



Understanding Regional Cultural-Psychological Variations and Their Sources in China: A Comprehensive Examination of Relevant Theories

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Abstract

This research comprehensively examined regional variations in individualism and collectivism within China and the explanatory power of 20 potential factors derived from the existing cultural psychological theories, including socioecological (e.g., climates, subsistence activities, and modernization) and population (e.g., ethnicity, genetic and linguistic features) ones. Three large-scale studies were conducted. In Study 1 ($N = 18,606$), we assessed 11 markers of individualism-collectivism. In Studies 2 and 3, we evaluated whether the main findings of Study 1 could be replicated in two large community samples ($N = 8,167$ and $20,590$, respectively) when perceived cultures of individualism and collectivism were considered and when the pandemic of COVID-19 was going on, respectively. Three studies consistently showed that (1) systematic East-West differences in individualism and collectivism existed, with higher individualism and lower collectivism in Eastern China than in Western China; meanwhile, there was some suggestive evidence of North-South differences, with higher individualism and lower collectivism in Southern China than in Northern China; (2) among the predictive socioecological (e.g., pathogen prevalence, modernization) and population factors (e.g., ethnicity, genetic and linguistic relatedness), modernization was the most potent and robust predictor of individualism and collectivism; (3) regional cultural variations often arose from the combined influences of multiple factors; and (4) the evidence supported most existing theories about the sources of cultural variation, with a few exceptions (e.g., the rice theory). These findings provide novel insights into regional cultural variations and the applicability of many relevant theories within China, and also shed light on cross-cultural psychology in general.

Keywords

individualism-collectivism, regional-cultural variation, socioecology, population factors, China

Introduction

Cross-cultural research has revealed extensive differences in human psychology and behavior across countries, including variations in values and norms, self-construal, cognitive style, and social interaction (e.g., Gelfand et al., 2011; Markus & Kitayama, 1991; Nisbett et al., 2001; Oyserman et al., 2002; Triandis, 1995). Recently, researchers have started to pay attention to cultural variations within a country (Cohen, 2009; Vandello & Cohen, 1999). China, as one of the most populous countries, has received growing attention (e.g., Chua et al., 2019; Talhelm et al., 2014; Van de Vliert et al., 2013). Several pioneering studies have examined North-South differences in individualism-collectivism and possible sources of these differences within China, producing intriguing yet sometimes conflicting findings (Talhelm et al., 2014; Van de Vliert et al., 2013).

In this research, we conducted three large-scale investigations in China, examining regional variations of individualism-collectivism and their socioecological (i.e., physical and social environments) and population-based (i.e., ethnicity, genetic and linguistic characteristics) sources. We assessed diverse manifestations of individualism-collectivism with a total of 11 markers and tested the predictive power of 20 macro factors. The research also aimed to conduct a comprehensive test of mainstream cultural theories in explaining cultural variations.

Unpacking Cultural Variations: Individualism and Collectivism

Cultural variations can be characterized and interpreted along numerous dimensions, such as power distance, survival versus self-expression values, tightness-looseness, and individualism-collectivism (Gelfand et al., 2011; Hofstede, 2011; Inglehart & Baker, 2000). Over the past decades, individualism-collectivism has received the most attention.

Individualism-collectivism has been approached from either a narrow or a broad perspective. The narrow perspective treats individualism and collectivism as mere representations of contrasting cultural orientations. In this case, individualism is conceptualized as a worldview that prioritizes the individual—individual goals, uniqueness, and personal control—over groups, whereas collectivism is conceptualized as a worldview that emphasizes groups and social interconnectedness more than individuals (Oyserman, et al., 2002). The broad perspective treats these concepts as two contrasting cultural syndromes (Brewer & Chen, 2007; Oyserman, 2017; Triandis, 1993), including not only individualistic and collectivistic orientations themselves but also diverse cultural processes or phenomena that are associated with them, such as independent and interdependent self-construals, holistic and analytic cognitive styles. In this case, individualism and collectivism have mostly been used as a framework or umbrella concept to comprehend diverse psychological differences across different cultures.

Individualism-collectivism has also been approached from either a subjectivist or an intersubjective perspective (Chiu et al., 2010; Heine et al., 2002). While the subjectivist perspective treats culture as internalized personal characteristics, the intersubjective perspective emphasizes beliefs and values that members of a culture perceive to be widespread in their culture. These perspectives are distinct but complement each other in providing important insights into our understanding of culture and its impacts.

