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Information Sources, Perceived Personal Experience, and Climate Change Beliefs

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Abstract

This study proposes and tests a model of serial mediation based on the norm activation model and value-belief-norm theory. It argues that beliefs about climate change are related to perceived personal experience, which is related to the use of different information sources. Structural equation modeling of survey data from 1084 adult residents of Singapore found mixed support for three hypotheses. Results showed that perceived personal experience of climate change was related to the use of traditional media (β = .20), social media (β = .16), and interpersonal sources (β = .13), but not institutional sources. Perceived personal experience of climate change was positively related to agreement with the new ecological paradigm (β = .36) awareness of consequences (β = .26), ascription of responsibility (β = .25), and personal norm (β = .20). Generally, perceived personal experience of climate change mediated the relationship between traditional media, social media, and interpersonal sources and each type of climate change belief. This suggests some types of information, but not all, offer vicarious experiences of an environmental phenomenon that largely escapes direct perception. In addition to those theoretical implications, this work has practical implications for audience segmentation and climate change communication.

Keywords: climate change; information; personal experience; personal norm; energy conservation

Information Sources, Perceived Personal Experience, and Climate Change Beliefs

Beliefs about environmental issues may reflect informational and normative factors (Shaw & Clarke, 1999). Regarding climate change, individuals can use the media to have indirect experiences of phenomena that, due to subtlety or distance, evade direct perception (Ho, Detenber, et al., 2014). They can learn about climate change from their close personal ties, such as friends and family, who may have a social-normative influence (Stevenson et al., 2019). They can also use institutional sources, such as the government, universities, and science centers, to learn about the policy and scientific aspects of the issue (Sanz-Menéndez & Cruz-Castro, 2019). Through reflecting on information about climate change, individuals may develop an environmental worldview, awareness of environmental harms, a sense of personal responsibility, and a moral imperative—or personal norm—to reduce harmful behaviors. Those beliefs can motivate proenvironmental behavioral change (Schwartz, 1977; Stern et al., 1999).

Although the effects of climate change generally occur too slowly for individuals to perceive directly and reliably, personal experience may be the most impactful source of knowledge affecting beliefs about climate change and a willingness to do something about it (Reser et al., 2014; Weinstein, 1989). Indeed, directly experienced information carries more decisional weight than indirectly experienced information (Simonsohn et al., 2008). But indirect experience via the media and sense-making through social interaction are also each a part of personal experience (Akerlof et al., 2013). There have been dozens of studies examining the relationship between personal experience and opinions about climate change (see Howe et al., 2019), and this remains an active area of research.

Whereas prior research shows a relationship between personal experience of climate change and awareness of its harms (e.g., Akerlof et al., 2013; Lee et al., 2015; Shepard et al.,

2018), the current study takes a broader approach, drawing on theories of altruism and proenvironmental behavior (Schwartz, 1977; Stern et al., 1999). I argue that individuals use personal experience as a basis of their environmental beliefs, starting with a worldview and ending with a personal norm. These linkages create a serial mediation model of climate change belief formation, focusing on the role of personal experience, while also accounting for the potential influence of mass media, interpersonal, and institutional information sources.

This study makes a theoretical contribution by responding in part to Howe et al. (2019), who called for better theoretical integration of experiential and analytical processing into models of environmental beliefs. The current focus is not on information processing, per se, but attention to different information sources implicates it. It also responds to Reser and Bradley (2020), who noted a dearth of research linking the subjective experience of climate change with climate change beliefs, attitudes, and behaviors. Consequently, this work emphasizes the personal contexts and perspectives from which individuals form beliefs about climate change, which has implications for the practice of climate change communication and the promotion of proenvironmental behaviors like energy conservation.

Personal Norm and Proenvironmental Behavior

Addressing climate change will require commitment and action at many levels, including governments, businesses, and individuals. Individuals can do their part through mindful consumption, policy support, and civic engagement (Stern et al., 1999; Tobler et al., 2012). The kinds of individuals who pursue those actions are both motivated and committed to effecting change. Such individuals often exhibit a strong environmental personal norm, which research has established as one of the most important factors explaining many kinds of proenvironmental behaviors (Geiger et al., 2019; Niemiec et al., 2020).

The concept of personal norm emerged in research on moral behavior, such as altruism. It refers to the behavioral expectations individuals hold of themselves, violations of which result in negative feelings about the self, such as guilt (Schwartz, 1973). Early work in this area suggested an awareness of consequences strengthens the link between personal norm and moral behavior and a denial of responsibility weakens it (Schwartz, 1977). Thøgersen (1996) argued that this framework, called the norm-activation model, is a good starting point to examine proenvironmental behaviors, because such behaviors have a moral component. Recent work has used that model to explain behavior in the context of energy conservation (Song et al., 2019), water conservation (Landon et al., 2017), litter reduction (Rosenthal & Yu, 2022), eco-tourism (Han et al., 2019), and eco-friendly agricultural practices (Rezaei et al., 2019), to name a few.

Stern et al. (1999) generalized the norm-activation model to explain attitudinal and behavioral support for the environmental movement. Through that effort, they developed a value-belief-norm theory. Whereas the norm activation model focused on altruistic behavior, the value-belief-norm theory argued that norm activation can occur with respect to any valued object and so can explain a broad range of behaviors. The generalization was, in some respects, a simple extension. But the theory also introduced personal values and worldviews as the first steps in a causal chain of five variables. In the context of environmental behaviors, personal values may reflect care for other people and care for nature as guiding principles in life. Those values influence a worldview, for example, the new ecological paradigm (Dunlap & Van Liere, 1978; Dunlap et al., 2000). The new ecological paradigm contains general beliefs about the constraints of the Earth to support human development and the environmental damages that humans cause, and it is related to an awareness of negative environmental consequences. That awareness of consequences is related in turn to beliefs about the necessary actions to redress

those harms. Finally, those beliefs can trigger a personal norm, or a sense of moral obligation to pursue the necessary actions.

