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# Confluence and Contours: Reflexive Management of Environmental Risk

Emma Soane,<sup>1,\*</sup> Iljana Schubert,<sup>1</sup> Simon Pollard,<sup>2</sup> Sophie Rocks,<sup>2</sup> and Edgar Black<sup>3</sup>

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Government institutions have responsibilities to distribute risk management funds meaningfully and to be accountable for their choices. We took a macro-level sociological approach to understanding the role of government in managing environmental risks, and insights from micro-level psychology to examine individual-level risk-related perceptions and beliefs. Survey data from 2,068 U.K. citizens showed that lay people's funding preferences were associated positively with beliefs about responsibility and trust, yet associations with perception varied depending on risk type. Moreover, there were risk-specific differences in the funding preferences of the lay sample and 29 policymakers. A laboratory-based study of 109 participants examined funding allocation in more detail through iterative presentation of expert information. Quantitative and qualitative data revealed a meso-level framework comprising three types of decisionmakers who varied in their willingness to change funding allocation preferences following expert information: adaptors, responders, and resisters. This research highlights the relevance of integrated theoretical approaches to understanding the policy process, and the benefits of reflexive dialogue to managing environmental risks.

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**KEY WORDS:** Agency; decision making; environmental risk; government funding; policy

## 1. INTRODUCTION

### 1.1. Creating the Risk Landscape: Confluence and Contours

Environmental risks pervade our daily lives. As individuals, we have some choice about our exposure to risk, yet our autonomy is limited because risk regulation and infrastructure are the responsibility of government agencies that must allocate funds to risk management in a meaningful and accountable manner. Hence policy decisions need to incorpo-

rate understanding of how lay people think about the funding allocation process, and of lay people's responsiveness to information from experts, if policies are to be accepted by the public. Furthermore, better environmental risk management supports economic growth by ensuring targeted spending on key risks. Organizations in the environmental goods and services sector (*ca.* £3.3 trillion global turnover; £122bn in the United Kingdom; employing *ca.* 1 m people) that demonstrate sound environmental risk governance quickly secure the confidence of their regulators, publics, and investors, with smoother approvals for projects and easier access to investment capital.<sup>(1)</sup>

The growth of attention to risk has been described in classic works by Beck<sup>(2,3)</sup> and Giddens,<sup>(4,5)</sup> who proposed that modernization has led to a "risk society," whereby individuals navigate a complex, uncertain world, and negotiate responsibilities for risk management. More recently, the term "risk landscape"<sup>(6)</sup> has been used to describe the

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interactions of various agents with responsibilities for managing risk and the consequences of these interactions. Theorizing about bridging the divide between policymakers, experts, and lay people has tended to focus on one of two levels of analysis (e.g., institutional policy<sup>(7)</sup> or individual decision making<sup>(8)</sup>); rational actor approaches;<sup>(9)</sup> or the examination of differences between lay people and experts.<sup>(10,11)</sup> However, a more theoretically comprehensive understanding of the policy process and lay beliefs could contribute to effective policy outcomes.

We use macro-level theory from sociology and micro-level theory from psychology to develop a meso-level categorization that could form the basis of policy discussion and development. We propose that institutions shape the risk environment through policy implementation, and that the policy process can be improved by understanding lay beliefs about agentic decision making, related to beliefs about trust and responsibility of institutions,<sup>(12)</sup> and reflexive decision making that is concerned with dialogue between policymakers and lay people.<sup>(13)</sup> We characterize the environmental risk landscape in terms of confluence, the joining together of individual beliefs about agency and the policy processes that seek to manage risk; and contours, the individual-level variation in perceptions of, and beliefs about, environmental risk.

Governments have the responsibility of managing complex portfolios of strategic risks, and democracies demand transparent and legitimate processes. These parameters have stimulated a more inclusive approach to policy development that encompasses understanding and acknowledgment of public perceptions of risk, termed reflexive risk management.<sup>(13,14)</sup> Reflexive processes imply dialogue,<sup>(15)</sup> and this challenges the notion that scientific knowledge is an objective, dominant, societal force,<sup>(16)</sup> and that lay people have deficits in their knowledge that may drive negative perceptions of science and risk that need to be rectified by one-way communication from experts.<sup>(17)</sup> Allocation of government funding is a primary mechanism for the management of public risk, yet funds are necessarily limited. A refreshed focus on risk as the basis of intelligent policy design and better regulation has been advanced to ensure recent environmental quality gains are maintained in the face of financial austerity. Hence, funding prioritization needs to encompass the science of risk and a responsiveness to public concern,<sup>(18,19)</sup> and doing so requires micro-level and

macro-level theories to be integrated and applied to a representative portfolio of risks.

This study contributes to the literature in three ways. First, although there are studies that have examined the involvement of the public in risk management,<sup>(20–22)</sup> the focus has typically been on specific risks or localized hazards. Here, we consider how to engage the public in a dialogue about a portfolio of strategic environmental risks—i.e., risks appraised at the national-policy level representing an umbrella of individual likelihoods and consequences within the policy domain they represent. Our research was designed in conjunction with a U.K. government department, and examined 12 risks within its portfolio: poor air quality; poor water quality; Foot and Mouth Disease (FMD); Bovine Tuberculosis (BTB); avian influenza; coastal erosion; flooding; genetically modified organisms (GMOs); engineered nanomaterials; reductions in wildlife biodiversity; reductions in marine biodiversity; and use of pesticides. The policy context of these risk comparisons were to inform Defra's case for well-reasoned financial arguments for protecting investment in certain risk areas while challenging them elsewhere in the policy portfolio. This type of cross-cutting analysis was not previously available to government, an absence of which was highlighted by Defra's Science Advisory Council in 2007 as a major policy delivery deficiency.<sup>(23)</sup>

Second, we respond to Hitt *et al.*'s<sup>(24)</sup> recommendation that macro and micro levels of theory need to be integrated to achieve more complete understanding of complex managerial challenges, and developing policy for a portfolio of risks is one example. We also acknowledge Taylor-Gooby and Zinn's<sup>(25)</sup> call for closer linkages across risk-related disciplines by considering insights from psychology within a broader social framework. In doing so we show that understanding individual differences in perception and decision making contributes to the policy process by providing a framework for engaging lay people in the risk management debate, thereby contributing to the social acceptability of policies. The psychological approach also enabled an alternative perspective to understanding lay preferences that moves away from the deficit model of decision making.<sup>(26)</sup>

Third, we present a two-study, mixed-methods test of an integrated theoretical model of beliefs about allocation of funding to manage risks, and the responsiveness of lay people to expert information. This approach enabled us to draw upon: research paradigms related to the psychometric research

into risk and comparisons of experts and lay people, which are primarily quantitative;<sup>(27)</sup> studies of decision making, which tend to be often laboratory based; and sociological studies, which may be qualitative or quantitative. Study 1 developed and tested a quantitative research model combining the constructs of agency<sup>(12)</sup> and perceptions of risk.<sup>(27,28)</sup> Laboratory-based Study 2 examined quantitative and qualitative lay responsiveness to information from policymakers through iterative information presentation and choice. Results yielded a meso-level categorization of the responsiveness of lay participants to expert information that supports a reflexive approach to theorizing about, and managing, environmental risks.

## 2. STUDY 1

The first study examined individual-level beliefs about risk management and risk perception. We considered how these factors influenced preferences for more or less government funding to manage risk.

