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The authors suggest that mere attention increases the perceived severity of environmental risks because attention increases the fear and distinctiveness of attended risks. In Experiments 1 and 2, participants were exposed to images of multiple environmental risks, with attention repeatedly oriented to a subset of these risks. Participants subsequently perceived attended risks to be more severe, more frightening, higher priority, and more distinctive than control risks. In Experiments 3 and 4, spatial cueing manipulations were used to briefly draw attention toward some risks and away from others. In Experiment 3, a briefly flashed rectangle drew attention toward one side of a computer screen just before 2 images depicting different risks appeared: 1 image near to where the rectangle appeared and 1 further away. In Experiment 4, incidental attention was cued toward some risks by giving participants an unrelated letter search task that required them to briefly attend near that location. Participants in Experiments 3 and 4 selected cued (attended) risks as more severe, distinctive, and frightening than noncued risks. Across experiments, serial mediation analyses indicated that the effect of the attention manipulation on severity was mediated by the effect of attention on fear which was mediated by distinctiveness. Across experiments, we equated duration of exposure to risks and sought to minimize demand characteristics.

Keywords: attention, emotion, environmental risk, judgment, risk perception

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Risk perception is among the mind's most important functions. To survive and thrive, people must detect, evaluate, and respond to threats (Boyer & Bergstrom, 2011; Cosmides & Tooby, 2000). Understanding how the mind perceives risks is particularly important because major threats often fail to elicit appropriate responses (Olivola, 2015). Serious environmental threats, in particular, often do not elicit much emotion or become priorities for voters and policymakers (Bazerman, 2006; Hansen, 1991; Weber, 2006).

We examine how the two core psychological systems of attention and emotion shape intuitive risk perception. We hypothesize that mere attention increases perceived risk severity. We derive this hypothesis from research demonstrating that attending to objects, focusing consciousness on one object more than others, makes those objects more perceptually distinctive (Carrasco, 2006; Carrasco, Ling, & Read, 2004; Fuller & Carrasco, 2006). Objects that are more vivid and distinctive, in turn, are more emotionally evocative (Kees, Burton, Andrews, & Kozup, 2010; Loewenstein, 1996). Attention therefore increases the intensity of emotional reactions (Mrkva, Westfall, & Van Boven, 2019). Because emotion influences intuitive perceptions of risk severity (Loewenstein, Weber, Hsee, & Welch, 2001), merely attending to risks should increase their perceived severity.

We test whether attention increases risk perception in the context of environmental risks such as climate change, water pollution, and ozone depletion. Environmental risks typify global, long-term, system-level threats that often fail to elicit concern and motivate action (Hansen, 1991; Markowitz & Shariff, 2012; Weber, 2010). Inattention to environmental risks may partly explain such inaction.

Attention Intensifies Perceptual Experience

Attention is the process of focusing consciousness on one object, thought, attribute, or area of space more than other objects, thoughts, attributes, or areas (Anderson, 2005; Chun, Golomb, & Turk-Browne, 2011; James, 1890/1952). Attention can be voluntary or involuntary (Posner, 1980). Involuntary attention is bottom-up and automatic, as when a sound or flash of light captures attention outside of people's intention to attend toward it. Voluntary attention is top-down and controlled, as when people

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All data files, materials, and analysis scripts are publicly available at https://osf.io/jktgz/.

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purposefully direct attention toward objects for which they are searching.[1] Our hypotheses concern both voluntary and involuntary attention.

Attention can also be visual or mental (Chun et al., 2011). Visual attention entails focusing consciousness on a visual stimulus such as an image in the external environment. Mental attention entails focusing consciousness on an internal stimulus such as a thought or memory. People encountering multiple articles in an online newsfeed, for example, could focus visual attention on images of wildfires in a news article about climate change while mentally attending to something else, such as the memory of a recent argument. Our theorizing on the relations between attention, emotion, and risk perception applies to both visual and mental attention. Our experiments emphasize visual attention because it can be manipulated in more controlled, precise ways, using visual displays.

Attention is distinct from related constructs of exposure, experience, and awareness. Attention differentiates the objects a person focuses on from other objects that are in view but not in focus (Anderson, 2005; Posner, 1980). Exposure, in contrast, differentiates objects based on whether and for how long they are in the visual field (Auclair & Siéroff, 2002; Drew & Weaver, 1990; Prinzmetal, Henderson, & Ivry, 1995). For example, two people might be exposed for the same duration to images in a news article about wildfires and climate change, yet one person might focus attention exclusively on images whereas the other person might attend to unrelated thoughts or distracting advertisements. People can be exposed to objects without attending to them and can focus attention on objects with varying intensity (Kahneman, 1973).

Like exposure, experience with risks concerns whether and for how long people directly or indirectly encounter a risk. Experience can influence risk perception. For example, people who have directly experienced floods and those who have had indirect experience with floods, such as living in flood-prone areas, perceive flood risks to be higher than people with less experience (Keller, Siegrist, & Gutscher, 2006; Lawrence, Quade, & Becker, 2014; Siegrist & Gutscher, 2006). Attention is distinct from experience just as it is distinct from exposure (Drew & Weaver, 1990; Shim & You, 2015).

Awareness differentiates objects people consciously perceive from those they do not (Koivisto, Revonsuo, & Salminen, 2005; Webb, Igelström, Schurger, & Graziano, 2016; Wyart & Tallon-Baudry, 2008). People can be aware of objects without attending to them. For example, a person focusing attention on images in a news article about wildfires might simultaneously be aware of (but not attend to) advertisement images. In our experiments, we manipulate attention to images of risks in contexts wherein people are aware of all risk images and exposed to all risk images for equal duration. Exposure and awareness are equated for all images while only some images are attended.

Attention profoundly influences perceptions and mental representations (Carrasco, 2006). William James argued that attention influences perception, writing that attention "makes a sense-impression more intense" (James, 1890/1952, p. 426). Directing attention toward objects increases their perceived distinctiveness and vividness (Fuller & Carrasco, 2006; Tse, 2005). Attention makes focal objects stand out from other objects in their surroundings more than unattended objects do (Carrasco et al., 2004; Liu, Abrams, & Carrasco, 2009). This has been demonstrated with a variety of attention manipulations. For example, spatial cueing entails drawing attention toward one side of a computer screen with a flash of light or sudden appearance of a rectangle, or with a task that requires looking at stimuli on that side of the screen (Carrasco, 2006; Liu et al., 2009). Attentional search manipulations, which entail searching repeatedly for a target image, also make images seem more distinctive (Mrkva et al., 2019; Mrkva & Van Boven, 2020). Attention increases perceived distinctiveness across several types of stimuli and across both self-report and psychophysical measures of distinctiveness (Fuller & Carrasco, 2006; Mrkva et al., 2019; Pestilli & Carrasco, 2005).

Attention also facilitates information accumulation (Carrasco & McElree, 2001; Krajbich, Armel, & Rangel, 2010; Noguchi & Stewart, 2018), as implied by sequential sampling models such as the attentional drift diffusion model (Krajbich et al., 2010; Krajbich, Lu, Camerer, & Rangel, 2012; Krajbich & Rangel, 2011) and decision field theory (Busemeyer & Townsend, 1993; Diederich, 1997; Roe, Busemeyer, & Townsend, 2001). These models suggest that people accumulate more information about attended stimuli than unattended stimuli. Unattended information is subsequently weighted less while attended information is weighted more (Fisher, 2017; Krajbich et al., 2010, 2012; Mormann, Malmaud, Huth, Koch, & Rangel, 2010; Rangel & Clithero, 2014; Webb, 2019). For example, when looking at consumer products, people who focus attention on a product with a high, unappealing price weight information about price more than do people who do not focus attention on price (Krajbich et al., 2012). Although such research demonstrates that attention is correlated with choice and information weighting, much of the work lacks experimental manipulations that directly establish a causal effect of attention. These correlational results could be explained, for example, by tendencies for more heavily weighted information to attract attention (reverse causality) or some other confounding factor such as emotionality that might influence both attention and weighting (Orquin & Mueller Loose, 2013; Towal, Mormann, & Koch, 2013).

Attention Intensifies Emotion

Attention intensifies emotion partly because it intensifies perceptual experience. Recent studies demonstrate that merely attending to objects such as neutral images intensifies emotional reactions to those objects (Mrkva et al., 2019). These effects emerged across different types of experimental manipulations of attention, including when people searched repeatedly for target objects and when they were spatially cued to attend to regions where images appeared, an incidental manipulation of attention. People reported that their emotional reactions to attended images were more intense than were their emotional reactions to unattended images.

In other research, directing attention *away* from objects reduces emotional intensity (Dandeneau, Baldwin, Baccus, Sakellaro-

[1] Voluntary attention includes any top-down or controlled allocation of attention. Some but not all instantiations of voluntary attention are goal-directed, as when people focus attention on an article in the news as a result of actively seeking out the article. For example, attending to a commercial is considered voluntary attention even if the observer does not have any goal of attending to the commercial but rather intended to watch a television show which was recently interrupted by the commercial (Du, Xu, & Wilbur, 2019).

poulo, & Pruessner, 2007; McCaul & Malott, 1984; Van Dillen & Koole, 2007). In one study, repeatedly attending away from angry faces and toward neutral faces reduced symptoms of social anxiety (Amir et al., 2009). And distractions that occupy attention or mental resources can reduce the intensity of pain or negative experiences (Van Dillen & Koole, 2007).

Emotion Influences Intuitive Risk Perception

If attention increases emotion, it might also influence intuitive risk perceptions. Broadly speaking, people judge risks through analysis or intuition (Slovic, Finucane, Peters, & MacGregor, 2004; Slovic & Peters, 2006). Analytical risk perception is rooted in logic, reasoning, and deliberation. Analytical risk judgments are calculated, effortful, and grounded in probabilistic and factual properties of risks (Loewenstein et al., 2001; Slovic, 1986, 1987). Our hypotheses concern intuitive risk perception, which is arguably the predominant way that most humans perceive risks, often overriding deliberative risk perception (Loewenstein et al., 2001; Slovic et al., 2004; Slovic & Peters, 2006).

Intuitive risk perception is not consequentialist, in that magnitudes and probabilities are not assessed using calculations of expected value (Loewenstein et al., 2001; Slovic, 1987; Slovic et al., 2004). Intuitive risk perceptions can be understood using psychometric approaches that identify different dimensions of risk perception. Severity and dread underlie the most prominent dimensions of intuitive risk perception (Slovic, 1987; Slovic, Fischhoff, & Lichtenstein, 1980). Other dimensions of risk perception include novelty (how new a threat is) and how widespread a threat is (how many people are affected; Slovic et al., 1980). People often neglect this latter dimension, failing to perceive risks affecting thousands of people as more important than risks that affect few people (Slovic, 2007; Sunstein, 2003).

A central idea in risk perception research is that intuitive risk perceptions are shaped by subjective experiences, especially emotion. According to the risk as feelings framework (Loewenstein et al., 2001; Slovic et al., 2004), emotions such as dread and fear influence risk perceptions. These emotions can be directly related to the risks at hand or they can result from incidental factors (Hirshleifer & Shumway, 2003; Loewenstein et al., 2001).