Although awareness of consequences and ascription of responsibility can provide a good empirical explanation of environmental personal norm (Bamberg & Möser, 2007), the norm-activation model and value-belief-norm theory may be limited to explain behavior in some contexts. In particular, they do not account for situational barriers to behavior, which might impact self-efficacy or behavioral control, nor do they address habitual or repetitive behaviors (Bamberg & Schmidt, 2003; Klöckner, 2013). Despite those limitations, there is evidence that personal norm can explain behaviors related to climate change, such as energy use (Aini et al., 2013; van der Werff & Steg, 2015). So there is still value in understanding the chain of beliefs that underlie a personal norm and can motivate climate action at the individual level.

But where do these beliefs come from? The ideas individuals have about the world do not arise in a vacuum. They emerge through a process of knowledge construction involving information processing and social interaction (Shaw & Clarke, 1999; Ulrike & Joachim, 2018). Below, I turn my attention to the literature on information sources pertaining to the formation of environmental beliefs. Following that, I consider the role of personal experience—as both a direct perception and vicarious phenomenon—in that process. Throughout those first two sections I highlight concepts and linkages that contribute to a theoretical model building on the norm-activation model and value-belief-norm theory, which I articulate in a third section.

Sources of Environmental Information

Media Sources

People often use the media to learn about the environment, making the media an important "tidbit provider" about environmental issues (Coyle, 2005). Research from around the

globe has addressed this topic. An early study in the U.S. found that environmental knowledge, concern, and behavior were positively related to newspaper use and negatively related to television use (Ostman & Parker, 1987). Later, Holbert et al. (2003) found that proenvironmental behavior was positively related to watching television for public affairs content and nature documentaries. In Portugal, Cabecinhas et al. (2008) found that watching public service channels was positively related to climate change knowledge. In Singapore, attention to traditional media was positively related to knowledge of climate change (Ho & Yang, 2018) and green buying intention (Ho, Liao, et al., 2014). In China, research found environmental knowledge, perceived environmental threats, and proenvironmental behavior were related to both traditional media use and internet use (Liu et al., 2021; Lu, 2021). In contrast to the studies above, Kahlor and Rosenthal (2009) found in the U.S. that knowledge of global warming was related not to any one information source but to the variety of sources individuals use.

Media scholars have increasingly focused on social media. As with earlier forms of media, individuals may use social media to learn about environmental phenomena (Anderson, 2017). But social media are distinct because users can frame issues and influence discussions in their social circles (Nisbet, 2010). On the one hand, this can mean more engagement with issues like climate change (Mavrodieva et al., 2019). On the other hand, it can provide a stage for anti-science perspectives. For instance, Lewandowsky et al. (2019) found that individuals were more supportive of blog posts when user comments were congruent with the article's position on the issue, even when the position was against science.

Whether individuals encounter environmental information in the traditional media, on the internet, or through social media, these sources of information provide a window on the

environment. That view can affect beliefs about the state of the environment, awareness of environmental problems, and environmental concern.

Interpersonal Sources

The formation of environmental beliefs also has an interpersonal component. For instance, when people experience extreme weather events, they often discuss those events with others (Leiserowitz et al., 2013). Even under normal circumstances, many people talk to their friends or family about climate change at least occasionally (Leiserowitz et al., 2015). Coleman (1993) found interpersonal conversations particularly influenced judgments about involuntary societal risks, a category of risks that that would include climate change. Those conversations may be especially influential because, at least in the U.S., individuals trust their friends and family as much as or more than they trust expert sources for information about climate change (Maibach et al., 2015). So it is unsurprising that discussing climate change with friends and family is positively linked to different proenvironmental behaviors (Ho, Liao, et al., 2014), including those that aim to address climate change (Valdez et al., 2018).

One drawback of interpersonal communication is its low-fidelity: as information passes from one person to the next, details evolve and the message may change. Böhm et al. (2019) studied that phenomenon in the context of climate change beliefs and attributed the low fidelity to worldview-linked selective recollection. A related drawback is groups of individuals may form echo chambers around shared perspectives—e.g., climate change denial—and actively undermine competing arguments (Nguyen, 2020). But the point stands that interpersonal communication can have a big impact on what people believe, so a model of environmental beliefs should account for it.

Institutional Sources

Individuals can also learn about environmental issues by engaging with knowledge institutions, whose authoritativeness distinguishes them from media and interpersonal sources (Sahut & Tricot, 2017). I consider three knowledge institutions appearing in prior research: government agencies, scientific researchers, and venues of informal science education (Alic, 1993; Dalsgaard et al., 2008).

At the government level, signatories of Agenda 21 committed to drafting national sustainable development strategies, which are blueprints that not only set policy objectives, but can communicate to the public about those efforts (Kardos, 2012). Such reports and other public outreach provide the residents of some countries with a wealth of information about environmental issues. In Singapore, the site of the current research, this strategy was published by the Inter-Ministerial Committee on Sustainable Development (IMCSD, 2009). The report emphasized communication, education, and community engagement in addressing sustainability challenges, including climate change.

Another knowledge institution is the scientists who conduct environmental research. Consensus works, like the assessment reports by the Intergovernmental Panel on Climate Change (IPCC), are a resource for the public to engage more directly with scientific knowledge they can use to understand environmental issues. Ogunbode et al. (2020) found in a longitudinal study that individuals who had been exposed to a recently released IPCC report had more elevated concern about climate change than those who were unaware of the report.

Finally, individuals can use venues of informal science education—such as museums, zoos, and science centers—to engage with environmental information (Adelman et al., 2000; Dierking et al., 2002). In the U.S., zoos and aquariums are the most popular kinds of informal

science education institutions (Besley & Hill, 2020) and individuals who visit those places tend to be more concerned and less doubtful about climate change compared to the general public (Kelly et al., 2014). There is also evidence that knowledge-based interventions at such learning centers can encourage discourse about climate change among visitors (Geiger et al., 2017).

As with media and interpersonal sources, institutional sources can provide people with environmental information. By engaging with and reflecting on that information, people can form beliefs about and have emotional responses to environmental issues.

Personal Experience of Climate Change

The previous sections drew attention to information sources that provide indirect knowledge about climate change, but experience may be the most impactful basis of environmental beliefs (Reser et al., 2014; Weinstein, 1989). Scholars have examined personal experience of climate change mainly using two overlapping approaches. The first is an objective approach that aims to understand people's actual experiences. One example of this is using postal codes reported by survey respondents to create area-specific profiles of extreme weather events (Hughes et al., 2020). This approach makes it possible to identify weather phenomena that individuals likely experienced around the time of the survey. It is useful because it can show the effects of actual experience on people's beliefs, intentions, and behaviors about climate change. Though, if people's thoughts and feelings mediate their environmental behaviors (Stern et al., 1999), it may be necessary to know not only what they may have experienced, but also what those experiences meant to them. So it is unsurprising there are mixed findings linking objective experience of extreme weather with climate change beliefs (Howe et al., 2019; Hughes et al., 2020; Marlon et al., 2021).

