Psychoneuroendocrinology (2015) xxx, xxx—xxx

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REPLY TO LETTER TO THE EDITOR

Testosterone—cortisol interactions and risk-taking: A reply to Hayes et al.

We thank Hayes and colleagues for their comments on the first studies to examine interactive effects of cortisol and testosterone on risk-taking (Mehta et al., 2015). We look forward to experimental research testing the causal relationships we propose. In our analyses, we controlled for time of day, and further, we now note that the time does not interact with our reported dual-hormone interactions (*ps* > .112). Although the wider timespan of data collection may increase error variance, this would more likely obscure the interactive effects we report rather than contribute to their occurrence. In Study 2, due to informed consent, participants knew in advance they would be completing a computerized game (the Balloon Analog Risk Task), although they were not informed of the name of the measure or that it was a measure of risk-taking. However, in Study 1, the possibility of hormones reflecting an anticipatory rise is less likely, as the study measured baseline hormone concentrations and risk-taking personality on different days.

Hayes et al. suggested that testosterone differences in gender and race/ethnicity may have influenced our results. However, as reported in the paper (see Section 1.2.3 as well as footnote 3), the pattern of results was similar in men and women (Study 1; Mehta et al., 2015). For race, the work Hayes and colleagues cite (Litman et al., 2006) does not report any significant differences in serum or bioavailable testosterone differences among Blacks, Hispanics, and Caucasians using a large sample size ($N = 1881$). If racial differences in testosterone exist but are undetected in such a large sample size, the differences are likely slight and of negligible influence on our data. Because of our predominantly Caucasian samples, any effects of racial differences in testosterone would have to be extremely large to systematically influence our results. Nevertheless, we did examine if differences between Caucasians and non-Caucasians existed for cortisol, testosterone, and our risk-taking measures in each study, but none were found (*ps* ≥ .380). Furthermore, controlling for whether participants were Caucasian did not alter the significance of our reported Testosterone × Cortisol interactions (*ps* ≤ .040), and moderated regression analysis testing 3-way Race × Testosterone × Cortisol interactions revealed that Caucasian status did not moderate our reported dual-hormone interactions (*ps* ≥ .307).

Hayes and colleagues also state our conclusion is unsubstantiated due to lack of statistical significance in a simple slope test from Study 2 ($p = .051$). However, Study 2 did report a statistically significant Testosterone × Cortisol interaction ($p = .008$), which was our key hypothesis (the dual-hormone hypothesis). Furthermore, building on the limitations of null hypothesis testing (NHST), statisticians strongly recommend effect size estimation with confidence intervals and meta-analyses to derive scientific conclusions rather than null hypothesis testing in individual studies (Cumming, 2008, 2012). Accordingly, we report an internal meta-analysis across both studies detecting a moderately sized Testosterone × Cortisol interaction effect with a statistically significant positive slope among low-cortisol individuals but not high-cortisol individuals. In 11 other studies, Testosterone × Cortisol effects on outcomes other than risk-taking mirror those of the present research (Mehta and Prasad, in press). Given the accumulation of research suggesting interactive dual-hormone effects, the replicable interactive pattern across two studies, consistent medium effect sizes of these interactions, and the internal meta-analysis in our paper, these results are likely not a false positive. We hope these statistical advances within psychology inspire psychoneuroendocrinologists to move beyond exclusive reliance on traditional NHST to advance psychoneuroendocrinology as a cumulative, quantitative science. In conclusion, we thank Hayes and colleagues for their interest in our paper, which has led us to conduct additional analyses that strengthen the contribution of this research.

Conflicts of interest

None declared.

Acknowledgments

Pranjal Mehta is supported by a National Science Foundation grant (#1451848). The funding sponsor was not involved in the writing of this letter or in the decision to submit it for publication.

http://dx.doi.org/10.1016/j.psyneuen.2015.05.012

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20 May 2015