Individual-specific mortality is associated with how individuals evaluate future discounting decisions

Authors:

Anthony J. Lee[1], Lisa M. DeBruine[1], Benedict C. Jones[1]

Author affiliations:

[1] Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, Scotland, United Kingdom.

Corresponding author:

Anthony J. Lee: anthony.lee@glasgow.ac.uk

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Abstract

How organisms discount the value of future rewards is associated with many important outcomes, and may be a central component of theories of life-history. According to life-history theories, prioritising immediacy is indicative of an accelerated strategy (i.e., reaching reproductive maturity quickly and producing many offspring at the cost of long-term investment). Previous work extrapolating life-history theories to facultative calibration of life-history traits within individuals has theorised that cues to mortality can trigger an accelerated strategy; however, compelling evidence for this hypothesis in modern humans is lacking. We assessed whether country-level life expectancy predicts individual future discounting behaviour across multiple intertemporal choice items in a sample of 13,429 participants from 54 countries. Individuals in countries with lower life expectancy were more likely to prefer an immediate reward to one that is delayed. Individuals from countries with greater life expectancy were especially more willing to wait for a future reward when the relative gain in choosing the future reward was large and/or the delay period was short. These results suggest that cues to mortality can influence the way individuals evaluate intertemporal decisions, which in turn can inform life-history trade-offs. We also found that older (but not very old) participants were more willing to wait for a future reward when there is a greater relative gain and/or shorter delay period, consistent with theoretical models that suggest individuals are more future-orientated at middle age.

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Organisms tend to favour immediate rewards over delayed rewards, even when the delayed reward may be larger (1). This discounting of future gains (also known as temporal discounting) is thought to be due to the inherent uncertainty associated with future rewards (2). As such, when faced with a choice between a smaller, immediate reward, or a larger, delayed reward, it can be more beneficial to capitalise on the immediate reward rather than to wait for a larger award that may not materialise. The ability to navigate these intertemporal decisions is associated with many important outcomes in humans; for instance, future discounting is associated with education attainment (3) and predicts cognitive and attentional competencies (4), as well as well-validated relationships with health-related outcomes, such as obesity (5) and addiction (6).

How organisms discount the value of future rewards may be integral to evolutionary theories of life-history trade-offs. An organism adopting an *accelerated* life-history strategy, characterised by fast reproductive development, quick senescence, and producing more offspring at the cost of investment in those offspring (7), could be interpreted as that organism prioritising immediacy (2). Indeed, future discounting is thought to influence mating and foraging strategies in many species (e.g., 8, 9). In humans, men are found to engage more in future discounting compared to women (10), which is consistent with predictions from life-history theories (2), and the propensity to discount the future has been associated with traits relevant to life-history theories (e.g., age of first sexual activity and relationship fidelity; 3).

Some research has extrapolated life-history theories to predict facultative adjustments of life-history traits within individuals in response to external factors. For instance, ecological unpredictability has been associated with increased future discounting and risk-taking behaviour (11-13). Similarly, early-life environmental harshness has been found to be associated with life-history traits and appears to carry through into adulthood (14). While individuals adopting an accelerated life-history strategy under “harsh” conditions has become a popular hypothesis, we note that this may be over-simplistic (i.e., the optimal life-history strategy may not be the same for all individuals in a given environment), and whether the hypothesis is supported by life-history theory itself is debated (see 15).

Another external factor proposed to lead individuals to adopt an accelerated strategy is high local mortality (e.g., 2, 16). This is thought to be because environments where mortality is high can lead organisms to prioritise immediacy in order to capitalise on fitness opportunities before the increased likelihood of death. In humans, previous cross-national research has used country-level life expectancy as a proxy for cues to mortality, and has provided insight into individual variation in life-history traits; for instance, country-level mortality is associated with a younger average age of first birth (17-20) and more violence and intrasexual competition (21), which could be interpreted as an evolved strategy of prioritising immediacy in these ecologies.

