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Original Research

Natural Resource Experience Affects Engagement with Emotionally Primed Presentations of Science☆

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ABSTRACT

Effective ecosystem management is supported by the communication of emerging science to a wide range of ecosystem stakeholders. Management-oriented audiences including policymakers, agency personnel, and agricultural producers vary in their values, beliefs, and experiences and consequently may receive scientific information in unique ways. We examine the impact of priming language presented before technical presentation of ecosystem science using emotionally loaded ("negative" and "positive") introductory paragraphs (primers). Wyoming ecosystem stakeholders ($n = 114$) were presented with technical text describing ecosystem uncertainty immediately after they read either positive or negative primers. Respondents with a background in agricultural production were more likely to respond in agreement with the scientific information presented in the text when it was introduced with the negative emotional (risk-based) primer. Respondents without production experience shifted their assessment of scientific information in response to both negative and positive (benefit-based) primers. All participants' responses were varied and unpredictable when technical text was not primed. Emotionally loaded primers did not lead respondents to contradict the scientific knowledge presented in the text, and in several cases primers caused stronger agreement with the text than did the control. We suggest that traditional "neutral" presentation of scientific contexts hinders rather than supports the transmission of scientific concepts and tools to management-oriented audiences. We more readily achieve successful transmission of science when emotional contexts familiar to audiences are evoked. Non-neutral primers followed by technical presentations of scientific concepts can engage audiences to increase potential field applications of emerging science.

Introduction

Effective ecosystem management is supported by partnership and communication between researchers and ecosystem stakeholders emerging from many different sectors, who can share knowledge and collaborate to set goals (Briske, 2012; Littell et al., 2012). In particular, ecosystem stakeholders such as agricultural producers, policymakers, and agency personnel tasked with enforcing policy must be able to access emerging science and evaluate that science in light of particular management challenges (Millar et al., 2007). Therefore, outreach to a diversity of stakeholder audiences is an important step in the translation of emerging science for application in management and policy (Briske, 2012).

Traditionally, scientists are trained to convey their findings neutrally, avoiding language that conveys values or beliefs (Lackey, 2007; Baram-Tsabari and Lewenstein, 2012). However, readers immediately begin judging text as they read; neutral writing is not neutrally received (Weber and Word, 2001). Many factors besides technical details of the science itself, such as audience experiences, values, and beliefs, affect how and whether an audience judges science to be true (Donner, 2011; Holtcamp, 2012). For example, debates surrounding climate change linger despite increased conveyance of scientific climate analyses (Nisbet and Mooney, 2007).

Stakeholder audiences are varied in perspectives and priorities, and their assessments of science depend on the role they play in interacting with the natural world. For example, hands-on managers often think of ecosystems in value-based terms and conceptualize conservation on broad scales (e.g., whole landscapes, species and/or populations) (Buijs and Elands, 2013). Producers, who have a specific livelihood stake in the functioning of an ecosystem, may be particularly sensitive to ecological risks and associated uncertainties when compared with other audiences (Marra et al., 2003). Among policymakers, risk aversion

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may lead this group to minimize potential environmental threats (Howlett, 2014). Despite this diversity of background stakes, both technical and nontechnical audiences conceptualize nature and landscapes emotionally (Buijs and Elands, 2013).

Bringing large-scale scientific issues to a more tangible human scale is important for fostering engagement with science and its applications. Personal experience plays a role in shaping beliefs about science (e.g., in the case of climate science), but beliefs also help shape how experiences are filtered and processed (Myers et al., 2012; Van Der Linden, 2014). Interventions and framing that focus on engaging at the personal level can potentially have a large impact in terms of broadening communication and understanding of scientific research and results. Effective science communication needs to account for differences in audience background and experience by specializing, rather than generalizing, the approach (Maibach et al., 2011).

Communication of emerging science to audiences who must apply that science occurs in many ways (Prokopy et al., 2015). Extension of research findings occurs in multiple formats (oral, online, written materials), but text-based outreach remains common among management-oriented audiences (Alston and Reding, 1998). Given the consistent utility of written outreach efforts, we ask how written outreach might more clearly convey emerging science and its application, depending on the type of stakeholder.

"Priming" was first documented by psychologists, who noted that an initial stimulus influences the response of a subject (often unconsciously) to a later stimulus or experience. Priming can affect the way that "neutral" information is interpreted. Participants who read a text describing intentionally ambiguous behavior are more likely to describe the behavior as positive or negative depending on their exposure to primers (Higgins et al., 1977). Priming effects are well established in social psychology literature and have been used to alter medical patient behavior (Kreuter et al., 2000; Webb et al., 2007). However, the application of priming to the communication of ecosystem science has been little explored. We suggest that priming audiences with non-neutral introductory material for scientific texts could facilitate reception of technically presented information.

We used a survey-based approach to document the impact of priming on audience assessment of technically presented scientific information. Surveys are commonly used to document the effectiveness of educational interventions in creating a shift in knowledge (Kelley et al., 2008). In the emergent field of science communication, surveys are used to assess translation of scientific information to diverse audiences (Ho et al., 2008).

