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Trust as Social Investment: A Life-History Model of Environmental Effects on Ingroup and Outgroup Trust

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Abstract

Trust among closely-related individuals (ingroup) and trust among non-related individuals (outgroup) can be seen as different social investment that involves different life-history tradeoffs. We tested this life-history model using the World Values Survey and the World Health Organization datasets and examined how ingroup and outgroup trust are related to sex, individual-level resource availability, and society-level environmental threats. Results show that, at the individual level, financially disadvantaged people trusted ingroups less. At the societal level, violent-conflict threats were associated with lower ingroup and outgroup trust. Furthermore, higher disease-caused mortality was associated with lower ingroup trust but not lower outgroup trust. Moreover, fertility was associated with lower outgroup trust but not lower ingroup trust. We also found that the sex effect (men trusted others more than women did) was more prominent in societies with greater violent-conflict threats and higher fertility, but less prominent in societies with lower mortality from communicable diseases. These findings are explained within the life-history framework.

Keywords: behavioral immune system; environmental threats; gender difference; life history theory; pathogen prevalence; trust

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1 Introduction

Trust, defined as an expectation of cooperation (Balliet & Van Lange, 2013), can be divided into ingroup trust, which concerns individuals with interpersonal ties or common group membership, and outgroup trust, which concerns unrelated others (Delhey, Newton, & Welzel, 2011; Welzel, 2010). Based on life history theory (Del Giudice, Gangestad, & Kaplan, 2015), we postulated a model that regards ingroup and outgroup trust as a future-oriented investment in cooperative relationships, which are differentially affected by various fitness tradeoffs. These tradeoffs depend on several factors, which are individually connected to trust in other evolutionary theories, including sex, resource availability, and environmental challenges that select for different reproductive strategies (e.g., violent-conflicts threats and pathogens). This study tested this life-history model of trust using a combination of large-scale survey data (the World Values Survey Wave 6, WVS6) and archival data from the World Health Organization (WHO).

Both ingroup and outgroup trust vary across societies (Delhey et al., 2011) and between sexes (Maddux & Brewer, 2005). The male warrior hypothesis (McDonald, Navarette, & Van Vugt, 2012; Van Vugt, De Cremer, & Janssen, 2007) highlights the role of violent conflicts in shaping sex differences and cross-society variations in trust. This evolutionary theory argues that such conflicts should select for psychological traits that encourage within-group cooperation and intergroup competition especially among men (Van Vugt et al., 2007). Indeed, research using experimental games demonstrated that men showed increased within-group contributions in intergroup

competition contexts compared with non-competition contexts (Van Vugt et al., 2007). Other studies have indicated that outgroup threats trigger outgroup discrimination and higher social dominance orientation among men but not among women (Navarrete, McDonald, Molina, & Sidanius, 2010; Yuki & Yokota, 2009).

Another environmental challenge that might have shaped trust in different societies is infectious diseases. Because of host-parasite coevolution, interactions with outgroups may be especially dangerous in areas with high pathogen prevalence because pathogens carried by outgroups might be more deadly when spreading among ingroups who have not developed immunity to them (Fincher & Thornhill, 2012). High pathogen environments might lead to outgroup distrust as a behavioral immune response (Fincher & Thornhill, 2012; Schaller, & Park, 2011). Indeed, evidence exists that high-pathogen regions tend to adopt strong family ties and collectivist values, which encourage favoritism toward related ingroups over unrelated outsiders (Fincher & Thornhill, 2012; Fincher, Thornhill, Murray, & Schaller, 2008). Nevertheless, direct evidence for the hypothesis that pathogen stress is associated with lower outgroup trust is scarce. Cross-society studies accounting for other factors such as governance, religion, and material security have found no evidence for low outgroup trust or high ingroup favoritism in societies with higher pathogen stress (Hruschka et al., 2014; Hruschka & Henrich, 2013). Unlike violent-conflict threats, which affect the two sexes differently, both sexes are exposed to similar pathogen risks. Therefore, gender differences in ingroup and outgroup trust should be less prominent in societies with higher disease-caused mortality.

Whereas previous theories emphasize the fitness costs of trust (especially outgroup trust) due to various environmental challenge, a life-history model that regard trust as a social investment would instead highlight different cost-and-benefit

tradeoffs posed by ingroup and outgroup trust. Life history theory identifies several fundamental reproduction-related tradeoffs affecting organisms' life-span development and behaviors: early versus late reproduction, offspring quantity versus quality, and mating versus parenting efforts (Del Giudice, Gangestad, & Kaplan, 2015). These tradeoffs lead to contingent expressions of biological and psychological traits in various environments to maximize reproductive fitness, and they converge into "life-history strategies" that vary along a fast-slow continuum (Chang & Lu, 2018; Ellis, Figueredo, Brumbach, & Schlomer, 2009). Fast life-history strategies, which allocate resources and efforts to achieve high fertility, prevail in unpredictable environments with high morbidity–mortality risks. By contrast, slow life-history strategies, which emphasize personal development, are favored in predictable environments (Ellis et al., 2009).