In a recent study, Bulley and Pepper (22) reported that countries with a lower life expectancy were more likely to have a higher proportion of individuals who favour an immediate reward over a larger, delayed reward. However, while Bulley and Pepper (22) demonstrated that ecological cues to mortality may influence propensity to discount future rewards, there are methodological limitations that restrict the study’s conclusions. First, Bulley and Pepper (22) measured future discounting using a single binary choice item (23). Previous research has indicated that the likelihood an immediate reward is chosen over a larger, delayed reward depends on the length of delay, and also the difference in relative gain between the immediate and delayed reward (10). This type of variation cannot be captured with a single item; as such it is still unclear whether ecological cues to mortality influence how individuals evaluate the length of delay period vs. the relative gain of the future reward, or whether individuals from countries with lower life expectancy simply favour immediacy overall.

Second, Bulley and Pepper (22) used aggregated proportions of future discounting choice for each country and overall country-level life expectancy in their analysis; therefore, they are unable to make inferences about the behaviour of individuals (assuming country-level and individual-level data show the same pattern is known as the ecological fallacy; 24, 25). However, we do note that a similar effect has been shown at an individual level, where cues to mortality are associated with preference for an immediate reward over a future reward (26-28).

If future discounting underpins life-history strategies, we can also predict sex and age differences in future discounting behaviour to emerge. Given that male reproductive success is more variable than that of female reproductive success and that men (on average) face higher senescence, men are more likely to benefit from capitalising on immediate opportunities compared to women (e.g., capitalising on immediate mating opportunities can be highly advantageous for men, while for women it may be more advantageous to wait for a high quality mate), we could predict men would engage in future discounting more compared to women. This would be consistent with previous a meta-analysis suggesting women are more likely to delay gratification (29, but see 30). However, straightforward predictions of age effects on future discounting are less clear; some models predict future discounting to increase with age as potential time to exploit future rewards decreases, other models predict younger individuals to prefer immediacy as they are more vulnerable during development (for a review, see 2), while some theoretical modelling suggests that discounting should be at its lowest during middle age (31).

Here, we test the influence of ecological cues to mortality and future discounting behaviour in a large, cross-country, online sample (N = 13,204 from 54 countries). Participants completed nine intertemporal choice items that varied in the relative difference in gains between the immediate and future rewards and the delay period of the future reward (32). We hypothesise that country-level life expectancy is positively associated with preference for a larger, future reward compared to a smaller, immediate reward. If ecological mortality influences how individuals evaluate intertemporal choices, we would also expect country-level life expectancy to interact with a discounting parameter that quantifies the relative gain in choosing the future reward compared to the delay period. To address the ecological fallacy, we also conducted an additional model using individual-specific life expectancy statistics (i.e., age-, sex-, year-, and country-specific life expectancy for each participant). We also test for a sex effect, as well as linear and non-linear age effects, on future discounting as predicted by life-history theories.

Method

Participants

Participants were online volunteers that completed the future discounting task at www.faceresearch.org between 2006 and 2017. Participants were recruited by following links from social bookmarking websites (e.g., stumbleupon.com) and were not compensated for participation. Online data has been used in many previous studies of regional differences in human behaviour (e.g., 33, 34). The full sample included 16,065 participants from 120 countries. Participants who did not report their country of residence (N = 2141), age (N = 119), reported an unrealistic age (< 6 years or > 100 years, N = 69), or did not identify as either male or female (N = 97) were removed from analyses. Analyses were restricted to participants from countries with at least 10 participants to aid in model convergence, which removed an additional 183 participants. Participants from an additional two countries were removed because country-level statistics were not available (N = 27). The final sample included in analyses was 13,429 participants from 54 countries (M = 24.85 years, SD = 9.24 years, min = 6.20 years, max = 91.50 years).

Future Discounting Measure.