That emotions influence risk perception is important because it implies that transient factors that evoke emotions can influence risk perception (Loewenstein et al., 2001). For example, people will pay more to avoid risks in the distant future when they are made to feel fear (Van Boven, Loewenstein, Welch, & Dunning, 2012). And because people perceive their immediate emotions as more intense than previous emotions, they perceive threats that happen to arouse immediate fear (because of random assignment) as more dangerous, risky, and worthy of mitigation than threats that happened to have aroused previous emotions (Huber, Van Boven, McGraw, & Johnson-Graham, 2011).

Emotions influence perception of environmental risks just as they influence perception of other risks (Leiserowitz, 2006; Weber, 2006). Environmental risks often do not elicit immediate affect and action (Hansen, 1991; Slovic & Peters, 2006; Weber, 2010). Such risks fail to elicit immediate emotion partly because they are abstract, complex, and occur over long time horizons, making them difficult to directly observe and experience firsthand (Markowitz & Shariff, 2012; Weber, 2006). The unemotionality may help explain inaction on environmental risks.

Does Attention Increase Environmental Risk Perception?

We hypothesize that mere attention increases the perceived severity of environmental risks. This hypothesis stems from the findings reviewed earlier, that attention intensifies emotional reactions to attended objects (Mrkva et al., 2019) and that emotion increases risk perception (Loewenstein et al., 2001; Slovic & Peters, 2006). We predict that inducing people to attend to some environmental risks more than others will make attended risks seem more distinctive, frightening, and severe than unattended risks. This hypothesis implies that the effect of attention on distinctiveness mediates the effect of attention on fear, and that the effect of attention on fear mediates the effect of attention on perceived severity.

Our investigation is primarily concerned with perceptions of the severity dimension of risks, which is closely associated with emotionality (Slovic & Peters, 2006; Van Boven, White, & Huber, 2009). We also explore whether attention influences two other dimensions of risk perception, novelty and how widespread a risk is (Slovic et al., 1980). Because novelty and being widespread are less closely connected with emotion than severity (Slovic & Peters, 2006), attention may not would influence those dimensions.

The conclusion that attention increases risk perception would advance broader understanding of how the core systems of attention and emotion interactively shape the mind's critical function of perceiving risk. Understanding how attention shapes intuitive risk perception would add important evidence regarding the role of attention in judgment and decision making, which relies heavily on attention as an explanatory construct (Birnbaum, 2008; Johnson & Busemeyer, 2016; Kahneman, Krueger, Schkade, Schwarz, & Stone, 2006; Weber & Johnson, 2009). For example, attention is used to explain why people overweight focal attributes such as sunny weather and salaries when predicting future feelings in, say, a new job in California (Kahneman et al., 2006; Schkade & Kahneman, 1998; Wilson, Wheatley, Meyers, Gilbert, & Axsom, 2000). The connection between attention and emotion has been invoked to explain several patterns of intuitive response to risk (Huber et al., 2011; Johnson & Busemeyer, 2016; Loewenstein et al., 2001) such as responses to terrorist threats (Van Boven et al., 2009) and humanitarian suffering (Huber et al., 2011). And attention has been invoked to explain why people in relatively unemotional *cold* states underestimate the strength of their response to psychologically close, emotionally evocative *hot* states (Van Boven & Loewenstein, 2003; Van Boven, Loewenstein, & Dunning, 2005; Van Boven et al., 2012). Much of this and related work presumes that shifting attention influences reactions to risk. Directly demonstrating that attention intensifies emotion to increase (environmental) risk perception would add critical evidence to undergird these various decision phenomena.

Overview of the Present Experiments

We used four different manipulations of attention across four experiments to test whether attention increases the perceived fear and severity of environmental risks. In each experiment,

participants first learned associations between specific environmental risks, such as air pollution, water pollution, and deforestation, and their corresponding images, such as smoggy skies, dirtied streams, and clear cut forests. In Experiments 1 and 2, participants sequentially searched for one or two risks in a larger set of sequentially presented risks (cf. Mrkva et al., 2019, Experiment 1). In Experiments 3 and 4, we used two spatial cueing manipulations that oriented attention toward some risks displayed side by side on a screen (Liu et al., 2009; Mrkva et al., 2019; Mrkva & Van Boven, 2017; Posner, 1980). Experiment 3 used the sudden appearance of a stimulus to cue attention toward one of two environmental risks (Posner, 1980). Experiment 4 used an incidental manipulation of voluntary attention to one of two risks (Liu et al., 2009).

We measured reported fear, distinctiveness, and, as dimensions of risk perception, severity, novelty, and being widespread (Slovic et al., 1980). We sought samples of at least 100 participants per experiment. This would provide more than 90% power to detect the effect size observed in a pilot study (see additional online materials at https://osf.io/jktgz). For laboratory experiments, we continued data collection until the university undergraduate participant pool deadline during the academic term, which resulted in more than 100 participants in Experiments 1 and 4. All experiments were approved by the IRB at the University of Colorado Boulder. The data files, materials, and analysis scripts are publicly available at https://osf.io/jktgz (Mrkva, Cole, & Van Boven, 2020).

Experiment 1: Attentional Search Increases Environmental Risk Perception

Method

Participants. Undergraduate students at the University of Colorado Boulder (N = 105, 77 females; M_{age} = 18.79) participated for course credit. All participants completed the entire survey and were included in our primary analyses.

Procedure. We used an attentional search procedure to manipulate attention (Janiszewski, Kuo, & Tavassoli, 2013; Mrkva et al., 2019). Participants read that the study was about "how judgments and decisions about feelings are influenced by the length of time between their experience and their responses, different ways of asking people to render judgments and decisions, comparisons to different groups of people, and so on."

Participants first viewed 10 images on a single screen, each labeled with a name of a corresponding environmental risk. Then the images were presented again with numbers above each one; participants were given a matching quiz to ensure that they had learned which risk corresponded to each image. To complete the quiz, they were told to look at the numbers above each image and type that number next to the risk label it corresponded to. If any images were matched to the wrong risk label, they were given an error message and told to try again. Participants were required to achieve 100% accuracy on the quiz before proceeding. The experimenter provided clarification for two participants who gave the same incorrect answer several times in a row.

One risk was randomly designated as the target, highlighted in yellow on a screen containing all 10 risks (see Figure 1). The 10 images were subsequently presented one at a time for 1.0 s separated by a 0.5-s fixation cross. Images were displayed 10 times in random order, with no images appearing consecutively. Participants were to press the J key whenever the target appeared and press the F key whenever any nontarget control risk appeared. Target and control images thus required similar motor responses. We referred to them as *J risks* and *F risks*, rather than *target* and *control*.

After viewing the images, participants selected one of the 10 risks about which they would write a letter to their Congressional

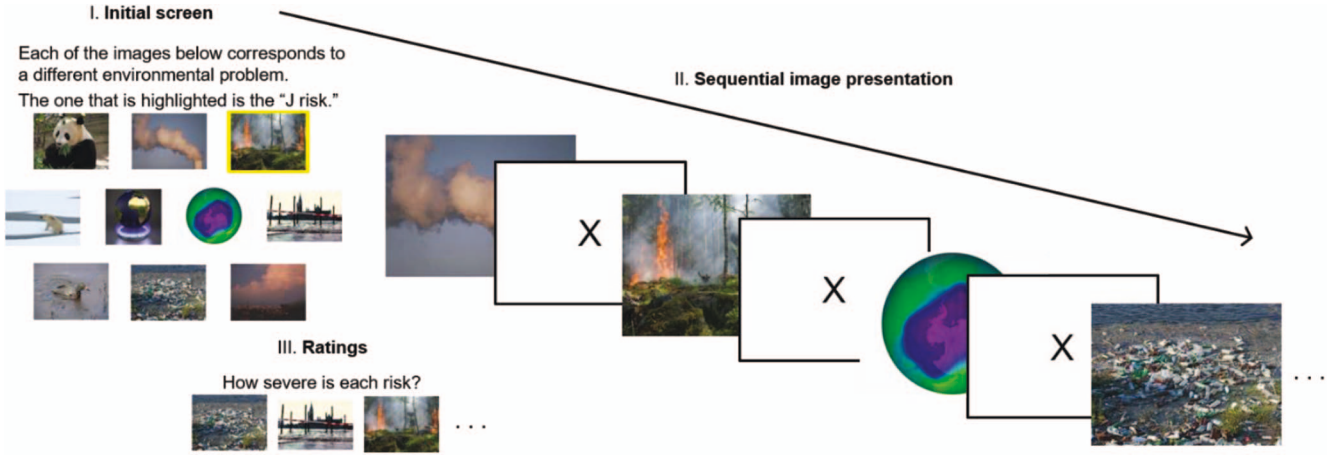

Figure 1. Illustration of Experiment 1 procedure. Participants first viewed a screen with 10 images depicting the different environmental risks (top left). One image was randomly assigned to be the "J risk" (target). Participants viewed the set of 10 images for 1.0 s each, separated by a fixation X presented for 0.5 s (right). During image presentation, participants were to repeatedly attend to their "J risk" and press the J key each time it appeared. They were to press the F key each time any other image appeared (control). Participants viewed all images 10 times, randomly ordered with no image presented two or more consecutive times. After image presentation, participants answered questions about each of the images, including the severity question illustrated in the bottom panel. All images have CC0 license (no permission required). See the online article for the color version of this figure.

representative advocating its importance. Next, to measure memory accessibility, participants recalled as many risks as possible "in the order they [came] to mind" (Grimes, Solberg Nes, Waldman, & Segerstrom, 2012; Higgins, King, & Mavin, 1982). We coded responses by entering each risk's position in the list.[2]

To measure perceived severity, participants answered, "How severe is each risk?" and "During the slideshow, how severe did this risk seem?" (0 = *not at all*, 6 = *extremely*; $r = .57$). We measured fear with three items, asking participants "How much fear does this risk evoke in you?" as well as how much fear and emotional intensity the risk evoked during the slideshow (0 = *none*, 9 = *the most possible*; $\alpha = .84$). We measured distinctiveness with, "During the slideshow, how distinctive did this risk appear?" (0 = *not at all*, 9 = *the most possible*).

We also collected exploratory measures of much each risk was novel and widespread: "Is this risk a new/novel one or an old/familiar one?" and "During the slideshow, did this risk seem like a new/novel one or an old/familiar one?" (0 = *very old/familiar*, 6 = *very new/novel*; $r = .78$). We measured perceptions of how widespread risks were with two questions: "How widespread is each risk?" and "During the slideshow, how widespread did this risk seem?" (0 = *not at all*, 6 = *extremely*; $r = .67$). Finally, participants read that the Environmental Protection Agency (EPA) must make tradeoffs, allocating limited resources toward reducing some risks but over other risks: "How much of a budget priority should each risk be for the EPA?" (0 = *very low priority*, 6 = *very high priority*).