From the life-history perspective, trust as a future-oriented social investment should be associated with slow, rather than fast, life-history strategies because trusting a defector would incur greater fitness costs in unpredictable environments (e.g., due to violent-conflict threats or pathogens). Consistent with this view, low birth weight—a biological marker for a fast life-history strategy—is associated with lower general trust in adulthood (Petersen & Aarøe, 2015). Another study reported that slow life-history traits (e.g., stable relationships, future planning, and high emotional intelligence) mitigated outgroup hostility (Figueredo, Andrzejczak, Jones, Smith-Castro, & Montero, 2011).

Despite the inherent costs of trust, some special features of human life history would nevertheless render ingroup and outgroup trust viable social investment in human society. A major benefit of ingroup trust in traditional human societies is cooperative breeding (i.e., childcare and material assistance by relatives or tribal

members, Kramer, 2010). This might be responsible for the high fertility of human hunter-gatherers (due to shorter interbirth intervals and improved infant survival rates) compared with that of other primates (Kramer, 2010). Given that ingroup trust facilitates cooperative breeding, this might offset some cost of trusting ingroups in high-fertility societies. Thus, this would lead to the hypothesis that societies with high fertility should demonstrate lower outgroup trust, but not lower ingroup trust. The benefits of outgroup trust lie in more diverse social interaction opportunities. By freely interacting with outgroups, one gains access to non-local goods and skills. Such interactions also allow diverse mating opportunities that increase the genetic diversity of offspring (Gangestad & Simpson, 2000). These benefits might partly offset the risks of trust in unpredictable situations caused by, for instance, violent conflicts and contagious diseases.

Societies facing violent-conflict threats should demonstrate lower ingroup trust, as such conflicts might reduce the availability of cooperative breeders, such as husbands (Annan & Brier, 2010). There had often been increases in domestic violence in regions traumatized by armed conflicts (Annan & Brier, 2010). Society-level threats of violent conflicts were also associated with increased sexist attitudes (Zhu & Chang, 2020). These findings imply that the benefit of cooperative breeding is more limited in unstable societies with violent-conflict threats, which might contribute to lower ingroup trust. Violent-conflict threats should also predict lower outgroup trust as intergroup conflict disturbs mutually beneficial exchanges with outgroups. Importantly, threats of violent conflicts (even without actual conflicts) might affect life-history tradeoffs because developmental calibrations of life-history strategies are sensitive to proximate psychological adjustments (Del Giudice, 2009).

From the life-history perspective, disease-caused mortality should be

associated with lower ingroup trust, but not necessarily outgroup trust. Distrust as a behavioral immune response might not just target outgroups (Aarøe, Osmundsen, & Petersen, 2016). The fact that people have a greater chance of interacting with ingroups than with outgroups causes the former to pose greater health risks during epidemics caused by pathogens with no long-term immunity (e.g., flu or influenza). This would limit ingroups' engagement in cooperative breeding, rendering ingroup trust less beneficial. By contrast, outgroup mating might become more desirable because it introduces good genes that provide superior immunity against pathogens (Gangestad & Simpson, 2000; Lu, Zhu, & Chang, 2015). This benefit should offset the tendency of people to distrust outgroups when faced with threats of communicable diseases.

The life-history perspective also has implications for gender differences in ingroup and outgroup trust. Women's heavier parental investment (Trivers, 1972) should predispose them to be more sensitive to defections in cooperative breeding compared with men, especially in environments that favor fast life-history strategies (e.g., because of violent-conflict threats). In such environments, prolonged periods of pregnancies and childcare activities due to having more children or shorter interbirth intervals keep women homebound, thereby reducing their chances of benefiting from outgroup exchanges. Given these reasons, women's ingroup and outgroup trust might be undermined to a greater degree than those of men in environments that favor fast-life-history strategies (e.g., indicated by high violent-conflict threats and high fertility).

To test these predictions, the current study used hierarchical linear models (HLM; Bryk & Raudenbush, 1992) to analyze two-level data obtained from the World Values Survey (WVS, Wave 6; Inglehart et al. 2014). The current model investigated

cross-society variations in ingroup and outgroup trust (and their gender differences), after controlling for individual-level variables that are relevant to human life-history strategies. Specifically, we expected that age should be positively correlated with trust because the benefits of trust as social investment render long-term returns (Del Giudice et al., 2015). Similarly, education (especially higher education) as an investment in one's future development should indicate slow the adoption of life-history strategies, which should be conducive to higher trust. By contrast, personal experience of resource scarcity should predict lower ingroup trust because defections in cooperative breeding obligations are more likely during within-group competition for resources (Barker, & Barclay, & Reeve, 2012). Indeed, evidence exists that low childhood socioeconomic status (SES) is associated with lower trust, an association that is mediated by life-history strategies (Stamos, Altsitsiadis, & Dewitte, 2019).

