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If We Seek, Do We Learn?

Predicting Knowledge of Global Warming

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Derived from the risk information seeking and processing model (RISP), this study sought to isolate predictors of the public's knowledge of global warming. Using a national sample (N = 805), multiple regression yielded a number of significant relationships among 13 moderators. Notably, the number of media sources used for information about global warming, information seeking effort, and general education were relatively strong predictors of knowledge. Counter to expectations, informational subjective norms were inversely related to knowledge.

Keywords: *global warming; climate change; knowledge; risk information*

Recent research suggests that the public is becoming increasingly science literate (Miller, 2004; National Science Board, 2008). Between 1957 and 1999, the percentage of American adults with a minimal understanding of the meaning of scientific study nearly doubled, increasing from 12% to 21% during that 42-year span (Miller, 2004). Similarly, the National Science Board's (2008) biannual report on science and engineering indicators notes an upward trend between 1988 and 2008, during which time the percentage of respondents who correctly identified that electrons are smaller than atoms increased from 43% to 53%, and that antibiotics do not kill viruses increased from 26% to 56%.

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However, these strides are modest when one considers that in a culture that has become increasingly dependent on science and technology nearly half of the population still believes that antibiotics can cure a common cold and electrons outsize atoms. Deficits in public knowledge about such basic scientific realities can negatively impact civic participation when topics even tangentially related to science and technology surface in political discourse and policy making.

Although policy makers and scientists have been reaching out to lay publics in an effort to build science literacy (and, as indicated above, had some success to this end), additional outreach is needed to bring the rest of America up to speed (Pereira, 2004). The assumption, of course, is that improving science literacy will lead to greater public involvement, or, in the very least, improved public awareness of current trends in science and technology.

To this end, a number of models for public education and civic engagement have evolved in recent decades to guide communication research and public outreach efforts aimed at improving scientific literacy. Four of the more oft-cited models are the deficit model (Locke, 1999; Ziman, 1991), the contextual model (Falk & Storksdieck, 2005; Mitchell, Devine, & Jagger, 1989; Slovic, 1987), the lay-expertise model (Epstein, 1995; Kerr, Cunningham-Burley, & Amos, 1998), and the public engagement model (Hamlett, 2002; Turner, 1990). Each model offers an alternate conceptualization of scientific illiteracy and its causes, and each serves as a paradigmatic framework for the study and practice of science communication (for an in-depth summary of each model see Brossard & Lewenstein, in press; Lewenstein & Brossard, 2006).

According to the deficit model, low levels of scientific literacy result from a lack of information. Solving scientific illiteracy from this point of view is simply an issue of increasing the availability of the knowledge that has been generated by experts. Critics of this model, however, assert that available information will not be assimilated by citizens if it is perceived to lack context or utility. The other three models—the contextual model, the lay expertise model, and the public engagement model—emerged as a result of this criticism (Brossard & Lewenstein, in press; Lewenstein & Brossard, 2006). The contextual model assumes that knowledge is nested within social contexts and that these contexts affect individual interpretation of and the perceived value of the information. Similarly, the lay expertise model assumes that knowledge is culturally bound; however, there is a greater emphasis on local knowledge, which must be considered when addressing an issue that affects localities. The public engagement model, on the other hand, argues that improving appreciation of science and involvement in scientific discourse requires building more opportunities for the public to engage directly with an issue (e.g., a town hall meeting to discuss the expansion of a community's public transit offerings).

These models have served as frameworks for a number of studies and as the basis of some public outreach (for a detailed review, see Lewenstein & Brossard, 2006). Researchers, however, have gravitated toward still more complex models that blend these (context, cultural factors, involvement) and other potential antecedents of science literacy and engagement. For example, a handful of researchers have looked to models of information seeking and processing as a means of better understanding how audiences interact with scientific information (see extended parallel process model [EPPM], Witte, 1992; risk information seeking and processing [RISP], Griffin, Dunwoody, & Neuwirth, 1999; Kahlor, 2007; Kahlor, Dunwoody, Griffin, Neuwirth, & Giese, 2003).

This current study will employ one such complex model, the RISP model, to explore potential predictors of scientific literacy. In this effort, scientific literacy is defined as accuracy and complexity of scientific knowledge. The specific knowledge domain of interest to this study is global warming. This study will test whether the antecedents to information seeking and processing found in the RISP model (and previously tested within the context of global warming, see Kahlor, 2007) also serve as antecedents to complex and accurate knowledge of global warming[1] (our intended science literacy domain). It is hoped that a more complex snapshot of the antecedents of science literacy will better position us to focus future efforts on the link between science literacy and civic engagement.

Literature and Hypotheses

Knowledge: Scientific and Otherwise

While the science and engineering indicators provide a glimpse into what people know about science, isolating knowledge as a cognitive-psychological variable is a complex affair. The nature of knowledge is postulated in numerous theories, many of which conceive of it as a structured arrangement of stored information. Among the more notable theoretical frameworks to emerge are the schema (Bartlett, 1932/1972; Craik, 1943), script (Graesser, Gordon, & Sawyer, 1979; Schank & Abelson, 1977), and frame theories (Minsky, 1975; Neisser, 1976). Although terminology is used variously across the studies these frameworks have generated, Alexander, Schallert, and Hare (1991) found that, generally speaking, most knowledge structure theories can be encapsulated within the broader realm of schema theory. Alexander et al. defined schemas as "knowledge represented in structures that are interconnected with, and embedded in, one another [. . . and] sometimes related to the organization of conceptual knowledge or to all one knows about the physical, social, or mental world" (p. 333).

That is, schemas contain an organized arrangement of conceptually related bits of information, and these structures are oriented in relation to other schemas. Combined, these schemas reside in long-term memory and constitute the knowledge used to make sense of the world. Schemas are particularly useful when it comes to acquiring and interpreting novel information. That is, if someone has a thorough understanding of a complex process, its representative schema can inform that person about a similar process when she or he encounters it for the first time. For example, if someone observes that boiling water will scald skin instantly but that air at the same temperature will not, she or he will have a rudimentary schema for the heat conductivity of water (versus air). If this person later observes that the summer air stays warm longer into the evening when it is humid, she or he might add this observation to her or his water-heat schema. Finally, when this person learns that water vapor is a powerful greenhouse gas, she or he will have an existing knowledge structure or schema for understanding the phenomenon. Another notable property of schemas, which the above example demonstrates and which was a major component of Bartlett's (1932/1972) original schema theory, is that they are dynamic and continually undergoing modifications as new information adds to and/or replaces the old.

Furthermore, schemas vary in the breadth and depth of the knowledge that they contain. However, conceptualizing such variance in an applied way can be a difficult task. What does it mean in a practical sense to have breadth and depth of knowledge? Researchers have found the concept of expertise helpful to this end (Federico, 1995). Generally, a person who possesses more breadth and more depth of knowledge on a subject can be described as having more expertise on that subject. Medin and Ross (1997) further described expertise as having breadth and depth in both experience with and understanding of a domain. Similarly, Ju (2007) described expertise as the mastery of a domain, which includes both declarative (I know) and procedural (I can do) knowledge, with declarative knowledge serving as the foundation for procedural knowledge. Finally, Burleson and Caplan (1998) suggested that the differences between experts and novices can be attributed to differences in schema complexity: "Hence, studies comparing cognitively complex with less cognitively complex individuals are analogous to studies of expert-novice differences" (p. 238).

