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War and Peace: A Diachronic Social Biogeography of Life History Strategy and Between-Group Relations in Two Western European Populations

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We report successful diachronic replication of two major sets of prior findings in the social biogeography of human life history (LH) strategy: (1) the constructive replication of the diachronic changes in the latent hierarchical structure of intelligence in Britannic populations, but as presently applied to the latent hierarchical structure of human LH strategy, now cross-validated in both Britannic and Gallic populations; and (2) the diachronic replication in both Britannic and Gallic populations of the structural relations found synchronically among human LH strategy, between-group competition, and economic productivity in cross-sectional data on contemporary samples of both national and subnational polities. In addition, a supplementary methodological objective was: (3) the convergent validation of diachronic lexicographic measures of LH strategy with respect to more traditional non-lexicographic indicators of LH strategy, such as infant mortality rates, total fertility rates, and life expectancies. We obtained complete *configural* invariance across Britannic and Gallic biocultural groups, meaning that the same model predictors were statistically significant, but incomplete *metric* invariance, meaning that most but not all model parameter estimates were statistically equivalent in magnitude and direction. All new results obtained from diachronic data in Britannic populations were replicated almost perfectly in Gallic populations.

Keywords: Social Biogeography, Life History Strategy, Between-Group Competition, Lexicographic Methods, Limiting Similarity Theory

Previous work developing models of human social biogeography from *synchronic* data has taken Hutchinson's (1957) niche theory as the basic conceptual framework through which ecological constraints on the existence of organisms, biosocial groups, and species are defined (Figueredo et al., 2017; Cabeza de Baca & Figueredo, 2017; Black, Peñaherrera-Aguirre, Chavarria Minera & Figueredo, 2017; Fernandes, Figueredo, Garcia & Wolf, 2017; Fernandes & Woodley of Menie, 2017; Figueredo, Cabeza de Baca & Peñaherrera-Aguirre, 2017); the word *synchronic* denotes event occurring "at the same time" or contemporaneously ("cross-sectionally" in methodological jargon). Such constraints determine the general selective contexts in which organisms evolve. In particular, processes that ecological constraints establish, such as niche splitting and character displacement, likely gave rise to individual differences in LH strategy — a latent construct that subsumes higher-order factors of personality, health, and many other aspects of human behavior (Figueredo, Fernandes, & Woodley of Menie, 2017). The "Coral Reef Model" construes selection for greater strategic differentiation of LH traits among individuals as an outcome of these ecological processes (Figueredo, Fernandes, & Woodley of Menie, 2017).

Hypotheses issuing from this evolutionary theory of LH differentiation have been tested using sequential canonical cascade analysis, which is an exploratory form of path analysis designed to examine hypothesized sequences of causal influence among variables, hierarchically partitioning their correlations into direct and indirect effects. These studies were thus able to estimate a set of plausible structural pathways from the physical ecology to the community ecology, and thence to the social, cultural, and cognitive ecology successively.

What follows is an exploratory exercise broadly situated in the field of *social biogeography;* a term which, before proceeding, warrants operationalization as it is at once central to our current work and obscure in relation to the mainstream literature within evolutionary psychology. Most succinctly, something of social bioegeography is known from its constituent parts — it studies social differences as they are distributed geographically. This, however, only speaks in the broadest sense to the locus of interest, without specifying underlying assumptions or methods. It is thus necessary to further state that social biogeography is fundamentally ecological in that it reduces some proportion of social variance to physical geography and climate, not limited to latitude, altitude, precipitation, vulcanism, wind and oceanic currents, as well as Milankovitch cycles, glaciation and other aspects of paleoclimate imparting lasting evolutionary consequences. In turn, social bioegeography analyzes vegetation, animals, parasites and related community ecological factors resulting from physical ecological factors. Together p*hysical ecology* and c*ommunity ecology* form the beginning of a causal chain progressing towards social ecology, cultural ecology and culminating in cognitive ecology. Among others such as Montesquieu (1965; 1984), Huntington (1913; 1916; 1922), and Murdock (1957; 1967; 1970; 1981), social biogeography has antecedents in the writings of Alfred W. Crosby (2003) whose *Columbian Exchange* details the conquest of the Americas, and William H. McNeill (1998) whose *Plagues and Peoples* is an early example of epidemiological history. As do Crosby (2003) and McNeill (1998), social biogeography mines historical documents, sociological data sets, currency values, and demographic trends among a range of related information. As is evident in reinterpretations of these aforementioned works (Hertler, Figueredo, Peñaherrera-Aguirre, Fernandes, & Woodley of Menie, 2018), where social biogeography differs is in its explicitly evolutionary orientation. *A Sequential Canonical Cascade Model of Social Biogeography: Plants, Parasites, and People* (Figueredo et al., 2017) and *A Social Biogeography of Homicide: Multilevel and Sequential Canonical Examinations of Intragroup Unlawful Killings* (Peñaherrera-Aguirre et al., 2018) are exemplars of social biogeographical studies respectively investigating cross national variation in life history speed and violence.

This first *diachronic* analysis of social biogeography performed upon *diachronic* data was termed the *Nexus 200* analysis, as it spanned the 210 years from AD 1800-2010, and examined temporal covariation among fifteen convergent indicators of three chronometric factors (five of each) in Britannic populations from AD 1800 to 2010: (*g.h*) heritable general intelligence, (*s.e*) specialized intelligences, and (*s.m*) anthropometric changes (Woodley of Menie, Figueredo, et al., 2017); the word *diachronic* denotes event occurring “across time” or historically (“longitudinally” in methodological jargon). The three factors were found to converge upon a common higher-order factor called the *Co-Occurrence Nexus*, which was hypothesized to track shifts in the balance of selection from the group to the individual level in Britannic populations over historical time. This temporal trend was interpreted as a consequence of climatic warming and stabilization lowering environmental harshness, which reduced between-group competition, thereby selecting for higher levels of general intelligence (Woodley & Figueredo, 2013), while simultaneously enabling life history speed slowing, thus increasing *s.e* and *s.m* (consistent with predictions from life history models of the Flynn effect and the synchronic work on social biogeography discussed above; Woodley of Menie, Figueredo, et al., 2017).

The second *diachronic* analysis of social biogeography performed upon *diachronic* data was termed the *Nexus 400*, as it spanned the entire 400 years from AD 1600-1999, and was conducted to test the proposed interpretations of the Nexus 200 analysis about the nature of the Co-Occurrence Nexus. Nexus 400 examined the impact of climatic changes from AD 1600 to 1999 on a chronometric group selection factor, variation in which was correlated with the only one out of the five original *g.h* indicators validated in the Nexus 200 for which there were data extending back to AD 1600: changes in usage frequencies of difficult vocabulary items, constituting a chronometric *hard words factor*. Results were consistent with Nexus 200 interpretations: colder and more variable climates were found to have positive effects on group selection, which in turn positively predicted the hard words factor, and was found to explain the preponderance of cross-temporal variation in that factor (Woodley of Menie, Figueredo, et al., 2017).

The present study focuses more specifically upon the structural relations between aggregate reproductive life history (LH) speed and levels of between-group competition in human populations. We examine these relations diachronically using historical biodemographic and lexicographic data from sources in the public domain on Britannic and Gallic populations over the past 200 years, contextualized against the backdrop of the climatic changes that have been occurring during the Late Modern Era, and the ultimate effects of all of the foregoing upon resource abundance and competition. Although slow LH speeds appear to foster enhanced levels of within-group altruism and in-group cohesion (*positive ethnocentrism*) through various mechanisms of social selection (Figueredo, Patch, & Gómez Ceballos, 2016), they also appear to inhibit between-group competitiveness (*negative ethnocentrism*) cross-culturally (Figueredo, Andrzejczak, Jones, Smith-Castro, & Montero-Rojas, 2011). This combination of findings appears to contradict Alexander's (1987) theory that historical and prehistoric conflict *between* human societies has selected for higher levels of cooperation *within* human societies.