2 Method

2.1 Data

We used data obtained from the latest WVS (Wave 6; Inglehart et al., 2014) between 2010 and 2014. The WVS is the largest non-commercial, international, time-series investigation of human beliefs and values covering countries and regions with vastly different levels of economic development and from all the major cultural zones of the world. These surveys are conducted using a common questionnaire to which nationally representative samples or participants respond. Among the 59 societies (countries and regions) originally included in the WVS Wave 6, one society (New Zealand) was excluded from analysis because of inadequate individual-level data. We combined the WVS data with additional society-level data from the World Health Organization (WHO) databases. Four societies (Taiwan, Palestine, Hong Kong,

and Egypt) were excluded because of missing society-level data. After excluding missing cases, the final analysis included data of 74,675 individuals from 54 societies. The sample sizes ranged from 963 (Poland) to 3,498 (South Africa).

2.2 Dependent Variables

We computed indices of ingroup and outgroup trust by using a battery of six items from the WVS originally devised by Welzel (2010). These items started with the question, "how much you trust people from various groups", and were rated from 1 to 4, with higher scores indicating higher levels of trust. An ingroup trust score was the average of three items: (1) family, (2) neighbors, and (3) people you know personally. An outgroup trust score was computed by averaging the following three items: (1) people you meet for the first time, (2) people of another religion, and (3) people of another nationality. Across all respondents, Cronbach's α coefficients for ingroup trust and outgroup trust were .58 and .79, respectively.

2.3 Society-level Predictors

We computed a society-level violent-conflict threats score by aggregating individual-level average ratings of three WVS items that asked respondents to indicate the extent to which they worried about "a terrorist attack," "a civil war," and "a war involving my country" (Cronbach's $\alpha = .80$). These items were rated from 1 to 4 and were recoded such that a higher score denoted higher threats of violent conflicts at the society level. The society-aggregated ratings, instead of individual ratings, reflect national concerns over violent conflicts that affect the whole society. We additionally included two society-level predictors from the WHO databases: age-standardized mortality caused by communicable diseases (WHO, 2008) and total fertility per woman (WHO, 2012), referred to below as disease-caused mortality and fertility, respectively.

2.4 Individual-Level Predictors

Resource insecurity at the individual level was assessed by the average rating of three WVS items that asked about the frequency of financial difficulties within the last 12 months: "gone without enough food to eat," "gone without medicine or medical treatment that you needed," and "gone without a cash income" (Cronbach's $\alpha = .92$). These items were rated from 1 to 4 and were recoded such that a higher average score denoted a higher degree of resource scarcity. We also included gender (dummy coded: 0 = *female*, 1 = *male*), age, and educational level (two dichotomous dummy variables representing secondary and higher education, respectively) as individual-level predictors.

2.5 Statistical Analysis

To account for inter-societal correlations of individual-level variables, hierarchical linear models (HLMs) were used. Using software package HLM 7, we conducted separate HLM analyses for ingroup and outgroup trust, respectively. Each model consisted of two levels of regression analyses. In the individual-level model, we included only the individual-level predictors and allowed their regression coefficients to be randomly estimated for each society. In the full model, the intercept of the dependent variables and the regression coefficients of gender were additionally regressed on the society-level predictors (i.e., violent-conflict threats, disease-caused mortality, and fertility). All the coefficients reported here were unstandardized coefficients. Because some estimates in HLM analysis may become extremely small in value but are still meaningful, we report four digits after the decimal points.

3 Results

Individual-level and society-level descriptive statistics and correlations are presented in Supplementary Material (Tables S1 and S2). Ingroup and outgroup trust

correlated with each other at the individual level (r = .35) and society level (r = .27). The intraclass correlation coefficients (ICCs) for ingroup and outgroup trust, calculated as the inter-societal variance divided by the total variance, were .11, and .14, respectively, with significant inter-societal variances on the intercept. These results justified using the HLM to further examine the inter-societal variances of ingroup and outgroup trust.

3.1 Ingroup Trust

Adding the individual-level predictors reduced the resulting individual-level variance in ingroup trust by 3.6% (from 0.2616 to 0.2521), indicating that 3.6% of previously unexplained individual-level variances in ingroup trust can be attributed to the individual-level predictors we included. In the individual-level model, older age and higher education level predicted higher ingroup trust (B = .0027, p < .001 and B = .0236, p = .037, respectively), whereas resource insecurity predicted lower ingroup trust (B = −.0867, p < .001). Men trusted related others more than women did (B = .0299, p < .001). The variance components of all individual-level predictors were significant, indicating that the effects of gender and resource scarcity on ingroup trust differed considerably across societies and are likely explained by other, society-level predictors (Table 1).

