

## Explaining illness with evil: pathogen prevalence fosters moral vitalism

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### Article citation details

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### Review timeline

Original submission: 14 January 2019  
1st revised submission: 4 July 2019  
2nd revised submission: 23 September 2019  
Final acceptance: 3 October 2019

Note: Reports are unedited and appear as submitted by the referee. The review history appears in chronological order.

## Review History

### RSPB-2019-0081.R0 (Original submission)

#### Review form: Reviewer 1

##### Recommendation

Major revision is needed (please make suggestions in comments)

**Scientific importance: Is the manuscript an original and important contribution to its field?**  
Acceptable

**General interest: Is the paper of sufficient general interest?**  
Acceptable

**Quality of the paper: Is the overall quality of the paper suitable?**

Good

**Is the length of the paper justified?**

Yes

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

Yes

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

No

**Is it clear?**

N/A

**Is it adequate?**

N/A

**Do you have any ethical concerns with this paper?**

No

### **Comments to the Author**

This paper investigates the relationship between pathogen threat and what the authors term “moral vitalism,” or folk belief in supernatural disease-causing forces. I was a reviewer on a previous version of this manuscript; in my opinion this is an improved version. For some of the issues that remain I’ve pasted from the previous review.

The research question is addressed using a diverse set of samples, and a range of outcome variables. Whether or not the reported outcomes represent an advance in knowledge sufficient to meet the bar for Proceedings B I will leave to the discretion of the editor.

In the introduction the authors correctly state that pre-germ-theory societies (“pre-scientific” societies probably isn’t an appropriate term) tend to create folk-causal theories of sickness. Murdock’s great Theories of Illness deals exclusively with this issue. As he reports, witchcraft/evil eye/evil spirits are just one causal explanatory category across the SCCS societies. The introduction would benefit from providing readers with a more comprehensive overview of the many different ways societies “explain” illness, and perhaps why the explanatory category the authors focus on would be for adaptive/functional than other lay theories.

The results across the three studies indeed reveal consistent correlational patterns, and the authors take a couple of reasonable steps to control for other variables that may account for their results. There are of course an infinite number of controls one “could” include in such analyses, but I wondered if the authors go far enough in convincing readers that the correlations can’t be otherwise accounted for. The SCCS has many variables that could serve as logically plausible controls, such as frequency of both ingroup and outgroup conflict, frequency of famine, and

resource uncertainty. Similarly for the country analyses; the authors list several important and conceptually distinct control variables and make reasonable arguments for including each. But what they instead end up doing is creating a composite of all of these variables, which essentially means that they are only controlling for the mutually shared element of these four variables. Cross-culturally speaking, just about everything is associated with everything else, and just because a PCA indicates that you could have a one factor solution it doesn't mean that you should adopt a one factor solution.

To that end, I would bet that entering disease into that PCA would produce a strong one-factor solution too, which creates an ontological dilemma for the authors given their current justification of their composite. I can appreciate their stated limitation that simultaneously controlling for each would deplete sample size (and the analysis would probably be too collinear to be of much use). One solution could be the addition of a series of regressions that just employs one of the control variables at once (probably just fully reported in the supplementary files). Another candidate control variable could be wealth inequality, which is suggested by some to decrease trust.

I also wondered about the mediation analyses in study 3. This is just one way to draw the arrows for the given variables; how does this model compare with others (i.e. with moral vitalism as the DV and conservative type values as mediators? Or with disease prevalence predicting both as outcomes simultaneously but independently?)

In the discussion the authors make a functional case for the given results, which I think is just one of many plausible interpretations of the data. From these correlations alone we have no idea whether moral vitalism is functional in the realm of pathogen transmission or not. It seems equally plausible that moral vitalism doesn't inhibit pathogen transmission at all, and rather is just a cultural byproduct of something like higher outgroup wariness. Functionally speaking humans certainly don't "need" a belief in agentic spirits to effectively predict and respond to the threat of disease. In humans and non-humans alike there exist plenty of cognitive and affective mechanisms (e.g., disgust) that do that job void of any conscious belief system. And again, these aren't the only lay theories of disease that exist around the world, so it's not immediately clear that moral vitalism does a better (if any) job of other theories in actually inhibiting pathogen transmission.

## Review form: Reviewer 2 (Corey L. Fincher)

### Recommendation

Major revision is needed (please make suggestions in comments)

### Scientific importance: Is the manuscript an original and important contribution to its field?

Excellent

### General interest: Is the paper of sufficient general interest?

Excellent

### Quality of the paper: Is the overall quality of the paper suitable?

Excellent

### Is the length of the paper justified?

Yes

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

N/A

**Is it clear?**

N/A

**Is it adequate?**

N/A

**Do you have any ethical concerns with this paper?**

No

#### **Comments to the Author**

I am generally positive about this manuscript. I like the combination of studies and I like the new thoughts about the links between conservative values and pathogen problems. I do however offer some comments and criticisms that when addressed could make for a stronger manuscript.

Some critics will tell you that your analyses across cultures are faulty because you did not attend to phylogenetic closeness between cultures. I am not one of them. Nevertheless, it could be an improvement to address this directly in your discussion or introduction, perhaps referencing something like this: Thornhill, R., & Fincher, C. L. (2013). The comparative method in cross-cultural and cross-species research. *Evolutionary Biology*, 40(4), 480-493.

I suspect some critics will take issue with the lack of treatment of measurement equivalence for your measure of moral vitalism. Perhaps you've dealt with this in Bastian et al. 2015. If that's the case then you should probably discuss it. If it isn't the case then you might want to deal with the issue. You might at least discuss why you think the scale measures the same thing for people in different cultures. I see you addressed issues of translation to other languages in a credible way.

In the first sentence, you say pathogens have been a consistent threat to groups. However, the literature and theory on this focuses on individual-level adaptations, even the behavioural immune system literature.

I think you really need to include discussion of the ideas presented in Tybur et al. 2015 that says sexual strategies are the mediating factor between pathogen stress and conservative ideology. How does your idea about moral vitalism influence this conclusion? Tybur, J. M., Inbar, Y., Güler, E., & Molho, C. (2015). Is the relationship between pathogen avoidance and ideological conservatism explained by sexual strategies?. *Evolution and Human Behavior*, 36(6), 489-497.

For study one, the introduction would be improved with some description of other ideas that have been used to explain the cultural variation in witchcraft and evil eye (e.g., Gershman, B. (2015). The economic origins of the evil eye belief. *Journal of Economic Behavior & Organization*,

110, 119-144 or Quinlan, R. J., & Quinlan, M. B. (2007). Parenting and cultures of risk: A comparative analysis of infidelity, aggression, and witchcraft. *American Anthropologist*, 109(1), 164-179).

For study two, as with study one, what do we know about 'belief in the devil' and hypotheses about its cross-cultural variation? This could make the paper better to say something about this.

In description of archival data for study two, you don't say you analysed the percentages of people that said they believed in the devil. Please do.

In lines 257-261, you present results for Model 3 and then the last line of the paragraph makes a contrast but talks about Model 3. This is a little confusing so I suggest looking at how to clarify this presentation.

Lines 385-387. Why not report the exact p-values?

