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To cite this article: Rebecca Rogers, Cornelia Wallner, Bernhard Goodwin, Werner Heitland, Wolfgang W. Weisser & Hans-Bernd Brosius (2017) When do people take action? The importance of people's observation that nature is changing for pro-environmental behavior within the field of impersonal, environmental risk, Journal of Integrative Environmental Sciences, 14:1, 1-18, DOI: [10.1080/1943815X.2016.1268165](https://doi.org/10.1080/1943815X.2016.1268165)

To link to this article: <http://dx.doi.org/10.1080/1943815X.2016.1268165>



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Published online: 15 Feb 2017.



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When do people take action? The importance of people's observation that nature is changing for pro-environmental behavior within the field of impersonal, environmental risk

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ABSTRACT

Prior experience has shown to be a highly influencing factor for risk perceptions and behavioral patterns. Yet, often prior experience is connected to a personal threat and damage. We assume that people's mere perception of nature changes, even if it is an impersonal risk and therefore not threatening humans but rather nature, is crucial for explaining effects in environmental and risk communication. A joint survey of biologists and communication scientists was conducted within a field experiment in two waves ($N_1 = 479$; $N_2 = 295$) in 12 German districts. Those regions differ in observable nature changes, evoked by the invasive moth *Cameraria ohridella*, which creates early leaf foliage on white flowering horse chestnut trees. Results show that the biological method, of deciding on sampling region, helps to define a sample of participants, who show different extents in nature change and risk perception. Further we could show that over a longitudinal design, nature change and risk perception increased, having slightly higher change scores in low infested areas, and that changed scores correlate with each other. Mediation analysis reveals that the overall effect of nature change perception on communicative and another active pro-environmental behavior is almost completely mediated by risk perception. Implementations of these results will be discussed.

ARTICLE HISTORY

Received 19 September 2016

Accepted 30 November 2016

KEYWORDS

Risk perception; environmental communication; direct experience; survey; field experiment; interdisciplinary research

1. Introduction

Prior experience is often described as a highly influencing factor for risk perception and behavioral patterns. However, we assume that the mere perceptions of nature and nature changes by individuals, even if a risk is not threatening humans but rather nature, are crucial for explaining effects in environmental and risk communication. Thus, in this paper, we discuss the interaction between (1) how people perceive nature changes differently, (2) the relation to individual risk perception, and (3) behavioral intentions related to interpersonal communication as passive behavior and an active pro-environmental behavior regarding

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the impersonal risk case example *Cameraria ohridella*. We are particularly interested in exploring these interactions in the context of so-called “impersonal risks” (Kahlor et al. 2006). Impersonal risks are of high relevance for environmental communication, as many risks that are evoked by nature changes can be categorized as impersonal risks (for more details, see theory section).

For our empirical analysis we use data from a two-wave survey, embedded in an experimental design, which was conducted in cooperation between communication scholars and biologists in Germany in 2014. Biologists chose a semi-quantitative rating procedure to define areas prior to the implementation of the surveys, identifying areas where a nature change is clearly observable, yet not threatening citizen (high infestation) and areas with low infestation. This categorization should help to ensure that there are participants with high nature change perception and those with low nature change perception. We are interested to verify how the cooperation with biological methods may support the acquisition of data.

1.1. Impersonal risks

Most studies have evaluated people’s risk perception for environmental personal risks, where a natural hazard may actually be experienced as a personal threat (like flooding). We are interested in the relevance of personal experience in a more distant manner: the personal observation of a nature change that does not cause harm to the people but that changes their direct living space, in the sense of environmental surrounding. Kahlor et al. introduced the term “impersonal risk” in contrast to “personal risk” (Kahlor et al. 2006). Thus, impersonal risks are defined as a threat to the environment and not as a direct threat for the individual (e.g. loss of biodiversity), but with probable direct consequences for the individual in the long run (e.g. loss of ecosystem services). In contrast, “personal risks” cause direct harm to individuals, like health diseases, drinking spoiled water or having personal damage through flood events (Wahlberg & Sjoberg 2000). As stated by Kahlor et al. (2006), there is great interest in how to create people’s awareness of risks that do not (yet) directly affect them but that have consequences for nature and the environment and, thus, might affect people indirectly and maybe with time delay. From the perspective of biologists, this category of risks is of high interest because of current environmental changes like loss of biodiversity, which does not threaten humanity right now, but which could on the long run, as more species are becoming extinct, which is leading to less ecosystem services, such as provisioning of clean drinking water.

It has to be mentioned, that the definition of an environmental change as impersonal or personal risk is as continuum, depending on the time and the target audience. For example, climate change can be a personal risk for people living in areas where strong flooding, droughts or changes in seasons are already causing direct harm for society, while for people in some European countries climate change is mostly still perceived as impersonal risk since their daily lives are not yet influenced or threatened. The definition of a risk as “personal” or “impersonal” is not only determined by the target group, but there is also a time effect. Climate change may not yet be a personal problem for many European people, but it is likely to be one in the next 50 years. Since the type of risk may change, it is of interest to not only investigate “personal risks” in the context of nature changes but also focus more on impersonal risks.