Future discounting was measured using the intertemporal choice task in Wilson and Daly (35). This involved nine trials where participants were presented with a choice of either choosing a specified amount “tomorrow” or a larger amount (difference ranging from $1 to $25) after a delay (ranging from 7 days to 186 days). For each trial a discounting parameter (k) was calculated such that:

$$k = (\text{future\$} - \text{tomorrow\$})/((\text{delay(in days)} \times \text{tomorrow\$}) - \text{future\$}) \quad (1)$$

Larger *k* values indicate a greater future reward relative to the immediate reward with a shorter wait period (32). Across the 9 trials, *k* ranged from 0.000159 (equivalent to $34 tomorrow or $35 in 186 days) to 0.404255 (equivalent to $11 tomorrow or $30 in 7 days). Hypothetical intertemporal choice items have been shown to be comparable to those with actual monetary rewards (36); however, this is debated (37).

Country-Level Statistics

Participants reported their current country of residence. Following Bulley and Pepper (22), the geographical region of each country was taken from the World Bank's "Country and Lending Groups" classifications (38). This was included in the model to control for potential non-independence between countries based on geographical location (e.g., similar climate, cultural history, see 24). For more detailed descriptive statistics for the country-level data, including number of participants per country, and mean life expectancy and GDP for participants in our sample, please see the supplementary materials.

Life Expectancy. The average life expectancy for each country refers to the statistical average time in years an individual in that country is expected to live if mortality rates remain steady. This statistic is often used to reflect quality of healthcare in countries. Both overall life expectancy at birth, and individual-specific life expectancy (i.e., age-, sex-, year- and country-specific life expectancy for each participant) were obtained from the World Health Organisation data repository (39). At the time of data analysis, life expectancy statistics were available for every year of data collection up to 2015. For data collected in a year where a life expectancy statistic for that country was not available, the statistic for the closest available year for that country was used (never more than two years). Age specific life expectancy statistics for each country were available in 5-year groups.

Gross Domestic Product. Gross domestic product (GDP) refers to the monetary value of all final goods and services produced within a country's market in a year. GDP is often used as an indicator for a country's wealth. GDP for each country was obtained from The World Bank (40). At the time of data analysis, GDP was available for every year of data collection up to 2016. Similar to with life expectancy, for data collected in a year where GDP was not available, the value for the closest available year for the country was used (never more than one year).

Statistical Analysis

Data were analysed using binomial linear mixed effect modelling using the lme4 (41) and lmerTest (42) packages in the R statistical software (43). For both models using overall life expectancy and individual-specific life expectancy, the outcome variable was whether the immediate (tomorrow) or delayed (future) choice was chosen in a given trial (coded 0 and 1 respectively). For the overall life expectancy model, separate country-level statistics within a country were used according to the year a participant completed the discounting measure. For the model including individual-specific life expectancy, given that years of life remaining and age are very highly correlated (leading to issues of multicollinearity), years already lived were included in individual-specific life expectancy. All predictors were z-standardised at the appropriate group-level (i.e., country level for overall life expectancy and GDP, trial level for the *k*-parameter) before being entered into the analysis. To aid model convergence, all outlier values on life expectancy (overall and specific) and GDP were windsorised (±3 *SD*). To assess the influence of the predictors on how individuals evaluate intertemporal decisions, an interaction term was added between both life expectancy and GDP, and the *k*-parameter. Participant sex (coded as -.5 for female and .5 for male), linear and non-linear effects of age, and their interactions with the *k*-parameter were also included in both models. To account for non-independence, random intercepts were specified for each trial, participant, country, and region, and random slopes were specified maximally following recommendations in Barr, Levy (44) and Barr (45). The fixed effects for both models are reported here; for full model specifications and full output for this analysis, including the estimated random effects, see the supplementary materials. The dataset and analysis code supporting this article can be accessed at https://osf.io/xyc8j.