Most existing theories and studies have treated individualism and collectivism as contrasting constructs located at opposite poles of a single dimension. However, emerging evidence suggests that they, as manifested in different domains and markers, may not always be strictly opposing; rather, in certain cases, the seemingly opposite components can coexist and covary (e.g., Kitayama et al., 2022; Kryś et al., 2022; San Martín et al., 2018; Uskul et al., 2023). For example, Latin Americans have been found to be both collectivistic and independent (Kryś et al., 2022), while Mediterraneans have been found to be both independent and interdependent (Uskul et al., 2023). In our research, we considered both narrow and broad perspectives, took both subjectivist and intersubjective perspectives into account, and treated the manifestations of individualism and collectivism as potentially distinct entities across domains and markers (Vignoles et al., 2016).

Research has uncovered substantial psychological differences between individualistic cultures, such as those in North America, and collectivistic cultures, like those in East Asia (e.g., Triandis, 1995; Yamagishi et al., 1998; cf. Takano & Osaka, 2018b). Generally, North Americans, compared to East Asians, are more likely to endorse individualistic (vs. collectivistic) values, have an independent (vs. interdependent) self-construal, exhibit an analytic (vs. holistic) thinking style, show a stronger inclination to trust strangers, and display a higher level of moral tolerance towards non-traditional lifestyle choices (for reviews, see Hamamura et al., 2018; Nisbett et al., 2001; Uz, 2015). In this research, we examined these aspects simultaneously to obtain a comprehensive understanding of cultural variations in individualism and collectivism in China as well as their sources.

Sources for Variations in Individualism-Collectivism

Numerous socioecological and population-based factors have been proposed to account for cultural variations in individualism and collectivism. Below, we briefly review the main factors as well as their associations with culture.

Socioecological Factors. Socioecological environments constitute primary exogenous sources of cultural variations (Berry, 2018; Kara et al., 2021). To date, seven main types of environmental factors that could potentially foster individualistic or collectivistic tendencies have been identified (see Table 1).

Table 1. Socioecological Accounts for Cultural Variations in Individualism-Collectivism.

Factor	Indicator	Condition predicting high individualism (or low collectivism)
Physical environment		
Climate	Temperature, rainfall, etc.	Lenient climates, or demanding temperature combined with steady rainfalls or other socioecological conditions such as affluence
Pathogen prevalence	The prevalence of infectious diseases	Low prevalence
Natural-disaster stress	The frequency or damage of natural disasters	Low frequency or low damage
Social environment		
Population density	Population per km ²	Low population density
Mobility	Residential mobility, relational mobility	High mobility
Subsistence style	Farming, fishing, herding	Subsistence styles requiring low coordination or cooperation
Modernization	Wealth, urbanization, post-/ industrialization, marketization, formal education	High modernization

The first three factors pertain to physical (natural) environments. Here, an overarching assumption is that collectivism, as opposed to individualism, is more adaptable in severe environments with heightened survival threats (Fog, 2017; Thornhill & Fincher, 2014). Consequently, demanding climates (e.g., extreme temperatures), high pathogen prevalence, and significant natural-disaster stress (e.g., earthquakes, floods) have been associated with strong collectivism or weak individualism (Hofstede, 2001; Oishi & Komiyama, 2017; Thornhill & Fincher, 2014). Yet, other environmental features may qualify these associations. Specifically, harsh temperatures might foster collectivism exclusively in impoverished countries or regions, while such climates could promote individualism in affluent countries (Van de Vliert, 2013) or regions with steady rainfalls (Welzel, 2013).

The remaining four factors pertain to social or anthropogenic environments, encompassing population density, social mobility, subsistence style, and modernization. High population density may facilitate collectivism (Vandello & Cohen, 1999), as there is a strong need for social coordination within densely populated areas (Gelfand et al., 2011). In contrast, high mobility, as reflected in a frequent change of residence (i.e., residential mobility) or the ease of developing new relationships (i.e., relational mobility), may cultivate individualism, given that fluid and open social networks undermine the benefits of ingroup-oriented collectivism (Macy & Sato, 2002; Yamagishi, 2011).

As to subsistence styles (i.e., how food is produced), those styles that require significant collective effort tend to foster collectivism while discouraging individualism (Talhelm & Oishi, 2019). Specifically, farming has been associated with collectivism, whereas herding and fishing have been linked to individualism (Nisbett et al., 2001; cf. Uskul et al., 2008). Furthermore, rice farming has been linked to collectivism, while wheat farming has been associated with individualism (Talhelm et al., 2014).

Lastly, modernization—the socioeconomic transformation from traditional, rural-based societies to modern, urbanized societies (Greenfield, 2009; Welzel, 2013)—is widely regarded as a potent catalyst for individualism. This perspective stems from the idea that socioeconomic progress (such as post-industrialization and marketization) emancipates individuals from existential constraints and group control, thereby fostering the spirit of individualism (Inglehart & Baker, 2000; Welzel, 2013).

