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Closer Than You Think: The Influence of Border Bias on Perceptions of Mapped Hazards

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On January 9, 2014, almost 300,000 West Virginia residents were left without water for up to a week after 10,000 gallons of chemicals used in coal processing leaked into Charleston's water supply. Little is known about the health effects of the chemicals, but residents were advised to avoid exposure and many complained of feeling ill. Long after Jeffery L. McIntyre, president of West Virginia American Water, assured residents that the levels of 4-methylcyclohexane methanol (MCMH) in the water supply was found to be less than the United States Centers for Disease Control and Prevention (USCDC) designated "protective of public health" level, local residents continued to complain about the foul smell. Despite his reassurances, McIntyre also conceded that pregnant women should consider an alternative drinking water source until the chemical was at a "non-detectable" level throughout the distribution system (McIntyre, 2014).

While the long term environmental effects of such disasters are unknown, there are some predictable outcomes. People will fear that their natural resources (the water supply, food supply, animal habitat) have been contaminated such that their health and wellbeing are endangered. As evidence of this, at one Charleston, WV town meeting just 1% of the 200 attendees reported that they had begun drinking the water again after four days. In contrast, the Boston Globe included just 17 stories about the WV chemical spill and coverage waned in weeks. Globe reporters never mentioned similar hazards in the metro area. There are certainly similar chemical tanks and hazards nearby, and similar events and outcomes may indeed impact the Boston area. Shouldn't other vulnerable areas across the country learn from the events in West Virginia? Globe reporters either did not see the connections between the West Virginia incident and local exposure or assumed that readers would not be interested. One explanation may be cognitive construals, which are how individuals perceive, comprehend, and interpret the world around them in relation to emotional, physical or temporal distance. Past research suggests that spatial distance (feeling closer to or farther from things) changes how people perceive, represent, and act on objects and ideas (Trope & Liberman, 2010). For example, construal theory suggests that people think about distant events more abstractly by attending to features that are central to meaning and goal relevance. Proximal events tend to be described concretely with more detail, contextual information, and incidental features (Liberman & Trope, 1998). This bias persists even when there is concrete, reliable information available (Henderson et al., 2010) and research suggests that spatial nearness, real or imagined, may result in very different levels of interest, attention to detail, and personal involvement. For instance, Fujita and Henderson (2006) asked participants to imagine helping a friend with a nearby move (within three miles), or a distant one (three thousand miles away). When considering a list of related behaviors, such as locking a door, participants who imagined helping with the nearby move tended to describe the effort concretely in terms of its means ("putting a key in the lock"), whereas those who imagined helping their friend move a great distance tended to give a more abstract description in terms of its ends ("securing the house"). Herbert (2010) called this tendency to think of distant events more abstractly than proximal events the "mapmaker heuristic." In another example, researchers primed participants with spatial closeness or distance using a Cartesian-plane coordinate system. After the manipulation, each participant read an embarrassing book excerpt and rated how much they liked it. Participants who had plotted points closely together on a graph reported more discomfort after reading the embarrassing story than those who graphed distant points. The authors concluded that the act of plotting close points primed participants to think about crowding or nearness of others, while participants who were given a sense of psychological distance felt less of the emotional discomfort (Williams & Bargh, 2008).