Often the emotional response to risks, which show not yet personal damage like climate change in many countries, is relatively modest. This may be related to the perceived geographical and temporal distance to areas affected by climate change (Spence et al. 2012). Once climate change is perceived as being present, personal damages are accompanying it. The same is true for the loss of biodiversity. As long as species composition is not affecting ecosystem services that provide the life basis for humans, it might be defined as “impersonal risk”. Learning on how to foster risk sensitivity and pro-environmental behavior of humans, even if a risk is not (yet) influencing the public personally, will help to prepare both humans and nature to inhibit or slow down impersonal risks of becoming personally threatening. If we can for example support pro-environmental actions against the fast extinction of species, this may lead on the long run for benefits for both: nature and humans. In this study, we focused on an impersonal risk which is already present and the public is able to perceive its negative influence on nature, but it is not threatening human life: an invasive moth species (*C. ohridella*), which is creating damage to the leaves of the cultural important tree *Aesculus hippocastanum* (white flowering horse chestnut tree).

1.2. Case example

For varying a nature change, which represents a truly impersonal risk yet is already present in the direct surrounding of people, we searched for an observable nature change in Germany, which would differ strongly in diverse regions and may be perceived differently by individual participants. Thus, in cooperation with biologists, we chose the damage of tree leaves of the white flowering horse chestnut tree caused by the horse chestnut leafminer, an invasive species, as a case example for impersonal risks.

The horse chestnut leafminer (*C. ohridella*, *Lepidoptera* (moth), *Gracillariidae*) is an invasive species – that is, it is not originally local to Germany, but invaded Europe recently in an unknown manner. It was first discovered in Macedonia in 1985 (Simova-Timosic & Filev 1985) and subsequently described as a new species (Deschka & Dimic 1986). It has spread over most parts of Europe in the last 20 years.

The horse chestnut leafminer causes considerable damage to the leaves of white-flowering horse chestnut trees (*A. hippocastanum*, *Sapindaceae*). The damage originates due to the natural lifecycle of the moth. Female moths deposit their eggs on the upper leaf surface beginning in spring. Immediately after hatching, larvae enter the leaves and begin feeding inside the leaves (hence “leafminer”). This causes a distinctive pattern of damage to chestnut trees (Freise & Heitland 2004). The leaves begin to turn brown earlier than normal and can even fall off in July and August rather than in autumn months. The moth undergoes three to four generations per year (Freise & Heitland 2004) and, thus, the damage increases over the year with an increasing amount of leaves being affected.

The damage to the leaves is clearly observable. This can be perceived as nature change by the public. Thus, the leafminer can be categorized as an impersonal risk. It has been shown that the horse chestnut leafminer weakens the tree, but does not kill it. Far, the damage caused has been considered mostly aesthetic, with some long-term effects on growth, seed weight, and water-uptake (Raimondo et al. 2003; Salleo et al. 2003; Thalmann et al. 2003) and has shown no direct harm to the public.

Due to their mass appearance and the high cultural value of the tree in Germany, measures against the horse chestnut leafminer were investigated early after first appearance. It could

be shown that the horse chestnut leafminer is quite resistant to various controlling measures, which are often very time/money consuming (Arnold & Cetin 2002). A very time-consuming, yet effective measure is collecting and destroying leaves with overwintering pupae to reduce the number of emerging adult moths in the following spring and thus the amount of damage in the following year (Snieskiene et al. 2011).

The horse chestnut leafminer provides an ideal case study for various reasons: (i) the damage is observable in nature and can be detected by anyone. Therefore, the influence of the perception of nature change can be measured (and does not need to be artificially induced in a laboratory situation). (ii) Infestation varies strongly within Germany and, thus, the degree of nature change differs among different regions. We have been assuming that in areas where strong infestation is occurring, people will show higher levels of nature change perception. (iii) Behavioural changes can be made visible as certain measurements like leaf collection can be undertaken by anyone willing to apply them.

1.3. Nature change perception – observation that nature is changing

It is commonly said that experience is the best teacher. The consequences of risks that we can see, hear and feel – like a burn from time in the sun – create impressions are kept in memory and throughout shape individuals' subsequent behavior, and in their retelling, even that of others (Marx et al. 2007). Various studies on environmental issues use hazards and environmental occurrences with direct consequences or threats for the people as case examples, such as flooding (Terpstra et al. 2009) or hurricanes (Sattler et al. 2000). These studies reveal the relevance of personal experience both for individual risk perception and behavioral intentions. In one of the first publications on risk perception, White found that people's past experience directly influenced their own behaviour when they were under threat (White 1945). This apparently happens because attitudes based on direct experiences are more accessible in memory (Regan & Fazio 1977; Fazio & Zanna 1981). Encountering endangering situations triggers emotional reactions, which then foster neuro-endocrine conditions, which enable the storage and retrieval of information about a specific situation. It should be expected that situations of consequence to an individual evoke affective reactivity (Spear & Riccio 1994).

In the case of natural hazards, Weinstein argues that direct experience provides greater vividness than pure hazard information, more rapid recall of relevant information, greater personal involvement, and also lower levels of uncertainty (Weinstein 1989). Individuals who have undergone a direct experience of an event like flooding, will be more likely to be concerned and, therefore, are more highly motivated to display pro-environmental behavior (Spence et al. 2011). In a study on air pollution in Great Britain, it was found that people with health problems caused by air pollution show a higher risk perception and are more likely to take actions related to climate change (Whitmarsh 2008). Further, research on flood experience indicates that people with first-hand experience of flooding perceive climate change as a higher risk and lower uncertainty and show a greater willingness to act, in this case, to save energy (Spence et al. 2011). Wachinger et al. made a literature review and found out that among the few external factors that seem to have impact on risk perception of natural hazards, was direct experience, which has been proven to exert a strong effect on risk perception (Wachinger et al. 2013). Direct experience may thus show a positive effect on risk perception (Plapp & Werner 2006). Others found that especially people living in endangered

areas, estimate risk smaller than those people living further away from a risk (Heitz et al. 2009). This raises the question of proximity of the risk source and the importance of personal damage or at least the possibility to perceive nature change in proximity. There are examples of individuals who had previous experience with a hazard event and who did not experience personal damages. Those were more likely to believe that a future event will unlikely affect them and, therefore, their risk perception decreases (Hall & Slothower 2009; Scolobig et al. 2012). Thus the general question is whether the observation that nature is changing in the close surrounding is related to risk perception, even though this “prior experience” is not harming the individual?