Our technical text was focused on the topic of "managing for uncertainty." We considered this a useful and important topic for the study because of its relatively recent popularization; an audience of diverse ecosystem stakeholders was less likely to have encountered the concept. We crafted introductions that used "positive" and "negative" emotional language ("primers") to precede the technical text. The priming approach was compared with the more common strictly "neutral" language of scientists to understand whether priming might constitute a useful tool for engaging ecosystem managers and decision makers. We examined the effects of including primers that evoke distinct emotional contexts alongside written transmissions of technical information immediately after reading and 1 − 2 months after exposure to the text. No attempt was made to sway the reader's *opinion* of the information presented. Instead, we ask how the reader assessed the veracity (trueness) of the scientific concepts presented in the technical text. We describe reader responses in terms of their closeness in agreement with "more correct" statements, or disagreement with "more incorrect" statements, based on the information conveyed in the technical text.

In previous work, we documented that priming was successful at shifting respondent assessment of technical information in the short term (Gunther et al., 2017, dissertation). Readers treated with negative primers can be more receptive to technical information immediately after exposure (Gunther et al., 2017, dissertation). Here, we consider how experiential backgrounds (agricultural and professional) of survey respondents interact with priming effects.

We ask whether background influenced reader assessment of technical information that is presented with either a positive or negative primer. To assess this question, we document differences in reader responses to individual survey statements. We also consider how reader experience and profession led to reader perception of material in order to draw conclusions about how primers influence different perceived types of material with different audiences (in this case, "tool-based" vs. "conceptual" information).

Our questions are 1) How does a respondent's experience in agricultural production (or lack of it) influence their response to the positive and negative emotional context? and 2) How does a reader's profession (policy enforcement vs. policymaking) interact with their response to primers? Ultimately, we document the ways that experience and profession influence an audience's assessment of scientific information.

Methods

We developed surveys to compare reader assessments of statements related to ecosystem uncertainty. Readers completed a prereading assessment of survey statements before exposure to experimental texts and repeated the survey immediately after reading, then again a month after initial survey. Groupings of stakeholders (agricultural producer, natural resource professionals, and/or policymakers) were based on their answers to demographic questions describing their professional and personal experience.

Development of Experimental Texts

We began developing the technical text, as well as "positive" and "negative" primers (introductory paragraphs), in January 2014. A two-paragraph informative technical text was developed to communicate 15 core pieces of content related to ecosystem uncertainty. The information presented included both conceptual and practical material. The text focused first on conceptual material related to identifying uncertainty as a feature of ecosystems (e.g., the existence of alternative ecosystem states). Further conceptual material defined the four major types of ecosystem uncertainty: 1) natural variability, both spatial and temporal; 2) measurement error; 3) ecosystem complexity and indirect effects; and 4) human unpredictability and variation. Practical material focused on tools and approaches available to manage for uncertainty: monitoring approaches; statistical calculations, including accounting for error; observations at the landscape scale; and improved outreach and communication practices (Walker et al., 2004; Burgman et al., 2005). Technical text was presented in a traditional scientific outreach format, avoiding the creation of an emotional context for neutral information. For example, the text described variability over time and space, and manager approaches to this variability, as follows: "One type of uncertainty comes from the fact that all ecosystems display an amount of natural variability over time and space, making it difficult to set baselines. Monitoring consistently over a long time period is an effective way to capture a good "picture" of a system." The first sentence describes a "concept," and the second describes the corresponding manager "tool."

We developed two differing introductory paragraphs using emotionally loaded language to serve as primers. One primer incorporated "positive" language evoking landscape contexts related to hope, optimism, and freedom (e.g., "opportunity," "profit"). The second primer incorporated "negative" language that evoked landscape contexts related to fear, anxiety, and constraint (e.g., "risk," "threat"). These introductory paragraphs contained parallel sentence structures and were of equal length. Each primer began with "Imagine," thereafter suggesting imagery that either evoked ecological invasion (negative) or the economy of nature (positive). The primers were provided to two Wyoming land managers, to verify that they successfully evoked negative and positive emotional contexts.

Survey Construction and Distribution

We developed 15 statements corresponding to the core concepts and tools communicated in the technical text (Table 1). The statements were randomly assigned to "true" and "untrue" conditions. Affirmative versus oppositional sentence construction was also randomized (e.g., referring to an action as "possible" or "impossible," or referring to the "availability" vs. "lack" of a tool). (See Fig. 1.)

Our survey required participants to assess "how true" they found each statement (a measure we refer to as "veracity"). The rating scale developed for participants to rate veracity ranged from 0 to 6, with 0 indicating a participant perceived a statement as "very untrue" and 6 indicating a statement was perceived as "very true," while 3 was labeled as true neutral. To document that we captured a variety of management backgrounds in our survey sample, demographic items were also developed, including questions to identify the agricultural production, resource management, and policymaking background of each participant.

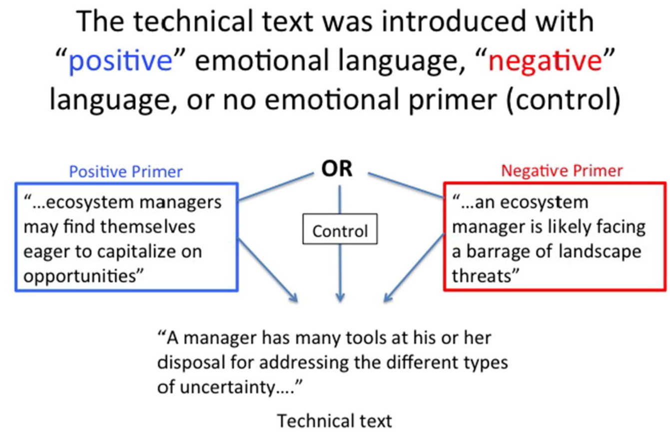

Fig. 1. Readers in the positive and negative treatment groups received emotional primers to introduce technical text. A control group received no primer. This approach allowed us to examine the effects of emotionally loaded introductory primers on reader perception of technical content veracity.