In contrast, there is robust evidence linking subjective experience of extreme weather with beliefs about climate change (Howe et al., 2019). This gets to the second approach, which regards personal experience more as an evaluation of past events than the actual experience of them. Those evaluations can influence the belief that an event occurred, expectations about its future occurrences, and behavioral responses thereto (Weinstein, 1989). In the case of climate change, there is an extra layer of psychological distance, reflecting a lack of perceptual concreteness (McDonald et al., 2015). This is in part due to the subtlety of the phenomenon. For example, the observed warming of roughly 1° Celsius above preindustrial levels (Allen et al., 2018) is considerably smaller than natural diurnal temperature fluctuations and difficult for individuals to reliably discern. Such aspects of climate change are generally unavailable to direct experience (Weber, 2010). This is due in part to limitations of human perception and cognition about complex systems (Kruse, 2011). Psychological distance appears also in the belief that climate change affects people far away and in the future (Leiserowitz, 2005).

Individuals may also experience climate change vicariously through information sources—such as the media, interpersonal conversations, and knowledge institutions—and through social construction (Akerlof et al., 2013; Weber, 2010). In the context of climate change, these processes can create representation and meaning about the more psychologically distant aspects of it. This is especially true of mass media, such as films, documentaries, and the news (Sakellari, 2015; Weber, 2010). Balog (2013) spoke about his use of time-lapse photography of receding glaciers: “We’ve been talking about seeing is believing. That’s what you see with these cameras. The images make the invisible visible.” The media provide eyes—in some instances, the only eyes—for the lay public to view such phenomena. As a result, individuals are often dependent on the media to glimpse those aspects of reality (Gavin, 2018; Ho, Liao, et al., 2014).

Then individuals use that information to discuss, frame, and arrive at claims about that reality (Hansen, 2015). The media can also create "experiences" of scientific consensus. Harris et al. (2019) found when scientific consensus about climate change was depicted as the opinions of several individual scientists, there was more change in beliefs about climate change in comparison to numeric descriptions of consensus (e.g., "97% of climate scientists agree"). They argued that effect was due to an experience of consensus. On the whole, the indirect experience of climate change and social construction of its meaning can influence beliefs, concern, and willingness to act (Reser et al., 2011).

Context

Research on climate change beliefs should account for features of the local context. For example, some scholars have focused on cultural cognitions (Verweij et al., 2006). Guy et al. (2014) found the belief that climate change is occurring is negatively related to hierarchical and individualistic worldviews. That is consistent with earlier research showing egalitarian communitarians are much more likely than hierarchical individualists to agree global temperatures are increasing and humans are causing global warming (Kahan et al., 2011). So it is interesting that Singaporeans tend to score high on hierarchical worldview measures and low on individualistic worldview measures, creating potentially conflicting influences on the formation of climate change beliefs.

The current study is not interested in the effects of those worldviews, per se, but I wish to highlight other idiosyncrasies of the Singapore context that may affect climate change beliefs. If perceived personal experience of climate change is related to the use of information, then the beliefs people have about climate change may reflect their local media landscape, social norms,

and knowledge institutions. Before presenting the methods and results, I briefly situate this work in its local informational context.

This study takes place Singapore, a low-lying tropical island city-state. Scholars have described Singapore's governance as technocratic, where policymakers base decisions on technical or scientific expertise (Gilley, 2017; Goh, 2001). This approach has prioritized economic growth, political stability, and social harmony (Martin-Jones, 1997).

On the subject of environmental policy, Han (2016) characterized Singapore's approach to land and resource management as "environmental authoritarianism." The National Climate Change Secretariat (NCCS) within the Prime Minister's Office published a national climate change strategy outlining the challenges Singapore faces and describing largely economic and technological solutions to bolster Singapore's future resilience (NCCS, 2012). As part of its outreach efforts, the NCCS partnered with Meteorological Service Singapore to create a permanent climate change exhibition at Science Centre Singapore (NCCS, 2008).

There is a similar pragmatic approach to setting a media landscape in which the press engage extensively in self-censorship (Tey, 2008). In 2019, the Singapore Parliament passed the Protection from Online Falsehoods and Manipulation Act, which enables ministers to issue directives against online messages they have determined are false statements of fact. In theory, ministers could issue directives against false scientific statements about climate change (George, 2020). Given the policy attention to climate change and the barriers to publishing contrarian viewpoints, it is unsurprising that more than 90% of the Singapore public agree climate change is happening (Detenber et al., 2016).

In the Singapore context, the local media landscape, social norms, and knowledge institutions present a consistent narrative about the existence of climate change. In other contexts

where narratives of climate change denial proliferate, the use of information sources may decrease the perceived personal experience of climate change. In other words, my theoretical arguments may depend on the informational context.

Theoretical Model

Based on the above literature review and with a focus on the Singapore context, I propose three hypotheses, which Figure 1 visualizes. The first hypothesis provides a conceptual replication of prior research linking different information sources with perceived personal experience of climate change.

> Hypothesis 1: Perceived personal experience of climate change is positively related to the use of (a) traditional media, (b) social media, (c) interpersonal sources, and (d) institutional sources to learn about climate change.

The second hypothesis extends prior research and links perceived personal experience of climate change with a chain of beliefs that, consistent with the norm-activation model and value-belief-norm theory, can motivate individual climate change action. In this hypothesis, I use numbering purposely to differentiate the sub-hypotheses.

> Hypothesis 2: Perceived personal experience of climate change is positively related to (i) agreement with the new ecological paradigm, (ii) awareness of consequences of climate change, (iii) ascription of responsibility for climate change, and (iv) personal norm to address climate change.

Finally, to the extent that information sources are bases of personal experience, it is possible those information sources do not directly predict environmental beliefs. If personal experience of climate change is partly a summary of indirect experiences obtained through engaging with information, then personal experience ought to mediate the effects of information sources on

beliefs. This is the third hypothesis, which reflects the cross-products of the lettered and numbered sub-hypotheses.