### 2.1. Confluence: Resource Allocation and Agency

Policy decisions and implementations require active deployment of strategies to mitigate risks, implying institutional agency, i.e., institutions manage risk actively to mitigate the effects of risks on the public.<sup>(12,29)</sup> Institutions also have a responsibility to generate beliefs about agency among the public, i.e., individual-level beliefs that institutions can and will manage and mitigate risk.<sup>(30)</sup> We propose that individual beliefs about institutional agency can be explored through the concepts of trust and responsibility, and we use the term “agentic beliefs” to encompass these concepts. Trust is relevant to perceptions and choices because people are more likely to believe that risk management activities are worthwhile,<sup>(31)</sup> and risks are lower,<sup>(32)</sup> when they have trust in risk management institutions. Recent research has suggested that trust can be a highly specific construct, hence trust in the policy process for one risk might not extend to different types of risk because of differences in perceived risk and public communication about the risk.<sup>(33)</sup> In addition, Petts’s<sup>(34)</sup> nuanced view of trust suggested that building “critical trust,” and fostering a spirit of debate between stakeholders and risk managers, are more important to the policy process than simply attempting to reduce lay concerns about risk. Hence, based on prior research, we propose that trust will be asso-

ciated with preferences for funding because funding will be directed toward active risk management.

Beliefs about responsibility are also relevant to individual perceptions relating to risk management because of the need for collaborative approaches from scientists and government institutions.<sup>(7)</sup> Policymakers need to commission and attend to scientific research, yet responsibility also extends to engaging stakeholders in the decision and communication processes.<sup>(35)</sup> Thus, we proposed that perceptions of institutional responsibility will be associated with preferences for funding to manage risk.

### 2.2. Contours: Individual Differences in Risk-Related Perceptions

The psychometric paradigm<sup>(36,37)</sup> proposes that risks can be characterized along several dimensions, such as “dread,” concerning fear and scale of impact, uncertainty, immediacy, and the number of people affected. However, Slovic<sup>(27)</sup> noted that there is no core set of generalizable risk characteristics, and that individual-level perceptions of risk may vary. Thus we drew on relevant research to identify properties that relate specifically to environmental risks. Environmental risks have impact, whether localized or widespread. Prpich *et al.*<sup>(38,39)</sup> demonstrated that it is possible to characterize environmental risks in terms of the extent of potential harm to the environment, the economy, and to human health and society. We build upon Prpich *et al.*’s work and propose a positive relationship between perceived impact and preference for more funding to manage risk.

Environmental risks vary in their immediacy, so it is relevant to consider perceived risk in the future. For example, flooding is a current and future threat with an immediate and significant impact upon communities whereas reductions in wildlife biodiversity have a longer-term and more uncertain impact. We propose a positive relationship between perceived future risk and preferences for funding to manage risk.

The psychometric component of risk also encompasses experience and perceptions of information. Prior experience of risks might play an important role in increasing the perceived salience of related information due to greater information processing.<sup>(40,41)</sup> Although experience does not always lead to differences in perception or behavior,<sup>(42,43)</sup> understanding information, even in the absence of experience, can increase engagement with risk management processes,<sup>(20,21,44)</sup>

particularly when risks are perceived as having severe consequences.<sup>(22,45)</sup> Hence, we propose that experience, and beliefs that risk-related information is understandable, will be associated with funding preferences, yet the direction will vary across the portfolio of environmental risks due to individual-level perceptions.

### 2.3. Policy Maker Versus Lay Perceptions and Choice

Understanding the differences between lay and policymakers' perceptions of risk is relevant to the development of an engaging policy dialogue.<sup>(46)</sup> Research in this area has focused on comparisons between experts and lay people so we consider those studies here while acknowledging that policymakers are not necessarily experts in their field; rather, they are key decisionmakers who apply information from experts to their policies. Siegrist *et al.*<sup>(47)</sup> found lay people perceived higher risks from nanotechnology than did experts, although there were no differences in perceived benefits. Rundmo and Moen<sup>(48)</sup> showed experts judged risk probabilities higher than lay people yet expert decision-making processes were sometimes flawed. Wright *et al.*<sup>(49)</sup> demonstrated that expert estimates of probability were only marginally superior to lay estimates, and that both groups were susceptible to a range of biases. Building on this prior research, we propose that policymakers might show some differences in funding allocation preferences, and these differences are likely to be due to greater knowledge and experience. However, we suggest that any differences highlight areas for dialogue between lay people and experts who inform policy rather than emphasizing deficits in lay knowledge and understanding, or reinforcing differences between lay people and experts.

## 3. METHOD

### 3.1. Participants and Procedure

Participants were recruited through a marketing organization. Data collection took place in June 2012, and did not coincide with major environment events such as the badger culling debate in autumn 2013 or the flooding in England during January 2014. A total of 2,179 British citizens residing in England for at least 10 years completed the survey and received points that can be redeemed against online shopping. The survey took approximately 30 min-

utes to complete. Participants who took less than 15 minutes ( $N = 62$ , 2.8%) or more than 24 hours ( $N = 14$ , 0.6%) were removed from the final analysis. Thirty-five (1.6%) participants were deleted due to missing data. The final sample was 2,068 (94.9% of completions). There were 930 (45%) women and 1,138 (55%) men. The mean age was 47.8 ( $SD = 13.8$ , range = 18–84). There were somewhat fewer women than the national average of approximately 50%, and the sample was older than the national average of approximately 38 years;<sup>(50)</sup> however, we met our aim of securing a large and diverse sample. Participants were drawn from a range of job types and had various educational levels. The policymaker sample comprised 29 participants from the relevant U.K. government department, of whom 14 (48.3) were women and 15 (51.7%) were men. The mean age was 42.3 ( $SD = 7.9$ , range = 34–67). All were educated to degree level or above.

### 3.2. Measures

The measures focused on individual-level beliefs and perceptions, in accordance with our theoretical model. Moreover, given the length of the questionnaire required to assess all constructs for 12 risks,<sup>(51,52)</sup> and the acceptability of single-item measures,<sup>(53)</sup> several constructs were assessed using one item.

Section 1 measured two constructs prior to presentation of the detailed risk-related information. In accordance with prior research,<sup>(54)</sup> we have focused on perceptions about risks, and examined constructs separately.

#### 3.2.1. Perceived Knowledge

Perceived knowledge was assessed with one item: "How much do you know about the following issues? Please rate your knowledge on the scale next to each item." The response range was a five-point Likert scale from "Nothing at all" to "Very much."

#### 3.2.2. Personal Experience of Risk

Personal experience of risk was assessed by asking participants whether they had ever experienced the risk (response range: "Yes," "No/don't know").

Section 2 provided participants with an explanation of each risk area. Items then assessed responses to the information. The same item set was presented for each risk area. The order of risks was randomized.

### 3.2.3. Information Understanding

Information understanding was assessed using one item that asked participants to rate understanding on a seven-point scale ranging from 1 “Very difficult” to 7 “Very easy.”

### 3.2.4. Trust

Trust was assessed using items developed from Petts.<sup>(34,55)</sup> Participants were asked to rate the extent to which they trusted the government, scientists, and industry to make the right decisions about the risk. A sample item is: “I trust the government to make the right decisions on air quality.” The response range was 1 “Strongly disagree” to 7 “Strongly agree.” Items were highly intercorrelated and used to create a scale for each risk. Each of the new scales had Cronbach’s alpha greater than 0.7, showing acceptable internal reliability.

