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# American residents' knowledge of brown bear safety and appropriate human behavior

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**Abstract:** The popularity of viewing wildlife, specifically brown bears (*Ursus arctos*), is increasing rapidly throughout North America. In addition, population distributions of both humans and brown bears are expanding, creating larger areas of overlap and increased possibility of human–bear interactions. Unfortunately, many who encounter brown bears may have never received any form of bear safety training or education. As a result, it is important for wildlife and park managers to understand the general level of bear safety knowledge and identify potential areas of improvement. To do so, this study employed a quantitative self-assessment questionnaire, distributed online to a representative sample of the American public in October of 2019. The questionnaires asked respondents about their experience viewing bears and then asked them to rate the likelihood of performing several actions as well as the perceived appropriateness of each behavior for 12 different bear viewing scenarios. Of 511 complete responses, 40% reported seeing a wild brown bear but the majority struggled to identify brown versus American black bears (*U. americanus*) in photographs, suggesting species-specific behavioral recommendations may be ineffective. Further, several factors were significant predictors of an individual's perceived appropriateness of the listed human behaviors, including age, gender identity, source of bear safety information, and experience with bears. Results were then used to develop a set of meaningful recommendations to improve the efficacy of current bear management and safety education. Primary recommendations include the following: 1) Increase the focus on appropriate rather than inappropriate behaviors, explaining the reasoning behind such suggestions; 2) Pay special attention to overly confident individuals or those with more experience; and 3) Use photographs, videos, and virtual reality experiences to better prepare visitors for a range of potential encounter scenarios.

**Key words:** bear safety, brown bear, human behavior, human dimensions, human–wildlife conflict, North America, online questionnaire, parks, *Ursus arctos*, visitor use management, wildlife viewing

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Despite continued human population growth (United Nations Department of Economic and Social Affairs, Population Division 2020), brown bears (*Ursus arctos*) have begun to recover throughout both the Northern Continental Divide Ecosystem and the Greater Yellowstone Ecosystem (Keating 1986, Schwartz et al. 2003, Kendall et al. 2009, Eberhardt and Breiwick 2010, Mace et al. 2012, Bjornlie et al. 2014, Costello et al. 2016, Haroldson et al. 2016). However, many still worry about the limited

genetic and landscape connectivity between these populations, restricting their long-term success and resilience (Haroldson et al. 2010, Schwartz et al. 2010, Proctor et al. 2015, Shafer 2015, Peck et al. 2017). The significant, negative impacts of human-dominated landscapes, such as habitat fragmentation and incidental take, on population recovery and expansion have been well-documented (e.g., Pyare et al. 2004, Schwartz et al. 2010, Proctor et al. 2015, Shafer 2015) and must be minimized to maintain successful brown bear recovery.

Human behavior plays a key role in such recovery efforts, largely determining the success of coexistence

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with the environment and coping with new ecological challenges (Goujon 2018). With expanding populations of both humans and brown bears, interactions between species are bound to occur. Negative interactions, however, may result in trapping, relocating, or euthanizing a bear (Wilson et al. 2014). Bear management and safety efforts have kept the level of bear-inflicted injuries to a minimum (Herrero 1970, Herrero and Fleck 1990, Gunther and Hoekstra 1998, Herrero 2018), but the same cannot be said for human-inflicted injuries to bears. Annually, thousands of American black bears (*U. americanus*) and over a hundred brown bears are killed in North America, largely as a result of human behavior such as unsecured attractants, roadway collisions, or incidental take (Masterson 2016:16). Unfortunately, even one human mistake could produce multiple generations of problem bears through habituation and intergenerational modeling (Aumiller and Matt 1994, Masterson 2016, Morehouse et al. 2016). Not only are human residents within areas that contain brown bears responsible for behaving properly, but large numbers of tourists and visitors to parks and other protected areas must behave appropriately as well.

Many visitors and residents may encounter a brown bear without any knowledge of appropriate human behavior, resulting in actions that could endanger members of both species. As a result, it is important to understand the general level of bear safety knowledge and awareness within the broader public. In a human–wildlife situation so dependent on complete adherence to appropriate human behavior, the effectiveness of management efforts and bear safety education can be maximized by incorporating new techniques and addressing common misconceptions and areas of uncertainty held in society. However, the public's interactions with and understanding of brown bears are largely unknown and understudied. Furthermore, it is not known how the public may respond to a brown bear in different settings, or how a bear's behavior, sex, or age class may influence the public's behavioral response to a brown bear encounter. To address this deficit of knowledge about the public's experience and perceptions of brown bears, we conducted an online survey with a self-administered questionnaire. The purpose of the study was to evaluate the bear safety knowledge of the American public when presented with several brown bear encounter scenarios. Specific research questions included the following:

1. What level of experience and familiarity does the American public have with brown bears and bear safety?
2. What human behavioral responses does the public perceive as appropriate during a brown bear encounter

scenario and how do responses differ across different types of settings and a bear's behavior, sex, or age class?

3. What are the primary factors that contribute to a respondent's perceived appropriateness of potential human behaviors during a brown bear encounter scenario?

4. What suggestions do respondents have, if any, to improve current efforts in bear safety education?

## Methods

### Study population

In October of 2019, we distributed an online quantitative questionnaire to a cross-sectional sample of the general American public using the online survey platform, Qualtrics ([www.qualtrics.com](http://www.qualtrics.com)). Many park visitors and residents may encounter a brown bear without having knowledge of proper behavior; therefore, we chose the general American public as the study population to best understand how such individuals may behave in bear encounter scenarios, with or without previous training. A cross-sectional representative sample allowed for efficient data collection given the broad intended population, similar to United States (U.S.) polling data during a presidential election year. Qualtrics and our sampling procedures allowed for a stratified random sample, segmented across age, education level, gender identity (henceforth referred to as 'gender'), income, race, and zip code of primary residence, using standard U.S. Census Bureau categories, to ensure representativeness.

Our resulting sample accurately represented the general American public, as estimated by the U.S. Census Bureau (USCB 2020), with the following demographics:

- 66.5% identifying as white, 16.6% as Hispanic or Latino–Latina;
- 18.4% earning <US\$24,999/year, 17.8% earning between US\$50,000 and US\$74,999, 14.9% earning between US\$25,000 and US\$49,999;
- 24.1% reporting high school graduate as their highest level of education, 24.1% reporting a 4-year college degree as their highest level of education; and
- 45% identifying as female.