Population Factors. Population characteristics serve as endogenous sources of cultural variations (Berry, 2018). To date, numerous population characteristics have been linked to culture, including ethnic heritages, religious denominations, genetic and linguistic relatedness between different populations (Bromham et al., 2018; Cohen, 2009; Eff, 2004; Kashima & Kashima, 2003). For example, many Western religions, such as Protestant Christianity, were thought to promote individualism, whereas Eastern religions, including Buddhism and Islam, were associated with collectivism (Cohen & Varnum, 2016; Schulz et al., 2019). Reflecting shared ancestry, genetic and linguistic relatedness also contribute to cultural variations: Populations that are more closely related genetically and linguistically tend to exhibit more cultural similarities (Bromham et al., 2018; Kashima & Kashima, 2003), as shared ancestry facilitates cultural learning and transmission (Becker et al., 2020; Spolaore & Wacziarg, 2009).

The Combined Influence of Socioecological and Population Factors. Socioecological and population forces may not independently shape culture (e.g., Berry, 2018; Bromham et al., 2018; Lu et al., 2023; Richerson & Boyd, 2008). Instead, they often interact in intricate ways. For instance, the climato-economic theory of culture posits that harsh climates and economic conditions together mold cultural patterns. Specifically, when harsh climates coincide with poverty, collectivism tends to prevail, whereas coupling harsh climates with affluence tends to promote individualism (Van de Vliert, 2013). Moreover, these factors can also work in a combined manner. For example, variations in climate, pathogen prevalence, natural disasters, and socioeconomic development can be attributed, at least in part, to the variation in solar energy across latitudes (though negligibly across longitudes). Consequently, they may together contribute to cultural psychological variation along latitude (Van de Vliert & Van Lange, 2019).

Recognizing the interdependence among these diverse factors, it is essential to examine sources of cultural variation holistically. While assessing the predictive power of a single factor provides insight into its gross contribution, a comprehensive analysis requires simultaneous consideration of all potential sources. This approach allows us to evaluate not only the unique impact of each of these factors but also their combined contributions, resulting in a more complete and accurate understanding (Bromham et al., 2018; Minocher et al., 2019).

Regional Variations in Individualism-Collectivism within China

As a civilization with a long history, China has a large population (more than 1.4 billion people) and a vast territory of about 9.6 million square kilometers. It has substantial latitudinal (between 18° N and 52° N) and longitudinal variations (between 75° E and 134° E), resulting in a rich diversity of climate (from tropical to subarctic) and geography (from basin to plateau). All major subsistence practices, including farming, herding, and fishing, can be found in different regions. Although most Mainland Chinese are Han and nonreligious, China does have 56 ethnic groups, several minority autonomous regions, including Tibet, Xinjiang, and Qinghai, and many believers of various religions, including Buddhism, Christianity, and Islam. Genetic and linguistic variations among Mainland Chinese are also substantial (Chiang et al., 2018; Li et al., 2018). Over the past few decades, rapid modernization has taken place in the country, resulting in huge regional socioeconomic disparities, especially between Eastern coastal areas inhabited mainly by Han Chinese and the Western inland regions inhabited mainly by ethnic minorities (Cochrane et al., 2019; Mackerras, 2003).

Corresponding to these socioecological and population variations, pronounced regional-cultural variations have long been observed, as manifested by not only ethnic minority traditions (McCarthy, 2013) but also local cultures among Han Chinese (e.g. *Lu* culture, *Chu* culture) (Young, 1988). In recent years, research has emerged investigating regional-cultural variations in China, which allows us to understand not only variations themselves but also factors contributing

to them. For example, by surveying 1,662 respondents from 16 provinces in Mainland China, Van de Vliert et al. (2013) compared each provincial group's overall collectivistic orientation. They found higher collectivism in Northern (vs. Southern) provinces with a more demanding climate and less developed economy, a finding consistent with their climato-economic theory. In another study involving 1,019 university students from 28 provinces, Talhelm et al. (2014) measured attributes of individualism-collectivism in the domains of self-construal, thinking style, and social interaction; They found higher collectivism in Southern (vs. Northern) provinces with a higher prevalence of rice (vs. wheat) farming, a finding in line with their rice theory from a subsistence style perspective.