In addition, direct experience predicts consequent behavior better than indirect experience (Fazio et al. 1978; Paton et al. 2000). Behavioral patterns may function to increase or decrease the physical risk itself (Kasperson et al. 1988). Thus, risk perception has shown to affect active behavioral intention, such as in the context of sun blockers and self-examination for melanoma (Rimal & Real 2003) or air pollution and actions related to climate change (Whitmarsh 2008). Also in research on natural hazards, such as hurricanes, risk perception influences behavioral intentions, such as evacuation intentions (Lazo et al. 2015). Besides the interest in these active behavioral intentions, communicative behavior is also of high interest. The intention to inform others is of outstanding relevance for environmental problems and sustainable development because interpersonal communication often “translates environmental information gleaned from news sources to adolescents’ everyday-life reality, thereby motivating pro-environmental behaviour” (Östman 2014). Interpersonal communication thus reinforces and multiplies media influence. In general it seems that prior experience and risk perception are connected and seem to foster behavioural patterns.

Yet most of the studies focus on risks that, once they are visible, are a personal threat to humans, such as flooding or hurricanes. We wanted to go one step further and investigated the relevance of direct observation of a nature change for individual risk assessment of impersonal risks on the basis of a case example, which does not threaten the public in Germany at all. So far, it is not defined if and how the mere perception of a nature change is important for the perception of a truly impersonal risk. As mentioned before, research indicates the relevance of direct experience in the context of rather personal risks, such as flooding showing some personal damage. We define “nature perception” as the everyday-perception and the direct observation people have when going outside. Thus, we define “nature change perception” as the individual perception of a change in the natural environment that people might have regarding if and how their natural environment is (visibly) different from what they have observed before or they remember to have observed. In this paper, we will use the term “nature change perception” to imply peoples’ individual perception in terms of observation of a change of their natural environment. Often the term “prior experience” is used for a direct experience. Yet, we decided to prefer the term “nature change perception” over “prior experience” as we tackle the effect of a pure perception – an observation that nature is changing – over a more active “making the experience”. Thus, we want to contribute to research on environmental and risk communication with the results from this project, focusing on impersonal environmental risks and the question: How important is the mere perception of people that nature is changing, which is not harming them, for individual risk perception and consequent behavior?

2. Research questions and hypotheses

First we wanted to know how the proximity of a nature change and thus the objectively rated level of infestation in our survey regions influences the individual nature change perception, risk perception and behavioral intentions of people. We argue that those living in the objectively rated highly infested areas also show a higher perception that leaves are damaged, higher risk perception and higher behavioral intentions to (a) inform others and (b) to take part in collective leaf disposal.

H1: Participants living in high infested areas will show higher nature change perception, higher risk perception and higher behavioral intentions compared to those living in low infested areas.

Second, we analyze the interrelations among nature change perception, individual risk perception, and two behavioral intentions: (a) willingness to inform others and (b) to take part in collective leaf disposals. As reported in the theoretical background section above, it is claimed in prior literature that an individual's prior experience influences the level of the individual's risk perception and the consequent adaption of behavior. Our research questions aim at understanding whether the mere observation of a nature change, which is no direct threat to the individual, also relates to individual risk perception and (a) individual communicative behavior and (b) the pro-environmental behavior "to take part in leaf disposal". Our corresponding propositions are that nature change perception correlates positively with individual risk perception and both intended behaviors. Further we argue that also the individual risk perception of an impersonal risk correlates positively with both of the intended behaviors. Further we want to understand whether the mere perception is the driver of behavioral intentions or whether it is mediated through individual risk perception. Thus we conduct a mediation analyses separately for both behavioral intentions. We focus on the interrelation of the three variables – nature change perception, individual risk perception, and each of the behavioral intention arguing that:

H2: The effect of nature change perception on behavioral intentions is mediated by the individual risk perception.

Further, we aim to ascertain how nature change perception and risk perception may have developed over a time span of five months (from first to second wave). We argue that nature change perception may increase as participants will now have the possibility to perceive and experience this environmental damage within the five months, which will lead to a higher risk perception. Further we are interested if change scores are correlating and how they vary depending on the objectively rated level of infestation.

H3: Nature change perception and risk perception will increase over a time span of five months.

Finally we analyze the investigated relationship of the mediation analysis of the first wave also for the second wave, using self-reported behavior "to inform others" instead of the behavioral intention:

H4: The effect of nature change perception on self-reported communicative behavior is mediated by the individual risk perception.

3. Method

In order to test our hypotheses, we created the following experimental design. We conducted a field experiment with a survey in two waves (first wave from 4/24/2014 to 7/20/2014,

$N_1 = 479$; second wave from 9/16/2014 to 11/3/2014, $N_2 = 295$) in 12 districts in Germany, using CATI-recruitment (Computer Assisted Telephone Interviews) and an online questionnaire for each wave.

