ELSEVIER_ENS_5954

Original Article

# The environment and life history strategies: neighborhood and individual-level models

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**Abstract**

Life history trajectories have been shown to be sensitive to local environmental conditions. Using English census data (2001), Copping, Campbell, and Muncer (2013) demonstrated that ecological indicators affect life history strategies (affecting levels of criminal violence and teenage conceptions). We replicated the original study using recently published census data (2011) to validate the model. We also examined whether census data from 2001 predict criminal violence and teenage pregnancy outcomes ten years later. Results demonstrated that the proposed model is applicable to both census periods. Predictions of violence and pregnancy rates in 2011 were higher when ecological estimates from 2001 rather than 2011 were modeled. Individuals' perceptions of ecological variables included in the models were also collected from 738 participants. There was a striking concordance between census and individual level data; all but five of the original pathways remained significant. Results highlight the importance of examining different units of analysis and implications are discussed from a life history perspective.

**Keywords:** Life history; Aggression; Evolution; Environmental uncertainty; Teenage pregnancy

## 1 Introduction

Research has demonstrated strong correlations between behaviors considered to be socially problematic, particularly between aggression and early reproduction (Celio, Karnik, & Steiner, 2006; Pickett, Mookherjee, & Wilkinson, 2005). Developments in human behavioral ecology and evolutionary psychology suggest that social 'pathologies' can be seen as rational, adaptive choices contingent on ecological circumstances. The conceptualization of local ecologies is often neglected however. This study aimed to empirically validate existing work on how ecological conditions affect behavioral trajectories. A brief discussion of the theoretical background follows.

Draper and Harpending (1982) demonstrated the significance of stable family functioning, highlighting how later reproductive strategy could be contingent on the earlier presence or absence of a father figure. Belsky, Steinberg, and Draper (1991), developing this model, suggested that father absence per se was not the trigger to later reproductive strategy, but the associated stress caused by that absence. Father absence represents one of many stressors that may disrupt parent-child attachment processes (Bowlby, 1969), conveying information to developing children that their environment is unstable. Children with less secure attachments are expected to develop a mistrustful and opportunistic view of the world, and furthermore, reach puberty earlier. Belsky et al. uniquely predicted that the early social experiences of children would contribute to determining the end point of somatic growth. This foreshortening of childhood would be associated with expectations of a harsher future, a tendency to act in a mistrustful, opportunistic way and sexually precocious behavior. This theory is now often referred to as Psychosocial Acceleration Theory.

Chisholm (1993) advanced psychosocial acceleration theory by integrating it with principles drawn from behavioral ecology and life history theory. Life history theory is an evolutionary grounded framework which suggests that organisms optimize investment of resources between somatic and reproductive development within finite parameters, necessitating a series of trade-offs. Trade-offs create variation in the phenotype which translate into variation in reproductive fitness (Roff, 1992; Stearns, 1992). While life history theory initially focussed on between-species variation, human behavioral ecologists and evolutionary psychologists have also applied life history principles to the study of variation within humans (see Cronk, 1991; Kaplan & Gangestad, 2005). For example, organisms can begin reproduction early despite being in a sub-optimal state in terms of somatic, physical or social resource availability. Doing so increases the length of their reproductive window and their potential number of offspring. Alternatively, organisms can delay reproduction and favor growth, allocating time to acquire resources for parenting but reducing the reproductive window. The switching point between growth and reproduction is often referred to as the general life history problem (Schaffer, 1983). Chisholm proposed that assays of one's mortality determine this switching point. Parents rearing children in difficult or 'uncertain' environments (e.g. single parenthood) are subject to stresses that disrupt parent-child attachments. Attachment disruption is internalized in the child as an expectation of an uncertain future with high mortality risks, causing developing children to advance their reproductive schedules and adopt strategies consistent with living fast and dying young. This increases the propensity for the expression of behaviors such as sexual precocity and aggression. Chisholm proposed that "uncertainty" in the environment was the ultimate cause of violence and teenage pregnancy and that these behaviors are adaptive survival responses aimed at avoiding lineage extinction in sub-optimal conditions.