### 3.2.5. Responsibility

Responsibility was measured using Schubert and Soane’s<sup>(56)</sup> items to assess responsibility of government and scientists to: research; inform the public about; manage; and take action. The response range was 1 “Strongly disagree” to 7 “Strongly agree.”

### 3.2.6. Future Risk

Future risk was assessed using one item: “Do you think that risks associated with [the risk] will change in the next 5–10 years?” The response range was 1 “Risk will reduce a lot” to 7 “Risk will increase a lot.”

### 3.2.7. Risk Impact

Risk impact was the extent of the impact that each risk has on each of the environment, the economy, and human health and society on a seven-point scale ranging from “Not at all serious” to “Very serious.” Correlations showed these items to be very closely associated within each risk; therefore, a set of scales was created from the mean of each item for each risk. Each of the new scales had Cronbach’s alpha greater than 0.7.

### 3.2.8. Dependent Variable: Preference for More or Less Funding

Participants were asked to make a choice between two statements for each of the 12 risks: 1. “Would you agree to a decrease in investment and an increase of problems/risks in any of the follow-

ing environmental issues?” and 2. “Would you agree to an increase in investment and a decrease of problems/risks in any of the following environmental issues?”

Section 4 included questions on demographic information: age (reported by participants), gender (0 “Female,” 2 “Male”), education (1 “Degree or degree equivalent, and above” to 7 “No qualifications”); and home environment (1 “Urban,” 2 “Suburban,” 3 “Small town,” 4 “Village or hamlet,” 5 “Rural”).

## 4. RESULTS

### 4.1. Descriptive Statistics

Descriptive statistics were produced for every variable. Main findings are presented here given the volume of data. The trust item mean scores exceeded the midpoint of the scale in all cases, suggesting that institutional trust was relatively strong. The highest level of trust was for FMD (mean = 4.47), the lowest level was for GMOs (mean = 3.88). The general trend was for government to be perceived as having greater responsibility than scientists, with flooding at the top of the government’s responsibilities (mean = 3.40), and nanomaterials as scientists’ biggest responsibility (mean = 2.62). Perceived knowledge was highest for flooding (mean = 2.84), and lowest for nanomaterials (mean = 1.66). Nanomaterials information was the hardest to understand (mean = 4.34) and flooding was the easiest (mean = 4.98). Flooding was the most likely to have impact (mean = 4.98) in contrast to coastal erosion (mean = 4.07). The greatest increases in future risk were both flooding and coastal erosion (mean scores = 4.84). FMD had the lowest perceived future risk (mean = 3.85). The strongest preference for more funding was for poor air quality (1,791 people preferred more funding, 277 preferred less funding), and coastal erosion was the lowest priority (1,339 people allocated more funding, 729 allocated less funding). The balance was in favor of more funding for all risks.

### 4.2. Comparisons between Lay People and Policymakers

Next, we examined preferences of lay people and compared them with policymakers with responsibility for environmental risk management. We focused on the dependent variable, preference for more or less funding. The data need to be interpreted with

**Table I.** Lay and Policymaker Preferences for More or Less Funding: Mean Values and *T*-Statistics

	Policymaker Mean Score	Lay Person Mean Score	<i>T</i> -Statistic
<i>Environmental Risk</i>			
<i>Policymaker mean scores higher than lay people</i>			
Wildlife biodiversity	1.97	1.79	-4.95***
Marine biodiversity	1.93	1.79	-2.95**
Air quality	1.97	1.87	-2.82**
Nanomaterials	1.90	1.74	-2.63*
<i>Lay mean scores higher than policymakers</i>			
FMD	1.24	1.74	6.13***
Coastal erosion	1.21	1.65	5.70***
BTB	1.38	1.74	3.88**
GMOs	1.52	1.72	2.17*
<i>No significant differences</i>			
Water quality	1.93	1.89	NS
Flooding	1.62	1.78	NS
Pesticides	1.72	1.79	NS
Avian influenza	1.62	1.69	NS

\**p* < 0.05; \*\* *p* < 0.01; \*\*\* *p* < 0.001.

some caution because there was a large difference in the group sizes (2,068 lay people, 29 policymakers). However, the data are worthy of exploration because policymakers are critical to decision and policy processes, and their opinions about risk illuminate any discrepancies in perceptions that need to be discussed with lay people. Results showed significant differences in funding preferences for 8 out of 12 risks (Table I).

Although there was consensus that more funding would be useful to manage poor water quality, flooding, pesticides, and avian influenza, the data showed that lay people and policymakers had some different funding priorities, which highlight a need for reflexive dialogue to increase the likelihood of policy success.

**4.3 Examination of Funding Preferences**

Binary logistic regression examined the factors associated with lay preferences for more or less funding. Data are shown in Tables II to V.

Results show three patterns that have implications for understanding funding preferences. First, constructs within the agency component of the model were associated significantly with preference for more funding for each risk type. Beliefs that the government is responsible for managing risks were significant in every case. Beliefs about the responsibility of scientists were significantly associated

with more funding for marine biodiversity, FMD, flooding, and coastal erosion. Trust was positively associated with preference for more funding for poor water quality, BTB, and FMD. One exception was the negative association between trust and funding for use of pesticides. Lower levels of trust were associated with preferences for more funding.

Second, the psychometric component also showed significant associations with funding preferences. However, the relationships function differently across the risk areas. Perceived impact was positively and significantly associated with preferences for more funding for each risk type. Beliefs about a threat in the future were similarly associated with funding preferences, with the exceptions of nonsignificance for flooding and BTB. The remaining constructs showed both positive and negative associations. For example, perceived understanding of risk information was associated with more funding for poor air quality, wildlife biodiversity, nanomaterials, and GMOs, and less funding for flooding and coastal erosion. Overall, these patterns indicate that agency beliefs function relatively uniformly; however, perceptual processes function differently for different risks. Furthermore, the associations between perceptions and preferences for more or less funding differ depending on whether the risk is considered a priority for government funding (e.g., poor air quality) or not (e.g., coastal erosion).

Third, the demographic factors had some significant associations with funding preferences. The associations were consistent in their direction: more funding is associated with older age, being male, and higher education. Yet, the pattern of associations varied by risk type. In addition, the agency and psychometric components show stronger associations with funding preferences in all cases with the exception of FMD, where education was the most significant associate of funding preferences, although agency and psychometric constructs were also significant.