The pioneering studies on China's regional variation in individualism-collectivism are intriguing. Yet, they have some limitations. First, while much attention has been directed toward North-South differences, East-West differences have remained relatively underexplored. Second, only a handful of socioecological factors (such as climates, subsistence practices, and population density) have been considered in explaining these variations. Many alternative factors, including both socioecological and population ones, as well as their unique and combined influences, have yet to be thoroughly examined. Third, different studies have approached individualism and collectivism from different perspectives and assessed them using different measures, which makes direct comparisons challenging. Fourth, inconsistent findings have been reported. For instance, Van de Vliert et al. (2013) approached collectivism from a narrow perspective (i.e., assessing overall cultural orientation) and reported higher collectivism in Northern regions, whereas Talhelm et al. (2014) approached individualism and collectivism from a broad perspective (i.e., assessing self-construal, thinking style, etc.) and found higher collectivism in Southern regions. These inconsistencies may stem from distinct measures, relatively small and uneven sample sizes (Ruan et al., 2015), inadequate control of important demographic variables (such as rural versus urban residence; Greenfield, 2009), and lack of consideration of potential confounding variables such as genetic and linguistic factors (Bromham et al., 2018; Talhelm & Oishi, 2019). Hence, studies using large samples, controlling for potential artifacts and taking a comprehensive view of individualism and collectivism are urgently needed.

The Present Research

Our research had two primary goals. First, we investigated how individualism-collectivism varies across two fundamental spatial and geographic dimensions: latitude (North-South) and longitude (East-West) in China. Second, we concurrently tested the applicability of many related cultural psychological theories by examining the explanatory power of socioecological and population factors derived from existing theories.

In approaching individualism and collectivism, we adopted both narrow and broad perspectives and considered both subjectivist and intersubjective viewpoints. Specifically, we assessed not only individualistic and collectivistic orientations, but also typical psychological attributes associated with them, such as self-construal, thinking styles, interpersonal trust, and moral tolerance.

We conducted three large-scale studies. In Study 1, we investigated a large sample of college students ($N = 18,606$) with a subjectivist approach and utilized a total of 11 markers related to individualism and collectivism. These markers included individualistic and collectivistic orientations (three markers), independent and interdependent self-construals (three markers), holistic and analytic thinking styles (three markers), interpersonal trust (one marker), and moral tolerance (one marker).

Study 2 leveraged published data from a large community sample ($N = 8,167$; Chua et al., 2019) to examine whether the key findings from Study 1 could be replicated when we took an intersubjective approach by investigating perceived collectivism and moral tolerance. In Study 3,

we conducted another large-scale investigation during the COVID-19 pandemic ($N = 20,590$) and explored whether the primary results from Study 1 remained consistent when a unique cultural factor, pathogen prevalence, was highly salient.

Across all three studies, we assessed the explanatory power of 20 socioecological and population factors derived from existing theories. These factors encompassed physical and social environments as well as ethnic, genetic, and linguistic characteristics.

Study 1

Methods

Respondents. The survey was conducted online from December 2018 to June 2019. We recruited respondents from universities in Mainland China. The recruitment advertisement, which contained a link to our online survey, was disseminated to students by their teachers at over 100 universities. Each respondent participated voluntarily and provided written consent. Most of them took the survey in classrooms (about 60%) or dormitories (about 30%).

A total of 30,069 respondents completed the survey. Among them, about 4% were not currently enrolled university students, and about 8% were identified as careless responders (the SI Appendix, p. 8). Both groups were excluded from the final analyses. To avoid confounds that interprovincial migration may bring about, such as self-selection (e.g., individualists moved to a more individualistic region) and assimilation (e.g., collectivistic migrants became less so in an individualistic region), our main analyses focused on 18,606 respondents who had never migrated out of their home provinces (i.e., they reported that they lived in the same province where they grew up). 25% of them were male students whose ages ranged from 18 to 29 years ($M_{\text{age}} = 20.29$, $SD = 1.32$). 94% were Han Chinese—the majority ethnicity in China, and 34% were urban residents. They were sampled from all 31 provinces in Mainland China. Supplemental Table S1 in the SI Appendix presents descriptive statistics for key demographic variables of each provincial sample.

Individual-Level Measures of Cultural-Psychological Markers. We assessed respondents' psychological manifestations of individualism-collectivism with 11 markers, measured with either explicit self-reported scales or implicit cultural tasks as described below. All materials were in Chinese, either using the established Chinese version of a given measure (e.g., the Triad Categorization Task) or translations made by bilingual researchers on our team.

Orientation Towards Individualism-Collectivism. Participants completed two Likert-scale scales to assess a respondent's overall individualistic and collectivistic orientations: The Individualism and Collectivism Scale (Triandis & Gelfand, 1998) and Collectivistic Orientation Scale (Van de Vliert et al., 2013).¹ Both were rated on a 7-point scale (1 = *Strongly disagree*, 7 = *Strongly agree*).