Stimuli. We used the following 10 risks in all experiments: air pollution, water pollution, animals going extinct, deforestation, polar ice caps melting, ozone depletion, global temperatures increasing, sea levels rising, carbon emissions increasing, and animal habitats being destroyed (Table S1 in the online supplemental materials).

Results

We analyzed data using mixed effects models in all experiments. There was one fixed effect of Target, contrast-coded to compare the target (1/2) and control (−1/2) risks, and random effects for Participant and Risk, including both the random intercepts and random slopes (Judd, Westfall, & Kenny, 2012). Including these random effects accounts for variation between participants in their risk judgment tendencies, variation between risks in how they are generally judged, and variation in the effects of target across different participants and risks.

As predicted, participants perceived target risks as more severe than control risks ($M_{\text{target}} = 4.37$, $SD = 1.37$; $M_{\text{control}} = 4.09$, $SD = 1.37$), $t(101.72) = 2.32$, $d = 0.18$, 95% CI [0.03, 0.33], $p = .022$. Participants were also more likely to choose a target risk (17%) to include in a letter to their Congressional representative than control risks (9%), $z = 2.34$, odds ratio (OR) = 1.96, 95% CI [1.08, 3.41], $p = .020$. And participants reported that target risks should be higher priority for the EPA than control risks ($M_{\text{target}} = 4.48$, $SD = 1.57$; $M_{\text{control}} = 4.08$, $SD = 1.57$), $t(935.53) = 2.67$, $d = 0.21$, 95% CI [0.06, 0.36], $p = .008$ (see Figure 2). Sequential search thus increased perceived severity and prioritization of risks.

In the analysis of exploratory measures, participants perceived target risks as more widespread than control risks ($M_{\text{target}} = 4.00$, $SD = 1.63$; $M_{\text{control}} = 3.85$, $SD = 1.59$), $t(936.01) = 2.04$, $d = 0.14$, 95% CI [0.01, 0.28], $p = .041$. They did not perceive target risks as more novel ($M_{\text{target}} = 1.48$, $SD = 1.53$; $M_{\text{control}} = 1.63$, $SD = 1.52$), $t(103.22) = -0.24$, $d = -0.02$, 95% CI [−0.16, 0.13], $p = .810$. Sequential search did not significantly influence all dimensions of risk perception in the same way. It increased perceived severity without impacting perceived novelty.

Participants also reported that target risks were more frightening ($M_{\text{target}} = 5.41$, $SD = 2.24$; $M_{control} = 4.87$, $SD = 2.30$), $t(101.68) = 2.59$, $d = 0.17$, 95% CI [0.04, 0.30], $p = .011$, and more distinctive than control risks ($M_{\text{target}} = 6.15$, $SD = 2.50$; $M_{\text{control}} = 5.00$, $SD = 2.49$), $t(7.45) = 3.16$, $d = 0.38$, 95% CI [0.14, 0.62], $p = .015$. Fear, distinctiveness, and severity were positively correlated with each other (see Table 1).

We conducted a serial mediation analysis with 5,000 bootstrapped resamples (Preacher & Hayes, 2008) to test whether sequential search increased distinctiveness which increased fear which increased perceived severity (see Figure 3). We included memory accessibility as a possible mediator because target risks were recalled earlier in participants' free recall lists than control risks ($M_{\text{target}} = 2.95$, $SD = 1.98$; $M_{\text{control}} = 5.00$, $SD = 2.57$), $t(23.91) = -6.71$, $d = -0.76$, 95% CI [−0.98, −0.54], $p < .001$. There was a significant indirect effect from target to distinctiveness to fear to severity (indirect effect = 0.18, 95% CI [0.10, 0.26]). There was no indirect effect from target to accessibility to severity (indirect effect = 0.01, 95% CI [−0.02, 0.04]). The serial mediation path reflected three component paths: from target to distinctiveness, $b = 1.01$, 95% CI [0.61, 1.43]; from distinctiveness to fear intensity, $b = 0.43$, 95% CI [0.40, 0.46]; and from fear intensity to perceived severity, $b = 0.43$, 95% CI [0.40, 0.46]. The effect of target on perceived severity was reduced (from $b = 0.25$, 95% CI [0.04, 0.45] to $b = 0.01$, 95% CI [−0.13, 0.14]) when controlling for distinctiveness and fear, consistent with full mediation (Baron & Kenny, 1986).

Discussion

Participants judged target environmental risks toward which they had sequentially directed their attention as more distinctive, frightening, severe, and of higher priority than control risks. Target risks were also perceived as more widespread (but not more novel) than control risks. A serial mediation analysis indicated a significant indirect effect from target to distinctiveness to fear to severity. These results provide initial support for the hypothesis that attention, operationalized as repeated sequential search, increases perceived severity of environmental risks.

Experiment 2: Isolating Attentional Search From Implied Uniqueness

We sought to conceptually replicate the findings that target risks are perceived as more severe, while differentiating effects of directing attention in search of a risk from singling out a risk. In Experiment 1, one risk was a target that was both searched for and singled out with a label that was different from the other nine risks (Lamy, Bar-Anan, Egeth, & Carmel, 2006; Theeuwes, 1992). It is possible that singling out one risk could have contributed to

[2] Nonrecalled risks were left as missing values.

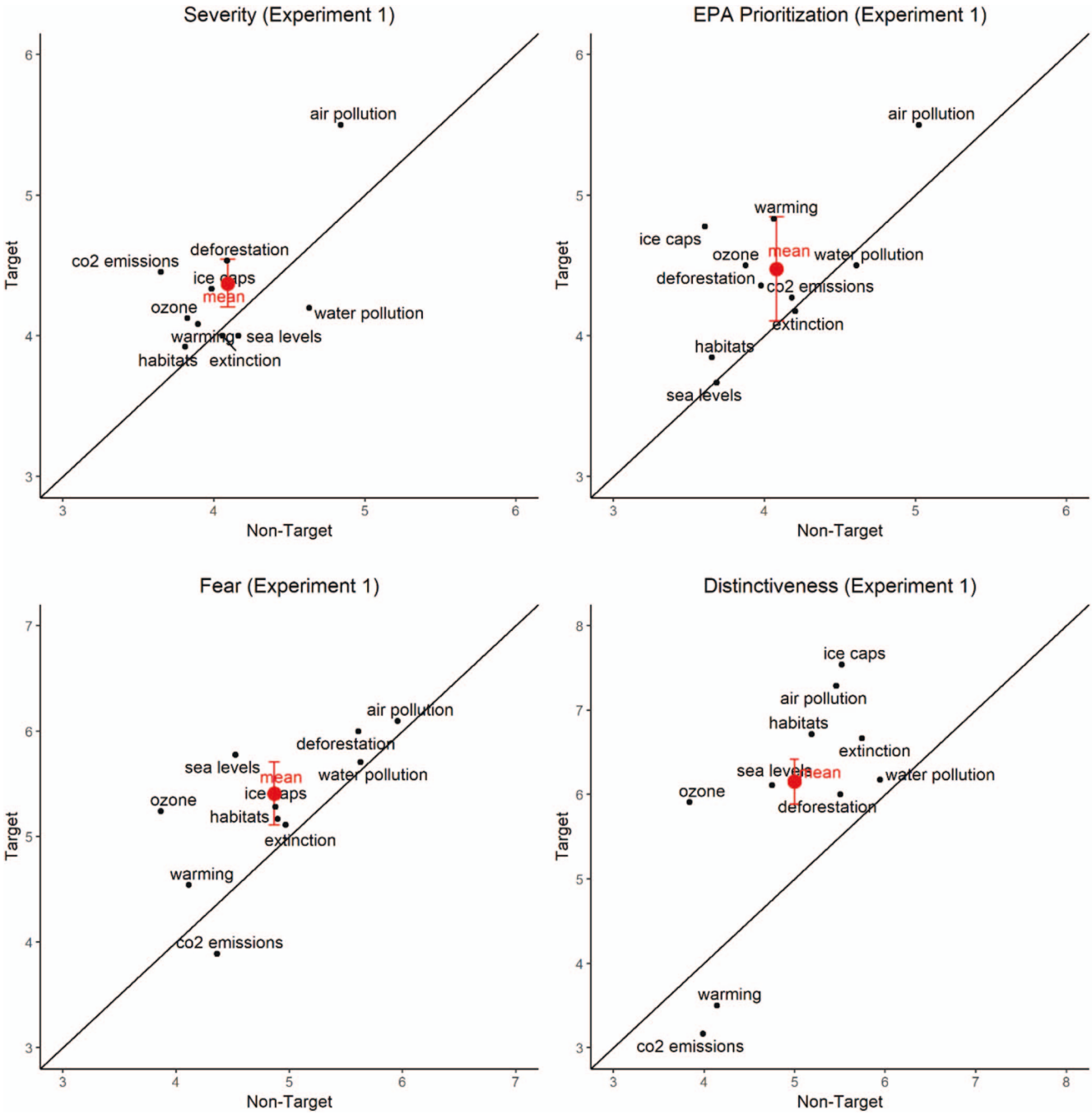

Figure 2. The effects of target on perceived severity, EPA prioritization, fear, and distinctiveness in Experiment 1. Risks located to the top left of the identity line were rated higher among participants for whom the risk was a target than among participants for whom the risk was a control. Error bar represents the 95% confidence interval of the difference between target and control risks. EPA = Environmental Protection Agency. See the online article for the color version of this figure.

increased perceptions of distinctiveness, fear, and severity. To address this possibility in Experiment 2, we used a similar procedure as in Experiment 1, but with two targets rather than one, and in a set of four total risks, equalizing the number of target and nontarget risks. As in Experiment 1, we tested our hypothesized mediational path from attention to perceived distinctiveness to fear to perceived severity. We also measured several exploratory individual differences that might moderate the effect of attention on risk perception: environmental concern, everyday attention to environmental risks, belief in climate change, and political ideology.

Table 1
Bivariate Associations Between Measures in Experiment 1

Experiment 1	Severity	Novelty	Widespread	Fear	Distinctiveness	Prioritization
Severity						
Novelty	−.08					
Widespread	.53*	−.04				
Fear	.45*	.00	.33*			
Distinctiveness	.26*	.01	.17*	.43*		
Prioritization	.53*	−.02	.43*	.72*	.59*	

Note. We estimated bivariate associations while adjusting for variance associated with each participant and with each risk by using mixed-effects models that modeled the random effects of participant and stimulus (following Judd, Garcia-Marques, & Yzerbyt, 2019). This corrects for several issues with raw correlations including participant response tendencies, which could otherwise inflate correlations if some participants use the same end of the scale across all measures.
* $p < .05$ after Bonferroni correction for the 15 associations.

Method

Participants. We requested 100 U.S. adults from Amazon Mechanical Turk who were paid $2.00. We excluded nine who did not complete key dependent measures and six who did not speak English and were not from the United States (resulting $N = 85$, 47 females; $M_{age} = 36.54$).[3] We requested only U.S. participants because measures such as EPA prioritization and political ideology would have different meanings in different countries.

