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Hotspots and borders interact in people's attitude toward the environment

Christophe Blaison[a,*], Till Martin Kastendieck[b], Thierry Ramadier[c], Ursula Hess[b]

[a] Université Paris Descartes, Paris, France
[b] Humboldt-Universität zu Berlin, Berlin, Germany
[c] Université de Strasbourg, Strasbourg, France

Most urban areas contain places that affectively stick out from the rest. These so-called "hotspots" (Blaison & Hess, 2016), such as a nice park or an unsafe housing block, affect how people perceive their surroundings. The influence of a hotspot propagates into its surroundings with declining intensity. Where the influence is intense, places are affectively assimilated, whereas farther away, they are contrasted (Blaison, Fayant, & Hess, 2017a; Blaison & Hess, 2016). The scale of this affective polarization depends on the reach of the hotspot's influence (its "gradient of influence", see below) and on the size of the area under consideration (Blaison & Hess, 2016).

One intriguing finding is that a hotspot's influence may be subjectively attenuated by a border even though that border presents no actual barrier (Galak, Kruger, & Rozin, 2007; Mishra & Mishra, 2010). This "border effect" shows up for example when the continuing threat from the epicenter of an earthquake is felt more intensely within the state of origin than across the state's border, all other things being equal (Mishra & Mishra, 2010). As a result, even though state borders clearly do not protect against earthquakes and geographic distances were the same, people subjectively preferred to live across the state border rather than in the state where the epicenter of a past earthquake had been located. In other words, the border effect emerges when people prefer places that are separated from a negative hotspot by a border, even when this border cannot protect those places against the negative influence of the hotspot.

This border effect has important implications for the affective perception of urban space. For instance, whenever an area is unattractive, a border will accentuate the attractiveness of the area across the border, even when the border is perfectly passable. Thus, a gap in the price of the real estate will result when a border is present. The border effect may also amplify residential segregation. Once an area is associated with a certain kind of inhabitants, salient borders may accentuate its perceived homogeneity and result in the perception that inhabitants living on the two sides of the border are more different than is actually the case. This phenomenon may start a vicious circle that accentuates residential segregation over time.

Hotspots and their spreading influence are a major cause of the good or the bad reputation of urban spaces. Thus, it is crucial to better understand how the influence of hotspots interacts with borders in determining how people perceive urban spaces affectively. In the following series of experiments, we investigate how the influence of different kinds of hotspots modulate the intensity of the border effect. For example, is the border effect as intense for a landfill as for an unsafe housing block? Specifically, we combine insights from research about the effects of hotspots (Blaison, Fayant, & Hess, 2017a; Blaison et al., 2018; Blaison, Gollwitzer, & Hess, 2017b; Blaison & Hess, 2016) with previous research on the border effect (Galak et al., 2007; Mishra & Mishra, 2010) to make new predictions about how hotspots modulate the border effect. After reviewing past research on the border effect, we will argue that the strength of this effect depends on the type and the intensity of a nearby hotspot's influence.

1. Past research on the border effect

Mishra and Mishra (2010), showed participants a map with two bordering U.S. states. There was a vacation home in each state. The two homes were equidistant (200 miles) from the epicenter of an earthquake, which recently took place in one of the states. The results showed that the participants preferred the vacation home in the state without the epicenter (Study 1). As states form powerful spatial categories, Mishra and Mishra (2010) argued that this border effect was due to a categorization process where elements from similar categories appear more similar to each other than to elements from different categories (e.g., Krueger & Clement, 1994; Schwarz & Bless, 1992; Tajfel, 1959; Tajfel & Wilkes, 1963). The vacation home in the state with the epicenter felt more negative because it somehow resembled the negative hotspot more than the vacation home across the border. Rendering the state border more salient caused an even larger border effect, which supports the categorization hypothesis (Mishra & Mishra, 2010, Study 2).

Galak et al. (2007) proposed an alternative account based on contagion theory (e.g., Rozin, Millman, & Nemeroff, 1986; Rozin, Markwith, & McCauley, 1994; Rozin, Nemeroff, Wane, & Sherrod, 1989). This account states that people overgeneralize a "contagion heuristic," whereby properties (such as dirt) transfer between objects

* Corresponding author. Laboratoire de Psychologie Sociale : Menaces et Société (LPS), UFR de Psychologie, Centre Henri Piéron, 71, avenue Édouard Vaillant, 92774, Boulogne-Billancourt Cedex, France.
E-mail address: christophe.blaison@parisdescartes.fr (C. Blaison).

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by simple contact, to situations where contagion is impossible. Participants not wanting to drink juice that was briefly in contact with a sterilized cockroach is an illustration of this heuristic (Rozin et al., 1986). As contagion necessitates contact (Morales & Fitzsimons, 2007), Galak et al. (2007) reasoned that the discontinuity of contact created by the border—irrespective of whether the border is an actual barrier or not—would disturb the contagion process, resulting in a border effect.

In our opinion, these two explanations are not mutually exclusive. The thicker border in Mishra and Mishra (2010, Study 2) rendered the border more salient but it also increased the visual gap between the states. In turn, the increased perceived discontinuity of contact may have facilitated the categorization process. As the perception of some boundaries is essential to any categorization process, we will consider the perceived discontinuity of contact as the primary cause of the border effect.

2. A Hotspot's influence modulates the border effect

How much discontinuity of contact is perceived—and thus, the resulting strength of the border effect—may not only depend on the visual gap caused by the border. The influence of a hotspot extending over an area that also includes a border may bridge the gap subjectively. In that sense, whereas borders divide, a hotspot's influence unites. Even more so, the more influence reaches across the border, the weaker should be the perception of discontinuity of contact. How much influence is perceived to cross the border depends on different factors. Just as the volume of water passing at a certain point of a river will be determined both by the width of the river bed and the pressure of the current upstream, a stronger hotspot influence will be perceived to cross the border either because the influence can more easily travel across the border (wider riverbed) or because it flows more intensely (higher pressure upstream). In contrast to previous theories, we claim that the border effect depends not only on the mere presence of a border and its visual salience but also on the characteristics of the hotspot's influence on the area. In the following, we will distinguish between the type of the influence and the intensity of the influence.

Some hotspots create an influence that flows more easily across borders than others. For instance, influence that propagates by air, like radioactivity from a nuclear power plant or bad smells from a landfill, can cross a border anywhere. In contrast, influence that propagates by surface transport, like criminal activity stemming from an unsafe housing block, flows mainly through the physical channels available to pass the border (e.g., streets or bridges). We posit that the perceived discontinuity of contact is weaker when more influence is perceived to cross the border. Consequently, perceived discontinuity of contact should be smaller for influence that propagates by air compared to influence that propagates by surface transport. Thus, the type of influence hypothesis predicts weaker border effects for the first compared to the latter.

As for the intensity of a hotspot's influence, what if Mishra and Mishra (2010) had placed the earthquake's epicenter at 20 instead of 200 miles from the state border? The threat at the border would have been much more intense. Would any border effect have emerged at all? Probably not. If the perceived discontinuity of contact is weaker when more influence is perceived to cross the border, the discontinuity of contact should be almost entirely masked when the influence of the hotspot is that intense, resulting in hardly any border effect at all. Thus, the influence intensity hypothesis predicts weaker border effects when the influence from the hotspot at the border is more intense.