From the supplement, this sentence: "Finally, although one example of spirit aggression refers to disease demons consistent with our argument, it also codes for aggression by the spirits of ancestors, kinsmen, nature spirits, lesser divinities or higher deities or gods." I don't understand what are 'disease demons'. Do you mean 'disease as demons'?

Supplement: you say "Therefore, in line with our argument that it is specifically the belief in an evil force which functionally models the effects of pathogens, we compared both the evil eye belief and a belief in Witchcraft to these other potential explanations."

What did you find when you did this?

Supplement: it looks like there are some significantly sex-biased samples. Can you say anything about ruling out sex-differences for your explanation? That is, I'm concerned that the bias towards a female sample may prevent you from making the more general conclusion you have made about all people. Can you address that issue?

## Decision letter (RSPB-2019-0081.R0)

08-Apr-2019

Dear Dr Bastian:

I am writing to inform you that your manuscript RSPB-2019-0081 entitled "Explaining illness with evil: Pathogen prevalence fosters moral vitalism" has, in its current form, been rejected for publication in *Proceedings B*.

This action has been taken on the advice of referees, who have recommended that substantial revisions are necessary. With this in mind we would be happy to consider a resubmission, provided the comments of the referees are fully addressed. However please note that this is not a provisional acceptance.

The resubmission will be treated as a new manuscript. However, we will approach the same reviewers if they are available and it is deemed appropriate to do so by the Editor. Please note that resubmissions must be submitted within six months of the date of this email. In exceptional

circumstances, extensions may be possible if agreed with the Editorial Office. Manuscripts submitted after this date will be automatically rejected.

Please find below the comments made by the referees, not including confidential reports to the Editor, which I hope you will find useful. If you do choose to resubmit your manuscript, please upload the following:

- 1) A 'response to referees' document including details of how you have responded to the comments, and the adjustments you have made.
- 2) A clean copy of the manuscript and one with 'tracked changes' indicating your 'response to referees' comments document.
- 3) Line numbers in your main document.

To upload a resubmitted manuscript, log into <http://mc.manuscriptcentral.com/prsb> and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Resubmission." Please be sure to indicate in your cover letter that it is a resubmission, and supply the previous reference number.

Sincerely,

Proceedings B  
mailto:proceedingsb@royalsociety.org

Associate Editor  
Board Member: 1  
Comments to Author:

Overall, two expert reviewers found this paper interesting. However, both raise substantive issues about the analytical approach and data interpretation that make the paper unsuitable for PRSB in its current form.

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)

This paper investigates the relationship between pathogen threat and what the authors term "moral vitalism," or folk belief in supernatural disease-causing forces. I was a reviewer on a previous version of this manuscript; in my opinion this is an improved version. For some of the issues that remain I've pasted from the previous review.

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Referee: 2

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Supplement: you say "Therefore, in line with our argument that it is specifically the belief in an evil force which functionally models the effects of pathogens, we compared both the evil eye belief and a belief in Witchcraft to these other potential explanations."  
What did you find when you did this?

Supplement: it looks like there are some significantly sex-biased samples. Can you say anything about ruling out sex-differences for your explanation? That is, I'm concerned that the bias towards a female sample may prevent you from making the more general conclusion you have made about all people. Can you address that issue?



## Author's Response to Decision Letter for (RSPB-2019-0081.R0)

See Appendix A.

### RSPB-2019-1576.R0

#### Review form: Reviewer 3

**Recommendation**

Accept with minor revision (please list in comments)

**Scientific importance: Is the manuscript an original and important contribution to its field?**

Excellent

**General interest: Is the paper of sufficient general interest?**

Good

**Quality of the paper: Is the overall quality of the paper suitable?**

Good

**Is the length of the paper justified?**

Yes

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

No

**Is it clear?**

No

**Is it adequate?**

No

**Do you have any ethical concerns with this paper?**

No

**Comments to the Author**

See attached file. (See Appendix B)

## Review form: Reviewer 4

### Recommendation

Accept as is

**Scientific importance: Is the manuscript an original and important contribution to its field?**

Excellent

**General interest: Is the paper of sufficient general interest?**

Excellent

**Quality of the paper: Is the overall quality of the paper suitable?**

Excellent

**Is the length of the paper justified?**

Yes

**Should the paper be seen by a specialist statistical reviewer?**

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

Yes

**Is it clear?**

Yes

**Is it adequate?**

Yes

**Do you have any ethical concerns with this paper?**

No

### Comments to the Author

MS. RSPB-2019-1576, Bastion et al.

This paper is remarkable. It is broadly interesting, theoretically inspired, relevant to and advancing of a major research area, and involves a range of strong tests of the central proposed hypothesis.

The authors hypothesize that concepts of evil spirits (demons, devils, evil forces) and their channels (e.g., witches) originated ancestrally and were maintained through time because they connote parasite (infectious disease) cues of contagion and threat, and because they motivated cognition and behavior that functions to avoid and manage parasites. This is a very novel way to think about the causes of evil and why evil is a feature of the cultural repertoire across societies and time. There is a major body of theory and evidence (the parasite-stress theory) that identifies

parasites as important in explaining human core values, religiosity, and many aspects of human social life. This paper expands that body of research in creative and relevant ways. It also reveals that it is not enough to explain evil as simply some correlated ideation that tags along with religiosity. Instead, conception of evil may be a functional part of disease defense (part of psychological and behavioral immunity).

Empirically, through three studies, the paper examines three predictions of the central hypothesis. The central prediction is that, across regions, belief in various evil forces will covary positively with parasite stress. These are all novel tests. The empirical part of the research includes analyses across traditional / indigenous societies (Standard Cross Cultural Sample), World Values Survey data, and a questionnaire study of 3,200 people in 32 countries. The results of the various tests all support the central hypothesis (the parasite hypothesis of evil spirits). The control variables used in the testing are explained very well. Furthermore, the authors understand the phylogenetic issues relevant to confounding in cross-cultural tests (as explained in detail by Thornhill & Fincher 2014, cited in the paper).

The paper is well written and prepared.

The research is of interest to scholars broadly: evolutionary biologists and ecologists interested in human behavior and psychology, cross-cultural psychologists and anthropologists.

I have no significant criticisms of this paper. I add here a few thoughts that may be of interest to the authors in their future research in this area; these topics do not need to be considered for this paper. Spirits are of two categories: good and evil. If we accept the authors' explanation of evil spirits, then what about the benevolent ones that also are ubiquitous cross-culturally? Is it enough to say they are associated with purity and hence low disease threat? I don't think so, because religiosity and belief in a god(s) that do some nice things is in all religions, major and minor. We know that religiosity covaries strongly with parasite stress (Fincher & Thornhill's cited work in the paper). So, belief in good spirits and belief in evil spirits show the same relationship with parasites.

This paper is complete enough as it is. I wondered, however, why the authors did not mention the history of major plagues and their explanation by evil forces. Witches are a cause of the Black Death, e.g.; witch hunts to remove the disease channels, too. Also, is moral vitalism the best label for the theory? Vitalism is just a transcendental force. It need not be harmful, right? Perhaps Bastion's earlier papers on the topic explain this.

## Decision letter (RSPB-2019-1576.R0)

21-Aug-2019

Dear Dr Bastian:

Your manuscript has now been peer reviewed and the reviews have been assessed by an Associate Editor. The reviewers' comments (not including confidential comments to the Editor) and the comments from the Associate Editor are included at the end of this email for your reference. As you will see, the reviewers and the Editors have raised some issues with your manuscript and we would like to invite you to revise your manuscript to address them.