Results

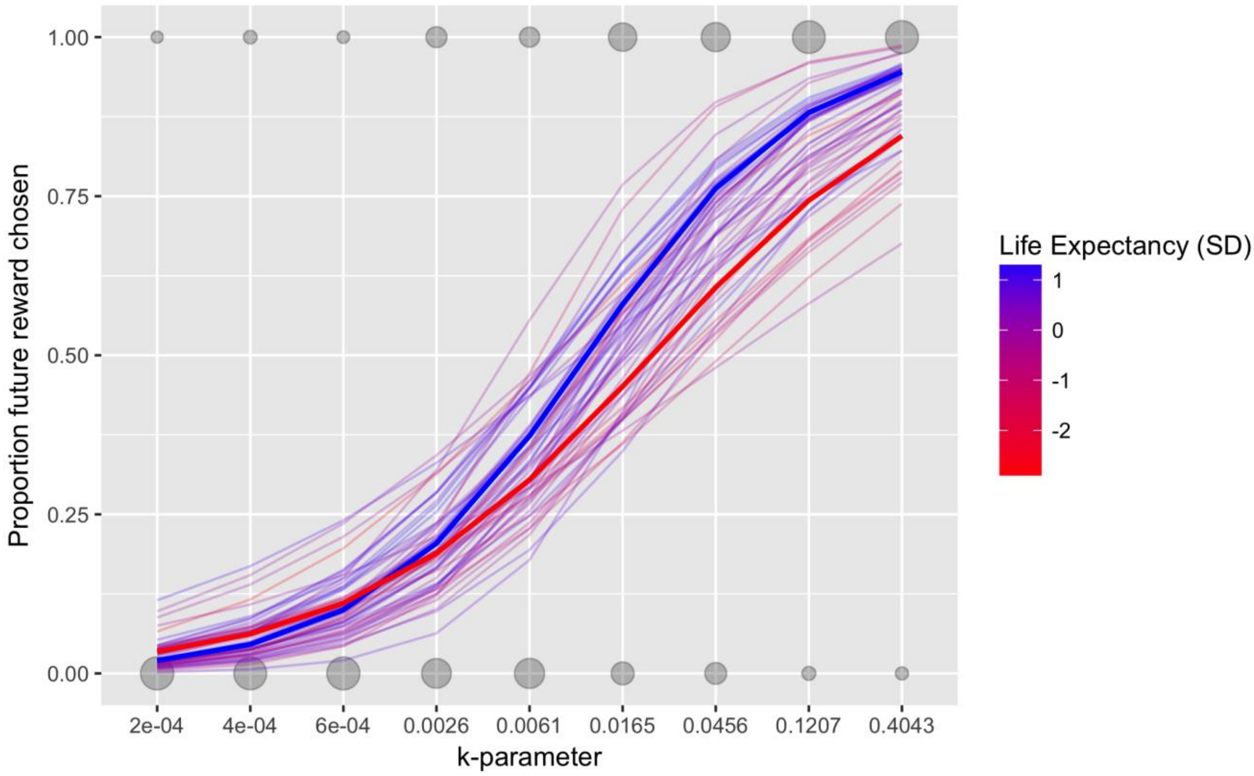
The models predicting whether a larger, future reward was chosen over a smaller, immediate reward using overall country life expectancy and individual-specific life expectancy are reported in Table 1. For both models, when random slopes were maximally specified, the model failed to converge, as such, random slopes for covariates and respective interactions were omitted (GDP), as recommended in Barr (45).

The model intercepts were both negative (significant in the individual-specific life expectancy model), suggesting that participants tended to favour the immediate reward over the future reward. As should be expected, there was a significant main effect of the *k*-parameter in both models, such that the future reward is more likely to be chosen when the relative gain is greater and the delay time is shorter. Consistent with predictions, in both models we found a significant positive effect of life expectancy on choosing the greater, delayed reward. Also, there was a significant interaction between life expectancy and the *k*-parameter in both models, suggesting that when the relative gain was large with a short delay period, individuals from countries with greater life expectancy were more willing to wait for a future reward (see Figure 1).

Table 1. The fixed effects for the mixed effect models predicting whether the future reward was chosen over the immediate reward using overall country life expectancy (left) and individual-specific life expectancy (right).