Procedure. Participants first viewed 12 images, the 10 from Experiment 1 and two additional images, on a screen along with labels indicating each risk. Before proceeding, participants completed a quiz in which they matched each image with its corresponding risk label (accuracy was 91%).[4]

Participants then viewed four risk images prior to a slideshow containing those four images. To manipulate attentional search, for two of the four images, we asked participants to press the up arrow on their keyboard whenever it appeared upright in the slideshow and the down arrow whenever it appeared upside-down (see Figure 4). These two images were targets, although they were not identified as such to participants (nor did they have any label). All four images were presented 10 times in the slideshow for 1.0 s each time. Each image was presented upside-down 50% of the time and upright 50% of the time. Images were randomly ordered, separated by a fixation cross that was displayed for 0.5 s. Both target and control images were thus presented for 10 s in total (10 times × 10 s).

After viewing the first slideshow, participants provided ratings of the four images in that slideshow for the same variables as in Experiment 1: distinctiveness, fear, severity, and EPA prioritization, as well as how novel and widespread the risks were. They repeated this process for the eight remaining risks, viewing two more slideshows with four new risks and completing the dependent measures for each. The order of the three slideshows was counterbalanced.

After the third slideshow, participants completed several exploratory individual difference measures by indicating their agreement with several statements (−3 = *strongly disagree*, +3 = *strongly agree*): environmental concern ("I am concerned with environmental issues" and "I am an environmentalist"; $r = .63$); belief in climate change (e.g., "Climate change is happening"; $\alpha = .92$; four items, Van Boven, Ehret, & Sherman, 2018); and the frequency with which people attend to environmental issues in everyday life (e.g., "I frequently think about environmental risks in everyday life"; $\alpha = .76$; four items). We included measures of political identity and ideology, which entailed party identification (−3 = *strong Democrat*, +3 = *strong Republican*) and three items assessing liberal to conservative ideology (−3 = *very liberal*, +3 = *very conservative*; $\alpha = .84$; see Appendix S1 in the online supplemental materials). And we included a seven-item measure of open-minded thinking (e.g., "People should revise their beliefs in response to new information or evidence"; −3 = *completely disagree*, +3 = *completely agree*; $\alpha = .82$; Haran, Ritov, & Mellers, 2013).

After completing these measures, participants completed the same perceived severity and fear items again. We collected these measures to explore whether the effects of attention persisted after participants answered other questions for several minutes.[5] Previous research suggests that simple time delays and engaging in intervening activities can reduce or eliminate transient effects of attention and emotion (Huber et al., 2011; Van Boven et al., 2009).

Finally, we included questions to assess participants' awareness of the research question and perceived demand characteristics. We asked participants, "Which of the following do you think was the purpose of the study?" giving them eight multiple-choice answers including the actual purpose (see online supplemental materials). We also asked them whether they thought the experimenter wanted the task (i.e., pressing the "up arrow" and "down arrow" for two of the risks) to influence their severity judgments. All participants were included in primary analyses. All effects remain significant when excluding people who guessed the research question correctly or thought the experimenter wanted them to judge searched-for risks as more severe.

Stimuli. We used the same 10 risks and images as in Experiment 1. We added two risks (wildfires and flooding; Table S1 in the online supplemental materials) because the procedure required four images per slideshow.

[3] It is unclear how these six got access to the survey given that we confined our sample to people in the United States. Most of these individuals were from India.

[4] In this and in Experiments 3 and 4, we did not require 100% accuracy, as we did in Experiment 1, to streamline the procedure.

[5] These fear and severity items were identical to the items presented immediately after the slideshow, except that we used only one of the two severity items: "How severe is each risk?" Note that the length of the delay varied across participants.

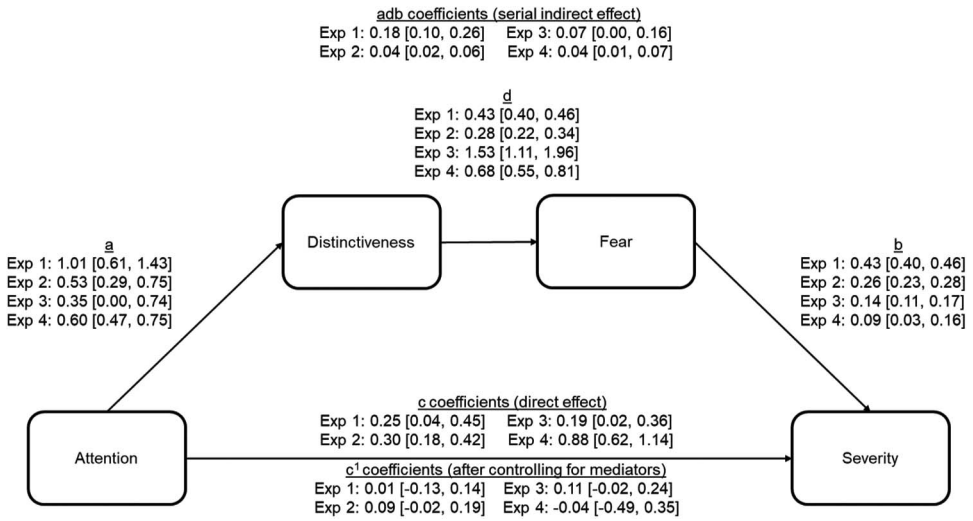

Figure 3. Mediation model examining the proposed path from attention to distinctiveness to fear to perceived severity of environmental risks in each study. Mediation coefficients here and throughout the paper are unstandardized coefficients (95% CI in brackets). For binary dependent variables, these coefficients (*b*) are log-odds ratios.

Results

As in Experiment 1, we analyzed data using mixed effects models with one fixed effect of Target, contrast-coded to compare the target and control risks (control = −1/2, target = +1/2). We again included random effects for Participant and Risk to account for variance associated with participants and variance associated with stimuli (Judd et al., 2012).

As predicted, participants perceived target risks as more severe than control risks (M_{target} = 4.08, *SD* = 1.49; $M_{control}$ = 3.78, *SD* = 1.59), $t(82.80) = 3.69$, $d = 0.19$, 95% CI [0.09, 0.30], $p < .001$. Participants also indicated that target risks should be higher priorities for the EPA than control risks (M_{target} = 4.35, *SD* = 1.56; $M_{control}$ = 4.17, *SD* = 1.57), $t(8.82) = 2.66$, $d = 0.12$, 95% CI [0.03, 0.21], $p = .027$. Sequential search thus increased perceived severity and prioritization of target risks even though there were equal numbers of target and control risks (see Figure 5).

Participants also perceived target risks as more widespread than control risks (M_{target} = 4.47, *SD* = 1.50; $M_{control}$ = 4.30, *SD* =

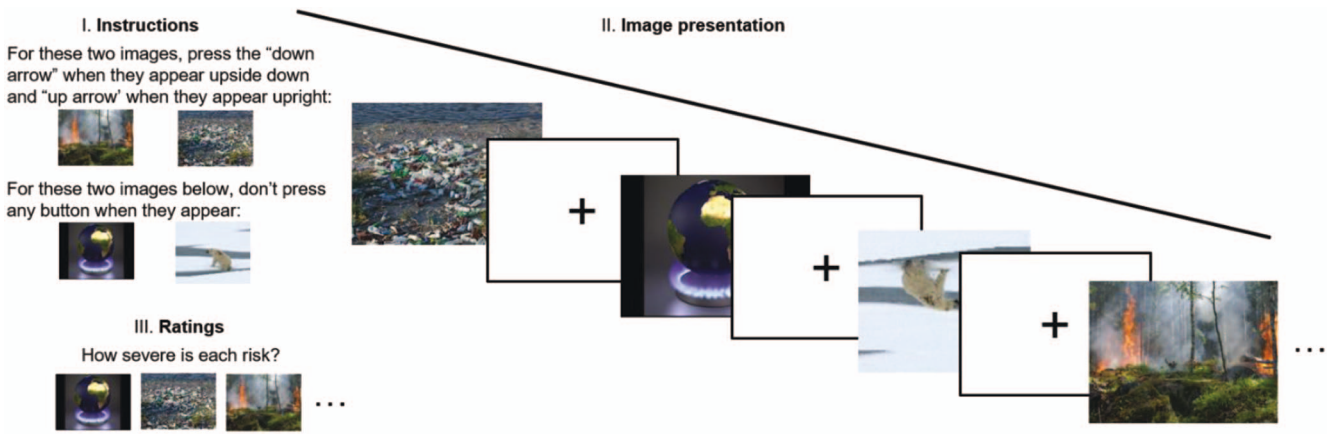

Figure 4. Illustration of Experiment 2 procedure. Participants viewed each of the four images for 1.0 s, separated by a fixation cross presented for 0.5 s. For two of the four images, participants were to press the "up arrow" each time they appeared upright and the "down arrow" each time they appeared upside-down. All four images appeared upright 50% of the time and upside-down 50% of the time. After image presentation, participants answered questions about each of the images, including the severity question illustrated in the bottom panel. All images have CC0 license (no permission required). From "Attention Influences Emotion, Judgment, and Decision Making to Explain Mental Simulation," by K. Mrkva, J. Ramos, and L. Van Boven, 2020, *Psychology of Consciousness: Theory, Research, and Practice*. Advance online publication. https://doi.org/10.1037/cns0000221. Copyright 2020 by American Psychological Association. See the online article for the color version of this figure.