Another factor implicated in cognitive distancing is the existence of borders. Mishra and Mishra (2010) coined the phrase "border bias" after participants considered an earthquake within the same state to be of greater risk than an equidistant one that occurred in a different state. The authors concluded that boundaries, such as state borders, may be cognitively processed as protective physical barriers rather than abstractions. In other words, people may use state borders to maintain an illusion of safety from disasters. To further examine border bias in this context, Mishra and Mishra (2010) used dark or light state borders on a map that depicted an environmental risk. As hypothesized, the dark borders enhanced border bias and the light borders reduced the effect. Border bias is reflected in past research regarding environmental concerns such as global warming. For example, Americans tend to report that climate change will affect geographically and temporally more distant places (Leisorwitz, 2005) and express little concern about any immediate dangers from global warming (Kellstedt, Zahran, & Vedlitz, 2008). In New Zealand, Milfont, et al. (2011) found that participants rated the quality of local ('My Area') and national ('New Zealand') environmental conditions more favorably than global environmental conditions and reported that, "things are better now than they will be in the future." In a related study Gifford (2011) found that participants were more engaged in climate change issues if they had previously read an excerpt about the effects of local rather than global climate change. Molloy et al. (2012; 2013) found similar local, regional and national biases in a series of studies on perceptions of pollution, environmental behaviors and global warming related natural disasters. Further indication that graphical representations alter risk perception comes from research focused specifically on map reading. According to Lahr and Kooistra (2009), maps are the best way to convey information about locations and depict disasters. The authors stress, however, that maps of hazards should only be created by someone with sufficient knowledge of cartography, environmental threat assessment, and risk communication, because poorly prepared maps can be misinterpreted and risks misjudged. For example, Arlikatti et al. (2006) found that only 36% of residents could correctly identify areas of hazardous risk in which their own homes were located, on maps that utilized small scales or few feature markers. Maps with insufficient structural (spatial representation) and feature detail (size, form, and color) appeared to impair participants' ability to process the map and make meaningful judgments about their own neighborhood (Johnson et al., 1995).

Table 1
Pilot Study Chi-Square Results for Home Choice

Condition	Expected		Actual	
	In	Out	In	Out
Fracking Site				
MA (n=50)	23.7	26.3	19*	31*
NH (n=52)	27.4	24.6	27	25
Control (no fracking)				
MA (n=73)	34.6	38.4	42*	31*
NH (n=51)	26.9	24.1	30	21

*Results significantly different from chance, $p < .05$

In Severtson and Burt's (2012) examination of mapped hazard risk assessment, the authors varied structural characteristics, by altering cluster shape and size to influence perceived density and proximity to hazards, and feature characteristics, by changing the color of dots depicted on maps of well-water test results for a fictitious contaminant.

Table 2
Current Study Chi-Square Results for Home Choice

Contaminant Cause	Actual	Expected
Fracking Site*		
Color Border	57	81
Double border	57	33
Total	114	114
Train Derailment*		
Color border	57	16
No border	57	98
Total	114	114
Chemical Spill*		
Closer to border	58	71
Farther from border	58	44
Total	116	116

* Results significantly different from chance, $p < .05$

While structural features did appear to influence risk beliefs, the feature manipulation, specifically the use of the color red, was more influential than cluster shape or size. Severston and Vatovec (2012) also found a strong effect for color. They had participants view three formats of water test results from a private well: a choropleth map (with shading, coloring, and symbols to show values), a dot map, and a table. The results of cognitive interviews that assessed what was seen on the maps and tables, perceived meaning, and prior knowledge about maps/tables, suggested that participants derived symbolic meanings of risk based on color: red meant warning, yellow meant caution, and blue/green meant safe. Griffith and Leonard (1996) found similar results in a study of the vocabulary of warning signals. Participants were given a signal word (out of 40 possible words) and were asked to respond with the first color that came to mind. The word 'danger' elicited the response "red," the word 'caution' prompted the response "yellow," 'warning' produced the response "orange," and 'fatal' or 'poisonous' invoked the response "black." Overall the color red was the most common response to all signal words and