3.1. Sample and procedure

The selection of the test regions was based on the level of infestation by the horse chestnut leafminer on the horse chestnut trees. A semi-quantitative rating procedure was conducted by trained biologists to assess the moth damage in various cities and regions in Bavaria and Schleswig-Holstein. The assessment of infestation levels of leaves (infestation in percentages: <1%, 2–10%, 10–25%, 25–50%, 50–75%, >75%) was done optical, by the same biologists. Researchers were able to show that the optical assessment of infestation within several infestation categories is precise enough to reflect the *Cameraria* population at the chosen site (Gilbert & Grégoire 2003). The cities were categorized into locations of “low” (15 randomly chosen trees at common public places in the city with fewer than 10% infestation) and “high” infestation (15 randomly chosen trees at common public places in the city with more than 25% infestation) and pairs of cities were chosen based on homogenous clusters on key data. A cluster analysis was undertaken in order to categories districts into homogen clusters concerning key data variables. Those variables were:

- (1) Number of people with university entrance diploma.
- (2) Number of people oscillating for working reasons to another area.
- (3) Fraction of recovery and forest area.
- (4) Age-distribution within a five scale ranking.
- (5) Number of inhabitants.
- (6) Population density.
- (7) Number of free-standing houses.

A random sample of participants in the 12 selected districts was contacted by telephone. Respondents were asked to participate in the survey, and if they agreed, they received a link to online questionnaires of the first and second wave. All relevant items for this paper are detailed in Table 1. A total of $N_1 = 479$ respondents completed the questionnaire in the first wave. The age of the participants ranged from 18 to 70 years. Further, 43% were male ($n = 205$), 53% were female ($n = 256$), and 4% provided no gender information ($n = 12$). Approximately half the participants (51%) had heard about the reasons for the early brown colouring of leaves. Moreover, 45% recognized the name of the horse chestnut leafminer. In the second wave five months later, $N_2 = 295$ out of the 479 from the first wave participated in our questionnaire. This sample consisted of $n = 168$ (57%) female, 123 (42%) male participants, and four participants (1%) provided no gender information.

3.2. Variables (see Table 1)

3.2.1. Individual risk perception

The developed items orient themselves along several scales used in risk communication (Worringen 2001; Kahlor et al. 2006). Perceiving *Cameraria* as a risk and rating *Cameraria* as a problem were queried in the first and in the second wave. The participants were asked to rate the likelihood of *Cameraria* occurrence and *Cameraria* as a problem on three different

Table 1. Constructs, items, and response options.

Construct	Item(s)	Response options	N, mean (SD) of indices, Cronbach's alpha
Nature change perception (first and second wave)	How often did you perceive the following appearances on chestnut trees?	Five-point scale "very often (5) –not at all (1)"	First wave: 479, 2.97 (1.26), 0.90 First wave (only participants which take part in first and second wave): 295, 3.21 (1.25) Second wave: 295, 3.30 (1.08), 0.89
	(1) The leaves of the chestnut already become brown in summer (2) The leaves of the chestnut tree fall earlier than usual		
Individual risk perception (neighborhood) (first wave and second wave)	(1) According to you, how likely is it that the chestnut leafminer will occur in your neighborhood?	Five-point scale "very likely (5)–not likely at all (1)" "big problem (5)–no problem at all (1)"	First wave : 477, 2.96 (1.07), 0.80 First wave (only participants which take part in first and second wave): 295, 3.17 (1.05) Second wave: 294, 3.31 (1.15), 0.87
	(2) The chestnut leafminer in my neighborhood is a ...		
Intended behavior (first wave)	I am planning to ...	Five-point scale "very likely (5)–not likely at all (1)"	1: 467, 3.02 (1.22) 2: 469, 2.18 (1.07)
	(1) ... inform others about the chestnut leafminer (2) ... take part in collective leaf disposals...		
Self-reported actual behavior (second wave)	Did you do any of these actions? I did ...	"Yes (1)"/"No (0)"	1: 295, 0.40 (0.49) 2: 295, 0.01 (0.12)
	(1) ... inform others about the chestnut leafminer (2) ... take part in collective leaf disposals		

Note: The "n" varies due to the analysis setting "exclude cases pairwise."

geographical levels on a five-point Likert scale: “Neighborhood” (individual risk perception), “Rural district,” and “Germany” (societal risk perception). An index was created by combining the question on *Cameraria* “as likely to occur” and “as a problem” for “the neighborhood”, which is equivalent to individual risk perception (Table 1).

3.2.2. Nature change perception

Nature change perception was questioned with two items on a five-point Likert scale, which were then summarized as an index. The first question asked about the perception of a premature brown coloring of leaves (also for people who did not own a chestnut tree) and secondly how often people perceived that leaves fall off chestnut trees earlier in the year than they ideally should. The perception of a nature change was questioned in the first wave and five months later in the second wave in order to check for differences in the perception of this nature change.

3.2.3. Intended and self-reported behavior

The intended behaviors regarding the moth were questioned in the first wave with two items on a five-point Likert scale of how likely a certain behavior of participants will be. These items were asked again in the second wave to identify which “actual” behavior participants showed over time. Informing other people was defined as a communicative pro-environmental behavior, as it is known that interpersonal communication influences the risk perception of people (Östman 2014). Thus, informing others of a nature change is one measure to make other people aware of a problem and, thus, one important step in risk communication. Taking part in collective leaf disposal activities was chosen as active pro-environmental behavior as every participants would have potentially be able to undertake this activity. Private collection of the leaves may only be undertaken by people owning a chestnut tree.