Hypothesis 3: Personal experience mediates the relationships between (a) traditional media, (b) social media, (c) interpersonal sources, and (d) institutional sources and (i) agreement with the new ecological paradigm, (ii) awareness of consequences of climate change, (iii) ascription of responsibility for climate change, and (iv) personal norm to address climate change.

Method

Data Source

Sampling

The Institutional Review Board at Nanyang Technological University, Singapore, approved a national door-to-door survey in Singapore (IRB-2019-10-032). Trained undergraduate students surveyed residents of public housing blocks from 2 December to 20 December 2019. Roughly 80% of Singapore citizens and permanent residents live in public housing (Singapore Department of Statistics, 2021). Prior survey research using that sampling frame found there was national census representativeness in terms of sex, ethnicity, public housing type, and citizenship status (Rosenthal & Ho, 2020; Rosenthal & Yu, 2022).

Sampling had three stages. The first stage involved randomly selecting 20 initial blocks from the complete list of public housing blocks. The second stage involved choosing up to five additional blocks randomly from within a 500-meter radius of each initial block for a total of 81 blocks. The number of additional blocks roughly balanced the total number of residential units in each cluster of blocks. The third stage involved student assistants randomly selecting a start floor in each building. The purpose of this randomization was to reduce correlations between the date

and time of surveying and the residential floor. Research in Hong Kong showed, relative to households on low floors, those on high floors use less energy during warmer months because they used more natural ventilation than air-conditioning (Du et al., 2020). Related, a survey of top-floor residents in Singapore identified breeziness as a factor that attracted them to their floor (Yuen et al., 2006). Within floors, the student assistants knocked on every door before moving down a floor. After completing the lowest occupied floor, the student assistants would move to the top floor. This way the student assistants approached all the households in all the selected blocks, which totaled 5061 units. When a resident answered the door, the student assistant asked to speak to an adult who is responsible for or familiar with the monthly utility bill at the residence.

Procedure

After agreeing to participate, residents received the information and consent form and a printed copy of the survey to fill out. The student assistant returned after roughly 30 minutes to collect the completed survey and give the respondent a $10 grocery voucher as a token of appreciation. Respondents also had the option to complete the survey online if they preferred. If on the first visit to a household there was no answer at the door or the student assistant received a "soft" refusal (see AAPOR, 2016, for a definition), a student assistant revisited it two days later. If on the second visit there was no answer, the student assistant left a recruitment letter at the door that included a link to the online version of the survey.

Sample

There were 1118 completed surveys. Before analyzing the data, I removed 29 cases with missing values on all the items used in the present analysis. I also removed five cases with zero variance across all five-point scale items, which suggested straight-lining (Kim et al., 2018). The

final sample size was 1084, which is comparable to that of other national surveys in Singapore (Detenber et al., 2016; Ho, Detenber, et al., 2014; Rosenthal & Ho, 2020). I obtained a conservative response rate estimate of 21% by dividing the final sample size by the number of households sampled. This corresponds with the RR2 response rate by the American Association for Public Opinion Research (AAPOR, 2016). Of the respondents, 130 completed the online survey. The only known difference between those who complete the paper version of the survey and online version is that the latter group did not answer their door when the student assistant knocked. I compared those groups using independent *t*-tests and found they did not differ on any of the demographic measures.

Instrument

The main goal of the survey was to gather data about household energy use to support the design of a laboratory experiment, which I am not currently reporting. In addition to those data, I included questions to measure concepts from the current theoretical model (Figure 1). Table 1 includes the wording and descriptive statistics for those measures. There were also items measuring demographics, which Table 2 summarizes and compares to census data.

In addition to an English version of the survey, there were Chinese and Malay versions, which were back-translated to ensure accuracy. These are three of the four official languages in Singapore, the fourth being Tamil. Based on past national surveys (e.g., Li et al., 2005; Rosenthal & Ho, 2020), there are few Tamil-speaking households and those households are generally comfortable using other languages.

Use of Information Sources

Adapted from Brossard and Nisbet (2007), I measured the use of information sources by asking respondents, “How much have you learned about climate change from the following

sources?" The list of sources included traditional media, social media, YouTube, government agencies, university researchers, different places of informal science learning, friends, and family. See Table 1 for the complete list. Response options ranged from 1 (*none at all*) to 5 (*a great deal*).

Perceived Personal Experience

I developed two items to measure perceived personal experience of climate change, for example, "I know from direct experience whether climate change is happening or not." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). These measures are subtly different than how recent studies have used self-reported measures of experience (see Reser & Bradley, 2020). Those studies measured self-reported experiences of weather events, climate change manifestations, and climate change impacts. In contrast, the current study measures the belief that climate change knowledge comes from direct personal experience.

New Ecological Paradigm

Five items from Dunlap et al. (2000) measured endorsement of the new ecological paradigm, for example, "Humans are severely abusing the environment." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Awareness of Consequences

Three items measured the belief that Singapore is getting warmer, sea level is rising, and atmospheric carbon dioxide is increasing. These were new items, but similar to those Engel et al. (2020) used to measure awareness of specific environmental consequences. Respondents rated statements about climate change impacts on a scale from 1 (*definitely false*) to 5 (*definitely true*).

Ascription of Responsibility

I adapted three items from prior research (Abrahamse & Steg, 2011; Yeboah & Kaplowitz, 2016) to measure ascription of responsibility, for example, "As an individual, I share responsibility for causing climate change." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Personal Norm

Based on Stern et al. (1999), I measured personal norm with three items, for example, "I feel a personal obligation conserve electricity at home." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Willingness to Save Energy

Although energy use was not part of the theoretical model, including it as an outcome of personal norm would be consistent with theory and provide a point of model validation. Therefore, I measured willingness to save energy with a single item, "I am willing to put extra effort into saving electricity at home." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

Analysis

I estimated the theoretical model using structural equation modeling in Mplus version 8.1. The first step in this analysis was to estimate a measurement model. The measurement model is equivalent to confirmatory factor analysis, where measurement items indicate latent factors and latent factors freely covary with each other. I examined the modification indices using a minimum chi-square value of 3.84, which shows modifications that would significantly improve the model fit. Based on that examination, I added three residual covariances (see superscripts in Table 1). The first was between two items measuring personal norm. The second and third were each between two items measuring the new ecological paradigm. Table 1 contains

the factor loadings and Table 3 contains the correlation/covariance matrix. Finally, I created the structural model, which estimated regression paths according to the theoretical model and correlations between exogenous variables.