Influence intensity at the border is also determined by the gradient of influence of a hotspot. The gradient of influence refers to people's belief about how quickly influence decreases with increasing distance to the hotspot (Blaison & Hess, 2016). Some hotspots have shorter gradients of influence because their influence is believed to dissipate quickly with increasing distance (e.g., bad smells from a landfill). Shorter gradients of influence thus have steeper slopes (Blaison & Hess, 2016). Other hotspots have larger gradients of influence because their influence is believed to dissipate at a slower rate (e.g., radioactivity from a nuclear power plant). Larger gradients of influence thus have slopes that are shallower. Since all other things being equal, larger gradients of influence imply a more intense influence for any given distance, weaker border effects should emerge in areas containing hotspots with larger gradients of influence because the influence is stronger when reaching the border.

To test these predictions, we conducted three experiments in which we compared the border effect for areas containing hotspots varying in the type or in the intensity of their influence. In Experiment 1 we tested the type of influence hypothesis by contrasting border effects elicited by a hotspots whose influence can either flow freely over the border or not. Experiment 2 replicated Experiment 1 conceptually and in addition tested the influence intensity hypothesis. For this, we contrasted the border effects elicited by two hotspots with the same type of influence but different gradients of influence. Experiment 3 replicated the results found in Experiments 1 and 2 regarding the type of influence hypothesis and provided a better controlled setting for testing the influence intensity hypothesis.

3. Experiment 1

Experiment 1 tested whether the type of influence (influence propagating by surface transport or by air) moderates the border effect. For this, participants were shown a satellite view of an urban area divided into two distinct neighborhoods by a railroad (see Fig. 1). Two bridges crossed the railroad tracks so that the railroad was not an actual obstacle. Thus, trivial alternative explanations of the border effect in terms of perceived functional distance (Kosslyn, Pick, & Fariello, 1974) could be safely excluded. One of the two neighborhoods contained a hotspot that was equidistant from the target locations distributed in the two neighborhoods. Participants were asked to estimate the hotspot's adverse effect on the target locations. In case of a border effect, this estimate should be lower for target locations situated across the railroad compared to those on the same side as the hotspot. Half of the participants were shown a hotspot in form of an unsafe housing block—gang criminality propagates by surface transport—whereas the other half was shown a landfill—toxic particles or bad smells propagate by air. Previously, unsafe housing blocks and landfills elicited similar aversion (i.e., participants gave the same negative evaluation) and affected areas of comparable size (i.e., same gradient of influence; Blaison, Gebauer et al., 2017b). Compared to toxic particles or bad smells, criminal activity should seem to cross the border less easily because it can only flow through narrow physical channels, the two bridges. Thus, if the type of influence hypothesis is correct, then the border effect should be stronger in the unsafe housing block condition than in the landfill one.

3.1. Method

3.1.1. Participants and Design

One hundred and eight participants (54 women, 1 gender unknown; all U.S. residents) with a mean age of 34.75 years ($SD = 10.89$) were recruited via Amazon Mechanical Turk. Participants were randomly assigned to a 2 (hotspot: unsafe housing block or landfill) x 2 (side: across the railroad, same side) x 7 (distance: 1 location in the block that contained the hotspot + 2 distractor locations + 4 locations from pairs of equidistant locations that were increasingly distant from the hotspot; see below Materials and Procedure) mixed design with the first factor as between-subjects factor and the two others as within-subjects factor. Even though the main conclusions remained unchanged by this procedure, we discarded extreme outliers with studentized-deleted residuals greater than 4 (Judd, McClelland, & Ryan, 2009). Therefore, the degrees of freedom may vary slightly between analyses.[1]

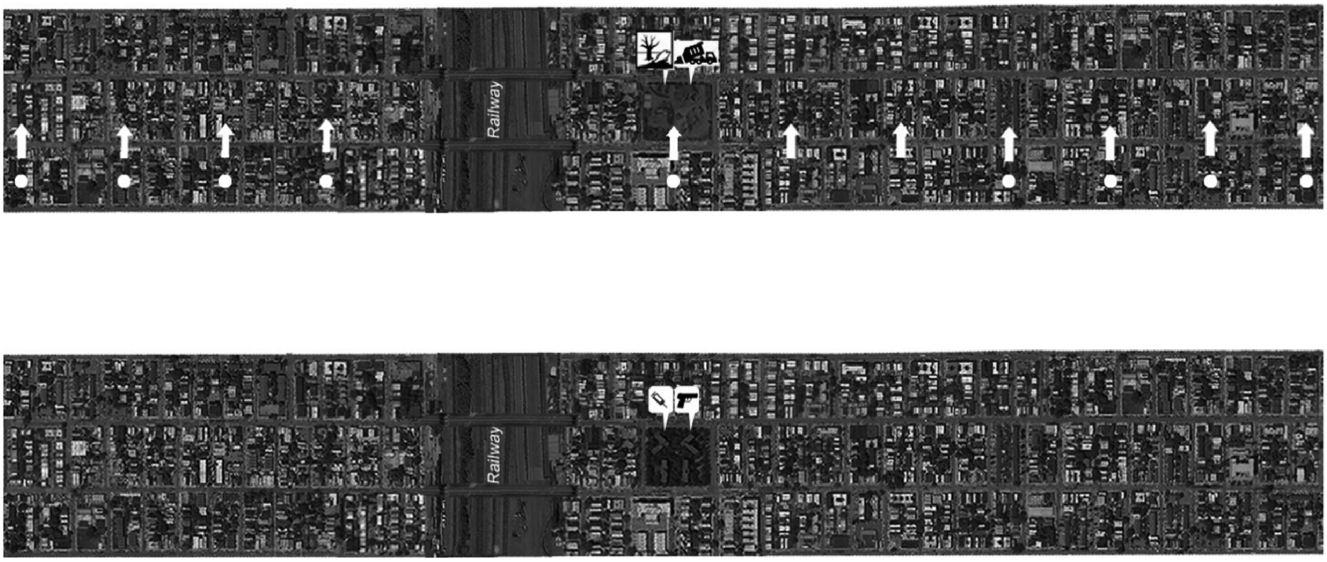

Fig. 1. Example of stimuli used in Experiment 1. Top panel: landfill condition; bottom panel: unsafe housing block condition. The white arrows indicate the 11 locations rated by the participants. Only the locations with the white dots were included in the analyses.

3.1.2. Materials and Procedure

We created fictitious satellite views of an urban area made up of a patchwork of satellite images (USGS Products; see Fig. 1). The satellite view was in grayscale to mitigate the positive impact that vegetation might have on the assessment (Sheets & Manzer, 1991; Ulrich, 1981). The area contained a hotspot (an unsafe housing project or a landfill) and a railroad, which, as participants were informed in writing, "separates the area into distinct neighborhoods." The instructions stated also that two bridges connected the neighborhoods. To emphasize that the unsafe housing block was indeed unsafe, we added the symbols of a gun and a syringe and informed the participants in writing that these convey the notion that "gang activity and drug trafficking pervade the housing block." To emphasize the threat elicited by the landfill, we added symbols depicting a dead tree and a dead fish and informed the participants that "landfills are toxic" and that "they harm the environment" (Blaison & Hess, 2016). There were 11 target locations distributed across the two neighborhoods (see Fig. 1). Four pairs of target locations were roughly equidistant from the hotspot (the locations with the dots in Fig. 1).[2] Participants rated the likelihood that the hotspot would adversely affect the 11 locations (see Fig. 1) using a scale ranging from 1 = "0% risk that the [unsafe housing block or landfill] adversely affects the block marked by the white arrow" to 9 = "100% risk that the [unsafe housing block or landfill] adversely affects the block marked by the white arrow." As perceived distance might also explain the emergence of a border effect, participants were then asked to estimate the distance (in yards) separating the 11 target locations from the hotspot. In both phases of the experiment (risk rating and distance rating), the white arrow pointed to the target location to be rated. The target locations were rated in a different random order for each participant and for each phase. In addition, the participants rated the block that contained the hotspot as well as two distractor locations (the locations without dots in Fig. 1). Only the ratings given to the equidistant pairs of locations were analyzed in Experiment 1. Finally, whether the railroad appeared to the left or to the right of the hotspot was counterbalanced across participants.