	Overall Country Life Expectancy			Individual-Specific Life Expectancy		
	Estimate (Std Error)	z value	p value	Estimate (Std Error)	z value	p value
Intercept	-.67 (.66)	-1.00	.316	-.71 (.29)	-2.50	.013*
k-parameter	3.11 (.62)	5.03	<.001***	5.40 (.23)	23.16	<.001***
Life Expectancy	.74 (.15)	4.86	<.001***	.28 (.11)	2.60	.009**
GDP	.15 (.12)	1.28	.202	.20 (.12)	1.69	.092
Participant Sex	.04 (.12)	.33	.738	.42 (.17)	2.50	.013*
Participant Age	.22 (.04)	5.36	<.001***	.20 (.04)	5.02	<.001***
Participant Age^2	-.02 (.02)	-.91	.360	-.01 (.02)	-.36	.716
k-parameter * Life Expectancy	.94 (.36)	2.58	.010**	.59 (.24)	2.46	.014*
k-parameter * GDP	.09 (.07)	1.23	.218	.12 (.04)	3.18	.001**
k-parameter * Participant Sex	.22 (.42)	.53	.597	1.14 (.49)	2.34	.019*
k-parameter * Participant Age	.22 (.06)	3.78	<.001***	.22 (.05)	4.63	<.001***
k-parameter * Participant Age^2	-.19 (.02)	-8.83	<.001***	-.10 (.04)	-2.60	.009**

Figure 1. Proportion of times the future reward is chosen over the immediate reward across multiple trials with varying k-parameter. The size of the circles represents number of times the future (top) or immediate (bottom) reward was chosen for each trial. Thick lines represent the binomial linear regression from countries above (blue) and below (red) the mean on life expectancy (across year and participants). Thin lines represent the binomial linear model for each country.



Both models also found a significant main effect of age, such that older participants were more likely to choose the future reward. Both linear and non-linear effects of participant age also significantly interacted with the *k*-parameter, suggesting that older participants (but not very old) were more willing to wait for a future reward when the relative gain was large and/or the delay period was short. See the supplementary materials for the Figure involving participant age. In the overall life expectancy model, there were no significant effects involving country GDP or participant sex. However, in the individual-specific life expectancy model, there was a significant interaction between GDP and the *k*-parameter, such that when the relative gain is large with a short delay period, individuals from countries with greater wealth were more likely to choose the future reward. Also, in the individual-specific life expectancy model, we found significant a significant main effect and interaction for participant sex, such that men were more likely to be future-orientated, particularly when the relative gain was large and/or the delay period was short.

Life expectancy and GDP were windsorised aid model convergence; re-running the model without windsorising outliers did not change the pattern of results with the exception that GDP and its interaction with the *k*-parameter were both positively significant in the overall life expectancy model.

Discussion

Here, we find across 54 countries an association between country-level life expectancy and future discounting behaviour. As expected, individuals from countries with higher life expectancy were more willing to wait for a relatively larger reward. However, compared to previous cross-national research, we are able to make better inferences about individuals' future discounting behaviour in response to mortality risk. These effects remained even when using age-, sex-, year-, and country-specific life expectancy for each participant, which more likely represents cues to mortality faced by each participant compared to that of overall country life expectancy. Effects also persisted despite controlling for country-level wealth (i.e., GDP), or accounting for regional non-independence through mixed effects modelling.

Overall, as shown by the significant main effect of the k-parameter, individuals were less willing to wait for the future reward when the difference between this and the immediate reward was relatively small and/or the delay period was relatively long. This association was influenced by country-level life expectancy, providing insight into how ecological cues to mortality influences different future discounting scenarios that vary on delay period and relative gain. We find that when the relative gain is large with a short delay period, individuals from countries with lower life expectancy were less likely to choose the future reward. This suggests that mortality cues are not merely associated with an overall preference for immediacy (i.e., the main effect of life expectancy), but that ecological factors could potentially influence the way individuals use information regarding delay and relative gain when evaluating intertemporal decisions. This could not have been detected without testing future discounting using multiple intertemporal choice trials.

