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Original Article

Cross-country relationships between life expectancy, intertemporal choice and age at first birth

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ABSTRACT

Humans, like other animals, typically discount the value of delayed rewards relative to those available in the present. From an evolutionary perspective, prioritising immediate rewards is a predictable response to high local mortality rates, as is an acceleration of reproductive scheduling. In a sample of 46 countries, we explored the cross-country relationships between average life expectancy, intertemporal choice, and women's age at first birth. We find that, across countries, lower life expectancy is associated with both a smaller percentage of people willing to wait for a larger but delayed reward, as well as a younger age at first birth. These results, which hold when controlling for region and economic pressure (GDP-per capita), dovetail with findings at the individual level to suggest that life expectancy is an important ecological predictor of both intertemporal and reproductive decision-making.

1. Introduction

Humans, like other animals, typically discount the subjective value of delayed rewards relative to those available in the present (Berns, Laibson, & Loewenstein, 2007). Explanations for this *delay discounting* phenomenon tend to emphasize that the uncertainty of future rewards makes capitalising on immediate opportunities a beneficial strategy in many circumstances (Andreoni & Sprenger, 2012; Daly & Wilson, 2005; Stevens & Stephens, 2010). Indeed, '*intertemporal choices*' between immediate and delayed rewards are highly sensitive to context in humans (Lempert & Phelps, 2015). One common prediction about the role of ecological context, grounded in evolutionary theorising, is that intertemporal decision-making should on average shift towards immediate rewards when local mortality rates are high (e.g. Daly & Wilson, 2005; Frankenhuis, Panchanathan, & Nettle, 2016; Hill, Jenkins, & Farmer, 2008; Kruger & Zimmerman, 2008). This is because a higher mortality risk equates to a lower likelihood of capitalising on delayed rewards due to the possibility of death. This is expected to take place both for an individual who may come to change their decision-making based on exposure to relevant information in their environment, but also at the group level whereby shared ecological factors like higher local mortality rates should produce on average steeper delay discounting.

Various lines of evidence support this proposition at the individual psychological level, including findings that exposure to natural disasters, violence or mortality cues is associated with a preference for immediate rewards over delayed ones (Lahav, Benzion, & Shavit, 2011; Li et al., 2012; Pepper & Nettle, 2013; Ramos, Victor, Seidl-de-Moura, & Daly, 2013). Thus far, the evidence on this front comes from between- or within-participant analyses within the same country (e.g. Ramos et al., 2013), and analyses have tended to focus on specific cues of mortality risk, such as exposure to violence, rather than local mortality rates more generally. Here we therefore extend this work by asking whether variation in life expectancy across countries acts as an ecological predictor of the average intertemporal decision-making in those countries.

A similar logic applies in the domain of reproductive scheduling (Chisholm, 1993; Nettle, 2011; Wilson & Daly, 1997). As local mortality risk increases, people are expected to reproduce earlier, and to produce more offspring throughout their reproductive careers (Charnov, 1991; Ellis, Figueredo, Brumbach, & Schlomer, 2009; Stearns, 1992). The benefits of accelerated reproductive scheduling when mortality risk is high are thought to arise from both an increased chance of reproducing, and increased time available to care for offspring, before death. There is evidence that both within and between countries, women's average age at first birth is younger when mortality rates are higher (Low, Hazel, Parker, & Welch, 2008). Local mortality risk indicators also predict total fertility, such that people in higher mortality-risk conditions tend to have more children on average throughout the lifespan (Guégan, Thomas, Hochberg, de Meeus, & Renaud, 2001; Zhang & Zhang, 2005). We therefore sought to also replicate these previously reported relationships between life expectancy and age at first birth. Steeper temporal

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discounting has also been associated with having more sexual partners, an earlier age of first sexual activity, more relationship infidelity, greater odds of having a past or current pregnancy, and lower contraceptive use (Chesson et al., 2006; McCoul & Haslam, 2001; Reimers, Maylor, Stewart, & Chater, 2009). However it has thus far gone unexamined how average intertemporal decision-making patterns relate to reproductive scheduling patterns across different ecologies.

The current study therefore had two main aims. Firstly, we aimed to explore the relationship between life expectancy, and both intertemporal choice and age at first birth. Secondly, we aimed to explore the association between intertemporal choice and age at first birth. We hypothesized that, across countries, (i) lower average life expectancy would be associated with a lower percentage of people willing to wait for a larger later reward, (ii) lower average life expectancy would be associated with younger age at first birth, as found in prior studies, and (iii) a lower percentage of people willing to wait for a larger later reward would be associated with younger average age at first birth.