Incorporating work on father absence and attachment dysfunction into his concept of environmental uncertainty, Chisholm claimed "ultimately, universal sources of parental stress are the routine social and environmental causes and correlates of high mortality rates—poverty, exploitation, hunger, disease, and war and their accompanying fear and hopelessness" (Chisholm, 1993:7). Many studies have demonstrated links between early stress, family breakdown, life expectancy, aggression, earlier sexual debut and earlier menarche (Belsky, Schlomer, & Ellis, 2012; Chisholm, Quinlivan, Peterson, & Coall, 2005; Ellis & Essex, 2007; Gibson & Tibbetts, 2000; Wilson & Daly, 1997). The role of the family unit as a mediator between environmental stress and expressed behavior is well supported. Ellis, Figueredo, Brumbach, and Schlomer (2009), while supporting the pivotal role of family environments, emphasized the importance of direct perception of environmental stressors. They argued that evolved sensitivities to ecological mortality cues uniquely contribute to behavioral outcomes alongside the influence of familial stress. Individuals internalize ecological information about the relative predictability of local conditions and organisms within it as statistical composites (Wilson & Daly, 1997). This composite is then used to regulate future strategic behavior. Because environmental cues are intercorrelated and operate on multiple levels, organisms consider environments holistically; knowing one facet alone cannot predict strategy development. Ellis et al. (2009) suggested that factors such as exposure to conspecific violence, low socioeconomic status, poor parental investment and poor heath represent cues potentially forecasting premature death or disability, thus impacting on strategy development. Many studies have supported this multi-level perspective on the environment (Belsky et al., 2012; Brumbach, Figueredo, & Ellis, 2009).

Copping, Campbell, and Muncer (2013) used structural equation modeling (SEM) to compare two models. One model was based on the family as a mediator between the environment and an individual's strategy, while the other model incorporated direct environmental effects as well as indirect effects via the family. England and Wales National Census (2001) were used to represent environmental factors potentially impacting upon local crime rates and teenage conceptions. The study demonstrated that a model with multiple levels of impact (on the family, overall strategy and specific behaviors) was the best predictor of crime and pregnancy rates at the level of the environment (indexed by local authorities). They concluded that, while the family unit was undoubtedly crucial (supporting Belsky et al., 1991; Chisholm, 1993), strategy could be influenced directly by environmental cues (supporting Ellis et al., 2009). Levels of overt behavior (aggression in particular) were susceptible to the direct effects of certain environmental factors, particularly those regulating exposure to conspecifics, such as the number and density of the youthful population (termed "local enabling circumstances").

## 1.1 Current studies

This model was useful in identifying relationships between environmental factors and behaviors of interest, and provided a basis for exploring perceptible environmental cues at the individual level. There were however several avenues for further investigation and some methodological limitations. This study aimed to expand on the original work by addressing the following issues.

The 'snapshot' nature of the original data limits interpretation. All relationships represented localities at a single point in time. Psychosocial acceleration theory however predicts that stress throughout early development (specifically around age 5) should affect the expression of strategy across adolescence (10-15 years later); the onset of adrenarche and the transition to adolescence being the key developmental milestone (Del Giudice, 2009). Without data from two time points, the predictive validity of the model cannot be established. The release of the 2011 census data afforded the opportunity to replicate the original model on comparable data while demonstrating predictive validity in forecasting strategy behaviors in 2011 from data in 2001. The original model specification should demonstrate comparable statistical parsimony using the new data. In addition, if this model validly expresses trajectory development, environmental indicators from 2001 should be more predictive of strategy related behaviors in succeeding years rather than concurrent years. The analysis of these two waves of census data is presented in Study 1.

Furthermore, relationships demonstrated at neighborhood levels, while informative, cannot be translated automatically to the individual as correlations studied at group level are not necessarily reflected at the individual level (the "ecological fallacy"; Robinson, 1950). Mapping environmental correlates to individual strategies therefore requires a study that can mirror these variables at an individual level. Our original model was constructed on the premise that the local ecology causes behavior because elements of it are perceived and processed by an as-yet-unknown psychological mechanism. These perceptions then affect the development of life history trajectories (Chisholm, 1993; Ellis et al., 2009; Wilson & Daly, 1997). While studies have proposed factors that contribute to stressful environments, there is one crucial gap in the literature. Little effort has been made to explore individuals' actual sensitivity to local environmental factors. While our earlier model supported previous findings that sex ratios, density and high youthful populations significantly affect strategy-driven behaviors, do individuals consciously detect this information (particularly, subtle factors such as sex ratio)? Only the study of individuals can determine whether and how such information is perceived and this should be an important research direction. Study 2 moves from macro to micro level analysis regarding key model components. Data were therefore collected to examine individual perception of key variables from the Copping et al. (2013) model and how they affect self-reported strategy based behavior.

# 2 Study 1

## 2.1 Method

Data were taken from the England and Wales National Census (2001, 2011). Local authorities are responsible for administering local education, health and government services, representing the smallest unit of analysis available to gather all necessary data while sensitively representing local environments. In the original study, 339 such authorities were analyzed.[1] Between census periods however, local authorities were reorganised in areas of England. Consequently, only 291 local authorities were available for analysis from the 2011 census. Data were merged from authorities in 2001 and recalculated making them comparable with authorities in 2011.

