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The evolution of predictive adaptive responses in humans: response

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We welcome the generalization by Del Giudice [1] of our model investigating the evolvability conditions for predictive adaptive responses (PARs) in long-lived species like humans [2]. In our original approach, environmental conditions in 1 year were modelled as the sum of the conditions in the previous year plus a perturbation term to represent exogenous sources of change. The perturbation terms were independent from year to year. If the exogenous perturbation forces are themselves temporally autocorrelated, then environmental change is described by a more complex autoregressive structure than the one used in our original model, one in which conditions in the current year are influenced by conditions in the previous year and the one before that. Del Giudice shows that when dependencies between successive years take this more complex form, the present becomes in effect a better guide to the future than it would otherwise have been. This makes the external PAR (using conditions experienced early in ontogeny as a guide to the likely adult external environment) an adaptive strategy under a somewhat wider range of conditions than those we originally reported.

The objective for our paper was to galvanize theoretical progress in an area where adaptive hypotheses have been discussed for some time without agreement about whether they are likely to be right, and without exposure of the precise assumptions on which they depend. We recognize that our initial model was not exhaustive; it provided a contribution, hopefully, to the eventual construction of a whole library of related models examining how developmental trajectories might evolve under different environmental regimes. It will be this library of cases taken together—rather than any single one—that will lead to general understanding. The modelling endeavour is also not isolated from empirical work. To quote George Box, who died in 2013, ‘science is a means whereby learning is achieved, not by mere theoretical speculation on the one hand, nor by the undirected accumulation of practical facts on the other, but rather by a motivated iteration between theory and practice’ [3, p. 791]. Our model aimed to make an initial bridge between adaptive hypotheses about PARs, on the one hand, and empirically measurable features of the environments inhabited by humans, on the other. Del Giudice’s model is welcome because it creates a second iteration, incorporating more detailed information about how environments vary to refine the model. We hope that his paper and ours will stimulate greater empirical research on environmental variation as experienced by individuals and populations (something that has also been called for elsewhere [4]). It may well be that some environmental forces are well captured by our original model, whereas others are not so well captured and require more complex specifications. Future empirical work will make this clearer.

An even more important thing that George Box taught us was to ‘remember that all models are wrong; the practical question is how wrong do they have to be to not be useful’ [5, p. 74]. Our model contained a highly simplified representation of how organisms experience the early environment and how that environment might change. Our main conclusions were that, for a long-lived organism, there is only adaptive advantage to using early life as an indicator of the adult environment if (1) the level of annual autocorrelation in the

environment is very high, and (2) the cues of environmental conditions received in early life are very accurate indicators of the present conditions. Del Giudice shows that allowing for delayed effects in environmental change leaves these two conclusions qualitatively intact, though the precise numbers change. Examining Del Giudice's fig. 1, panels (c) and (d) show that even where strong delayed effects are included, the adaptive advantage of plasticity is found only in the top right quadrant of the parameter space. The quantitative details of our evolvability criteria might need amending if the environmental factor under study were shown to exhibit strong delayed effects; where we specified an annual autocorrelation of at least 0.95, in fact 0.80 might be sufficient. Though this amendment is important, both models concur that there would have to be strong positive annual autocorrelation (not 0, 0.2 or 0.5, for example) coupled with high cue validities. When models using different assumptions come to qualitatively similar conclusions, it adds to our confidence

about the robustness of those conclusions. We also note that quite different modelling approaches have recovered conclusions that are in some ways similar to ours [6–8]. Thus, we stick by our contention that conclusions (1) and (2) constrain the plausibility of the idea that humans use early-life cues to gain information about the likely external environment in adulthood, and reiterate our call to examine accommodation to the directly detrimental effects of early adversity on health as an alternative explanation of observed phenomena [9].

There has been a flurry of recent papers trying to test empirically what can broadly be characterized as PAR hypotheses. These are very diverse in design, character and results. Some find the predicted effects, while many do not [10–14]. Being more precise about the assumptions of the theory may help understand what the exact predictions are for particular systems and particular traits, and, especially, when we should expect to find PARs and when we should not.

References

1. Del Giudice M. 2014 Life history plasticity in humans: the predictive value of early cues depends on the temporal structure of the environment. *Proc. R. Soc. B* **281**, 20132222. (doi:10.1098/rspb.2013.2222)
2. Nettle D, Frankenhuys WE, Rickard IJ. 2013 The evolution of predictive adaptive responses in human life history. *Proc. R. Soc. B* **280**, 20131343. (doi:10.1098/rspb.2013.1343)
3. Box GEP. 1976 Science and statistics. *J. Am. Stat. Assoc.* **71**, 791–799. (doi:10.1080/01621459.1976.10480949)
4. Via S, Gomulkiewicz R, De Jong G, Scheiner SM, Schlichting CD, Van Tienderen PH. 1995 Adaptive phenotypic plasticity: consensus and controversy. *Trends Ecol. Evol.* **10**, 212–217. (doi:10.1016/S0169-5347(00)89061-8)
5. Box GEP, Draper NR. 1987 *Empirical model building and response surfaces*. New York, NY: John Wiley.
6. Baig U, Belsare P, Watve M, Jog M. 2011 Can thrifty gene(s) or predictive fetal programming for thriftiness lead to obesity? *J. Obes.* **2011**, 861049. (doi:10.1155/2011/861049)
7. Moran NA. 1992 The evolutionary maintenance of alternative phenotypes. *Am. Nat.* **139**, 971–989. (doi:10.1086/285369)
8. Leimar O, Hammerstein P, Van Dooren TJM. 2006 A new perspective on developmental plasticity and the principles of adaptive morph determination. *Am. Nat.* **167**, 367–376. (doi:10.1086/499566)
9. Rickard IJ, Frankenhuys WE, Nettle D. 2014 Why are childhood family factors associated with timing of maturation? A role for internal prediction. *Perspect. Psychol. Sci.* **9**, 3–15. (doi:10.1177/1745691613513467)
10. Storm JJ, Lima SL. 2010 Mothers forewarn offspring about predators: a transgenerational maternal effect on behavior. *Am. Nat.* **175**, 382–390. (doi:10.1086/650443)
11. Uller T, Nakagawa S, English S. 2013 Weak evidence for anticipatory parental effects in plants and animals. *J. Evol. Biol.* **26**, 2161–2170. (doi:10.1111/jeb.12212)
12. Hayward AD, Rickard IJ, Lummaa V. 2013 Influence of early-life nutrition on mortality and reproductive success during a subsequent famine in a preindustrial population. *Proc. Natl Acad. Sci. USA* **110**, 13 886–13 891. (doi:10.1073/pnas.1301817110)
13. Hayward AD, Lummaa V. 2013 Testing the evolutionary basis of the predictive adaptive response hypothesis in a preindustrial human population. *Evol. Med. Public Health* **2013**, 106–117. (doi:10.1093/emph/eot007).
14. Sandman CA, Davis EP, Glynn LM. 2012 Precocious human fetuses thrive. *Psychol. Sci.* **23**, 93–100. (doi:10.1177/09567976.11422073)