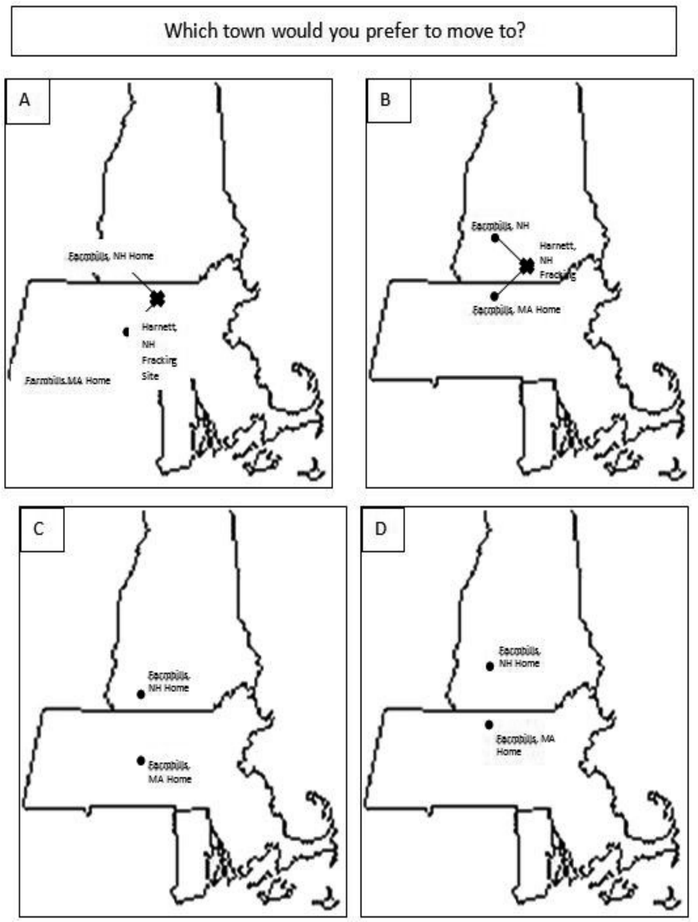

Figure 1: Pilot Study Map Choice. After reading a scenario about having to move to a new location for school or work, participants viewed one of the four maps. In the experimental conditions, participants chose between two home locations equidistant to a hydraulic fracking site; the control conditions did not contain a fracking site.

more signal words were evoked by the color red than by any other color. The authors believed the results reflect the way the color red is encountered in everyday life, such as on stop signs and red lights that indicate risk.

While the research described above indicates that nearness and maps with clear structure and feature information prompt more local and concrete thoughts regarding risks, Heath et al. (1998) found contradictory evidence. The authors surveyed two communities in the Houston area, each of which was divided into three subsamples based on their zip codes. The level of risk to subsamples was categorized as high (within 5 miles) and low (more than 20 miles) based on distance from local chemical plants. Participants were asked questions about their proximity to the chemical plants and opinions about their health and safety. The authors found that people in communities closer to chemical plants reported less concern about their health and safety and more confidence in efforts to protect the environment than those in more distant communities. While their responses seem counterintuitive, much research on risk aversion suggests that exposure to unavoidable risk may skew our perceptions of hazards and change how we deal with them (Paulsen et. al, 2012). Those who already live near hazards may deal with their exposure to risk with denial, creating explanations to minimize vulnerability, and focusing on the best possible outcome—that they will escape any ill effects of living near a chemical plant.

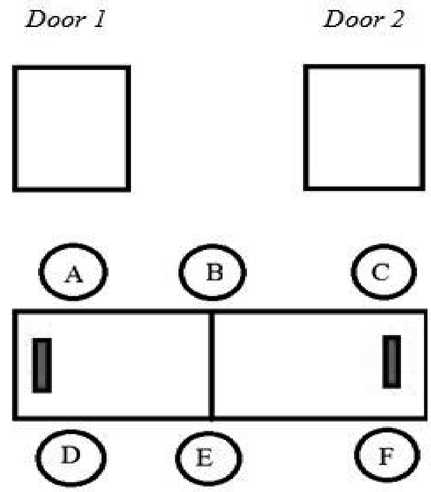

Figure 2: Current Study Lab Seating Choice. Behavior was recorded when participants arrived in the lab to find contaminants at each end of their table. Participants were offered 6 seating options on either side of two connected tables: 4 directly next to a contaminant and 2 on the "double border" (location where the two tables met).

Most research on risk aversion focuses on a gambling paradigm, not mapped hazards. A long history of research indicates that, although people tend to prefer a small gain over a gamble for more, when faced with outcomes framed as losses, people often express a preference to gamble, even when the mathematical probability of the gamble is inferior (Kahnenman & Tversky, 1984; Paulsen et. al, 2012). More relevant to the current research and Heath et al.'s (1998) findings, such behavior has been observed in medical decision making. For example, Eraker and Sox (1981) found when the outcomes were adverse drug effects (a loss), participants were willing to risk experiencing severe side effects in order to have a chance of experiencing no adverse reaction. Also relevant to the current studies, a substantial body of evidence supports ambiguity aversion, also known as the Ellsberg paradox (Ellsberg, 1961). Most decision makers prefer risky prospects with equal outcome probabilities over ambiguous options (Camerer & Weber, 1992; Frisch & Baron, 1988; Rode,