If expertise is synonymous with the presence of extensive domain knowledge, it follows that an expert would have one or more well-developed schemas organizing that knowledge. Thus, when new domain-specific information is encountered, an expert will be better equipped to make sense of it than a layperson. Furthermore, someone with a more developed schema should possess domain knowledge that is both more complex and, by virtue of his or her strong reasoning skills and experience with the domain, more accurate. Supporting this assertion, Vu, Hanley, Strybel, and Proctor (2000) found that self-reported expertise is a strong predictor of both the complexity and accuracy of declarative knowledge.

Complex and accurate knowledge can benefit both the individual and, by extension, the social realm in which the individual interacts. From an intrapersonal perspective, understanding the intricacies of a complex domain can help a person make informed decisions that affect his or her life directly. For example, someone concerned about his or her carbon footprint might make the obvious decision of driving less or using less hot water at home. Someone who has a deeper understanding of the sources of greenhouse gases might also choose to purchase alternatives to energy-intensive products (e.g., rammed earth and kiln-dried lumber replacing concrete and steel construction). Such decisions also carry with them social and/or interpersonal ramifications—for example, behavior change can impact others, shift social norms, and/or impact public discourse.

As suggested by the public engagement model touched on above, complex knowledge also can facilitate civic engagement. However, such knowledge is only useful or productive if it contains accurate information. If, for example, policy makers are considering a bill that addresses greenhouse gas emissions, the public cannot make meaningful contributions to the discourse if they do not know—or if they misunderstand—how greenhouse gases are formed and how they trap heat. The distinction of accurate versus inaccurate information is important; research indicates that in the case of global warming, people are just as willing to act on inaccurate information as they are on accurate information (Bord, O'Connor, & Fisher, 2000).

Predictors of Knowledge

The mass media are an important source of information about science, serving as a bridge between scientists and the lay public (Gerbner, Gross, Morgan, & Signorielli, 1981; Miller, Augenbraun, Schulhof, & Kimmel, 2006). However, in terms of the impact that media use has on general knowledge acquisition, research indicates conflicting results. For example, Eveland and Scheufele (2000) found that newspaper use augments the relationship between education and knowledge, while television use reduces it. Similar findings have been reported elsewhere (see Kwak, 1999; Pan, Ostman, Moy, & Reynolds, 1994). In a similar vein, Vincent and Basil (1997) investigated the effect of newspapers, news magazines, broadcast news, *The News Hour,* and the CNN on current events knowledge, finding that only printed news and the CNN are significantly related to knowledge.

Pan et al. (1994) suggested that network television exposure might be related to cursory, image-oriented information, while exposure to newspapers, cable television, and public broadcasting services (PBS) might be related to more complex and abstract information. Interestingly, this suggests that there is not a strict print-television split, but that a medium's effect is related to a combination of variables, which might include content and format or audience variables that bring certain audience segments to specific channels. In sum, understanding the relationship between media use and knowledge acquisition requires taking into account specific media, and a number of audience variables, including education and past information seeking behaviors.

For example, Kahlor, Dunwoody, Griffin, and Neuwirth (2006) found that education is positively related to systematic processing of information related to scientific issues. This finding, which is consistent with the knowledge gap hypothesis (see Tichenor, Donohue, & Olien, 1970), suggests that education level functions as a socioeconomic divide—those with more education should have a greater capacity for integrating new information into preexisting structures or for creating new knowledge structures. Viswanath and Finnegan (1995) wrote that "higher formal education provides a 'trained capacity' to follow certain issues, to relate these to other similar events and causes, and to better comprehend their significance" (p. 200).

An additional audience variable likely to impact knowledge is perceived personal relevance. When a message contains information that is perceived as personally relevant, an individual is more likely to be motivated to attend to and think about the message. For example, if a message is not perceived as relevant and the recipient does not connect the message back to his or her own behaviors, there can be little hope that the message will have any notable impact on the recipient (Gollwitzer & Bargh, 1996). According to Liberman and Chaiken (1996), this is because when a message is framed in high-relevance terms, it increases the accessibility of existing schemas.

The link between personal relevance and knowledge, then, is based on the assumption that deeper processing will lead to an increased likelihood of schema building (and, as a result, stored knowledge). Looking at science and environmental knowledge more specifically, research indicates that personal interest is an important motivator of knowledge gain and related behaviors (Falk, Storksdieck, & Dierking, 2007; Wall, 1995). This point will be revisited in a discussion of perceived hazard characteristics below.

Based on the preceding literature, therefore, our first set of hypotheses address these potential correlates of knowledge:

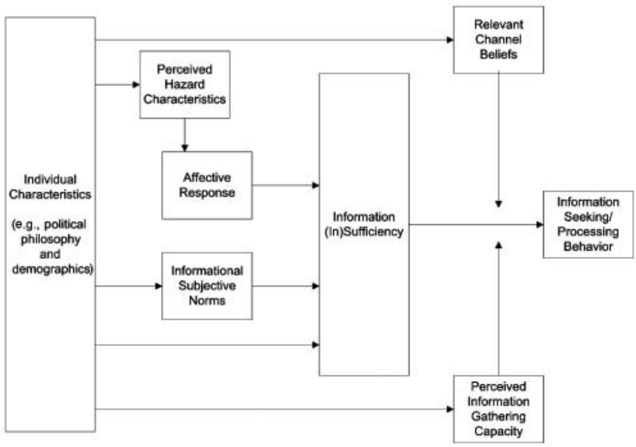
Hypothesis 1a: Use of newspapers will be positively correlated with knowledge about global warming.
Hypothesis 1b: Use of the Internet for news will be positively correlated with knowledge about global warming.
Hypothesis 1c: Use of television for news will be negatively correlated with knowledge about global warming.
Hypothesis 2: Education will be positively correlated with knowledge about global warming.
Hypothesis 3: Perceived personal relevance of global warming will be positively correlated with knowledge about global warming.

The RISP model

The RISP model (Griffin et al., 1999) offers additional guidance in determining potential predictors of knowledge. The RISP model was designed to explain variance in information seeking and processing specifically within the context of risk (Griffin et al., 1999). Figure 1 offers a simple schematic of the model. The RISP model is most heavily influenced by Chaiken and colleagues' work on heuristic-systematic processing (see Chaiken, 1980; Eagly & Chaiken, 1993), not only in its focus on information processing but also in its focus on the concept of information sufficiency. Information sufficiency is rooted in Eagly and Chaiken's (1993) concept of sufficiency and judgmental confidence. In the RISP, this concept translates to the perceived gap between knowledge held and knowledge needed; that gap serves as a pivotal point in the decision to seek or process information.

The RISP also features the concepts of perceived hazard characteristics and affective response to risk, which are adapted from the literature on risk (see Gregory & Mendelsohn, 1993; Slovic, 1987, 2001); the concepts of relevant communication channel beliefs and information seeking behaviors, which are adapted from the mass communication literature (see Becker &

Figure 1
The Risk Information Seeking and Processing Model



Kosicki, 1996; Kosicki & McLeod, 1990; McLeod, Kosicki, & Pan, 1991; McQuail, 1987); and the concepts of subjective norms and information gathering capacity, which are adapted from Ajzen's theory of planned behavior (Ajzen 1991, 2002). Support for the model has been relatively robust (see Griffin et al., 1999; Griffin, Neuwirth, Dunwoody, & Giese, 2004; Griffin, Neuwirth, Giese, & Dunwoody, 2002; Griffin, Powell, et al., 2004; Johnson, 2005; Kahlor, 2007; Kahlor et al., 2003; Trumbo, 2002). Indeed, the only concepts to not receive consistent support within the model are channel beliefs and information gathering capacity.