The present study also addresses the need to replicate the results of previous social biogeography models that were conducted cross-sectionally on variation among national and then subnational polities, which support the findings of studies on individual variation in LH speed within some of these same polities that also show an association between slow LH speed and heightened positive and lessened negative ethnocentrism. One further goal is to cross-validate this cross-sectional, *synchronic* pattern of results *diachronically* with longitudinal data. Replicating findings across the orthogonal dimensions of the Cattell (1966) *data box* is no foregone conclusion, as different principles might govern different components of covariance among cases, measures, and occasions. For example, examining relations *among* persons and their characteristics at a single point in time (*inter*-individual differences) may yield different results from examining relations among those same characteristics *within* persons but *across* multiple measurement occasions (*intra*-individual differences). Consequently, the latent structure of *chronometric* common factors might differ systematically from that of *psychometric* common factors derived from the same set of measures (e.g., Figueredo, Brooks, Leff, & Sechrest, 2000; Woodley of Menie, Figueredo, et al., 2017). Finally, a supplementary methodological objective was the convergent validation in both Britannic and Gallic biocultural groups of diachronic lexicographic measures of LH strategy with respect to more traditional non-lexicographic indicators of LH strategy, such as infant mortality rates, total fertility rates, and life expectancies.

The Demographic Transition and Life History Evolution

Although minor variations in the rates of life history indicators had been reported across small-scale societies (Walker et al., 2006), prior to the 19th Century, the ethnographic, paleodemographic, and paleopathological evidence indicate that relative to contemporary nations, life expectancy at birth (e_o) was lower and that total fertility was higher. With respect to e_o, cross-cultural comparisons with small-scale societies had found that e_o was under 60 years. This pattern persists even after considering the level of sociopolitical complexity, and the type of subsistence economy. For instance, the average e_o for five hunter-gatherer societies, the Hadza, the Ache, the Hiwi, the !Kung, and the Agta, was 31 years; that of forager-horticulturalists, including the Yanomamo, the Tsimane, the Machiguenga, and the Gainj, was 33 years (Gurven & Kaplan, 2007).

Post-Neolithic ancient nation states exhibited similar rates. Historical reconstructions based on census and archaeological data suggest e_o was between 21.11 to 35.3 years across Roman Provinces including Egypt, Greece and Illyricum, and Iberia (Frier, 1983). Roman Italian provinces experienced equivalent rates during Imperial times with e_o ranging between 20 to 30 years (Hin, 2017). Medieval English towns during the 14th and the 15th century were not able to surpass these 30 years with male English aristocrats exhibiting an e_o of 24 years (Clark, 2008). Prior to the 19th Century, the figures for modern nation states were similar. For example, Swedish data corresponding to AD 1754 to 1759 indicate e_o was close to 34 years (Gurven & Kaplan, 2007). Across the Atlantic, demographic reconstructions for pre-Columbian Mesoamerican and South American sites indicate these societies fit this pattern. Concerning the latter, Andean and coastal villages in northern South America (2278- 1835 BC) had e_o rates between 29 and 40 years (McCaa, 2005), whereas for Mesoamerican societies e_o was estimated to be 37 years for Early Horizon sites (1400-900 BC) and 20 years for a Postclassic urban site (AD 1325-1500; Morfin, McCaa, Storey, & Angel, 2005). It is worth noting that even though the paleopathological data suggest the adoption of agriculture as well as urbanity impacted e_o (Armelagos & Cohen, 1984; Steckel & Rose, 2005), most paleodemographic estimations place the average e_o for hunter-gathering, horticulturalist, and agriculturalist societies between 20 and 55 years.

Improvements in health, nutrition, and sanitation during the 19th Century modified this historical trend (Caldwell, 2007). Mortality rates decreased at a faster pace relative to fertility rates, generating rapid population growth (Bongaarts, 2009). Individuals following a fast LH strategy could maintain their reproductive rate without increasing their parental or somatic effort. This initial burst was followed by progressive declines in fertility rates in response to stable and reliable environments, with low extrinsic morbidity and mortality, selecting for slow LH strategies. In some nations, fertility rates were observed to drop below the replacement level, increasing the mean age of the population and eventually leading to a demographic contraction (Bongaarts, 2009; Lee, 2003). It is worth noting, however, that the adoption or modification of cultural practices, often interpreted as catalysts of the demographic transition, had an indirect effect on population dynamics dependent on how individuals prioritized the allocation of bioenergetic resources among different components of fitness, such as increasing investment in somatic as opposed to reproductive domains. This 19th Century historical phenomenon has been referred to as the demographic transition (Caldwell, 2007).

This secular slowing of LH strategy over the past 200 years thus counts as an alternative explanation for the reduction in between-group competition also experienced, especially between the larger and increasingly industrialized European states (*Great Powers*), that started around the beginning of the 19th Century.

Lexicographic Methods and Psycholinguistic Considerations

The subfields of linguistics have many advocates for the Darwinian nature of language, which is seen in phenomena such as the evolution of speech organs (Pinker & Bloom, 1990) and in the fact that recursion is an adaptation unique to human language (Hauser, Chomsky, & Fitch, 2002). In fact, Darwin himself was aware that the nature of languages was "curiously parallel" to his own ideas of evolution (Darwin, 1871). This observation was in reference to the social and spatial parameters of the lingual population that ultimately determines the success of a language, such as population decline or dominance of another language (Solé, Corominas-Murtra, & Fortuny, 2010; Crawford 1996). Ultimately, the evolutionary perspective is supported by the fact that many modern languages, including Indo-European languages such as English and French, share common recent phylogenies, having evolved from recent common ancestors (Lynch, 2014).

The *lexical hypothesis*, initially proposed by Galton (1884), further predicts that words will arise by convergent evolution in all human languages for any traits, states, and objects that regularly exist in the ecology, despite the nearly 6000 exclusive languages that still exist today. Following their discovery of evidence supporting the notion that every language shares a common vocabulary of concepts, Goddard and

Wierzbicka (1994, 2013) developed the natural semantic metalanguage (NSM) to consolidate universal key concepts in all languages into one minilanguage. The NSM is made up of semantic primes, universal concepts that can be translated into any language, which include color, body parts, determiners, quantifiers, and others (Goddard & Wierzbicka, 2013). This approach has been used to preserve endangered languages (Goddard, 2008) and soften language barriers (Wierzbicka, 1992), and can be applied to research on the cognitive manifestations of Fodor's (1983) modularity of mind for language in future research.

For example, the relative frequencies of usage of words derived from the *Descent of Man* (Darwin, 1871) were interpreted to serve as indicators of within-group altruism and between-group competition in humans, and have been previously used and validated as such (Woodley of Menie, Figueredo, et al., 2017):

> … a sampling of 10 words used in Darwin's (1871) *Descent of Man* to describe altruistic dispositions as lexical indicators of behaviors that are clearly beneficial to the group but that incur a fitness cost to the individual group member performing them. We refer to these items as "altruistic words" for that reason… It furthermore serves as a potentially direct measure of the change in the strength of group selection over time — on the premise that less group-selected populations will tend to use altruistically valenced words less frequently in their literatures. (p. 62)

Although more than 10 words were initially found that satisfied these criteria, only 10 words were used as the additional words were closely related variants of those selected, such as *kind* and *kindness*. Furthermore, we only retained nouns for consistency.

In the present study, each *Descent of Man* Altruism Word was also translated into French by generating an array of plausible synonyms, from which we selected the optimal choices using psychometric criteria of internal consistency among items within each lexicographic scale. The existence of the semantic primes in the NSM removes uncertainty of the fluidity of translation for more concrete concepts, such as body parts, but not for more abstract concepts.

The added step of psychometric selection among synonyms within each class is therefore crucial to cross-cultural research, to control statistically for their semantic contexts, as words may not translate to denote the exact same concept from one language to another, especially between phylogenetically distant languages from different branches like English and Japanese (Wagatsuma, 1977). Nevertheless, modern English is partially descended from Old French, and is therefore a linguistic "cousin" of modern French. Thus, the translations are probably sufficiently accurate that even in the case of English words with more abstract concepts, such as *courage*, it can be safely assumed that the corresponding French terms have the same essential meaning (Lynch, 2014).