### *2.1.1 Census measures*

Variables from the original study were implemented in this replication (see Copping et al., 2013 for conceptual justifications). Where calculation changes were made, they are described. The following independent variables were measured.

**Number of Youths** The number of 15–29 year old males and females were summed and calculated as a rate per 1000 of the local authority population.

**Youth Sex Ratio** The ratio of reproductively fit males to females was calculated as the number of males per 100 females in the age range of 15-29.

**Father Absence** This was indexed by calculating the rate per 1000 of female lone parents.[2]

**Education** Education was originally assessed using a latent measure derived from KS3 English, Maths and Science data (achievement at approximately age 14). Changes to government education policy between census periods prevented comparable data in 2011. Education was therefore measured by examining the percentage of children achieving level 4 or above in English and Maths at KS2 (approximately age 11) as this was the only measure common to both census periods. As latent variables cannot be constructed from just two items, the average was taken and is now represented as an observed rather than a latent variable in the models.

**Unemployment** The rate per 1000 of registered job seekers aged 18 to 65 was taken for each authority.

**Life Expectancy** Originally, disability free life expectancy from birth was used as a mortality index. This measure was not calculated in 2011. Standard life expectancy from birth estimates were used instead to allow comparison across the period.

**Population Density** The number of people per hectare.

The following dependent variables were measured.

**Teenage Conception Rate** The rate of conceptions (not births) per 1000 females between ages 15–17.[3]

**Victimful Criminality** Crimes from the following categories were summed and converted to a rate per 1000 of the total adult population: violence against the person, wounding or life endangering acts, other wounding offenses, harassment and penalty notices for disorder and common assault.[4] This variable therefore represents any crime where a victim suffered some form of direct physical aggression.

## 2.2 Results

Descriptive statistics and correlations are presented in Table 1. Correlations were calculated on the 2001 and 2011 samples separately and compared. Descriptives are presented for each census period. Because correlations for the 2001 census were recalculated based on the modified variables resulting from administrative changes, they are not identical to those presented in Copping et al. (2013).

**Table 1** Correlations and descriptives (2001/2011).

| | Violence | Pregnancy | Life expectancy | Education | Unemployment | Father absence | Population density | Number of youths | Youth sex ratio |
|---|---|---|---|---|---|---|---|---|---|
| Pregnancy | .64/.61 | | | | | | | | |
| Life expectancy | – .61/– .56 | – .80/– .77 | | | | | | | |
| Education | – .58/– .53 | – .72/– .56[a] | .53/.41 | | | | | | |
| Unemployment | .56/.56 | .74/.75 | – .81/– .81 | – .54/– .45 | | | | | |
| Father absence | .61/.62 | .78/.76 | – .80/– .85 | – .56/– .42[a] | .81/.88 | | | | |
| Population density | .58/.70[a] | .57/.50 | – .48/– .47 | – .50/– .32[a] | .48/.57 | .58/.60 | | | |
| Number of youths | .44/.68[a] | .46/.46 | – .43/– .50 | – .48/– .35 | .37/.49 | .40/.55[a] | .65/.69 | | |
| Youth sex ratio | – .26/– .26 | – .43/– .29[a] | .41/.24[a] | .26/.08[a],* | – .35/– .32 | – .44/– .32 | – .26/– .25 | – .10/– .13 | |
| Mean (2001) | 29.71[b] | 39.00[b] | 78.67[c] | 74.84[d] | 20.01[b] | 65.08[b] | 9.99[e] | 174.90[b] | 103.06[f] |
| SD (2001) | 15.33[b] | 13.13[b] | 1.35[c] | 5.03[d] | 11.50[b] | 19.98[b] | 10.91[e] | 31.45[b] | 7.16[f] |
| Mean (2011) | 25.03[b] | 29.43[b] | 81.14[c] | 81.33[d] | 29.85[b] | 56.90[b] | 10.69[e] | 182.75[b] | 103.81[f] |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SD (2011) | 9.87[b] | 9.94[b] | 1.44[c] | 3.77[d] | 12.79[b] | 14.70[b] | 11.87[e] | 35.91[b] | 8.34[f] |

[a] Correlations differ significantly.

[b] Rate per 1000.

[c] Years.

[d] Percentage.

[e] People per hectare.

[f] Males per 100 females.

* $p > .05$.

Correlations between *Teenage Conception Rate* and *Victimful Criminality* were still moderate and in the expected direction ($r = .64/.61$). Intercorrelations between all variables were significant ($p < .01$) and in predicted directions unless stated otherwise. A small number of the correlations differed significantly ($p < .05$) across census periods, but the majority were consistent over time.