Components of the RISP model of particular interest to the present study are perceived hazard characteristics, affective response to the risk, subjective norms regarding information seeking (other's expectations that one seek information about the topic), and information gathering capacity. Perceived hazard characteristics often include perceptions of risk severity, personal and societal impact, risk-benefit balance, and immediacy of the risk (Griffin et al., 1999; Slovic, 2001); however, we focus on one specific dimension of perceived hazard characteristics: personal impact (Seguin, Pelletier, & Hunsley, 1998; Slovic, 2001), which relates to perceived personal relevance described in Hypothesis 3.

The related concept of affective response to risk typically is captured as fear, dread, or worry (see Griffin et al., 1999; Meijnders, Midden, & Wilke, 2001; Witte, 1992, 1994), and it has been shown to be strongly correlated with perceived hazard characteristics such as severity (see Griffin, Neuwirth, et al., 2004). Not surprisingly, the more severe a risk is perceived to be, the more one worries about it. In addition, the more a person worries, the more likely she or he is to perceive a need for additional information about the risk (see Griffin et al., 2002; Griffin, Neuwirth, et al., 2004; Griffin, Powell, et al., 2004; Kahlor, 2007, 2008). Worry has also been linked in the environmental literature to behaviors such as environmental activism and responsible environmental practices (see McKenzie-Mohr, Nemiroff, Beers, & Desmarais, 1995). Hayward (1994) asserted that environmentally active people worry more about the environment than people who are not active. As a result, the relationship between worry and knowledge is of particular interest in the present study.

Subjective norms regarding information seeking behaviors is defined as perceived social pressure to perform the behavior (injunctive norms) and perceptions whether others are already performing the behavior (descriptive norms; Ajzen, 1991). The concept of informational subjective norms is of particular interest to this effort because it has emerged in the RISP and related literature as significantly and positively related to the perceived need for more information, information seeking, and information processing (see Griffin et al., 2002; Griffin, Neuwirth, et al., 2004; Griffin, Powell, et al., 2004; Kahlor, 2007, 2008). As a result, we expect this concept to be among those most strongly related to actual knowledge.

Our current conceptualization of information gathering capacity is consistent with Ajzen's concept of perceived behavioral control—which is one's confidence in one's ability to perform the behavior and the perceived availability of resources that may hinder or facilitate the behavior (Ajzen, 1991, 2002). It is also consistent with the conceptualization of that construct in the seminal RISP work (Griffin et al., 1999).

Adding to the original RISP concepts, we also investigate the role of attitude toward the behavior, another concept from the theory of planned behavior (Ajzen, 1991, 2002; Kahlor, 2007). Attitude toward the behavior is conceptualized as aggregate beliefs about the perceived outcomes of the behavior and the evaluation of those outcomes. Typically, these evaluations touch on both experiential (related to enjoyment) and instrumental (related to utility) aspects of the outcomes. A recent application of the RISP (Kahlor, 2007) suggests the promise of attitude toward the behavior as a potential predictor of information seeking—and knowledge, by extension.

Although the RISP model (Griffin et al., 1999) and subsequent iterations (Kahlor, 2007, 2008) incorporate constructs of knowledge, they employ a measure of perceived knowledge, which they treat as an independent variable. Our intent, by contrast, is to measure actual knowledge and to treat knowledge as a dependent variable. In doing so, we will test several of the RISP concepts as predictors of actual knowledge. As such, this study allows us to address whether linkages exist between knowledge and beliefs about information seeking (i.e., control, norms, and attitudes), affect, and past information seeking behavior. As the title of this article suggests, we are looking for evidence that risk perceptions and risk information seeking—and positive beliefs about such seeking—lead to better risk knowledge. This is an important link that has been missing from the literature on risk information seeking and processing.

Our second set of hypotheses, therefore, addresses whether these risk information seeking and processing correlates are also correlates of risk knowledge. Specifically, we predict the following:

Hypothesis 4: Worry about global warming will be positively correlated with knowledge about global warming.

Hypothesis 5: Subjective norms (i.e., perceived social pressure) regarding seeking information about global warming will be positively correlated with knowledge about global warming.

Hypothesis 6: Attitudes (experiential and instrumental) toward seeking information about global warming will be positively correlated with knowledge about global warming.

Hypothesis 7: Perceived behavioral control regarding seeking information about global warming will be positively correlated with knowledge about global warming.

Hypothesis 8: Perceived understanding of global warming information encountered during past seeking efforts will be positively correlated with knowledge about global warming.

In addition to offering another dimension of behavioral control, Hypothesis 8 also touches on self-efficacy: The focus in on whether one has the cognitive ability to comprehend information that is sought—and, by extension, draw knowledge from that information.

Our next hypotheses look at whether past seeking efforts predict to actual knowledge as is commonly assumed in the literature.

Hypothesis 9a: Self-reported efforts to seek information about global warming will be positively correlated with knowledge about global warming.

Hypothesis 9b: Number of sources used for information about global warming will be positively correlated with knowledge about global warming.

Method

Sample and Procedure

This study employed an online survey to measure the aforementioned theoretical concepts and test our hypotheses. Survey respondents were recruited through an online research panel hosted at a large, public university in the Southwest. At the time of data collection, the panel consisted of about 20,000 participants. Participation was voluntary, and incentive to participate was in the form of cash drawings. In 2005 August, 3,000 U.S. panel members were invited to participate in the survey, which was available for a 2-week period. The invitation was sent via e-mail with the subject line, "A new online survey is open for participation." A URL within the body of the e-mail provided a hyperlink that took recipients to the survey Web site. The homepage of the survey Web site began with a very brief description of the study and its sponsor. The study was described as survey of media use and beliefs about global warming.

Incomplete or expired e-mail addresses led to 230 intended recipients not receiving the invitation. The response rate was 35.4%, which is comparable to those of other online response rates (e.g., Goritz, Reinhold, & Batinic, 2002; Kaplowitz, Hadlock, & Levine, 2004). After deleting cases less than 70% complete, the final sample size was 828, which effectively reduced the response rate to 30%. While this response rate does not allow for adequate generalizability, it does allow for testing theoretical linkages, which is the crux of this effort.

The final sample ranged in age from 18 to 79 (M = 40.8, median = 40, SD = 12.7), and it reported education levels ranging from eighth grade or less to an advanced degree (median = college graduate) and income levels ranging from US$1,000 to US$500,000 (M = US$63,200, median = US$50,000, SD = US$48,400). Eighty-four percent of respondents were White and 66% were women. These demographics are comparable to those of the entire panel of 20,000. Seventy-four survey items were employed to capture attitudinal, perceptual, behavioral, and demographic variables related to global warming as well as basic demographic variables. The current study draws from a selection of those items, of which nondemographic items are listed in Table 1 with means and standard deviations. The analyses reported below should be considered secondary, as the original data were gathered for the primary purpose of studying information seeking behaviors (Kahlor, 2007).

Independent Measures

General media use, education. Consistent with previous measures of media consumption (see Diddi & LaRose, 2006; Vincent & Basil, 1997), television, newspaper, and Internet use each were captured with a single item asking respondents to report the number of days per week that they use a particular medium for news. Respondents reported using television the most (M = 4.86, median = 5), followed by the Internet (M = 4.37, median = 5) and newspapers (M = 3.51, median = 3). Although this item measured general news consumption, these findings are consistent with those reported by the science and engineering indicators (National Science Board, 2008) that the public's primary source of science information is television, followed by the Internet. Education was measured as the highest level of education achieved by respondents. Response options ranged from 1 (8th grade or less) through 6 (advanced degree). As reported above, the median response was 5 or college graduate.