Results

Model Fit

I evaluated the model fit according to Hu and Bentler's (1999) joint information criteria, which includes CFI values close to .95 or higher, RMSEA values close to .06 or lower, and SRMR values close to .08 or lower. According to those criteria, the initial measurement model had acceptable fit (CFI = .945; RMSEA = .046, 90% CI [.043, .050]; SRMR = .036). However, the CFI value was on the cusp of the recommended cutoff and would surely decrease with the additional constraints of the structural model. With the model modifications I was able to improve the fit significantly (CFI = .961; RMSEA = .040, 90% CI [.036, .043]; SRMR = .033). Using the modified measurement model, the structural model also had acceptable fit (CFI = .957; RMSEA = .041, 90% CI [.037, .044]; SRMR = .034). For ease of interpretation, I report only the standardized model estimates.

Hypothesis Testing

There was mixed support for Hypothesis 1, which stated positive relationships between perceived personal experience of climate change and the different information sources. Consistent with predictions, perceived personal experience was positively related to the use of traditional media ($\beta = .20$, $p < .001$), social media ($\beta = .16$, $p = .010$), and interpersonal sources ($\beta = .13$, $p = .012$). However, it was not related to the use of institutional sources ($\beta = .05$, $p = .461$). See the top panel of Table 4.

In support of Hypothesis 2, perceived personal experience of climate change was positively correlated with the new ecological paradigm ($r = .42$, $p < .001$), awareness of consequences of climate change ($r = .49$ $p < .001$), ascription of responsibility for climate change ($r = .59$, $p < .001$), and personal norm to address climate change ($r = .57$, $p < .001$). These correlations are from the measurement model (Table 3). In the structural model, perceived personal experience of climate change positively predicted agreement with the new ecological paradigm ($\beta = .36$, $p < .001$), awareness of the consequences of climate change ($\beta = .26$ $p < .001$), ascription of responsibility for climate change ($\beta = .25$, $p < .001$), and personal norm to address climate change ($\beta = .20$, $p < .001$). See the top panel of Table 4.

To test Hypothesis 3, I examined the indirect effects of each information source on agreement with the new ecological paradigm, awareness of consequences, ascription of responsibility, and personal norm. This model used 5,000 bias corrected bootstrap samples to estimate standard errors of the indirect effects. The results were straightforward and mostly supported Hypothesis 3. With one exception, perceived personal experience mediated the effects of using traditional media, social media, and interpersonal sources. The exception was the indirect effect from interpersonal sources to personal norm. Further, personal experience did not mediate any of the linkages with using institutional sources. See the middle panel of Table 4.

There were two additional illuminating results beyond the hypotheses. First, I modeled the indirect effects from perceived personal experience through the causal chain of variables predicting personal norm. Although the effect was small, there was a significant indirect relationship between perceived personal experience and personal norm, which agreement with the new ecological paradigm, awareness of consequences, and ascription of responsibility mediated ($\beta = .04$, 95% CI [.02, .07], $p = .004$). See the bottom panel of Table 4. Second, the

relationship between personal norm and energy conservation willingness was strongly positive ($\beta = .77$, $p < .001$). See Figure 2.

Based on these results, I created a reduced structural model that omitted the non-significant paths (see Figure 2). This more parsimonious model had acceptable fit (CFI = .957; RMSEA = .040, 90% CI = .036, .043; SRMR = .035) and did not significantly increase χ^2 relative to the baseline model in which it was nested, $\Delta\chi^2(12) = 16.35$, $p = .176$. The pattern of results was consistent with the full model with one exception: In the reduced model, the use of institutional sources was significantly related to awareness of consequences ($\beta = .17$, $p < .003$), while in the full model it was not.

Discussion

Individual climate action may reflect an environmental worldview, environmental concern, individual responsibility, and personal obligation. This study drew on the norm activation model (Schwartz, 1977) and value-belief-norm theory (Stern et al., 1999) to test a model of environmental beliefs. It incorporated personal experience as a novel explanatory factor related to the use of different information sources. Results supported most of the hypothesized relationships. But even the unsupported hypotheses have theoretical value because they implied an alternative model. Below I interpret the findings and relate them to prior research.

The Link Between Information and Personal Experience

Consistent with prior research, perceived personal experience was related to the use of mass media and interpersonal sources. Although this is not a new finding, it has some value as a replication. Akerlof et al. (2013) had mentioned mass media and social construction as factors contributing to personal experience of climate change, but their work focused on the direct experience of environmental phenomena, such as changes in seasons individuals attribute to

climate change. Similar, Gavin (2018) and Ho, Liao, et al. (2014) argued that people are dependent on the media to learn about phenomena of which they lack immediate personal experience. The current findings are consistent with the argument that, absent direct experience of climate change, mass media and interpersonal sources can influence the perceived experience of it. This reinforces the idea of the media as an important "tidbit provider" (Coyle, 2005) and emphasizes the social dimension of perceived experience.

In contrast, perceived personal experience was unrelated to the use of institutional sources. Dual process theory describes two modes of information processing (Bellini-Leite, 2018; Kahneman, 2011). The first is heuristic, automatic, and fast, while the second is systematic, deliberate, and slow. Howe et al. (2019) suggested such a framework is necessary to understand people's experiences of weather phenomena, arguing that people tend to process direct experiences more automatically. However, when the issue is complex or abstract, individuals may employ more deliberate processing. This is similar to other work characterizing reliance on experience as more heuristic and reliance on detailed scientific information as more systematic (Trumbo, 1999). However, Trumbo and McComas (2003) found that individuals process government-sourced information heuristically or systematically depending on the level of perceived credibility. So it may be that characteristics of individuals or sources moderate the relationship between perceived personal experience and the use of institutional sources. For instance, it is intuitive that visiting zoos and aquariums would contribute to a sense of experience, since such places are meant to provide experiences (Packer & Ballantyne, 2010). Does the perceived authoritativeness of those places override more experiential aspects when individuals reflect on what they learned? Future research could seek to answer such a question.