**5. DISCUSSION**

Integration of macro- and micro-level perspectives on risk provided insights into understanding funding preferences. We proposed that both agentic beliefs concerning trust and responsibility, and perceived risk, would be associated with preferences for more funding across a portfolio of 12 environmental risks. Comparisons of lay and policymaker perceptions accorded with prior research<sup>(47,57)</sup> in that some significant differences were revealed. However,

**Table II.** Regression of Demographics, Agency, and Psychometric Variables on Air Quality, Water Quality, and Marine Biodiversity Funding

	Air Quality				Water Quality				Marine Biodiversity			
	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)
Age	0.01	0.01	4.36*	1.01	0.01	0.01	3.88*	1.01	0.01	0.00	3.16	1.01
Gender	0.27	0.15	3.42	1.31	0.26	0.16	2.87	1.30	0.21	0.12	2.98	1.24
Education	-0.02	0.04	0.35	0.98	-0.00	0.04	0.00	1.00	0.05	0.04	2.03	1.05
Home environment	-0.08	0.07	1.32	0.93	-0.02	0.07	0.05	0.98	-0.01	0.06	0.03	0.99
Trust	0.08	0.06	1.70	1.08	0.12	0.06	3.97*	1.13	-0.03	0.05	0.42	0.97
Responsibility gov	0.24	0.05	22.15***	1.27	0.22	0.05	19.03***	1.24	0.27	0.04	43.08***	1.30
Responsibility sci	0.06	0.05	1.63	1.06	0.09	0.05	3.45	1.10	0.10	0.04	6.53*	1.11
Hazard experience	-0.80	0.23	12.30***	0.45	0.22	0.24	0.84	1.25	0.19	0.39	0.26	1.21
Knowledge	-0.08	0.07	1.07	0.93	-0.17	0.08	4.59*	0.85	0.29	0.06	20.05***	1.33
Understanding	0.12	0.06	4.29*	1.12	0.04	0.06	0.56	1.04	0.05	0.04	1.25	1.05
Impact	0.27	0.05	25.70***	1.31	0.30	0.05	33.09***	1.35	0.36	0.05	55.68***	1.43
Future threat	0.19	0.06	9.79**	1.21	0.22	0.07	10.58**	1.24	0.19	0.06	11.17**	1.21
Chi-square model	160.13***				127.40***				256.76***			
df	12				12				12			
Nagelkirk R square	0.14				0.12				0.18			
Hosmer & Lemeshow Chi-square	3.38				7.62				16.47*			
% classification predicted	86.7%				88.6%				78.8%			

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

Responsibility gov (sci) = Beliefs in the responsibility of government (scientists) to manage risk.

the current modeling has broader implications for policy since difference in either direction could lead to a mismatch between public perceptions of risk management and policy formulation. Resolution of mismatches through reflexive dialogue could contribute to a more effective policy development process, particularly when supplemented by understanding of risk-related beliefs and perceptions.

An examination of the two components of our model showed that agentic beliefs (trust and responsibility) were almost uniformly, positively associated with preferences for more funding. Trust and belief in the role of government and, to some extent, scientists to manage risk were associated with preferences for funding, confirming the importance of agentic beliefs to understanding funding preferences. Hence, development of critical trust in institutions<sup>(34)</sup> and demonstrable responsibility of government<sup>(30,35)</sup> and scientists could form a positive platform for engagement with policymakers and, ultimately, greater acceptance of policy-driven spending on risk management.

Conversely, the multivariate analyses showed that facets of the psychometric component of the model (perceived risk, experience, and perceptions about information) showed different patterns and

directions of association that were dependent upon risk type. Results reflected prior research that different aspects of perception can increase or decrease responses to risks because specific patterns related to specific properties of the risk.<sup>(40,42,43)</sup> The current research highlights the need to develop agentic beliefs that risk can be managed and, concurrently, to understand how perception functions for each risk type. The challenge for policymakers is to generate constructive debate concerning beliefs about risk and the risk management process, and to uncover risk perceptions, rather than merely drive consensus.<sup>(15)</sup> For example, someone should not have to experience avian influenza to be aware of avian influenza risks, nor should more familiar risks, such as pesticides, be underestimated. Similarly, expert opinion on longer-term threats, such as loss of wildlife diversity, could highlight the importance of biodiversity to society and encourage support for relevant policy. Thus a case for investment in reducing the threat of biodiversity loss could be relevant to building social acceptance of government investment.

In summary, Study 1 has shown that understanding agentic beliefs and risk perceptions is important to understanding preferences for allocation of funding to mitigate risk. However, to contribute further to



**Table III.** Regression of Demographics, Agency, and Psychometric Variables on Wildlife Biodiversity, BTB, and Avian Influenza Funding

	Wildlife Biodiversity				BTB				Avian Influenza			
	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)
Age	0.00	0.00	0.01	1.00	0.01	0.00	3.44	1.01	-0.00	0.00	0.24	1.00
Gender	0.09	0.12	0.56	1.10	0.06	0.11	0.29	1.06	0.02	0.10	0.04	1.02
Education	0.05	0.04	2.35	1.06	0.10	0.03	10.46**	1.11	0.06	0.03	4.24*	1.06
Home environment	-0.01	0.06	0.06	0.99	0.04	0.05	0.64	1.04	-0.04	0.05	0.76	0.96
Trust	-0.10	0.05	3.42	0.91	0.12	0.04	8.35**	1.13	0.03	0.04	0.49	1.03
Responsibility gov	0.17	0.04	16.09***	1.18	0.18	0.04	19.38***	1.20	0.16	0.04	13.17***	1.17
Responsibility sci	0.04	0.04	1.24	1.04	0.02	0.04	0.36	1.02	0.04	0.04	1.55	1.05
Hazard experience	0.88	0.36	5.87*	2.41	-0.07	0.32	0.05	0.93	-0.43	0.26	2.71	0.65
Knowledge	0.26	0.06	16.81***	1.30	0.13	0.06	5.47*	1.14	0.08	0.06	1.93	1.08
Understanding	0.13	0.04	8.91**	1.13	-0.03	0.04	0.62	0.97	-0.04	0.04	0.86	0.96
Impact	0.35	0.05	55.61***	1.42	0.31	0.04	70.04***	1.37	0.26	0.04	55.06***	1.30
Future threat	0.20	0.06	11.32**	1.22	0.09	0.05	3.07	1.10	0.16	0.05	11.11**	1.17
Chi-square model	268.59***				165.41**				136.36***			
<i>df</i>	12				12				12			
Nagelkirk <i>R</i> square	0.19				0.11				0.09			
Hosmer & Lemeshow Chi-square	12.88				11.11				3.71			
% classification predicted	79.4%				74.3%				69.5%			

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

Responsibility gov (sci) = Beliefs in the responsibility of government (scientists) to manage risk.

developing a framework for understanding risk, and to informing policy debate, additional exploration was required to understand how lay people respond to information from experts.

## 6. STUDY 2

### 6.1. Confluence and Contours: Aligning Perceptions of Policymakers and Lay People

Study 2 considered whether lay perspectives of environmental risk can be influenced through iterative exposure to expert information and decision making. The process of influence is important because it is necessary to achieve alignment with policymakers, and to highlight differences that require reflexive dialogue.