Following conventional practices (e.g., Marshall, 2008), for the former scale, mean scores were calculated to reflect individualism (internal consistency: $\alpha = .66$, 8 items) and collectivism ($\alpha = .78$, 8 items) separately. For the latter scale, mean scores² were calculated to reflect collectivism ($\alpha = .85$, 12 items).

Independence-Interdependence. We implemented the Scale for Independent and Interdependent Self-Construals (Singelis, 1994) to assess orientations in independence ($\alpha = .74$, 12 items) and interdependence ($\alpha = .80$, 12 items) separately. Items were rated on a 7-point scale (1 = *Strongly disagree*, 7 = *Strongly agree*). Mean scores were calculated for each subscale.

Furthermore, we included a widely-used pictorial measure of self-other closeness, viz., the Inclusion of Others in the Self Scale (Aron et al., 1992), to measure the degree of independence-interdependence. Respondents were shown seven pairs of two circles whose overlap varies linearly (1 = *two completely overlapping circles*, 7 = *two completely separated circles*). Each respondent selected one pair of circles that best characterized their relational closeness to a specific target, including an individual's mother and father. In line with previous research (e.g., Na et al., 2020), we used relational closeness to family members (averaging between IOS scores for mother and father, $\alpha = .73$) to reflect independence-interdependence. A high score indicated high interdependence (lower independence).

Holistic-Analytic Thinking Style. We implemented two established measures to tap into holistic-analytic tendencies. The first measure is a commonly used, pictorial task of categorizing objects, viz., the Triad Categorization Task (Ji et al., 2004), which assesses the tendencies of relational reasoning (a manifestation of holistic thinking) versus categorical reasoning (a manifestation of analytic thinking). More specifically, respondents were asked to select two out of three objects that were most closely related to them. The proportion of choices that pair objects based on their thematic (relationship-based) connection rather than taxonomic (category-based) connection was calculated, reflecting the degree of holistic thinking ($\alpha = .87$, 14 items). This task has been considered an implicit, social-desirability-free measure, and has been used as a key instrument by Talhelm et al. (2014) to assess regional-cultural differences in China.

The second measure is a classic, pictorial task of attributing fish movement (Morris & Peng, 1994) by which the tendencies of external attribution (a manifestation of holistic thinking) and internal attribution (a manifestation of analytic thinking) are assessed separately. Respondents saw a fish swimming ahead of other fishes, and then indicated to what extent they believed the fish's movement was influenced by internal factors (internal attribution; 1 item) or by other fishes (external attribution; 1 item) on a 5-point scale (1 = *Very weakly*, 5 = *Very strongly*). Like the Triad Categorization Task, this task is considered an implicit measure of thinking style.

The Tendency to Trust Strangers. We used a single question, "*to what extent do you trust strangers*" (1 = *Do not trust very much*, 7 = *Trust very much*), to measure stranger trust, as adapted from the World Values Survey module (Welzel, 2010). The marker effectively captures the cross-national and regional differences between individualistic and collectivistic cultures, with stranger trust being higher in individualistic cultures (Jing et al., 2021)

Moral Tolerance. We implemented the Morally Debatable Behaviors Scale (Harding et al., 1986) to assess people's tolerance of morally debatable behaviors related to personal-sexual choices (e.g., homosexuality, prostitution, etc.). Respondents made their evaluations on a 7-point scale (1 = *Completely unjustifiable*, 7 = *Completely justifiable*), and mean scores were calculated across all items ($\alpha = .83$, 6 items). By using this marker, past research has shown that moral tolerance was higher in individualistic cultures than in collectivistic cultures (e.g., Minkov et al., 2013; Vaclair & Fischer, 2011).

Provincial-Level Measures of Spatial, Socioecological, and Population Predictors. In addition to latitude and longitude, we identified 20 provincial-level socioecological and population predictors (see Table 1) and sourced each of interest (i.e., predictors) from public databases (e.g., China Statistics Yearbooks released by the National Bureau of Statistics of China) or published studies. These predictors tap into a province's spatial location (i.e., latitude and longitude), climatic harshness, pathogen prevalence (i.e., annual incidence rate of nationally notifiable infectious diseases), natural-disaster stress (i.e., percentage of the population suffering natural disasters), population density (i.e., the number of residents per square kilometer), mobility (i.e., relational mobility and

residential mobility), subsistence style (i.e., farming, fishing, and herding), modernization (i.e., an index derived from seven major aspects: wealth, manufacturing industries, service economies, urbanization, marketization, formal education, and single-person households), ethnic feature (i.e., the percentage of ethnic minority population), genetic and linguistic features (i.e., relatedness between Chinese Han population across provinces), as well as religious features (i.e., the percentage of Buddhist, Christian, or Islamic believers) (for more details, see the SI Appendix, pp. 3–6).