Participant Demographic Descriptions

Demographic questions were used to identify the agricultural production experience, as well as the professional resource management and policymaking background of each participant. Participants were asked about both "professional" and "personal" experience, with space to explain and justify any "personal" experience in a production-based livelihood but not explicitly in a production "career" (e.g., the spouse of an animal producer, an adult who was raised in a ranching family). Demographic characterizations were used to further clarify factors that may influence responses to the primers. We categorized respondents with production experience by identifying respondents who reported either professional or specific personal experience ("Production Experience") in agricultural production compared with respondents who reported no experience in production (Table 2).

We also created a second variable ("Natural Resource Management") to identify respondents who declared a specific professional background in either rangeland management or general natural resource management, versus those who did not. Policymaking experience was also treated as a separate variable, based on indication of professional experience in policymaking.

Policymakers and natural resource managers may or may not have production experience. Each participant completed demographic questions and then was asked to rate the veracity of the 15 statements related to the core material in the technical text.

Timing of Survey Implementation and Repetition of Ratings

After completing initial demographic information and statement ratings, participants placed completed materials into an envelope and read a randomly assigned text. Positive and negative treatment groups received the technical text with either the positive or negative primer. Because the primers were developed to evoke emotional context by discussing subjective experience, we determined that it was not possible to create a truly "neutral" version of the introductory paragraph. Therefore, our control group received the technical text with no emotionally loaded introduction. The positive and negative treatments were evenly distributed among surveys: 45% of surveys included the technical text with a positive primer, while 45% included the technical text with a negative primer. Ten percent of surveys distributed were

Table 1
Ecosystem uncertainty concepts rated by survey participants before and after initial intervention ($n = 114$) and $1-2$ months after intervention ($n = 34$). Statements were randomly assigned to be "true" or "untrue" compared with the content within the material that was presented to all readers in the intervention text. Affirmative vs. oppositional sentence construction (e.g., "possible" vs. "impossible," "is" vs. "is not") was randomly assigned to statements. Statement accuracy either supported or contradicted 5 core concepts: ecosystem uncertainty as an ecological concept or 1 of the 4 types of uncertainty identified in the text (natural variability, random variation, ecological complexity, or human unpredictability). Each statement relays either conceptual material ("concept") or applications ("tool"). When neutrally presented (without the influence of positive or negative primers) readers should shift ratings to be higher (more true) for accurate statements, and values to lower for inaccurate statements.

	Statement	Accurately reflects text?	Tool or concept?	Concept or tool	Direction of expected shift
1	Past experiences in an ecosystem do not provide a reliable model for predicting future outcomes.	Yes	Tool	Ecosystem uncertainty	Closer to 6
2	Managers have the tools to address ecosystem uncertainty.	Yes	Tool	Ecosystem uncertainty	Closer to 6
3	Defining the "baseline" state of an ecosystem is difficult.	Yes	Concept	Natural variability	Closer to 6
4	It is impossible to eliminate error in measures of ecosystem characteristics.	Yes	Tool	Random variation	Closer to 6
5	The lasting effect of DDT in ecosystems is an example of an unpredictable indirect relationship.	Yes	Tool	Ecological complexity	Closer to 6
6	Ecological complexities that are not as visible at the quadrat or plot scale are often more visible at the landscape scale.	Yes	Tool	Ecological complexity	Closer to 6
7	Humans contribute to ecosystem uncertainty.	Yes	Concept	Human unpredictability	Closer to 6
8	Uncertainty is a part of some, but not all, ecosystems.	No	Concept	Ecosystem uncertainty	Closer to 0
9	We cannot predict potential alternative future states in an ecosystem.	No	Tool	Ecosystem uncertainty	Closer to 0
10	We can determine the likelihood that an alternative future state will occur in an ecosystem.	No	Tool	Ecosystem uncertainty	Closer to 0
11	Monitoring is only useful for describing an ecosystem in the short term, not over the long term.	No	Tool	Natural variability	Closer to 0
12	Few random forces affect ecosystems.	No	Concept	Random variation	Closer to 0
13	Humans tend to have good control over indirect ecological relationships.	No	Concept	Ecosystem complexity	Closer to 0
14	Managers do not often have opportunities to make good observations of ecosystem complexities.	No	Tool	Ecosystem complexity	Closer to 0
15	Human values, as they relate to ecosystems, tend to be stable and consistent over time.	No	Concept	Human unpredictability	Closer to 0

Table 2
Participant agricultural experience and professional background, and primer treatment group membership—positive (+), negative (−), and control (C)—responding to surveys. No analyses included groups where $N = 1$.

Agriculture	Positive primer	Negative primer	Control	Total
Production experience	43	27	9	79
No production experience	12	19	1	32
Professional background				
Natural resources	23	24	5	52
Policymaking	13	14	5	32

assigned to a control state. After participants had read the text, they placed the text in the same envelope as completed survey materials and rerated the same 15 statements. One month after the initial intervention and surveys, participants were given the option to complete a follow-up survey in which they rated the same 15 statements once more.