The Present Study

The present study uses historical biodemographic and lexicographic data from sources in the public domain on Britannic and Gallic populations over the past 200 years to explore the structural relations between: (1) climate change, as indicated by temporal trends in the 25-year moving averages and standard deviations of mean global temperatures; (2) relative speed of aggregate reproductive LH strategies; (3) and levels of between-group competition; and (4) effects upon economic productivity and resource abundance, as indicated by Gross Domestic Products (GDP) *per capita*.

Methods

Populations Sampled

Data from AD 1800 to 1999 were collected for the following Britannic nations: UK, USA, Canada, New Zealand, Australia; data from the Gallic nation were also collected, including Continental France as well as its several overseas departments in French Algeria (North Africa) and French Guiana (South America), all counted as part of the French Republic in the national census.

Biodemographic Measures

Population size and GDP per capita data were obtained for both samples from the Maddison Project database (Bolt, Inklaar, de Jong, & van Zanden, 2018), a repository curated by the Groningen Growth and Development Center (GGDC). Warfare mortality estimates were gathered from the Correlates of War database (Sarkees & Wayman, 2010); although this database contains both inter-state and within-state (civil) wars, we excluded all intra-state conflicts and included only conflict between states for present purposes. Wars containing at least one Britannic nation were kept in the database; similar procedures were employed with the Gallic sample. Standardized rates (per 100,000) were computed after accounting for population size, as population size confounds the intensity of warfare due to the fact that societies with a larger population experience a greater absolute number of deaths. The proportion of the world population was estimated based Roser's demographic database (Roser & Ortiz-Ospina, 2017). Total fertility rates (Ajus, Lindgren, & Rosling, , 2015), infant mortality rates (Johanson, Lindgren, & Rosling, 2015), and life expectancy information (Lindgren, 2015) were obtained from the Gapminder database repository.

Lexicographic Measures

For all lexicographic measures, the diachronic utilization of specific classes of words by each biocultural group was evaluated via their relative frequencies of usage through Google Ngram Viewer (Michel et al. 2011), an interactive textual corpus encompassing over 5.9 million texts and 500 billion written words from AD 1500-2008. The data are obtained in the form of frequency counts of each word within its respective language across the 200 years spanning AD 1800-1999.

All lexicographic scales used in this study were originally created in English and then translated into French for the cross-cultural comparison. As we suspected that using simple literal translations might miss important cultural differences in the contexts of their usage, we instead generated lists of plausible synonyms in French for all the original words in English and then selected the French synonym that had the highest part-whole correlation to its respective lexicographic scale in the French language. By this psychometric process of selection, we obtained the optimal French-language equivalent to each English-language word based on its consistency with all the other synonyms selected for each lexicographic scale. The part-whole correlations for each scale are presented below in parallel for each English-language word and the optimal French-language synonym.

Most words selected for these scales were theorized to reflect existing *semantic primes* of the natural semantic metalanguage (NSM), which have been shown to translate conceptually into all languages (Goddard & Wierzbicka, 1994). Google Ngram Viewer (Michel et al., 2011) was used to query the relative frequencies of usage of each word within its respective language across the 200 years spanning AD 1800-1999.

Statistical Analyses

All univariate and multivariate analyses were performed using SAS 9.3 and UniMult 2. A hierarchical analytical strategy was employed. Some missing data at the item level were imputed by the EM algorithm using SAS PROC MI; unit-weighted common factor scales (Gorsuch, 1983) were then estimated using SAS PROC STANDARD and DATA, as the means of the standardized scores for the items on each scale and for the scales on each factor (Figueredo, McKnight, McKnight, & Sidani, 2000). Also computed were the covariance matrices of the subscales using SAS PROC CORR, as well as the part-whole correlations of the items with the scales and of the scales with the unit-weighted factors.

Unit-weighted factors were then entered as manifest variables into SAS PROC MIXED for multilevel longitudinal analysis and the MLM residuals were afterwards entered into UniMult for sequential canonical cascade modeling. MLM residuals were thus statistically adjusted prior to structural modeling for the logarithmic effect of time as well as of any single-lagged heterogeneous autoregressive serial dependencies among successive data, thus circumventing this potential problem as a threat to the validity of correlational analysis (see Hertler et al., 2018).

Results

The Measurement Model

Lexicographic Scales

Darwin Altruism Words. This is a list of words employed by Darwin (1871) to describe within-groups altruism and between-groups competition in humans, harvested from the original text of *The Descent of Man*, that had been previously used to construct a psychometric scale in earlier published work on the diachronic social biogeography of cognitive abilities in Britannic populations (Woodley of Menie, Figueredo, et al., 2017), in which it was validated with respect to diachronically convergent indicators of between-group competition using heterogeneous methods (Table 1). Some words derived from *The Descent of Man* (Darwin, 1871) were used that are not currently found in the Goddard and Wierzbicka (2014) NSM catalogue, though our results show that some concepts should

Table 1
Part-Whole Correlations of Darwin's Descent of Man Altruism Words converging upon a single lexicographic scale for altruistic words in Britannic and Gallic population

Original English Words	*r* Britannic Darwin Altruism Words	Optimal French Translations	*r* Gallic Darwin Altruism Words
Self-sacrifice	.286*	*Abnégation*	.671*
Kindness	.841*	*Bienveillance*	.907*
Aid	.303*	*Charité*	.865*
Sympathy	.675*	*Compassion*	.612*
Duty	.905*	*Devoir*	.943*
Fidelity	.766*	*Dévouement*	.895*
Courage	.855*	*Hardiesse*	.837*
Heroism	.857*	*Héroïsme*	.400*
Obedience	.690*	*Obéissance*	.829*
Patriotism	.915*	*Patriotisme*	.771*

*p<.05

be considered candidates for consideration. Table 1 shows the part-whole correlations.

Slow LH Words and Fast LH Words. These were lists of words harvested from the collections of words observed by Sherman, Figueredo, and Funder (2013) to be employed disproportionally in conversation by either slower or faster LH strategists, respectively, which were identified by non-lexicographic methods. Both the English-language and the French-language equivalents used as items in each of these lexicographic scales were psychometrically selected on the basis of obtaining adequate part-whole correlations for each word to the corresponding aggregate scale score in its respective language, thus maximizing the internal consistency of each lexicographic scale. This procedure was constrained to select an equal number of semantically equivalent words in both languages, thus protecting against capitalization on chance associations in the psychometric selection of words by insuring that each individual word was cross-validated semantically in the other language. As the negative and statistically non-significant part-whole correlations of the French-language translations for “Win” and “Dream” illustrate, this psychometric selection procedure did not guarantee producing scales with perfect internal consistencies.

We thus selected words in both languages from the initially larger lists based on their convergent validity with respect to each other, as indicated by the internal consistency of the constructed scales. The presumption was that the items would be differentially valid as a function of how well they reflected the central latent constructs, which were Slow and Fast LH strategy, and should therefore be selected on that basis. Recall that the compilation of Slow and Fast LH words in Sherman, Figueredo, and Funder (2013) was conducted empirically in an exploratory rather than a theoretically-guided manner. We therefore deemed it quite likely that there would be some Type I errors present in the published word lists due to the inevitable capitalization on chance. Our psychometric selection procedure was deemed to be the most straightforward way of identifying the best item-level indicators of these constructs, and eliminating any items that might have been included based on chance fluctuations among their correlation coefficients. Tables 2 and 3 display the part-whole correlations of each equivalent word in both the English and French languages.