The Link Between Information and Beliefs via Personal Experience

The focus and novelty of this study was the integration of perceived personal experience into models of environmental behavior. This addresses Reser and Bradley (2020), who noted a recent neglect in the literature of self-reported experience and its association with beliefs, attitudes, and behaviors about climate change. I wish to highlight two sets of findings. First, traditional media, social media, and interpersonal sources of information were indirectly related—through perceived personal experience—to agreement with the new ecological paradigm, awareness of consequences, and ascription of responsibility. In slight contrast, personal norm was indirectly related to traditional media and social media, but not interpersonal sources. These findings are consistent with an argument that engagement with climate change information underlies the perceived experience of climate change and thus influences the formation of climate change beliefs. Although the current data do not permit a test of such a causal sequence, the argument is logical. To understand where people learn about climate change is to understand the beliefs that guide their environmental behaviors. Related, Kahan (2012) argued that people who deny climate change are not irrational, but that "their reasoning powers have become disabled by a polluted science-communication environment" (p. 255). He also pointed to research showing individuals may interpret the same weather phenomenon differently depending on their worldview. He did not draw a direct link between scientific misinformation and personal experience, but it makes sense that polluted information would taint the perception of events.

Second, the relationship between perceived personal experience and personal norm was mediated by agreement with the new ecological paradigm, awareness of consequences, and ascription of responsibility. Effectively, this was a parallel version of value-belief-norm theory, which replaced environmental values with perceived experience. So why did the current model

not also include environmental values? There are a couple reasons. First, Stern et al. (1995) argued values are general principles that underlie behavioral decisions and are resistant to the influence of information. Consistent with that argument, if there were any linkages between perceived personal experience and environmental values, it would be difficult to argue for a mediation model in which the former causes the latter. It would also be difficult to rule out spuriousness. Second, Dietz et al. (2005) argued that contextual factors—for example, the novelty of the behavior—influence the salience or importance of values and studying these antecedents requires elaborate designs using survey panels or experiments. The current design was not oriented to such a task. Admittedly, including environmental values in this study would have been useful as a covariate in the prediction of environmental worldview. Such a model could suggest to what extent worldview reflects relatively stable values versus more transient or dynamic social and informational processes.

I wish to briefly return to the topic of authoritativeness and, more broadly, source credibility. On that topic, Dong et al. (2018) found the relationship between climate change information and risk perceptions was stronger when participants rated media and institutional sources as more credible. To reiterate an earlier point, it may be worthwhile to examine perceived authoritativeness of institutional sources, perhaps as a moderating factor in belief formation. It may also be worthwhile examining the perceived credibility of other information sources. When individuals trust media and interpersonal sources, perhaps those sources are more likely to affect their subjective experience of an event. It is probably unnecessary to evaluate the credibility of personal experience, as people tend to trust their experiences as bases of making environmental decisions (Wright & Shindler, 2001). Future research can address these potential roles of source credibility in perceived experience and the formation of environmental beliefs.

The Link Between Personal Norm and Willingness

I should also briefly address the strong positive relationship between personal norm and energy conservation willingness. Eriksson et al. (2006) found a similarly strong relationship in the context of car use. Both findings are consistent with early conceptualizations of willingness in relation to personal norm (Zuckerman et al., 1977). However, recent work in the context of green transportation behavior suggests information provision moderates the relationship between willingness and action (Wang et al., 2020). In the context of recycling behavior, Rosenthal (2018) found that information seeking moderates the relationship between intention and self-reported behavior. Thus, it may be that information use is both an antecedent and consequence of environmental beliefs and willingness, which is an example of a reinforcing spiral (Slater, 2007).

Practical implications

This study has practical implications for climate change communication. The results align with a contextual model of public understanding of science (Brossard & Lewenstein, 2009). According to that model, building public acceptance of science is not as simple as filling knowledge gaps. Rather, the public will engage with scientific information that has relevance to their experiences and worldviews. As differing interpretations can lead to divergent beliefs, so can motivations to hold beliefs comporting with a desired state of things (Bromberg-Martin & Sharot, 2020). Understanding personal perspective is an important starting point to know how to craft engaging climate change information. Over a decade ago, Maibach et al. (2009) used segmentation analysis—traditionally a marketing tool—to understand how different segments of the United States public think about climate change. More recently, Wonneberger et al. (2019) found that the "concerned" Americans paid more attention to media coverage of the COP21 meeting than did the "doubtful" Americans. In Singapore, Detenber et al. (2016) found that trust

in interpersonal and institutional information sources helped differentiate "concerned" and "disengaged" segments of the public. Segmentation has been used in many other countries to define population subgroups based on their shared knowledge, values, emotion, and behaviors (Detenber & Rosenthal, 2020).

The current findings reaffirm the importance of understanding population subgroups in this way. They also highlight the importance of personal experience. To the extent that people's worldviews reflect their experiences, then climate change communicators should seek to understand groups of people in terms of their shared experiences—whether real or subjective—and craft messages that speak to that personal context. Future work can expand on this by considering features of the cultural context, for example, hierarchical and individualistic worldviews (Guy et al., 2014; Kahan et al., 2011; Verweij et al., 2006).

Limitations

There are four limitations I wish to point out. First, this study took place in Singapore, which is unique in some ways. The kinds of information available in the media, the government's focused stance on climate change, and the relative uniformity of public opinion limit the generalizability of the current findings to other national contexts. The response rate of 21% is a second limitation. During the door-to-door survey, research assistants introduced the study as "a brief survey about energy saving behaviors." It is possible, for example, that some individuals declined to participate because they were disinterested in energy-saving. If such individuals were systematically absent from the dataset, then the generalizability within the national context is also limited. Third, this study measured concepts using a small number of items, some of which were single-item measures. Although it is possible to measured unidimensional constructs using single items, such measures rely on face validity and do not

allow for tests of reliability (Ornstein, 2013). The fourth limitation is statistical. The current analysis tested several effects. For example, Hypothesis 3 predicted 16 indirect effects. This inflates the probability of making a type I error. Although some scholars have recommended correcting for this, an adjustment is unnecessary when each test is of a single pre-planned effect (Armstrong, 2014). I reported exact *p*-values down to the 0.1% alpha level so readers can draw their own conclusions about statistical significance.