4. Results

H1: Participants living in high infested areas will show higher nature change perception, higher risk perception and higher behavioral intentions compared to those living in low infested areas.

As levels of infestation in cities were defined by natural scientists we were interested to analyze how this objective categorization of areas with low and high leaf damage might actually influence participant’s individual perception of nature change (early leaf defoliation), risk perception of the moth and behavioral intentions (active and passive). From our participants, 192 lived in districts that were scientifically rated as low infested districts (2 in Bavaria, 4 in Schleswig-Holstein), while 275 lived in high infested districts (4 in Bavaria, 2 in Schleswig-Holstein); 12 participants did not provide information on which city they lived in.

Table 2. Differences in nature change perception, individual risk perception and behavioral intentions depending on the pre-defined infestation level of where participants were recruited (low/high).

	Means (SD) of people living in LOW infested areas	Means (SD) of people living in HIGH infested areas	p-Value, testing for significant differences
Nature change perception	2.83 (1.20)	3.09 (1.28)	<0.05
Individual risk perception	2.75 (1.04)	3.12 (1.06)	<0.001
Behavioral intention “to inform others”	3.03 (1.19)	3.03 (1.25)	=0.95 (n.s.)
Behavioral intention “to take part in collective leaf disposal”	2.09 (1.04)	2.24 (1.09)	=0.12 (n.s.)

We were able to detect that the scientifically determined infestation level created a significant difference between the nature change and risk perceptions of participants (Table 2). There was a significant effect for the scientifically determined infestation level on the individual nature change perception ($t(465) = -2.20, p < 0.05$) and risk perception ($t(463) = -3.68, p < 0.001$) by people. People who live in districts with higher infestation and thus greater leaf damage show a higher nature change perception, which means that they had higher observations of the fact that nature is changing and also a higher perception that the moth is a risk. Yet for the later intention of people to either (a) inform others or (b) take part in collective leaf disposal, the objectively rated level of infestation in the city showed not to be of significant influence (Table 2).

H2: The effect of nature change perception on behavioral intentions is mediated by the individual risk perception.

For the mediation analysis we decided to use the individual nature change perception, which was indicated by the participants personally (instead of the scientifically determined infestation level) as we derived data through a field experiment. Even though we selected those districts taking into account the proportion of commuters (amongst other socio-demographic characteristics) based on official statistics (see methods), we were not able to control how far the participants are travelling around their district during the time of the survey and, therefore, cannot exclude that other infestation levels were observed in other districts. Through mediation analysis we wanted to analyze if nature change perception, risk perception and two behavioral intentions are related. Further we chose mediation analysis to screen whether the pure perception of leaf damage is having a direct effect on behavioral intentions or whether it is mediated through the individual risk perception. To investigate the interrelations among individual risk perception, nature change perception and two behavioral intentions (a: “to inform others” and b: “taking part in collective leaf disposal”) two separate mediation analyses based on Hayes Macro Process for SPSS (Hayes 2012) were conducted as researchers, such as Kellens et al. (2013), note that more attention should be paid to mediation analysis as it is important to analyze and understand the relationships between variables (Kellens et al. 2013). The inclusion of socio-demographic data, such as age and level of education did not alter the mediation model and those variables were therefore excluded from the analyses.

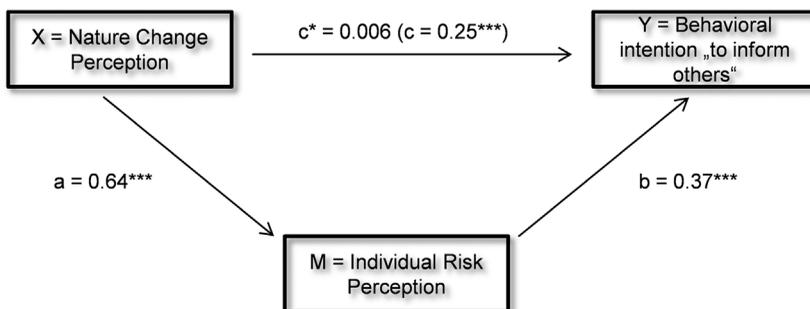


Figure 1a. Relationship among nature change perception, individual risk perception, and intended behavior to “inform others”.

Notes: Mediation analysis: $N = 466$. X = nature change perception, Y = the intended behavior “to inform others.” The mediator M is the individual risk perception (for the own neighborhood). $C, c^*, a,$ and b are standardized beta-values. C is the total effect, while c^* is the direct effect left over when controlling the mediation effect.

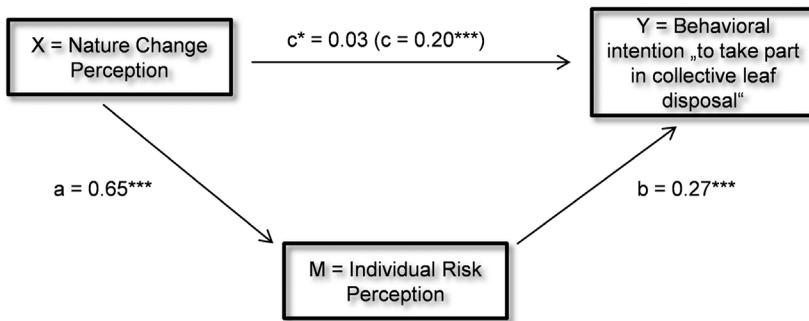


Figure 1b. Relationship among nature change perception, individual risk perception, and intended behavior to “to take part in collective leaf disposal”.