The addition of society-level predictors reduced the variance component of society-level intercept of ingroup trust by 2.4% (0.04818 to 0.04701), indicating that 2.4% of previously unexplained society-level variances in ingroup trust can be attributed to the society-level predictors we included. Both violent-conflict threats and disease-caused mortality predicted lower ingroup trust (Bs = −.0437, −.1983, ps = .041, .043, respectively), whereas fertility was not (B = .0128, p = .530). Furthermore, violent-conflict threats positively predicted the slope of gender (B

= .0180, p = .011), whereas the opposite was true for disease-caused mortality (B = −.0921, p = .004). Like violent-conflict threats, fertility also positively predicted the slope of gender (B = .0334, p = .016).

3.2 Outgroup Trust

The addition of individual-level predictors reduced individual-level variance of outgroup trust by 2.5% (0.4385 to 0.4276). We found that age and higher education both predicted higher outgroup trust (B = .0014, .1281, p < .001, respectively). Resource scarcity was not associated with outgroup trust. Like ingroup trust, men exhibited greater outgroup trust than women (B = .0186, p = .033). Besides, the variance components of all individual-level predictors were significant (Table 1).

The addition of society-level predictors reduced the variance component of society-level intercept of ingroup trust by 14% (0.07337 to 0.06274). Both violent-conflict threats and fertility predicted lower outgroup trust (Bs = -.0622, -.0942, ps = .032, .019, respectively), whereas disease-caused mortality was not (B = .1676, p = .254). The slope of gender was positively associated with violent-conflict threats and fertility (Bs = .0227, .0259, ps < .01, respectively), and negatively associated with disease-caused mortality (B = −.0542, p = .002). Combined with the results of ingroup trust, this means that the gender effect (men trusting others more than women) was stronger in societies with greater violent-conflict threats, higher fertility, and lower disease-caused mortality (Table 2).

4 Discussion

Our findings supported the view that ingroup and outgroup trust are functions of sex, resource availability, environmental threats, and life-history strategies. Furthermore, some of our findings expanded or challenged existing predictions of evolutionary hypotheses regarding trust but are effectively explained by a life-history

model. This model regards trust as a social investment that confers specific fitness tradeoffs in different environments.

At the society level, violent-conflict threats were associated not only with lower outgroup trust, as predicted by the male warrior hypothesis, but also with lower ingroup trust. This seemingly deviates from the male warrior hypothesis, which predicts increased ingroup favoritism—especially among men—when faced with intergroup conflicts (Van Vugt et al., 2007). Our model, however, considers the tradeoff between the benefits (e.g., cooperative breeders) and costs of ingroup trust in societies confronted with threats of violent conflicts. This view is corroborated by a growing body of evidence showing that violent-conflict threats are associated with increased sexism and violence between intimate partners, both of which undermine the benefits of ingroup trust (e.g., Annan & Brier, 2010; Zhu & Chang, 2020). Moreover, societies facing greater violent-conflict threats exhibited a larger gender difference with men showing higher ingroup and outgroup trust than women. From the male warrior hypothesis perspective, this might be attributed to women being more likely to become victims of sexual assault during violent conflicts (McDonald et al., 2012). This is not mutually exclusive with the life-history explanation, which focuses on women's higher sensitivity to defections in cooperative breeding and limited access to outgroup cooperative opportunities during intergroup conflicts.

Our finding that disease-caused mortality negatively predicted ingroup trust, but not outgroup trust, appears to be inconsistent with the prediction of the parasite stress theory (Fincher et al., 2008). However, recent research has questioned whether outgroups had more dangerous pathogens historically, which contribute to a link between disease threat and outgroup avoidance (e.g., Aarøe et al., 2016). Moreover, behavioral immune systems might trigger general avoidance of interpersonal

interactions (Schaller & Park, 2011) to reduce infection possibilities from one's extended social network, including ingroups, as people interact with ingroups more frequently than with outgroups. Meanwhile, the benefits of outgroup trust from additional trading and mating opportunities should partially offset its fitness costs imposed by contracting diseases from outgroups. We also found that disease-caused mortality reduced the gender difference of ingroup and outgroup trust, which is consistent with the view that danger posed by common infectious diseases evenly affects the reproductive success of women and men.

Our finding that higher fertility was associated with lower outgroup trust but not ingroup trust is consistent with the findings of Figueredo et al. (2011) regarding the association between life-history strategy and outgroup hostility. Although high fertility represents a fast life-history strategy that should reduce future-oriented social investment (Del Giudice et al., 2015), the benefits of trusting ingroups in exchange for cooperative breeding might be vital to sustaining a high fertility rate. Additionally, the finding that women are generally less trusting than men, especially in high-fertility societies, is consistent with women's higher reproductive costs. Such asymmetry in reproductive costs increases women's sensitivity to defections in ingroup cooperative breeding and limits their ability to benefit from outgroup interactions, thereby increasing the costs of ingroup trust and reducing the benefits of outgroup trust for women.