### Study design

To address the research questions, we used 2 independent samples designs: a  $3 \times 3$  and a  $3 \times 1$  design. The first design ( $3 \times 3$ ), 'setting treatment,' compared respondent's ratings of appropriate human behaviors across 3 different settings, 3 bear age classes, and sex. During completion of the questionnaire, a respondent viewed 2 videos—each randomized based on the  $3 \times 3$  design—and then completed questions in the questionnaire. For the  $3 \times 3$  design, the randomized videos

displayed 3 settings, including a salmon stream without a designated viewing area, a meadow, and a viewing platform; whereas, age and sex classes included a solitary adult male, a female with cubs, and a subadult. Although brown bear encounters can occur in other settings, the 3 settings included in this study represent the most common viewing scenarios across the United States (Penteriani et al. 2017). We designed these videos to best replicate an in-person encounter, but we did not inform respondents about the sex or age class of the focal bear in the video.

Study design 2 ( $3 \times 1$ ), ‘behavior treatment,’ acted as a qualifier and was intended to help evaluate respondents’ perceptions about appropriate human behaviors across 3 different bear behaviors, while controlling for the setting and sex or age class. The 3 bear behaviors displayed in the  $3 \times 1$  videos were feeding, curious, and aggressive. Although respondents viewed videos of these behaviors, they were not provided with a narrative interpretation or description. Curiosity was depicted by a bear looking at the camera then standing on its hind legs. Aggression was depicted by a bear looking at the camera and then charging toward it. Behavior was held constant across the entire  $3 \times 3$  design, but was tested here to alleviate the threat to external validity resulting from the lack of independence between bear behavior and an individual’s response. This second design also served as an additional test of current education efforts and an individual’s ability to identify appropriate behaviors across varying brown bear encounter scenarios.

### Treatment videos

Researchers engaged in visitor use management in parks and protected areas often use visual methods, in the form of computer-altered photographs, to help identify the type and range of social or ecological conditions that park visitors report as ideal, preferred, requiring management action, and acceptable (Laven and Krymkowski 2005, Cribbs et al. 2019). For example, park visitors may be shown a series of 5 photographs depicting the number of people at a popular overlook (perhaps ranging from 0 to 50) to understand the acceptable level of human use and density at the location. Such findings can help managers allocate permits, improve infrastructure, and determine ideal temporal or spatial distributions to achieve high-quality park experiences, among other potential management actions (Manning 2011). This body of research has long confirmed that photographs (1) can be used as suggestive surrogates for actual conditions (Newman et al. 2001), (2) are much more effective than traditional narrative descriptions (Manning and Freimund 2004), and

(3) have been used successfully to determine park visitors’ preferred conditions for both ecological states and social circumstances, such as crowding (Hallo et al. 2018, Price et al. 2018).

Although photographs and videos do not replace actual conditions or experiences, videos are used widely across diverse disciplines and applications beyond visitor use management. For example, videos have been used in human factors psychology for studying job task response (Cucina et al. 2015), computer science for studying air crew coordination (Jentsch and Bowers 1998), medicine for surgical simulations (Satava 2019), behavioral psychology to study elements of distracted driving (Kim et al. 2019), and conservation social science for studying tourists’ relationships with polar bears (*U. maritimus*; Fefer 2019). Related to natural settings found in many parks and protected areas, White et al. (2018) found that ‘nature exposure’ in videos alone can assist with pain management, alleviation of neurological disorders, relaxation, and general mental health. Furthermore, Browning et al. (2019) found that simulated videos of nature provided similar physiological markers to nonsimulated, real outdoor environments. Findings from these studies and others reveal that videos and associated simulations of nature are not only reasonable proxies for actual nature-based experiences, but that they elicit similar physiological responses, affect, and outcomes. Although not without limitations, videos are an accepted surrogate for representing a variety of conditions, particularly when exposure to simulated conditions (e.g., bear’s sex, age, behavior, and setting) cannot be controlled by researchers or research participants may not otherwise have reasonable access to the simulated conditions.

To best simulate the 9 setting treatments, we captured high-quality videos at Katmai and Lake Clark National Parks & Preserves that effectively demonstrated the intended scenarios, while minimizing any confounding variables due to unintended differences across videos, such as lighting, weather, microhabitat, size and positioning of the bear, and video quality. These parks support abundant brown bear populations, while providing high-quality viewing experiences in all 3 of the intended settings (Nettles et al. 2020). To construct some videos, we retrieved publicly available videos from online bear-viewing communities, online video-sharing sites, and public access documentaries. We selected videos that displayed only the focal bear and clearly illustrated intended behavior, while minimizing differences due to microhabitat, lighting, weather, age or sex of the bear, and video quality. All final videos were edited to 15 sec-



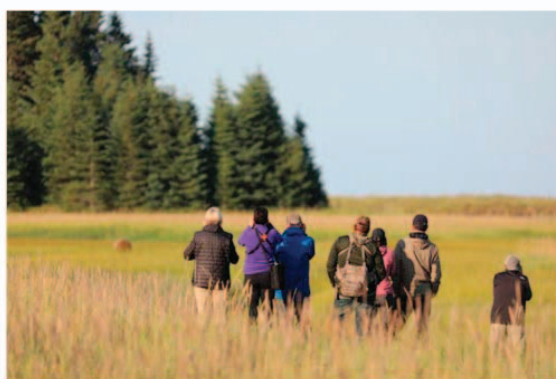
Meadow



Stream



Platform



Behavior

**Fig. 1.** Images shown to respondents (from survey sample of the general American public during October 2019) prior to viewing the respective setting and behavior treatment videos illustrating possible behaviors when encountering a bear.

onds and are available online (<https://doi.org/10.6084/m9.figshare.c.5296204>).

### **Quantitative questionnaire**

While completing the self-administered quantitative questionnaire (full questionnaire is available by contacting the corresponding author), each respondent viewed a randomly selected video from each treatment group (i.e., one video for the ‘setting treatment’ and one video for the ‘behavior treatment’ per respondent). We developed the questionnaire using best practices for online survey construction as described by Dillman (2011) and Vaske (2008). Prior to viewing each video and completing the questionnaire, we included a photograph of the viewing scenario and explicit instructions for respondents to imagine themselves fully immersed in the scenario displayed

in the video. Per instructions, respondents were encouraged to respond based only on immediate reactions to each video. Figure 1 displays the photographs for each setting category (i.e., meadow, stream, and platform) and the generic bear-viewing photo displayed prior to respondents watching a behavior treatment video. The quantitative questionnaire contained several measures described below.

**Measure 1: Perceived appropriateness of human behavior.** After viewing each video, respondents were asked to rate the ‘appropriateness’ of 15 potential human behaviors based on the scenario displayed in the video. Respondents rated how appropriate they viewed each of the 15 behaviors using a 7-point Likert-type scale (1 = extremely inappropriate, 7 = extremely appropriate). For this question, respondents were given the

additional option to select “I don’t know” for each behavior. We listed potential behaviors in alphabetical order and selected the 15 behaviors based on historical accounts of human–bear interactions and conflicts discussed by Gunther and Hoekstra (1998) and Herrero (2018).