Table 2

Part-Whole Correlations of Slow LH Words converging upon a single lexicographic scale for slower LH in Britannic and Gallic populations

Original English Words	*r* Britannic Slow Life History Words	Optimal French Translations	*r* Gallic Slow Life History Words
Work	.900*	*Travail*	.907*
Class	.969*	*Classe*	.688*
Boss	.967*	*Boss*	.777*
Student	.974*	*Etudiant*	.904*
College	.822*	*Université*	.937*
Try	.960*	*Essayer*	.867*
Goal	.850*	*Objectif*	.903*
Win	.968*	*Victoire*	-.107

*p<.05

Table 3

Part-Whole Correlations of Fast LH Words converging upon a single lexicographic scale for faster LH in Britannic and Gallic populations

Original English Words	*r* Britannic Fast Life History Words	Optimal French Translations	*r* Gallic Fast Life History Words
Asleep	.731*	*Endormi*	.478*
Bath	.642*	*Bain*	.538*
Breast	.746*	*Poitrine*	.836*
Brother	.925*	*Frère*	.854*
Burial	.295*	*Sépulture*	.652*
Coffin	.729*	*Cercueil*	.663*
Cough	.878*	*Toux*	.791*
Cousin	.801*	*Cousin*	.606*
Dead	.902*	*Mort*	.826*
Dreams	.904*	*Songes*	-.286*
Eat	.370*	*Diner*	.678*
I	.944*	*Je*	.908*
Me	.956*	*Me*	.845*
My	.906*	*Mon*	.851*
Our	.822*	*Nos*	.804*
Sleep	.447*	*Coucher*	.917*
Swallow	.883*	*Avaler*	.598*
They	.731*	*Eux*	.885*
We	.874*	*Nous*	.636*

*p<.05

Biodemographic Scales

Three classic Biodemographic LH Indicators are aggregated here to create a single composite scale: (1) Life Expectancy; (2) Total Fertility Rate; and (3) Infant Mortality Rate. Total Fertility and Infant Mortality Rates were reverse-scored prior to aggregation to orient the direction of the scale towards indicating slower LH strategies. Table 4 displays the part-whole correlations of each biodemographic LH indicator, in parallel for Britannic and Gallic populations.

Table 4
Part-Whole Correlations of Biodemographic Slow LH indicators converging upon a single lexicographic scale for slower LH strategies in Britannic and Gallic populations

Biodemographic Indicators	*r* Britannic Slow Life History	*r* Gallic Slow Life History
Life Expectancy	.994*	.962*
Total Fertility Rate	-.952*	-.902*
Infant Mortality Rate	-947*	-.979*

**p*<.05

Common Factor Models

Slow Life History (LH Factor). This was a latent common factor constructed to measure slower LH strategies using the following three convergent indicators: (1) the Biodemographic Slow LH scale; (2) the Lexicographic Slow LH Words scale; and (3) the Lexicographic Fast LH Words scale. The Fast LH Words scales were reverse-scored prior to aggregation for both Britannic and Gallic populations to orient the direction of the scale towards reflecting slower LH strategies.

Table 5 displays the part-whole correlations of each convergent LH indicator with the latent LH common factor, in parallel for Britannic and Gallic populations. These part-whole correlations may be interpreted as convergent validity coefficients, and indicate that the novel lexicographic indicators converge well with the more traditional biodemographic indicators of LH strategies in both Britannic and Gallic biocultural groups, thus providing some empirical support for the validity of lexicographic methods with respect to biodemographic methods for measuring LH strategies.

Between-Group (BG) Competition Factor. This was the same latent common factor that had been previously constructed to indicate between-group competition in earlier published work on the diachronic social biogeography of cognitive abilities in Britannic populations (Woodley of

Menie, Figueredo, et al., 2017). In this study, we constructed a parallel latent common factor for Gallic populations as well.

Table 5

Part-Whole Correlations of Methodologically heterogeneous slow LH scales converging upon a multi-method slower LH common factor in Britannic and Gallic populations

Methodologically Heterogeneous Slow LH Scales	*r* Britannic Slow LH Factor	*r* Gallic Slow LH Factor
Biodemographic Slow LH	.990*	.982*
Lexicographic Slow LH Words	.953*	.976*
Lexicographic Fast LH Words	-.941*	-.965*

**p*<.05

Table 6 displays the part-whole correlations of each BG Competition indicator, in parallel for Britannic and Gallic populations. Once again, these part-whole correlations may be interpreted as convergent validity coefficients, and indicate that the novel lexicographic indicator converges significantly with the more traditional biodemographic indicators of BG Competition, thus providing some empirical support for the validity of lexicographic methods with respect to biodemographic methods for measuring BG Competition in both Britannic and Gallic biocultural groups.

Table 6

Part-Whole Correlations of Between-group (BG) Competition indicators converging upon a single common factor for Between-group (BG) Competition in Britannic and Gallic populations

Between-Group Competition Scales	*r* Britannic BG Competition Factor	*r* Gallic BG Competition Factor
Darwin's Descent of Man Altruism Words	.415*	.923*
Proportion of the World's Population	.662*	.816*
War Mortality per 100,000	.463*	.518*

**p*<.05

Multilevel Models (MLMs)

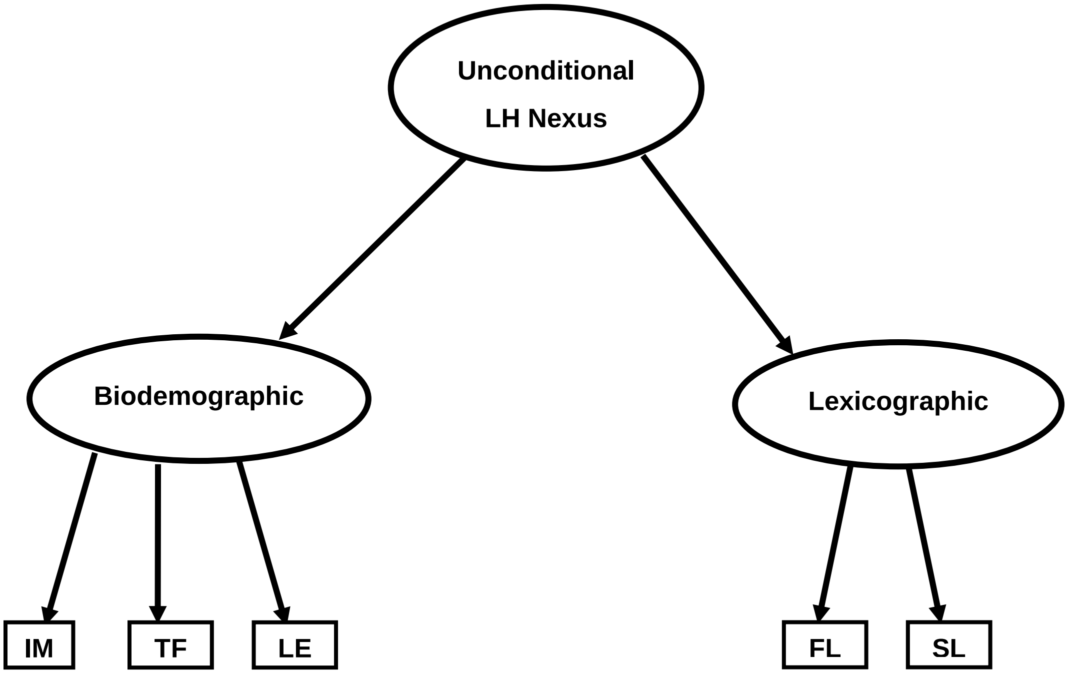
We constructed a series of nested MLMs to determine whether the same chronometric data aggregation strategy would work for a diachronic "Life History Strategy Nexus" as had been successfully applied with the

"Co-Occurrence Nexus" of cognitive abilities (Woodley of Menie, Figueredo, et al., 2017).

Five hypothesized Life History (LH) Strategy Nexus indicators (ranging from AD 1800-1999) were each individually standardized then entered as parallel measures into a Multilevel Model (MLM), using SAS PROC MIXED, with Heterogeneous Autoregressive (ARH-1) residual covariance structures, random intercepts, fixed logarithmic slopes, and maximum likelihood (ML) estimation.

Two Level 2 Chronometric LH SubNexus Method Clusters were used as a grouping factor for the five Level 1 Chronometric LH SubCluster Indicators: (1) Biodemographic Methods *(BIODEM);* and (2) Lexicographic Methods *(LXGRPH)* The Biodemographic Methods (*BIODEM*) Cluster encompassed the first three Level 1 Chronometric LH SubCluster Indicators: (1) Infant Mortality (*IMR*) – Reversed; (2) Total Fertility (*TFR*) – Reversed; and (3) Life Expectancy (*LEX*). The Lexicographic Methods (*LXGRPH*) Cluster encompassed the two final Level 1 Chronometric LH SubCluster Indicators: (4) Fast LH Words (*FLW*) – Reversed; and (5) Slow LH Words (*SLW*).