[1] We applied the same procedure to all experiments.

[2] To compensate for the fact that borders may increase perceived distance (e.g., Holding, 1994; McNamara, 1986), the target locations across the railroad were slightly nearer to the hotspot than the ones on the other side.

3.2. Results & discussion

3.2.1. Distance ratings

We first tested whether differences in perceived distance could constitute an alternative explanation for the border effect. For this, we standardized the distance ratings within participants to minimize between-subjects variability in the estimates. We further averaged the perceived distance for the two nearer equidistant pairs of distances and the two farthest ones. We then conducted a 2 (hotspot: unsafe housing block or landfill) x 2 (side: across the railroad, same side) x 2 (distance: near or far) mixed ANOVA on the standardized distance estimates. As the analysis yielded no significant effect, all Fs < 1.53, $p > .23$, differences in perceived distance cannot account for the border effect reported below.

3.2.2. Risk ratings

The risk ratings were averaged for the two nearest target locations and the two farthest ones. The results showed a significant effect of side, $F\,(1,105) = 6.90$, $p = .01$, $\eta^2_p = .06$, a significant side × distance interaction, $F\,(1,105) = 231.87$, $p < .001$, $\eta^2_p = .69$, and more importantly, a significant side × hotspot interaction, $F\,(1,105) = 4.44$, $p = .04$, $\eta^2_p = .04$ (see Fig. 2). Simple effects analyses showed that there was less perceived risk across the railroad in the unsafe housing block condition, $F\,(1,105) = 11.31$, $p = .001$, $\eta^2_p = .10$, whereas similar risk was perceived on both sides of the railroad in the landfill condition, $F\,(1,105) = 0.13$, $p = .72$, $\eta^2_p = .001$.

In accordance with the type of influence hypothesis, the border effect was stronger for influence propagating by surface transport than for influence propagating by air. This result supports the notion that people consider criminal activity as flowing less easily across the border than bad smells or toxic particles, as expected. Somewhat surprisingly, however, no significant border effect emerged for influence travelling by air. One reason could be that the influence was perceived to bridge the gap too easily. However, Mishra and Mishra (2010) obtained a border effect even though earthquakes cross state borders at least as easily. A different possibility is that the influence was too intense as the landfill was much closer to the border here than the epicenter in Mishra and Mishra's experiment. A different reason that is independent of how much influence is perceived to cross the border could lie in the fact that we asked participants to evaluate a risk. This type of question may have primed logical reasoning ("railroads cannot impede bad smells or toxic particles travelling by air"). Yet, a border effect may more readily occur

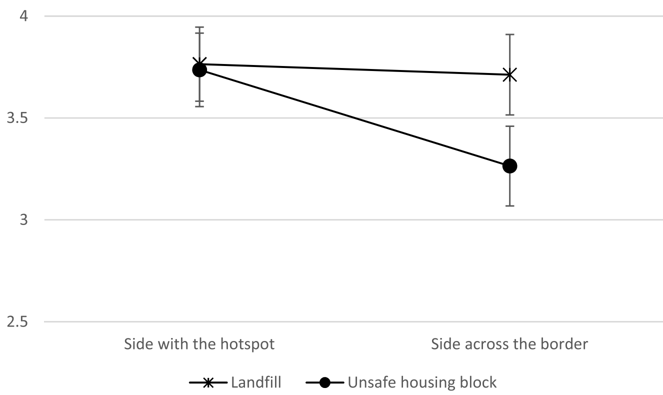

Fig. 2. Experiment 1: Risk ratings (Y-axis) as a function of side and type of hotspot. The risk scale ranges from 1 = "0% risk" to 9 = "100% risk." The error bars represent standard errors.

when asking about preferences with regard to the locations on either side of the border because preferences tap into affective reactions that are less based on explicit reasoning processes. Therefore, Experiment 2 tested the type of influence hypothesis with preference instead of risk ratings.

4. Experiment 2

Participants were shown the same kind of urban areas and the same type of hotspots as in Experiment 1, except that they were asked how much rent they would be prepared to pay for an apartment located on either side of the border. We used rent as a proxy for preference because it has an open format and is more resistant to framing or communication biases than attitude Likert scales (e.g., Birbaum, 1999; Wedell, Hicklin, & Smarandescu, 2007; see also; Blaison, Fayant, et al., 2017a; Blaison & Hess, 2016). Moreover, money is a widely used proxy for measuring perceived utility (i.e., the value or amount of pleasure provided by a good; Buechel & Morewedge, 2014) and rent money is appropriate for an urban housing setting. Willingness to pay higher rents across the border than on the same side as the hotspot would indicate a border effect. If type of influence moderates the border effect, it should be weaker for the landfill than for the unsafe housing project. In addition, we tested the influence intensity hypothesis in introducing a third hotspot condition with a nuclear power plant. As radioactivity propagates by air, we expect the same type of influence as for the landfill. However, as radioactivity travels farther than toxic particles or bad smells, it has a larger gradient of influence while being similarly aversive (Blaison & Hess, 2016; Blaison, Gebauer et al., 2017b; see supplementary material 1). Thus, if the influence intensity hypothesis holds true, a weaker border effect should emerge for the nuclear power plant compared to the landfill. As a control condition, we introduced an area without any hotspots. Here the border should not have any effect on the rents. In sum, the border effect should be a) stronger in the hotspot conditions than in the control condition (border effect hypothesis); b) stronger in the unsafe housing project condition compared to both the landfill condition and the nuclear power plant one (type of influence hypothesis); c) and stronger in the landfill condition than in the nuclear power plant one (influence intensity hypothesis).

As a secondary aim, Experiment 2 explored the effect of the characteristics of the border. Mishra and Mishra (2010) used an imaginary state line. In Experiment 1, the border was a physical object–yet one that could be easily crossed. Nonetheless, it created a large visual gap between the neighborhoods. In Experiment 2, half of the participants were shown an urban area with passable railroad tracks as in Experiment 1, whereas for the other half it was divided by a narrow avenue (see Fig. 3), not unlike other roads on the map. As in Mishra and Mishra (2010), we expected a stronger border effect for the railroad than for the avenue because the former was visually more salient and hence more likely to create a perception of discontinuity of contact.