Perceived personal relevance, worry related to global warming. Two items (α = .92) measured perceived personal relevance of global warming. Specifically, these items assessed perceived impact of global warming on one's health and one's life (e.g., activities, work, etc.).[2] Response options ranged from 0 through 10 (0 = *not at all*, 10 = *very much*; M = 5.53). Worry was measured with a single item that asked respondents to indicate the extent to which they worry about global warming. Again, response options ranged from 0 through 10 (0 = *not at all*, 10 = *very much*; M = 4.42). These items are conceptually consistent with the RISP model; however, the first two measures do deviate from typical RISP measures in their focus on personal impact versus personal risk/severity estimates. This deviation was justified with the assumption that perceived risk estimates would be quite low across the sample—especially given that the survey was conducted before the release of Al Gore's *An Inconvenient Truth* and the subsequent media attention the film spurred.

Information-seeking subjective norms. Consistent with Ajzen's (2002) recommendations, these subjective norms were captured with five items that assessed both injunctive (others' expectations) and descriptive (the

Table 1
Questionnaire Items, Constructs, Means, and Standard Deviations

Construct	Item Wording	*M*	*SD*
Instrumental attitudes: seeking	Please indicate whether you feel that seeking information about global warming is harmful or beneficial, with 1 = *more harmful* and 7 = *more beneficial*.	5.60	1.46
	Please indicate whether you feel that seeking information about global warming is bad or good, with 1 = *more good* and 7 = *more bad*.	5.54	1.46
	Please indicate whether you feel that seeking information about global warming is worthless or valuable, with 1 = *more worthless* and 7 = *more valuable*.	5.45	1.55
Experiential attitudes: seeking	Please indicate whether you feel that seeking information about global warming is unpleasant or pleasant, with 1 = *more unpleasant* and 7 = *more pleasant*.	3.89	1.48
	Please indicate whether you feel that seeking information about global warming is unenjoyable or enjoyable, with 1 = *more unenjoyable* and 7 = *more enjoyable*.	3.77	1.64
Prior information seeking effort	I have actively looked for information about global warming.[a]	2.64	1.17
	I don't go out of my way to seek information about global warming.[a]	2.28	.981
	I have tried to find information about global warming.[a]	2.91	1.15
Perceived control: seeking	It is very difficult to find accurate information about global warming.[a]	2.69	1.08
	When I want to, I am easily able to locate information about global warming.[a]	3.47	1.08
	How much control do you think you have when it comes to seeking information about global warming? Response options were 0 to 10, with 0 = *no control* and 10 = *total control*.	3.62	0.849
Understanding of information	I usually understand what I read or hear when I encounter information about global warming.[a]	3.84	0.836
Perceived personal relevance of global warming	How likely is it that global warming will have an impact on your personal health? Response options were 0 to 10, with 0 = *no impact* and 10 = *big impact*.	5.66	2.96
	How likely is it that global warming will have an impact on your life, in terms of activities you engage in, your work, and so on? Response options were 0 to 10, with 0 = *no impact* and 10 = *big impact*.	5.40	2.98
Worry about global warming	How much do you worry about global warming? Response options were 0 to 10, with 0 = *not at all* and 10 = *very much*.	4.42	3.04

(continued)

Table 1 (continued)

Construct	Item Wording	*M*	*SD*
Subjective norms: seeking	Most people who are important to me think that I should seek information about global warming.[a]	2.33	0.992
	It is expected of me that I seek information about global warming.[a]	2.49	1.03
	People whose opinions I value would approve of my staying on top of information about global warming.[a]	3.12	0.940
	I think that people whose opinions I value seeking.[a] information about global warm	2.88	0.919
	The people I spend most of my time with are likely to seek information related to global warming.[a]	2.49	0.955

a. Response options were 1 = *strongly agree*, 2 = *agree*, 3 = *neutral*, 4 = *disagree*, 5 = *strongly disagree*.

perception of others' behaviors) norms regarding information seeking ($\alpha = .81$). Although these items are conceptually consistent with the RISP model, the measures do deviate in their attempt to capture both injunctive and descriptive norms; most RISP measures to date focus only on the injunctive norms.

Attitude toward seeking. Also consistent with Ajzen's (2002) recommendations, attitude toward seeking was measured along two dimensions: instrumental evaluations of the target behavior (i.e., evaluating the behavior as an instrument) and experiential evaluations of the target behavior (i.e., evaluating the behavior as an experience). Studies of information and mass-media behaviors have also focused on these two dimensions (e.g., Novak, Hoffman, & Duhachek, 2003; Sanchez-Franco & Roldán, 2005). In the current study, instrumental and experiential evaluations of information seeking were captured using 7-point semantic differential scales. Respondents were asked to indicate whether seeking information about global warming is harmful/beneficial, bad/good, valuable/worthless, unpleasant/pleasant, and unenjoyable/enjoyable. Responses were coded with lower values as less favorable. Principle axis factor analysis revealed two factors consistent with instrumental and experiential evaluations. The instrumental factor consisted of harmful/beneficial, bad/good, and valuable/worthless ($\alpha = .86$), while the experiential factor consisted of unpleasant/pleasant and unenjoyable/enjoyable ($\alpha = .77$). This concept/construct was not included in the original conceptualization of the RISP model (Griffin et al., 1999); however, it was included in a subsequent iteration of that model (Kahlor, 2007).

Perceived control over seeking, perceived understanding. The perceived seeking control construct consisted of three items ($\alpha = .62$) that measured respondents' confidence in their ability to seek information. Two of the items tap into respondents' self-efficacy, and one item taps into the perceived controllability of the behavior. Although the reliability of this construct is undesirable, it is above the unacceptable .6 cutoff as defined by DeVellis (1991). These measures are consistent with earlier RISP model measures. To assess perceived understanding, we used a 5-point Likert-type item to measure the degree to which participants felt they understood information about global warming when they encountered it in the mass media. This measure (and its related hypothesis) is intended to capture yet another dimension of perceived control, which references a person's confidence in his or her cognitive ability to perform the behavior.

Global warming information sources, seeking effort. Past information seeking effort was captured with three items that measured respondents' self-reported past efforts to gather information about global warming ($\alpha = .84$). We were also interested in the variety of mass-mediated information sources respondents turned to for information about global warming. The corresponding survey item prompted respondents with the following: "When you do encounter information about global warming, the source is." Source options were the Internet/Web, radio, television, magazines, newspapers, and books. Respondents were also asked to indicate whether they encountered these sources *sometimes* or *frequently* (coded 1), or *never* (coded 0). We created a summated index with each respondent's score reflecting the number of sources she or he reported using (scores ranged from 1 to 6, $M = 4.28$, $SD = 1.44$). These measures are not reflective of the original conceptualization of the RISP model, which does not explicitly account for past seeking.

Dependent Measure: Knowledge of Global Warming

In our dependent measure, we sought to account for variance in respondents' actual knowledge of global warming. This measure of knowledge was based on an open-ended question that asked respondents as follows: "In your judgment, when people use the term *global warming*, what are they referring to?" Our appendices offer details on how we coded the resulting responses in our effort to quantify knowledge complexity (Appendix A) and accuracy (Appendix B). An explanation for how we arrived at complexity and accuracy as variables of interest follows here in the text.