Notes: Mediation analysis: $N = 466$. X = nature change perception, Y = the intended behavior “to take part in collective leaf disposal”. The mediator M is the individual risk perception (for the own neighborhood). C , c^* , a , and b are standardized beta-values. C is the total effect, while c^* is the direct effect left over when controlling the mediation effect.

For the passive, but very important behavioral intention “to inform others”, we detected that there was a total effect of nature change perception on the behavioral intention “to inform others” ($\beta(c) = 0.25, p < 0.001$), and that a big part of the individual risk perception of participants toward infestation by *C. ohridella* is also explained by their nature change perception ($\beta(a) = 0.64, p < 0.001$) (Figure 1a). While controlling for the mediator M (individual risk perception), the total effect from nature change perception decreased to a direct effect of only $\beta(c^*) = 0.006$, which was not significant. This shows that we do have an almost complete mediation, as $c^* < c$ and c^* is almost equal to zero.

The Sobel-Z-test, which testifies the significance of the indirect effect, showed a significant indirect effect (completely standardized indirect effect = 0.24) of nature change perception over individual risk perception on intended behavior ($Z = 6.22, p < 0.001$). A bootstrap-analysis, also performed with the Hayes Macro, with $m = 10,000$ also indicated a significant indirect effect ($CI_{95-} = 0.16, CI_{95+} = 0.31$).

For the active behavioral intention of “taking part in collective leaf disposal” the results of the mediation analysis are similar to the passive behavioral intention. We detected that there was a total effect of nature change perception on the behavioral intention “taking part in collective leaf dispersal” ($\beta(c) = 0.20, p < 0.001$), and that a big part of the individual risk perception of participants toward infestation by *C. ohridella* is also explained by their nature change perception ($\beta(a) = 0.65, p < 0.001$) (Figure 1b). While controlling for the mediator M (individual risk perception), the total effect from nature change perception decreased to a direct effect of only $\beta(c^*) = 0.03$, which was not significant. This shows that we do have an almost complete mediation, as $c^* < c$ and c^* is almost equal to zero.

The Sobel-Z-test showed a significant indirect effect (completely standardized indirect effect = 0.20) of nature change perception over individual risk perception on intended behavior ($Z = 4.47, p < 0.001$). A bootstrap-analysis, also performed with the Hayes Makro, with $m = 10,000$ also indicated a significant indirect effect ($CI_{95-} = 0.10, CI_{95+} = 0.25$).

Therefore, we can support hypothesis H2 for both behavioral intentions. Analyzing the total effect does at first indeed support that individual nature change perception affects behavioral intentions, but controlling for M , the individual risk perception, the left direct effect of nature change perception on intended behaviors shows that only a minimal

percentage of nature change perception directly explains the intended behavior and that the bigger portion is mediated by individual risk perception. These results indicate that apart from the results in research that show an effect of prior direct experience (see Section 1), we could show that the mere perception of a nature change is already related to passive (communicative) and active behavioral intentions, which are both mediated by individual risk perception, even if a risk has no negative influence on the participants itself.

H3: Nature change perception and risk perception will increase over a time span of five months.

For the second wave, 295 participants out of the 479 participants of the first wave participated. Therefore, the following analyses use the lower N of participants. First, we tested how the perception of a nature change and the individual risk perception changed over the longitudinal design. Nature change perception only increased slightly from the first to the second wave, but this difference was not significant ($t(294) = -1.54, p > 0.05$). Risk perception on the other hand increased significantly from the first to the second wave five months later ($t(-2.48), p < 0.05$) (Table 1). In order to test how the changes in nature change perception from wave 1 to wave 2 and those of risk perception over both waves are connected to each other, we computed a correlation between the change scores of these two variables. Pearson correlation indicated a significant correlation of $r = 0.51, p < 0.01$. Therefore, in general we can say that the slight higher changes in nature change perception correlate with the change scores of individual risk perception. Further we could show that depending on the pre-defined infestation level of the area, in which participants have been recruited, the change in scores varied not significantly in both cases ($p > 0.05$). Yet participants low infested areas show in general slightly greater changes in risk perception (delta risk perception_l = 0.21 (1.01)) than those living in high infested areas (delta risk perception_h = 0.13 (0.91)). A similar tendency can be observed for the greater changes of scores concerning nature change perception in low infested areas (delta nature change perception_l = 0.14 (1.03)) compared to high infested areas (delta nature change perception_h = 0.08 (1.09)).

H4: The effect of nature change perception on self-reported communicative behavior is mediated by the individual risk perception.

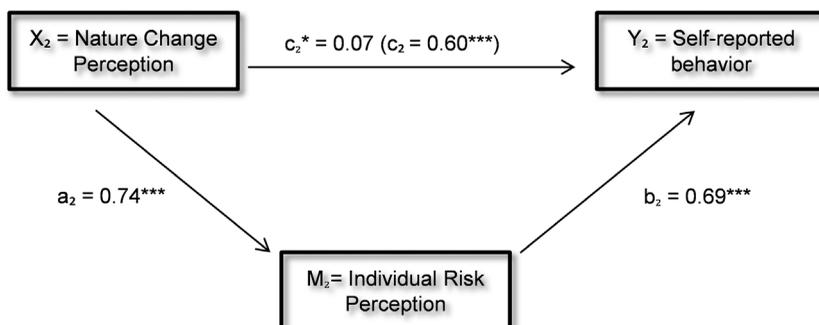


Figure 2. Relationship of nature change perception (second wave), individual risk perception (second wave), and self-reported behavior to “inform others.”