Extending our findings to facultative responses on life-history traits in general, our findings suggest that cues to mortality could influence how organisms evaluate future fitness opportunities respective of the delay period and the gain in fitness. This strategy is advantageous over a general preference for immediacy as it allows organisms in ecologies where mortality is low to still capitalise on immediate fitness opportunities when the perceived delay for any potential future opportunity is long and/or the additional gain in fitness is small. Such intertemporal decisions are relevant to many domains relevant to life-history theories; for instance, when an organism is faced with a choice between an immediate mating opportunity, or the chance of potentially procuring a higher quality mate in the future. While our data are on humans, this challenge is present for other species as well.

While our finding of a positive effect of age on future discounting are in line with the notion that younger participants may prioritise immediacy due to being more vulnerable during development. Another alternative explanation is that older participants having accrued more capital throughout their lifespan, and therefore are more able to afford waiting for a future reward. We also found a significant, negative interaction between the *k*-parameter and the nonlinear age coefficient. This combined with the positive linear interaction between the *k*-parameter and age suggests that older participants (but not too old) were more future-orientated when there is greater relative gain and/or the delay period is shorter. This is consistent with theoretical models that future discounting occurs the least during middle-aged adulthood, with future discounting increasing in older adulthood due to higher intrinsic mortality, and declining fertility (31).

Similar to Bulley and Pepper (22), we did not find a main effect of GDP on future discounting behaviour when overall life expectancy was included in the model. This was thought to be because country-level life expectancy and wealth are in part linked, and that ecological, rather than economical factors are more likely to influence future discounting choices. However, in the individual-specific life expectancy model, we found a significant interaction between GDP and the *k*-parameter, which could not have been detected without having multiple observations at the individual-level. This interaction suggests that individuals in richer countries were more willing to choose the future reward when the relative gains were small and/or the delay period was long. One possible explanation is that individuals from richer countries possess an abundance of resources, and as such can afford the luxury of waiting for a future reward, even if the added benefit is small. This should be interpreted cautiously, however, as the interaction between GDP and the *k*-parameter was not significant in the overall life expectancy model. Also, contrary to predictions, we found that men were more likely to be future orientated compared to women in individual-specific life expectancy model. This is contrary to previous findings that men discount the future more than women (3, 10, 29). However, we did not find a sex difference in future discounting behaviours in the overall life expectancy model; therefore, sex differences should be interpreted cautiously. Overall, our findings suggest that while life-history theories can account for some findings (e.g., mortality and age effects), other findings (e.g., a potential opposite sex effect) are harder to reconcile. Social and economic factors are also likely to also play a role in future discounting behaviour.

While we have taken the perspective that ecological factors are influencing individual future discounting behaviour, our data equally suggest that the reverse causality could be true, where countries in which individuals are more likely to favour immediacy lead to higher rates of mortality. Indeed, health behaviours often have delayed benefits; accordingly, future discounting behaviour is associated with engaging in risky or unhealthy behaviours, such as alcohol and tobacco use, which can significantly account for the mortality of a country (for a review, see 46). Our analysis used national level statistics of life expectancy, and though finer geographic statistics (e.g., neighbourhoods as used in 47), would provide a more accurate proxy for local mortality cues, using country-level statistics has previously provided insight into variation in life-history related traits

(17, 18, 20-22). Participants were also presented the choices in the same currency regardless of their country ($), which could potentially influence results as $1 is worth more in some countries than in others. Our data also cannot speak to whether future discounting behaviours are flexibly adaptive in response to ecological conditions. In order to investigate this, within-subjects studies with experimental manipulations are required; though previous work indicates that individual propensity to discount the future can be malleable (26, 35, 48).

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Authors' Contribution

BCJ and LMD designed the study and collected the data. AJL, BCJ and LMD carried out data analysis. AJL drafted the manuscript, which was revised by all authors.

Ethical Approval

This research was approved by the University of Aberdeen's Psychology Ethics Committee.

Data Accessibility

Data and code supporting this article are available at https://osf.io/xyc8j.