### 2.2.1 Model replicability

The first objective was to confirm the model proposed by Copping et al. (2013) on the 2011 data set. This was tested using SEM and by modeling as depicted in Fig. 1. An ellipse represents life history strategy with dependent variables loading onto it. Observed variables are represented by rectangles. Residual error and intercorrelations between predictors were assumed but are omitted from diagrams for clarity. Models were generated using Maximum Likelihood Estimation. Models were evaluated by several criteria. Chi square values indicate the degree of fit between the predicted and observed covariance matrices of the model but this is sensitive to sample size and strong inter-item correlations (Kline, 2005). These are examined in conjunction with practical fit indices such as the comparative fit index (CFI) and the Root Mean Square Error of Approximation (RMSEA). CFI should be greater than 0.90 and the RMSEA lower than 0.10 (Kline, 2005).


**Fig. 1** Copping et al. (2013) model with fixed linkages across samples from 2001 and 2011 ($N = 582$).

Model validity was tested in two ways. Firstly, a model for each census was created to determine statistical fit on each sample. Secondly, a model with fixed linkages across both samples was tested (allowing data to be compared assuming relationship invariance). Table 2 shows model fit statistics.

**Table 2** Structural model comparisons.

| Model | *N* | $\chi^2$ | *df* | $\chi^2/df$ | *p* | RMSEA | CFI | Crime $r^2$ | Pregnancy $r^2$ |
|---|---|---|---|---|---|---|---|---|---|
| 2001 | 291 | 14.48 | 9 | 1.61 | .11 | .05 | .99 | .53 | .82 |
| 2011 | 291 | 39.14 | 9 | 4.35 | .00 | .10 | .98 | .66 | .77 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Combined | 291/291 | 204.00 | 44 | 4.64 | .00 | .08 | .96 | .40 | .81 |

The model remained a good fit for the 2001 data, and adequately fitted the 2011 data. The model assuming fixed relationships was also parsimonious although $\chi^2$ values were significant in two of the models. Fit statistics therefore validated the original model. Fig. 1 illustrates coefficients for the model with fixed linkages (representing both samples). All links were significant ($p < .01$).

### 2.2.2 Predictive validity

The second aim was to examine the predictive ability of the model over time. Do developmental environments in 2001 predict crime and teenage conceptions in 2011? This was modeled using environmental variables from the 2001 census to predict dependent variables in 2011. The model was evaluated as before, and model coefficients are given in Fig. 2.

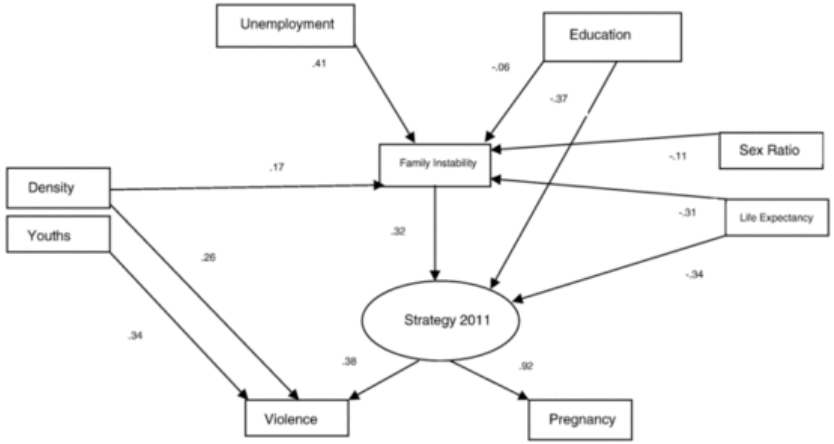


**Fig. 2** Model predicting outcomes in 2011 from stressors in 2001 ($N = 291$).

Statistics indicated that the model fitted adequately to the data ($df = 9$, $\chi^2 = 36.96$, $p < .01$, $\chi^2/df = 4.12$, CFI = .99, RMSEA = .10). In predicting variance in the dependent variables, this model had $r^2$ values of .67 for *Victimful Criminality* and .85 for *Teenage Conception Rate*. These values were higher than in the models restricted to data from single census years. All links in the model were significant with one exception (*Education* and *Female Lone Parenting*, $p > .05$).

To further validate this effect over time, this model was conceptually reversed and compared to the previous analysis. In order to demonstrate that reversing the temporal order of events produced a less parsimonious fit, the independent variables from 2011 were used to predict dependent variables from 2001. Results indicated this model did not adequately fit the data ($df = 9$, $\chi^2 = 52.40$, $p < .01$, $\chi^2/df = 5.82$, CFI = .98, RMSEA = .13) and was significantly worse than the original ($\chi^2_{diff} = 15.44$, $df_{diff} = 0$, $p < .001$). Several links were also no longer significant. Results suggest that the proposed model is potentially indicative of a developmental pattern.