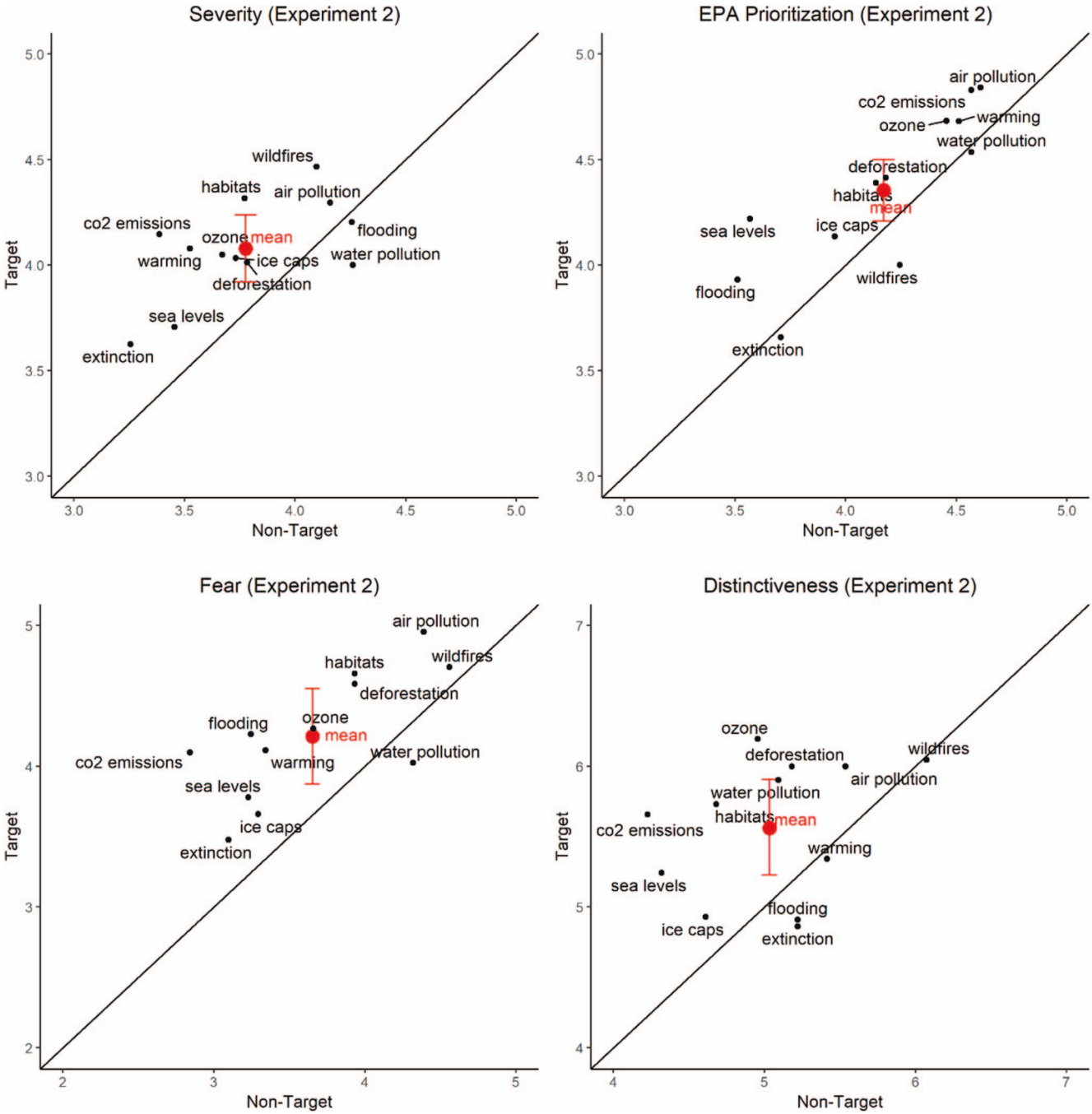

Figure 5. The effect of target on perceived severity, EPA prioritization, fear, and distinctiveness in Experiment 2. Risks located to the top left of the identity line were rated higher among participants for whom the risk was a target than among participants for whom the risk was a control. Error bar represents the 95% confidence interval of the difference between target and control risks. EPA = Environmental Protection Agency. See the online article for the color version of this figure.

1.56), $t(82.55) = 2.18$, $d = 0.11$, 95% CI [0.01, 0.21], $p = .032$. They did not perceive target risks as more novel than control risks ($M_{\text{target}} = 2.21$, $SD = 1.95$; $M_{\text{control}} = 2.20$, $SD = 1.95$), $t(7.33) = 0.13$, $d = 0.01$, 95% CI [−0.09, 0.10], $p = .900$.

In examining the two mediators, target risks were, as predicted, more frightening than control risks ($M_{\text{target}} = 4.21$, $SD = 3.06$; $M_{control} = 3.65$, $SD = 3.01$), $t(32.16) = 2.98$, $d = 0.18$, 95% CI [0.06, 0.30], $p = .005$, and more distinctive than control risks ($M_{\text{target}} = 5.56$, $SD = 2.77$; $M_{\text{control}} = 5.03$, $SD = 2.77$), $t(82.45) = 3.85$, $d = 0.19$, 95% CI [0.09, 0.29], $p < .001$. Fear, perceived distinctiveness, and severity were positively correlated (see Table 2).

Table 2
Bivariate Associations Between Measures in Experiment 2

Experiment 2	Severity	Novelty	Widespread	Fear	Distinctiveness	Prioritization
Severity						
Novelty	.12*					
Widespread	.33*	.02				
Fear	.31*	.05	.14*			
Distinctiveness	.21*	.07	.15*	.34*		
Prioritization	.38*	.10	.43*	.47*	.38*	

Note. We estimated bivariate associations while adjusting for variance associated with each participant and with each risk by using mixed-effects models that model the random effects of participant and stimulus (following Judd et al., 2019). This corrects for several issues with raw correlations including participant response tendencies, which could otherwise cause artificially high correlations if some participants use the same end of the scale across all measures.
* $p < .05$ after Bonferroni correction for the 15 associations.

We conducted a serial mediation analysis with 5,000 bootstrapped resamples (Preacher & Hayes, 2008) to test whether sequential search increased distinctiveness which increased fear which increased perceived severity. There was a significant indirect effect from target to distinctiveness to fear to severity (indirect effect = 0.04, 95% CI [0.02, 0.06]). This reflected the combination of an effect of target on distinctiveness, $b = 0.53$, 95% CI [0.29, 0.75], and paths from distinctiveness to fear, $b = 0.28$, 95% CI [0.22, 0.34], and from fear to perceived severity, $b = 0.26$, 95% CI [0.23, 0.28]. The effect of target on perceived severity was significantly reduced (from $b = 0.30$, 95% CI [0.18, 0.42] to $b = 0.09$, 95% CI [−0.02, 0.19]) when controlling for distinctiveness and fear. This is consistent with the idea that attentional search increased perceived severity because it increased the distinctiveness and fear associated with attended risks.

In exploratory analyses, we examined whether the individual difference variables moderated the effects of attentional search on our primary dependent measure of perceived severity. None of our measured individual differences significantly moderated the effect of attention: environmental concern, $t(82.09) = -0.26$, $d = -0.01$, 95% CI [−0.12, 0.09], $p = .795$; attention to environmental issues, $t(82.22) = 0.64$, $d = 0.03$, 95% CI [−0.07, 0.14], $p = .527$; belief in climate change, $t(81.85) = 1.51$, $d = 0.08$, 95% CI [−0.02, 0.18], $p = .135$; political ideology, $t(81.88) = -0.98$, $d = -0.05$, 95% CI [−0.15, 0.05], $p = .328$; or open-minded thinking, $t(82.05) = 1.50$, $d = 0.08$, 95% CI [−0.02, 0.18], $p = .136$. Although they did not significantly moderate the attention effects, higher environmental concern, belief in climate change, and everyday attention to environmental issues were all associated with higher perceived severity (all ts > 3.00, all ps $< .01$, see SOM for full results). Open-minded thinking and political ideology were not significantly associated with severity judgments (both $|t|$s < 1.25, ps $> .20$).

We also explored whether the effects of attention would diminish over time after participants completed other tasks. For perceived severity, the Target × Delay interaction was not significant, $t(1855.62) = -1.37$, $d = -0.07$, 95% CI [−0.18, 0.03], $p = .171$. For fear, there was a significant interaction, $t(1855.85) = -2.64$, $d = -0.13$, 95% CI [−0.23, −0.03], $p = .008$. We caution against overly strong conclusions based on these results, however, given that the elapsed time included active participation in other tasks. Differences between immediate and delayed ratings could be attributable to time delay or attending toward other tasks, either of which can reduce emotional intensity (Huber et al., 2011; McCaul & Malott, 1984; Van Dillen & Koole, 2007).

Discussion

Sequential attentional search increased the perceived severity of environmental risks. Target risks were also prioritized more, were more frightening, and were more distinctive than control risks. The effect of attentional search on severity was mediated by the effect of attentional search on fear, which was mediated the effect of search on distinctiveness. These effects of attentional search occurred with multiple targets and with equal numbers of target and control risks.

Experiment 3: Cued Involuntary Attention Increases Environmental Risk Perception

In Experiments 3 and 4, we examined whether merely attending toward risks one time, without searching repeatedly for them, would increase their perceived severity. In Experiments 1 and 2, participants were explicitly instructed to search for risks or to make a response when a risk appeared. Sequential search procedures have external realism because they are similar to situations in which people purposefully look for certain types of threats such as wildfire risks. Sequential search procedures entail processes beyond mere attention, however, so it is possible that something else about search, repetition, or those instructions, rather than attention itself, increased perceived risk severity. We therefore sought to manipulate attention independent of search in order to isolate the effect of mere attention.

In Experiment 3, we examined involuntary attention. Whereas voluntary attention involves conscious control, involuntary attention is bottom-up and automatic, as when a flash of light or pop-up advertisement captures attention outside of any intent to attend toward it. Involuntary attention may characterize important features of how attention works in everyday life. For example, media presentation of environmental threats in "attention grabbing" ways (Smith & Joffe, 2009) elicits involuntary attention, wherein the public's attention is drawn (rather than directed) toward environmental risks. Of course, the media usually manipulates attention by directly increasing the vividness and salience of presentations. Our

hypothesis is that mere attention, whether voluntary or involuntary, would increase distinctiveness and fear, which would therefore increase perceived severity.

Participants viewed two images of environmental risks, one on each side of a screen. A white rectangle briefly flashed on the screen to draw their attention toward one randomly determined side just before the two risk images appeared. One image was at the location where the white rectangle had just appeared while the second image appeared on the other side of the screen. This procedure involuntarily orients attention toward the region where the attended image appears (Chun & Wolfe, 2001; Posner, 1980; Santangelo, Botta, Lupiáñez, & Spence, 2011). Each risk image appeared only once for only one second. We hypothesized that participants would perceive the cued risk as more severe.

We also varied the wording of questions, randomly assigning some participants to choose the risk in each pair that was "more severe" and others to choose the risk that was "less severe." This allowed us to examine whether attention increases perceived severity as we predicted, or whether it simply increases the tendency for people to choose cued risks regardless of the question (following Fuller & Carrasco, 2006).

Method

Participants. Undergraduate students at the University of Colorado Boulder ($N = 128$, 73 female, $M_{age} = 19.34$) participated in exchange for course credit. All participants completed the entire study and no participants were excluded from primary analyses.

Procedure. We examined how cueing attention toward some environmental risks and away from others influences perceived risk severity. To disguise the purpose of the experiment, participants were told that the researchers were examining how distractions such as sudden flashes of light influence memory and the speed of judgments. They read that some participants would see a white rectangle briefly appear which would look like a flash of light. They were shown the 10 images used in Experiment 1 with corresponding risk labels and achieved 94% accuracy in a matching test.

Each trial began with a 3.0 s presentation of a white fixation cross against a black background. We cued involuntary attention with the appearance of a white unfilled rectangle for 0.15 s (Posner & Cohen, 1984). The white rectangle was randomly assigned to appear on the left or right side of the screen. Immediately after the rectangle disappeared, two environmental risk images were presented for 1.0 s. One appeared at the location where the rectangle had been, whereas the other appeared on the other side of the screen (see Figure 6).

Participants then selected which of the two risks was more (or less) severe, serious, novel, and widespread. To minimize response bias and spatial compatibility effects (Fitts & Seeger, 1953; Liu et al., 2009), the direction of choice varied across participants with some selecting which risk had more of each property and some selecting which had less of each property. We averaged responses to the two severity items (how severe and how serious the risks were; 77% correspondence).