4.1. Method

4.1.1. Participants and Design

We collected a total of 472 observations online via Amazon Mechanical Turk. Of these, 10 were from participants who participated more than once. In the case of repeated participation we kept only the first. This resulted in a total of 457 participants (254 women, 2 unknown gender; all U.S. residents) with a mean age of 35.60 years (SD = 11.40). Participants were randomly assigned to a 4 (hotspot: unsafe housing block, landfill, nuclear power plant, or no hotspot control) x 2 (type of border: railroad or avenue) x 2 (side: across the railroad, same side) x 7 (distance: 1 location in the block that contained the hotspot + 2 distractor locations + 4 locations from pairs of equidistant locations that were increasingly distant from the hotspot) mixed design with the first two factors as between-subjects factors and the two other factors as within-subjects factors.

4.1.2. Material and Procedure

We used slightly modified satellite views from Experiment 1 (see Fig. 3). In the avenue condition, the instructions stated that "the 10th avenue separates the area in two neighborhoods called Ingledale [or Blanton] and Blanton [or Ingledale]." The names of the neighborhoods were counterbalanced across participants. The same applied to the railroad condition except that the instructions stated that a passable railroad with bridges separated the area into two neighborhoods. In the nuclear power plant condition, we added the symbols of an electric shock and of radioactive hazard and informed the participants in writing that the nuclear power plant was "old but still functioning" (Blaison & Hess, 2016). The unsafe housing block and the landfill, as well as the target locations were marked and described as in Experiment 1. For each target location participants were asked how much rent they would be willing to pay for a 750 Sq Ft apartment with 1 bedroom and 1 bathroom, and that the minimum rent was $300 in this city (Blaison, Fayant, et al., 2017a; Blaison & Hess, 2016). The rest of the procedure was identical to Experiment 1. The control condition was similar except no hotspot was presented and no reference to it was made.

4.2. Results

To check whether the hotspots were identically aversive, we conducted a 4 (hotspot: unsafe housing block, landfill, nuclear power plant, or no hotspot control) x 2 (type of border: railroad or avenue) ANOVA on the amount of rent the participants were willing to pay in the block that contained the hotspot. The results showed a significant main effect of hotspot, F (3,445) = 71.89, p < .001, η^2_p = .33, and a significant hotspot x type of border interaction effect, F (3,445) = 5.62, p = .001, η^2_p = .04. Except that in the avenue border condition the rent was slightly lower for the unsafe housing block than for the nuclear power plant, t (110) = 2.01, p = .05, the other hotspot comparisons yielded no significant differences, all ts < 1.49, all ps > .14 (overall rent: M = 318.70, SD = 64.84). In both border conditions, the rent in the control condition was systematically higher than in the hotspot conditions, ts > 4.77, all ps < .001 (overall M = 459.38, SD = 142.98). The interaction effect emerged because the rent in the control condition was higher for the avenue than for the railway border, t (110) = 2.75, p = .007. This result suggests that railroad tracks by themselves have a negative influence on the surroundings compared to an avenue. We will come back to this result later.

We then tested the target hypotheses. Similar to Experiment 1, we averaged the rent participants were willing to pay for the two nearest distances and the two farthest ones. We then conducted a 4 (hotspot: unsafe housing block, landfill, nuclear power plant, or no

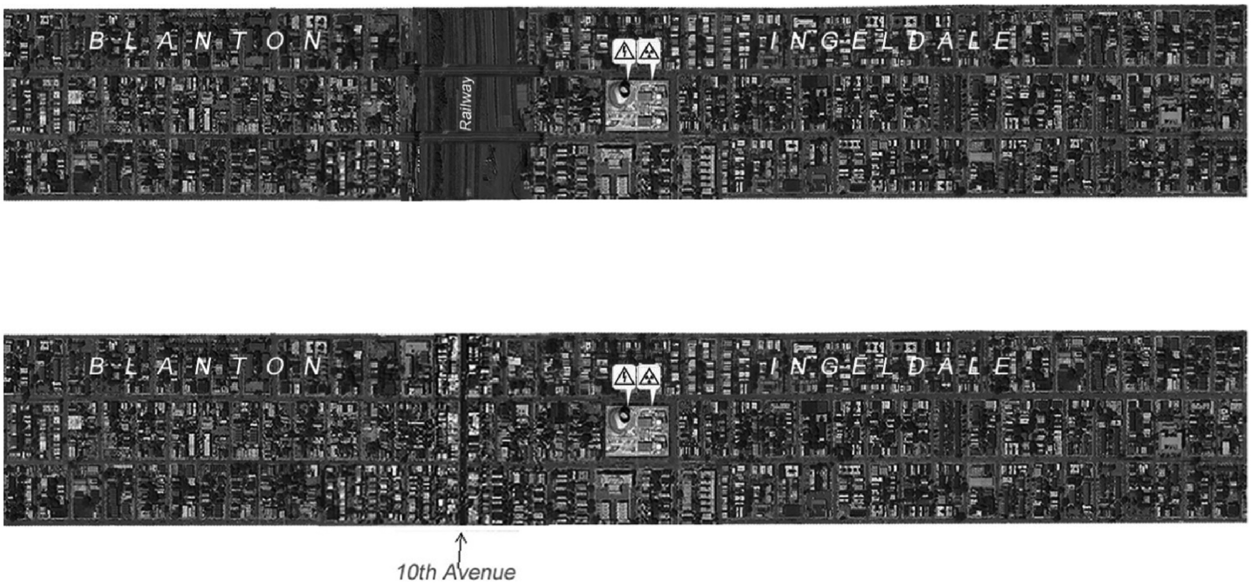

Fig. 3. Example of stimuli shown in Experiment 2. Top panel: nuclear power plant/railroad condition; bottom panel: nuclear power plant/avenue condition.

hotspot = control) x 2 (type of border: railroad or avenue) x 2 (side: across the railroad, same side) x 2 (distance from the hotpot: near or far) mixed ANOVA on the amounts of rent. We expected border effects only for the hotspot conditions and not for the control one. A border effect would be indexed by a significant side × hotspot interaction. However, the interaction could also indicate a significant effect of type of influence [unsafe housing block (surface transport) versus landfill and nuclear power plant (air)] or of influence intensity [landfill (less intense) versus nuclear power plant (more intense)]. Planned contrasts were conducted to distinguish between these effects. Finally, we predicted that if the salience of the border moderates the border effect, then a side x hotspot x type of border interaction effect should emerge as well.

The results showed a significant effect of distance, F (1,446) = 360.42, $p < .001$, $\eta^2_p = .45$, and significant distance x hotspot, F (3,446) = 23.19, $p < .001$, $\eta^2_p = .14$, distance x type of border, F (1,446) = 16.40, $p < .001$, $\eta^2_p = .04$, distance x hotspot x type of border, F (3,446) = 7.54, $p < .001$, $\eta^2_p = .05$, and distance x type of border × side interactions, F (1,446) = 4.64, $p = .03$, $\eta^2_p = .01$. Briefly, these effects indicate that compared to the control condition, participants in the hotspot conditions were willing to pay more rent at locations further away from the hotspot, and that the railroad had a more negative influence on the surroundings than the avenue. No other effect involving distance reached the conventional significance level.