Figure 1.
The Latent Hierarchical Structure of the Life History (LH) Strategy Nexus.



Three nested MLMs were estimated to test the need for increasing parameterization as alternative hypotheses:

1. MLM1 estimated a single intercept and a single logarithmic slope (Unconditional LH "Nexus") for all LH Clusters and Indicators over time, as well as the same intercepts and logarithmic slopes for all LH SubCluster Indicators nested within each LH SubNexus Method Cluster
2. MLM2 estimated a separate intercept and a separate logarithmic slope for each SubNexus LH Method Cluster over time, but the same intercept and logarithmic slopes for all LH SubCluster Indicators nested within each SubNexus LH Method Cluster
3. MLM3 a separate intercept and a separate logarithmic slope for each LH SubNexus Method Cluster over time as well as a separate intercept and a separate logarithmic slope for each LH SubCluster Indicator over time within each LH SubNexus Method Cluster

Table 7 displays the pertinent nested model comparisons. The systematic AIC and -2RLL comparisons performed among the nested models representing the specific variance components of the Level 2 and Level 1 Chronometric LH Constructs indicated the following: (1) The Level 2 Chronometric LH SubNexus Method Cluster specific variance components were not statistically significant for either Britannic or Gallic populations; and (2) The Level 1 LH Chronometric SubCluster Indicator specific variance components were nonetheless statistically significant for the Britannic but not the Gallic population.

Comparisons of squared multiple correlations among the three nested MLMs yielded essentially the same results. The magnitude of the specific variances of the Level 2 and Level 1 LH SubNexus Method Clusters and LH SubCluster Indicators were found to be negligibly small in contrast with the common factor variance of the Level 3 "Unconditional" LH Nexus, which was found to be quite large for both the Britannic and Gallic populations. The unitary Level 3 "Unconditional" LH Nexus explained a "common factor variance" of more than 80% of the total variance in both populations. These results provide further convergent validation diachronically for the novel lexicographic methods with respect to the traditional biodemographic measures of LH strategy in both Britannic and Gallic biocultural groups.

Given the strength of these findings, we report the model parameters for only the unitary Level 3 "Unconditional" LH Nexus (*MLM1*), as the extra model parameters added by *MLM2* and *MLM3* were virtually irrelevant to an adequate account of the diachronic variances in LH strategy.

Table 7

Nested MLM Comparisons for Level 1 and Level 2 with Level 3 Latent Chronometric Life History (LH) Constructs as natural logarithmic functions of time with Britannic and Gallic populations across the 200 years spanning AD 1800-1999

	Common Factor Variance *(MLM1)*	Common Method Variance *(MLM2)*	Specific Indicator Variance *(MLM3)*
Britannic population			
AIC	1102.1	1105.9	1088.2
-2RLL	1094.1	1093.9	1064.2
	$\Delta\chi^2$ =	0.2	29.7*
R^2	.824*	.824*	.829*
	ΔR^2=	.000	.005*
	ΔModel df =	2	7
Gallic population			
AIC	894.4	898.3	908.4
-2RLL	886.4	886.3	884.4
	$\Delta\chi^2$ =	0.1	1.9
	.857*	.857*	.858*
R^2	ΔR^2=	.000	.001
	ΔModel df =	2	7

*p<.05

Table 8 displays the basic parameters of the Level 3 "Unconditional" *MLM1*. The latent chronometric LH Nexus construct for both Britannic and Gallic populations is modeled as a natural logarithmic function of time (*LNT*), using SAS PROC MIXED, with single-lagged heterogeneous autoregressive (*ARH-1*) residual covariance structures, maximum likelihood (*ML*) estimation, fixed slopes, and random intercepts. In both cases, the magnitudes of the *ARH-1* residual covariances were estimated at zero to two decimal places. The independently-estimated intercepts and slopes were nearly identical across the two populations, and the logarithmic slopes of the Level 3 latent LH Nexus construct with respect to time were positive and statistically significant. These results indicate that LH strategy was *slowing* significantly in both Britannic and Gallic populations over the 200 years spanning AD 1800-1999 as a logarithmic function of time.

Table 8

Multilevel Model of Latent Chronometric Life History (LH) Constructs as a natural logarithmic function of time (LNT) with Britannic and Gallic populations across the 200 years spanning AD 1800-1999

Covariance parameter	Estimate	*SE*	*z*	*p*
	Britannic population			
Variance	0.00			
ARH-1	0.00			
Residuals	.142	.006	22.36*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-229.230	0	-77.48*	.
LNT	30.366	998	77.48*	<.0001
	Gallic population			
Variance	0.00			
ARH-1	0.00			
Residuals	.175	.008	22.36*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-224.780	0	-68.49*	.
LNT	29.776	998	68.49*	<.0001

**p*<.05

Given the robustness of these findings, we now report the measurement model parameters ("factor structures") for the Level 2 LH SubNexus Method Clusters with respect to the unitary Level 3 "Unconditional" LH Nexus as well as for the Level 1 LH SubCluster Indicators with respect to both the Level 2 LH SubNexus Method Clusters and the unitary Level 3 "Unconditional" LH Nexus. These will serve as the MLM equivalent of factor loadings, with the correlations of the latent lower-order to the latent higher-order common factors (Table 9) as well as the correlations of the manifest indicators to both the latent lower-order and higher-order common factors (Table 10). The part-whole correlation coefficients for the Britannic population are tabulated first, and then the corresponding part-whole correlation coefficients for the Gallic population are tabulated after the commas within each cell of the two tables that follow. An asterisk (*) indicates statistical significance at the conventional level of p<.05.

Table 9

Measurement Model for Level 2 with Level 3 Latent Chronometric Life History (LH) Constructs (Part-Whole Correlation Coefficients = Britannic, Gallic)

Level 2 LH SubNexus Method Clusters	*r* Level 3 Unconditional LH Nexus Loading
Biodemographic (*BIODEM*) LH SubNexus Method	.913*, .922*
Lexicographic (*LXGRPH*) LH SubNexus Method	.900*, .932*

**p*<.05

Even a cursory perusal of Table 10 immediately reveals that the two Level 2 LH SubNexus Method Clusters are so highly correlated with each other that their factor loadings on the manifest Level 1 SubCluster Indicators are identical to within two decimal places. Furthermore, the factor loadings on both biodemographic and lexicographic indicators are all quite high and most of them are nearly equivalent to each other in their magnitudes. This indicates that the "method variance" associated with using biodemographic versus lexicographic approaches to assessing LH strategy is virtually negligible, in stark contrast to the repeated and empirically under-substantiated claims made by various critics of the psychometric approach to measuring LH (e.g., Copping, Campbell, & Muncer, 2014), at least with data such as these in which multivariate

Table 10

Measurement Model for Level 1 with Level 2 and Level 3 Latent Chronometric Life History (LH) Constructs (Part-Whole Correlation Coefficients = Britannic, Gallic)

Level 1 LH SubCluster Indicator	*r* Level 2 LH SubNexus Method Cluster Loading	*r* Level 3 Unconditional LH Nexus Loading
Infant Mortality (*IMR*) – Reversed	.824*, .938*	.824*, .938*
Life Expectancy (*LEX*)	.958*, .929*	.958*, .929*
Total Fertility (*TFR*) – Reversed	.958*, .899*	.958*, .899*
Fast LH Words (*FLW*) – Reversed	.817*, .915*	.817*, .915*
Slow LH Words (*SLW*)	.983*, .948*	.983*, .948*

**p*<.05

attenuation due to item unreliability is minimized. These results provide further support for the nearly–perfect aggregate convergent validity of the novel lexicographic methods with respect to the traditional biodemographic measures of LH strategy in both Britannic and Gallic biocultural groups.