Participants then completed a recognition check to ensure that they had seen both images. They viewed four images including the cued and noncued image and two foil images depicting different environmental risks. They selected which two had been presented (accuracy = 98% for cued and 97% for noncued images). The foil images were different images depicting some of the same environmental risks and other similar environmental risks.

Participants then viewed both the cued and non-cued images individually and were asked the same fear and EPA prioritization items as in Experiment 1. They selected which image was more distinctive. As a manipulation check they selected, "Which risk did your eyes focus on more?"

Participants also completed a series of exploratory individual difference measures. We used the same measures from Experiment 2 of environmental concern, political party, political ideology, open-minded thinking, and belief in climate change. We also included the same probes for demand characteristics and awareness of the research question (Appendix S2 in the online supplemental materials). All effects remained significant when excluding participants who guessed the research question correctly or those who thought the experimenter wanted the white rectangle to increase perceived severity of the cued risk (see the online supplemental materials). Finally, after completing these measures, participants completed one severity item a second time as an exploratory test of whether the effect would persist after a delay and intervening tasks.

Results

We analyzed data using mixed effects models. Unlike in previous experiments, many of the outcome measures were binary rather than continuous. So we used binomial generalized mixed effects models for the binary (forced-choice) outcome variables and linear mixed effects models for continuous outcome variables (ratings). For the binary outcome variables, responses were coded 1 if the risk was chosen as having more of a quality relative to the other option and 0 if it was chosen as having less of the quality.[6]

The manipulation check suggested participants visually attended more to cued (60%) than noncued (40%) risks, $z = 4.15$, OR = 2.50, 95% CI [1.56, 3.48], $p < .001$.

As predicted, participants were more likely to choose that cued risks were more severe (55%) than noncued risks (45%), $z = 2.19$, rate ratio (RR) = 1.21, 95% CI [1.02, 1.43], $p = .029$ (see Figure 7). Involuntary attention increased the perceived severity of attended risks.

There was no significant effect of cue on perceived novelty ($M_{cued} = 47\%$; $M_{noncued} = 53\%$), $z = -1.33$, OR = 0.77, 95% CI [0.54, 1.10], $p = .184$, or on perceptions of how widespread risks were ($M_{cued} = 54\%$; $M_{noncued} = 46\%$), $z = 1.66$, OR = 1.38, 95% CI [0.95, 2.00], $p = .097$. Cued risks were not prioritized significantly more than noncued risks, unlike in Experiments 1 and 2 ($M_{cued} = 4.59$, $SD = 1.24$; $M_{noncued} = 4.56$, $SD = 1.22$), $t(124.92) = 0.40$, $d = 0.04$, 95% CI [−0.15, 0.23], $p = .689$.

Consistent with previous experiments, cued risks were perceived as more distinctive (54%) than noncued risks (46%), $z = 2.02$, OR = 1.43, 95% CI [1.00, 2.07], $p = .044$. Cued risks also evoked more fear than did noncued risks ($M_{cued} = 5.21$, $SD =$

[6] For example, for participants asked, "Which risk is more serious?", a risk was coded 1 if it was chosen and 0 if it was not chosen. For participants asked, "Which risk is less serious?", it was coded 0 if it was chosen and 1 if it was not chosen. For measures which were combinations of two binary items, we ran generalized Poisson mixed effects models with a sum of the two items as the outcome. For ease of interpretation, the means we report use averages rather than sums of the two items.

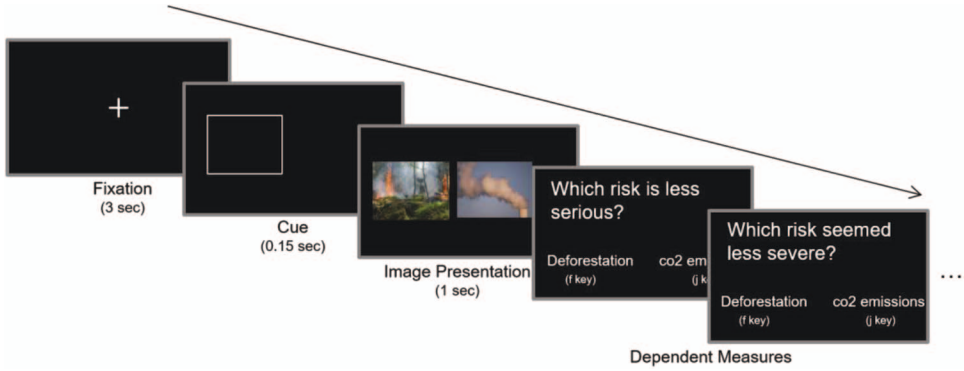

Figure 6. Illustration of Experiment 3 procedure. A brief flash of a white rectangular cue appeared on the left or right side of the screen, which was designed to draw participants' attention toward that side. Immediately after the cue disappeared, two images corresponding to two environmental risks appeared. Participants then rated which image was [more/less] severe, serious, novel, widespread, and distinctive. They also completed a recognition memory task, rated the amount of fear that each evoked, reported how much the EPA should prioritize each, and chose which they focused their eyes on [more/less]. All images have CC0 license (no permission required). From "Attention Influences Emotion, Judgment, and Decision Making to Explain Mental Simulation," by K. Mrkva, J. Ramos, and L. Van Boven, 2020, *Psychology of Consciousness: Theory, Research, and Practice*. Advance online publication. https://doi.org/10.1037/cns0000221. Copyright 2020 by American Psychological Association. See the online article for the color version of this figure.

2.56; $M_{\text{noncued}} = 4.97$, $SD = 2.47$), $t(178.70) = 2.28$, $d = 0.20$, 95% CI [0.03, 0.38], $p = .024$. The direction of question wording did not significantly moderate the effects of cued attention on perceived distinctiveness, $z = 1.01$, OR = 1.46, 95% CI [0.70, 3.05], $p = .311$, severity, $z = 1.82$, RR = 1.37, 95% CI [0.98, 1.94], $p = .069$, novelty, $z = 1.14$, OR = 1.50, 95% CI [0.75, 3.03], $p = .256$, or how widespread risks were perceived $z = -0.55$, OR = 0.82, 95% CI [0.39, 1.71], $p = .585$.

We computed a serial mediation model to examine the hypothesized path from attention to distinctiveness to fear to severity. We used 5,000 bootstrapped resamples to estimate this indirect effect. There was a significant indirect effect from cued risk to distinctiveness to fear to severity (indirect effect = 0.07, 95% CI [0.00, 0.16]). This reflected the combination of an effect of cue on distinctiveness, $b = 0.07$, 95% CI [0.00, 0.16], and paths from distinctiveness to fear intensity, $b = 1.53$, 95% CI [1.11, 1.96], and from fear intensity to perceived severity, $b = 0.14$, 95% CI [0.11, 0.17]. The effect of cue on perceived severity was reduced (from $b = 0.19$, 95% CI [0.02, 0.36] to $b = 0.11$, 95% CI [−0.02, 0.24]) when controlling for distinctiveness and fear.

In exploratory analyses, the effects of cued attention were not significantly moderated by any of the individual difference variables. There was no significant interaction between cued attention and political ideology, $z = -0.24$, OR = 0.98, 95% CI [0.86, 1.13], $p = .811$, environmental concern, $z = 0.34$, OR = 1.03, 95% CI [0.89, 1.18], $p = .732$, belief in climate change, $z = 0.88$, OR = 1.14, 95% CI [0.85, 1.52], $p = .378$, or open-minded thinking, $z = 0.19$, OR = 1.02, 95% CI [0.82, 1.27], $p = .851$. We explored whether the effect of attention on perceived severity would diminish over time. The Cue × Delay interaction was not significant, $z = -1.22$, OR = 0.71, 95% CI [0.41, 1.23], $p = .222$.

Discussion

These results replicated the findings from Experiments 1 and 2 that attention increases perceived severity, fear, and distinctiveness of environmental risks. Though the manipulation was of involuntary attention and did not entail searching for a risk or repeatedly attending to it, attention increased perceived severity. This is consistent with our hypothesis that mere attention is sufficient to increase perceived severity, regardless of whether involuntary or voluntary attention is directed toward a risk. Additionally, there was evidence for serial mediation in which attention increased distinctiveness which increased fear which increased severity.

Experiment 4: Incidental Voluntary Attention Increases Environmental Risk Perception

We next sought to test whether orienting *incidental* attention toward a risk would increase perceived severity. We manipulated incidental voluntary attention by giving participants a primary task that, as a byproduct of the task, required them to orient attention toward some risks and away from others (Liu et al., 2009; Mrkva & Van Boven, 2017; Mrkva et al., 2019). Participants monitored a string of letters for appearance of an "X." As they were engaged in this letter monitoring task, one cued risk image appeared near the letters and one noncued risk appeared on the other side of the screen. Incidental attention was thus oriented toward one risk and away from the other. The spatial orientation of attention and risks was thus similar to Experiment 3. Unlike involuntary cueing, however, participants' attention was not cued directly to the environmental risk image but was instead cued to a region adjacent to the image.

We used this procedure for three reasons. First, it would allow generalization of the effects observed in Experiment 3 from invol-