Knowledge complexity. Prior research efforts attempted to quantify science knowledge in terms of its complexity. Building on the work of Zajonc (1960), and on Crockett's (1965) Role Category Questionnaire, Kahlor, Dunwoody, and Griffin (2004) developed a means of quantifying knowledge complexity as (a) the quantity of isolable units of knowledge and (b) the degree to which these units are conceptually linked. The researchers were interested in causal explanations of scientific phenomena. This operationalization of knowledge complexity resonates with Fiske and Dyer's (1985) description of schemas as "cognitive structure[s] that [contain] units of information and the links among them" (p. 839). Furthermore, Burleson and Caplan (1998) described cognitive complexity as an arrangement of interconnected cognitive elements. They wrote as follows:

> More developed systems of constructs [or schemas] will be more differentiated (contain greater numbers of constructs [or sub-schemas]), articulated (consist of more refined and abstract elements), and integrated (organized and interconnected). These more developed systems of constructs can be characterized as relatively complex. (p. 237)

That is, a schema may be considered complex if it contains a variety of domain-specific elements that share conceptual linkages; thus, a measurement of cognitive complexity should seek to measure the number of elements and the degree to which they are associated. In the Kahlor et al. (2004) study, isolable units of knowledge were defined as "words or strings of words that [act] as contributing factors in [. . .] respondents' causal explanations" (p. 17). Our effort builds on Kahlor and colleagues' measure of cognitive complexity, with some adjustments necessitated by limitations of the current data and survey method. For additional explanation of this variable, see Appendix A.

Knowledge accuracy. In addition to complexity, we were interested in accounting for the accuracy of the responses. We were not satisfied with merely quantifying the responses, if it remained possible that a response could be complex—that is, have breadth and depth—but also be inaccurate. Because people are just as willing to act on inaccurate information as they are accurate information (Bord et al., 2000), we had to assume that some of our respondents (even those who had well-established schema in this domain) had built their schema on faulty information. The scheme for coding accuracy reflects a similar scheme developed by Hoz, Bowman, and Kozminsky (2001), who coded the validity of participants' knowledge about geology and geomorphology. Details of our resulting measure can be found in Appendix B.

Intercoder reliability. We used Krippendorff's alpha to assess intercoder reliability for all the above coding schemes.[3] To compute alpha, we randomly selected a subsample of 90 (11%) of the 828 explanations.[4] There were three coders for complexity and two for accuracy. We used an SPSS macro developed by Hayes and Krippendorff (2007) to compute the alphas for six sets of data: the number of contributing elements ($\alpha = .81$), the number of causal connections ($\alpha = .81$), the number of cause/effect/change statements ($\alpha = .91$), the statement accuracy scores ($\alpha = .89$), and the composite scales for complexity ($\alpha = .89$) and accuracy ($\alpha = .86$).[5]

Knowledge as complexity × accuracy. The final construct, which we used for hypotheses testing, was computed as the product of participants' complexity and accuracy scores. Thus, a high score would represent both accurate and complex knowledge, whereas a low score would represent a deficiency in one or both underlying constructs. Of the total sample, 23 respondents did not provide an answer to the open-ended question and thus received no score for complexity or accuracy. The descriptive statistics of the remaining 805 knowledge scores revealed a nonnormal distribution (skewness = 1.61; kurtosis = 4.12). Generally, a score greater than an absolute value of 3 on either statistic indicates nonnormality. For positively skewed, platykurtotic distributions, Rummel (1970; also Stevens, 2002) recommended using the natural logarithm of the variable of concern. However, because knowledge scores in this sample ranged from 0.0 to 10.0 and the natural logarithm of 0.0 is incalculable, we used log(X + 1). By adding 1, the minimum of the range remains at 0.0. Using this computation results in an acceptably normal distribution (skewness = .04; kurtosis = –.40). The final knowledge construct ranged from 0 to 2.4 ($M = 0.85$, $SD = 0.52$).

Results

Data were analyzed using SPSS version 15.0 for Windows. First we conducted a hierarchical multiple regression analysis to account for the variance in knowledge of global warming (in this case, complexity ×

accuracy). Regression results related to the hypotheses are reported below and in Table 2.

Contradicting Hypothesis 1a, newspaper use was negatively related to knowledge of global warming, and this relationship approached significance ($p < .055$). Hypotheses 1b and 1c were not supported, which suggests that consumption of Internet and television news is not significantly related to knowledge of global warming.

Hypothesis 2 predicted a positive relationship between general education level and knowledge about global warming. This relationship was supported and in the predicted direction ($\beta = .14$, $p < .001$). Hypothesis 3 predicted a positive relationship between perceived personal relevance and knowledge. This relationship was not supported. Relationships between worry and global warming knowledge (Hypothesis 4), and subjective norms and global warming (Hypothesis 5) also were not supported.

We found partial support for Hypothesis 6, which predicted a positive relationship between information seeking attitudes and knowledge. Instrumental attitudes were positively related to global warming knowledge ($\beta = .14$, $p < .01$), while experiential attitudes were negatively related with such knowledge ($\beta = -.08$, $p < .05$). Hypothesis 7 was not supported. Perceived behavioral (information seeking) control was not significantly related to knowledge about global warming.

Both Hypotheses 9a and 9b were supported. The number of information sources used ($\beta = .12$, $p < .01$) and past seeking effort ($\beta = .15$, $p = .001$) were both significantly and positively related to global warming knowledge. Finally, perceived understanding of global warming information encountered in the mass media was found to be significantly related with knowledge (Hypothesis 8; $\beta = .17$, $p < .001$).

Next, we ran post hoc regression analyses of these same predictors on each of the four knowledge components: elements, connections, complexity, and accuracy. These results, which are offered in Table 3, allow us to determine whether these components are differentially related to our independent variables. They also allow us to reflect on knowledge breadth (elements) versus depth (connections). Finally, to further illuminate relationships among our variables, we ran a Pearson correlations matrix, which is offered in Table 4.

Discussion

Inspired by recent research on scientific literacy and civic engagement, this study sought to identify potential predictors of science knowledge—in

Table 2
Multiple Regression of Global Warming Knowledge Complexity

Independent Variables	Block 1	Block 2	Block 3
Newspaper use	–.05	–.04	–.07
TV news use	–.03	–.03	–.06
Web news use	–.01	–.02	–.06
Education	.21***	.16***	.14***
Personal relevance	–.02	–.08	–.07
Worry	.06	.01	–.03
Control		.04	.04
Understanding		.21***	.16***
Norms		–.01	–.09
Attitude: instrumental		.15**	.14**
Attitude: experiential		–.07	–.09**
Effort			.16***
Media sources			.13**
R^2 change	.05	.06	.03
Multiple R	.22	.34	.38
Adjusted R^2	.04	.10	.13

Note: $N = 805$.
*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 3
Multiple Regression of Four Knowledge Components

Independent Variables	Elements	Connections	Complexity	Accuracy
Newspaper use	–.04	–.09*	–.06	–.02
TV news use	–.06	–.07	–.07	.01
Web news use	–.06	–.02	–.05	–.07
Education	.06	.09*	.08*	.12**
Personal relevance	–.02	–.03	–.03	–.04
Worry	.02	–.04	.01	–.06
Control	.04	.07	.05	.002
Understanding	.14***	.11**	.15***	.09*
Norms	–.10*	–.06	–.10*	–.02
Attitude: instrumental	.12**	.10*	.13**	.04
Attitude: experiential	–.03	–.04	–.03	–.06
Effort	.08	.08	.09	.12*
Media sources	.12**	.06	.12**	.11**
Multiple R	.30	.28	.31	.35
Adjusted R^2	.07	.06	.08	.05