We do not allow multiple rounds of revision so we urge you to make every effort to fully address all of the comments at this stage. If deemed necessary by the Associate Editor, your manuscript will be sent back to one or more of the original reviewers for assessment. If the original reviewers are not available we may invite new reviewers. Please note that we cannot guarantee eventual acceptance of your manuscript at this stage.

To submit your revision please log into <http://mc.manuscriptcentral.com/prsb> and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions", click on "Create a Revision". Your manuscript number has been appended to denote a revision.

When submitting your revision please upload a file under "Response to Referees" in the "File Upload" section. This should document, point by point, how you have responded to the reviewers' and Editors' comments, and the adjustments you have made to the manuscript. We require a copy of the manuscript with revisions made since the previous version marked as 'tracked changes' to be included in the 'response to referees' document.

Your main manuscript should be submitted as a text file (doc, txt, rtf or tex), not a PDF. Your figures should be submitted as separate files and not included within the main manuscript file.

When revising your manuscript you should also ensure that it adheres to our editorial policies (<https://royalsociety.org/journals/ethics-policies/>). You should pay particular attention to the following:

#### Research ethics:

If your study contains research on humans please ensure that you detail in the methods section whether you obtained ethical approval from your local research ethics committee and gained informed consent to participate from each of the participants.

#### Use of animals and field studies:

If your study uses animals please include details in the methods section of any approval and licences given to carry out the study and include full details of how animal welfare standards were ensured. Field studies should be conducted in accordance with local legislation; please include details of the appropriate permission and licences that you obtained to carry out the field work.

#### Data accessibility and data citation:

It is a condition of publication that you make available the data and research materials supporting the results in the article. Datasets should be deposited in an appropriate publicly available repository and details of the associated accession number, link or DOI to the datasets must be included in the Data Accessibility section of the article (<https://royalsociety.org/journals/ethics-policies/data-sharing-mining/>). Reference(s) to datasets should also be included in the reference list of the article with DOIs (where available).

In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should also be fully cited and listed in the references.

If you wish to submit your data to Dryad (<http://datadryad.org/>) and have not already done so you can submit your data via this link

[http://datadryad.org/submit?journalID=RSPB&manu=\(Document not available\)](http://datadryad.org/submit?journalID=RSPB&manu=(Document not available)), which will take you to your unique entry in the Dryad repository.

If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link.

For more information please see our open data policy <http://royalsocietypublishing.org/data-sharing>.

Electronic supplementary material:

All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI. Please try to submit all supplementary material as a single file.

Online supplementary material will also carry the title and description provided during submission, so please ensure these are accurate and informative. Note that the Royal Society will not edit or typeset supplementary material and it will be hosted as provided. Please ensure that the supplementary material includes the paper details (authors, title, journal name, article DOI). Your article DOI will be 10.1098/rspb.[paper ID in form xxxx.xxxx e.g. 10.1098/rspb.2016.0049].

Please submit a copy of your revised paper within three weeks. If we do not hear from you within this time your manuscript will be rejected. If you are unable to meet this deadline please let us know as soon as possible, as we may be able to grant a short extension.

Thank you for submitting your manuscript to Proceedings B; we look forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Best wishes,  
Professor Hans Heesterbeek  
mailto:proceedingsb@royalsociety.org

Associate Editor

Comments to Author:

Both reviewers found this paper very interesting and both provide comments that should be carefully considered in a revision.

Reviewer(s)' Comments to Author:

Referee: 3

Comments to the Author(s).

See attached file

Referee: 4

Comments to the Author(s).

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The authors hypothesize that concepts of evil spirits (demons, devils, evil forces) and their channels (e.g., witches) originated ancestrally and were maintained through time because they connote parasite (infectious disease) cues of contagion and threat, and because they motivated cognition and behavior that functions to avoid and manage parasites. This is a very novel way to think about the causes of evil and why evil is a feature of the cultural repertoire across societies and time. There is a major body of theory and evidence (the parasite-stress theory) that identifies parasites as important in explaining human core values, religiosity, and many aspects of human

social life. This paper expands that body of research in creative and relevant ways. It also reveals that it is not enough to explain evil as simply some correlated ideation that tags along with religiosity. Instead, conception of evil may be a functional part of disease defense (part of psychological and behavioral immunity).

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## Author's Response to Decision Letter for (RSPB-2019-1576.R0)

See Appendix C.

## Decision letter (RSPB-2019-1576.R1)

03-Oct-2019

Dear Dr Bastian

I am pleased to inform you that your manuscript entitled "Explaining illness with evil: Pathogen prevalence fosters moral vitalism" has been accepted for publication in Proceedings B.

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Thank you for your fine contribution. On behalf of the Editors of the Proceedings B, we look forward to your continued contributions to the Journal.

Sincerely,

Professor Hans Heesterbeek

Editor, Proceedings B

mailto: [proceedingsb@royalsociety.org](mailto:proceedingsb@royalsociety.org)

Associate Editor:

Board Member

Comments to Author:

(There are no comments.)

# Appendix A

To the Associate Editor, Proceedings B

Re: Manuscript ID RSPB – 2019 – 0081

Thank you for handling this paper and for considering a resubmission of our work. We have endeavored to address all of the reviewers concerns and believe that the manuscript is now stronger as a result. We detail how we have responded to each comment below:

## Reviewer 1:

***R1.1: This paper investigates the relationship between pathogen threat and what the authors term “moral vitalism,” or folk belief in supernatural disease-causing forces. I was a reviewer on a previous version of this manuscript; in my opinion this is an improved version. For some of the issues that remain I’ve pasted from the previous review.***

We thank the reviewer for providing additional comments and are glad that they feel the manuscript is improving with each iteration.

***R1.2: The research question is addressed using a diverse set of samples, and a range of outcome variables. Whether or not the reported outcomes represent an advance in knowledge sufficient to meet the bar for Proceedings B I will leave to the discretion of the editor.***

We note the reviewers caution here, although would also note that this set of findings have spurred a good deal of activity with collaborators in the USA, UK, and New Zealand. We are currently pursuing several high impact projects that would not have been conceived if not for the findings we report here. We think this provides good reason to think these findings are making an advance in knowledge and spurring new research questions as a result.

***R1.3: In the introduction the authors correctly state that pre-germ-theory societies (“pre-scientific” societies probably isn’t an appropriate term) tend to create folk-causal theories of sickness. Murdock’s great Theories of Illness deals exclusively with this issue. As he reports, witchcraft/evil eye/evil spirits are just one causal explanatory category across the SCCS societies. The introduction would benefit from providing readers with a more comprehensive overview of the many different ways societies “explain” illness, and perhaps why the explanatory category the authors focus on would be for adaptive/functional than other lay theories.***

We have now replaced all instance of ‘pre-scientific’ with ‘pre-germ theory’

We are sympathetic to the reviewers request to provide a more comprehensive review of the many different way’s societies have explained illness, and it certainly is something that we already note, however we simply do not have the word count available to expand further, especially with the request for us to report additional results. The article is already at the maximum length the journal allows.