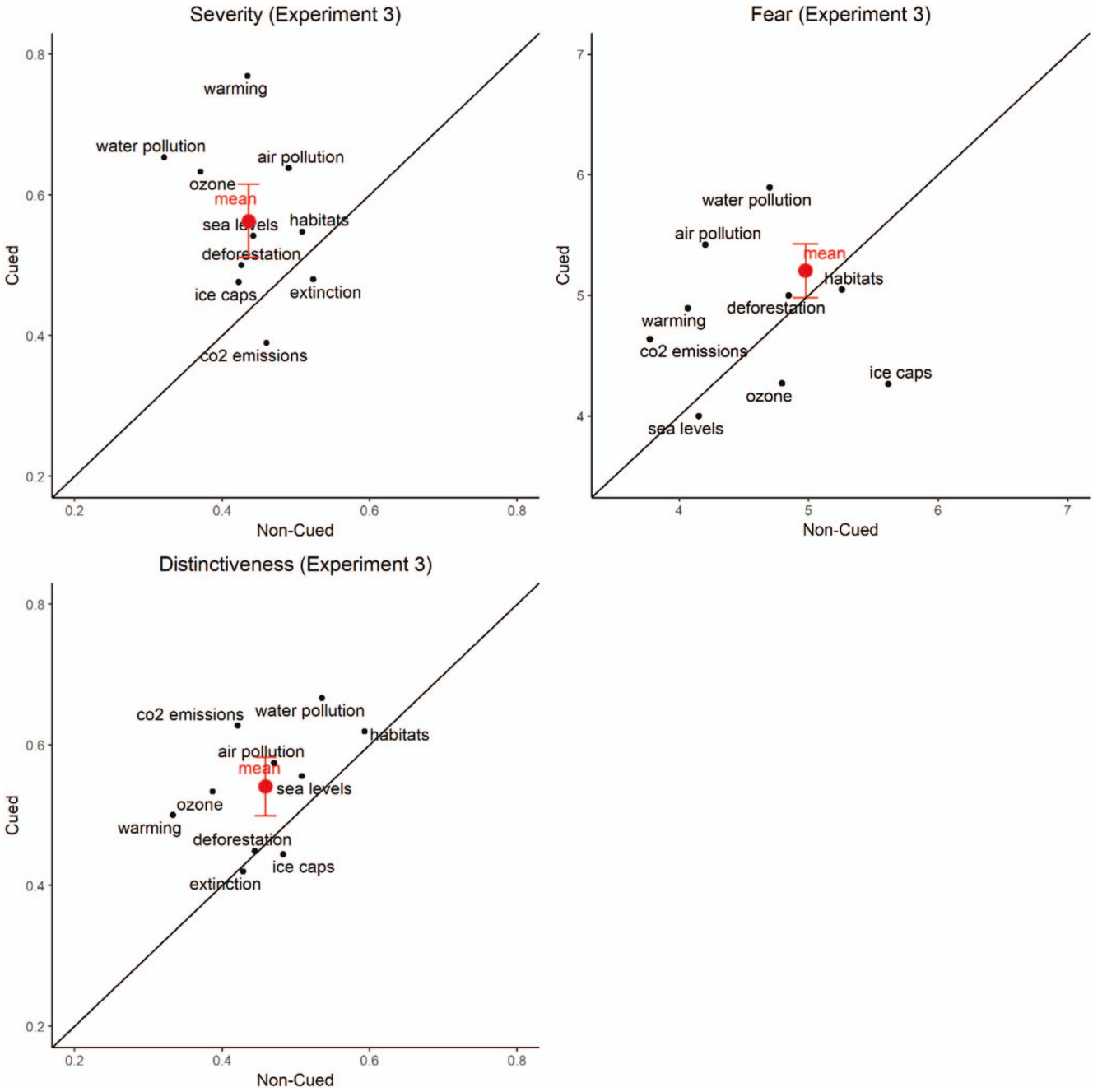

Figure 7. The effect of cue on perceived severity, fear, and distinctiveness in Experiment 3. Risks located to the top left of the identity line were more often perceived as more severe when cued than when not cued. Eight of the 10 risks were perceived as more severe when cued than noncued, on average. Error bar represents the 95% confidence interval of the difference between cued and noncued risks. See the online article for the color version of this figure.

untary to voluntary attention, namely, that merely attending toward a risk is sufficient to increase perceived severity. Second, by focusing participants on a different task, we sought to minimize demand characteristics (following Liu et al., 2009), making people even less likely to infer that we were interested in how attention influences their risk judgments. Third, we sought to provide converging evidence that different types of attention increase perceived severity. That is, whether attention is directed because people explicitly search for the risk (Experiments 1 and 2), because a flash of light draws attention toward the risk (Experiment 3), or because they are doing something unrelated that entails attending toward the risk (Experiment 4), attention increases perceived se-

verity. We hypothesized that participants would perceive the spatially cued risk as more severe.

Method

Participants. We requested 100 U.S. adult participants from Amazon Mechanical Turk who participated in exchange for $0.50 ($N = 100$; 58 male, $M_{age} = 34.99$). All participants completed the full study and there were no exclusions from our primary analyses.

Procedure. Participants were first shown the 10 images from Experiments 1 and 3 with corresponding risk labels (Table S1 in the online supplemental materials). They achieved 94% accuracy in a subsequent matching test. Participants read that the researchers were examining "task-switching and multitasking ability." They were asked to read a series of letters presented in rapid succession (rapid serial visual presentation: RSVP) and press the spacebar whenever an "X" appeared.[7] In each trial, all 16 RSVP letters were presented for 0.2 s each on either the left or right side of the screen, randomly determined. Two of the environmental risk images were presented during the final 2.0 s of the RSVP and for 1.0 s thereafter. The cued image appeared below the RSVP stream (near the focus of attention) and the noncued image appeared on the other side of the screen (see Figure 8).

Participants then selected which risk seemed more (or less) severe. We manipulated the direction of question wording (i.e., "more" vs. "less") between-subjects; some participants were randomly assigned to select which risk was less severe for all trials, while others were assigned to select which risk was more severe. Participants also selected which seemed more (or less) distinctive and vivid. We averaged these two items (1 = more or not less; 0 = less or not more), which had 90% correspondence.[8]

Participants then viewed each risk individually, rating how much fear it evoked. Participants repeated this procedure for a total of five trials, viewing all 10 risks once. After the fifth trial, participants answered the EPA prioritization question as in Experiments 1 and 2.

Results

We used binomial generalized mixed effects models for the binary outcome variables and linear mixed effects models for continuous outcome variables with random effects for Participant and Risk (Judd et al., 2012).

As predicted, participants were more likely to select cued risks as more severe (61%) than noncued risks (39%), $z = 3.58$, OR = 2.70, 95% CI [1.55, 4.82], $p < .001$ (see Figure 9). There was no interaction between cue and the direction of question wording, $z = -0.34$, OR = 0.84, 95% CI [0.30, 2.34], $p = .733$. In other words, participants who were asked which risk was more severe were more likely to choose cued risks, $z = 2.68$, OR = 2.52, 95% CI [1.27, 5.14], $p = .007$, and participants who were asked which risk was less severe were *less* likely to choose cued risks, $z = 2.62$, OR = 3.00, 95% CI [1.31, 7.06], $p = .009$. Cued attention increased perceived severity for both wordings of the question.

Cued risks were not prioritized significantly more than noncued risks ($M_{cued} = 5.24$, $SD = 1.54$; $M_{noncued} = 5.19$, $SD = 1.61$), $t(35.53) = 0.71$, $d = 0.24$, 95% CI [−0.10, 0.21], $p = .482$. Spatially cued voluntary attention thus increased perceived severity, but not prioritization, replicating the results of Experiment 3.

Also as predicted, spatially cued attention influenced perceptions of fear and distinctiveness, our two hypothesized mediating variables. Participants reported that cued risks evoked more fear than noncued risks ($M_{cued} = 4.82$, $SD = 2.85$; $M_{noncued} = 4.39$, $SD = 2.96$), $t(11.90) = 2.25$, $d = 0.14$, 95% CI [0.02, 0.27], $p = .044$. And cued risks were selected as more distinctive (65%) than noncued risks (35%), $z = 5.49$, OR = 1.99, 95% CI [1.64, 2.22], $p < .001$. The direction of question wording did not moderate the effect of cued attention on distinctiveness, $z = 0.57$, OR = 1.13, 95% CI [0.78, 1.64], $p = .567$.

We conducted a bootstrapped mediation model with 5,000 resamples. As in previous experiments, there was a significant indirect effect from cued risk to distinctiveness to fear to severity (indirect effect = 0.04, 95% CI [0.01, 0.07]). The serial mediation reflected three component paths: from cued attention to distinctiveness, $b = 0.60$, 95% CI [0.47, 0.75], from distinctiveness to fear, $b = 0.68$, 95% CI [0.55, 0.81], and from fear to perceived severity, $b = 0.09$, 95% CI [0.03, 0.16]. The effect of cue on perceived severity was reduced (from $b = 0.88$, 95% CI [0.62, 1.14] to $b = -0.04$, 95% CI [−0.45, 0.36]) when controlling for distinctiveness and fear, suggesting full mediation. This is consistent with our hypothesis that cued attention increases perceived distinctiveness which increases fear which increases perceived severity.

Discussion

The results of Experiment 4 suggest that incidental visual attention increases the perceived severity of environmental risks. This result conceptually replicates the findings of Experiments 1–3, but with an incidental attention manipulation. Though the incidental attention manipulation was brief and less susceptible to demand characteristics because it emphasized a different task (Liu et al., 2009), attention nonetheless increased perceived severity. Various instantiations of attention including repeated voluntary attention (Experiments 1–2), brief involuntary attention (Experiment 3), and incidental attention (Experiment 4) all similarly increased the perceived severity of risks.

Attention did not significantly increase EPA prioritization in Experiments 3 and 4, although it did in Experiments 1 and 2. It is unclear why this effect emerged in one paradigm but not the other. The single spatial cueing attention manipulations in Experiments 3 and 4 might produce weaker effects than the repeated sequential search manipulations in Experiments 1 and 2. It is also possible that the effect of attention on prioritization is weaker with smaller sets of two risks in each trial rather than the sets of 10 and four used in Experiments 1 and 2, respectively. Or perhaps manipulating attention by explicitly identifying and searching for targets produces larger effects than incidental and involuntary manipulations of attention. In Experiments 3 and 4, the cued images were likely perceived with higher visual acuity than noncued images

[7] Following previous research that used this paradigm (Liu et al., 2009; Mrkva & Van Boven, 2017), 20% of the trials had an "X." We included all trials in our analyses.

[8] Generalized mixed-effects models were used on the sum of these two items. The two items were averaged in descriptive statistics for ease of interpretation.

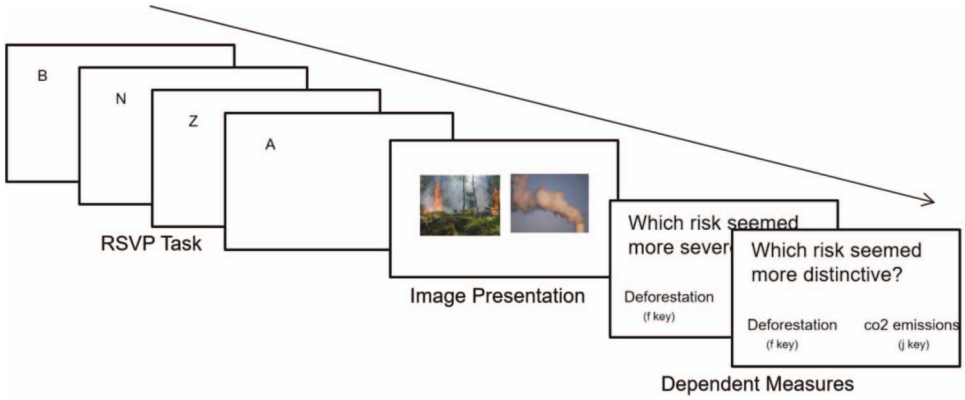

Figure 8. Illustration of Experiment 4 procedure. Participants were to monitor the letters in the rapid serial visual presentation (RSVP) stream for an "X" and press the space bar if an "X" appeared. Then, two images corresponding to two environmental risks appeared, one just below the letters and one on the other side of the screen. Participants then rated which image was [more/less] severe, distinctive, and vivid. They also rated the amount of fear that each evoked (vividness and fear not pictured). All images have CC0 license (no permission required). See the online article for the color version of this figure.

(e.g., Kerr, 1971), although this was likely not true of target compared to control images in Experiments 1 and 2.

General Discussion

Attention increased perceived severity and fear of environmental risks in four experiments. These results were robust across two different manipulations of attentional search (Experiments 1 and 2), a manipulation of cued involuntary attention (Experiment 3), and a manipulation of incidental voluntary attention (Experiment 4). Participants were also more willing to write a letter to their Congressional representative about target risks than control risks (Experiment 1) and in two experiments indicated that target risks should be higher priority for the EPA (Experiments 1–2). In each experiment, attention increased perceived severity but did not influence perceived novelty. Thus, attention does not influence all dimensions of risk perception in the same way.