More importantly, the predicted side x hotspot, F (3,446) = 12.52, $p < .001$, $\eta^2_p = .08$, as well as the side x type of border interaction emerged, F (1,446) = 7.22, $p = .007$, $\eta^2_p = .02$. Both were moderated by the predicted significant side x hotspot x type of border interaction, F (3,446) = 8.13, $p < .001$, $\eta^2_p = .05$ (see Fig. 4). To decompose the interaction effect according to our hypotheses while saving maximum statistical power, we used the following set of orthogonal contrasts: C1 = no hotspot versus unsafe housing block, landfill and nuclear power plant (border effect hypothesis); C2 = unsafe housing block versus landfill and nuclear power plant (type of influence hypothesis); C3 = landfill versus nuclear power plant (influence intensity hypothesis). Border was coded −1 for the avenue and +1 for the railroad. This set of predictors and their interactions with type of border were entered simultaneously in a multiple regression that predicted the size of the contrast between the rent given for the locations situated on the side with the hotspot (coded −1) and the rent for the locations across the border (coded +1). If a border effect emerges, then C1 should be significant; if type of negative influence moderates the border effect, then C2 should be significant; if influence intensity moderates the border effect, then C3 should be significant. If type of border moderates these effects, then interactions involving type of border should emerge significantly.

The results first showed a significant effect of C1 (border effect hypothesis), $b = 11.65$, t (446) = 5.60, p < .001, 95% CI [7.56, 15.75], which indicates that the border effect (i.e., participants are willing to pay higher rents across the border than on the same side as the hotspot) was stronger in the hotspot conditions than in the control condition. This effect, however, was qualified by a C1 x type of border effect, $b = 9.97$, t (446) = 4.79, p < .001, 95% CI [5.87, 14.06], which shows that the border effect was significantly stronger in the railroad than in the avenue condition. More precisely, C1 was significant in the railroad condition, $b = 21.62$, t (446) = 7.34, $p < .001$, 95% CI [15.83, 27.41] but not in the avenue condition, $b = 1.68$, t (446) = 0.57, $p = .57$. Closer inspection of Fig. 4 (right panel) suggests that the border effect in the railroad condition was mainly driven by the results in the control condition; it was due to the negative effect of the railroad on the surroundings as shown above. When comparing the hotspot conditions, the border effect emerged more strongly in the unsafe housing block condition than in the other hotspot conditions. Specifically, the contrast C2 comparing the unsafe housing block to the landfill and nuclear power conditions (type of influence hypothesis) was significant, $b = -7.30$, t (446) = 2.51, $p = .013$, 95% CI [-13.02, −1.58]. Simple effects analyses showed that participants were willing to pay significantly higher rents across the border than on the side of the hotspot in the unsafe housing block condition, $b = 23.12$, t (446) = 3.23, $p = .001$, 95% CI [9.06, 37.18], but not in the landfill condition, $b = 2.99$, t (446) = 0.43, $p = .67$, 95% CI [-10.84, 16.81], or in the nuclear power plant condition, $b = -0.52$, t (446) = 0.07, $p = .94$, 95% CI [-14.52, 13.48]. This pattern of results is in line with our type of influence hypothesis. Interestingly, the salience of the border had no effect on the border effect as shown by the non-significant C2 x type of border interaction, $b = 3.51$, t (446) = 1.21, $p = .23$). The effect of C3 (landfill versus nuclear power plant), was in the expected direction but did not emerge significantly, $b = -1.75$, t (446) = −0.35, $p = .72$, 95% CI [-11.59, 8.09]. Thus, the influence intensity hypothesis was not supported.

Finally, there was a main effect of type of border, $b = -9.60$, t (446) = 2.69, $p = .007$, 95% CI [-16.61, 2.58], such that the rents participants were willing to pay across the border, compared to the other side, were lower in the railroad condition than in the avenue

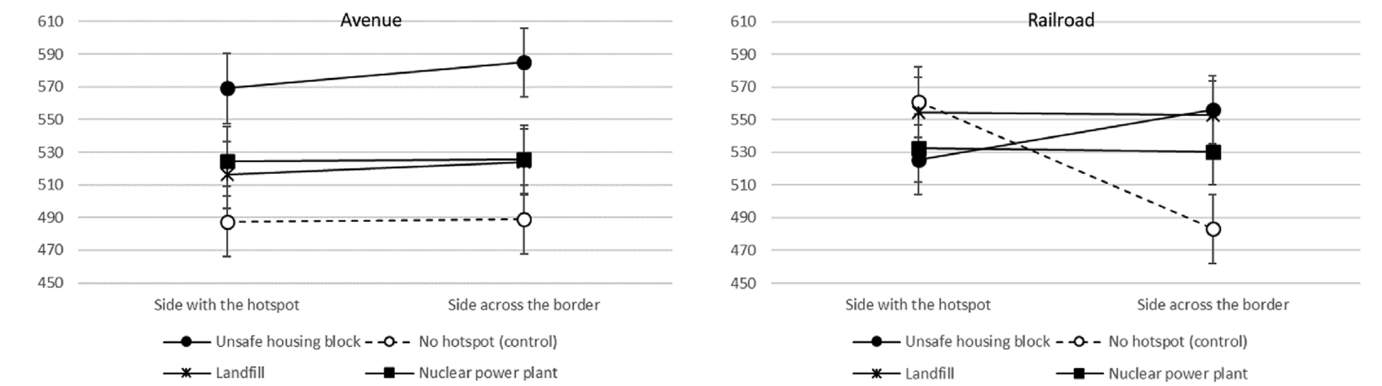

Fig. 4. Experiment 2: Amount of rent ($; Y-axis) as a function of side, type of hotspot, and type of border (left panel = avenue border; right panel = railroad border). The error bars represent standard errors.

condition. This result seems mainly driven by the railroad's negative influence, that is, the railroad itself was perceived as unattractive and spread negative influence. The remaining effects had *bs* < 1.75, *ts* < 0.35, *ps* > .73.

4.3. Discussion

Experiment 2 tested the border effect as a function of the type of influence and influence intensity with a dependent measure based on preference (amount of rent the participants would be willing to pay per month). In line with the type of influence hypothesis, the border effect in the unsafe housing block condition was stronger than in both the landfill and the nuclear power plant conditions. Thus, the border effect does not only depend on the visual salience of the border as previously thought, but also on the type of hotspot influence. The influence intensity hypothesis, however, was not supported, even though we used preference instead of risk ratings. Finally, in line with previous findings, a more salient border led to more intense border effects.

As in Experiment 1, no border effect emerged for influence propagating by air (landfill and nuclear power plant conditions). It might be argued that in the avenue condition, the border was lacking in salience. Yet, similar results were found for the railroad although it is itself quite salient. Before concluding that border effects do not emerge when influence travels by air (at least at the scale of a neighborhood), a last alternative explanation must be investigated. As both the hotspot and the railroad itself have negative influence, the absence of border effect should have led to lower rents across the railroad in the hotspot conditions compared to the rents in the control condition. That the rents were not lower but in fact higher (see Fig. 4) actually argues for a border effect that could not fully express itself because the railroad's negative influence tamped down the rents across the border. To investigate this possibility in Experiment 3, we tested the border effect by controlling for the negative effect of the railroad.