We would also note, however, that we are not necessarily advancing an argument that a belief in evil forces is the best explanation. Indeed germ-theories are probably better. Our argument is that by focusing on evil forces in particular, and specifically an understanding of these forces as contagious, contaminating, and also transferrable – an account that has specifically been provided by moral vitalism theory – we can arrive at a more acute understanding of how a range of beliefs, such as witchcraft, evil-



eye, and even aspects of several other theories which we already review in our supplemental materials, have guided the human response to disease. None of these previous accounts has clearly demarcated how people's belief in metaphysical evil forces maps clearly onto the structure of germ theory and as such provides a more nuanced and fulsome view from which to understand explanation and prediction of disease within pre-germ theory societies. We have highlighted this in the discussion, noting that moral vitalism effectively modelled disease prevalence in terms of its spread (contagion) and influence (possession).

We would further note that whereas Murdoch (1980) explicitly examines stated explanations for illness, we focus on a set of beliefs – evil eye, the devil, and abstract evil forces – which are not themselves framed as explanations for illness. This distinguishes our approach as it provides evidence that pathogen threats may have shaped cultural beliefs in a way that had broader social implications. We have now added a point in the discussion to bring out this aspect of the contribution more clearly:

“Finally, it goes beyond prior work (e.g., Murdoch, 1980) which examined explicit explanations limited to understanding illness, focusing instead on a general tendency to believe in the existence of evil forces. This provides insight into avenues through which pathogen threat may have motivated and reinforced belief systems with broader social implications.”

***R1.4: The results across the three studies indeed reveal consistent correlational patterns, and the authors take a couple of reasonable steps to control for other variables that may account for their results. There are of course an infinite number of controls one “could” include in such analyses, but I wondered if the authors go far enough in convincing readers that the correlations cant be otherwise accounted for. The sccs has many variables that could serve as logically plausible controls, such as frequency of both ingroup and outgroup conflict, frequency of famine, and resource uncertainty.***

This is a good point, and we have now substantially overhauled our analysis in Study 1, including 6 new control variables designed to capture conflict (3 measures, focusing both on internal and external conflicts), resource security (including famine and agricultural potential) as well as wealth inequality. We draw this idea from a reference provided by Reviewer 2 below, and also felt that it provided the possibility of responding to this reviewer's comments regarding wealth inequality below (R1.5). Including these additional control variables did not alter our conclusions.

We think that our reporting and analysis of Study 1 is now significantly improved due to these suggestions.

***R1.4: Similarly for the country analyses; the authors list several important and conceptually distinct control variables and make reasonable arguments for including each. But what they instead end up doing is creating a composite of all of these variables, which essentially means that they are only controlling for the mutually shared element of these four variables. Cross-culturally speaking, just about everything is associated with everything else, and just because a PCA indicates that you could have a one factor solution it doesn't mean that you should adopt a one factor solution. To that end, I would bet that entering disease into that PCA would produce a strong one-factor solution too, which creates an ontological dilemma for the authors given their current justification of their composite. I can appreciate their stated limitation that simultaneously controlling for each would deplete sample size (and the analysis would probably be too collinear to be of much use). One solution could be the addition of a series of regressions that just employs one of the control variables at once (probably just fully reported in the supplementary files).***

We take the reviewers point and have changed our approach and reporting in line with their recommendations. We now report a series of regression models where we control for each country-level control variable one at a time to conserve power and avoid problems with collinearity.

***R1.5: Another candidate control variable could be wealth inequality, which is suggested by some to decrease trust.***

We thank the reviewer for noting this additional control variable. In developing our theory around what country-level variables we felt were important to control for, we considered that social unrest, crime, or conflict would be important. To this end, we controlled for the Corruption Index and the Peace Index. We did not have any specific reason to expect that income inequality might lead to a belief in good and evil/the devil beyond the adverse impact that income inequality can have on interpersonal relations. As the reviewer notes, the link between wealth inequality and the beliefs we focus on probably occurs via decreased trust. We feel that we have captured important elements of trust by using the Corruption Perceptions Index.

Nonetheless, as part of this revision, we did obtain data on GINI from both the OECD and the World Bank data sets. We matched this to the year of data collection (in both Studies 2 and 3) as closely as possible. Unfortunately, we could only obtain GINI scores for 20 (OECD data) or 39 (WB data) countries out of the 46 used for Study 2 and 22 (OECD data) or 20 (WB data) countries out of the 28 used in Study 3.

Beyond reducing power, we also found high correlations between Disease Prevalence and the GINI coefficient  $r(39) = .48$ ,  $p = .002$  (WB data) to  $r(19) = .69$ ,  $p < .001$  (OECD data) in Study 2 and  $r(20) = .71$ ,  $p < .001$  (WB data) and  $r(21) = .72$ ,  $p < .001$  (OECD data) in Study 3. It is also noteworthy that these correlations tended to be somewhat higher compared to other country-level controls in Study 2 ( $-.592$  to  $-.682$ ) and Study 3 ( $-.433$  to  $-.647$ ).

Our analysis indicated that GINI has a similar relationship to Belief in the Devil ( $r(19) = .57$ ,  $p = .008$  [OECD data];  $r(41) = .50$ ,  $p = .003$  [WB data]) as does Disease Prevalence ( $r(46) = .52$ ,  $p < .001$ ) in Study 2 and has a similar relationship to moral vitalism in Study 3: GINI; ( $r(21) = .62$ ,  $p = .002$  [OECD data];  $r(19) = .48$ ,  $p = .034$  [WB data]); Disease Prevalence ( $r(27) = .50$ ,  $p = .007$ ).

When we entered both Disease Prevalence and GINI into the regression model, neither was a significant predictor of belief in the devil in Study 2 (OECD GINI  $B = 5.71$ ,  $p = .073$ ; DP  $B = 0.580$ ,  $p = .182$  / WB GINI  $B = 0.023$ ,  $p = .218$ ; DP  $B = .319$ ,  $p = .218$ ) or moral vitalism in Study 3 (OECD GINI  $B = 4.059$ ,  $p = .063$ ; DP  $B = 0.092$ ,  $p = .664$  / WB GINI  $B = 0.014$ ,  $p = .609$ ; DP  $B = .355$ ,  $p = .181$ ).

We think these findings are hard to interpret, given the significant zero-order correlations. It also suggests that issues such as multi-collinearity may be present.

Given that a) we feel we have already included measures that capture the downstream consequences of wealth inequality which would be theoretically related to our focal measures of belief, and the statistical problems associated with including the GINI in our analysis (i.e., loss of power and potentially multicollinearity) we think that there is little to be gained from including these analyses but will do so if the editor disagrees.

We would also note that we have now included a measure of class inequality in the SCCS analysis, also based on Reviewer 2s recommendation. This has been previously linked to evil eye beliefs (Gershman, 2015) and the available data covered all countries in our original analysis, providing for a more powerful examination of this potential confound.

***R1.6: I also wondered about the mediation analyses in study 3. This is just one way to draw the arrows for the given variables; how does this model compare with others (i.e. with moral vitalism as the DV and conservative type values as mediators? Or with disease prevalence predicting both as outcomes simultaneously but independently?)***

In our original submission we had provided evidence for reverse mediation models in the Supplementary materials. In the case of the moral binding foundations, a reverse mediation model cannot be assessed because there is no significant association between the independent variable pathogen prevalence and the mediating variable moral binding foundation ( $B = 0.114$ ,  $SE = 0.094$ ,  $p = 0.226$ ). When we tested the alternative mediation model involving conservative values as the mediating variable, we found that all paths were significant and the indirect effect revealed to be significant as well. However, contrary to the hypothesized mediation model, there was evidence for only partial and not full mediation (reported in Figure S1 in the Supplementary Materials). Hence, the hypothesized mediation models are better supported by the data than the alternative models.