**Measure 2: Bear identification.** Although differentiating between bear species can be difficult, especially in the field, it occasionally plays a role in determining appropriate behavior (Floyd 1999, Masterson 2016, Herrero 2018). The starkest example is the differences in safe human behavior during a physical attack and contact with a brown bear versus an American black bear. Among other public service agencies, the U.S. National Park Service (NPS) recommends ‘playing dead’ if attacked by a brown bear, but ‘fighting back using any object available’ if attacked by a black bear (NPS 2018). At the beginning of the questionnaire, we provided brief descriptions about the differences between brown and black bears and the taxonomic relationship between brown and grizzly bears. This was followed by a range map for the 3 North American bear species. We then presented respondents with 6 bear photographs at one time and asked them to select the brown bears. The photo series contained 2 black bears, 2 brown bears, 1 polar bear, and 1 giant panda (*Ailuropoda melanoleuca*). This question was included to evaluate a respondent’s ability to accurately identify a brown bear while helping to further direct their attention to brown bears as the focus of the study and the questionnaire. All mentions of “brown” bears within the questionnaire were followed by the term “grizzly” in parentheses to minimize confusion among respondents.

**Measure 3: Self-reported knowledge of bear safety.** Regardless of a respondent’s previous experience with any bear species or bear safety education, we asked them to assign a letter grade to themselves (henceforth referred to as self-assigned grade) on their ability to behave safely around bears. Respondents used a common grading scale in the United States with 13 categories encompassing standard letter grades ranging from A+ to F with an A+ representing the highest or best self-assigned grade for the ability to behave safely around bears. Respondents that reported taking a bear safety class or receiving bear safety instruction previous to participation in this study were also asked to identify the source that provided the information. Several choices were provided, including (a) commercial guide, (b) taught themselves, (c) park or destination staff, or (d) friend or family member.

**Measure 4: Suggestions to improve bear safety efforts.** Near the end of the survey, we asked respondents to rate their perceived efficacy of 3 potential strategies (as described by Wilson [2008]) that may en-

courage appropriate human behavior around brown bears. The strategies presented to respondents were (1) being informed about the reasoning and justification underpinning recommended behaviors, instructions, or policies; (2) relating the recommended human behaviors to the goals of park and wildlife management; and (3) using one’s own personal values to justify safe behavior. Afterward, we asked respondents to list any suggestions they might have to improve bear-safety education efforts beyond these 3 strategies provided.

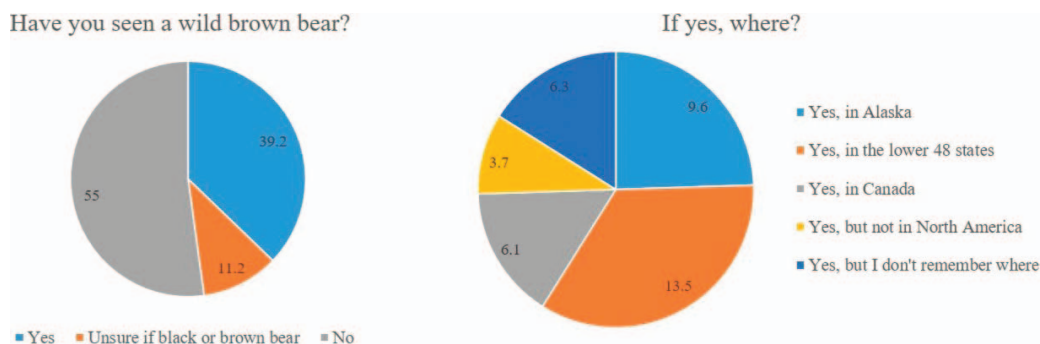
## Analysis

We conducted statistical analyses of the questionnaire responses using IBM’s Statistics Package for the Social Sciences (SPSS) version 24.0 (SPSS, Armonk, New York, USA). To address Research Questions 1, 2, and 3 we used descriptive statistics, including measures of central tendency, aimed at understanding variation present within responses. To address the second half of Research Question 2, and Research Question 3, we performed the 2 analyses described below.

1. To understand the factors that may predict respondents’ perceived appropriateness of behaviors, we conducted a univariate general linear model with Bonferroni post hoc tests for each potential human behavior with 7 categorical variables (video treatment, bear species found in their home state, previous experience with bear sightings, been taught bear safety, who taught bear safety, gender, and education) and 3 continuous explanatory variables (feelings toward bears, self-assigned bear safety grade, and age). Each respondent was provided a random video from each treatment and was included twice in this analysis, once for the setting treatment and once for the behavior treatment. We measured a respondent’s general feelings toward bears using a 7-point Likert scale (1 = extremely negative, 4 = neither positive nor negative, 7 = extremely positive). For the binary variable of previously seeing a brown bear in the wild, we used 0 to represent not having seen a bear and 1 to represent having seen a bear. We determined these 10 variables prior to analysis and included them in all models.

2. To further understand the relationship between self-assigned safety grades and having seen a bear and its impact on perceived appropriateness of human behaviors, we performed an additional post hoc analysis. We conducted a univariate general linear model to predict the level of perceived appropriateness from the product interaction between the self-assigned bear safety grade and previous bear viewing or encounter experience.

To confirm that the sample produced sufficient statistical power to detect differences in means, we calculated



**Fig. 2.** Respondents' responses to questions regarding an individual's past experience viewing brown bears (*Ursus arctos*), from a survey sample of the general American public during October 2019.

the minimum sample size per treatment cell needed to maintain a power of 0.8. Statistical power decreases with further segmentation, so we determined the minimum sample size required for each of the 12 cells across both study designs (i.e., setting and behavior treatments). If the true effect size was 0.2, each cell would require a sample size of 36 to produce a power of 0.8 at a significance level of 0.05. If the true effect size was 0.15, each cell would require a sample size of 63.

## Results

After prescreening them for representativeness, we invited 2,766 individuals to complete our survey. After 26 hours, we had received 511 complete responses (18.5% response rate) with approximately 57 responses (SD = 4.39) for each of 9 setting treatments and 170 responses (SD = 7.76) for each of 3 behavior treatments. For all sample-wide analyses, this produced an overall confidence interval of 4.3% at the 95% confidence level, suggesting a limited margin of error in the responses.

### RQ1: Experience viewing brown bears

Of all respondents, 55% had never seen a wild brown (grizzly) bear, whereas 11.2% reported seeing a wild bear, but were unsure of the species (Fig. 2). When asked to select the regions within the Lower 48 States in which they had seen a brown (grizzly) bear, many sightings were reported for either viable regions with no confirmed population (i.e., North Cascades and Bitterroot Regions; 47.8% of sightings) or for additional areas such as Colorado, California, or Tennessee that currently have no potential for brown bear sightings (33.4% of sightings; Table 1). Among those who reported previously seeing a bear, 23% had never received any form of bear safety

education and 30% were taught by themselves or a friend or family member.