Uncertain and complex risks require scientific knowledge and expertise to bring information into the public domain and to shape policy. However, there is rarely an objective perspective.<sup>(58)</sup> Hence policy process relies on both maximum available knowledge and alignment of perceptions and beliefs.<sup>(59)</sup> We were interested in the responsiveness of lay participants to expert information, and the possibility of aligning expert opinion with lay beliefs and perceptions. Prior research has concluded

that changes to decision processes may lead to internal dissonance and poor judgments.<sup>(60)</sup> When considered within a deficit model of lay decision making, demonstrations of variable decision processes could be used to support the argument that expert opinion is paramount to policy making, and a top-down approach is required. However, an alternative position is to consider changes in preferences as indicative of responsiveness to new information, and we propose that this could be positive in the context of policy decisions. Alignment between lay perceptions and an expert view could also be beneficial to individuals because it reduces the dissonance that occurs when conflicting views are held concurrently.<sup>(61)</sup>

We propose that alignment of lay perspectives could occur through the process of adjustment around a previously held belief. Anchoring and adjustment is a form of heuristic that accounts for amendments around an initial choice.<sup>(62)</sup> Once a perception has been formed, it can be relatively resilient. Hence changes tend to be adjustments, rather than large-scale deviations, that reduce the need for effortful information search.<sup>(63,64)</sup> The phenomenon has been observed in many contexts,<sup>(65)</sup> although it has not been considered for a portfolio of environmental risks. People are likely to have some knowledge of environmental risks due to personal

**Table IV.** Regression of Demographics, Agency, and Psychometric Variables on FMD, Pesticides, and Nanomaterials Funding

	Foot and Mouth Disease				Pesticides				Nanomaterials			
	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)
Age	0.01	0.00	3.83	1.01	0.02	0.00	21.70***	1.02	0.01	0.00	7.27**	1.01
Gender	0.16	0.12	2.13	1.17	0.32	0.12	6.82**	1.37	0.07	0.12	0.36	1.07
Education	0.14	0.03	18.82***	1.15	0.00	0.03	0.01	1.00	-0.01	0.03	0.17	0.99
Home environment	-0.06	0.05	1.41	0.94	-0.06	0.05	1.19	0.94	-0.04	0.05	0.46	0.97
Trust	0.10	0.04	6.18*	1.11	-0.12	0.05	6.27*	0.89	-0.05	0.05	1.04	0.95
Responsibility gov	0.14	0.04	10.51**	1.15	0.21	0.04	26.32***	1.24	0.21	0.04	30.61***	1.23
Responsibility sci	0.07	0.04	3.94*	1.08	0.01	0.04	0.06	1.01	0.02	0.04	0.39	1.02
Hazard experience	-0.04	0.18	0.05	0.96	0.46	0.24	3.49	1.58	-0.14	0.49	0.08	0.87
Knowledge	0.16	0.06	7.22**	1.17	0.03	0.07	0.24	1.03	0.03	0.06	0.30	1.04
Understanding	-0.05	0.04	1.07	0.96	0.08	0.05	2.90	1.08	0.14	0.04	15.71***	1.15
Impact	0.15	0.04	15.79***	1.17	0.27	0.05	31.61***	1.30	0.31	0.04	60.01***	1.36
Future threat	0.11	0.05	3.97*	1.12	0.15	0.05	7.46**	1.16	0.24	0.05	21.52***	1.27
Chi-square model	91.58***				180.41***				251.96***			
<i>df</i>	12				12				12			
Nagelkirk <i>R</i> square	0.06				0.13				0.17			
Hosmer & Lemeshow Chi-square	11.90				9.10				9.77			
% classification predicted	74.1%				78.9%				75.2%			

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

Responsibility gov (sci) = Beliefs in the responsibility of government (scientists) to manage risk.

experience or media influence, and there might be a tendency to anchor on this prior knowledge.<sup>(66)</sup> We propose that participants might have preconceived ideas about the risks, yet perceptions could be adjusted when they are shown to be different from expert opinion.

Adjustment could occur due to motivated reasoning<sup>(67)</sup> whereby individuals are motivated to increase the accuracy of their decisions. We suggest that such changes have utility to individuals because they take into account expertise, and to the policy process because they show responsiveness to information. Alternatively, individuals can be motivated to retain their self-directed choices,<sup>(67)</sup> and this would account for not adjusting around an initial anchor and resistance to information from experts. There are also potentially negative consequences for the policy dialogue process.

## 7. METHOD

### 7.1. Participants and Procedure

The study was carried out in a research laboratory to allow participants to focus on complex information within a controlled environment.

One-hundred-thirteen participants were recruited via a behavioral laboratory participant pool. There were missing data for four participants, yielding an overall sample of 109 participants (96.5%). All participants were British citizens and had been resident in the United Kingdom for more than five years. There were 59 women (54.1%) and 50 men (45.9%). The mean age was 24.8 ( $SD = 8.5$ , range = 18–60). Overall, the Study 2 sample comprised a large number of participants in full-time education, and holding a university degree. However, a number of participants had part-time work in addition to their studies and there was some variance in age. Thus, although the sample did not represent the U.K. population as a whole, there was demographic heterogeneity. Data need to be interpreted with these considerations in mind.

### 7.2. Measures

Participants completed an online survey within a behavioral research laboratory. First, participants were presented with descriptive information about the same 12 risks examined in Study 1 (see Appendix). Then participants answered a series of questions.

Table V. Regression of Demographics, Agency, and Psychometric Variables on GMOs, Flooding, and Coastal Erosion Funding

	GMOs				Flooding				Coastal Erosion			
	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)	B	SE	Wald	Exp(B)
Age	0.01	0.00	2.45	1.01	0.00	0.00	0.33	1.00	-0.00	0.00	0.13	1.00
Gender	0.18	0.11	2.71	1.20	0.29	0.12	6.12*	1.34	0.09	0.11	0.66	1.09
Education	0.03	0.03	1.05	1.03	0.02	0.03	0.38	1.02	0.08	0.03	6.69*	1.08
Home environment	-0.05	0.05	0.91	0.95	0.02	0.05	0.10	1.02	-0.05	0.05	0.92	0.96
Trust	-0.06	0.04	2.23	0.94	-0.04	0.05	0.81	0.96	-0.04	0.04	0.91	0.96
Responsibility gov	0.16	0.04	17.41***	1.18	0.19	0.05	13.47***	1.21	0.12	0.04	7.76**	1.13
Responsibility sci	0.07	0.04	3.09	1.07	0.09	0.04	5.08*	1.09	0.07	0.03	4.15*	1.07
Hazard experience	0.56	0.37	2.27	1.76	0.11	0.17	0.41	1.12	0.02	0.21	0.01	1.02
Knowledge	0.05	0.06	0.88	1.06	0.12	0.06	3.31	1.12	0.04	0.05	0.54	1.04
Understanding	0.12	0.04	10.02***	1.13	-0.15	0.05	9.44**	0.86	-0.14	0.05	9.87**	0.87
Impact	0.30	0.04	53.72***	1.35	0.38	0.04	76.14***	1.46	0.46	0.04	133.20***	1.58
Future threat	0.13	0.05	8.31**	1.14	0.09	0.05	2.76	1.09	0.13	0.05	7.13**	1.14
Chi-square model	188.01***				164.14***				289.15***			
df	12				12				12			
Nagelkirk R square	0.13				0.12				0.18			
Hosmer & Lemeshow Chi-square	5.62				6.63				6.85			
% classification predicted	73.0%				78.2%				69.8%			

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

Responsibility gov (sci) = Beliefs in the responsibility of government (scientists) to manage risk.

7.2.1. Initial Funding Allocation

Participants were asked to allocate a hypothetical amount of government funding of £1 billion per year in total to all 12 environmental risks presented in random order. Participants chose how much, if any, funding to allocate to each risk. Participants were asked to explain their choices in an open text box.

7.2.2. Understanding Information

Participants were provided with additional information about each of the risks. First, they were shown a graph depicting the relative comparison of the overall current residual risk of all 12 environmental issues as judged by experts and policymakers.<sup>(23)</sup> The graph was accompanied by a brief explanation about the format and nature of the data. In addition, overall residual risk information written by experts for each environmental risk was provided in hard copy written form to each participant. Participants were asked to rate the perception of their understanding of the overall information on a seven-point Likert scale ranging from 1 “Very difficult” to 7 “Very easy.”