***R1.5: In the discussion the authors make a functional case for the given results, which I think is just one of many plausible interpretations of the data. From these correlations alone we have no idea whether moral vitalism is functional in the realm of pathogen transmission or not. It seems equally plausible that moral vitalism doesn't inhibit pathogen transmission at all, and rather is just a cultural byproduct of something like higher outgroup wariness. Functionally speaking humans certainly don't "need" a belief in agentic spirits to effectively predict and respond to the threat of disease. In humans and non-humans alike there exist plenty of cognitive and affective mechanisms (e.g., disgust) that do that job void of any conscious belief system. And again, these aren't the only lay theories of disease that exist around the world, so it's not immediately clear that moral vitalism does a better (if any) job of other theories in actually inhibiting pathogen transmission.***

We thank the reviewer for these comments. We agree that we cannot be sure about the functional argument, and we had only stated that "moral vitalistic beliefs are likely to be functional". We do, however, feel that there is a good theoretical basis for suggesting this possibility.

We take the reviewers point that it could be something like 'higher outgroup wariness'. Yet, the apparent overlap between moral vitalistic theories of evil forces and how they operate in the world via transmission (contagion) and possession (infection), so closely models how current germ theories model the effects of pathogens, that this association seems to have significantly greater theoretical support. We had also noted in the second last paragraph of the discussion other potential explanations such as heightened death anxiety or reduced psychological control, making afterlife beliefs more attractive. Here again, however, we have argued that the functionally equivalent framework provided by moral vitalism beliefs provides strong theoretical support to our interpretation.

We also take the reviewers point that humans don't "need" a theory or belief system to be capable of responding to the threat of pathogens. In fact, we are careful not to argue that this is the case. Rather we argued that "threat detection in humans is improved in the presence of a theory (lay or scientific) on which to base prediction and response". We had also noted that "lay theories may not be necessary for

adaptive behavioral responses to emerge, but their presence likely reinforces, constrains, and encourages such responses.” Supportive of this point, germ theory provides a scientific framework which goes well beyond unconscious cognitive and affective mechanisms and has been very useful in dealing with the threat of disease.

Finally, as we note above, our claim is not that moral vitalism does a better job than other theories of preventing illness, but that it provides a more acute understanding of how a specific set of beliefs may have modelled pathogen transmission – because they model the process of infection and transmission in ways that other theories have not made clear. As we have acknowledged, with a focus on belief in the evil eye and witchcraft, aspects of moral vitalism are indeed evident within other explanations – so we are not trying to argue that our account uncovers the best explanation, but it does provide more nuance to the specific kinds of beliefs that may have emerged, or been reinforced, in environments characterized by high pathogen load. Consistent with this, as we note above (and now also in our discussion), our analysis provides insight into the ways in which pathogen threat shaped beliefs which have broader social implications. This goes beyond a focus on explicit explanations limited to understanding illness (such as those outlined by Murdoch, 1980), and provides an account of how pathogens may be associated with the prevalence of more general theories about the world.

## **Review 2**

***R2.1: I am generally positive about this manuscript. I like the combination of studies and I like the new thoughts about the links between conservative values and pathogen problems. I do however offer some comments and criticisms that when addressed could make for a stronger manuscript.***

We thank the reviewer for these positive and encouraging comments

***R2.2: Some critics will tell you that your analyses across cultures are faulty because you did not attend to phylogenetic closeness between cultures. I am not one of them. Nevertheless, it could be an improvement to address this directly in your discussion or introduction, perhaps referencing something like this: Thornhill, R., & Fincher, C. L. (2013). The comparative method in cross-cultural and cross-species research. *Evolutionary Biology*, 40(4), 480-493.***

This is a good point and we have now noted this in the discussion. Specifically, we have noted that in line with Thornhill & Fincher (2013) we see our failure to deal with phylogenetic closeness between cultures to be an issue for interpreting our analysis as evidence of cultural trait emergence, but not cultural trait persistence. That later is indeed sufficient for our purposes. We also note that Study 1 relies on the SCCS data set, which arguably accounts for some of these issues of non-independence.

***R2.3: I suspect some critics will take issue with the lack of treatment of measurement equivalence for your measure of moral vitalism. Perhaps you've dealt with this in Bastian et al. 2015. If that's the case then you should probably discuss it. If it isn't the case then you might want to deal with the issue. You might at least discuss why you think the scale measures the same thing for people in different cultures. I see you addressed issues of translation to other languages in a credible way.***

We agree that this is important and in response to this comment ran measurement invariance tests, finding that the moral vitalism measure has metric invariance, but that one item needed to be dropped to achieve scalar invariance. We re-ran the key analyses with the 4-item measure and found that the

results remained virtually the same (see Supplementary Materials Table S5). We refer to this in the main manuscript as well.

***R2.4: In the first sentence, you say pathogens have been a consistent threat to groups. However, the literature and theory on this focuses on individual-level adaptations, even the behavioural immune system literature.***

We have now changed this sentence to focus just on “threat to the survival and growth of humans”

***R2.5: I think you really need to include discussion of the ideas presented in Tybur et al. 2015 that says sexual strategies are the mediating factor between pathogen stress and conservative ideology. How does your idea about moral vitalism influence this conclusion? Tybur, J. M., Inbar, Y., Güler, E., & Molho, C. (2015). Is the relationship between pathogen avoidance and ideological conservatism explained by sexual strategies?. Evolution and Human Behavior, 36(6), 489-497.***

This is a good point. Tybur et al (2015) argue that conservatism arises to support more restrictive sexual strategies which avoid the transmission of infectious disease in high pathogen environments. Our argument leverages from the use of particular beliefs which are used as explanations and support effective prediction, as opposed to behavioral strategies associated with avoidance. We suggest that moral vitalism as an explanation can help to explain conservative ideologies which themselves reinforce behavioral avoidance. How this relates to sexual strategies remains somewhat of an open question to our minds. While there is no clear theoretical reason for expecting that a belief in evil forces should shape sexual behavior, there is also no clear theoretical reason for expecting that sexual strategies should lead to a specific belief in evil forces. Tybur et. al.'s (2015) sexual strategies account argues that these strategies motivated a suite of socially conservative attitudes that are strategically advantageous for those who have invested in monogamous pair bonds. While conservative ideologies broadly specified contain attitudes associated with sexual practice, a specific belief in evil forces does not (or at least does not directly). As such, it remains unclear whether these two accounts can be rectified or integrated, or whether they may represent two alternative pathways through which pathogen prevalence may have given rise to conservative ideology.

***R2.6: For study one, the introduction would be improved with some description of other ideas that have been used to explain the cultural variation in witchcraft and evil eye (e.g., Gershman, B. (2015). The economic origins of the evil eye belief. Journal of Economic Behavior & Organization, 110, 119-144 or Quinlan, R. J., & Quinlan, M. B. (2007). Parenting and cultures of risk: A comparative analysis of infidelity, aggression, and witchcraft. American Anthropologist, 109(1), 164-179).***

We can see value in this suggestion and have added both of these references to be beginning of Study 1. Although we could not discuss these alternative accounts in detail due to word limits, we have now included wealth inequality as a covariate in Study 1 drawing directly on the Gershman (2015) approach.