We distributed surveys from June through December 2014 across a variety of Wyoming stakeholder groups. We targeted respondents with experience in agricultural production, policymaking, and policy enforcement (e.g., federal and state agency personnel). Participants ($n = 114$) were recruited at four locations around the state (Sheridan, Powell, Lingle, and Laramie, Wyoming) from attendees of University of Wyoming Agricultural Experiment Station Research and Extension Center field days. Additional participants were recruited from Wyoming Weed and Pest, the Wyoming Section of the Society for Range Management, and the Wyoming Stock Growers Association. County commissioners and members of the Wyoming Wildlife and Natural Resources Trust were contacted by telephone and email for direct recruitment into the study.

Surveys were distributed in hard copy and electronic forms. Follow-up surveys were administered via mail or email, or over the phone, depending on the preference indicated by respondent.

Data Analysis

To document whether the agricultural background of respondents interacted with the primers, we used two-way analysis of variance. We also analyzed preintervention statement ratings of all respondents to identify any preexisting differences among groups. Tukey's honest significant difference separation was performed to compare treatment means.

To evaluate the effect of professional background on response to treatment, we performed 1-way ANOVAs on preintervention and postintervention statement ratings. We first analyzed preintervention ratings to ensure no preexisting differences existed among treatment groups. Separate 1-way ANOVAs were then performed on statement rating values both immediately after intervention and 1 − 2 months after intervention. Tukey's post-hoc comparisons were used to determine differences among groups. Thirty percent (34 of 114) of respondents completed a follow-up response up to 2 months after the initial survey. Although this return rate represents an acceptable subsample of our initial survey sample, the smaller pool of respondents 1 − 2 months after intervention constrain our ability to analyze the follow-up surveys among professional groups (Wright, 2015).

Demographic analysis (gender, educational background, and income level) was completed for each professional and experiential subpopulation (production, natural resource management, and policymaking). In order to evaluate how respondents from each professional and experiential subcategory conceptualized the survey items after exposure to the technical text (regardless of intervention), we performed factor analyses. Factor analysis documented whether respondents from experiential and professional backgrounds differ in their perception of the survey questions within the "tool" versus "concept" dichotomy that we created in the statements. We generated two-factor solutions for participant responses after intervention for each respondent experiential and professional group using a generalized least squares (GLS) extraction. A Varimax rotation was used to ensure orthogonality.

Factor analyses were completed separately for respondents reporting background in agricultural production and respondents who did not report this background. Factors were generated using statement ratings completed immediately after intervention, across all treatment groups. Two-factor solutions were also generated for respondents with professional natural resource experience. For respondents reporting a professional background in policymaking, a two-factor factor analysis solution could not be generated using GLS extraction, and therefore a maximum likelihood extraction was conducted. We compared factor analyses using visual inspection of factors.

Results

Respondent Demographics

A total of 114 respondents completed the survey. Of these, 79 reported agricultural experience and 52 reported professional experience in natural resource management, while 32 reported professional experience in policymaking (see Table 2). While the majority of those reporting resource management experience also had production experience ($N = 38$), more than half of those reporting production background ($N = 41$) did not have natural resource experience as defined in this study.

Education level did not differ between respondents with and without production experience ($F_{1,109} = 0.192$, $P = 0.662$). Education levels were also not different between those who reported a professional background in range or natural resources and those who did not ($F_{1,109} = 2.357$, $P = 0.128$). However, respondents who explicitly identified themselves as having professional experience in "natural resource management" reported a higher level of education compared with those who did not ($F_{1,109} = 5.521$, $P = 0.021$). Respondents with and without professional background in policymaking did not differ by educational level ($F_{1,109} = 0.136$, $P = 0.713$).

Reader Response to Primers Within Agricultural Production Experience Groups

Among respondents in the control group (who received no primer), only one respondent reported having no production background (see Table 2). Consequently, this respondent was removed from analysis and only treatment comparisons between positive and negative primer groups are reported. In no case did responses differ among production

Table 3
Reader rating 2-way analysis of variance from 15 survey statements immediately after intervention to assess the interaction and simple effects of primer treatment and experiential background. Probabilities with asterisks are ≤0.075. Survey statements are described fully in Table 1.

Survey statement #	*Primer treatment*	*Agricultural background*	*Primer x background*
1	0.335	0.381	0.396
2	0.749	0.740	0.139
3	0.350	0.231	0.464
4	0.079	0.501	0.026*
5	0.310	0.214	0.886
6	0.661	0.308	0.038*
7	0.869	0.820	0.502
8	0.165	0.972	0.614
9	0.234	0.136	0.532
10	0.366	0.659	0.739
11	0.088	0.139	0.039*
12	0.538	0.571	0.348
13	0.673	0.843	0.089
14	0.046*	0.639	0.073*
15	0.622	0.462	0.597