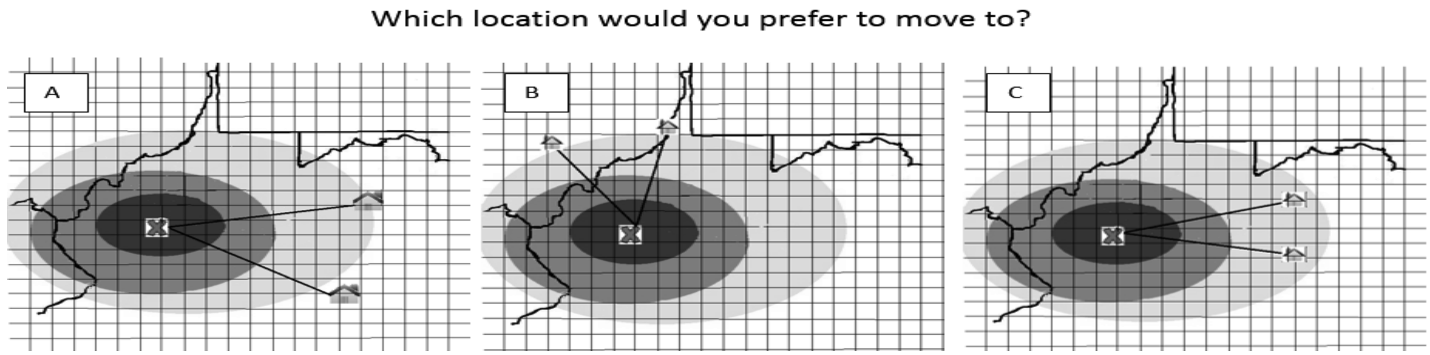

Figure 3: Current Study Map Choice. Participants read a scenario for each of the three water contaminations: hydraulic fracturing, train derailment, and a chemical spill. They then viewed each of the three maps below, which provided them with two choices for home selection equidistant to the water contamination.

Cosmides, Hell, & Tooby, 1999). Pulford and Colman (2008) recently found that ambiguity aversion was strong even when the need for mental calculation was eliminated, leading them to conclude that ambiguity may prompt aversive psychological state generated by exposure to uncertainty. In sum, humans appear to be naturally risk averse and demonstrate preference for certainty, but may gamble with money or their health when faced with outcomes framed as losses.

Taken together, these results suggest that, in evaluating hazards and risks, individuals may understand events and represent activities more concretely in the aftermath of a nearby disaster, but more abstractly and globally when temporal and spatial distance is increased. Cognitive distancing is a heuristic that not only influences perceptions of actual distance in inches and miles, it also affects our perceptions of emotional distance, and our sensitivity to threat. Because our brains have formed a deep-wired connection between distance and safety, the mapmaker heuristic may influence evaluations of and judgments about risk (Herbert, 2010). In addition, research indicates that the way in which disasters or hazards are displayed on colored maps, with nearby or more distant borders, could impact perceptions of risk and decision making under uncertainty.

Previous research on border bias utilized black and white maps (see Figure 1) and focused on natural disasters (Mishra & Mishra, 2010; Molloy et al., 2012; 2013), not chemical hazards. Therefore, a pilot study was conducted to establish that borders would be relevant in judgments about contaminated groundwater. Materials included black and white, single border maps depicting a hydraulic fracturing site where groundwater could be contaminated, and equidistant food sources or home alternatives, either within or outside of state borders. Stimuli were similar to those used by Molloy and appear in Figure 1. Results replicated previous research in that the vacation home choice reflected border bias. As expected, control condition participants preferred the in state equidistant homes, and when the fracking site was in Massachusetts, they preferred a New Hampshire vacation home. However, a fracking site in New Hampshire appeared less likely to inspire border bias (see Table 1 for details).