***R2.6: For study two, as with study one, what do we know about 'belief in the devil' and hypotheses about its cross-cultural variation? This could make the paper better to say something about this.***

We looked carefully for any research documenting variation in belief in the devil across countries / cultures. We could not find anything that specifically related to this, or which we could use to reasonably infer variation, and so we have not been able to respond to this point further. We would be happy to do so if the reviewer had any papers in mind.

***R2.7: In description of archival data for study two, you don't say you analysed the percentages of people that said they believed in the devil. Please do.***

We now make it clear that we are analyzing a binary variable reflecting proportions (and not percentages; p. 13).

***R2.8: In lines 257-261, you present results for Model 3 and then the last line of the paragraph makes a contrast but talks about Model 3. This is a little confusing so I suggest looking at how to clarify this presentation.***

The text has changed because we are no longer reporting the covariate analyses in the main manuscript, and therefore, this is no longer an issue.

***R2.9: Lines 385-387. Why not report the exact p-values?***

We now report exact p values

***R2.10: From the supplement, this sentence: "Finally, although one example of spirit aggression refers to disease demons consistent with our argument, it also codes for aggression by the spirits of ancestors, kinsmen, nature spirits, lesser divinities or higher deities or gods." I don't understand what are 'disease demons'. Do you mean 'disease as demons'?***

We had reported this verbatim from the definition provided of spirit aggression as coded in the SCCS. However, we have now replaced 'disease demons' which is not intuitively meaningful with 'supernatural beings'.

***R2.11: Supplement: you say "Therefore, in line with our argument that it is specifically the belief in an evil force which functionally models the effects of pathogens, we compared both the evil eye belief and a belief in Witchcraft to these other potential explanations." What did you find when you did this?***

We report these correlations in Table S1. We also report the association between evil-eye beliefs and pathogen prevalence and witchcraft beliefs and pathogen prevalence when controlling for these alternative explanations in Study 1 of the main manuscript.

***R2.12: Supplement: it looks like there are some significantly sex-biased samples. Can you say anything about ruling out sex-differences for your explanation? That is, I'm concerned that the bias towards a female sample may prevent you from making the more general conclusion you have made about all people. Can you address that issue?***

We controlled for gender in the regression analyses by including them as fixed effects. We also examined whether random slopes of gender would affect the predictive power of pathogen prevalence which was not the case (see Table 2, Model 3).

We hope that we have been able to satisfy the various considerations raised and feel that our paper is much stronger as a result of having this important input. We are, of course, open to further revisions if these are deemed warranted.

Yours truly

Brock Bastian

## Appendix B

First off, I should mention that I read this manuscript before looking at any of the previous reviewers' comments or the author's responses to those comments. My initial impression of the manuscript was positive, and that it certainly contributes to the literature. Some of the information did seem a bit excessive and needless, however, after reading the previous reviewers' comments and the authors responses, it made more sense. For example, the discussion of sexual strategies (Tybur et al., 2015) seemed to come out of nowhere, especially since the authors didn't see how it could be linked with moral vitalism. However, this connection reminded me of Purity pageants where daughters are equated to angels if they are virgins. They are encouraged to stay virgins, be monogamous, and to have sex only after marriage. Many religions promote these ideas too. Also, historically weren't prostitutes sometimes labeled as witches. A quick google search found some interesting ideas so perhaps, think more about the possible links between moral vitalism and sexual strategies.

The main reservation I had about the article was the abstract which can be amended easily. For example, the second sentence is very confusing, especially for readers learning about the behavioral immune system for the first time. How would they know what "early explanatory frameworks" are? I interpreted the second sentence as "We examined how conservatism developed to explain and predict the devastating effects of pathogens and the spread of infectious disease. I hope you see this sentence doesn't make sense. Rewrite. The next sentence was also confusing because of the "case in point" reference. Furthermore, the reanalysis aspect is misleading because I assumed you were going to reanalyze some studies that have previously linked disease prevalence to conservatism. What studies did you reanalyze? The abstract only references study 3, which is annoying because I was excited to see mediation analysis throughout all the three studies, but this was not the case for study 1 and 2. Related to this point, I am



guessing you have done some tests to determine if mediation is found in study 1 and 2. It would strengthen your argument if you did, but I understand that the moral vitalism question is only a proxy to your full scale, and hence, it might not be adequate to show a full mediation.

In study 1, you mentioned nothing about the sample size, just that the sample was representative. Perhaps give a bit more information about the sample range in each distinct culture. I was really confused about the ‘political and religious differentiation’ and the ‘religious and political overlap’ control variables. Do you not have separate political ideology and religious belief metrics? Separating these metrics seem far more relevant as control variables. I need more information about why you used these unusual controls. From the main report of Study 1, I don’t believe you mention what statistical analysis you ran (regression). Study 2 is much better at helping the reader understand the analysis you ran.

- In Study 1 and 2, I feel you should also report a model where all the control variables are included in the model. This full model can be put in the supplementary materials. I imagine you don’t report it because it knocks out the significant effect due to sample size and multicollinearity, but for transparency reasons, it would be nice to see. Editors need to become more accepting of results that aren’t always significant, so the results of this full model would not be grounds for rejection.
- For study 2, perhaps clearly state the prediction.
- In study 3, how much were participants reimbursements?
- Why are moral binding foundations described as antipathogen psychological tendencies when Study 3 shows that they do not relate to pathogen prevalence? Do some of the subdimensions better relate to pathogen prevalence?

- I was a bit disappointed that you didn't gather responses to the perceived vulnerability to disease scale or the three domains of disgust scale in Study 3. It would be fascinating to see moral vitalism mediate the relationship between participants fear of diseases and conservatism at the individual level. Perhaps a future study.

Below, I am referring to page X of XX.

- Page 7, Line 52: I do not know what "for this purpose" is referring to.
- Page 8 Line 87: "for which (whom?) resistance is low" By resistance are you referring to the immune system?
- Page 9, Line 104: antipathogen psychological tendencies. I find this terminology a bit confusing. Can you make it clearer? Basically, you are just describing biases humans have to avoid disease transmission.
- Page 17, Line 276: Is it not meant to be Table S6? Check throughout.
- Page 20, Line 358: Is it not Table 2?
- Page 20, Line 363: "where themselves significant predictors (add) of moral vitalism"
- Page 22, Line 405: You mention ingroup preference. This is just one of the subdimensions of moral foundation theory. Additionally, perhaps outgroup derogation is instead the driving mechanism?
- Page 21, Line 414: Rewrite/fix "specific belief system was selected for that (to) allow(ed) for the emergence of a suite of (psychological) tendencies, (such as .....), which limited pathogen transmission.
- Check that all your references are included. I could not see Tybur et al. (2015).

## Appendix C

Dear Professor Hans Heesterbeek

Re: Manuscript ID RSPB – 2019 – 1576

We are delighted to have the opportunity to submit a revision of our manuscript for consideration at Proceedings B. We have carefully detailed how we have responded to each of the queries raised by the reviewers below.