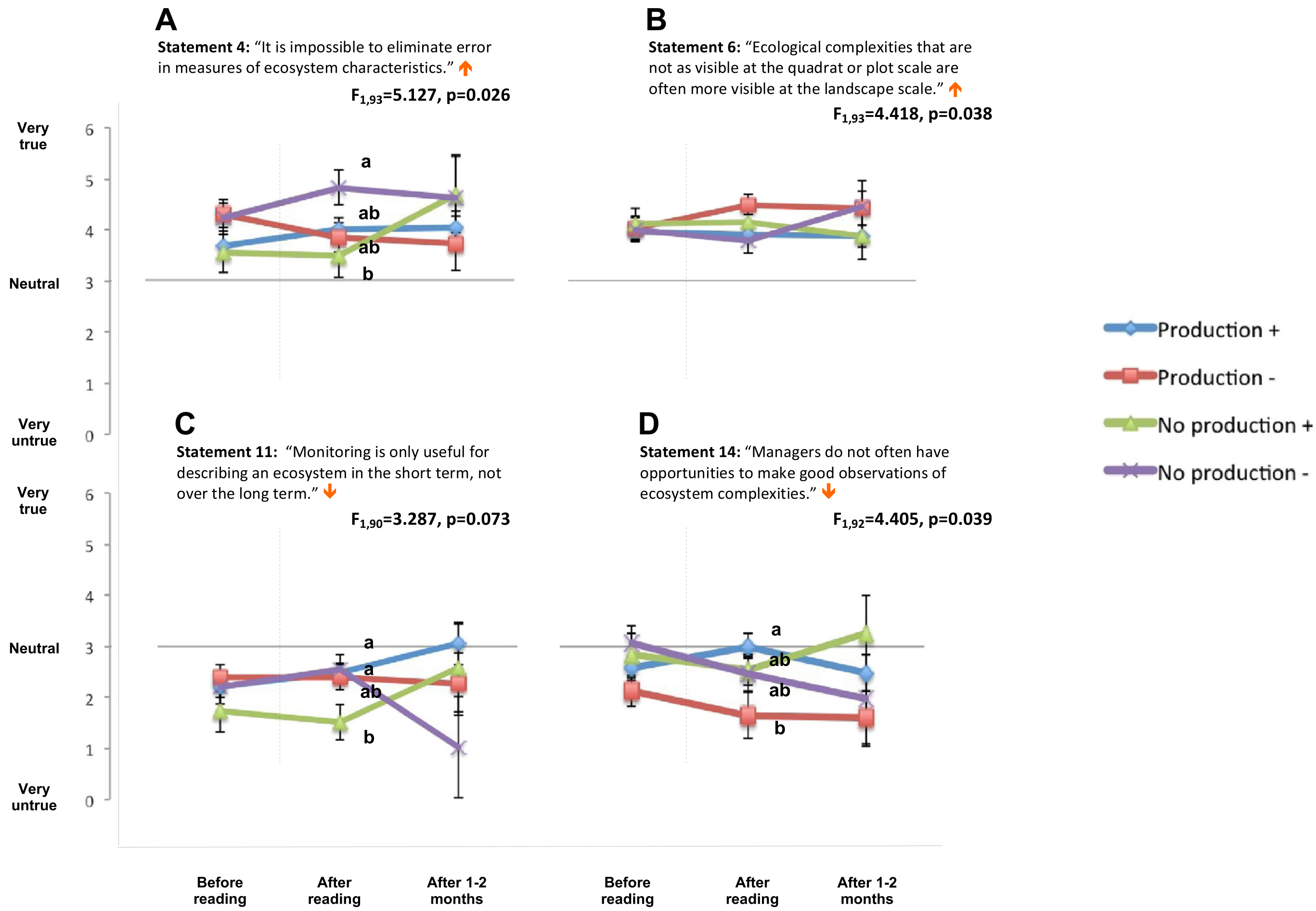

Fig. 2. a-d. Statement ratings from survey respondents within two experience-based groups (with or without agricultural production experience) receiving positive or negative primers. Responses for survey statements 4 (a), 6 (b), 11 (c), and 14 (d) are shown. Arrows after statements indicate direction of anticipated reader shift (Table 1). F-test values and probabilities from two-way ANOVAs are for interactions of primer treatments and experience groups. In survey statement 14, the response of primer groups also differed ($p = 0.046$), regardless of production experience. Error bars represent standard error of the means. Letters separate *primer x experience* means only within the sampling date immediately after reading. In statements 4 and 6, accurately engaging the neutral technical text should cause reader ratings to increase after reading, whereas in statements 11 and 14 the ratings would decrease after reading. N = 34 respondents completed the survey after 1-2 months; N = 27 producers, N = 7 non-producers.

experience groups alone, irrespective of primer. The simple effect of agricultural production experience was nonsignificant for all 15 statements. No effects of primer were found between the respondents within experience groups 1 − 2 months after intervention.

Immediate responses of participants to primers depended on their production experience (an experience by primer interaction) on 4 of the 15 survey statements (statements 4, 6, 11, and 14; Table 3, Fig. 2A − D). Readers with no production experience who received the negative primer rated statement 4 (Fig. 2A) more "true" (they aligned with the technical text more closely) immediately after intervention. For another statement (statement 11, Fig. 2C), nonproducers who received the positive primer rated the statement in accord with text immediately after intervention.

Among respondents with agricultural production experience, the group receiving the negative primer assessed statement 14 in closer accordance with the technical text (Fig. 2D) immediately after intervention. The response of readers with production experience who received the positive primer was more uniformly neutral on the four statements. The negative primer resulted in a shift in assessment (reader assessments aligned more closely to the text content) among producers.

Production experience appears to have differentiated how respondents conceptualized the relationships between statements (Table 4a and b). Results of the factor analyses indicate that respondents with production experience tended to associate "concept" and "tool" statements distinctly, mirroring the deliberate construction of the text and survey items. Table headings (see Table 4a) reflect the balance of tool vs. concept content represented within the factors. Among respondents with production experience, one factor (labeled "ecosystem stability concepts") was driven completely by "concept" statements (factor loadings 0.747, 0.694, 0.668, 0.602). The second factor ("Ecosystem experiences and tools") was driven by two "tool" statements (factor loadings 0.667, 0.590) and Statement 3, a "concept" statement (factor loading 0.722). Though statement 3, which conveyed material about the difficulty of setting ecosystem "baselines," had been designed as a "concept" statement, it was interpreted as and associated with tool-based material.