### Bear identification

Only 18.6% of respondents were able to correctly select both brown bear photos, whereas 9.1% selected more incorrect photos than correct photos. A large majority of the sample (93.2%) was able to correctly select one of the brown bear photos, but only 42.5% correctly selected the second of 2 brown bear photos (Fig. 3).

### Self-reported knowledge of bear safety

Overall, 75% of respondents had never participated in an official bear-safety training program and 47.2% had

**Table 1.** Locations in which respondents (from survey sample of the general American public during October 2019) report viewing a wild brown (grizzly) bear (*Ursus arctos*) within the Lower 48 States of the United States.

Location	Frequency	Percent
Greater Yellowstone Region	28	40.6
North Cascades Region <sup>a</sup>	19	27.5
Northern Continental Divide Region	17	24.6
Bitterroot Region <sup>a</sup>	14	20.3
None of these	9	13.0
Colorado <sup>b</sup>	4	5.8
Selkirk Region	3	4.4
Cabinet–Yaak Region	3	4.4
California <sup>b</sup>	3	4.4
Tennessee <sup>b</sup>	3	4.4
Pennsylvania <sup>b</sup>	2	2.9
Michigan <sup>b</sup>	2	2.9

<sup>a</sup>Within the U.S. Fish and Wildlife Service recovery zone, but currently no confirmed population.

<sup>b</sup>No populations of brown (grizzly) bears.



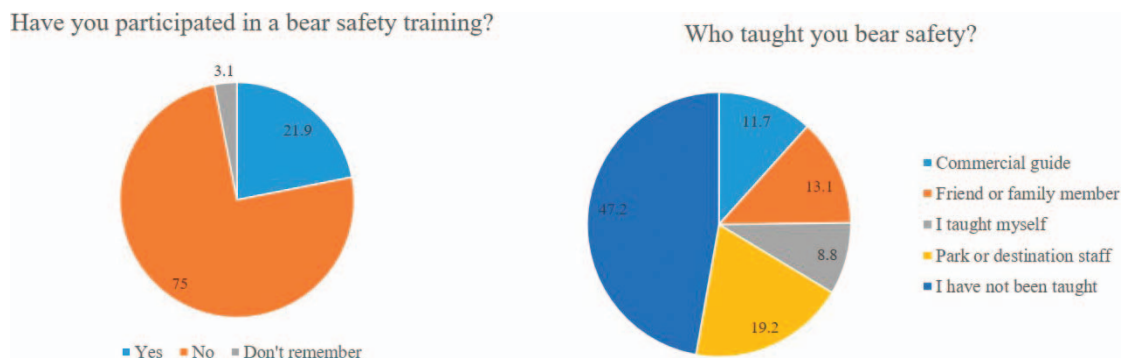


**Fig. 3.** Images shown to respondents (from survey sample of the general American public during October 2019) to assess accuracy in identifying bear species, with the percent of sample selecting each image. Respondents were asked to select all brown (grizzly) bears (*Ursus arctos*).

never received any bear safety instruction (Fig. 4). Individuals who taught themselves reported slightly higher self-assigned grades (scale of 1–13; mean = 9.69; B+, SD = 2.8) than did those who learned from other sources, but all were significantly higher ( $P < 0.05$ ) than those who

had not been taught (mean = 5.82; C, SD = 3.5; Table 2). Further, respondents who had seen a bear (M = 9.04; B, SD = 0.21) reported statistically higher self-assigned safety grades than did those who had never seen a bear (M = 6.51; C+, SD = 0.21;  $t_{509} = 8.27$ ,  $P < 0.001$ ).



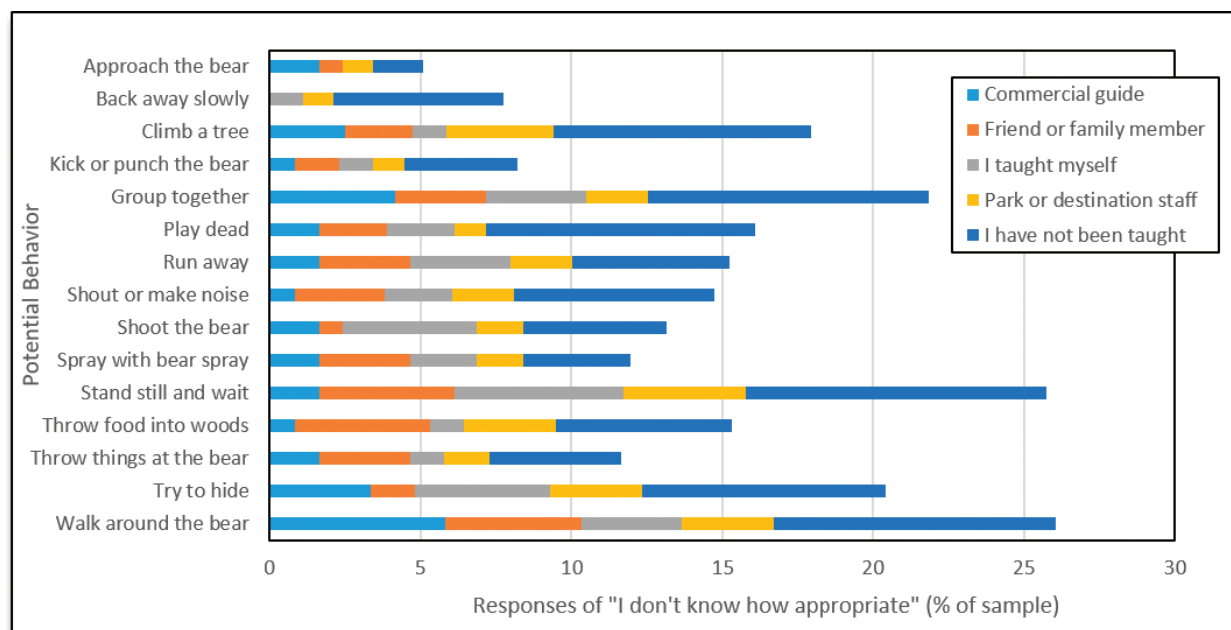


**Fig. 4.** Respondents' responses to questions regarding an individual's past experience with bear safety education (from survey sample of the general American public during October 2019).

### RQ2 and RQ3: Appropriateness of human behaviors and influential factors

In all cases, the general linear model was statistically significant ( $P < 0.01$ ), but explained relatively little of the variation in the data, as evidenced by a low  $R^2$  value. As a result, although these models are valuable in highlighting potential sources of variation between individuals, they are not intended to be used to make predictions.