After substantiating that groundwater contamination risk assessment could be influenced by a border bias manipulation, the current study was designed to reflect our main interest: the effect of color and boundary ambiguity on the risk assessment of mapped hazards. It was once again hypothesized that evidence of border bias will be found in participants' choices of where they might like to live, shop, or attend school, their ratings on various explicit questions about risk, and their legal attributions. Based on past research on the effects of color, we expected that color borders would prompt a bias similar to state boundaries. Based on research on risk and ambiguity aversion, it was also hypothesized that participants would feel vulnerable on a "double border" (being in two places at once). The current study was designed to test this hypothesis in two ways. First, maps in one condition included a double border in the form of a state border and a color border (See Figure 3, labeled Current Study map choice), which participants were expected to avoid in preference for an equidistant option on just one border. Second, behavior was recorded when participants arrived in the lab to find contaminants at their table (see method section for more details).

It was hypothesized that seating choice would reflect ambiguity aversion in that participants would be more likely to risk sitting in a seat next to one contaminant in order to avoid the ambiguous vulnerability of exposure to two contaminants.

Method

Participants

The sample, 38 male and 73 females from Bridgewater State University, ranged in age from 18 to 34 (M = 19.35), having six participants who chose not to reveal their age. Participants received research participation credit in a psychology course.

Materials

Survey packets included summaries of equivocal legal case vignettes and colored maps depicting potential water contaminants, equidistant food sources or home alternatives (see Figure 3). Participants reviewed three vignettes and maps, one for each event (train derailment, chemical spill, or oil fracturing wastewater leak), that precipitated potentially contaminated ground water. The train derailment, the chemical spill, and the oil fracturing vignettes were brief summaries of current, equivocal legal cases resulting from disasters that impacted the environment and can be seen as hazardous. As for the maps, distance from the event remained the same across conditions; only the proximity of borders was experimentally manipulated. All three maps were devised to measure the effects of border bias. Map B was designed to measure the effect of a "double border." Participants were asked to determine where they might like to live, shop, attend school, etc., and indicated their perception of risk on a Likert scale (A 4 item measure of severity specific to the environmental impact of each potential hazard). Demographic questions and several individual difference scales were used including: the Need for Cognition scale (Cacioppo & Petty, 1982), and three measures of environmental concern: the New Ecological Paradigm scale (NEP; Dunlap, Van Liere, Mertig & Jones, 2000), the Behavior-based Environmental Attitude scale (BBEA: Kaiser & Wilson, 2004), and Personal Efficacy Global Warming (PEGW: Kellstedt, Zahran,& Vedlitz,. 2008).

Procedure

Participants (up to six at a time) arrived at the psychology lab to find a "contaminant" (rumpled tissues) on the both ends of a work surface comprised of two tables pushed together. The participants were asked by the researcher to find a seat at the table. Participants were offered 6 seating options on either side of two connected tables: 4 directly next to a contaminant and 2 on the "double border" (location where the two tables met). The seating arrangement was used to measure risk aversion; seats next to the contaminant would be considered certain risks, while those on the "double border" were ambiguous options because they were equally distant to each of the contaminants (causing the participant to be at risk for exposure to both; see Figure 2 for a schematic). Once all the participants were seated the researcher acknowledged the contaminant, apologized for the mess, and cleaned the table. The seat chosen by each participant and the order in which they sat served as an implicit measure of ambiguity aversion. Participants were then asked to begin the pencil and paper survey. After each participant finished and returned their survey, the researcher handed them a debriefing slip.

Results

As hypothesized evidence for border bias was found for all three cases and maps. In the train derailment case, participants preferred the equidistant home beyond the color border (X2(1) = 58.98, p =.00; Figure 3, Map A). In the fracking scenario, participants were significantly less likely to choose a home on a "double border" indicated by both color and state lines (X2(1) = 20.21, p = .00; Figure 3, Map B). Finally, in the chemical spill case there was a significant difference in home selection when neither of the homes were located on an identifiable border (X2(1) = 6.34, p = .01; Figure 3, Map C). This finding was not predicted, but does support border bias because even though the two locations were within one state, participants preferred the location that was closer to the state border over the location that was further from the state border.