References

1. Berns GS, Laibson D, Loewenstein G. Intertemporal choice - Toward an integrative framework. Trends in Cognitive Sciences. 2007;11(11):482-8.
2. Daly M, Wilson M. Carpe diem: adaptation and devaluing the future. Q Rev Biol. 2005;80(1):55-60.
3. Reimers S, Maylor EA, Stewart N, Chater N. Associations between a one-shot delay discounting measure and age, income, education and real-world impulsive behavior. Personality and Individual Differences. 2009;47(8):973-8.
4. Shoda Y, Mischel W, Peake PK. Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. Developmental Psychology. 1990;26(6):978-86.
5. Amlung M, Petker T, Jackson J, Balois I, MacKillop J. Steep discounting of delayed monetary and food rewards in obesity: a meta-analysis. Psychological Medicine. 2016;46(11):2423-34.
6. Amlung M, Vedelago L, Acker J, Balodis I, MacKillop J. Steep delay discounting and addictive behavior: a meta-analysis of continuous associations. Addiction. 2017;112(1):51-62.
7. Stearns SC. The evolution of life history. Oxford: Oxford University Press; 1992.
8. Woyciechowski M, Kozlowski J. Divison of labor by division of risk according to worker life expectancy in the honeybee (Apis mellifera L.). Apidologie. 1998;29(191-205).
9. Engqvist L, Sauer KP. A life-history perspective on strategic mating effort in male scorpionfiles. Behav Ecol. 2002;13:632-6.
10. Kirby KN, Maraković NN. Delay-discounting probablistic rewards: Rates decrease as amounts increase. Psychon Bull Rev. 1996;3(1):100-4.
11. Hill EM, Jenkins J, Farmer L. Family unpredictability, future disconting, and risk taking. The Journal of Socio-Economics. 2008;37:1381-96.

12. Hill EM, Ross LT, Low BS. The role of future unpredictability in human risk-taking. Human Nature. 1997;8(4):287-325.

13. Kruger DJ, Reischl T, Zimmerman MA. Time perspective as a mechanism for functional developmental adaptation. Journal of Social, Evolutionary, and Cultural Psychology. 2008;2(1):1-22.

14. Brumbach BH, Figueredo AJ, Ellis BJ. Effects of harsh and unpredictable environments in adolescence on development of Life History strategies. Human Nature. 2009;20:25-51.

15. Baldini R. Harsh environments and "fast" human life histories: what does the theory say? bioRxiv. 2015:014647.

16. Pepper GV, Nettle D. The behavioural constellation of deprivation: Causes and consequences. Behav Brain Sci. 2017;40:e314.

17. Low BS, Hazel A, Parker N, Welch KB. Influences on women's reproductive lives: Unexpected ecological underpinnings. Cross-Cultural Research: The Journal of Comparative Social Science. 2008;42(3):201-19.

18. Anderson KG. Life expectancy and the timing of life history events in developing countries. Human Nature. 2010;21(2):103-23.

19. Low BS, Parker N, Hazel A, Welch KB. Life expectancy, fertility, and women's lives: A life-history perspective. Cross-Cult Res. 2013;47(2):198-225.

20. Bulled NL, Sosis R. Examining the relationship between life expectancy, reproduction, and educational attainment. Human Nature. 2010;21(3):269-89.

21. Wilson M, Daly M. Life expectancy, economic inequality, homicide, and reproductive timing in Chicago neighbourhoods. Br Med J. 1997;314(7089):1271-4.

22. Bulley A, Pepper GV. Cross-country relationships between life expectancy, intertemporal choice and age at first birth. Evolution and Human Behavior. 2017;38:652-8.

23. Wang M, Rieger MO, Hens T. How time preferences differ: Evidence from 53 countries. Journal of Economic Psychology. 2016;52:115-35.

24. Kuppens T, Pollet TV. Mind the level: problems with two recent nation-level analyses in psychology. Frontiers in Psychology. 2014;5(1110):1-4.