Respondent age and the source of information for receiving bear safety information were both statistically significant contributors ( $P < 0.05$ ) for 11 of the 15 potential human behaviors, whereas attending bear safety training and the self-assigned bear-safety grade were only significant for 1 and 2 behaviors, respectively (see Table 3). Regardless of video treatment, males reported statistically higher levels of perceived appropriateness for fight or flight behaviors, such as kicking or punching the bear



**Fig. 5.** Percent of sample (from survey sample of the general American public during October 2019) who were unsure of the appropriateness of 15 potential behaviors when encountering a bear, by source of bear safety information.

**Table 2. Respondents' self-reported grades for knowledge of safe behavior around bears (from survey sample of the general American public during October 2019), split by source of bear safety education.**

Source	Mean <sup>a</sup>	SD	Grade <sup>b</sup>
Commercial guide	9.25A	3.2	B
Friend or family member	9.33A	3.1	B
I taught myself	9.69A	2.8	B+
Park or destination staff	9.17A	2.6	B
I have not been taught	5.82B	3.5	C

<sup>a</sup>Capitalized Roman letters represent statistically significant differences among means ( $P < 0.05$ ).

<sup>b</sup>Grade was on a 13-point scale using standard letter grades from F to A+.

( $F_{2,995} = 7.69$ ,  $P < 0.001$ ), shooting the bear ( $F_{2,995} = 15.61$ ,  $P < 0.001$ ), or running away ( $F_{2,995} = 5.67$ ,  $P = 0.004$ ) than did females (Table 4). Additionally, older individuals classified a majority of the listed actions as less appropriate than did younger individuals (Table 4), such as climbing a tree ( $F_{1,995} = 19.77$ ,  $P < 0.001$ ), hiding ( $F_{1,995} = 19.83$ ,  $P < 0.001$ ), throwing things at the bear ( $F_{1,995} = 30.32$ ,  $P < 0.001$ ), or approaching the bear ( $F_{1,995} = 37.50$ ,  $P < 0.001$ ). Further, those who had seen a wild brown bear viewed backing away slowly ( $F_{1,995} = 7.20$ ,  $P = 0.009$ ) or grouping together ( $F_{1,995} = 4.15$ ,  $P = 0.042$ ) as less appropriate, and kicking or punching the bear ( $F_{1,995} = 4.35$ ,  $P = 0.037$ ) or throwing things at the bear ( $F_{1,995} = 8.95$ ,  $P = 0.003$ ) as more appropriate than did those who had not (Table 3). Lastly, individuals reporting higher self-assigned bear safety grades saw approaching the bear ( $F_{1,995} = 4.59$ ,  $P = 0.032$ ) and running away ( $F_{1,995} = 7.63$ ,  $P = 0.006$ ) both as more appropriate than did individuals reporting lower bear self-assigned safety grades (Table 3).

Based on independent-samples  $t$ -tests, respondents who had seen a wild bear reported statistically higher levels of perceived appropriateness ( $P < 0.05$ ) for approaching the bear ( $t_{1020} = 6.26$ ,  $P < 0.001$ ), climbing a tree ( $t_{1020} = 3.16$ ,  $P = 0.002$ ), kicking or punching the bear ( $t_{1020} = 5.11$ ,  $P < 0.001$ ), running away ( $t_{1020} = 4.25$ ,  $P < 0.001$ ), shouting or making noise ( $t_{1020} = 2.80$ ,  $P = 0.005$ ), shooting the bear ( $t_{1020} = 2.93$ ,  $P = 0.003$ ), throwing things at the bear ( $t_{1020} = 5.94$ ,  $P < 0.001$ ), and walking around the bear ( $t_{1020} = 2.93$ ,  $P = 0.003$ ), than did those who had not. Backing away slowly was the only human behavior that was rated as statistically more appropriate by those who had not seen a bear than those who had ( $t_{1020} = -2.98$ ,  $P = 0.003$ ; Table 4).

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**Table 3.  $F$ -values<sup>a</sup> resulting from univariate general linear models of respondents' perceived appropriateness<sup>b</sup> of performing listed behaviors when encountering a bear (from survey sample of the general American public during October 2019).**

Behavior	Corrected model $F_{26,995}$	Intercept $F_{1,995}$	Video treatment $F_{11,995}$	Bears where you live $F_{2,995}$	Ever seen a bear $F_{1,995}$	Feelings toward bears $F_{1,995}$	Taught bear safety $F_{2,995}$	Who taught bear safety $F_{4,995}$	Bear safety grade $F_{1,995}$	Gender $F_{2,995}$	Age $F_{1,995}$	Education $F_{1,995}$	Adjusted $R^2$
Approach the bear	7.2**	46.5**	1.2	0.7	2.9	0.9	0.8	9.3**	4.6*(+)	6.7**	37.5**(-)	0.9	0.14
Back away slowly	2.6**	125.4**	2.5**	4.7**	7.2**(-)	6.2*(+)	0.5	0.5	0.0	0.7	4.6*(+)	2.8	0.04
Climb a tree	3.4**	67.9**	1.3	0.4	0.7	1.7	1.4	4.2**	1.8	0.0	19.8**(-)	1.4	0.06
Kick or punch the bear	5.1**	54.8**	2.0*	0.6	4.3*(+)	0.1	3.6*	5.7**	2.6	7.7**	17.2**(-)	1.7	0.10
Group together	2.1**	89.1**	2.0*	1.0	4.1*(-)	2.1	0.7	2.6*	1.2	0.5	9.4**(-)	0.3	0.03
Play dead	2.0*	112.2**	1.0	0.7	0.0	0.0	0.3	2.0	1.5	2.8	5.1*(-)	2.5	0.02
Run away	4.1**	58.1**	1.4	0.2	3.3	0.2	0.7	3.0*	7.6**(+)	5.7**	33.1**(-)	1.5	0.07
Shout or make noise	3.1**	47.0**	2.4**	2.7	1.0	0.2	1.0	5.8**	1.3	1.8	0.3	0.1	0.05
Shoot the bear	5.3**	84.8**	3.6**	2.4	0.4	4.9*(-)	2.6	4.2**	1.8	15.6**	12.3**(-)	4.8*(-)	0.10
Spray with bear spray	3.5**	63.1**	2.4**	0.9	0.2	0.1	2.0	3.7**	1.3	10.4**	3.3	2.3	0.06
Stand still and wait	1.9**	109.7**	1.0	11.7**	2.0	1.7	1.5	0.3	2.5	2.0	0.8	1.7	0.02
Throw food into woods	2.4**	65.4**	1.4	3.4*	2.2	0.3	0.7	2.6*	0.0	1.8	13.5**(-)	2.7	0.04
Throw things at the bear	6.0**	60.0**	2.4**	0.0	9.0**(+)	0.2	0.9	7.0**	1.8	6.0**	30.3**(-)	0.7	0.11
Try to hide	3.2**	113.6**	1.1	0.0	0.0	0.2	0.5	3.4*	0.4	2.2	19.8**(-)	9.6**(-)	0.05
Walk around the bear	2.1**	66.9**	0.7	3.7*	0.8	4.9*(+)	0.1	1.7	3.7	1.2	0.7	1.5	0.03

<sup>a</sup> $P < 0.05$ , <sup>\*\*</sup> $P < 0.01$ . For binary or continuous independent variables, negative relationships are indicated with (-) and positive relationships are indicated with (+).