Notably, we derived two comprehensive dimensions for genetic factors (Genetic I and Genetic II) and two for linguistic factors (Linguistic I and Linguistic II) from the existing database to represent the overall relatedness of genetic and linguistic factors across regions, respectively (see SI Appendix, p. 6). Based on their correlations with latitude and longitude, higher scores on Genetic I and Linguistic I can be interpreted as greater similarity to Southern Chinese (vs. Northern Chinese), whereas higher scores on Genetic II and lower scores on Linguistic II suggest greater similarity to Western Chinese compared to Eastern Chinese (SI Appendix, pp. 15–16).

Analytic Strategies

Multilevel Modeling. We performed two-level multilevel regression in which the individual respondents were nested within their home provinces. Equations 1.1 and 1.2 display regression models for illustration purposes; the subscript i refers to the i th respondent within a province, and j refers to the j th province.

$$\begin{aligned} \text{Level 1: } Y_{ij} = & \beta_{0j} + \beta_{1j} \text{ Gender} + \beta_{2j} \text{ Age} + \beta_{3j} \text{ Education Level} + \beta_{4j} \text{ Family SES} \\ & + \beta_{5j} \text{ Rural – Urban Residence} + \beta_{6j} \text{ Majoring Psychology} \\ & + \beta_{7j} \text{ Majoring Sciences, Engineering, Agronomy, and Medicine} \\ & + \beta_{8j} \text{ University Prestige} + \varepsilon_{ij} \end{aligned} \quad (1.1)$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01} \text{ Provincial Factor}_{0j} + \mu_{0j} \quad (1.2)$$

As illustrated in Equation 1.1, at the individual level, we regressed each of the 11 cultural-psychological markers on 8 personal demographic covariates, with each covariate grand-mean-centered (value of zero denotes average characteristics across all respondents). Controlling for covariates in this way, the estimated average cultural tendency in each province was adjusted for provincial disparities in demographic compositions that may bias our comparisons (for more detailed reasons why we focused on these covariates, please refer to the SI Appendix, pp. 2–3). At the provincial level, we regressed each province's covariate-adjusted cultural tendency (intercept β_{0j}) on the provincial factor(s) of interest to test their predictive power (Equation 1.2). Additionally, we checked various key model assumptions (normality of residuals, normality of random effects, heteroscedasticity, and multicollinearity) to avoid misspecification.

Given that we tested each provincial factor's predictive ability across 11 markers, we employed the Benjamini–Hochberg (BH) procedure (Benjamini & Hochberg, 1995) to adjust p values in multiple testing and thereby reduced false-positive results.³ To quantify a predictor's explanatory power, we calculated effect size by converting the regression coefficient of multilevel modeling into Pearson r correlation coefficient.⁴

For more details about the software program that we used to perform the aforementioned statistical analyses, please refer to the SI Appendix (pp. 6–7).

Transparency and Openness. The study protocol was pre-registered at https://aspredicted.org/GDS_WGD.⁵ Data and survey materials are available upon reasonable request. All R codes and outputs were deposited at Science Data Bank (<https://doi.org/10.57760/sciencedb.07672>).

Results

We first report whether socioecological and population-level features vary across latitude and longitude, as a prerequisite for analyzing their predictive value. Next, we examine how psychological markers are independently predicted by latitude, longitude, and each of the socioecological and population factors. Finally, we evaluate the unique contribution of significant predictors by regressing each marker on all significant predictors simultaneously, and comparing their unique explained variance with the total explained variance.

The Regional Variation in Socioecological and Population Features. Zero-order correlations revealed that the majority of socioecological factors varied systematically with latitude or longitude (Supplemental Table S3 in the SI Appendix): Higher-latitude (further North) provinces were associated with greater climatic harshness, higher prevalence of herding economies, and lower prevalence of rice farming and fishery economies; higher-longitude (further East) provinces were associated with higher societal modernization, higher population density, higher prevalence of fishery economies, lower pathogen prevalence, and lessened stress of natural disasters. These results confirmed that Northern and Southern China differed strikingly in climates (Kwon & Shan, 2012) and that Eastern and Western China differed strikingly in socioeconomic development (Cochrane et al., 2019). Meanwhile, steady rainfalls, residential, and relational mobility did not vary substantially with both latitude and longitude (in a linear way).