Notes: X_2 = nature change perception in the second wave, Y_2 = the real behavior “to inform others” in the second wave. The mediator M_2 is the risk perception after five months. C_2 , a_2 , and b_2 are unstandardized B -values. C_2 is the total effect, while c_2^* is the direct effect left over when controlling for the mediation effect.

The mediation analysis on the earlier hypothesis was based on the first wave and therefore, on the behavioral intentions of participants. In the second wave, we asked participants to report their “real behavior”. Unfortunately only 4 participants out of 295 reported that they took part in collective leaf disposal. Therefore we cannot undertake mediation analysis for this active behavior, but only for the passive one: “to inform others”. We will discuss reasons for this low number of active behavior in the discussion section. In order to check whether the observed trend in our model is also reflected when checking self-reported behavior, we conducted the same mediation analysis using new indices of nature change perception and individual risk perception within the second wave. To indicate whether a certain behavior was carried out, participants answered with “Yes” or “No” (Table 1). As our dependent variable is dichotomous, a logistic analysis is often recommended. Unstandardized Bs are reported. The mediation analysis for real behavior “to inform others” shows a similar trend as that for self-reported behavioral intentions; however, values cannot be compared directly as we have standardized values for the mediation analysis of behavioral intentions and unstandardized Bs for the mediation analysis of real behavior. Even if we would have standardized these Bs to Exp (B), from a statistical viewpoint, we cannot compare these values directly. However, tendencies can be discussed.

There was a significant total effect of nature change perception on self-reported behavior “to inform others” ($B(c_2) = 0.60, p < 0.001$), and the big role played by the individual risk perception of participants with regard to infestation by *C. ohridella* is also explained by nature change perception ($B(a_2) = 0.74, p < 0.001$) (Figure 2). While controlling for the new mediator M (individual risk perception after five months), the total effect from nature change perception decreases to a direct effect of only $B(c_2^*) = 0.07$, which is not significant. This shows that we have again an almost complete mediation, as $c^* < c$ and c^* is almost equal to zero. The influence of our mediator on self-reported behavior is given by $B(b_2) = 0.69, p < 0.001$. The Sobel-Z-test showed a significant indirect effect (0.55) of nature change perception over individual risk perception on self-reported behavior ($Z = 3.92, p < 0.001$). Further, a bootstrap-analysis with $m = 10,000$ also showed a significant effect ($CI_{95-} = 0.31, CI_{95+} = 0.85$).

Therefore, for our hypothesis we can state that our results support hypothesis H4. Analyzing the total effect does show an indirect effect again, but controlling for M, the left direct effect of nature change perception onto real behavior shows that only a small percentage directly explains behavior and that the bigger part is mediated by individual risk perception.

5. Discussion

The aim of our study was to investigate (1) the interrelations among individual risk perception, nature change perception, and the intention to change behavior. (2) Additionally we investigated whether a biological method was useful for the decision on sampling areas prior to CATI-recruitment, to make sure that the sample consist of different heights of individual risk and nature change perceptions. Finally, (3) we wanted to understand changes in perceptions on the “long-run” and ascertain the relationship among nature change perception, individual risk perception, and self-reported behavior. All this was analyzed for the concept of environmental impersonal risks – risks which do not threaten humans, but currently only nature itself.

Results of hypothesis 1 indicate that the objective proximity of a nature change to the corresponding living areas seems to be influencing the individual observation that nature is changing and individual risk perception. This seems to be logical, as areas highly infested make it easier for inhabitants to detect the visible nature change, even if they might not be interested in trees. Yet the peculiarity might enhance individual nature change and risk perception. In areas which are hardly infested, people might get fewer opportunities to observe the nature change. As described in the introduction, direct experience is among the few external factors which has been proven to exert a strong effect on risk perception (Wachinger et al. 2013). Direct experience may thus show a positive effect on risk perception (Plapp & Werner 2006). Yet researchers found that especially people living in endangered areas, estimate risk smaller than those people living further away from a risk if they have not experienced personal damage (Heitz et al. 2009). This raises the question of proximity of the risk source and the importance of personal damage? In this part of the analysis we could show that the proximity of a nature change which is perceivable, yet is not threatening participants personally, is affecting their nature change perception and their risk perception. Of course there might be other reasons that may cause the significant difference in nature change perception and risk perception in the two objectively rated infestation areas. Despite this discussion, the result also raises the issue of how natural sciences can be integrated into social science research. Through the biological rating method we were able to implement a field survey in distinct areas, while trying to ensure that we will have a wide variety of nature change and risk perceptions within the sample. We would like to encourage that environmental scholars should become integrated into projects within social sciences and while undertaking their own research (such as defining the level of infestation in Germany), they can provide interesting data for social scholars, leading to a “win-win” situation.