<sup>b</sup>Perceived appropriateness of listed behaviors was rated on a 7-point Likert scale (1 = extremely inappropriate, 7 = extremely appropriate).

**Table 4. Results of univariate general linear models for the effect of the interaction between having seen a bear and safety grade on respondents' perceived appropriateness of performing listed behaviors (from survey sample of the general American public during October 2019).**

Behavior	Seen a bear	Perceived appropriateness <sup>a</sup>				Impact of safety grade <sup>b</sup>			Linear model	
		Mean	SD	<i>t</i> <sub>1020</sub>	<i>P</i>	$\beta$	SE	<i>P</i>	<i>F</i> <sub>2,1019</sub>	<i>P</i>
Approach the bear	No	1.54	1.28	6.26	<0.001	0.10	0.02	<0.001	32.56	<0.001
	Yes	2.17	1.93			0.05	0.02	0.008		
Back away slowly	No	5.57	1.60	-2.98	0.003	-0.02	0.02	0.201	4.21	0.015
	Yes	5.26	1.80			0.02	0.02	0.343		
Climb a tree	No	2.90	1.77	3.16	0.002	0.07	0.02	<0.001	9.14	<0.001
	Yes	3.28	2.00			0.04	0.02	0.047		
Kick or punch the bear	No	2.22	1.76	5.11	<0.001	0.10	0.02	<0.001	19.09	<0.001
	Yes	2.83	2.06			0.05	0.02	0.013		
Group together	No	4.38	1.90	-0.21	0.838	0.03	0.02	<0.001	2.65	0.071
	Yes	4.35	2.03			0.05	0.02	0.025		
Play dead	No	3.77	1.95	1.94	0.053	0.05	0.02	0.007	3.60	0.028
	Yes	4.02	2.05			0.04	0.02	0.071		
Run away	No	2.71	1.93	4.25	<0.001	0.10	0.02	<0.001	19.62	<0.001
	Yes	3.27	2.24			0.04	0.02	0.058		
Shout or make noise	No	3.17	2.17	2.80	0.005	0.08	0.02	<0.001	9.03	<0.001
	Yes	3.56	2.20			0.04	0.02	0.064		
Shoot the bear	No	2.49	2.00	2.93	0.003	0.08	0.02	<0.001	9.42	<0.001
	Yes	2.87	2.13			0.04	0.02	0.049		
Spray with bear spray	No	2.81	2.04	1.92	0.056	0.08	0.02	<0.001	8.63	<0.001
	Yes	3.06	2.16			0.05	0.02	0.024		
Stand still and wait	No	4.70	1.77	-0.08	0.934	0.03	0.02	0.066	2.07	0.127
	Yes	4.69	1.86			0.04	0.02	0.056		
Throw food into woods	No	3.31	2.03	-0.11	0.909	0.01	0.02	0.449	0.29	0.750
	Yes	3.29	2.08			0.01	0.02	0.617		
Throw things at the bear	No	2.02	1.63	5.94	<0.001	0.10	0.02	<0.001	27.53	<0.001
	Yes	2.72	2.05			0.03	0.02	0.160		
Try to hide	No	4.01	1.95	1.10	0.273	0.02	0.02	0.223	1.22	0.296
	Yes	4.15	1.99			0.00	0.02	0.869		
Walk around the bear	No	4.44	2.04	2.93	0.003	0.08	0.02	<0.001	9.53	<0.001
	Yes	4.81	1.94			0.05	0.02	0.021		

<sup>a</sup>Perceived appropriateness of listed behaviors was rated on a 7-point Likert scale (1 = extremely inappropriate, 7 = extremely appropriate).

<sup>b</sup>Safety grade was self-reported and on a 13-point grade scale from F to A+.

As displayed in Table 4, the additional post hoc analysis revealed the relationship between the self-assigned safety grade and perceived appropriateness generally to be a stronger, positive relationship among respondents who had never seen a wild bear compared with those who had (Table 4). With increased self-assigned safety grades, the perceived appropriateness for approaching the bear, climbing a tree, kicking or punching the bear, running away, shouting or making noise, shooting the bear, spraying the bear with bear spray, throwing things at the bear, and walking around the bear increased at a faster rate (i.e., higher  $\beta$  values) among those who had not seen a bear than those who had (Table 4).

For the effect of video treatment in the original models, (i.e., which of the 12 potential videos the individual was responding to), shouting or making noise ( $F_{11, 995} = 2.39$ ,  $P = 0.026$ ), shooting the bear ( $F_{11, 995} = 3.62$ ,  $P < 0.001$ ),

and spraying bear spray ( $F_{11, 995} = 2.41$ ,  $P = 0.026$ ) were all reported by respondents as significantly more appropriate for an aggressive bear than a feeding bear (Table 5). In addition, throwing things at the bear was rated to be significantly more appropriate when encountering a curious bear than when encountering an adult male bear in a stream ( $F_{11, 995} = 2.42$ ,  $P = 0.026$ ; Table 5). Further, those who live in states with American black, but not brown bears, viewed standing still and waiting for the bear to leave as significantly less appropriate than did those who live in states with no bears or both black and brown bears ( $F_{2, 995} = 11.71$ ,  $P < 0.001$ ; Table 6).