5. Experiment 3

Participants were shown urban areas that differed in two aspects from Experiments 1 and 2. Instead of rating several target locations, participants were asked to choose between moving into one of two target locations on each side of the border (forced choice; as in Mishra & Mishra, 2010, Study 1; Galak et al., 2007, Study 1). Importantly, the two locations were situated at equal distance from a *set* of railroads (see Fig. 5). The latter modification ensured that the railroads' negative influence would affect both targets to the same extent. We also varied the size of the urban area under consideration. Half of the participants were shown an urban area identical to Experiments 1 and 2, whereas the other half were shown a larger area (Fig. 5). As influence is more intense at closer distance, we were interested in whether the border effect would be smaller in the smaller spatial context. The border effect is indexed by a higher preference for the location across the central railroad in the hotspot conditions compared to the control condition. If the type of influence hypothesis holds true, then participants should be more likely to choose the target location across the central railroad in the unsafe housing block condition rather than in the landfill and nuclear power plant conditions. If the influence intensity hypothesis holds true, participants should be more likely to choose the location across the central railroad in the landfill condition rather than in the nuclear power plant condition.

5.1. Method

5.1.1. Participants and Design

We collected a total of 444 observations online via Amazon's Mechanical Turk. Of these, two were from participants who participated more than once. In the case of repeated participation, we kept only the first. This resulted in a total of 442 participants (225 women, 2 gender unknown; all U.S. residents) with a mean age of 35.44 years (*SD* = 12.55). The participants were randomly assigned to a 4 (hotspot: unsafe housing block, landfill, nuclear power plant, or no hotspot control) x 2 (spatial context: small or large) between-subjects design.

5.1.2. Material and Procedure

We created survey views of urban areas as in the previous experiments. In the control condition, participants were shown an urban area with several railroads “separating the area into distinct neighborhoods” (see Fig. 5). In contrast with the previous experiments, we added railroads on either side such that each target location was situated at equal distance from a set of two railroads (the central railroad + one of the side railroads; see Fig. 5). The instructions stated that bridges are connecting the neighborhoods, and that the target locations A and B are at equal distance from the railroads. Participants were asked to “imagine as vividly as possible that [they] were contemplating the purchase of a new home.” Further the instructions asked participants to select a home either at location A or at location B with a dropdown menu containing the options “A” and “B.” In the hotspot conditions, the same neighborhood was used only that it contained one of three types of hotspots (an unsafe housing block, a landfill or a nuclear power plant). Similar symbols as in Experiments 1 and 2 accompanied the visual depiction of the hotspots. In the large perspective condition, the satellite view was taken from a greater altitude and the distance between the hotspot and the target locations was greater than in the small perspective one (see Fig. 5). The position of the hotspot on either the left or the right side of the central railroad was counterbalanced across participants.

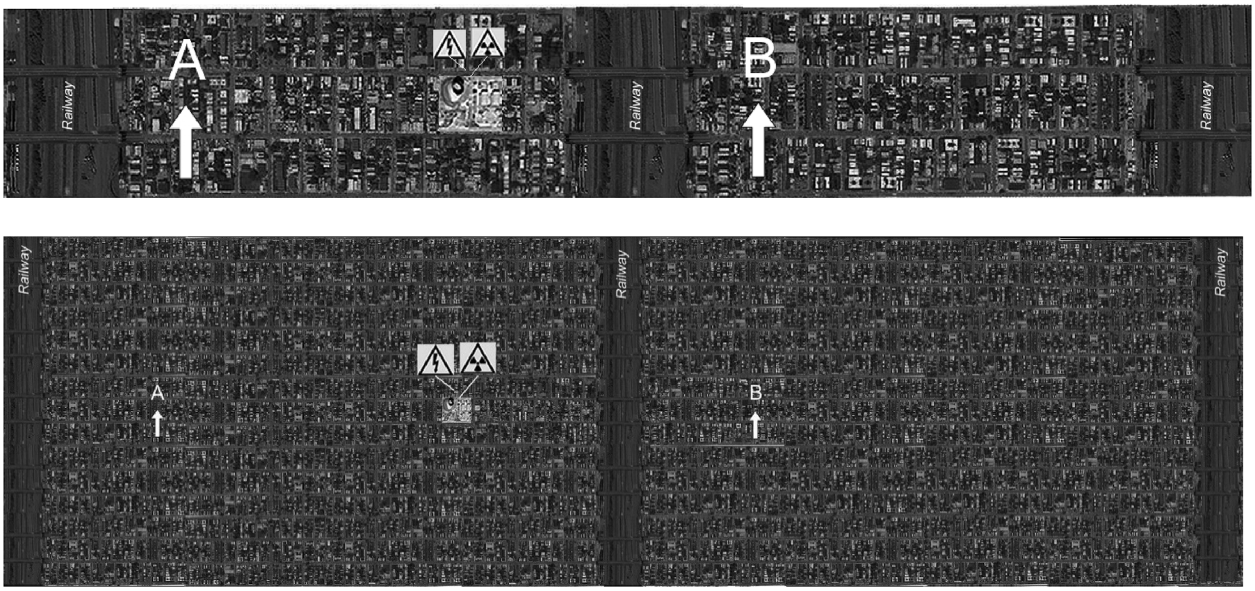

Fig. 5. Example of stimuli used in Experiment 3. Top panel: nuclear power plant/small spatial context condition; bottom panel: nuclear power plant/large spatial context condition. Each location is at the same distance from a set of railways.

5.2. Results

To predict participants' choice of location (side containing the hotspot or side across the border) as a function of type of hotspot (no hotspot, unsafe housing block, landfill or nuclear power plant) and spatial context (small or large), we conducted a logistic regression. Type of hotspot was coded using similar sets of orthogonal contrasts as in Experiment 2: C1 (border effect hypothesis) = no hotspot versus unsafe housing block, landfill and nuclear power plant; C2 (type of influence hypothesis) = unsafe housing block versus landfill and nuclear power plant; and C3 (influence intensity hypothesis) = landfill versus nuclear power plant. Spatial context was coded (−1) for small and (+1) for large. This set of predictors and their interactions (C1 x spatial context, C2 x spatial context, C2 x spatial context) were entered simultaneously into the logistic regression to predict choice of location. A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguish between the two choices of location (chi square = 44.08, $p < .001$ with df = 7). Prediction success overall was 66.20% (54.10% for the side of the central railroad containing the hotspot and 74% across). The Wald criterion indicates that C1 (Wald = 26.08, $p < .001$), C2 (Wald = 7.01, $p = .008$), C3 (Wald = 4.05, $p = .04$), and spatial context (Wald = 6.08, $p = .01$) made a significant contribution to the prediction, whereas the interaction terms did not (all Walds < 0.10, all $ps > .29$) (Fig. 6). As expected, the change in the odds ratio for C1 indicates that the participants in the hotspot conditions were 34% more likely to choose the location across the central railroad than they were in the control condition [Exp(B) = 1.34]. In accord with the predictions, the odds ratio for C2 indicates that the participants were 21% less likely to choose the location across the central railroad in the landfill and the nuclear power plant conditions than they were in the unsafe housing block one [Exp(B) = 0.79]. The change in odds ratio for C3 indicates that the participants were 25% less likely to choose the location across the central railroad in the nuclear power plant condition than in the landfill condition [Exp(B) = 0.75]. Finally, the change in odds ratio for spatial context indicates that the participants were 29% more likely to choose the location across the central railroad in the large spatial context compared to the small one. Additional analyses (Bonferroni adjusted alpha level $p < .017$) showed that the participants in both the landfill and the unsafe housing project conditions taken in isolation were more likely to choose the location across the central railroad than the participants in the control condition: unsafe housing block versus control, Wald = 29.71, $p < .001$, Exp(B) = 2.30; landfill versus control, Wald = 18.38, $p < .001$, Exp(B) = 1.85, whereas the participants in the nuclear power plant condition were slightly more likely to do so compared to the control participants, Wald = 5.56, $p = .018$, Exp(B) = 1.39.