The results also revealed that population factors exhibited systematic latitudinal or longitudinal variations: Firstly, genetic and linguistic relatedness between Han Chinese populations varied more strongly with latitude compared to longitude (Supplemental Table S3)⁶; secondly, higher-longitude provinces were inhabited by fewer ethnic minorities and fewer Buddhist and Islamic believers, but more Christian believers (Supplemental Table S3).

Taken together, the socioecological and population factors of current interest had rich and systematic variations, which permit a sensible test of their explanatory power for regional-cultural differences.

The Regional Variation in Overall Individualistic and Collectivistic Orientation

Spatial Pattern. Longitude significantly predicted all three markers in this domain (see Table 2): Participants from higher-longitude-provinces (further East) exhibited stronger individualism (“Ind”: $\gamma = .01$, $t [29] = 3.80$, $p = .002$, effect size $r = .58$) and weaker collectivism (“Col1”: $\gamma = -.01$, $t [29] = -3.17$, $p = .006$, $r = -.51$; “Col2”: $\gamma = -.01$, $t [29] = -3.08$, $p = .007$, $r = -.50$). By contrast, none of these markers were substantially predicted by latitude. These findings are inconsistent with the latitudinal account of cultural variation (Van de Vliert & Van Lange, 2019).

Socioecological Predictors. Among the five physical factors, only pathogen prevalence significantly predicted the individualistic orientation (see Table 2): Consistent with the parasite-stress theory (Thornhill & Fincher, 2014), individualism was weaker in provinces where the annual prevalence of noticeable infectious diseases was higher (“Ind”: $\gamma = -.002$, $t [29] = -3.47$, $p = .018$, $r = -.54$). Meanwhile, no physical predictor explained variations in the two markers of collectivism.

Compared to physical factors, more social factors (three) significantly predicted the markers. Consistent with the mobility account and the modernization account, lower collectivism was associated with higher residential mobility (“Col1”: $\gamma = -.80$, $t [29] = -3.64$, $p = .004$, $r = -.56$; “Col2”: $\gamma = -.65$, $t [29] = -2.55$, $p = .030$, $r = -.43$) and higher modernization (“Col1”: $\gamma = -.05$, $t [29] = -3.50$, $p = .003$, $r = -.54$; “Col2”: $\gamma = -.05$, $t [29] = -3.21$, $p = .006$, $r = -.51$). Meanwhile, population density predicted all three markers: Inconsistent with the finding from the U.S. (Vandello & Cohen, 1999), higher population density was associated with stronger individualism and weaker collectivism in China (Table 2).

Table 2. Effect Sizes (*r*) for Spatial, Socioecological, and Population Factors that Significantly Predict Regional Variations in Psychological Manifestations of Individualism-Collectivism in Study 1.

	Individualism-collectivism			Independence-interdependence			Holistic-analytic				
	Ind	ColI	Col2	Indep	Inter	Close	Holl	Hol2	Analy	Stranger trust	Moral tolerance
Spatial factors											
Latitude											
Longitude	.58**	-.51**	-.50**		-.45*	-.56**		-.62***	-.41*	.66***	.62***
Physical factors											
Climatic harshness											
Climate by wealth											
Climate by rains											
Pathogen prevalence											
Natural disasters	-.54*										
Social factors											
Population density	.45*	-.41*	-.50**		-.48*	-.55**		-.66***		.51**	.71***
Residential mobility		-.56**	-.43*		-.55**			-.44*		.54**	.58**
Relational mobility											
Rice farming					-.57**						
Fishery economies										.62**	
Herding economies										-.61**	
Modernization		-.54**	-.51**		-.55**			-.66***		.62***	.75***
Population factors											
Ethnic minority	-.62***	.44*	.61***		.48**	.71***		.78***	.63***	-.56**	-.63***
Genetic I		-.56*			-.69**	-.84***					
Genetic II					-.49*	-.61**					
Linguistic I											
Linguistic II						.62**		.57*			
Buddhism											
Christianity											
Islam		.42*			.46*	.49*				.52*	

Note. Each marker was regressed onto a given provincial factor separately. The table only presents effect sizes for significant associations after controlling the False Discovery Rate (FDR; adjusted $p < .05$) in multiple testing. Missing cells indicate no significant associations between the predictor and the marker.

Ind = Individualism (Triandis & Gelfand, 1998); ColI = Collectivism (Triandis & Gelfand, 1998); Col2 = Collectivism (Van de Vliert et al., 2013); Indep = Independence; Inter = Interdependence; Close = Relational closeness (IOS) to family members; Holl = Relational reasoning; Hol2 = External attribution; Analy = Internal attribution; Moral tolerance = The reported justifiability of non-traditional personal-sexual practices.