In response to directions regarding ethical protocols, we have now also noted in the participants and procedure section of Study 3 that “All samples were collected in line with relevant ethical protocols and informed consent procedures for each country”. As Studies 1 and 2 are based on publicly available data, we were not required to gain ethical clearance for these analyses.

In response to directions regarding data availability, we can confirm that we will make all our data sets available on-line once our manuscript is accepted for publication. We can update the reference to these data sets as part of editorial process, if that is acceptable?

Otherwise, we were encouraged by the positivity of the reviewers and hope that we have been able to sufficiently address all points raised. We feel that our paper is much stronger as a result of having this important input. We are, of course, open to further revisions if these are deemed warranted.

Yours truly

Brock Bastian

### Reviewer 3:

**R3.1** First off, I should mention that I read this manuscript before looking at any of the previous reviewers’ comments or the author’s responses to those comments. My initial impression of the manuscript was positive, and that it certainly contributes to the literature. Some of the information did seem a bit excessive and needless, however, after reading the previous reviewers’ comments and the authors responses, it made more sense. For example, the discussion of sexual strategies (Tybur et al., 2015) seemed to come out of nowhere, especially since the authors didn’t see how it could be linked with moral vitalism. However, this connection reminded me of Purity pageants where daughters are equated to angels if they are virgins. They are encouraged to stay virgins, be monogamous, and to have sex only after marriage. Many religions promote these ideas too. Also, historically weren’t prostitutes sometimes labeled as witches. A quick google search found some interesting ideas so perhaps, think more about the possible links between moral vitalism and sexual strategies.

**Response:** We acknowledge this reviewer found that some of the information seemed excessive and needless. We would agree, and while we have tried to be responsive to all reviewer feedback, and to cover all possible angles, the discussion had become less concise that it should have been.

For this reason (and also because expanding our discussion of Tybur further (see below) led to problems with word count, we have now provided some additional discussion points in the Supplemental Materials. We don't see these points as necessary for understanding the implications of our findings, but do provide consideration of several broader points for those who wish to read further. We think that the discussion now reads more clearly and concisely as a result.

We also thank the reviewer for pushing us to reconsider our analysis of Tybur's work, and as a result we have now changed our analysis to the following: "Second, recent work by Tybur et al. (2015) suggests that sexual strategies played a central role in reinforcing socially conservative attitudes that promoted monogamous pair bonds. We see our account as consistent with this possibility. As noted by Bastian et al. (2015), a belief in moral vitalism is associated with concerns over purity of behavior and mental content, suggesting that it may have reinforced sanctioned behavioral standards associated with sexual conduct."

**R3.2** The main reservation I had about the article was the abstract which can be amended easily. For example, the second sentence is very confusing, especially for readers learning about the behavioral immune system for the first time. How would they know what "early explanatory frameworks" are? I interpreted the second sentence as "We examined how conservatism developed to explain and predict the devastating effects of pathogens and the spread of infectious disease. I hope you see this sentence doesn't make sense. Rewrite. The next sentence was also confusing because of the "case in point" reference. Furthermore, the reanalysis aspect is misleading because I assumed you were going to reanalyze some studies that have previously linked disease prevalence to conservatism. What studies did you reanalyze? The abstract only references study 3, which is annoying because I was excited to see mediation analysis throughout all the three studies, but this was not the case for study 1 and 2. Related to this point, I am guessing you have done some tests to determine if mediation is found in study 1 and 2. It would strengthen your argument if you did, but I understand that the moral vitalism question is only a proxy to your full scale, and hence, it might not be adequate to show a full mediation.

**Response:** We thank the reviewer for this excellent feedback. We have made the following changes

1. We removed "early explanatory frameworks" and used the more direct term "spiritual beliefs".
2. We removed "case in point" and replaced with "is higher in geographical regions characterized by historical higher levels of pathogens.
3. We removed the word "reanalysis" and replaced it with "analysis". We only meant to say we were analyzing existing data and can see how our phrasing would be confusing
4. We have now referenced Studies 1 and 2 where we talk about existing data, and Study 3 where we refer to the mediation analysis. While it may have been possible to examine mediation in Studies 1 and 2, we did not run these analyses, and it would require sourcing additional variables from the data sets to use as proxy's for conservative values. Beyond not having the space to explore these additional analyses (our manuscript is only just compliant with word limits), the reviewer is correct to note that we only had proxy measures in Studies 1 and 2, making such analysis less convincing. Our main goal with these studies was to provide additional support to the main relationship we were focused on (pathogen load and moral vitalism), with the mediation analysis of secondary importance to our overall claims.

**R3.3** In study 1, you mentioned nothing about the sample size, just that the sample was

representative. Perhaps give a bit more information about the sample range in each distinct culture. I was really confused about the ‘political and religious differentiation’ and the ‘religious and political overlap’ control variables. Do you not have separate political ideology and religious belief metrics? Separating these metrics seem far more relevant as control variables. I need more information about why you used these unusual controls. From the main report of Study 1, I don’t believe you mention what statistical analysis you ran (regression). Study 2 is much better at helping the reader understand the analysis you ran.

**Response:** The SCCS is a data set based on anthropological observation of different cultures. Thus, there is not data on individuals within those cultures – so we cannot comment on sample range within each culture. The sample size is just observational data on the 186 distinct cultures, with a data point for each culture.

This may also provide an answer to the reviewer’s query about the mixture of religious and political differentiation/overlap. These are observational data coded for in anthropological records, and therefore we cannot separate the data or treat it any differently. We would need to go back to the records from which the SCCS coding is derived and code our own variables using expert coders, which would take months of work. We have stated in the manuscript that: “The SCCS includes observational data for 186 distinct cultures”. We now also state in the Supplemental Materials: “The SCCS includes observational data for 186 distinct cultures with a significant number of variables coded from these observations in the existing data set. We draw on a number of these to control for several other potential explanations for the emergence and maintenance of evil eye and witchcraft beliefs”. Hopefully this makes the nature of the data and how we used it clearer.

We have now stated that we used multiple regression analyses in the results section of Study 1.

**R3.4** In Study 1 and 2, I feel you should also report a model where all the control variables are included in the model. This full model can be put in the supplementary materials. I imagine you don’t report it because it knocks out the significant effect due to sample size and multicollinearity, but for transparency reasons, it would be nice to see. Editors need to become more accepting of results that aren’t always significant, so the results of this full model would not be grounds for rejection.

**Response:** We have now provided these analyses. For Study 2 in model 6, Table S4 and for Study 3 in model 5, Table S5. We have referred to these findings in the manuscript as well. When entering all country-level predictors simultaneously, we find that all predictors become non-significant in Study 2, but that pathogen prevalence remains the strongest predictor in Study 3.

**R3.5** For study 2, perhaps clearly state the prediction.

**Response:** We have added this at the end of the introduction to Study 2: “A belief in the Devil entails the existence of a specific evil force in the world and is therefore relevant to moral vitalism. We therefore predicted this belief would be higher in countries which historical higher levels of pathogens.”

**R3.6** In study 3, how much were participants reimbursements?

**Response:** The participants were all students and were not paid. We now state that they “participated in this study for course credit”.

**R3.7** Why are moral binding foundations described as antipathogen psychological tendencies when Study 3 shows that they do not relate to pathogen prevalence? Do some of the subdimensions better relate to pathogen prevalence?