Table 1

Summary of Measurement Items

Construct/Item	*M* (*SD*)	λ
Use of traditional media		
News media (television, newspapers, radio, etc.)	3.71 (0.96)	
Use of social media (AVE = .54, CR = .70)		
Social media (Facebook, Twitter, Reddit, etc.)	3.43 (1.15)	.70
YouTube	2.97 (1.23)	.78
Use of interpersonal sources (AVE = .77, CR = .87)		
Friends	2.66 (1.02)	.86
Family	2.65 (1.10)	.89
Use of institutional sources (AVE = .49, CR = .74)		
Government agencies	3.04 (1.11)	.67
University researchers	2.50 (1.19)	.75
Zoos, science centres, aquariums, museums, etc.	2.63 (1.19)	.67
Perceived personal experience (AVE = .66, CR = .79)		
I know from direct experience whether climate change is happening or not.	3.69 (0.80)	.86
Most of what I know about climate change is because I have seen it for myself.	3.60 (0.84)	.76
New ecological paradigm (AVE = .49, CR = .82)		
[1]Humans are severely abusing the environment.1	4.05 (0.82)	.66
[1]Despite our special abilities, humans are still subject to the laws of nature.	4.13 (0.71)	.64
[2]The Earth is like a spaceship with very limited room and resources.	3.93 (0.92)	.61
[2]The balance of nature is very delicate and easily upset.	3.98 (0.83)	.73
If things continue on their present course, we will soon experience a major ecological catastrophe.	4.15 (0.80)	.82
Awareness of consequences (AVE = .45, CR = .71)		
Over the years, it has gotten warmer in Singapore.	4.30 (0.75)	.59
Sea level has been rising in Singapore and will continue to rise.	3.88 (0.83)	.67
The amount of carbon dioxide in the atmosphere is increasing.	3.96 (0.83)	.75
Ascription of responsibility (AVE = .41, CR = .68)		
My use of electricity at home contributes to climate change.	3.80 (0.86)	.59
By saving electricity at home, I can reduce my carbon emissions.	4.04 (0.84)	.63
As an individual, I share responsibility for causing climate change.	4.00 (0.79)	.70
Personal norm (AVE = .52, CR = .76)		
[3]I would feel guilty if I wasted electricity at home.	4.03 (0.84)	.65
[3]I feel a personal obligation conserve electricity at home.	4.00 (0.76)	.68
I must do my part to combat climate change.	4.08 (0.70)	.82
Willingness to save electricity		
I am willing to put extra effort into saving electricity at home.	4.16 (0.68)	

Note. AVE = average variance extracted. CR = composite reliability. *M* = mean. *SD* = standard deviation. λ = factor loading. Superscripts indicate pairs of items with correlated residual variances.

Table 2
Sample Demographics Versus 2018 National Census

	Sample	Census
Sex		
Female	53%	51%
Male	47%	49%
Age		
Median bracket	40 – 49 years	46 – 50 years
Ethnicity		
Chinese	69%	74%
Malay	15%	13%
Indian	11%	9%
Others	5%	3%
Public housing type		
1-and 2-room	14%	8%
3-room	10%	22%
4-room	36%	40%
5-room and executive	40%	29%
Household size		
Mean	3.80	3.22
Total monthly household income		
Median bracket (Singapore dollars)	$4,000 – $4,999	$9,000 – $9,999

Note. The census figures included only households headed by a Singapore citizen or permanent resident. Housing indicates types of HDB (Housing and Development Board) apartments, which the government builds and sells to Singapore citizens and permanent residents. Roughly 80% of Singapore citizens and permanent residents live in HDB apartments. The census household income figure excluded households without a working adult. The current study did not measure employment status, which means we were unable to exclude households with low incomes due to unemployment.

Table 3
Correlation and Covariance Matrix of the Measurement Model

	1	2	3	4	5	6	7	8	9	10
1. Use of traditional media	0.93	0.32	0.20	0.33	0.21	0.15	0.13	0.18	0.17	0.14
2. Use of social media	.42	0.63	0.31	0.36	0.18	0.12	0.07	0.12	0.13	0.13
3. Use of interpersonal sources	.23	.44	0.77	0.35	0.16	0.02	0.06	0.07	0.10	0.11
4. Use of institutional sources	.45	.60	.53	0.55	0.16	0.11	0.10	0.15	0.14	0.11
5. Perceived personal experience	.32	.33	.27	.31	0.48	0.16	0.15	0.20	0.22	0.21
6. New ecological paradigm	.29	.28	.03	.27	.42	0.29	0.15	0.18	0.17	0.12
7. Awareness of consequences	.30	.20	.45	.29	.49	.62	0.20	0.15	0.13	0.10
8. Ascription of responsibility	.36	.30	.17	.39	.58	.64	.69	0.26	0.21	0.17
9. Personal norm	.32	.29	.20	.34	.57	.55	.52	.77	0.31	0.30
10. Willingness to save electricity	.22	.23	.19	.22	.44	.32	.32	.49	.80	0.46

Note. The diagonal contains item variances. Covariances are above the diagonal. Correlations are below the diagonal. The correlation between interpersonal sources and new ecological paradigm was not significant ($p = .39$). Otherwise, $p < .001$ for all correlations.