Finally, at the individual level, age was associated with higher ingroup and outgroup trust. College (but not secondary) education was also associated with higher ingroup and outgroup trust. Meanwhile, personal experiences of resource scarcity predicted lower ingroup trust. These findings are consistent with previous research showing that age and college education are associated with higher trust in others

(Castle et al., 2012; Huang, van den Brink, & Groot, 2011), and that socioeconomic status was positively related to trust (Stamos et al., 2019). They supported the life-history view that trust serves as a long-term social investment in one's lifespan. However, Stamos et al (2019) did not distinguish between ingroup and outgroup trust, whereas our findings showed that resource scarcity did not predict lower outgroup trust. The potential resource benefits of trading with outgroups might partly offset the detrimental effects of resource scarcity on outgroup trust. Interpreting these findings requires caution, however. The relatively large sample size of the WVS at the individual level might also have contributed to some significant results with low effect sizes. Primary studies specifically designed to test the life-history model of trust are needed.

Because of the data and measures we used, one limitation of our study is that variables not included in the model might affect some of the results, and this limitation challenges the robustness of our findings. For example, violent-conflict threats might also include within-society violence, such as police brutality and crime, in addition to worries about war and terrorism. Other factors that are often linked to trust include economic development and modernization (Inglehart & Welzel, 2005). These factors can be roughly reflected at the society level by using per capita gross domestic product (GDP). To account for the factors not included in the current HLM analyses, we tested alternative models that (1) used WVS items measuring community insecurity to indicate violence threats, (2) added economic development (log-transformed per capita GDP) along with the three society-level predictors, and (3) used national statistical reporting of casualties in violent conflicts as an alternative, objective measure of violent-conflict threats. The results for these additional analyses are reported in the Supplementary Materials. Most of our findings were robust in the

additional analyses.

Overall, our findings attributed many cross-societal and between-sex variations in trust to flexible, environment-contingent psychological adjustments that are under predictions of our life-history models. As an important complement to existing evolutionary explanations of trust, variations in trust can be regarded as not just passive defenses against fitness costs imposed by environmental threats such as violent conflicts and contagious pathogens. Individuals' levels of ingroup and outgroup trust also reflect the unique fitness tradeoffs predicted by human life-history traits, such as cooperative breeding, outgroup resource exchange, and outgroup mating.

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Table 1

Individual-level model results

	Regression coefficients			Variance components	
Variable	Coefficient	*SE*	*t*	Variance component	χ^2
Outcome: Ingroup trust					
Intercept	3.0544	0.0300	101.97***	0.0482	1193.95***
Slope of Age	0.0027	0.0003	9.87***	<0.0001	244.04***
Slope of Education = Secondary	0.0040	0.0059	0.68	0.0008	95.26***
Slope of Education = Higher	0.0236	0.0111	2.14*	0.0047	181.15***
Slope of Resource Insecurity	-0.0880	0.0121	-7.25***	0.0063	726.44***
Slope of Gender = Male	0.0299	0.0088	3.40***	0.0035	298.18***
Outcome: Outgroup trust					
Intercept	1.9867	0.0356	55.77***	0.0658	1084.56***
Slope of Age	0.0014	0.0003	4.35***	<0.0001	244.47***
Slope of Education = Secondary	0.0151	0.0088	1.71	0.0024	127.68***

Slope of Education = Higher	0.1281	0.0187	6.86***	0.0156	306.73***
Slope of Resource Insecurity	-0.0231	0.01323	-1.74	0.0088	720.48***
Slope of Gender = Male	0.0247	0.0093	2.65*	0.0027	166.82***

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 2

Effects of society-level variables on intercepts and individual-level regression coefficients

Variable	Coefficient	*SE*	*t*
Outcome: Ingroup trust			
Intercept	3.0600	---	---
Violent-Conflict Threats	-0.0437	0.0208	-2.10*
Disease-Caused Mortality	-0.1983	0.0954	-2.08*
Fertility	0.0128	0.0203	0.63
Slope of Gender Intercept	-0.0320	---	---
Violent-Conflict Threats	0.0180	0.0068	2.64*
Disease-Caused Mortality	-0.0921	0.0303	-3.04**
Fertility	0.0334	0.0134	2.50*
Outcome: Outgroup trust			
Intercept	2.1724	---	---
Violent-Conflict Threats	-0.0622	0.0282	-2.21*
Disease-Caused Mortality	0.1676	0.1452	1.16
Fertility	-0.0942	0.0387	-2.44*
Slope of Gender Intercept	-0.0310	---	---
Violent-Conflict Threats	0.0227	0.0060	3.78***
Disease-Caused Mortality	-0.0542	0.0161	-3.35**
Fertility	0.0259	0.0082	3.17**