Chi-Square results supported the hypothesis that participants would demonstrate ambiguity aversion when choosing a seat in the lab. They preferred available seating choices located near the contaminants over the seating choices located on the "double border" (X2(1) = 7.35, p = .007; see Figure 2).

Participant's responses to the 4 item measure of severity specific to the environmental impact of each potential hazard was significantly correlated with scores on the measures of environmental concern (rNEP (114) = .264, $p < .01$; rBBEA (110) = .280, $p < .01$; and rPEGW (109) = .289, $p < .01$; and with Need for Cognition (r (97) = .220, $p < .05$).

Since each participant reviewed all three water contamination events, a Within Subjects ANOVA test was used to measure whether environmental impact assessment differed in the fracking, chemical spill and train derailment disasters. Each participants rated the environmental impact (environmental severity: property values, health risks, and other features of the homes and surrounding areas) as less severe in the train derailment event than the fracking and chemical spill disasters (F (2,114) = 34.36, p = .00, $\eta 2$ = .38), however there was no indication that preferences regarding homes, schools or shopping were influenced by environmental impact.

Discussion

The purpose of the current study was to demonstrate that mapped state and color borders may be perceived as protective barriers in groundwater contamination. Results from the current study replicated previous research that state borders may be perceived as protective barriers, and extended the findings to color edges, which may also be cognitively processed as borders and perceived as protective. Results also showed support for the hypothesis that participants would be less likely to choose a home on a "double border" and would rather sit closer to one contaminant than be in the more ambiguous position of sitting further away, and equidistant from, two contaminants. This may indicate a perceived vulnerability of being in two potentially hazardous locations at once. The finding supported research in the areas of risk aversion because participants appeared to gamble in the face of a sure loss (exposure to contamination). Similar to Eraker and Sox's (1981) patients, participants in this study appeared willing to risk experiencing more severe health outcomes (illness due to closer contact with one set of germs), in order to have a chance of experiencing no ill effects (possible immunity). The results also support research on ambiguity aversion because participants choose certain exposure to one contaminant over ambiguous exposure to two. Perhaps by sitting nearer to one contaminant the participants felt sure of their level of exposure, but perceived the "double border" as an uncertain level of risk.

The finding that the fracking and the chemical spill cases were perceived as having more environmental impact than the train derailment case was not predicted. Since all of the legal cases described disasters that led to potential groundwater contaminants, and cases were counterbalanced, there was no reason to expect significant differences between cases. One possibility is that participants were influenced by recent media coverage on the dangers of chemical spills and fracking. The New England area, from which the student population was drawn, was expected to experience increased prices for natural gas, which had prompted a temporary uptick in media coverage of hydraulic fracturing. In addition, while New England area coverage of the West Virginia disaster was minimal in comparison with the area more proximal to the event, it was a more recent and nearby event than the train derailment in Canada. It is also possible that the ratings for environmental impact severity are another reflection of border bias. A train derailment that spilled chemicals into the groundwater in Sudbury, Ontario, Canada may have been perceived as less severe because it occurred over a national border. This would be in alignment with Molloy (2013) who found national biases in a series of studies on perceptions of pollution, environmental behaviors and global warming related natural disasters.

The current studies contributed to the body of research on how border bias and colors may influence risk assessment of mapped hazards that involve pollution and contamination and suggests the need for further research on map how map reading skills and education may enrich short and long term decision-making, including risk assessment. The information gathered from current and future research could change how the media, insurance agencies, environmental agencies, governments, etc., communicate risk to the public. Lahr and Kooistra (2009) argued that maps are the best way to convey information about locations and disasters and, the current findings regarding map features indicate that color, structure, and borders can be successfully manipulated to change how one views a hazard. Color could be used to depict what areas will be most affected by the hazard. Structure could be altered to display the hazardous location in relation to the rest of the world. The effects of border bias might be reduced by making borders appear less noticeable to decrease the false sense of security that seems to be primed by boundaries. The preparation of maps should be left to experienced map makers, who could and should use these manipulations as a tool to communicate risk. Proper map design could lead to better awareness of local and global environmental issues, fewer miscommunications regarding the risks of exposure to hazards, and fewer casualties in times of crisis.

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