2. Method

2.1. Measures

2.1.1. Intertemporal choice

Intertemporal choice data were collected as a single binary choice item in the International Test of Risk Attitudes (INTRA) survey conducted by the University of Zurich and made publicly available in a recent publication (Wang, Rieger, & Hens, 2016). Participants were asked to indicate whether they would prefer: (A) a payment of $3400 this month; or (B) a payment of $3800 next month (from Frederick, 2005). Participants were university students (mostly in the departments of economics, finance, and business administration) and the monetary amounts in the choice question were adjusted according to the Purchasing Power Parity and monthly income and expenses of the students in each country. The sample contained intertemporal choice data from 6901 participants from 53 countries. These responses were used to calculate the percentage of respondents from each country who chose the delayed but larger reward. More details about the methodology of the INTRA survey are available from Wang et al. (2016) and Rieger, Wang, and Hens (2015).

2.1.2. GDP-PC, life expectancy, age at first birth and region

Data on gross domestic product per capita (GDP-PC) and life expectancy for 52 of the 53 countries for which intertemporal choice data were available from the World Bank open data bank available online (The World Bank, 2016). INTRA survey data on percentage of people willing to wait were available for Taiwan, but GDP-PC, life expectancy and age at first birth data were not. Therefore, Taiwan was not included in our analyses. Data on age at first birth were available from the CIA World Fact Book online (CIA, 2016). Age at first birth data were not available for Argentina, Chile, China, Lebanon, Malaysia, or Vietnam, leaving complete data for 46 countries. Because the INTRA data on intertemporal choice were collected over a number of years (between 2007 and 2012), GDP-PC and life expectancy data were averaged over the years during which the intertemporal choice data were collected in each country (details of the years during which data were collected were provided by Wang et al. in correspondence, and can be seen in the data provided as an electronic supplement). The available data on age at first birth lacked the same level of temporal specificity, and were instead collected at various time-points ranging from 2006 to 2012.

GDP-PC was measured in USD, and is defined by the World Bank as "gross domestic product divided by midyear population". The World Bank defines GDP as "the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources." Life expectancy, another World Bank indicator, is defined as: "the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life". Age at first birth, as defined by the CIA world fact book, represents: "the mother's mean age at first birth" for a given country. Region classifications were assigned as per the World Bank's "Country and Lending Groups" classifications, available online.

2.2. Data analysis

Hypotheses, measures, and our analytical plan were pre-registered with the Open Science Framework (available online, https://osf.io/yu2hs/)[2]. All statistical analyses were performed in R studio (R Core Team, 2008). We created a series of linear mixed models to address each hypothesis, with a random intercept of 'region' to control for the potential non-independence of the sample countries due to shared features such as climate and cultural histories, using *lme4* (Bates, Maechler, & Walker, 2015). The sample sizes obtained in the INTRA survey varied by country (range = 38–540, Wang et al., 2016). Analyses were therefore weighted for the sample size of the intertemporal choice data. All predictors were standardised in order to deal with the scale differences between GDP-PC and the other predictor variables. Plots were created with *ggplot2* (Wickham, 2009) and *ggrepel* (Slowikowski, 2016). We also used the *dplyr* (Wickham, 2016) and *psych* (Revelle, 2014) packages to organise the data and generate descriptive statistics. The R script used for analysis is available as an electronic supplement to this paper, as is the dataset and an information sheet about the included variables. As part of our electronic supplement, we have also created maps to visualise the cross-country variation in life expectancy (available online here: https://goo.gl/YN7CDG), intertemporal choice (available online here: https://goo.gl/FQKH4E), and age at first birth (available online here: https://goo.gl/B2eyoa).

3. Results

3.1. Descriptive statistics

Descriptive statistics for the percentage of people willing to wait, GDP-PC, life expectancy and age at first birth are available in Table 1. As might be expected, countries with a higher GDP-PC tended to have longer life expectancies ($\times^2(1) = 33.33$, $p < 0.001$, $\beta = 3.13$, s.e. = 0.45).

3.2. Relationship between life expectancy and intertemporal choice

We conducted a linear mixed effects analysis of the relationship between life expectancy and intertemporal choice, controlling for GDP-PC and a random effect of geographic region. As fixed effects, we entered GDP-PC and life expectancy, and as a random effect we included a random intercept of region. We obtained *p*-values by running likelihood ratio tests, using the drop1 function (Chambers, 1992) to compare the fit of the full model with those of models with each predictor removed. Results revealed a relationship between life expectancy and intertemporal choice ($\times^2(1) = 9.88$, $p < 0.01$), such that a higher life expectancy was associated with a higher percentage of people willing to wait for the larger, later reward on average ($\beta = 0.09$, s.e. = 0.03, Fig. 1, Table 2). Thus, people in

[2] Changes to the pre-registered analytical plan were as follows: Firstly, due to a serious lack of adherence to statistical assumptions, models with the 'fertility' variable were removed from our final analyses. Subsequently, we generated new hypotheses about age at first birth and included analyses to test these hypotheses after failing to fit adequate models with the fertility data. Finally, we removed the planned mediation analysis due to concerns about testing for individual-level psychological mechanisms using country-level data (the ecological fallacy; see Kuppens & Pollet, 2014), and employed linear mixed models with a random effect of region instead of standard linear models.