Note: $N = 805$.
*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Table 4
Correlation Matrix for Independent Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Newspaper use	—	.22**	.20**	.13**	.08*	.14**	.02	.05	.11**	.11**	.18**	.18**	.29**
2. TV news use		—	.16**	–.18**	.12**	.13**	–.07*	–.01	.10**	.10**	.12**	.14**	.20**
3. Web news use			—	.13**	.08*	.13**	.04	.10**	.16**	.08*	.14**	.29**	.20**
4. Education				—	–.03	–.02	.14**	.17**	.02	.07*	.09*	.09*	.13**
5. Personal relevance					—	.66**	.13**	.14**	.40**	.49**	.17**	.27**	.17**
6. Worry						—	.11**	.16**	.53**	.45**	.20**	.42**	.26**
7. Control							—	.34**	.15**	.21**	.20**	.10**	.16**
8. Understanding								—	.16**	.22**	.15**	.30**	.19**
9. Norms									—	.43**	.25**	.55**	.24**
10. Instrumental attitude										—	.38**	.29**	.20**
11. Experiential attitude											—	.26**	.15**
12. Effort												—	.37**
13. Media sources													—

*$p < .05$. **$p < .01$.

this case, knowledge of global warming. Our effort was guided by the Griffin et al. (1999) RISP model. Specifically, we tested whether the antecedents to information seeking and processing found in the RISP model also surfaced as antecedents to complex and accurate knowledge of global warming, and whether self-reported information seeking predicted this knowledge as well. Our hope was that by identifying antecedents shared by information seeking and actual knowledge, we bring researchers one step closer to understanding science literacy and deficits therein.

One of the stronger RISP-related relationships to emerge in our analysis was that between instrumental attitudes toward seeking information about global warming (i.e., that seeking such information is beneficial, valuable, good) and knowledge of global warming. This relationship was significant and positive. However, we also looked at the relationship between experiential attitudes toward seeking information about global warming (i.e., that seeking such information is pleasant, enjoyable) and knowledge of global warming. Although we predicted another positive relationship here, this relationship emerged as significant but negative. In hindsight, however, both these relationships seem intuitive. That is, the unexpected negative relationship makes sense if one considers that the tone of much of the news coverage on global warming is likely to be somewhat negative. Thus, exposure to that coverage might very well be productive and valuable (as indicated by the positive relationship) and unpleasant (as indicated by the negative relationship).

Yet another way to interpret the positive result between instrumental seeking and knowledge is through the expectancy-value theory (e.g., Babrow, 1989; Palmgreen & Rayburn, 1982), which is a derivation of the uses and gratifications paradigm (see Rubin, 2002). The theory holds that behavior is the product of beliefs (expectations) and evaluations (values), such that engaging in a certain behavior will occur when there (a) is a belief that it will result in a desired end state and (b) attitudes of the target end state are positively valenced. In other words, if someone values knowledge about global warming, and she or he believes that seeking information about global warming will result in greater knowledge, then she or he will be likely to engage in seeking behavior. If seeking behavior results in more knowledge, the belief that initiated the behavior will be reinforced. This further supports the theoretical significance of the positive relationship between instrumental attitudes and knowledge.

Kahlor (2007) reflected on the concept of attitudes toward information seeking as a potential complement to the original RISP model and suggested that it captures some of the variance likely accounted for by the original RISP concept of relevant channel beliefs (which was not measured in the current study). The justification for this is that beliefs about channels that facilitate seeking are likely contributors to one's overall assessment of seeking information. While the findings reported by Griffin, Powel et al. (2004) had demonstrated a significant relationship between channel beliefs and information seeking (when information seeking is regressed on channel beliefs), the significant changes in R^2 reported in several regression analyses have been incremental, ranging from .01 to .07. Thus, while relevant channel beliefs do show some promise as a predictor of information seeking, there is the possibility that this is a concept that can be subsumed within the aggregate concept of attitudes toward seeking. Such an alteration does not appear to represent a significant risk to the predictive potential of the model.

Another notable RISP variable employed in our analysis was information-seeking subjective norms. We predicted a positive relationship between such norms and knowledge, instead we found a negative, albeit weak, relationship that approached significance ($p < .07$). One potential explanation for this negative relationship is that when actual knowledge is low and we are aware of that deficit, we might perceive that others expect us to be better informed. Prior research does indicate a positive relationship between seeking norms (other's expectations) and information insufficiency (one's perceived knowledge deficit; Kahlor, 2007). However, because our explanation for the negative relationship between norms and actual knowledge assumes that the individual is aware of his or her knowledge deficit, we conducted a post hoc bivariate Pearson correlation between perceived information insufficiency and knowledge about global warming. (Information insufficiency is a key concept in the RISP model; it is described briefly in the literature review above.) Perceived information insufficiency was measured as the difference between participants' self-reported current knowledge of global warming and their estimate of how much knowledge they would need to achieve a comfortable understanding of global warming. Both items ranged from 0 to 100, with 100 representing greater knowledge. The correlation supported our assumption ($r = -.11$, $p < .01$). That is, the larger one's perceived knowledge deficit (the gap between current knowledge and knowledge needed) the lower one's actual knowledge. This suggests a complex relationship between perceived social pressure, self-inflicted pressure (in the form of perceived knowledge insufficiency), and actual knowledge. This deserves further attention in future research.

The lack of a relationship between perceived control and knowledge is likely a result of methodological issues; the items employed demonstrated a minimally acceptable reliability ($\alpha = .62$). This refrain can be found in many of the RISP-related studies (for a discussion, see Griffin et al., 2008). Griffin and colleagues (2008) have begun to address these concerns and seen improved results. That said, we did find a significant positive relationship between knowledge and our secondary measure of perceived control, which was perceived ability to understand information about global warming. This suggests that a person's confidence in his or her cognitive ability to perform the behavior is positively related to knowledge.

As the title of this article suggests, we were interested not only in whether information seeking and knowledge share notable predictors but also whether past information seeking was positively related to knowledge. Our results suggest it is. Both our measures of past seeking—number of sources and seeking effort—were significantly and positively related to global warming knowledge. These findings reflect on the role of schema building in public understanding of such issues as global warming. A schema is considered well developed when sufficient and varied construct-specific information has been integrated, such that the schema can be used to make sense of novel construct-relevant information. If we consider our knowledge measurement as a proxy for schema complexity, it is logical that someone who employs effortful or varied information seeking will have more complex and accurate knowledge.

To explore this relationship further, we dichotomized the sample (median split) and compared means for both past information seeking variables, finding significant ANOVA statistics for the number of sources used, $F(1, 803) = 1496.2$, $p < .001$, and prior seeking effort, $F(1, 786) = 19.5$, $p < .001$. The relatively large F statistic of the former ANOVA suggests that the primary driving force in the relationship between prior seeking behavior and knowledge is the number of sources used. Indeed, participants who used many sources had nearly three times the knowledge score ($M = 1.27$) of participants who used few sources ($M = 0.44$), while the means were closer between participants who reported high prior seeking effort ($M = 0.94$) and those who reported low prior seeking effort ($M = 0.78$).

We also examined this relationship with both past seeking variables combined into a single construct. Logically, someone who seeks information from many sources and employs high seeking effort should have greater knowledge than someone who seeks from few sources but with high effort or who seeks from many sources but seeks with low effort; and someone who seeks from few sources with low effort should have the poorest knowledge. This interaction can be expressed as the equation that follows:

$$K_i = V \times S$$

in which a portion (i) of knowledge (K) that is explained by the variety of sources used (V) and past seeking effort (S). To test this equation, we computed V × S as the product of the number of sources used and past seeking effort. Again dichotomizing participants and comparing means, we found that high-V × S participants had significantly higher knowledge scores ($M = 0.93$) than did low-V × S participants ($M = 0.78$), $F(1, 786) = 15.9$, $p < .001$; however, the differences were smaller than when we considered the past seeking variables individually. Furthermore, a univariate general linear model (GLM) test reveals a nonsignificant interaction between seeking effort and number of sources used, $F(1, 134) = .94$, $p > .05$.