5.3. Discussion

Experiment 3 tested the border effect in more favorable conditions than Experiments 1 and 2. It is in effect plausible that in Experiments 1 and 2 the railroad's negative influence masked the weaker border effect in the landfill and nuclear power plant conditions. In Experiment 3, where the influence of the railroad tracks was controlled for, the border effect emerged significantly for every kind of hotspot (see supplementary material 2 for an alternative interpretation). Apart from visual salience, this finding points to the importance of another characteristic of borders for the emergence of border effects: to the degree that a border has negative influence it may mask weaker border effects.

As in Experiment 1 and 2, the results support the type of influence hypothesis: the border effect was greater for influence by surface transport (unsafe housing block) than for influence by air (landfill and nuclear power plant). The results of Experiment 3 also support the influence intensity hypothesis: weaker influence elicited a stronger border effect. However, as the influence intensity effect emerged only in the better controlled conditions of Experiment 3, the effect seems rather weak (at least for influence by air and at the scale used here).

6. General discussion

The border effect emerges when people prefer places that are separated from a negative hotspot by a border, even though this border is useless in protecting those places against the negative influence of the hotspot. The present research tested whether the influence stemming from different types of hotspots moderated the border effect. We claimed that when more influence is perceived to cross the border, a weaker perception of discontinuity of contact follows, leading to a weaker border effect. We reasoned that more influence is perceived to cross a border when influence appears to travel across the border more easily (type of influence hypothesis) or when it flows more intensely (influence intensity hypothesis). Specifically, as influence by air may

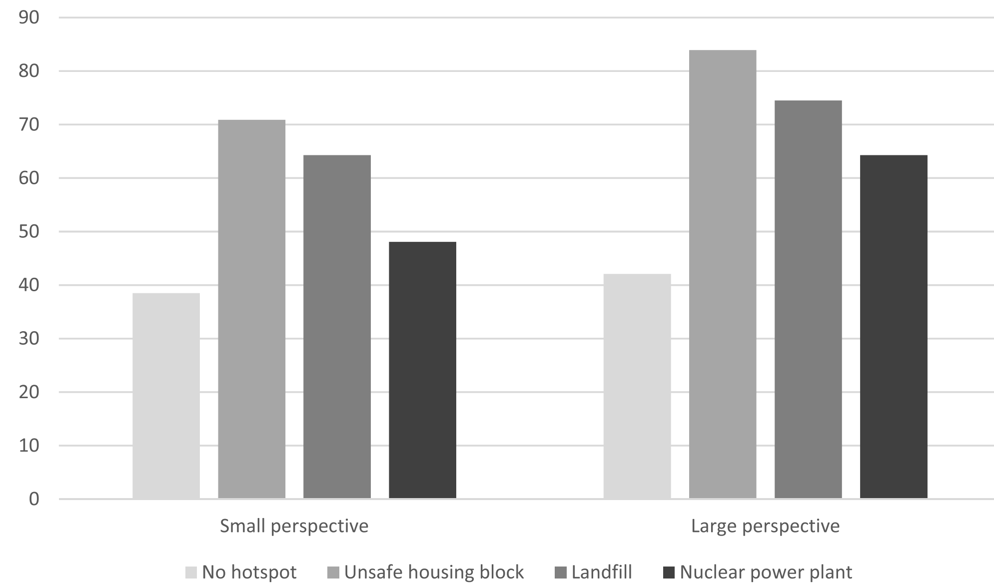

Fig. 6. Experiment 3: Percentage of choice across the railroad (Y-axis) as a function of size of spatial context (small versus large) and type of hotspot (no hotspot, unsafe housing block, landfill or nuclear power plant).

cross the border everywhere whereas influence by surface transport cannot, we predicted that, compared to hotspots with surface influence, hotspots with aerial influence would lead to weaker border effects. As influences carrying across a longer distance feel more intense for any given distance, we further predicted that, compared to hotspots with a shorter reach, hotspots with a greater reach would lead to weaker border effects.

The results from three experiments support this set of predictions overall. Specifically, a passable border elicited stronger border effects for influence by surface transport (criminal activity emanating from an unsafe housing block) than for influence by air (bad smells or radioactive particles emanating from a landfill or a nuclear power plant, respectively; see Experiments 1 to 3). This effect generalized to three different dependent variables (risk estimates, rent amount and dichotomous choice). Influence intensity was important too, even though its effect was more elusive and necessitated better controls. More intense influence by air decreased the border effect compared to milder one (nuclear power plant versus landfill, see Experiment 3). In addition, the border itself can exert a negative influence, which may mask weaker border effects. As a result, only in Experiment 3 were we able to detect a significant border effect for influence by air due to the border's negative influence being controlled for.

Are there any alternative interpretations to the results? It might be argued that the stronger border effect in the unsafe housing block condition was due to participants applying naïve theories about residential segregation (Schelling, 1969) more readily in that condition. More than in the other hotspot conditions, the participants might have felt that the side containing the unsafe housing block concentrated the less privileged inhabitants and the lowest quality of life overall. According to the same residential segregation logic, however, why would a landfill or a nuclear power plant that devalue a neighborhood not also lead to the same conclusion? After all, it seems only natural to infer less privileged inhabitants and a lower quality of life overall from the presence of a landfill or a nuclear power plant in a neighborhood compared to one without. Hence, this residential segregation explanation cannot account for the differences observed between the hotspot conditions without additional assumptions. We would argue that the perception of residential segregation is an outcome rather than a cause: residential segregation should appear more intense when the border feels less passable. For instance, it may have been greater in the case of a less passable border like a railroad without bridges.

One might further argue that the causal effect of influence intensity (weaker border effect for more intense influence) is somewhat unclear because we manipulated intensity (larger gradient of influence for the nuclear power plant) and type of aerial influence (radioactive particles versus bad smell and toxic particles) at once. In the smaller spatial context of Experiment 3, however, shorter distances to the border caused more intense influence to reach the border all things being equal. In support of the influence intensity hypothesis, the border effect was weaker in the smaller spatial context than in the larger one. In sum, the empirical evidence shows that, all other things being equal, the border effect is attenuated when variations in influence intensity are operationalized as differences in the gradient of influence or as differences in the distance of the hotspot to the border. A third operationalization to be tested in the future concerns the negative intensity of the hotspot *per se*. All other things being equal, a hotspot that is more intensely negative should spread more negative influence towards the border. Hence, a no-go area should attenuate the border effect compared to an area with a reputation that is only mildly negative.