For respondents without production experience, the "tool" versus "concept" dichotomy was not reflected in respondent characterization of statements. Table headings (see Table 4b) represent this balance of content within factors. One factor captured a diverse mix of "concept" and "tool" statements all related to direct human interaction with ecosystem uncertainty ("Human interaction with environment"). The driver variables were two tool statements (factor loadings 0.699, 0.677) and one concept statement (0.760). The second factor, composed of only three statements, emerged around conceptual statements related to ecosystem instability. The driver variables were both concept statements (factor loadings 0.999, 0.669) asserting the relative predictability of ecosystems.

Reader Response to Primers by Profession

Natural resource professionals who received either the negative primer or no primer (controls) more closely agreed with the technical text, compared with natural resource managers receiving positive primers, who were more neutral (Table 5, Fig. 3A−C). On statement 9 (see Fig. 3B) only the control group's assessments more closely agreed with the technical text after intervention, whereas both the negative and positive treatment groups did not assess the information as more true or untrue, remaining neutral. In another case, veracity assessments of natural resource professionals who received the negative primer more closely agreed with the text (statement 4; see Fig. 3A). No differences between treatment and control groups were documented before intervention. No differences were recorded after 1−2 months for natural resource respondents completing the final survey ($n = 15$). A two-factor solution suggested that natural resource managers tended to adhere to the "tool" (factor loadings of drivers 0.932, 0.649, 0.621) versus "concept" (factor loadings of drivers 0.798, 0.639) dichotomy among survey statements (see Table 4c). Table headings reflect the adherence to this dichotomy.

Veracity assessments of policymakers who received either the positive or negative primer more closely matched the technical text compared with policymakers who received the control language (statement 6, see Table 5, Fig. 4). No differences between treatment and control groups were documented before intervention. Policymaker assessments did not differ between primer treatments 1−2 months after intervention ($n = 8$). In a two-factor solution, policymakers adhered to the "concept" versus "tool" dichotomy only in terms of which statements drove the factors (Table 4d, factor loadings 0.800, 0.727, 0.709, 0.697, 0.718, and 0.639). Four statements (3, 6, 9, and 10) loaded into both factors, suggesting that statements were not perceived dichotomously.

Table 4

Factor loadings (in parentheses) > 0.3 are reported, and factor loadings > 0.6 (in bold) are considered to indicate variables "driving" the pattern of the factor and all variables with factor loadings.

(a) Respondents reporting production experience

Ecosystem stability concepts	Ecosystem experiences and tools
12: Few random forces (0.747)	**3: Difficult to set baseline (0.722)**
15: Values stable (0.694)	**9: Cannot predict future states (0.667)**
13: Humans have control (0.668)	**11: Monitor for short term, not long (0.590)**
−7: Humans contribute to uncertainty (0.602)	14: Opportunities for observations (0.458)
8: Not all ecosystems have uncertainty (0.467)	1: Past experiences not reliable (.0385)
10: Can predict likelihood (0.405)	−10: Can predict likelihood (0.381)
−3: Difficult to set baseline (0.403)	
11: Monitor for short term, not long (0.367)	
−5: DDT unpredictable (0.353)	
−6: Quadrat and plot vs. landscape (0.305)	

(b) Respondents not reporting production experience

Human interaction with environment	Ecosystem predictability
15: Values stable (0.760)	**12: Few random forces (0.999)**
14: Opportunities for observations (0.699)	**13: Humans have control (0.669)**
10: Can predict likelihood (0.677)	−1: Past experiences not reliable (0.482)
−9: Cannot predict future states (0.548)	
4: Impossible to eliminate error (0.523)	
8: Not all ecosystems have uncertainty (0.456)	
−7: Humans contribute to uncertainty (0.425)	
13: Humans have control (0.366)	
−2: Managers have tools (0.329)	

(c) Respondents reporting professional experience in natural resources

Ecosystem stability concepts	Tools and measurements
13: Humans have control (0.932)	**9: Cannot predict future states (0.798)**
12: Few random forces (0.649)	**3: Difficult to set baseline (0.639)**
−6: Quadrat and plot vs. landscape (0.621)	14: Opportunities for observations (0.526)
15: Values stable (0.577)	11: Monitor for short term, not long (0.506)
−4: Impossible to eliminate error (0.488)	4: Impossible to eliminate error (0.435)
−7: Humans contribute to uncertainty (0.485)	1: Past experiences not reliable (0.392)
10: Can predict likelihood (0.436)	

(d) Respondents reporting professional experience in policymaking

Stability concepts and human control	Inability to predict long term
12: Few random forces (0.800)	**11: Monitor for short term, not long (0.718)**
15: Values stable (0.727)	**−10: Can predict likelihood (0.639)**
−7: Humans contribute to uncertainty (0.709)	1: Past experiences not reliable (0.576)
13: Humans have control (0.697)	9: Cannot predict future states (0.485)
−5: DDT unpredictable (0.513)	−2: Managers have tools (0.481)
−3: Difficult to set baseline (0.426)	3: Difficult to set baseline (0.465)
−10: Cannot predict future states (0.378)	14: Opportunities for observations (0.443)
10: Can predict likelihood (0.346)	−6: Quadrat and plot vs. landscape (0.301)
−6: Quadrat and plot vs. landscape (0.337)	

Table 5

Primer treatment differences among survey respondents who identified as natural resource professionals or policymaking professionals. Table reports analysis of variance F-test probabilities (*P* values) to assess primer treatment differences within respondents grouped by profession immediately after intervention. Probabilities with asterisks are ≤0.05.