7.2.3. Appropriateness of Expert View

Participants rated the extent to which they perceived the expert information to be appropriate. The item was rated on a seven-point Likert scale ranging from “Strongly disagree” to “Strongly agree.”

7.2.4. Similarity of Expert View

Participants rated the extent to which the expert view was similar to their own view on a seven-point Likert scale ranging from “Strongly disagree” to “Strongly agree.”

7.2.5. Second Funding Allocation

The government funding question was repeated, and the ordering of risks was randomized. Participants were invited to explain in an open text box why their funding had changed or not changed.

8. RESULTS

8.1. Descriptive Statistics

The descriptive data showed that there was a relatively good level of perceived understanding of risk-related information. FMD was perceived to

**Table VI.** Funding Allocation Following Information from Experts

Risk	Initial Choice		Second Choice		T-Statistic <sup>a</sup>
	Mean	Std. Deviation	Mean	Std. Deviation	
1. Air quality (= 1)	139.93	72.90	136.79	70.25	0.59
2. Flooding (+1)	113.80	61.48	131.25	66.60	-2.91**
3. Water quality (-1)	117.22	60.11	114.81	65.28	0.51
4. Wildlife biodiversity (= 4)	117.22	60.11	88.57	59.47	-2.42*
5. Bovine TB (+6)	66.49	52.77	85.98	56.14	-3.77***
6. Marine biodiversity (+1)	70.24	54.73	83.33	54.07	-3.39**
7. Foot and Mouth Disease (+3)	66.75	52.00	76.91	52.80	-2.43*
8. Nanomaterials (-3)	78.61	72.31	61.81	52.89	3.47**
9. Avian influenza (+3)	58.30	51.64	57.65	46.80	0.15
10. GMOs (-2)	68.73	61.20	57.84	60.31	0.2.92**
11. Pesticides (-5)	73.08	45.98	54.79	42.60	4.92***
12. Coastal erosion (-3)	68.30	50.98	50.28	41.58	3.76***

Note: The figure in parentheses represents the increase, decrease, or no change in ranking compared with the initial funding allocation choices.

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

<sup>a</sup>A positive number indicates that the second funding mean was lower; a negative sign indicates that the second funding mean was higher.

be understood best (mean = 6.18), flooding is the hardest to understand (mean = 5.43). The mean response to appropriateness of the expert rating was 5.11 (range = 2–7,  $SD = 1.06$ ). The mean score for similarity between the expert view and personal opinion was 4.33 (range = 1–7,  $SD = 1.24$ ). The highest initial funding allocations were for air quality, water quality, and flooding. The least funding was allocated to BTB, FMD, and avian influenza. The sets are notable in their themes: widespread risks that affect large numbers of people versus animal diseases. However, there were some changes to funding allocations following the additional information, as shown in Table VI below.

The data showed that the top three funding choices remained the same. However, the animal diseases all moved up the rankings, whereas GMOs, use of pesticides, and coastal erosion moved down the rankings. The data suggest that the expert information influenced perceptions of both the risks, and the risks relative to each other, resulting in changes to funding allocations.

## 8.2. Analysis of Funding Preferences

Regression analyses examined associations between the concurrently assessed constructs and change. Predictor variables were demographic factors (age, gender, education, home environment), perceptions of information (ease of understanding, appropriateness of expert judgment, agreement with expert judgment), and initial funding to examine the

extent of anchoring. Data showed that the model was significant in each case, with initial funding allocation being the most significant associate of funding change. There were additional associate variables in some cases, as shown in Table VII.

Repeated regressions omitting the initial funding choice showed no evidence of initial funding allocation having a mediating role; thus the data are interpreted as indicative of a direct effect of first funding allocation on second funding allocation.

## 8.3. Qualitative Analysis of Funding Preferences and Decision Processes

The decision process was examined further through thematic analysis of the qualitative data concerning choice, perceptions of expert opinion, and responsiveness to opinion. Data were coded independently by two authors. There was complete agreement concerning the main themes. First, we considered comments concerning the rationale for allocating high levels of funding. The highest funding allocations were for water quality, air quality, and flooding. The scale of impact was a significant, recurring theme. Gender and age are indicated after each quotation.

Poor air quality is shown to reduce life expectancy and has an impact on all life, whether it be humans, plants etc. Also the impact on the environment needs to be further understood, e.g., in terms of global warming etc.—this seems the most fundamental issue as it affects ALL life, and so merits the most funding. (Woman, 30)

**Table VII.** Results of Regression of Predictor Variables on Allocation of Funding

Environmental Risk	Antecedent	Beta Weight	R	R Square	F-Statistic
Air quality	Initial funding	0.70***	0.72	0.52	13.74***
Water quality	Initial funding	0.63***	0.72	0.51	13.60***
Flooding	Initial funding	0.49***	0.60	0.36	6.92***
	Difficulty in understanding information	-0.21*			
Avian influenza	Initial funding	0.60***	0.62	0.39	7.83***
Bovine TB	Initial funding	0.49***	0.54	0.30	5.25***
FMD	Initial funding	0.68***	0.68	0.46	10.58***
Nanomaterials	Initial funding	0.83***	0.79	0.62	20.66***
	Home environment	-0.21**			
	Difficulty in understanding information	-0.17*			
	Appropriateness of expert judgment	0.33***			
GMOs	Initial funding	0.79***	0.83	0.68	20.04***
	Home environment	0.14*			
Marine biodiversity	Initial funding	0.73***	0.72	0.55	15.29***
wildlife biodiversity	Initial funding	0.73***	0.74	0.54	14.76***
Pesticides	Initial funding	0.64***	0.69	0.47	11.05***
Coastal erosion	Initial funding	0.42***	0.45	0.21	3.25*

\* $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

However, there were compelling reasons for alternative choices.

Loss of marine biodiversity is the second most important area because once species start to become extinct, or if the ecosystem is damaged, it is infinitely more complex to rectify this. If money is spent on preventing a loss of marine biodiversity it will be an investment in the future. (Woman, 24)

The three lowest choices for funding allocation were GMOs, pesticides, and coastal erosion. There were comments about the perceived limited impact of these risks and the potential for benefits as well as risks.

Genetically modified organisms do not pose a large threat in my opinion, this is because they're mainly used commercially and have proven to have an extremely positive impact on production. This has reduced food prices, and without GMOs, some people may starve due to food shortages and thus, reducing the use of GMOs may create a bigger problem. (Man, 18)

Next, participants were asked to explain their responses to the expert information. The majority showed agreement with the expert opinion.

I agree with the expert view because I have full confidence in the experts' research. The majority of these organizations have been established for many years and have a great amount of research material. (Man, 22)

I would much rather believe the expert rating rather than my own! I would also agree with their interpretation as it is based on facts and scientific research whereas mine was a little opinion and limited information. (Woman, 24)

Some participants had a more mixed response.