Table 4

Standardized Direct and Indirect Effects of the Full Structural Model

Model Path		Perceived Personal Experience			New Ecological Paradigm (i)			Awareness of Consequences (ii)			Ascription of Responsibility (iii)			Personal Norm (iv)		
		β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*
	AR →													.60	.39, .84	<.001
	AC →										.35	.21, .48	<.001	-.10	-.26, .05	.195
	NEP →							.50	.41, .60	<.001	.27	.15, .39	<.001	.10	-.03, .22	.141
H1a	TM →	**.20**	.12, .28	<.001	.11	.02, .19	.011	.07	-.01, .15	.107	.05	-.02, .13	.194	.02	-.07, .10	.698
H1b	SM →	**.16**	.04, .28	.010	.12	.01, .23	.032	-.14	-.26, -.03	.013	-.03	-.14, .10	.677	.01	-.11, .13	.810
H1c	INT →	**.13**	.02, .22	.012	-.23	-.32, -.13	<.001	.05	-.05, .14	.327	-.05	-.15, .05	.368	.07	-.02, .16	.129
H1d	INS →	**.05**	-.08, .19	.461	.15	.01, .28	.022	.11	-.02, .24	.089	.16	.04, .29	.009	-.03	-.15, .10	.628
H2	EXP →				**.36**	.28, .45	<.001	**.26**	.15, .36	<.001	**.25**	.15, .35	<.001	**.20**	.08, .32	.001
H3a	TM → EXP →				**.07**	.04, .11	<.001	**.05**	.03, .09	.001	**.05**	.03, .08	.001	**.04**	.02, .08	.007
H3b	SM → EXP →				**.06**	.02, .11	.013	**.04**	.01, .09	.029	**.04**	.01, .09	.033	**.03**	.01, .07	.033
H3c	INT → EXP →				**.05**	.01, .08	.018	**.03**	.01, .07	.027	**.03**	.01, .06	.024	**.03**	.01, .06	.067
H3d	INS → EXP →				**.02**	-.03, .07	.467	**.01**	-.02, .05	.478	**.01**	-.02, .05	.473	**.01**	-.01, .05	.480
	EXP → NEP →							.18	.13, .24	<.001	.10	.05, .15	<.001	.04	-.01, .08	.149
	EXP → NEP → AC →										.06	.04, .10	<.001	-.02	-.05, .01	.214
	EXP → NEP → AC → AR →													.04	.02, .07	.004

Note. AR = ascription of responsibility. AC = awareness of consequences. NEP = new ecological paradigm. EXP = perceived personal experience. TM = traditional media. SM = social media. INT = interpersonal sources. INS = institutional sources. The bottom portion of the table shows the indirect effects through perceived personal experience. The 95% confidence intervals were estimated using 5,000 bias-corrected bootstrap samples. Bolded values indicate the effects associated with each hypothesis. For example, the test of H2(iv) involves the regression of personal norm on EXP (β = .20). Likewise, the test of H3d(ii) involves the indirect effect of institutional sources on awareness of consequences (β = .01).

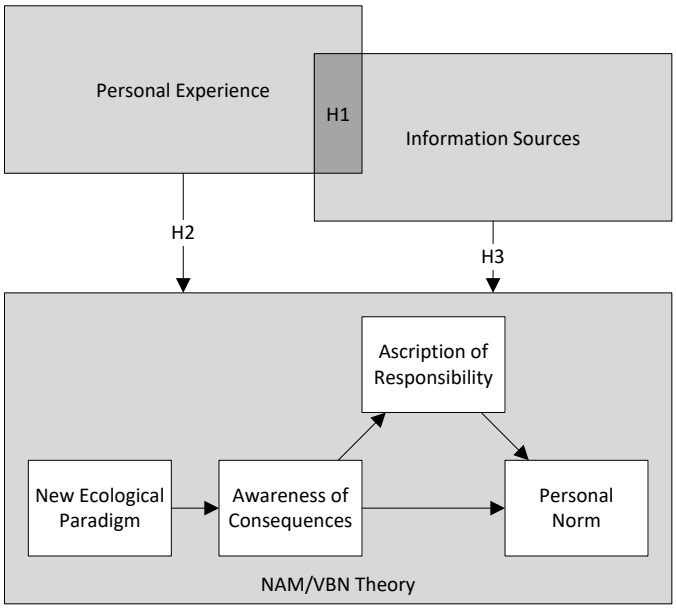

Figure 1. Theoretical model linking personal experience, information sources, and climate change beliefs.

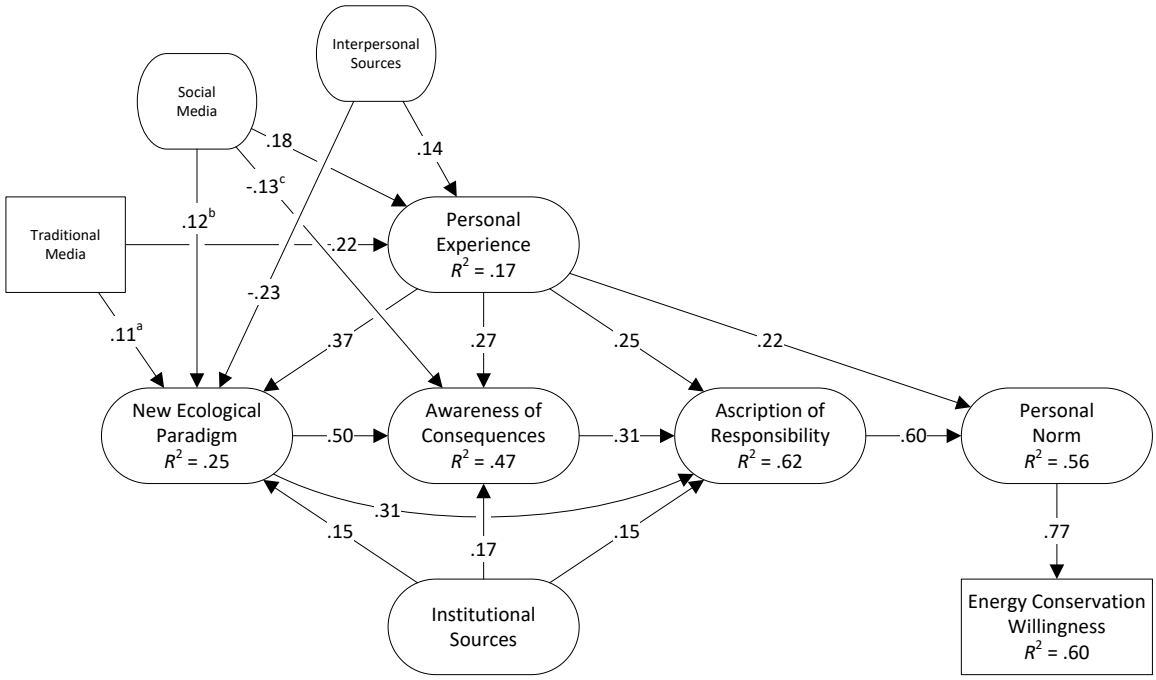

Figure 2. Standardized estimates of reduced structural model. Ovals represent latent variables; rectangles represent observed variables. [a]$p = .003$. [b]$p = .037$. [c]$p = .021$. Otherwise, $p < .001$ for all paths.

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