## 2.3 Discussion

Study 1 demonstrated that the original model of environmental effects on behaviors was replicable when applied to local authority data across two census collections. The similarity of correlations between variables across censuses suggests these relationships are stable over the period, demonstrating that the proposed model (Copping et al., 2013) has strong validity over time.

Behavior was more strongly predicted by indices from ten years previous than the concurrent year. Psychosocial acceleration theory predicts that the developmental environment is critical in determining strategy trajectories (Belsky et al., 1991; Chisholm, 1993). These findings support the notion that environmental circumstances have long-term behavioral consequences. In the original paper, children developing under the modeled conditions were entering the critical phases of development (such as puberty, Del Giudice, 2009) and in 2011 would be entering the 15–29 year old age group; the group responsible for teenage pregnancies and much of the victimful criminality rate (Steffensmeier, Allan, Harer, & Streifel, 1989; Wilson & Daly, 1985). While this interpretation cannot be considered conclusive from census data, it provided support for psychosocial acceleration theory and demonstrated that its proposals can be observed over time on a macro level. The fact that reversing the model produced a significantly worse fit than a temporally predictive model allowed a measure of confidence that this finding was not spurious. Causality cannot be truly established in correlational data however and this study represented the closest approximation to a longitudinal test of psychosocial acceleration theory using census data only.

# 3 Study 2

The aim of Study 2 was to examine whether a model constructed on neighborhood level (census) data would fit data derived from individuals' self-reports of direct perceptions of their neighborhoods.

## 3.1 Method

### *3.1.1 Cross-sectional sample and measures*

Data were collected using an online questionnaire examining variables of interest (detailed below). Participants were recruited opportunistically though social networking sites, secondary school and college recruitment and university participant pools. No exclusion criteria were implemented except that participants had to be at least age 13 (for ethical reasons). Seven hundred thirty eight participants provided useable data with an age range between 13 and 69 (303 males, mean age 16.11, SD 5.14; 435 females, mean age 17.50, SD 6.32). The following independent variables were assessed.

**Number of Youths** Participants indicated on a four-point Likert scale whether individuals in the local area were predominantly young or old. Higher scores indicate that neighborhoods were predominantly youthful.

**Population Density** Participants indicated on a four-point Likert scale how crowded they felt their local neighborhood was. Higher scores represent denser populations.

**Youth Sex Ratio** Participants indicated on a four-point Likert scale whether they noticed that their neighborhood had more females than males. Lower scores represent environments with more females.

**Family Instability** To capture the dimensions of family instability in detail, participants completed a 15 item questionnaire assessing four domains: discipline (three items examining consistency of disciplinary action taken during childhood, $\alpha = .60$), family mobility (four items examining frequency of movement to different jobs, schools, homes and the movement of new individuals in and out of the family unit, $\alpha = .68$), meal provisioning (four items examining healthiness, consistency and availability of meals, $\alpha = .67$) and attachments (four items examining time spent with and closeness to parents, $\alpha = .83$). While three of scales had low alpha values, Confirmatory Factor Analysis (CFA) demonstrated that all scales were acceptable fits to the data ($\chi^2 > .01$, CFI > .96, RMSEA < .10 in all cases). As these latent variables represented dimensions of family instability, all four were loaded onto a higher order factor for the purposes of the model. CFA again confirmed the higher order construct was a good fit to the data ($\chi^2 < .01$, CFA = .93, RMSEA = .06) despite a now significant $\chi^2$ value (likely attributable to the large sample and strong variable intercorrelations; Kline, 2005).

**Unemployment** Perceiving unemployment directly (as a proxy for economic deprivation) is difficult as 'unemployment' itself is not a perceptible physical characteristic. Due to difficulties in measurement and the need to include this variable in the model, postcode data (supplied by the respondents) were used to ascertain the number of unemployed individuals in the immediate area. Employment data are recorded in the same database as census material and can be extrapolated to what the UK government define as an 'output area'. This area covers a small geographical area (usually only three or four streets) and therefore covers the immediate environment of an individual's dwelling. The number of unemployed people in each area was expressed as a percentage to control for different population sizes in each area.

**Education** Measuring individual education attainment across age groups is difficult because different levels and stages are not comparable in the English education system. This makes a meaningful measure impossible without the administration of a standardized test (which was not possible in this study). Nevertheless, education has been highlighted as an important predictor of strategic behavior and should be included. Thus, individuals in an 'output area' (corresponding to postcode) who reached at least level 2 (any General Certificate of Secondary Education at grade C or above at age 16) was expressed as a percentage of all individuals in the local environment.