Further we were then interested how individual nature change perception, risk perception and behavioral intentions are related. Our results indicate that the mere perception of a nature change is an important factor explaining behavioral adaption, especially communicative behavior (intended and self-reported), and a major part of explaining individual risk perception (H2, H4). So far, for truly impersonal risks, we did not know how a pure observation of a nature change may affect people’s risk perception and consequent behavior. Our data indicate that the actual observation of a nature change plays an important role in perceiving impersonal risks. Yet, mediation analyses showed that when individual risk perception was included as a mediator, the direct effect of nature change perception on behavior (intended or self-reported real) decreased strongly. Thus, the decision to take action and the intensity of the resulting behavior is determined by the level of individual risk perception. This is in line with other research findings. A survey by Terpstra et al. (2009) also found that peoples’ risk perceptions are generally regarded as important factors of peoples’ decisions to adjust to natural hazards. Nevertheless, nature change perception correlated strongly with individual risk perception and, therefore, is indirectly related to behavioral adaption. The underlying effect would be that by perceiving an actual event, the personal relevance increases. Many other studies have reported these results in more personal risk areas (Spence et al. 2011), such as health problems due to air pollution (Whitmarsh 2008) or loss of property due to flooding (Spence et al. 2011), which reflect a direct prior experience of personal risks. Our results are also in line with results based in climate change communication (Akerlof et al. 2013), which may be seen as impersonal risk, which starts to become personal as some of the reported experiences “changes in season”, may already have negative influences on

specific target groups. We provided evidence that for impersonal environmental risks, the mere observation is already affecting communicative “own behavior” through the mediation of individual risk perception. Yet, our research indicates that for impersonal risks, the actual trigger to show an intention to change behavior is the individual risk perception, even though nature change is not a direct threat for the personal well-being of the individual. These results give hints on how environmental communication and education can be enhanced when we need to increase risk sensitivity for truly impersonal risk, such as loss of biodiversity. Institutions need to create platforms and options for the public to actually see and observe impersonal environmental changes themselves. This will correlate with risk perception. In H3 we could show that even though the increase of nature change perception was not significant it correlated strongly with the change scores of risk perception. Further the infestation level of the cities was of no significant influence, even though from a descriptive point of view, the change scores were higher in low infested areas. This would make sense, as through the survey, perception may have been raising faster than in the areas where the nature change may have already been observed.

Yet the question is: Why were so few people adopting the behavior of “taking part in foliage disposal”, even though the intention to do so was rather high in spring? Our explanation for this was derived through an additional contact with participants after the second wave. Some participants allowed us to contact them, as they wanted a biologist to evaluate the infestation level of their own or their neighborhood’s horse chestnut tree/s or as they wanted some advice on measurements against *C. ohridella*. As only 11 people used this offer, the results cannot be evaluated statistically. Nevertheless, the impressions can be taken into account. Participants told us, that the offer of information from the cities about *C. ohridella* itself and the options of how to fight it are quite few. The majority had no information on where to bring the collected leaves and had to become very active calling the regional governments. Also within the timeframe of our survey only very few organized collective leaf disposals took part, which were not widely announced. It was therefore hard for participants of our survey to take part – if offers are so few. Cities should organize and announce collective leaf disposal more widely, as their citizen show intentions to take part, even though they are not personally threatened by this invasive species. Yet the effort to organize a private disposal seems to be too high for this impersonal risk.

Finally we would like to mention several shortcomings. One of the limitations of our study was also revealed through the private talks with participants. An impression we obtained from visiting the participants was that often people were not able to distinguish between the infestation evoked by *C. ohridella* and the brown coloring of leaves due to other diseases, like fungi *Guignardia aesculi*. Even though the attribution of premature browning of leaf foliage to the horse chestnut leafminer may not have always been entirely correct, this does not change or influence the significance of our results, as the measures that are taken to fight *Cameraria* are also helpful for fighting other diseases of chestnut trees, which are also impersonal risks. Furthermore, causality needs to be taken into account concerning mediation analysis for the relationship of the individual risk perception and nature change perception. Causal explanations are of high importance in risk communication and are often neglected (Kellens et al. 2013). Causality cannot be inferred as it is always possible that other variables explain the relation between risk perception and nature change perception. Yet from previous literature analyzing the relation of prior experience and risk perception we would argue that nature change perception is affecting risk perception. Further we would

like to stress again that impersonal and personal risks are not two clearly distinct categories, but rather a continuum. Yet it seems of high need to analyze factors influencing risk perception and behavioral patterns for environmental risks, which are not yet affecting humans, such as loss of biodiversity, as at some point in time these nature changes become personal risks. The final limitation we would like to mention is that we had a high loss from first to second wave. From analyzing the data we may remark that participants who took part in the second survey showed slightly higher nature change perceptions and risk perceptions as those who dropped out after the first survey. This might also explain why the increase in nature change perception and risk perception was relatively small. Despite all these limitations we believe that our results provide some very interesting insights into the field of environmental and risk communication, which may be helpful for communication scientists, natural scientists and environmental conservationists.

6. Conclusion

First, the mediation analyses for environmental impersonal risks conducted in this study shows that individual risk perception mediates the effect from nature change perception to self-reported behavioral intentions. Nature change perception and risk perception strongly correlate, as well as their change scores over a longitudinal design. For impersonal risks, it was shown that the mere observation of a nature change, may be a possible tool to influence individual risk perception and throughout behavioral patterns related to nature changes. The horse chestnut leafminer was used as a model organism, but if we consider other impersonal risks, such as loss of biodiversity, a direct experience in terms of the mere observation is often not possible for people. Therefore, educational and political facilities need to increase their effort in terms of creating the possibilities for the public to perceive nature changes if they want to encourage the public in pro-environmental actions, before impersonal risks are becoming personal. Further we would like to stress that integrating natural sciences in social scientific research might be a suitable option for many different environmental scholars.

Acknowledgement

Anja Uretschläger was part of the research team and assisted in the field work of this project.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Deutsche Forschungsgemeinschaft [grant number BR 904/42-1], [grant number WE 3081/24-1].

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