* $p < .05$ ** $p < .01$ *** $p < .001$

Supplementary Material

Article Title: "Trust as Social Investment: A Life-History Model of Environmental Effects on Ingroup and Outgroup Trust"

This document represents the correlations among individual-level variables (Table S1) and society-level variables (Table S2), and a figure showing the comparison of ingroup and outgroup trust across societies (Figure S1). It also details three sets of alternative hierarchical linear models examined by the authors using the same dependent variables but not included in the final results. Specifically, Alternative Model 1 was similar to the model presented in the main results except that it used a different set of WVS items measuring community insecurity to replace the violent-conflict threats measure at the society level. This model tested the possibility that the effects of violent-conflict threats were merely reflecting the general effects of violent-conflict threats. Theoretically, community insecurity should be similarly conducive to fast life-history strategies and, thus, low trust. We used the items measuring worries about intergroup conflicts instead of those measuring community insecurity because the former is more likely to account for society-level variations in trust, which is the focus of our paper.

Alternative Model 2 added log-transformed per capita gross domestic product (GDP) reported by United Nations Statistical Division (UNSD, 2010) a fourth society-level variable and predictor of the slope of gender. This model served to test the notion that the effects of economic development overlap with other effects in predicting ingroup and outgroup trust. We did not include economic development in the model reported in the manuscript because from an evolutionary perspective, we are more interested in specific environmental effects on trust rather than a broad

composite measure such as economic development. A measure of economic development implicitly encompasses many aspects of ecological and social environment. For example, economically developed societies would, at the same time, have less intergroup conflicts, better healthcare systems, and lower fertility rates compared with developing societies (this is supported by the data we used, see Table S2 for correlations between society-level variables reported in the alternative models).

Alternative Model 3 sought to replicate the findings regarding violent-conflict threats using an objective measure of national threats of violent conflicts that do not rely on self-reports. Specifically, we used Uppsala Conflict Data Program (UCDP) dataset for non-state conflicts (Pettersson, & Öberg, 2020; Sundberg, Eck, & Kreutz, 2012), which documented combat-related fatalities in conflicts between organized armed groups across the world from 1989 to 2019. We replaced the original variable of violent-conflict threats with the best estimates of total fatality in non-state conflicts in the UCDP dataset. We did not use data on inter-state conflicts or civil wars with international interventions because different countries' involvement in these conflicts can vary greatly (e.g., deploying troops but the battles took place in faraway lands) and might not contribute to a sense of national threats. Total fatality in non-state conflicts had a positive but modest correlation (r = .25) with violent-conflict threats as measured by the WVS items.

All three sets of alternative models were tested with ingroup trust and outgroup trust as dependent variables, respectively. The other aspects of the alternative models were the same as the original model reported in the final results.

Data and Measures

We used data obtained from the latest WVS (Wave 6) combined with additional society-level data from the World Health Organization (WHO) and the UNSD

databases.

Insecurity. Insecurity was measured at the individual level as the average score of five items that start with the question "how frequently do the following things occur in your neighborhood". These items were "robberies", "alcohol consumed in the streets", "police or military interfere with people's private lives", "racist behavior", and "drug sale in streets" and were recoded (1 = Not at all frequently; 2 = Not frequently; 3 = Quite frequently; 4 = Very frequently) so that higher score reflects greater insecurity. The individual insecurity score is then averaged at the society level to produce society-level scores of insecurity.

Economic development. The per capita GDP from the database of the UNSD (2010) was used as the proxy for economic development. We used logarithmic transformation on the raw data to adjust for the potential non-linear effects of economic development.

Fatality in non-state conflicts (alternative measure of violent-conflict threats). We added together for each country the best estimates for combat-related deaths in the UCDP Non-State Conflict Dataset that it involved in over the last thirty years (1989-2019) and divided it by 1,000. This produced a society-level measure of total fatality in non-state conflicts, which served as an alternative of society-level violent-conflict threats.

The dependent variables (ingroup trust and outgroup trust), individual-level predictors, and other society-level predictors were the same as those reported in the manuscript.

Results and Discussion

Table S1 showed the correlations among individual-level variables and their descriptive statistics. A comparison between ingroup and outgroup trust in individual

societies is shown in Figure S1. At societal level, average ingroup trust (mean [*M*] = 3.21, standard deviation [*SD*] = 0.19) was significantly higher than average outgroup trust ($M = 2.09$, $SD = 0.27$), $t(57) = 29.88$, $p < .001$, 95% CI [1.04, 1.19]. This pattern held for all societies (Figure S1).