**Life Expectancy** Participants were asked to estimate the age (in years) to which they expected to live.

The following dependent variables were assessed.

**Aggression** Participants completed the Richardson Conflict Response Questionnaire (RCRQ; Richardson & Green, 2003). Participants self-reported the frequency of various aggressive activities they had engaged in over the past year using a five-point Likert scale. Positive scores represent more aggressive tendencies. As this represents a latent variable in SEM, the validity of the construct was established using CFA. Five items from the RCRQ best represented the construct of aggression ($\chi^2 > .05$, CFI .99, RMSEA, .03). The scale reliability was high ($\alpha = .91$).

**Attitude to Mating** As this study recruited young adolescents, it was ethically inappropriate to measure sexual behavior directly. As a proxy, attitudes toward sex and relationships were assessed. Participants rated their agreement on items assessing attitudes to casual sex, long-term commitments and short-term relationships using a Likert scale. Positive scores represented attitudes favoring short term relationships. Like aggression, this variable was represented as a latent trait in SEM and was therefore validated using CFA. A four item scale provided a reliable measure with a good fit to the data set ($\alpha = .76$, $\chi^2 > .01$, CFI .99, RMSEA .07).

## 3.2 Results

Table 3 presents descriptive statistics and correlations between variables. Of the 36 significant relationships in the macro level data (Table 1), 19 were reflected in the micro equivalent, albeit more weakly, and were in the same direction as those from the census data. In general, the correspondence between macro and micro level data was substantial.

**Table 3** Table of descriptives and correlations from self-report data ($n = 738$).

| | Aggression | STM/LTM | Life expectancy | Education | Unemployment | Family Instability | Population density | Number of youths | Youth sex ratio |
|---|---|---|---|---|---|---|---|---|---|
| STM/LTM | .29** | | | | | | | | |
| Life expectancy | – .14** | – .09** | | | | | | | |
| Education | – .15** | – .06 | .00 | | | | | | |
| Unemployment | .09* | – .01 | .06 | – .57** | | | | | |
| Family instability | .34** | .42** | – .20** | – .09** | .02 | | | | |
| Population density | .13** | .18** | – .07* | – .07* | .01 | .30** | | | |
| Number of youths | .11** | .11** | – .01 | – .03 | .01 | .22** | .31** | | |
| Youth sex ratio | – .03 | – .22** | .03 | – .05 | – .05 | – .13** | – .15** | – .16** | |
| Mean | 5.52 | 4.01 | 81.92 | 36.16 | 4.65 | 16.50 | 1.15 | 1.32 | 1.52 |
| SD | 5.47 | 2.79 | 15.01 | 14.73 | 3.24 | 7.81 | .83 | .81 | .70 |

Fig. 3 represents the census-derived structural model applied to these data. For clarity, the model is displayed in a manner similar to macro models in Study 1 for the purposes of comparison. Linkages represent standardized beta weights. Statistically, when applied to individual data, the model was a good fit ($df = 380$, $\chi^2 = 856.04$, $\chi^2/df = 2.25$, CFI = .93, RMSEA = .04). There were differences between this model and the macro level equivalent however. Of the 12 pathways, five were non-significant ($p > .05$) in the micro level model (*Unemployment* to *Family Instability*, *Life Expectancy* to *Strategy*, *Education* to *Strategy*, *Number of Youths* to *Aggression*, *Density* to *Aggression*). The $r^2$ values for aggression and attitude to mating were lower than the equivalent census-based values for victimful criminality and teenage pregnancy rates, $r^2 = .25$ and .40 respectively ($r^2$ values in the census models were .53/.82 in 2001 and .66/.77 in 2011 respectively).


**Fig. 3** Copping et al. (2013) model applied to individuals ($N = 738$). *$p < .05$.

## 3.3 Discussion

In Study 2, the macro models were validated against equivalent data collected from individuals. This is important because conclusions from macro data alone prohibit firm conclusions regarding individual life history strategy development (the ecological fallacy). Individual data allow clarification of pertinent environmental facets to which individuals are sensitive and demonstrates their importance in the context of psychosocial acceleration theory. While the model based on individuals was not an exact match to census-based models, similarities between them allowed some confidence in the core findings. This finding suggested that the core principles of psychosocial acceleration theory were observable across different units of analysis and validated the premise that these environmental indices are important in determining strategy trajectory.