Attention and exposure are distinct constructs which can influence judgments in different ways (Drew & Weaver, 1990; Prinzmetal et al., 1995; Shim & You, 2015). It is therefore important that our experimental procedures isolated attention from exposure by presenting all images for the same duration, equating exposure. Unlike mere exposure, which increases perceived familiarity (Montoya, Horton, Vevea, Citkowicz, & Lauber, 2017; Zajonc, 1968), attention did not influence the degree to which risks were perceived as novel or familiar in our experiments. Furthermore, mere exposure increases perceptual fluency and liking, which would seem to decrease rather than increase perceived severity (Song & Schwarz, 2009). Attention appears to influence risk perception in different ways than exposure influences judgments.

Previous research has suggested that accessibility influences risk perception, with more accessible risks seeming more likely (Folkes, 1988; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978). However, our data suggest that accessibility does not explain the effects of attention on perceived severity. Although our manipulation in Experiment 1 increased accessibility, as measured by recall order, this did not statistically account for the effect of attention on severity in the mediation model whereas fear and distinctiveness did. We obtained correlational evidence across experiments for a serial mediation path in which attention increases distinctiveness which increases fear which increases perceived severity. It should also be noted that previous research found that accessibility increased perceived likelihood of risks, not necessarily perceived severity (Folkes, 1988; Lichtenstein et al., 1978). It is possible that different factors influence judged likelihood and severity. Indeed, we found mixed evidence across experiments that attention manipulations influenced perceptions of how widespread risks were (significant in Experiments 1 and 2 but not Experiment 3). Although attention, severity, accessibility, and likelihood are undoubtedly associated in everyday life, they were not in our experiments.

Previous research has identified associations between risk perception and personal experience with environmental risks, such as living in an area affected by flooding or wildfires (Morgenstern, Isensee, & Hanewinkel, 2013; van der Linden, 2014; Whitmarsh, 2008). Attention is distinct from experience (Shim & You, 2015). Two people who have the same amount of experience and exposure to risks can attend to risks to vastly different degrees. Our results improve understanding of how even basic processes of focusing visual attention on something influence environmental risk perception.

We minimized response bias and demand characteristics in several ways. In Experiment 2, we measured participants' perceptions of demand characteristics, finding that the effects were robust even when we excluded participants who perceived that the experimenter wanted them to rate target images as more severe. In Experiment 4, rather than explicitly telling participants to attend toward a risk, we gave them a primary task requiring attention to letters at a location close to the risk (Liu et al., 2009). We also varied the direction of question wording in Experiments 3 and 4 to address the possibility that participants simply chose the cued risk, which they did not.

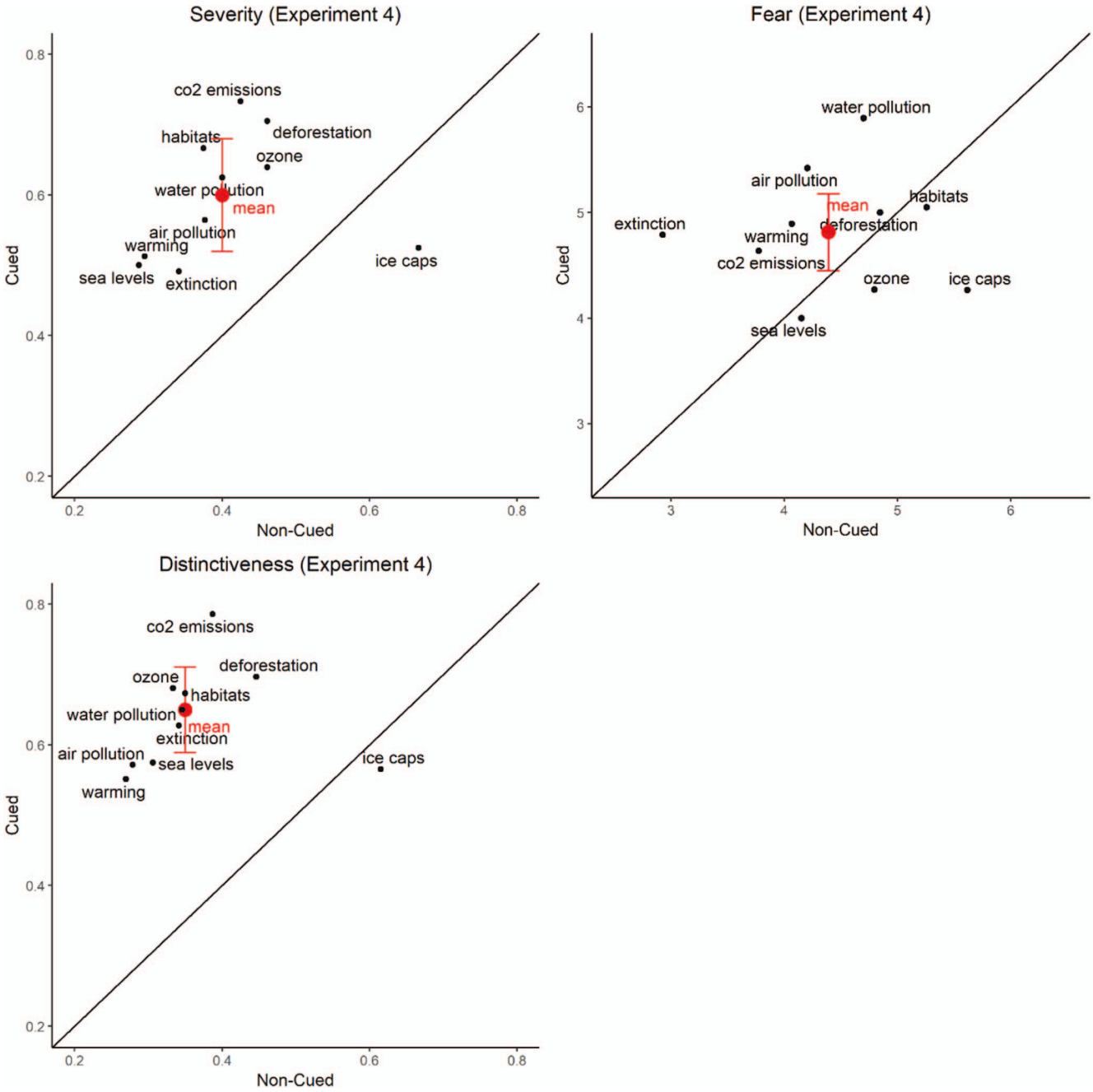

Figure 9. The effect of cue on perceived severity, fear, and distinctiveness in Experiment 4. Risks located to the top left of the identity line were more often perceived as more severe when cued than when not cued. Error bar represents the 95% confidence interval of the difference between cued and noncued risks. See the online article for the color version of this figure.

We did not find that the effects of attention manipulations on perceived severity significantly decreased over time and intervening tasks (Experiments 2 and 3), although the effect of attention on fear did significantly decrease (Experiment 2). We are hesitant to draw strong conclusions based on nonsignificant differences and given that the delay involved completion of several other tasks that might have caused emotion to fade. We would be surprised if attending to a risk for a few seconds would have a substantial impact several hours or days later, unless the attention orientation prompted people to ruminate on the risks. Nevertheless, more careful examination of the effects of delay and durability must await future research. Such research will be important for those seeking to motivate action to mitigate environmental risks, suggesting a need to strike when the "iron is hot."

Another question for future work is the generalizability of these effects to perception of other types of risks. Would attention also increase intuitive perceptions of financial and medical risk? People evaluate financial and medical risks using affect and intuitive processes, just as with environmental risks (Blumenthal-Barby & Krieger, 2015; Hirshleifer & Shumway, 2003; Peterson, 2007). Because financial and medical risks also are shaped by affect and intuitive processes, we suspect that increasing attention to those risks should similarly make them seem more severe and worthier of mitigation. Additionally, future research should examine whether directing attention toward a risk repeatedly has larger effects than directing attention just once. One previous study found that attending to an object three times results in larger effects than attending just once (Mrkva & Van Boven, 2017); however, more research is needed to address this question. Future research could also examine how noticing whether others attend to a risk could influence one's own reaction to the risk. Because people often attend more to an object after noticing others attending toward it (Shepherd, 2010), others' attentional patterns should increase risk perception by increasing one's own attention toward the risk. It is possible that information about others' attention would also increase perceived risk by making the risk seem more important or interesting (Bayliss, Paul, Cannon, & Tipper, 2006).

The finding that attention increases perceived risk could partially explain why other variables such as sudden changes and novelty make risks seem more severe. Sudden changes attract attention (Abrams & Christ, 2003; Ludwig, Ranson, & Gilchrist, 2008), which might explain why natural disasters, epidemics, and suddenly changing risks garner more concern than chronic risks (Small, 2010). Similarly, novel stimuli capture and hold attention (Fantz, 1964; Loftus & Mackworth, 1978), which could partially explain why novel risks are perceived more severe than familiar risks (Slovic, 1987). Future research should examine whether attention accounts for the impact of these and other variables on risk perception.

In demonstrating that attention increases perceived severity, these findings have broader implications for theories of attention. Theorists have long debated whether attention influences perception (Ebbinghaus, 1908; Fuller & Carrasco, 2006; Fechner, 1877; James, 1890/1952; Prinzmetal, Long, & Leonhardt, 2008). Much of this debate has focused on perception of auditory and visual features such as noise volume, color saturation, and distinctiveness. We find that attention influences perceptions of risks, making attended risks seem more severe than unattended risks, and that these effects might be explained by fundamental changes in perceived distinctiveness and fear. Existing theories of risk perception emphasize how emotions influence perceived risk (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic & Peters, 2006). Our findings help explain what makes some risks more emotionally intense in the first place.

We believe this work can also deepen understanding of the role of attention in judgment and decision making more generally. Research on judgment and decision making relies heavily on attention as an explanatory construct (Birnbaum, 2008; Johnson & Busemeyer, 2016; Kahneman et al., 2006; Weber & Johnson, 2009). For example, theorists have suggested that the tendency to overweight present emotions, overweight the importance of rare events such as terrorist attacks, and neglect numerical information about probability are caused by attention (Johnson & Busemeyer, 2016; Sunstein, 2003; Van Boven et al., 2009; Wilson et al., 2000). Despite this widespread reliance on attention as an explanatory construct, few studies have examined the causal impact of attention on judgments or decisions (cf. Ghaffari & Fiedler, 2018; Pärnamets et al., 2015). Of the studies that have directly manipulated attention, none have examined how attention influences risk perception.

The present research suggests that the mind evaluates risks in part by harnessing the core psychological systems of attention and affect. These findings have implications for those who are concerned that environmental risks such as global climate change often fail to elicit fear and fail to rise to the top of policy priority lists (Pew Research Center, 2014). Our results suggest such that simply reorienting attention toward environmental risks can make them more frightening and more severe.

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