Table S2 showed the correlations among society-level variables and descriptive statistics. Society-level community insecurity was positively correlated with mortality caused by communicable diseases and negatively correlated with ingroup trust, but not outgroup trust. It was not significantly correlated with violent-conflict threats, indicating that it constitutes a different environmental factor. However, fatality in non-state conflicts was positively correlated with violent-conflict threats. Both violent-conflict threats and mortality caused by communicable diseases was positively correlated with fertility. This is consistent with the view that unpredictable threats are conducive to fast life-history strategies. Violent-conflict threats was also negatively correlated with outgroup trust. As expected, economic development measured by log-transformed GDP was negatively correlated with community insecurity, violent-conflict threats, mortality caused by communicable diseases, and fertility. Economic development was also positively associated with outgroup trust, but not ingroup trust, although the two forms of trust was positively and moderately correlated with each other.

We applied a similar analytic process to the two sets of alternative models, conducting two separate HLM analyses with ingroup trust and outgroup trust as respective dependent variables. The unconditional mean model (used to calculate the intraclass correlation coefficients [ICCs] for ingroup and outgroup trust) and the individual-level models for the alternative analyses were identical to the ones reported in the final results. Therefore, we only report the society-level results here.

In Alternative Model 1, the intercept of the dependent variables and the regression coefficients of gender were regressed on the society-level predictors of community insecurity, mortality caused by communicable diseases, and fertility. The results (Table S3) showed that mortality caused by communicable diseases was associated with lower ingroup trust and less prominent gender difference in ingroup trust (men trusting ingroups to a larger degree than women do). It also had the tendency to be associated with smaller gender difference in outgroup trust. Fertility was associated with greater gender difference in ingroup trust. Fertility was also associated with lower outgroup trust and greater gender difference in outgroup trust. All of these findings replicated our findings reported in the final results. Community insecurity, however, was associated with neither the dependent variables nor the slopes of gender. This seemed to indicate that average community insecurity at society level was not relevant to trust after accounting for communicable diseases and life-history strategies.

In Alternative Model 2, the intercept of the dependent variables and the regression coefficients of gender were regressed on the three society-level predictors in the final results as well as economic development represented by log-transformed GDP in 2010 as an additional society-level predictor. The results (Table S4) showed that violent-conflict threats was associated with lower ingroup and outgroup trust, and more prominent gender differences in these two forms of trust. Morality caused by communicable diseases was associated with smaller gender differences in ingroup and outgroup trust. These results, again, replicated our final findings. However, after accounting for society-level economic development, morality caused by communicable diseases was not associated with ingroup trust and was associated with higher outgroup trust. Fertility was not associated with ingroup and outgroup trust.

However, fertility remained a positive predictor of gender differences in ingroup trust and had a tendency to be associated with greater gender differences in outgroup trust. Finally, economic development was associated with higher ingroup and outgroup trust but was not associated with the slopes of gender. Therefore, even though economic development appeared to account for some variances in ingroup and outgroup trust that might have been attributed to the effects of fertility, it did not fully supplant the effects of fertility on gender differences in trust.

In Alternative Model 3, the intercept of the dependent variables and the regression coefficients of gender were regressed on the society-level predictors of fatality in non-state conflicts, mortality caused by communicable diseases, and fertility. The results (Table S5) showed that, like violent-conflict threats in the original analysis, fatality in non-state conflicts was also associated with lower ingroup trust. It was not significantly associated with gender difference in ingroup trust, but the qualitative pattern was consistent with the original results (countries with higher fatality in non-state conflicts tended to have more prominent gender difference). Additionally, like violent-conflict threats in the original analysis, fatality in non-state conflicts was associated with more prominent gender difference in outgroup trust. It was not significantly associated with outgroup trust, but the qualitative pattern was, again, consistent with the original results (countries with higher fatality in non-state conflicts tended to score lower in outgroup trust). Other results were qualitatively consistent with the original findings: mortality caused by communicable diseases was associated with lower ingroup trust and less prominent gender difference in ingroup trust and outgroup trust. Fertility was associated with lower outgroup trust and greater gender difference in ingroup trust and outgroup trust. Overall, results for these alternative models further supported the robustness of the original findings.

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Table S1

Correlation coefficients, means, and standard deviations of variables at individual level

Variable	1	2	3	4	5
1 Gender	--				
2 Age	-.03***	--			
3 Resource insecurity	-.02***	-.08***	--		
4 Ingroup trust	.02***	.09***	-.13***	--	
5 Outgroup trust	.02***	.07***	-.04***	.35***	--
Mean	--	41.96	1.70	3.19	2.10
Standard Deviation	--	16.51	0.79	0.54	0.72

*** $p < .001$

Table S2

Correlation coefficients, means, and standard deviations of society-level variables

Variable	1	2	3	4	5	6	7	8
1 Community insecurity	--							
2 Violent-conflict threats	.10	--						
3 Fatality in non-state conflicts	.10	.25*	--					
4 Communicable diseases [a]	.32*	.23	.17	--				
5 Fertility	.19	.41**	.29*	.61***	--			
6 Economic development	-.29*	-.53***	-.11	-.55***	-.64***	--		
7 Ingroup trust	-.38**	-.10	-.06	-.17	.08	.09	--	
8 Outgroup trust	.03	-.59***	-.08	-.06	-.18	.49***	.27*	--
Mean	1.72	2.82	1.77	2.29	3.91	0.17	3.20	2.09
Standard Deviation	0.29	0.54	5.93	0.94	0.55	0.27	0.19	0.27

* $p < .05$ ** $p < .01$ *** $p < .001$

[a] Stands for mortality caused by communicable diseases.