Nineteen of the 36 correlations in the individual-level data set were significant in the same direction as in the macro data (although reduced in magnitude). Relationships were also significant in expected directions. Aggression was significantly related to all independent variables except sex ratio, while mating orientation was significantly related to all variables except education and unemployment, affirming the fact that these variables are sensitive to environments. In the structural models, seven of the 12 links remained

significant between the concurrent/predictive macro models and the individual-level model. Furthermore, the individual-level model was more statistically parsimonious despite the non-significant pathways. This supported the high concordance between the macro and micro levels. Generally, the non-significant correlations represented relationships between the measures used for unemployment and education with the remaining variables. The lack of significance is probably attributable to the fact that direct measures of an individual's own education or personal economic circumstances were not employed in this study (see general discussion).

The seven relationships that remained significant between all models reflect the effects of education, sex ratio, life expectancy and population density on family instability, the effects of family instability on strategy behaviors and the relationships between aggression and mating orientation as indices of a latent strategy variable. As these were significant regardless of level, it allows a strong measure of confidence to be placed on them as stressors relevant to the development of life history strategies. Their implications will be discussed more thoroughly in the general discussion.

The non-significant relationship between unemployment and family instability ($p < .05$) in the individual level data was inconsistent with current literature (Lewin, 2005; Lichter, Qian & Mellott, 2006). While the number of unemployed in an area is a representative indicator of economic insecurity, unemployment has no inherently perceptible characteristics. Measures examining local indices with perceivable manifestations (such as abandoned, dilapidated buildings etc.) may be better indicators. Education, albeit significant in the model, was more weakly correlated in micro compared to macro data and suffer from a similar problem. Nevertheless, both variables were maintained in the model so as to control for potential distal effects on other variables.

The direct relationship between life expectancy and strategy was also non-significant, although life expectancy's relationship with family instability remained significant. While it maintained an indirect effect on strategy through family instability, it would seem that strategy behavior and predicted life expectancy are not directly linked, supporting Chisholm's (1993) original model of indirect perception of mortality stressors. Although previous macro-level studies have found strong correlations between local life expectancy estimates and strategy behaviors (Copping et al., 2013; Low, Hazel, Parker, & Welch, 2008; Wilson & Daly, 1997), fewer studies have shown the same effects when individuals are asked for their personal estimates of life expectancy. More indirect indices of mortality or threat such as exposure to violence, general health, and measures of pathogenesis (Johns, 2011; Mishra & Lalumière, 2008; Nettle, Coyne, & Colléony, 2012) may be better correlates of strategy and more likely to have the direct effects observed in macro models.

# 4 General discussion

Results from life history studies at macro and micro levels have demonstrated findings consistent with evolutionary theory. In this study, an attempt was made to synthesize data from both levels in order to more accurately identify developmental stressors which could potentially modulate life history strategy development in the context of psychosocial acceleration theory. Between the micro- and macro-level models, seven key relationships remained consistent and significant. The conceptual relevance of these relationships will now be briefly addressed.

Family instability is perhaps the key variable in life history strategy development. Studies have indicated that instability can take forms beyond father absence (Belsky et al., 1991, 2012), encompassing multiple facets such as discipline and mobility. The impact of general family instability on strategy in the micro model was much larger than that of father absence (used as a proxy for instability in the macro model). In both models, family instability was susceptible to the effects of variation in local population densities. Higher population density may make competition for resources more frequent, increasing levels of strain on effective parenting practices. An abundance of females (indexed by negative sex ratios) also strains family stability. A skewed sex ratio means that men are better able to access alternative mates, stretching provisions further, increasing marital disharmony and conveying signals to developing individuals that bi-parental care cannot be relied upon (Barber, 2000a, 2000b). An imbalanced sex ratio may drive up father absence and the number of lone female parent households and thus increase stress (Belsky et al., 1991; Draper & Harpending, 1982). In both models, indices of earlier mortality were significant in predicting the stability of familial functioning. The familial stress associated with shorter life expectancies in some environments strongly supports Chisholm's suggestion that heightened mortality risks support behaviors associated with faster strategies. Finally, the role of education in the stability of families was also important. Education acts as a gateway into accessing resources and opportunities (Kaplan & Gangestad, 2005) or potentially as a safeguard against pregnancy due to insufficient knowledge regarding contraception (Copping et al., 2013).

Competitive and reproductive behaviors (indexed as criminal violence and pregnancy on macro levels, and as aggression and short-term mating orientations at the micro level) rise and fall together across neighborhoods and individuals. While correlations are stronger on the neighborhood level, this is evidence to suggest shared etiological origins, supporting earlier works (Copping et al., 2013; Ellis et al., 2009). While the macro and micro measures were not identical (the micro measures perhaps representing milder, less socially detrimental expressions of behavior), the conceptual overlap between them and the strength of these results presents a compelling case for local ecological conditions as being strongly associated with their behavioral expression.