I acknowledge that the expert view is backed up by far more research and experience than my own, yet I feel they are over-emphasizing the economic impact of potential issues in making decisions, with less focus on the potential long-term effects of the problems that I selected as the three most appropriate (poor air quality, and loss of marine and wildlife biodiversity), which as I mentioned before are far more difficult to reverse, and often under-prioritized as a result of a lack of tangible financial impact. I respect their view as policymakers and individuals with a connection to the government (including all the issues surrounding trust that entails), but I choose to disagree with their ideas, as a response to my own criteria, which I feel are valid. (Man, 21)

There were concerns about complexity, uncertainty, and the need for research.

I feel the experts give quite a vague idea of what is happening. It seems all the issues are neither too severe nor too unimportant. It seems everything is a little bit uncertain. (Woman, 26)

There was also some skepticism about the role of experts and the process of funding allocation.

The experts know much more about the problem than me, however they are motivated by the public opinion of the Government and money rather than just impact on the environment/ people. (Woman, 21)

Finally, participants commented on whether the second set of funding allocations differed from the first. Some participants acknowledged the importance of expertise and reported that they were influenced by the expert view.

I have increased the TB in cattle funding, due to the handout information that it is an ongoing problem and has direct economic effects if not addressed. My water quality funding has decreased the most as again the experts' view has assured me that there are more immediate needs and the wildlife/marine life funding has increased significantly as I feel my understanding of its importance has grown since reading the handout. (Woman, 30)

A second category of participants showed changes to align allocation of funding in areas where their views were different from the experts, while retaining allocations that were aligned with experts. These comments reflect the quantitative data concerning the extent of change across the first and second funding allocation questions.

After considering the impact of public trust in government I can see why it is important for certain issues (TB in cattle and F&M Disease) to be well controlled and well understood. I would stand by my choices regarding water and air quality as these are my environmental concerns and may lead to greater problems in the future. (Man, 18)

I kept everything the same as my views haven't changed I just thought I would equal out the funding for my lowest 3 choices the expert opinion has provided me with more thought about foot and mouth, and the flooding has confirmed by beliefs about how severe and how likely it is. So the amount for each of these has gone up. (Woman, 22)

However, some participants elected to make minimal changes to their funding allocation choices.

I have invested more in coastal erosion this time and left flooding out of my top 3 because I feel that losing parts of our coastal line are very important and it will be very devastating to people living in these areas. I have kept everything else the same because I still believe that these are my views and I don't believe everything I read or hear from the government. (Woman, 26)

Overall, the qualitative data demonstrated that willingness to take expert information into account when choosing to amend funding allocations depends on initial stance and beliefs about institutions and the information they provide.

## 9. DISCUSSION

Drawing on theory relating to anchoring and adjustment<sup>(62)</sup> and motivated reasoning,<sup>(67)</sup> we proposed that prior attitudes to risks and funding could influence initial allocation of funding to risks and that funding allocations would be susceptible to change following presentation of expert information for individuals motivated to increase the accuracy of their

choices. Data showed that participants made initial funding allocations and justified their choices by drawing on beliefs about scale of impact and severity and likelihood of risk. The quantitative and qualitative data highlighted two key findings. First, highest priorities for funding were given to air quality, water quality, and flooding. These priorities were robust and relatively unsusceptible to change as a result of seeing expert information. Qualitative data indicated that the consistency of these choices is due to the perceived properties of these risks: they are pervasive and impact directly upon large numbers of people.

Second, the lowest funding priorities were changed as a result of exposure to expert information. The initial lowest funding allocations were the animal diseases: BTB, avian influenza, and FMD, which participants perceived to be relatively low-impact risks. However, these funding preferences were not robust. The second opportunity for funding allocation that followed examination of the expert opinion graph showed a different set of choices: GMOs, coastal erosion, and use of pesticides. Qualitative explanations of the quantitative results showed three types responsiveness to expert information.

The first category, "responders," comprised participants who changed their views based on the information provided by experts. Variable choices did not necessarily indicate poor quality decision making.<sup>(66)</sup> Rather, participants showed responsiveness to expert information, noting the "eye-opening" nature of the expert data, and indicating some flexibility in their decision making.<sup>(68)</sup> The differences observed between the expert and participant opinion could have created dissonance<sup>(61)</sup> that participants sought to resolve through motivated reasoning,<sup>(67)</sup> thus changing their funding allocations and justifying their choices by citing the impact of information and the size of discrepancy between own and expert opinion.

The second "adaptors" category of participants reported that they changed some funding allocations, while retaining their own opinions about other risks. These participants reported that some of their views were "confirmed" by the expert information. This process can be explained by the nature of anchoring and adjustment whereby initial judgments form a significant anchor and thus complete decision shifts become unlikely yet adjustments are made to take account of significant dissonance or particularly salient information.<sup>(64)</sup> However, there was evidence of limited motivated reasoning<sup>(67)</sup> for the lesser known risks, such as BTB, where expert information prompted change in funding allocation.

The third “resistors” category was participants who were relatively resistant to information. These people reported a clear stance based on their own opinions, and demonstrated doubts about the motivation behind expert information. We propose that resistors do not experience dissonance because their strongly rooted beliefs are grounded in alternative sources of information<sup>(64)</sup> and they are motivated to retain their views.

In summary, the qualitative data show that many participants could engage with expert opinion concerning environmental risks, and could articulate clearly their rationale for funding allocation, and for changes following expert information. However, some participants were resistant to additional information. These data highlighted the need to understand individual differences, provided further support for dialogue at the heart of an effective policy process, and revealed three categories of decision-maker that could form the basis of policy discussions.

## 10. GENERAL DISCUSSION

Institutions craft a risk landscape for individuals to inhabit. We have proposed that the concept of confluence provides a path toward bringing together macro-level perspectives on institutional risk management with micro-level understanding of how lay people and policymakers generate beliefs about agency through perceived institutional trust, and beliefs about responsibility of government and scientists to manage risks. Quantitative data from the first study showed that agentic beliefs are likely to have a strong, positive association with beliefs about funding. The implication is that policy decisions are likely to be supported when agentic beliefs about the ability of government institutions to mitigate risk have been created and sustained, as demonstrated in Europe and the USA.<sup>(26,69,70)</sup>

The concept of contours has been advanced to reflect the relevance of examining micro-level individual-level perceptions of specific risks. Some risks have properties that provide a degree of objectivity to judgments, for example, poor air quality has a wide-ranging impact on a relatively large number of people. However, there are also more idiosyncratic personal beliefs, experiences, and perceptions about risk and risk management processes,<sup>(45,71)</sup> for example, coastal erosion may be particularly pertinent to people living in threatened areas but may seem to be a relatively unimportant risk for urban dwellers.

Further exploration about funding preferences in Study 2 highlighted the potential for information from experts to have a positive influence on lay decision making. Rather than assuming a deficit model, whereby lay processes should be corrected by information, the current study demonstrated that decision processes could be both labile and effective, contrary to some previous research.<sup>(66)</sup> Data revealed three categories of participants. Responders were able to make a number of adjustments to their funding allocation choices following policymaker information. Adaptors combined retention of some preferences with adjustment of others. Resistors were relatively impervious to information from experts and, in some cases, sceptical of its provenance. Understanding this typology provides a meso-level framework for developing theoretical extensions and practical applications.