We made choices that restrict the generalizability of the results. The design did not fully cross type of influence with intensity of influence. Thus, we cannot conclude whether the intensity effect found for influence by air generalizes to influence by surface transport. On one hand, intensity effects could emerge less easily when influence cannot cross the border freely. On the other hand, they could emerge more easily because the border effect is more reliable in that case. Although the present research simply aimed at providing support for the existence of the influence intensity effect, future research could investigate whether it generalizes to every type of influence. The results showed that the salient railroad elicited greater border effects (Experiment 2) but that it also carries a negative affective charge that may mask weaker border effects. What would happen with a salient border that had a positive affective charge, like a pleasant river stream? The positive influence could arguably intensify the border effect. However, since the negative influence of negative hotspots devalues positive hotspots (Blaison, Gebauer, et al., 2017b), it is unclear whether a positive border like a river stream would remain positive under the influence of a negative hotspot. Do border effects emerge in combination with positive hotspot? Since positive and negative hotspots have symmetrical effects (Blaison, Gebauer, et al., 2017b), positive hotspots should elicit border effects such that the area across the border appears more negative. As an example, Galak et al. (2007) showed that attractive places, like a park, feel less pleasant across a border than on the same side as a very positive hotspot like one's own home. However, the positive influence of an attractive border may mask weaker border effects due to positive hotspots.

One might further argue that participants' skin color could play a moderating role in the results. According to past empirical evidence, people generally associate areas with lower quality of life with black inhabitants (Bonam, Bergsieker, & Eberhardt, 2016; Bonam, Taylor, & Yantis, 2017). As a result, our participants may have inferred black inhabitants in the neighborhood with the negative hotspots. This inference may have led to different consequences for black participants than for non-black participants. Black participants may have identified the inhabitants of the neighborhood with the hotspot as in-group members whereas non-black participants may have identified them as out-group members. As non-black Mturkers greatly outnumber black Mturkers (black Mturkers circa. 8.6% of Mturkers; Casey, Chandler, Levine, Proctor, & Strolovitch, 2017), this difference may restrict the generality of the present results. For instance, past research showed that places linked to one's self shield against the propagation of negative influence (Blaison, Gebauer, et al., 2017b). Similarly, in the eyes of black participants, the presence of in-group inhabitants could have shielded against the influence of the negative hotspots. Black participants may thus have judged the neighborhood with the hotspot less negatively than non-black participants. As we did not collect skin color information nor controlled for it, future research should investigate the effects of participants' skin color on the polarization and the border effect.

The results open several other interesting research avenues. People may differ in their beliefs about how much influence crosses the border. For instance, an anti-nuclear activist may perceive the border as more porous to radioactive particles than someone keen on cheap electricity. Similarly, policemen facing delinquency on a daily basis may report a different border effect for crime than people less exposed to it. Furthermore, someone high in prevention focus (i.e., someone who seeks to avoid harm or failure chronically; Higgins, 1998) may need borders that offer a clearer guarantee of protection than someone low on this trait. Thus, personal experience as well as personality traits may modulate the border effect.

Collective experiences and beliefs may moderate the border effect as well. Physical borders such as rivers, parks, roads, or railroads facilitate the emergence of consensual spatial categories like neighborhoods. For example, the Harlem River in New York acts like a boundary between Manhattan and the Bronx. Categorization processes in turn amplify mild differences between areas. These spatial categories are further reinforced by people's daily journeys and by socially constructed meanings associated with them (Ramadier, Petropoulou, Bronner, & Borja, 2008). If you spend most of your time in Manhattan, less familiar neighborhoods, such as the Bronx, may appear more subjectively distant, which triggers thinking in terms of abstract (spatial) categories (Fujita, Henderson, Eng, Trope, & Liberman, 2006; Liberman, Trope, & Stephan, 2007) and amplify the process. With time, developing social representations about neighborhoods, sometimes in the form of space-focused stereotypes (Bonam et al., 2016; Bonam et al., 2017), should further consolidate this phenomenon. Thus, physical borders may trigger a cascade of socio-cognitive processes that intensify and consolidate the perceived differences between neighborhoods. These differences may also concern the perceived differences between inhabitants. Spatial context influences person perception (Corell, Park, Judd, & Wittenbrink, 2011; Wittenbrink, Judd, & Park, 2001). Thus, inhabitants living across the border should be perceived as more different than they actually are, which could fuel residential segregation over time.

However, when a hotspot's influence perceived to be crossing a border is disproportionately large, this should hinder the emergence of consensual spatial categories. For instance, when a nuclear power plant flanks an avenue, the uniting effect of the nuclear power plant should cover up any perceived discontinuity of contact created by the avenue. Therefore, a different physical border creating discontinuity of contact further away from the hotspot may in turn facilitate the generation of a consensual spatial category. In sum, spatial categories should form along the uniting and the dividing effects of hotspots and borders. When these uniting and dividing effects overlap, border effects—and thus borders to consensual spatial categories—should be less likely to emerge. This is especially true when a hotspot has a strong uniting effect (i.e., its influence is intense or flows easily across the border) or when the border has a weak dividing effect (i.e., it provides a weak perception of discontinuity of contact).

One of the implications of our findings is that neighborhood attractiveness measured in terms of real-estate prices should be more contrasted along salient borders like railroads, large avenues, passable rivers, etc., then somewhere else (except in cases where no border effect emerges). If we represent the real-estate price as a landscape where local minima in price indicate negative hotspots, whereas local maxima indicate the most attractive areas, then salient borders that run through the landscape should trace significant edges. One way to test this prediction with real world data is to spot a city's local minima in real-estate price and compare the price of real-estate located at a similar distance. Compared to properties located on the same side as the local minimum, properties located across a border should on average be more expensive. This hypothesis can be tested using archival data. Sometimes, specific parts of a city deteriorate, dragging real estate prices down. The rate of decrease, however, should be different on either sides of a salient border. Across the border, prices should resist more.

The results also have implications for the “not in my backyard” phenomenon. Unpopular developments should elicit less resistance if they are located across a border, even when that border is not an actual physical barrier. In addition, unpopular developments that act as a passable border (like railroad tracks) should elicit less resistance if they subjectively shield from a negative hotspot.

Finally, we would like to take a broader perspective on the results, looking at not only urban or environmental perception but also social perception. It has been argued that distance is such a fundamental dimension that it is processed similarly in the spatial, temporal, and social domain (Trope & Liberman, 2003, 2010). Thus, results concerning spatial distance may also generalize to social distance. Imagine group members separated by varying social distances because they have different mutual relationships (e.g., love relationship, friendship, or acquaintance). One member may be a negative hotspot in the social field because she is disliked. If spatial and social distances are homologues, that member should polarize the surrounding social space. Members close by in terms of social distance should be perceived more negatively, whereas the perception of those further away in the sociogram should be biased toward the positive. Furthermore, any perceived border between subgroups (e.g., they work in different rooms) might reinforce this effect. However, a border effect is less likely for group members that are close in the sociogram.

In conclusion, the present research contributes to our understanding of environmental perception. Passable borders accentuate the affective differences between areas through the border effect. Hotspots, however, may mitigate the border effect depending on the type and the intensity of a hotspot's influence in the area. Thus, for a full understanding of how people form affective representations of the environment, it is crucial to take into account the interaction between the effects of borders and hotspots on affective judgment.

Author note

Christophe Blaison, Université Paris Descartes, Institut de Psychologie, Laboratoire de Psychologie Sociale: Menaces et Société, France. Till Martin Kastendieck and Ursula Hess, Institut für Psychologie, Lehrstuhl für Sozial-und Organisationspsychologie, Humboldt-Universität zu Berlin, Germany. Thierry Ramadier, CNRS

(UMR 7363), Laboratoire SAGE, Université de Strasbourg, France.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2019.101337.

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