The role of unemployment (indexing local resource shortages) was not consistent across the two studies. At a macro-level, indices of poverty have been linked to a multitude of behaviors pertinent to this study, including aggression, sexual precocity, mortality and family breakdown (Brewster, 1994; Coulton, Korbin, Su, & Chow, 1995; Lewin, 2005; Tan & Quinlivan, 2006; Wilson & Daly, 1997). The individual level model produced results that were inconsistent with the current literature. This is likely a result of the measurement problems discussed earlier. We conclude that resource deprivation is an important stressor in relation to family disruption and therefore life history strategy trajectories. Education is likely to be equally important for similar reasons. Future studies with valid, individual-level indicators of these variables may confirm this conclusion.

Direct effects of density and proportion of youths on aggression were non-significant at the micro model but remained significant in the macro model. Density and number of youths may be distal causes of strategic behaviors that are not perceived directly but, in combination with other factors, set the context for increased expression of aggressive behavior. These factors may reflect what Copping et al. (2013) call 'local enabling circumstances': Circumstances that could directly

increase the likelihood of a specific behavior independent of actual strategy trajectory (such as an increasing likelihood of reactive aggression due to more frequent exposure to conspecific competition). Alternatively, self-report measures of demographic characteristics may not be accurate representations of local conditions. If so, it is possible that their real impact on behavioral outcomes is masked by a mismatch between perception and reality. Research on the perception of neighborhood characteristics (such as density) suggests that people access them through indirect proxies such as noise, smell, traffic, number of residential buildings and so on (Bergdoll & Williams, 1990; Moch, 1996). Measures employed in this study may not have been sensitive enough to accurately reflect perceived densities. Further research is required and firm conclusions about density-dependent effects on behavior cannot be drawn from these data.

## 4.1 Limitations and future directions

The cross-sectional nature of the data gathered from individuals was a limiting factor in this study. A well-designed longitudinal study of children during the key developmental periods identified by psychosocial acceleration theory would be desirable. The use of a macro educational and unemployment variable in this study rather than the individual's own circumstances was also problematic. Furthermore, other indicators of inequality (such as GINI coefficients) could be used in macro-level studies and may provide a more sensitive measure of local environmental stress. Future studies should aim to accurately measure these at the individual level and, if this were done, we anticipate that these important variables would have stronger effects on key behavioral outcomes. Future studies could also expand the range of dependent measures to include other pertinent life history variables (such as low birth weights, timing of pubertal onset or theoretically-relevant personality traits). While this is not possible using census data, it could be incorporated into a longitudinal research design and would represent an important validity test for psychosocial acceleration theory. This study was unable to eliminate the possibility that strong correlations between environmental facets (at the macro level) could be due to genotypic covariation or assortative mating within communities (Junger, Greene, Schipper, Hesper, & Estourgie, 2013). This is an important consideration as many life history traits demonstrate high levels of heritability (Bouchard, 2004). This research was also unable to eliminate the potential effects of 'social contagion' in crime and precocious sexual behavior (Ludwig & Kling, 2007; Rodgers & Rowe, 1993). The role of social influences, including deviant peer clustering, has been highlighted as significant to life history strategy and thus should be factored into individual level models (Dishion, Ha, & Ve´ronneau, 2012).

Individuals' perceptions of their environment requires further investigation. Self-reported perceptions of demographic factors generally showed the expected associations with life history variables (albeit more weakly in magnitude). Exploring the accuracy of people's perceptions of their environment is important for further development of psychosocial acceleration theory and life history theory. If environments are directly or indirectly responsible for developing strategies and if individuals are able to assess these with accuracy, correlations between perceived and actual demographic stressors should exist. If not, it raises questions about how individuals perceive and encode environmental 'uncertainty'. Perceptions of local population characteristics (such as density and sex ratio) would be interesting to examine in further detail, in light of our finding that population density and proportion of youths in the population were significantly associated with levels of violence at macro but not at micro levels. Suggestions have been made as to how ecological data are internally represented including the notion of statistical composites (Wilson & Daly, 1997) and unpredictability schemas (Ross & Hill, 2002). As yet however, firm conclusions on the nature of these representations have not been reached. Understanding how we map the environment could reveal much about strategy development.

# 5 Uncited references

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## Footnotes

[1]Thirteen authorities excluded from the original work remain so owing to differences in administration.

[2]Does not exclude families with other investment sources (including fathers or other males) or stable mother-only environments.

[3]While pregnancy is possible at earlier ages, this information is confidential and unobtainable from local authorities. Actual rates may be higher than those presented. Statistics represent number of live and still births and registered abortions. Spontaneous abortions are not included.

[4]Homicides are not included as they are not recorded on local levels.

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