Table S3

Alternative Model 1: Effects of society-level variables on intercepts and individual-level regression coefficients

Variable	Coefficient	*SE*	*t*
Outcome: Ingroup trust			
Intercept	3.0498	---	---
Community insecurity	-0.0115	0.0378	-0.30
Communicable Diseases [a]	-0.2045	0.0905	-2.26*
Fertility	0.0169	0.0216	0.78
Slope of Gender Intercept	-0.0295	---	---
Community insecurity	-0.0030	0.0156	-0.19
Communicable Diseases [a]	-0.0861	0.0246	-3.50**
Fertility	0.0320	0.0110	2.91**
Outcome: Outgroup trust			
Intercept	2.2515	---	---
Community insecurity	0.0511	0.0497	1.03
Communicable Diseases [a]	0.1258	0.1624	0.78
Fertility	-0.1203	0.0362	-3.33**
Slope of Gender	-0.0423	---	---
Community insecurity	-0.0072	0.0118	-0.61
Communicable Diseases [a]	-0.0422	0.0212	-1.99†
Fertility	0.0306	0.0066	4.62***

† $p < .08$ * $p < .05$ ** $p < .01$ *** $p < .001$

Note. [a] Stands for mortality caused by communicable diseases.

Table S4

Alternative Model 2: Effects of society-level variables on intercepts and individual-level regression coefficients

Variable	Coefficient	*SE*	*t*
Outcome: Ingroup trust			
Intercept	2.6023	---	---
Violent-conflict threats	-0.0413	0.0189	-2.18*
Communicable Diseases [a]	-0.1559	0.0924	-1.69
Fertility	0.0348	0.0253	1.37
Economic Development	0.1023	0.0479	2.14*
Slope of Gender Intercept	-0.0338	---	---
Violent-conflict threats	0.0178	0.0076	2.34*
Communicable Diseases [a]	-0.0951	0.0310	-3.07**
Fertility	0.0331	0.0162	2.04*
Economic Development	0.0008	0.0242	0.03
Outcome: Outgroup trust			
Intercept	0.8592	---	---
Violent-conflict threats	-0.0748	0.0250	-2.99**
Communicable Diseases [a]	0.2766	0.1262	2.19*
Fertility	-0.0162	0.0425	-0.38
Economic Development	0.2895	0.0703	4.12***
Slope of Gender	0.1071	---	---
Violent-conflict threats	0.0206	0.0062	3.33**
Communicable Diseases [a]	-0.0646	0.0168	-3.84***
Fertility	0.0184	0.0099	1.86†

Economic Development	-0.0303	0.0204	-1.48

$^{\dagger} p < .08$ $^{*} p < .05$ $^{**} p < .01$ $^{***} p < .001$

Note. [a] Stands for mortality caused by communicable diseases.

Table S5

Alternative Model 3: Effects of society-level variables on intercepts and individual-level regression coefficients

Variable	Coefficient	*SE*	*t*
Outcome: Ingroup trust			
Intercept	3.0288	---	---
Fatality in Non-State Conflicts	-0.0071	0.0016	-4.56***
Communicable Diseases [a]	-0.0255	0.0093	-2.74**
Fertility	0.0405	0.0213	1.90†
Slope of Gender Intercept	-0.0265	---	---
Fatality in Non-State Conflicts	0.0011	0.0008	1.32
Communicable Diseases [a]	-0.0083	0.0024	-3.52***
Fertility	0.0296	0.0112	2.65*
Outcome: Outgroup trust			
Intercept	2.1781	---	---
Fatality in Non-State Conflicts	-0.0022	0.0034	-0.65
Communicable Diseases [a]	0.0142	0.0161	0.88
Fertility	-0.0937	0.0351	-2.67*
Slope of Gender	-0.0308	---	---
Fatality in Non-State Conflicts	0.0022	0.0007	2.99**
Communicable Diseases [a]	-0.0048	0.0023	-2.09*
Fertility	0.0239	0.0081	2.95**

† $p < .08$ * $p < .05$ ** $p < .01$ *** $p < .001$

Note. [a] Stands for mortality caused by communicable diseases.

Figure S1 Society-level comparison of ingroup and outgroup trust.