### 10.1. Implications for Practice

The current research has implications for policymakers who seek to apply understanding of individual differences and sociological frameworks to dialogue and communications. The quantitative and qualitative data have shown that processes that build a sense of agency, i.e., beliefs about, and confidence in, the government’s responsibility to manage risk, will also contribute to socially acceptable risk management policies. The two-way dialogue required to establish a sense of government agency will highlight discrepancies in perceived risk, and will also inform policymakers whether risk communication needs to highlight the importance of risks and additional funding for risk management, or whether lay people could benefit from information about why lower levels of funding are reasonable for some areas of risk management. For example, different processes will be needed within nanomaterials debates compared with flood management debates because of the differing roles of experience and perceived understanding of information. The overall requirement is for a collective consideration of risk character, public perceptions, and options for intervention to inform the design of legitimate policies that target risk reductions when implemented through efficient regulation.<sup>(72)</sup> Being able to account for citizens’ perceptions of a portfolio of risks, rather than running campaigns on single issues, is particularly important at a time when government funding is under pressure. In short, governments and

lay people need to know, and build some consensus about, where risk management priorities lie.

## 10.2. Limitations and Future Research

The current studies have addressed the perception of 12 environmental risks. Concepts and measures were derived from the extant literature. Efforts have been made to ensure that measures were valid and reliable. Nonetheless, the current research has some limitations that could be addressed in future research. An expanded research model could have enabled further understanding of agency, perceived risk, and beliefs about funding allocations. While the current study examined the U.K. portfolio of environmental risks that policymakers need to fund, future research could examine similar portfolios in other areas of government. Interviews could have provided supplementary qualitative data. Future studies could also include more in-depth or face-to-face interactions between lay people and policymakers. There could also be cultural aspects of perceived risk as well as institutional risk management, and similar research in other countries could consider the cultural implications of agency, trust, and risk management.

## 11. CONCLUSION

To conclude, individual differences psychology and sociological approaches to understanding beliefs about agency and risk could contribute to providing meaningful foundations for effective policy processes. Lay support for government funding directed toward management of environmental risks rests upon beliefs about responsibility, trust, and risk-related beliefs and perceptions. Communications from policymakers have strong potential to influence lay beliefs, yet the policy process also needs to be attentive to public perceptions of risk. Thus communications that increase salience of risks that experts believe require government funding could be more likely to receive support when framed within the context of reflexive dialogue. Moreover, policymakers who heed lay concerns are likely to make effective, socially acceptable policy decisions.

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## APPENDIX: SUMMARY INFORMATION FOR ENVIRONMENTAL RISKS PROVIDED FOR PARTICIPANTS IN STUDIES 1 AND 2

### Coastal Erosion

- Natural weathering processes affect the English coastline causing erosion, particularly in the East and South of England.
- Erosion is natural, can be gradual or drastic (e.g., cliff slump), and provides benefits to beaches and habitat.
- Local authorities estimate that 200 properties may be lost over the next 20 years, resulting in house price reduction and detrimental impacts on individuals and communities.

### Nanomaterials

- Nanomaterials are tiny man-made particles, with one dimension less than 100 nanometers (1/40,000th of a human hair).
- They can be hazardous to humans and the environment if they are released, e.g., during manufacturing or from products that have reached the end of their lives and are dumped.
- The impacts of nanomaterials are uncertain due to a lack of data, but they are likely to be latent (i.e., they are not currently evident or active, but have the potential to become so in the future).

### Foot and Mouth Disease

- Foot and Mouth Disease is a group of highly contagious diseases that affect cows, pigs, goats, sheep, and deer.
- The severity of an outbreak is influenced by the length of time it takes to detect the disease and number of livestock in the immediate area.



- The disease is normally controlled by killing infected animals and potential carriers. While vaccines are available, no single vaccine is effective against all types of the disease.

**Flooding**

- Floods can occur throughout the year from rivers, the sea, rainfall, or rising groundwater. The area affected depends upon a combination of weather, rainfall patterns, topography, and the degree of development in the area.
- The severity of a flood is influenced by the speed and duration of inundation, as well as the impact on the population, property, and infrastructure in the area.
- Flooding from the sea is considered more severe than flooding from rivers; 50% of the total properties at risk in England and Wales are located along the coast.

**GMOs**

- Genetically modified organisms (GMOs) have genetic material that has been altered in a way that does not occur naturally by mating and/or natural recombination.
- All GMO research must be authorized by the Government and carried out under strict controls, with an assessment of the risks made in advance.
- There is currently no commercial cultivation of GM crops in the United Kingdom. GM animal feed is used in the United Kingdom and mostly imported, during which accidental spillage or release may occur.

**Marine Biodiversity**

- Reduced marine biodiversity arises from a reduction in the abundance, variety, or complexity of the United Kingdom’s marine life.
- Drivers of marine biodiversity loss include human activities (such as intensive fishing, which results in habitat destruction), the spread of invasive species, and changing climate.
- The impacts of marine biodiversity loss are very complex to understand and predict. Changes can be progressive or rapid.

**Pesticides**

- Pesticides used as plant protection products include insecticides, herbicides, and fungicides.

- Exposure to these substances at excessive levels can lead to acute and chronic toxicity to humans, domestic animals, wildlife, and plants.
- Pesticides are widely used by farmers to control pests, weeds, and diseases; thereby helping to produce high quality, reasonably priced and locally grown foodstuffs.

**Water Quality**

- Pressures affecting the quality of the water in our rivers, lakes, estuaries, coastal bathing waters, and groundwater may derive from episodic events (e.g., storm-related sewage overflows or chemical spills) or chronic events (e.g., nutrient run-off from agricultural land and water abstraction).
- In England, approximately 30% of surface water and 60% of groundwater bodies are considered to be at “good or better” ecological status.
- At least 50% of surface waters are affected by diffuse nutrient pollution originating from the agricultural and transport sectors.

**Wildlife Biodiversity**

- Reduced wildlife biodiversity arises from a reduction in the abundance, variety, or complexity of the United Kingdom’s wildlife.
- Change in biodiversity is difficult to quantify. Our understanding of ecosystem complexity is limited, the interactions with human wellbeing are under-explored and there is little data.
- In the United Kingdom, the general trend is toward a loss in biodiversity, mostly as a result of habitat loss, pollution, invasive species, and changing climate. Over time, cumulative effects may lead to significant, irreversible harm with knock-on impacts.

**Air Quality**

- Air quality is concerned with the introduction of chemicals or particulates into the air that may cause harm or discomfort to humans and/or the environment.
- Man-made sources of air pollution may originate from industry, power generation, or vehicle emissions.
- Impacts to human health are well founded, with elevated levels of particulate matter estimated to reduce life expectancy in the United Kingdom by approximately 6 months.

## Bird Flu

- Bird flu (or avian influenza) is most common in wild bird populations (e.g., waterfowl) and is most commonly transmitted through them to domestic poultry.
- Mutation to the highly pathogenic variety is of concern because it may increase the potential for cross-species infection (e.g., to pigs and humans).
- 519 cases of bird flu, resulting in 309 deaths, have been reported worldwide since 2003, however transfer to humans is not common as it requires very close contact with infected birds.

## TB in Cattle

- TB in cattle (or bovine tuberculosis) also occurs in badgers. The majority of incidents are in the South West and Central regions in England.
- In rare instances, TB in cattle can be transmitted into humans. Human health risks from food are low due to controls (e.g., meat inspection and milk pasteurization).
- Diagnosis is difficult and incidences in England are increasing. In 2009, 25,000 cattle were slaughtered, resulting in Government compensation of £31 million and taxpayer costs in excess of £90 million.

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