The relationship between prior seeking and knowledge validates the increasing focus on information seeking in the health and environmental risk literature. That seekers are more knowledgeable suggests that interventions intended to bring people to risk information are likely to lead to increased knowledge—if other factors are in place. Those other factors might include education, which was positively related to knowledge in this effort. The relationship between number of sources sought and knowledge is also intriguing and deserves further exploration in future efforts that might explore the way in which the various sources work in tandem to build and enhance knowledge. Looking at the contributions of seeking via specific sources in future research might also provide additional data on how these modes of seeking might affect processing differentially.

Given the role that sources seem to play in knowledge, we were somewhat surprised to find that general use of individual media (television, newspapers, and the Internet) did not predict knowledge as hypothesized. Indeed, no one medium was related significantly to knowledge in either direction. One logical reason for this might be that prior to 2005, there was considerably less news coverage of global warming. In other words, there was not enough media coverage to foster these relationships. Approaching significance, the negative relationship between newspaper use and knowledge was surprising, but can also be explained to some extent by invoking prior research, which indicates that news reporters have tended to have a limited understanding of global warming. For example, Wilson (2000) found that while 87% of reporters could correctly identify carbon dioxide as a greenhouse gas, far fewer could correctly identify chlorofluorocarbons (CFCs; 55%) and nitrous oxide (30%) as greenhouse gases. Other measures reported in the same study seem to indicate that reporters tend to be knowledgeable about general aspects of global warming but are widely ignorant of specific causes and effects. It is possible that, as a result, media coverage has been oversimplified, possibly even inaccurate. Reflecting on this problem, Wilson also reported that the primary source of news stories about global warming are other news stories. Further research might look more closely at these relationships, especially because coverage of global warming and climate change has seemed to increase over the last decade.

We were also surprised at the lack of a relationship between global warming knowledge and worry and perceived personal relevance. If a better understanding of global warming is the result of a person's ability to integrate global warming concepts with preexisting knowledge structures (as suggested in the above literature review), then it should follow that personal relevance should be related to better knowledge. And if worry is positively related to information seeking (see Kahlor, 2007), then it should follow that worry is related to knowledge. But this was not the case in either scenario. Further research might examine whether seeking inspired by worry is less productive (in terms of knowledge gain) because it is somehow under duress. The research on fear appeals might be useful in informing this research (see Dillard, 1994; Dillard & Peck, 2000).

The lack of a relationship between perceived relevance and global warming knowledge could be the result of encountering information that does not frame the information as personally relevant or foster the ability to make such linkages. For example, Trumbo (1996) analyzed news stories about climate change and located them within the first three stages (preproblem; alarmed discovery, euphoric optimism; and realizing the cost) of Downs' (1972) issue attention cycle. He found that as the stories progressed through the stages, their focus shifted from the problems and causes of climate change to judgments and remedies, and he argued that "the years following 1994 should present a continued decline of media attention to the issue punctuated by a 'spasmodic recurrence of interest'" (pp. 280-281). Although current (i.e., 2008-2009) interest in global warming seems to be relatively high, at the time of data collection, the issue might have been in one of the final stages of the cycle, corresponding to a drought in media coverage of global warming. Indeed, Boykoff (2008) found that U.S. television news coverage of anthropogenic climate change more than quadrupled from 1996 to 1997 and then receded roughly 50% by

2004. Although his analysis ended with the year 2004, it is not unlikely that the trend of declining coverage continued through 2005, the year when the data for our study were gathered.

Another reason these hypotheses were not supported might be that our measures of worry and personal relevance did not accurately reflect respondents' affect toward global warming. The items measuring personal relevance related individual effects of global warming (i.e., its effects on one's life and health). Furthermore, the item measuring worry was ambiguous as to the proximity of the object of concern. That is, rather than measure respondents' affect related to, say, their local community, they were asked only to indicate the degree to which global warming is important and worrisome. However, Lieserowitz (2005, 2006) found that Americans' concern about global warming is focused primarily on global human and environmental impacts, and less on how it affects themselves, their families, and their local communities. This finding suggests that our measurements of personal relevance and worry as related to global warming might not have been appropriate. Furthermore, it suggests that personal relevance might not be important at all, and that a measurement of worry should focus on geographically distant people and ecosystems.[6]

Finally, our finding that worry does not correlate with knowledge might be the result of a suppressor effect of perceived self-efficacy related to the global warming. That is, the more people worry about global warming, the less they feel they have control over it and the more likely they are to avoid information about it. This effect has been demonstrated in several studies interested in health information avoidance (Case, Andrews, Johnson, & Allard, 2005; Lee, Hwang, Hawkins, & Pingree, 2008; Miles, Voorwinden, Chapman, & Wardle, 2008). However, this effect is likely confounded by the fact that individuals have and likely perceive less immediate control over global warming than over their own health. Furthermore, if participants exhibited this effect uniformly with regard to global warming, then a negative relationship should have emerged instead of the near-zero relationship we found. Thus, if the relationship between worry and knowledge about global warming is mediated by self-efficacy, there are additional moderating variables that must be considered.

Reflecting on the measurement of our dependent variable(s), we were able to offer readers a relatively novel approach to measuring and coding knowledge complexity and accuracy in a survey setting. A promising finding is that independent variables were better predictors of the composite knowledge scale (R^2 = .13) than the contributing/affected elements

(R^2 = .07), causal connections (R^2 = .06), overall complexity score (R^2 = .08), or overall accuracy score (R^2 = .05; see Table 3) individually. This suggests that the overall knowledge scale reflects facets of knowledge that extend beyond any of the subscales taken alone. However, there are important considerations for future research that might replicate our methods. Of primary concern is the fact that the data that emerged from this questionnaire and coding scheme resulted in a knowledge variable with a restricted range. A variable is said to have restricted range when its variance is less than that of the population to which it is to be generalized. A problem with restricted range is that correlation and regression coefficients will be attenuated (Grissom & Kim, 2005).

Looking at the raw data, one obvious culprit was the short length of participants' responses. As noted in the literature review, the Kahlor et al. (2004) study that informed this coding scheme analyzed responses that were at least a paragraph in length. Many of the responses in this current effort were a single sentence, and in some cases, not even a complete sentence. One approach to overcoming this limitation is to employ follow-up prompts/probes. Although probing is difficult in an online survey, it can certainly be done in a telephone survey and managed in some capacity (with a little creativity) in a mail or online survey. In an online survey, a researcher might ask for a free response and then follow up with a prompt that elicits more specific knowledge. Another method would be to supplement the open-ended response with several closed-ended measures of knowledge (see Bord et al., 2000; National Science Board, 2008).

In conclusion, this study addressed whether antecedents of information seeking as portrayed in the RISP model (with the addition of attitude toward the behavior) surfaced as antecedents of actual global warming knowledge. The results were mixed. Among the key RISP concepts employed in this model—risk perception, worry, control, and subjective norms—only our secondary measure of control (understanding) surfaced in the predicted direction. One additional concept, attitude toward the behavior, also surfaced in the analysis, albeit not entirely as predicted. Among our strongest predictors were education, prior seeking effort, and the number of news media sources used. These findings suggest that future research continue to examine the relationships between information seeking intent, actual information seeking, and knowledge. As our introduction suggests, a more complex understanding of the antecedents of science knowledge/literacy can go a long way in informing efforts to build more effective models for improving science literacy and civic engagement. This study accounted for slightly more than 10% of the variance in global warming knowledge, indicating that there are many more antecedents of science knowledge/literacy yet to isolate.