The relationship between the source of bear education information and perceived appropriateness of behaviors was significant. Specifically, those taught by park or destination staff reported the lowest levels of appropriateness for 11 of the 15 models ( $F_{4, 995} > 2.38$ ,  $P < 0.05$ ). Of

**Table 5. Marginal mean estimates and difference-of-mean tests for perceived appropriateness of listed behaviors of respondents when encountering a bear (from survey sample of the general American public during October 2019), split by video treatment. M represents the mean estimate with standard error (SE). Capitalized Roman letters in M column represent statistically significant differences among means ( $P < 0.05$ ).**

Behavior <sup>a</sup>	Meadow						Stream						Platform						Behavior					
	Adult male			Adult female and cubs			Subadult			Adult male			Adult female and cubs			Subadult			Adult male			Adult female and cubs		
	M	SE		M	SE		M	SE		M	SE		M	SE		M	SE		M	SE		M	SE	
	M	SE		M	SE		M	SE		M	SE		M	SE		M	SE		M	SE		M	SE	
Back away slowly	5.8	0.4		6.4	0.4		6.2	0.4		6.1	0.4		6.5A	0.4		5.8	0.4		5.6	0.4		6.0	0.4	
Kick or punch the bear	2.7	0.4		3.0	0.4		3.1	0.4		2.4	0.4		2.6	0.4		3.3	0.4		2.6	0.4		3.0	0.4	
Group together	4.6	0.5		4.9	0.5		5.4	0.4		5.2	0.5		4.8	0.5		4.8	0.5		4.4	0.5		4.4	0.4	
Shout or make noise	3.8	0.5		3.8	0.5		3.9	0.5		4.1	0.5		3.9	0.5		4.2	0.5		3.7	0.5		4.1	0.5	
Shoot the bear	3.2	0.5		3.2	0.5		3.6	0.5		3.4	0.5		2.7B	0.5		3.9	0.5		3.1	0.5		3.2	0.5	
Spray with bear spray	3.4	0.5		3.5	0.5		4.0	0.5		3.9	0.5		3.3	0.5		4.2	0.5		3.4	0.5		3.8	0.5	
Throw things at the bear	2.7	0.4		2.7	0.4		2.5	0.4		2.2B	0.4		2.5	0.4		3.2	0.4		2.6	0.4		2.9	0.4	

<sup>a</sup>Only general linear models with significant effects of "Video treatment" (Table 3) on perceived appropriateness of listed behaviors are included in this table. Perceived appropriateness of listed behaviors was rated on a 7-point Likert scale (1 = extremely inappropriate, 7 = extremely appropriate).

these 11 actions, 6 are generally considered inappropriate, 4 are dependent on the situation, and 1 is generally considered appropriate. Individuals taught by a commercial guide or who taught themselves generally reported the highest levels of appropriateness ( $F_{4,995} > 2.38$ ,  $P < 0.05$ ; Table 7). There also were 5 activities that respondents were largely uncertain about, regardless of the source of safety information: climbing a tree, grouping together to appear larger, standing still and waiting for the bear to leave, trying to hide, and walking around the bear, with approximately 17.9%, 21.9%, 25.7%, 20.4%, and 26.0%, respectively, unsure of the appropriateness of such behavior (Fig. 5).

#### RQ4: Suggestions to improve bear safety efforts

Near the end of the survey, we asked respondents to rank the efficacy of 3 educational strategies, as described by Wilson (2008). Of 511 complete responses, 66.3% selected that being told the logic and reasoning behind instructions or policies would be the most effective strategy, followed by relating recommendations directly with the goals of park and wildlife management (21.3%). Finally, 12.4% reported that using one's own personal values to justify safe behavior would be the most effective strategy. These results stress the importance of explaining to visitors and residents not only safe behavior, but the reasoning behind the suggestions as well, and the contribution to park and wildlife management.

The last survey question asked respondents to record any suggestions to improve current bear-safety education efforts. From these suggestions, 3 main ideas emerged. In order of frequency, these were (1) broaden the audience by producing public service announcements for television or online, (2) provide scenario-specific information and training, and (3) initiate a mandatory bear-safety course or training prior to admission in all relevant parks. Additional suggestions included more extensive signage, classes, and educational materials, teaching bear safety in local schools and communities, providing information on bear behavior, and including the reasoning behind suggested behaviors.

## Discussion

Although the videos, questionnaire, and analyses were specific to brown bears, the propensity for misidentification among participants suggests visitors may not respond differently to encountering an American black bear. This is important because encounters with black and brown bears occasionally require different human

**Table 6. Marginal mean estimates and difference-of-mean tests for perceived appropriateness of listed behaviors of respondents (from survey sample of the general American public during October 2019), split by presence of bears in a respondent's home state. M represents the mean estimate with standard error (SE). Capitalized Roman letters in M column represent statistically significant differences among means ( $P < 0.05$ ).**

Behavior <sup>a</sup>	No bears where I live		American black bears only		Both black and brown bears	
	M	SE	M	SE	M	SE
Back away slowly	5.6	0.3	5.3	0.2	6.8	0.7
Shout or make noise	3.4	0.3	3.7	0.3	4.7	0.9
Shoot the bear	2.9	0.3	2.8	0.3	4.5	0.9
Stand still and wait	5.3B	0.3	4.8A	0.3	7.2B	0.8

<sup>a</sup>Only general linear models with significant effects of "Bears where you live" (Table 3) on perceived appropriateness of listed behaviors are included in this table. Perceived appropriateness of listed behaviors was rated on a 7-point Likert scale (1 = extremely inappropriate, 7 = extremely appropriate). Presence of bears was determined based on respondent-reported zip code of primary residence.

behaviors (Floyd 1999, Masterson 2016, Herrero 2018). Even after respondents were provided information about the 2 species, many inaccurately identified photographs of brown bears in the questionnaire, emphasizing the need for further elaboration on species identification during bear safety education. In terms of self-assigned bear safety grades, it is important to note that these are self-reported, so a slightly higher grade among those who taught themselves does not necessarily mean this group is more knowledgeable. A higher self-assigned grade simply represents that they describe themselves as such.

In preparing for increased interactions between brown bears and people, park and wildlife managers must continue to develop skills to best encourage safe practices

among residents and park visitors alike. The results of this study demonstrate the higher risk level among younger and more experienced individuals, those who view themselves as more knowledgeable, or those who may be more likely to respond aggressively to an encounter. Respondents who had seen a bear or reported higher levels of safety knowledge reported higher levels of appropriateness for potentially dangerous actions, such as running away, throwing things at the bear, or kicking or punching the bear, but lower levels of appropriateness for typically correct behaviors, including backing away or grouping together to appear larger. This might have been a result of increased confidence around bears, or feelings that such behavior is unnecessary when one's past

**Table 7. Mean estimate and difference-of-mean tests for perceived appropriateness of listed behaviors of respondents when encountering a bear (from survey sample of the general American public during October 2019), split by source of bear safety information. M represents the mean estimate with standard error (SE). Capitalized Roman letters in M column represent statistically significant differences among means ( $P < 0.05$ ).**