After all of these preliminary psychometric results were obtained, we deemed it sufficiently supported by the data to aggregate the two major criterion constructs in this study by means of unit-weighted factor scoring. These common factors were: (1) the Slow LH Factor; and (2) the BG Competition Factor. GDP *Per Capita* was already encoded into a single scale and did not require any such data aggregation. All the standardized (z) scores of all three of these constructs were then subjected to analysis and residualization as unitary scales by means of Multilevel Modeling (MLM), again using SAS PROC MIXED, with Heterogeneous Autoregressive (ARH-1) residual covariance structures, random intercepts, fixed logarithmic slopes, and maximum likelihood (ML) estimation.

Tables 11-13 display the results of these analyses across the 200 years spanning AD 1800-1999. Perusing Tables 11 and 13, we can see that both the Slow LH Factor and GDP *Per Capita* were significantly increasing over time for both Britannic and Gallic populations. In both cases, the magnitudes of the *ARH-1* residual covariances were estimated at zero to two decimal places, and the independently-estimated intercepts and slopes were nearly identical across the two populations. Examining Table 12, however, we see that the BG Competition Factor was only decreasing significantly over time for the Gallic and not the Britannic populations; the estimated Britannic slope was also in the negative direction, but of substantially lesser absolute magnitude. In both cases, the magnitudes of the *ARH-1* residual covariances were once again estimated at zero to two decimal places for the BG Competition Factor.

Table 11

Multilevel Model of the Unit-Weighted Chronometric Life History (LH) Factor as a natural logarithmic function of time (LNT) with Britannic and Gallic populations across the 200 years spanning AD 1800-1999

Covariance parameter	Estimate	*SE*	*z*	*p*
		Britannic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.092	.009	10.00*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-235.840	0	-44.27*	.
LNT	31.241	198	44.27*	<.0001
		Gallic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.059	.006	10.00*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-240.190	0	-56.57*	.
LNT	31.818	198	56.57*	<.0001

*p<.05

Table 12

Multilevel Model of Unit-Weighted Chronometric Between-Group (BG) Competition Factor as a natural logarithmic function of time (LNT) with Britannic and Gallic populations across the 200 years spanning AD 1800-1999

Covariance parameter	Estimate	*SE*	*z*	*p*
		Britannic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.992	.099	10.00*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	13.325	0	.76*	.
LNT	-1.765	198	-.76*	.4468
		Gallic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.507	.051	10.00*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	173.480	0	13.89*	.
LNT	-22.980	198	-13.89*	<.0001

*p<.05

Table 13

Multilevel Model of the Chronometric GDP per capita Construct as a natural logarithmic function of time (LNT) with Britannic and Gallic populations across the 200 years spanning AD 1800-1999

Covariance parameter	Estimate	*SE*	*z*	*p*
		Britannic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.240	.024	10.00*	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-215.720	0	-25.11*	.
LNT	28.576	198	25.11*	<.0001
		Gallic population		
Variance	0.00			
ARH-1	0.00			
Residuals	.059	.006	10.00	<.0001
Fixed Effect	Estimate	DDF	*t*	*p*
Intercept	-240.190	0	-56.57*	.
LNT	31.818	198	56.57*	<.0001

$^{*}p<.05$

The studentized residuals for all three constructs were then exported for further analyses within the structural models. These residuals were thus statistically adjusted for the logarithmic effect of time as well as of any single-lagged heterogeneous autoregressive serial dependencies among successive data. The residualized longitudinal data within each of the three time streams can therefore be treated as independent observations and *Galton's Problem* was thus circumvented as a threat to the validity of correlational analysis (see Hertler et al., 2018).

The Structural Model

The structural models were operationalized as hierarchical cascade models constructed to test the relations among the three major constructs of interest in the present study. These cascade models analyzed the MLM-residuals of each of these constructs, statistically controlled for the logarithmic effect of time as well as of any single-lagged heterogeneous autoregressive serial dependencies among successive data. To keep our description of results concise, however, we will not be referring repeatedly to each of these variables as MLM "residuals", as is done in the tables that follow to preserve technical accuracy in reporting.

Tables 14 and 15 present and compare two theoretically plausible alternative cascade models (ordered systems of hierarchical multiple regression equations) across the 200 years spanning AD 1800-1999, examining the sequential semipartial correlations *(sR)* among indicators of physical ecology, national life history (LH), between-group (BG) competition, and gross domestic product (GDP) per capita. Twenty-five-year moving averages *(25-YMA)* and twenty-five-year moving average standard deviations *(25-YMSD)* were used for global temperatures. The binary "Gallic Dummy" variable distinguishes Britannic (=0) from Gallic (=1) populations (see Cohen & Cohen, 1983).

In Table 14, slow LH strategy was included hierarchically prior to between-group (BG) competition. This hierarchical order is consistent with those used in previous works on synchronic social biogeography (*e.g.*, Figueredo et al. 2017) on a cross-sectional sample of national-level polities, and is based on the proposed indirect effects of slow LH strategy *via* promoting greater social and sexual equality in the distribution of resources and hence reducing both within-groups and between-groups competition and conflict.

In this model, the Slow LH Factor was positively influenced by warmer and more variable temperatures, with a negative interaction between them indicating that the two positive main effects were less than fully additive. None of the interactions of the above with the Gallic Dummy variable were statistically significant, indicating metric as well as configural invariance of these effects across the Britannic and Gallic populations.

As expected, the BG Competition Factor was negatively influenced by the Slow LH Factor. In addition, the BG Competition Factor was positively influenced by colder and less variable temperatures, with the negative interaction between them indicating that the two negative main effects had a joint effect that was, in this case, *more* negative than their simple sum. Once again, none of the interactions of any of the above with the Gallic Dummy variable were statistically significant, indicating metric as well as configural invariance of these effects across the Britannic and Gallic populations.

As in the synchronic social biogeography models cited above, GDP Per Capita was negatively influenced by the BG Competition Factor and positively influenced by the Slow LH Factor. In addition, GDP Per Capita was positively influenced by more variable temperatures, as well as a positive interaction between warmer and more variable temperatures. None of the interactions of the above with the Gallic Dummy variable were statistically significant, with the single exception of a positive interaction between the Gallic Dummy variable and BG Competition. This latter effect indicated that the effect of BG Competition on GDP Per Capita was significantly less negative for Gallic than Britannic populations, although still negative in its aggregate effect. For this last hierarchical regression equation in the present cascade model, this meant that we observed configural invariance but incomplete metric invariance of effects across the Britannic and Gallic populations.

Table 14

Cascade model of hierarchical multiple regression analyses across 200 years examining semipartial correlations (sR) among indicators of physical ecology, national life history, between-group competition, and gross domestic product (GDP) per capita, with slow life history (LH) strategy included hierarchically prior to between-group (BG) competition [N=400; Parsimony Count=15]

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
Slow LH Factor (Residuals)					
		Average Temperature	.20*	1	<.0001
		Standard Deviation Temperature	.31*	1	<.0001
		Average by Standard Deviation Temperature	-.15*	1	.001
		Gallic Dummy	.00	1	.90
		Gallic Dummy by Average Temperature	-.05	1	.32
		Gallic Dummy by Standard Deviation Temperature	-.03	1	.58
		Gallic Dummy by Average by Standard Deviation Temperature	-.03	1	.52
	Multiple *R*=		.63*	7	<.0001

Table 14 (Continued)

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
BG Competition Factor (Residuals)	Slow LH Factor (Residuals)		-.41*	1	<.0001
		Average Temperature	-.11*	1	.02
		Standard Deviation Temperature	-.12*	1	.009
		Average by Standard Deviation Temperature	-.20*	1	<.0001
		Gallic Dummy	.00	1	.90
		Gallic Dummy by Slow LH (Residuals)	-.01		.77
		Gallic Dummy by Average Temperature	-.04	1	.41
		Gallic Dummy by Standard Deviation Temperature	.07	1	.10
		Gallic Dummy by Average by Standard Deviation Temperature	.04	1	.32
	Multiple *R*=		.70*	9	<.0001

Table 14 (Continued)

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
GDP Per Capita (Residuals)	BG Competition Factor (Residuals)		-.43*	1	<.0001
	Slow LH Factor (Residuals)		.15*	1	<.0001
		Average Temperature	-.02	1	.64
		Standard Deviation Temperature	.22*	1	<.0001
		Average by Standard Deviation Temperature	.25*	1	<.0001
		Gallic Dummy	.00	1	.90
		Gallic Dummy by BG Competition (Residuals)	.26*		<.0001
		Gallic Dummy by Slow LH (Residuals)	.06		.13
		Gallic Dummy by Average Temperature	-.03	1	.46
		Gallic Dummy by Standard Deviation Temperature	.06	1	.14
		Gallic Dummy by Average by Standard Deviation Temperature	.02	1	.62
	Multiple *R*=		.79*	11	<.0001

**p*<.05

In Table 15, BG competition was included hierarchically prior to slow LH strategy. This alternative hierarchical order is consistent with the body of theory deriving the evolution of faster LH strategies from selection against slower LH strategies under elevated levels of extrinsic morbidity and mortality (Ellis, Figueredo, Brumbach, & Schlomer, 2009). In this view, violent between-group competition and armed conflict may impose elevated casualty rates, including numerous injuries and deaths.

