producing activities to other non-CO_2 activities such as those that emit CH_4 and N_2O (Hansen, Sato, Ruedy, Lacis, & Oinas, 2000). Along these lines, environmental organizations have promoted vegetarianism as the most effective action an individual can undertake to reduce climate change in the near future (Mohr, 2005). Recently, the chair of the IPCC has become a vocal proponent of individuals reducing their meat consumption to mitigate climate change (Pachauri, 2008 September 19). In spite of the attention being paid to this issue by some in the scientific community, the present sample did not recognize the effectiveness of not eating meat in reducing GW. Participants in this study rarely listed eating meat as a cause of GW and rated eating meat as having a small impact on GW in the forced choice questions. However, the results of this study also showed that those who believe that reducing meat consumption mitigates GW are much more likely to intend to stop eating meat. Thus, education about the GW-benefits of reduced meat consumption may be an effective strategy to undertake. Considering Dr. Pachauri's high status, additional research could be conducted examining whether his internet blog is persuasive in changing knowledge, attitudes and behavior regarding eating meat.

Not recycling was the third most commonly listed cause of GW in the open-ended question and was listed near the top in terms of impact in the forced choice responses. Additionally, recycling was the second most commonly listed solution to GW and was rated as an effective behavior at reducing GW. Although the percentage of participants who listed recycling in this study was more than double that of Read et al. (1994) and more than one and a half times that of Reynolds et al. (2010), other recent studies in the U.K. have found results similar to the current study, with participants frequently listing recycling as a very effective behavior to reduce climate change (Downing & Ballantyne, 2007). The U.S. EPA (2009b) has estimated that an increase in the percentage of total recycled U.S. waste from the current 32%–35%, it would save 5.2 million metric tons of carbon dioxide equivalent emissions, which is approximately equivalent to removing over 950,000 cars from the road each year (U.S. EPA, 2009a). Although these numbers seem quite impressive when aggregated, at a disaggregated level, the U.S. EPA (2009b) has estimated that a family of four could save roughly 340 pounds of carbon equivalent emissions by recycling all of its mixed plastic waste in one year, which is approximately equivalent to removing just one-tenth of a car from the road each year (U.S. EPA, 2009c). Further, the prevailing assumption that recycling household waste greatly reduces emissions has been questioned (Lave et al., 1999). Thus, the perceived effectiveness of recycling may be overestimated in this sample and those of previous research. Additional research in the physical sciences is needed to compare the greenhouse gas emissions (and savings of alternative behaviors) of direct carbon dioxide emitters such as driving and household energy use to those of indirect emitters such as recycling and eating meat as well as behaviors such as aerosol spray can use and fertilizer application that emit other greenhouse gases besides carbon dioxide.

One of the major trends identified in previous research is that people view GW more generally as an environmental problem whereby general environmentally unfriendly behaviors contribute to it and behaviors that are good for the environment in general are judged as being good for reducing GW (Read et al., 1994). The same tendency to equate environmentally unfriendly actions and GW was found in the present sample. Littering was rated relatively high in terms of impact in causing GW, while throwing away garbage instead of littering was seen as the most effective behavior to reduce GW. Using environmentally friendly cleaning products and turning off the sink when brushing teeth were also viewed as effective at reducing GW. The issue of concern here is that the extent to which participants perform behaviors to reduce GW because of their belief in the mitigating potential of that behavior, they may be performing behaviors that have relatively little impact in mitigating GW while neglecting more impactful behaviors (Bostrom et al., 1994). Additionally, people have been found to succumb to the single action bias, the tendency to take one action to reduce a risk but be unlikely to adopt additional behaviors to further reduce the risk (Weber, 2006). The single action bias may be especially problematic if the first behavior people adopt is actually ineffective. This study showed that debunking the myths that using environmentally friendly cleaning products and turning off the sink

when brushing teeth are very effective in mitigating GW is necessary as both of these beliefs are highly endorsed and highly related to intention to perform these behaviors. However, it may not be necessary to focus a great deal of attention on the widespread false belief found in this study that throwing away garbage instead of littering mitigates GW as this belief has a relatively low correlation with behavior intention.

As described above, we have used the results from this study to point to areas where additional educational efforts may be effective. This is not to suggest that this will be an easy task. Educating the public about climate change is particularly difficult due to the complicated nature of GW, the scientific uncertainty associated with climate models, the politicization of the issue in the U.S., and the fact that GW effects are rarely directly experienced by the lay-public and instead are frequently received via media reports of scientific findings (Sundblad, Biel, & Garling, 2008). Further, the extent to which general GW knowledge influences GW concern has been shown to be related to existing levels of trust in scientists and political party affiliation (Malka, Krosnick, & Langer, 2009). As such, Republicans and those who have little trust in scientists may be dismissive of GW information, particularly when the evidence is not directly observable (i.e., requires trust that scientists are presenting their findings accurately). However, the results from previous research on the Knowledge Structure Model (Frick et al., 2004; Kaiser & Fuhrer, 2003), suggest that the more complicated system knowledge may not be as closely related to behavior intention as action and effectiveness knowledge. Could focusing on increasing GW effectiveness and action knowledge supplant the need for system knowledge? Experimental research that presents participants with information addressing the various knowledge structures and then assesses behavioral intention would be quite revealing in extending the present results.