Survey statement no.	Natural resources	Policymaking
1	0.161	0.594
2	0.534	0.204
3	0.380	0.523
4	0.039*	0.727
5	0.261	0.303
6	0.374	0.022*
7	0.144	0.209
8	0.105	0.575
9	0.039*	0.404
10	0.694	0.241
11	0.695	0.408
12	0.394	0.959
13	0.441	0.441
14	0.032*	0.505
15	0.552	0.341

Discussion

We found that responses to primers differed among respondents on the basis of their experience and profession in 4 of 15 survey questions. The fact that primer response depended on reader experience leads us to conclude that primers do not universally alter the reception of science in all audiences. However, in some cases, knowledge of the audience experience and profession can result in stronger assessments of technical information. Across all experience and background categories, responses to primers differed exclusively for "tool-based" statements (see Table 1). We found neither treatment nor interaction effects for statements related to the conceptual material presented ("types of uncertainty"). This observation is bolstered by results of the factor analysis, which demonstrate that readers in hands-on roles and natural resource-

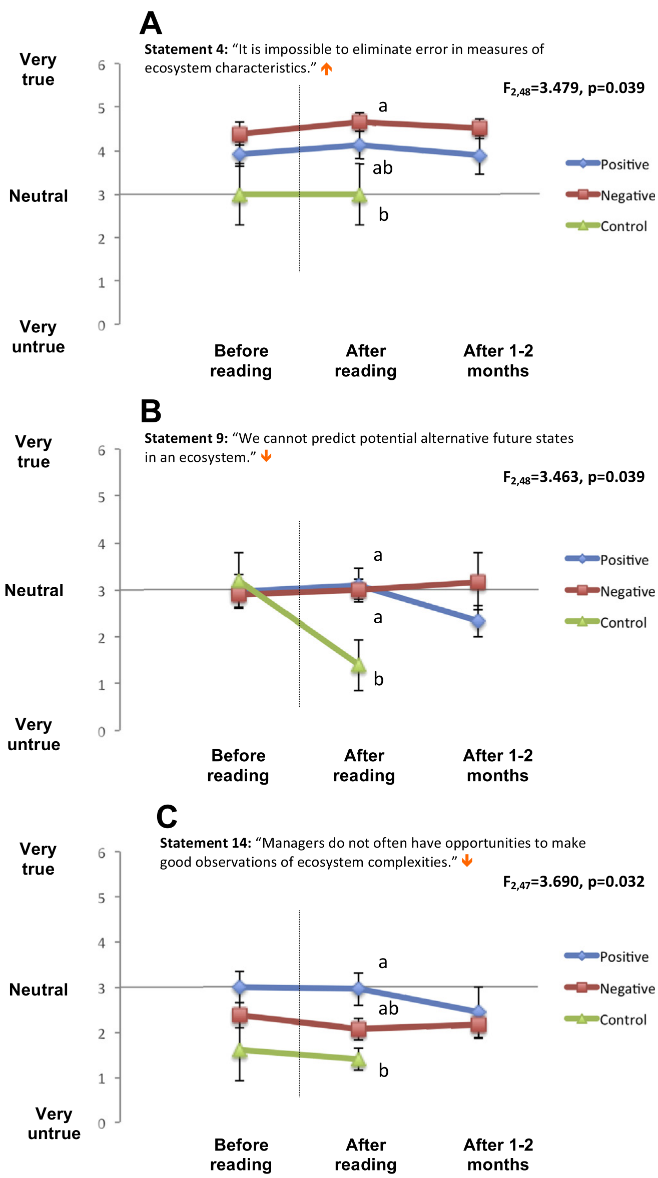

Fig. 3. a-c. Responses among natural resource professionals on statements 4(a), 9(b) and 14(c) before, after, and 1-2 months after intervention. Arrows after statement indicate direction of predicted reader shift (Table 1). Error bars represent standard error of the mean. F-test values and probabilities (p values) for one way ANOVAs for treatment (primer) effects included. Letters separate treatment means only in the time period immediately after intervention. For statement 4, accurately engaging the neutral technical text should cause reader ratings to increase after reading, whereas in statements 9 and 14 the ratings would decrease after reading. N = 15 natural resource professionals completed the survey after 1-2 months.

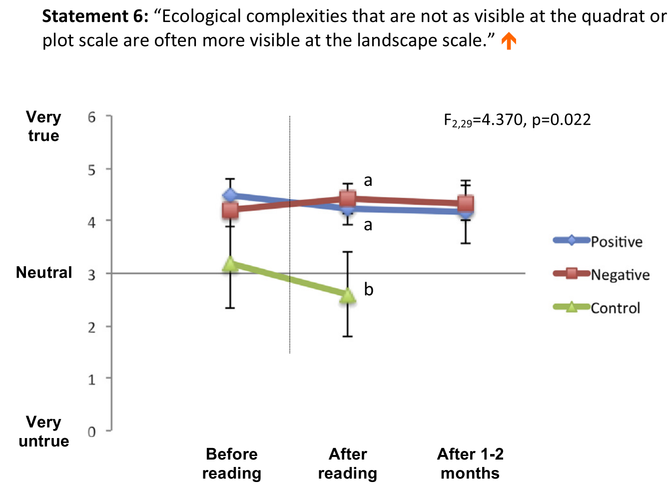

Fig. 4. Response among policymakers on statement 6 before, after, and 1-2 months after intervention. Arrow after statement indicates predicted direction of reader shift (Table 1). Error bars represent standard error of the means. F-test values and probabilities (p values) for one way ANOVA analysis of treatment (primer) effects included. For statement 6, accurately engaging with the neutral technical text should cause reader ratings to increase after readings. Letters separate treatment means only in the time period immediately after intervention. N = 8 policymakers completed the survey after 1-2 months.

specific professions perceived a clear distinction between "conceptual" and "tool"-based material.