In this model, the BG Competition Factor was positively influenced by colder and less variable temperatures, with the negative interaction between them indicating that the two negative main effects had a joint effect that was, in this case, *more* negative than their simple sum. Once again, none of the interactions of any of the above with the Gallic Dummy variable were statistically significant, indicating metric as well as configural invariance of these effects across the Britannic and Gallic populations.

As expected, the Slow LH Factor was negatively influenced by the BG Competition Factor. In addition, the Slow LH Factor was positively influenced by warmer and more variable temperatures, with a negative interaction between them once again indicating that the two positive main effects were less than fully additive. None of the interactions of any of the above with the Gallic Dummy variable were statistically significant, indicating metric as well as configural invariance of these effects across the Britannic and Gallic populations.

Although the hierarchical order of these two prior criterion variables was reversed in this alternative model as compared to the cascade model reported immediately above, GDP Per Capita was still positively influenced by the Slow LH Factor and negatively influenced by the BG Competition Factor. In addition, GDP Per Capita was once again positively influenced by more variable temperatures, as well as a positive interaction between warmer and more variable temperatures. As in the previous cascade model, none of the interactions of the above with the Gallic Dummy variable were statistically significant, with the single exception of a positive interaction between the Gallic Dummy variable and BG Competition. This latter effect once again indicated that the effect of BG Competition on GDP Per Capita was significantly less negative for Gallic than Britannic populations, although still negative in its aggregate effect. For this last hierarchical regression equation in the alternative cascade model, this meant that we observed configural invariance but incomplete metric invariance of effects across the Britannic and Gallic populations.

Table 15

Cascade model of hierarchical multiple regression analyses across 200 years examining semipartial correlations (sR) among indicators of physical ecology, national life history, between-group competition, and gross domestic product (GDP) per capita, with between-group (BG) competition included hierarchically prior to slow life history (LH) strategy [N=400; Parsimony Count=15]

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
BG Competition Factor (Residuals)					
		Average Temperature	-.19*	1	<.0001
		Standard Deviation Temperature	-23*	1	<.0001
		Average by Standard Deviation Temperature	-.14*	1	.003
		Gallic Dummy	.00	1	.90
		Gallic Dummy by Average Temperature	-.02	1	.67
		Gallic Dummy by Standard Deviation Temperature	.08	1	.10
		Gallic Dummy by Average by Standard Deviation Temperature	.06	1	.21
	Multiple *R*=		.58*	7	<.0001

Table 15 (Continued).

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
Slow LH Factor (Residuals)	BG Competition Factor (Residuals)		-.41*	1	<.0001
		Average Temperature	.13*	1	.03
		Standard Deviation Temperature	.23*	1	<.0001
		Average by Standard Deviation Temperature	-.20*	1	<.0001
		Gallic Dummy	.00	1	.90
		Gallic Dummy by BG Competition (Residuals)	.00	1	.90
		Gallic Dummy by Average Temperature	-.05	1	.20
		Gallic Dummy by Standard Deviation Temperature	.00	1	.90
		Gallic Dummy by Average by Standard Deviation Temperature	-.01	1	.81
	Multiple *R*=		.73*	9	<.0001

Table 15 (Continued).

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
GDP Per Capita (Residuals)	Slow LH Factor (Residuals)		.31*	1	<.0001
	BG Competition Factor (Residuals)		-.33*	1	<.0001
		Average Temperature	-.02	1	.64
		Standard Deviation Temperature	.22*	1	<.0001
		Average by Standard Deviation Temperature	.25*	1	<.0001
		Gallic Dummy	.00	1	.90
		Gallic Dummy by Slow LH (Residuals)	-.05		.18
		Gallic Dummy by BG Competition (Residuals)	.26*		<.0001
		Gallic Dummy by Average Temperature	-.03	1	.46
		Gallic Dummy by Standard Deviation Temperature	.06	1	.14

Table 15 (Continued).

Criterion Variables	Prior Criterion Variables	Predictor Variables	*sR*	*DF*	*p*
		Gallic Dummy by Average by Standard Deviation Temperature	.02	1	.62
	Multiple *R*=		.79*	11	.0001

*p<.05

As a cascade model can be used to serve as an exploratory form of path analysis (Figueredo & Gorsuch, 2007), we have developed an index of the model parsimony that one might expect upon the cross-validation of results upon an independent sample. In exploratory factor analysis one may count the number of non-salient factor loadings that would be fixed at zero upon cross-validation with a confirmatory factor model, and this number is referred to as the *hyperplane count*. By analogy, in an exploratory path analysis one may count the number of statistically non-significant path coefficients that would be similarly fixed at zero upon cross-validation with a confirmatory path model, and this number is one that we refer to as the *parsimony count*. When comparing different hierarchical orders among criterion variables in a cascade model, the total amount of variance explained remains invariant; the model parsimony, however, might or might not change. The parsimony count can therefore sometimes be used to decide among two or more alternative path models based on their relative degrees of parameterization, where preference would be given to one that explains the same amount of variance with a lesser number of parameter estimates.

Regrettably, however, in the case of the two alternative cascade models presently under consideration, the parsimony count was equal to 15 in both cases, and can therefore not be used to decide empirically upon their relative adequacy. In the Discussion section that follows, we will be proposing a *post hoc* interpretation of these results from which we derive testable predictions that can help support one or the other hierarchical order given the future completion of some follow-up studies to this one.

Discussion

We applied the same chronometric multilevel modeling procedures for examining the latent hierarchical structure of human LH strategy diachronically as had Woodley of Menie and colleagues (2017) to the latent hierarchical structure of human intelligence in Britannic populations and found quite similar results, supporting a diachronic Co-Occurrence Nexus of LH traits parallel to that previously found for cognitive abilities. The present results for the latent structure of LH strategy also replicated almost perfectly for Gallic populations. Our present chronometric multilevel longitudinal models also revealed that LH strategy has been significantly *slowing*, and GDP per capita significantly *increasing*, as a logarithmic function of time over this past couple of centuries. Both of these temporal trends were also found to be virtually identical for Gallic and Britannic populations. The present diachronic findings are also consistent with the previous synchronic findings on the current positive relation between completed fertility and individual-difference-level indicators of slower LH, as a moderated function of their additive heritabilities, in recently collected cross-sectional and longitudinal data from both the USA and Sweden (Woodley of Menie, Cabeza de Baca, et al., 2017).

Furthermore, the results of the sequential canonical cascade model on the MLM residuals of the diachronic data are also consistent with the previous two sets of synchronic findings on the dynamics of human social biogeography. The first such set had examined synchronic data from 66 national polities in Asia, Europe, and Africa, finding that temperate, forested, colder, and wetter climates, having significantly lower parasite burdens on human populations, tend to select for slower LH speeds, which successively predicted significant increases within the following cascade of direct and indirect *sequelae:* (1) social equality; (2) within-group peace; (3) between-group peace; (4) sexual equality; (5) strategic differentiation; (6) macroeconomic diversification; (7) human capital; (8) brain volumes; (9) and aggregate national intelligence (Figueredo et al., 2017). The second such set had been performed subsequently to cross-validate this general pattern of results using synchronic data from subnational regions of Spain, Italy, and Mexico on: (1) climate, parasite burden, population density, and consequently LH speed (Cabeza de Baca & Figueredo, 2017); (2) economic inequality and sexual inequality (Black et al., 2017); (3) cognitive differentiation of intelligence, strategic differentiation of LH, and consequently macroeconomic diversification (Fernandes et al, 2017); and (4) human capital and consequently aggregate regional intelligence (Fernandes & Woodley of Menie, 2017). Taken together, the results of the various studies were found to indicate that colder and wetter climates tend to select for slower LH speeds, which in turn favor higher levels of social and sexual equality, higher levels of cognitive and strategic differentiation, consequently higher levels of macroeconomic specialization, and thus higher levels of human capital and aggregate intelligence (Figueredo, Cabeza de Baca & Peñaherrera-Aguirre, 2017).