**Response:** We have based our predictions regarding conservative values and moral binding foundations on past work which has reported a relationship between these psychological tendencies and pathogen prevalence (for binding foundations see: van Leeuwen, Park, Koenig, & Graham, 2012). While we did not replicate the van Leeuwen findings here, our predictions and rationale was based on this previous finding.

**R3.8** I was a bit disappointed that you didn't gather responses to the perceived vulnerability to disease scale or the three domains of disgust scale in Study 3. It would be fascinating to see moral vitalism mediate the relationship between participants fear of diseases and conservatism at the individual level. Perhaps a future study.

**Response:** We agree that this data would be fantastic to have, and that it would be good to focus on in our future data collection efforts

**R3.9** Below, I am referring to page X of XX.

Page 7, Line 52: I do not know what "for this purpose" is referring to.

**Response:** This has been changed to "prediction and management" referring to the purpose identified in the previous sentence.

Page 8 Line 87: "for which (whom?) resistance is low" By resistance are you referring to the immune system?

**Response:** We have changed this to "pathogens for which one's immune system resistance is low"

Page 9, Line 104: antipathogen psychological tendencies. I find this terminology a bit confusing. Can you make it clearer? Basically, you are just describing biases humans have to avoid disease transmission.

**Response:** We see this can be slightly awkward, however we need a term which captures a range of tendencies (e.g., such as holding conservative values) which may have reduced pathogen transmission. We don't think we can refer to conservative values as a bias, and so have opted to keep this terminology.

Page 17, Line 276: Is it not meant to be Table S6? Check throughout.

**Response:** Yes – thank you. We have now checked throughout.

Page 20, Line 358: Is it not Table 2?

**Response:** Yes – thank you! We have now checked throughout.

Page 20, Line 363: “where themselves significant predictors (add) of moral vitalism”

**Response:** Yes – thank you. We have amended this

Page 22, Line 405: You mention ingroup preference. This is just one of the subdimensions of moral foundation theory. Additionally, perhaps outgroup derogation is instead the driving mechanism?

**Response:** This may be possible, however given the key mechanism is a desire to stay close to one’s own group we are very much focusing on the function of the ‘binding foundations’ to hold people together. Also the literature on pathogen prevalence suggests it is a preference from close others, rather than a dislike of distant others, which fulfils the relevant function.

Page 21, Line 414: Rewrite/fix “specific belief system was selected for that (to) allow(ed) for the emergence of a suite of (psychological) tendencies, (such as .....), which limited pathogen transmission.

**Response:** We have rewritten this as follows: “Second, it provides a parsimonious account in which a specific belief system was selected to allow for the emergence of a suite of psychological tendencies (such as conservative ideologies) which limited pathogen transmission.”

Check that all your references are included. I could not see Tybur et al. (2015).

**Response:** Thank you for picking this up. We have now carefully checked all references.

#### **Reviewer 4:**

**R4.1** *This paper is remarkable. It is broadly interesting, theoretically inspired, relevant to and advancing of a major research area, and involves a range of strong tests of the central proposed hypothesis. The authors hypothesize that concepts of evil spirits (demons, devils, evil forces) and their channels (e.g., witches) originated ancestrally and were maintained through time because they connote parasite (infectious disease) cues of contagion and threat, and because they motivated cognition and behavior that functions to avoid and manage parasites. This is a very novel way to think about the causes of evil and why evil is a feature of the cultural repertoire across societies and time. There is a major body of theory and evidence (the parasite-stress theory) that identifies parasites as important in explaining human core values, religiosity, and many aspects of human social life. This paper expands that body of research in creative and relevant ways. It also reveals that it is not enough to explain evil as simply some correlated ideation that tags along with religiosity. Instead, conception of evil may be a functional part of disease defense (part of psychological and behavioral immunity). Empirically, through three studies, the paper examines three predictions of the central hypothesis. The central prediction is that, across regions, belief in various evil forces will covary positively with parasite stress. These are all novel tests. The empirical part of the research includes analyses across traditional / indigenous societies (Standard Cross Cultural Sample), World Values Survey data, and a questionnaire study of 3,200 people in 32 countries. The results of the various tests all support the central hypothesis (the parasite hypothesis of evil spirits). The control variables used in the testing are explained very well.*

*Furthermore, the authors understand the phylogenetic issues relevant to confounding in cross-cultural tests (as explained in detail by Thornhill & Fincher 2014, cited in the paper).*

*The paper is well written and prepared.*

*The research is of interest to scholars broadly: evolutionary biologists and ecologists interested in human behavior and psychology, cross-cultural psychologists and anthropologists.*

**Response:** We thank the reviewer for both a concise and insightful review of our paper and also their positive comments regarding the theoretical implications, novelty, and the level of evidence provided.

**R4.2** I have no significant criticisms of this paper. I add here a few thoughts that may be of interest to the authors in their future research in this area; these topics do not need to be considered for this paper. Spirits are of two categories: good and evil. If we accept the authors' explanation of evil spirits, then what about the benevolent ones that also are ubiquitous cross-culturally? Is it enough to say they are associated with purity and hence low disease threat? I don't think so, because religiosity and belief in a god(s) that do some nice things is in all religions, major and minor. We know that religiosity covaries strongly with parasite stress (Fincher & Thornhill's cited work in the paper). So, belief in good spirits and belief in evil spirits show the same relationship with parasites.

**Response:** This is a very insightful and important comment. We would note that our moral vitalism scale used in Study 3 does focus on belief in both good and evil forces. The reviewer is also right to point out the link between religion in general and parasite stress – suggesting that a belief in good forces covaries with parasite stress (not a lack of it) – and this is again consistent with our data in Study 3.

While we note the reviewer does not ask us to provide further reflection on this in the paper, we provide one such reflection here. In our work on moral vitalism we have come to see that a belief in evil forces is much more powerful than a belief in good forces. The fact that people place a greater emphasis on negative or bad things is a very well-known finding elsewhere in the literature. To this extent, it may be that a belief in evil is the more powerful (explanatory) belief, than a belief in good. That said, a belief in God is important – yet, this may be less about explanation and more about reassurance, and perhaps a belief in forces of good provides a more palliative than explanatory function. That said, we see this as a fruitful avenue to further inquiry and were encouraged by the reviewers' engagement with these ideas.

**R4.3** This paper is complete enough as it is. I wondered, however, why the authors did not mention the history of major plagues and their explanation by evil forces. Witches are a cause of the Black Death, e.g.; witch hunts to remove the disease channels, too.

**Response:** This is an excellent example. Due to being at the outer limit in terms of word length, we have not been able to expand on this. We have, however, now mentioned it as a case in point when we discuss the reliance on supernatural forces to explain illness and disease in the introduction (line 59)

**R4.4** Also, is moral vitalism the best label for the theory? Vitalism is just a transcendental force. It need not be harmful, right? Perhaps Bastion's earlier papers on the topic explain this.

**Response:** Again, we are encouraged by this reviewer's engagement with the theory and ideas. We have developed the term Moral Vitalism (in past work) and used vitalism because it relates to the lay belief that there are natural forces in the world. We added to this the term moral to denote our contribution, which is the idea that these forces can be moralized – both good and evil. It is the moralization, and therefore the notion of evil forces, which brings in the possibility of harm, we believe.