25. Robinson WS. Ecological correlations and the behavior of individuals. American Sociological Review. 1950;15:351-7.

26. Pepper GV, Nettle D. Death and the time of your life: experiences of close bereavement are associated with steeper financial future discounting and earlier reproduction. Evolution and Human Behavior. 2013;34:433-9.

27. Griskevicius V, Tybur JM, Delton AW, Robertson TE. The influence of mortality and socioeconomic status on risk and delyaed rewards: A life history theory approach. Journal of Personality and Social Psychology. 2011;100(6):1015-26.

28. Griskevicius V, Delton AW, Robertson TE, Tybur JM. Environmental contingency in life history strategies: The influence of mortality and socioeconomic status on reproductive timing. Interpersonal Relations and Group Processes. 2011;100(2):241-54.

29. Silverman IW. Gender differences in delay of gratification: A meta-anlaysis. Sex Roles. 2003;49:451-63.

30. Cross CP, Copping LT, Campbell A. Sex differences in impulsivity: A meta-analysis. Psychological Bulletin. 2011;137(1):97-130.

31. Sozou PD, Seymour RM. Augmented discounting: interaction between ageing and time-preference behaviour. Proceedings of the Royal Society B-Biological Sciences. 2002;270:1047-53.

32. Kirby KN, Santiesteban M. Concave utility, transaction costs, and risk in measuring discounting of delayed rewards. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2003;29(1):66-79.

33. DeBruine LM, Jones B, C., Crawford J, R., Welling L, L., M., Little A, C. The health of a nation predicts their mate preferences: cross-cultural variation in women's preferences for masculinized male faces. Proceedings of the Royal Society B: Biological Sciences. 2010;277(1692):2405-10.

34. Kandrik M, Jones BC, DeBruine LM. Scarcity of female mates predicts regional variation in men's and women's sociosexual orientation across US states. Evolution and Human Behavior. 2014.

35. Wilson M, Daly M. Do pretty women inspire men to discount the future? Biol Lett. 2004;271:S177-S9.

36. Madden GJ, Begotka AM, Raiff BR, Kastern LL. Delay discounting of real and hypothetical rewards. Experimental and Clinical Psychopharmacology. 2003;11(2):139-45.

37. Camerer C. Differences in behavior and brain activity during hypothetical and real choices. Trends in Cognitive Science. 2017;21(1):46-56.

38. World bank country and lending groups [Internet]. 2017 [cited 17 October 2017]. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

39. Global Health Observatory data [Internet]. 2017 [cited 13 September 2017]. Available from: http://www.who.int/gho/mortality_burden_disease/life_tables/en/.

40. GDP (current US$) [Internet]. 2017 [cited 3 October 2017]. Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

41. Bates D, Mächler M, Bolker BM, Walker SC. Fitting linear mixed-effects models usng lme4. Journal of Statistical Software. 2015;67(1):1-48.

42. Kuznetsova A, Brockhoff PB, Christensen RHB. lmerTest: Tests for random and fixed effects for linear mexed effect models. 2015.

43. R Core Team. A language and environmental for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2013.

44. Barr DJ, Levy R, Scheepers C, Tily HJ. Random effects structure for confirmatory hypothesis testing: Keep it maximal. Journal of Memory and Language. 2013;68(3):255-78.

45. Barr DJ. Random effects structure for testing interactions in linear mixed-effects models. Frontiers in Psychology. 2013;4:328.

46. Story GW, Vlaev I, Seymour B, Darzi A, Dolan RJ. Does temporal discounting explain unhealthy behavior? A systematic review and reinforcement learning perspective. Frontiers in Behavioral Neuroscience. 2014;8(76).

47. Nettle D. Dying young and living fast: variation in life history across English neighborhoods. Behav Ecol. 2010;21(2):387-95.

48. Giordano LA, Bickel WK, Loewsenstein G, Jacobs EA, Marsch L, Badger GJ. Mild opioid deprivation increases the degree that opioid-dependent outpatients discount delayed heroin and money. Psychopharmacology. 2002;163:174-1892.