Appendix A

While the Kahlor, Dunwoody, & Griffin (2004) data were gathered verbally in a telephone interview and was aided by interviewer prompts for elaboration, the current study was conducted online—respondents had to type their answers and there were no prompts for elaboration. As a result, our responses were notably shorter. For example, while the scale of measurement used by Kahlor et al. (2004) was on the magnitude of a paragraph, and contributing constructs were on the magnitude of a clause, our respondents' explanations ranged from a single word to a short paragraph. Consequently, we were able to extract fewer isolable constructs; indeed, we were limited in many cases to single nouns.

Development of an appropriate coding scheme began with three coders who were instructed to read a sample of 10 explanations and, for each explanation, count the number of individual elements contributing to or affected by global warming. Generally, such elements could be considered causes and effects of global warming. However, comparing the coders' results revealed a number of points of confusion as to what constitutes a contributing/affected element. After two additional rounds, coding 10 new explanations in each round, we arrived at the following six restrictions to the original instructions: (a) When a noun/element is described as possessing another, the possessive element is not counted, for example, in the clause *the Earth's atmosphere*, the word *Earth* is not counted as a contributing element (atmosphere is counted); (b) compound nouns such as greenhouse gases are counted as a single element; (c) pronouns are not counted as elements; (d) noun forms of verbs, for example, *warming* in *warming of the planet* are not counted (planet is counted in that example); (e) such expressions as *etc.* and *and the like* are not counted; and (f) the phrase global warming is not counted, as that was what respondents were asked to explain.

To illustrate our coding more clearly, consider the following response intended to explain global warming: The temperature is rising because of pollution. This is causing the world's weather patterns to change [and] water levels to rise because of the polar caps melting.

In that response, our coding scheme isolated five contributing elements: (a) temperature, (b) pollution, (c) world's weather patterns, (d) water levels, and (e) polar ice caps.

As mentioned above, however, we also needed to assess a second dimension of complexity in these responses: the degree to which these elements were related. The purpose for assessing this additional dimension is to get at the depth (not just breadth) of the knowledge within this domain. That is, we assume that a

(continued)

Appendix A (continued)

statement containing elements (breadth) whose relationships are explained to some degree (depth) is more complex than one in which the elements are presented as unrelated. We termed these relationships causal connections. To develop this stage of the coding scheme, our three coders were instructed to count the number of explicit causal connections. Examples of these connections included *due to*, *because of*, and *resulting in*. However, through the same iterative process described above, we discovered that when explanations included either implied causation (the atmosphere warms, melting the ice caps) or partial causation (greenhouse gases enable the atmosphere to trap more energy) the count was inconsistent across coders. Thus, it was more reliable to count only explicit causal connections—that is, complete causal statements that usually contained the connections noted above. This adjustment allowed us to assess a clearer (albeit not as complete) snapshot of complexity across individual responses.[7]

In the example above, which contained five contributing elements, we were able to locate three causal connections: (a) temperature rising because of pollution, (b) this is causing the world's weather patterns to change, and (c) water levels rise because of the polar ice caps melting.

The composite complexity score for each response was calculated as the sum of the number of contributing elements and the number of causal connectors. For the above example, the total complexity score would be 5 + 3 = 8. This method is consistent with that used by Kahlor et al. (2004). The number of contributing elements ranged from 0 to 17 ($M = 2.28$, $SD = 1.59$), the number of causal connectors ranged from 0 to 4 ($M = 0.52$, $SD = 0.71$), and the composite complexity score ranged from 0 to 20 ($M = 2.79$, $SD = 2.10$).

Appendix B

We began by locating cause/effect/change statements so that we could assess the accuracy of those statements. This is slightly different than when coders identified contributing elements and causal connections. While the former two dimensions assessed elements and their relationships with one another, the latter construct assesses all of the phenomena (i.e., cause, effect, change, circumstance) mentioned within the response. Let us revisit our example: The temperature is rising because of pollution. This is causing the world's weather patterns to change [and] water levels to rise because of the polar caps melting.

In that example, we isolated the following five cause/effect/change statements (phenomena): (a) the temperature is rising, (b) because of pollution, (c) world's weather patterns [. . .] change, (d) water levels rise, and (e) polar ice caps melt.

(continued)

Appendix B (continued)

Note that the accuracy of each statement was scored on a three-level scale: erroneous (0), partially correct (1), and correct (2). Specifically, a cause/effect/change statement was scored as erroneous if it contradicted scientific findings (e.g., the planet is cooling) or identified a different phenomenon (e.g., a hole in the ozone layer). A statement was coded as partially correct if identified a relevant phenomenon but failed to indicate a direction (e.g., the Earth's climate is changing), identified a relevant but general phenomenon (e.g., natural disasters happen), identified a relevant but general cause (e.g., pollution), or was so overly general that any phenomenon might be described (e.g., a state of the universe). A statement was scored as correct if it correctly identified a trend resulting from global warming and the direction of that trend (e.g., average ocean temperatures are increasing), correctly identified a specific cause of global warming (e.g., is caused by CO_2 emissions), or invoked the term *greenhouse effect*. Thus, (a) the temperature is rising (change statement, correct, 2 points), (b) because of pollution (cause statement, partially correct, 1 point), (c) world's weather patterns [. . .] change (effect/change statement, partially correct, 1 point), (d) water levels rise (effect/change statement, correct, 2 points), and (e) polar ice caps melt[. . .] (effect/change statement, correct, 2 points).

Finally, to calculate the total accuracy score for each explanation, we summed the initial accuracy scores and divided this number by the number of cause/effect/change statements, and then again by 2 (the maximum score for each statement). This scaled the accuracy scores to a minimum value of 0 and a maximum value of 1. Thus, the example above had a total accuracy score of $(2 + 1 + 1 + 2 + 2) \div (5 \times 2) = 8/10 = .8$. The number of cause/effect/change statements ranged from 0 to 13 ($M = 2.00$, $SD = 1.24$), initial accuracy scores ranged from 0 to 11 ($M = 2.38$, $SD = 1.79$), and final accuracy scores ranged, as designed, from 0 to 1 ($M = 0.60$, $SD = 0.34$).

Notes

1. The term *global warming*, rather than climate change, was employed throughout this study. At the time these data were gathered (summer of 2005), it was the impression of this research team that the media and scientists were employing the term global warming more frequently than the term climate change. As a result, it was assumed that respondents would be more familiar with the term global warming.

2. These items correspond with the personal impact dimension of Slovic's (2001) psychometric risk perception paradigm.

3. According to Leiva, Rios, and Martinez (2006), other common methods for computing intercoder reliability—Cohen's K, Holsti's CR, and Scott's Pi, among others—are only useful when the data are nominal. As our data are at the ordinal and ratio levels, Krippendorff's alpha is the most appropriate. In addition, Krippendorff's alpha is appropriate for any number of coders and at any level of measurement with or without missing data (Hayes & Krippendorff, 2007).

4. This number was computed from Lacy and Riffe's (1996) formula for subsample size generation for intercoder reliability checks.

5. Leiva et al. (2006) reported an acceptable Krippendorff's alpha level of .75.

6. Furthermore, the correlation matrix presented in Table 4 reveals that personal relevance and worry are highly correlated ($r = .70$, $p < .01$), and both have moderate to high correlations with subjective norms, instrumental attitudes, and seeking effort. While this multicollinearity might explain why Hypothesis 3 and Hypothesis 4 were not supported, the first block of the hierarchical regression indicates that the exclusion of norms, attitudes, and effort does not improve the regression coefficients for personal relevance and worry.

7. Among a sample of 100 responses, 44 made explicit causal connections, while only 3 made nonexplicit causal connections. Thus we feel the amount of data lost is acceptable.

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