We found no cases in which the use of negative or positive language caused readers to shift their veracity ratings to contradict the science presented in the technical text. However, we did observe that in one case veracity assessments of the control group more closely matched the text, while the treatment groups did not assess statements as more true or untrue and remained neutral. We conclude in general that our primers do not cause incorrect assessments of otherwise technically written science, but that traditional technical presentation may be a good communication choice for natural resource professional audiences.

Participant background in agricultural production affected how they responded to positive and negative primers. For respondents who reported production experience, negative language was effective at leading reader assessments of veracity to more closely match the science (see Fig. 2). Producers are strongly attuned to risks and losses in uncertain ecosystems (Marra et al., 2003; Menapace et al., 2012).

By contrast, readers who reported no production experience were responsive to the use of negative language for one statement and by the use of positive language in another, suggesting the outcome of primer use is less predictable in audiences who lack hands-on production experience.

Not surprisingly, the differences we documented between respondents with and without production experience indicate that readers' experiential background interacts with their assessment of technical information. Those with hands-on experience displayed more concrete ability to distinguish conceptual material (types of uncertainty) from the tools presented for addressing uncertainty. Presentation of tangible examples that connect to a subject's experience is a common approach for increasing audience comfort with technical information (Crimmins et al., 2007).

Among natural resource professionals, positive language did not alter reader assessment of statement veracity, whereas veracity assessments of negative and control readers more closely matched the technical text. The most dramatic divergence between treatments among natural resource professionals occurred when readers were exposed to unprimed technical language, which suggests that technical language may be an effective communication tactic for natural resource professionals who often receive and digest traditional scientific communications in their professional roles. Natural resource professionals were more likely to report a higher level of education, which may contribute to familiarity and comfort with technical language. However, technical language did not reliably drive reader assessments to match the text in other experiential and background groups.

Policymakers in the control group present the only case in which respondent assessments shifted toward a veracity rating that contradicted the technical text. On the basis of our findings, policymakers are less predictable than our other subgroups in their response to technical language. Generalizing across all primer treatments and control language, technical text was unpredictable in its potential to shift reader assessment toward accurate engagement with the science. As readers encounter technical, more "neutrally" presented text, they may quickly judge it as either negative or positive (Weber and Word, 2001).

Presenting readers with emotional primers in advance of technical text led readers from multiple backgrounds to accurately assess scientific material. Negative language in particular generated this effect more often in our study. This finding accords with much of the observational experience of, for example, extension educators, who often rely on risk- and threat-related contexts to convey material to ecosystem stakeholders and communities.

Our study results are limited by recording differences between treatment groups in only 4 of 15 survey statements. Our conclusions are also limited by our survey sample, which represents a relatively small population of Wyoming stakeholders: animal and crop producers, state and federal personnel, and local and state policymakers. Our respondents represent relatively motivated audiences who seek education outreach-focused events. We cannot address audiences who gain their information via media or who learn from reading but seldom attend outreach events (an increasing resource management group). However, on the basis of the observed changes in reader assessment and results of factor analysis, we conclude that future study and application should more closely examine the effects of primers on tool-focused material, particularly for hands-on audiences.

Our results suggest that if we are to achieve successful communication of scientific research for practical applications and effective policymaking, audience background must be considered. Translation of emerging research is employed for varied “endpoints” and applications among different audiences (Grimshaw et al., 2012). Our study sought to identify how primers that evoked a negative or positive emotional context affected receptiveness to technical conceptual and tool-based ecosystem management information. We conclude that primers can, but do not always, improve reader assessment of technically presented scientific materials depending on the background and relationship of the reader to natural resource decisions. Nevertheless, the use of priming language presents opportunities to capture the attention and improve response to technical information among ecosystem stakeholders.

Although neutrally presented scientific writing has important philosophical and professional value, we must examine the ways in which we communicate scientific information to meet the needs of the intended audience(s). Engagement with emotion is a means to improve communication and success of scientific applications.

This research suggests that investigating the ways that technical information is received and applied to decision making provides an important avenue of future exploration.

Management Implications

For extension personnel and scientists alike, our findings suggest that readers may be most responsive to a negative (risk-based) emotional context for learning new technical information. Further, hands-on management applications provide stronger engagement. Extension educators have always recognized that understanding the specific background of an audience is important. In most cases, evoking a negative emotional context may strengthen ecosystem manager engagement with little risk of unanticipated shifts in reader response. However, extension audiences are increasingly managers with little hands-on experience. Among audiences who do not have hands-on production experience, using a positive *or* negative emotional context to introduce neutral information seems to confer little risk, but the outcomes of this approach are less predictable among novice audiences.

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