In the present set of results, slower LH speeds were found to promote higher levels of within-group peace (the inverse of between-group competition), and both promoted the achievement of higher levels of human capital, which was a composite that included GDP *per capita* as well as average levels of monetary savings and educational attainment (Figueredo et al. 2017). These effects were formally found to be statistically equivalent for Gallic and Britannic populations. In contrast, the presently obtained relationship between temperature and LH might variously be thought counterintuitive or understood to contradict expected causal relationships between physical ecology and human social biogeography. Interpreting this finding as a failure of the diachronic results to replicate the synchronic would constitute a misperception of both the actual relationship between LH and physical ecology and of the scope and sample presently under investigation.

As exemplified by Lynn (2006), ecologically informed theorists have documented negative correlations between mean annual temperature and aggregate national intelligence. Rushton (1999) has done the same with respect to latitude and LH speed. Even as robust negative correlations have thus been generated, it has been more explicitly recognized recently that such relationships are curvilinear as opposed to linear when estimated over extensive geographical areas. Thus, increasing latitude slows LH progressively into the 40th parallel, entering what is, in effect, a golden mean before being attenuated as it approaches the 60th parallel. Strong reversals in LH are apparent thereafter, especially as one crosses the Arctic Circle.

This reversal, like the effects of latitude more generally, has been contextualized within a biome approach, wherein temperate broadleaf deciduous forests, existing within the aforementioned “golden” latitudinal range, indirectly slow human LH by reducing extrinsic morbidities and mortalities attributable to decreased parasite burden (Figueredo et al., 2017); moreover, the hydrological and soil ecology of such biomes support dense human populations that anthropogenically further the slowing of human LH (Hertler & Peñaherrera, 2017). In the present study, we have examined a highly restricted range of latitudes, the truncated extent of which should not be expected to recapitulate trends evident only across vast global expanses. France, even at its southernmost territorial extent, is already well within our golden range of latitude; the British Empire, in its northernmost extent, just begins to push out of this favorable latitudinal range.

Concluding Remarks

This study constituted an attempt to replicate two major sets of prior findings in the social biogeography of human LH strategy. The first set involved the constructive replication of the diachronic changes in the latent hierarchical structure of intelligence, originally estimated only for Britannic populations, but this time as applied to the latent hierarchical structure of human LH strategy, now cross-validated in both Britannic and

Gallic populations. The second set involved the diachronic replication in both Britannic and Gallic populations of the structural relations found synchronically among human LH strategy, between-group competition, and economic productivity in cross-sectional data on contemporary samples of both national and subnational polities. In addition, we have provided ample evidence for the convergent validities of our relatively novel lexicographic measures of both LH strategy and BG Competition with respect to the more traditional biodemographic indicators of the same in both Britannic and Gallic biocultural groups, using both common factoring and MLM techniques.

With a few minor exceptions, these constructive replications were successful. At least *configural* invariance was found for all tested effects, meaning that the same model predictors were found statistically significant, and *metric* invariance was found for most effects, meaning that model parameter estimates were found statistically equivalent (non-significantly different) in magnitude and oriented in the same direction. The effects of previous synchronic studies of the social biogeography of human LH strategy were replicated almost perfectly in the current diachronic data, and the results obtained from the diachronic data for Britannic populations were replicated almost perfectly in Gallic populations.

Based on our interpretation of these findings, testable hypotheses were generated for future research *via* the application of the Theory of Limiting Similarity to competition among human biocultural groups. Preliminary predictions concerning the relative historical magnitudes and temporal trajectories of population growth and decline parameters of Britannic *vis-à-vis* Gallic populations over the two centuries in question provide some tentative support for these interpretations.

Limitations of the Study

Several limitations of this study might be worthy of note. First, the lexicographic measures used are relatively novel, and their only validation to date lies in the fact that they converge with other measures that use different methods, such as biodemographic indicators of both between-groups competition and slow LH strategy. Nevertheless, this is a relatively new method for biohistorical research and stands in need of more exhaustive validation against other methods.

Second, both the Britannic and Gallic populations were treated as relatively homogeneous biocultural groups, where they instead can both be considered to have some degree of internal heterogeneity, especially when considering their population expansions into what were formerly overseas colonies. Nevertheless, we do believe that there exists sufficient sociopolitical coherence to these biocultural groups to be able to function as such within modern evolutionary models of multilevel selection and gene-culture coevolution, which accommodate organization into structured demes (*trait groups*) within a metapopulation (e.g., Bowles, Choi, & Hopfensitz, 2002; Hauert & Imhof, 2012; Nuismer, Thompson, & Gomulkiewicz, 1999; Thompson, 1999).

Third, the war mortality rates used as convergent indicators of the between-group competition scales for both Britannic and Gallic populations were collected from violent conflicts with *all* opponents, and not just from such conflicts with *each other*. This made possible relating both aggregate slow LH and GDP *per capita* to the level of between-group competition *in general*, but limited its usefulness in predicting the dynamics occurring between Britannic and Gallic populations *in particular*. The latter interpretations, however, are admittedly *post hoc* and did not constitute a consideration in the original design of the study. Specifically targeted investigations of those more tentative interpretations must await further testing in future research.

Fourth, another limitation is the inability of the cascade models employed in social biogeography to model the effects of *reciprocal* causation among successive criterion variables. For example, we have cited past research demonstrating how the association between physical and cognitive ecology is plausibly mediated by the social ecology (including social institutions), but understand how the social ecology can in turn modify the ambient physical as well as the community ecology. Nevertheless, past publications have also demonstrated that indicators of physical and community ecology, such as low parasite burden, are better predictors of slow life history than GDP (Peñaherrera-Aguirre, Hertler, Figueredo, Fernandes, Cabeza de Baca, Matheson, 2018). Thus, effects can be reciprocal in direction without necessarily being symmetrical in magnitude. We argue that the theoretically specified causal sequences in our social biogeography models represent the more evolutionarily significant directions of effect.

Methodological Considerations

The reported analyses employ several relatively novel quantitative methodologies. Some of these advanced statistical techniques had been used separately in the past, but this present work was designed to make them work synergistically in addressing some challenging technical problems.

Among these were: (1) the theoretically-guided use of Google Ngram to determine the relative frequencies of usage of selected word lists over the past 200 years of written records in both the French and English languages; (2) the application of psychometric selection procedures for the development of lexicographic scales for group-directed altruism, fast life history strategy, and slow life history strategy, which showed excellent convergence with the traditional biodemographic indicators of the same constructs in both languages; (3) the use of diachronic biohistorical data to cross-validate substantive results that had been previously derived from synchronic cross-sectional and cross-cultural analyses of different national and subnational polities; (4) the application of multilevel models to confirm the convergent validities among longitudinal indicators of several diachronic latent variables, while statistically controlling for any autoregressive serial dependencies among successive data; (5) the use of hierarchically nested model comparisons to analyze the latent hierarchical structures of those diachronic latent variables, and partition the common and specific factor variances among the hierarchically nested levels so as to establish and quantify the optimal degree of data aggregation; (6) the use of multilevel models to statistically adjust for those same serial autocorrelations for the subsequent structural analysis of the "pre-whitened" residuals by means of cascade modeling; and (7) a built-in cross-cultural constructive replication of all of the above procedures, for the measurement as well as the structural models, in both Gallic and Britannic populations.

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