

*Invited reply*

## Further evidence for regional variation in women's masculinity preferences

In our original paper [1], we demonstrated a relationship between a measure of national variation in health and women's preferences for male facial masculinity, but we also suggested that income inequality, among other variables, might be an important predictor of regional variation in women's preferences for masculine men. We are delighted that Brooks and colleagues [2] have used our published data to further explore this idea. Our original aim was to demonstrate that ecological factors affecting the trade-off between the benefits and costs associated with choosing a masculine mate can predict variation in women's preferences for masculine men. While our paper focused on one aspect of the trade-off (health), Brooks and colleagues' response focuses on another potentially important aspect of the trade-off (male–male competition).

Their analyses raise interesting questions and clearly demonstrate that income inequality, homicide rates and national health are all very good predictors of variation in women's masculinity preferences among countries. However, Brooks and colleagues also make the strong claim that indices of male–male competition, rather than health (or both), mediate the relationship between income inequality and national preference for masculine faces (NPMF). Here, we present additional analyses of the original data that suggest the evidence for this claim may be somewhat fragile. Additionally, we present new data from the USA that suggest income inequality is not always a better predictor of regional variation in women's masculinity preferences than is health.

Brooks and colleagues acknowledge that the relationship between income inequality and NPMF could come about through the effect of income inequality on health. Nonetheless, they conclude that indices of male–male competition, rather than health (or both), mediate the relationship between income inequality and NPMF. Their evidence for this claim is a multiple regression analysis in which homicide rate predicts NPMF, but the national health index (NHI) does not. However, a regression analysis that we have conducted including homicide rate and NHI, while also controlling for the effects of variation in wealth (gross national product, GNP, as used in [1]), reveals significant effects of NHI (std  $\beta = -0.554$ ,  $t = -2.38$ ,  $p = 0.025$ ) and GNP (std  $\beta = 0.613$ ,  $t = 4.51$ ,  $p < 0.001$ ), but not homicide rate

(std  $\beta = 0.153$ ,  $t = 0.68$ ,  $p = 0.50$ ). Moreover, adding NHI to a model consisting of homicide rate and GNP causes a significant increase in the  $R^2$  ( $R^2$  change = 0.070,  $F_{1,26} = 5.67$ ,  $p = 0.025$ ), indicating that NHI explains variance in NPMF that is not explained by homicide rate and GNP. In contrast, adding homicide rate to a model consisting of NHI and GNP does not cause a significant increase in the  $R^2$  ( $R^2$  change = 0.006,  $F_{1,26} = 0.46$ ,  $p = 0.50$ ), indicating that homicide rate does not explain any variance in NPMF over and above that which is explained by NHI and GNP. Collectively, these results suggest that the claim that indices of male–male competition, rather than health (or both), mediate the relationship between income inequality and NPMF should be treated somewhat cautiously; analyses that also consider the effects of regional variation in wealth lead to very different conclusions about the role of national health.

While the analyses described above call into question Brooks and colleagues' strong claim that indices of male–male competition, but not health (or both), mediate the relationship between income inequality and NPMF, we do not at all dispute that Brooks and colleagues' analyses show that income inequality is a better predictor of variation among countries in women's masculinity preferences than is health (though we note that income inequality and health are highly correlated). In light of this interesting new analysis, we investigated whether income inequality is also a better predictor of regional variation in women's masculinity preferences than either health or homicide rates in a different sample of women.

Using identical methods to our original paper, we collected masculinity preferences from 8338 women in the USA and calculated the average masculinity preference for each state. Additionally, we calculated a state health index (SHI) for each state using age-adjusted mortality rates owing to illness and disease (i.e. excluding mortality owing to accidents, homicide and suicide; see electronic supplementary material, S1). As with the NHI in our original paper, high values on the SHI indicate low mortality. We also obtained measures of income inequality, fertility rate, wealth and homicide rates (see electronic supplementary material, S2 for correlations among these variables).

First, we analysed these data following Brooks and colleagues' stepwise regression analysis. Including SHI, income inequality, fertility rate and wealth as predictors, the best model (fitted to weighted data by forward stepwise regression) includes only an intercept and SHI (adj  $R^2 = 0.144$ ,  $F_{1,48} = 9.23$ ,  $p = 0.004$ ; SHI std

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$\beta = -0.402$ ,  $t = -3.04$ ,  $p = 0.004$ ; all variance inflation factor (VIF)  $< 1.03$ , indicating multi-collinearity is not an issue here) and no other terms. Next, we repeated this analysis with homicide rate in place of income inequality. This analysis showed the same pattern of results as our initial analysis (electronic supplementary material, S3). Repeating both of these analyses using regression models in which all of the predictors were entered simultaneously using the enter method revealed the same pattern of results; SHI was a better predictor of masculinity preferences than any of the other variables (electronic supplementary material, S3). Collectively, these results show that the SHI is a considerably better predictor of variation in women's masculinity preferences among US states than income inequality or homicide rate.

Brooks and colleagues' analysis of our original data [1] suggests that income inequality is a better predictor of regional variation in women's masculinity preferences than health is and that the relationship between income inequality and masculinity preferences is mediated by indices of male–male competition, rather than health (or both). Our new analyses of national variation in masculinity preferences suggest that the evidence for the latter claim may be somewhat fragile; controlling for the effects of GNP alters the conclusions that can be drawn about the role of national health and the role of income inequality. Additionally, our analyses of new data suggest that regional variation in masculinity preferences among women in the USA is better explained by health than by income inequality or homicide rate. While Brooks and colleagues suggest that health factors may be relatively unimportant for explaining regional differences in masculinity preferences compared with indices of male–male competition, our analyses of both the original and new data suggest this is not necessarily the case—measures of health relate to masculinity preferences in both samples.

Of course, the relationship between mate preferences and indices of health and male–male competition may not be identical across all regions. For example, indices of health and/or male–male competition may explain different amounts of the variance in mate preferences among regions depending on the range of pathogen load, violence or other factors. Moreover, it is difficult to draw strong conclusions about which environmental factor is the best predictor of regional variation in mate preferences when predictors are highly correlated. We propose that analyses of additional samples and, perhaps more importantly, the use of experimental methods to manipulate perceptions of environmental factors relating to health and/or male–male competition will shed further light on these issues and be fruitful directions for future research. Investigating how perceptions of pathogens and/or violence predict systematic variation in mate preferences among individual women within a given region

or culture may also provide insight into these issues (e.g. [3,4]). Indeed, a recent study [5] demonstrated that women's preferences for masculinity in male faces, but not female faces, increased after viewing images with pathogen cues, but did not change after viewing matched images without pathogen cues.

While we agree that identifying the specific factors that best predict regional variation in women's masculinity preferences is certainly important, it is critical not to lose sight of the fact that all of the analyses of regional variation in women's masculinity preferences presented here, in Brooks and colleagues' comment and in our original paper, clearly show that variation in women's masculinity preferences is systematic, rather than arbitrary. More importantly, they all show that this variation occurs in ways that are highly consistent with trade-off theories of sexual selection.

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