It is also important to reiterate that we are not suggesting that information provision alone will be enough to motivate behavior. Although a recent meta-analysis has shown that general knowledge of environmental problems is a strong, though distal, correlate of environmental behavior (Bamberg & Moser, 2007), it has repeatedly been shown that environmental knowledge is not sufficient for behavior (Gardner & Stern, 2002; Schultz, 2002). In other words, knowledge is necessary to promote behavior, but is not enough on its own; other factors must also be present to motivate behavior. Key variables in the GW domain include personal norms (Steg, Dreijerink, & Abrahamse, 2005; Stern, 2000), social norms (Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008), and identity (Whitmarsh & O'Neill, 2010).

4.1. Limitations and suggestions for future research

One potential limitation of this study concerns the student sample. The use of this convenience sample allowed for in-depth probing of perceptions of GW causes and mitigators through both open-ended and closed-ended survey questions and is useful in that it provides a comparison for Read et al.'s and Reynolds et al.'s descriptive work and also an opportunity in which to test the new hypotheses. We recognize that this college-educated sample likely has more accurate knowledge about the causes and mitigators of GW than the general public and the comparison with Reynolds et al.'s (2010) results partially supported this assumption. Nevertheless, this sample still showed important misperceptions, namely lack of realization of the relative impact of not eating meat and adjusting the house thermostat on mitigating GW. Thus it is expected that building on the results from this sample and those from Read et al. (1994) and Reynolds et al. (2010) by using a more representative sample of the American public would reflect less, not more, knowledge of the behaviors that contribute to and mitigate GW compared to the current sample. Additionally, this study revealed an important first look at the relationships between belief in the GW-mitigating potential of a behavior and intention to adopt that behavior and between knowledge of GW mitigators and behavior intention. Additional research should evaluate the perceptions of GW-mitigating behaviors (and energy efficient behaviors such as appliance purchase and home weatherization) among non-students and homeowners to determine the extent to which perceptions differ between students vs. non-students and renters vs. homeowners. Considering that efficiency investments have a higher energy saving potential compared to curtailment behaviors (Gardner & Stern, 2008) and that the monetary and energy use savings of high impact behaviors are underestimated compared to lower impact behaviors (Attari, DeKay, Davidson, & de Bruin, 2010; Kempton, Harris, Keith, & Weihl, 1985), efficiency behaviors should be included alongside curtailment behaviors in future research in this area. Nevertheless, the current study, albeit with a student sample, sheds much-needed light on the GW behavior perceptions of non-experts and their influence on intentions and sets the stage for additional research in this area.

A second limitation is that we did not measure perceived behavioral control or prior behavior. It is possible, as has been suggested by reviewers, that the order of effectiveness beliefs-intentions correlations in Table 5 reflects perceived behavior control or perceived ease/difficulty of the behaviors with high effectiveness belief-intention correlations for behaviors participants already perform or believe are easy to perform. As we did not assess perceived behavioral control or prior behavior performance in this study, evaluating this assertion directly is not possible. However, behaviors that are difficult to perform can be understood to be behaviors that are performed by relatively few people in a sample (Kaiser & Keller, 2001). For example, if one finds that the vast majority of a sample recycles, while very few drive a fuel-efficient vehicle, then it can be assumed that recycling is an easy behavior and driving a fuel-efficient vehicle is a difficult behavior. In line with this reasoning, the order of mean intention to perform behaviors can be used as a rough proxy for behavior ease/difficulty or perceived behavioral control. By comparing the behavioral intention ratings to the effectiveness belief–intention relationships, we can evaluate (albeit somewhat crudely) whether the ordering of the correlations reflects an underlying perceived ease/difficulty dimension. We would expect that high effectiveness belief–intention correlations would correspond to high intention ratings. However, the five highest effectiveness beliefs–intention relationships relate to three of the lowest mean intention items (adjust thermostat, reduce meat consumption, and avoid products tested on animals). On the flip side, the five lowest effectiveness–belief relationships do not correspond to the lowest intention items and the lowest rated effectiveness–belief relationship (throw away garbage instead of littering) is actually the highest mean intention item. Overall, we find little support for the assertion that the rankings of the correlations reflect an underlying ease of performance dimension. Nevertheless, although the approximation of intention with ease/difficulty was revealing in this post hoc test, further research with the explicit assessment of perceived ease/difficulty or behavioral control should be used. Additionally, as this study only measured behavioral intention, we are limited in our ability to make conclusions about prior behavior. Assessment of prior performance of behaviors would be a good route for future research and would also allow for the role of other variables known to be related to behavior regardless of intention or to interfere with the intention–behavior relation to be tested. Specific variables of interest are: habit (Verplanken, Aarts, van Knippenberg, & Moonen, 1998), perceived behavioral control (Heath & Gifford, 2002), actual behavioral control (Ajzen, 1991) and descriptive norms (Nolan et al., 2008).

4.2. Conclusions

Previous research has found that the members of the public do not frequently identify their own actions as causes of GW (Whitmarsh, 2009a). When participants were specifically asked to do so in the present study, some interesting perceptions were revealed. Although knowledge about behaviors' mitigating potential did not relate to intention, beliefs about the mitigating potential of specific behaviors (whether accurate or not) strongly correlated with intention to perform the behaviors. Participants correctly recognized the importance of driving as a major behavior that causes GW, and also rated recycling as an important mitigator. On the other hand, participants incorrectly rated not littering as a major mitigator and underestimated the impact of adjusting the thermostat and not eating meat in reducing global warming. These results, coupled with the findings regarding the relationships between belief in mitigating potential of each behavior and intention to perform each behavior, have the potential for practical application in mass communication campaigns and behavior change strategies.

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