Behavior <sup>a</sup>	Commercial guide		Friend or family member		I taught myself		Park or destination staff		I have not been taught	
	M	SE	M	SE	M	SE	M	SE	M	SE
Approach the bear	2.9B	0.3	2.4B	0.3	2.5B	0.3	1.9A	0.3	2.2A	0.3
Climb a tree	3.8B	0.4	3.3	0.4	3.6	0.4	2.9A	0.4	3.3	0.4
Kick or punch the bear	3.1B	0.4	2.8	0.4	3.3B	0.4	2.3A	0.4	2.7	0.4
Group together	4.8	0.4	4.6	0.4	5.3B	0.4	4.6A	0.4	4.7	0.4
Run away	3.5B	0.5	3.1	0.4	2.7	0.5	2.8A	0.4	3.0	0.4
Shout or make noise	4.2	0.5	3.6A	0.5	4.7B	0.5	3.7A	0.5	3.6A	0.4
Shoot the bear	3.7B	0.4	3.5B	0.4	3.6	0.4	2.9A	0.4	3.3	0.4
Spray with bear spray	3.8	0.5	3.7	0.4	4.3B	0.5	3.3A	0.4	3.5A	0.4
Throw food into the woods	3.5B	0.5	3.1	0.4	3.1	0.5	2.8A	0.4	2.8	0.4
Throw things at the bear	3.1BC	0.4	2.7	0.4	3.2C	0.4	2.2A	0.4	2.6AB	0.4
Try to hide	4.6B	0.4	3.9A	0.4	4.1	0.4	3.9A	0.4	4.1	0.4

<sup>a</sup>Only general linear models with significant effects of "Who taught bear safety" (Table 3) on perceived appropriateness of listed behaviors are included in this table. Perceived appropriateness of listed behaviors was rated on a 7-point Likert scale (1 = extremely inappropriate, 7 = extremely appropriate).



experiences have been positive. Although positive encounters may help to improve feelings toward bears (Skibins and Sharp 2017, 2018), they may override previous safety instruction (Coleman 2014). To avoid this, the importance of behaving appropriately must be reinforced for all individuals, regardless of past experiences.

Among sources of bear safety information, we found park and destination staff to be perceived by respondents to be an effective source when educating visitors about inappropriate behaviors, such as approaching the bear, kicking the bear, running away, and throwing things at the bear, whereas those who were taught by themselves or a commercial guide generally viewed these actions as more appropriate. However, those taught by park or destination staff reported significantly lower levels of appropriateness for generally appropriate behaviors, such as grouping together, making noise, and spraying the bear with bear spray, than those who taught themselves. These results suggest park bear-safety education efforts might currently focus more on inappropriate behaviors than appropriate behaviors, leaving visitors unsure of the correct way to respond to encounters with brown bears. Further, current bear-safety instructional efforts could benefit from addressing common but questionable behaviors, including climbing a tree, grouping together to appear larger, standing still and waiting for the bear to leave, trying to hide, and walking around the bear. Regardless of experience or source of bear safety information, respondents were generally unaware of the appropriateness of these actions. Several parks and protected areas have robust educational requirements for visitors prior to venturing into the backcountry. For example, visitors to Katmai National Park & Preserve view a 20-minute video prior to engaging with bears at the Brooks Camp area. Several minutes in this video are dedicated to both appropriate and inappropriate human behaviors.

### Limitations

Despite efforts to minimize limitations, some were unavoidable. Although a representative sample with adequate sample size was collected, those willing to take the survey may not be entirely representative of the American public, or of those visiting national parks or other protected areas where brown bear viewing may occur. To design the experiment appropriately while keeping both bears and humans safe and avoiding distractions during onsite experiences, survey respondents were provided with videos representing each scenario as opposed to firsthand experience. As a result, an individual may respond differently in an actual bear encounter experience as opposed to viewing a video. This online survey

format allowed respondents to pause and reflect prior to answering and potentially to select answers believed to be correct rather than true. Lastly, despite significant effort to minimize other variables among videos, slight differences may have unintentionally altered responses.

### Future research

Investigators and managers could use virtual reality to advance visual methods within the human dimensions of wildlife management, and park and visitor use management research. We feel it is important to test the applicability of virtual reality technology in representing onsite encounters. Although still more contrived than actual experiences, improvements in this technology may allow park managers and bear safety educators to accurately represent different scenarios and encourage appropriate behavior across all scenarios. An additional area of interest is the applicability of these methods to other settings or wildlife species. Videos and questions included in this survey focused on brown bears, but behavioral similarities and misidentification suggest results may be highly transferable to American black bears. Future research efforts could assess this degree of transferability to not only black bears, but entirely different contexts as well, such as African safaris, tiger (*Panthera tigris*) viewing in India, underwater viewing of sharks (Selachimorpha), or even more consumptive-oriented activities, such as deer (*Odocoileus* spp.) hunting.

An additional area for potential research is the impact of emotional reactions on an individual's ability to behave appropriately. Research on emotional reactions to viewing wildlife, especially carnivores, has been limited in scope. Many previous studies have addressed feelings toward carnivores (e.g., Farber and Hall 2007, Raadik and Cottrell 2007, Jacobs et al. 2012a,b) or opinions regarding potential management action (e.g., McFarlane et al. 2007, Glikman et al. 2012, Johansson et al. 2012, Hayman et al. 2014), but the focus on how these reactions affect behavior in a wildlife context is currently understudied. Future research could use similar methods as were used here or participant observations and onsite qualitative interviews to better understand complex emotional responses beyond what quantitative questionnaires would allow.

### Management implications

From these results and suggestions, we developed 10 recommendations to improve the overall effectiveness of bear-safety training and education efforts.

1. Education efforts should continue to address the appropriateness of uncertain or popular response behaviors,

including climbing a tree, running away, trying to hide, grouping together, and walking around the bear.

2. Pay special attention to overly confident individuals, those with more experience, and those more likely to respond aggressively (particularly younger males), emphasizing the importance of safe behavior regardless of past experience. Park rangers and educators could identify these individuals through a series of questions and prompts during a bear education or information session.

3. Provide logic and reasoning behind all policies, regulations, and behavioral instructions, including potential negative results.

4. Provide residents and area visitors with broad information regarding bear biology, behavior, and management as a way for individuals to sympathize with managers and internalize the goals of their efforts.

5. Safety instruction by park and destination staff may benefit from an increased focus on appropriate behavior rather than inappropriate behavior.

6. Regions with established brown bear populations, as well as those on the edge of dispersing populations, should release bear-safety public service announcements across several forms of media to reach the widest audience possible.

7. Place educational materials (e.g., signs, pamphlets, interactive displays, etc.) at various locations outside of park visitor's centers.

8. Use photographs, videos, or virtual reality experiences to incorporate various scenarios and bear behaviors in preparing users for potential bear encounters.

9. Continue to develop curriculum and workshops for use by communities, private organizations, and schools.

10. If necessary and feasible, mandatory bear-safety training prior to park admission may be an effective solution. If not, consider implementing a mandatory bear-safety lesson or video prior to backcountry use or purchasing park passes online.

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