Genetic I = Genetic relatedness to Southern Chinese (vs. Northern Chinese); Genetic II = Genetic relatedness to Western Chinese (vs. Eastern Chinese); Linguistic I = Linguistic relatedness to Southern Chinese (vs. Northern Chinese); Linguistic II = Linguistic relatedness to Eastern Chinese (vs. Western Chinese).

* $p < .05$, ** $p < .01$, *** $p < .001$ (denoting the significance level of corresponding regression coefficients).

Population Predictors. Three population factors each significantly predicted at least one marker (see Table 2). Specifically, the ethnic minority population predicted all three markers: Individualism was weaker and collectivism was stronger in provinces inhabited by more ethnic minorities, which supports the conventional belief in China (Yuan, 2008). Additionally, both the genetic index and Islamic population predicted the same marker of collectivism: Participants from Southern (vs. Northern) China reported weaker collectivistic orientations (“Col2”: $\gamma = -.04$, $t [20] = -3.06$, $p = .022$, $r = -.56$), and participants from provinces with more Islamic believers reported stronger collectivistic orientations (“Col2”: $\gamma = .41$, $t [29] = 2.52$, $p = .048$, $r = .42$).

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of significant predictors for each marker, we regressed each marker on all significant predictors simultaneously (see Table 3). In terms of the unique versus total explained variance, while most of the variation in one marker of collectivistic orientation (“Col1”) was uniquely explained by residential mobility and the ethnic minority population, variations in the other two markers (“Ind” and “Col2”) were primarily explained by the combined effect of relevant socioecological and population factors (i.e., a large amount of the total variance was explained by the regression model, but each individual predictor within that model explained limited unique variance).

Regional Variations in Independence-Interdependence

Spatial Pattern. Longitude significantly predicted two markers of interdependence (see Table 2): Participants from Eastern (vs. Western) provinces exhibited lower interdependence, as manifested in lower self-reported interdependent tendencies (“Inter”: $\gamma = -.00$, $t [29] = -2.70$, $p = .016$, $r = -.45$) and decreasing closeness with family members (“Close”: $\gamma = -.03$, $t [29] = -3.65$, $p = .002$, $r = -.56$). On the other hand, longitude was not significantly associated with the self-reported independent tendency (“Indep”: $\gamma = -.00$, $t [29] = -.45$, $p = .658$, $r = -.08$), highlighting that independence is not necessarily the opposite of interdependence. Meanwhile, no marker in this domain was predicted by latitude (Table 2).

Socioecological Predictors. Physical factors did not predict any marker of independence and interdependence (Table 2). By contrast, four social factors each predicted at least one marker. Consistent with the mobility account and the modernization account, interdependence, as manifested in the self-reported interdependent tendency, was lower in provinces with higher residential mobility (“Inter”: $\gamma = -.80$, $t [29] = -3.55$, $p = .004$, $r = -.55$) and higher modernization (“Inter”: $\gamma = -.05$, $t [29] = -3.58$, $p = .003$, $r = -.55$); Closeness with family members, another marker of interdependence, was also lower in more modernized provinces (“Close”: $\gamma = -.28$, $t [29] = -3.17$, $p = .006$, $r = -.51$). Inconsistent with the population-density account and the rice theory, however, both markers of interdependence were lower in provinces with higher population density and higher prevalence of rice farming (Table 2).

Population Predictors. Five population factors each significantly predicted at least one marker (see Table 2). Consistent with the conventional wisdom, the two markers of interdependence were higher in provinces inhabited by more ethnic minorities (“Inter”: $\gamma = .23$, $t [29] = 2.93$, $p = .008$, $r = .48$; “Close”: $\gamma = 1.91$, $t [29] = 5.41$, $p < .001$, $r = .71$) and Islamic believers (“Inter”: $\gamma = .42$, $t [29] = 2.76$, $p = .037$, $r = .46$; “Close”: $\gamma = 2.40$, $t [29] = 3.03$, $p = .028$, $r = .49$); Interdependence, as manifested in closeness with family members, was also higher in provinces inhabited by more Buddhist believers ($\gamma = 2.03$, $t [24] = 3.86$, $p = .008$, $r = .62$). Meanwhile, according to the predictions of genetic and linguistic factors, interdependence was lower among Southern Chinese than among Northern Chinese (Table 2).

Table 3. Regressing Cultural-Psychological Markers on Relevant Socioecological and Population Predictors in Study I.

	Individualism (Ind)			
	Standardized γ	95% CI	p value	Unique variance explained
Pathogen prevalence	-.03	[-.06, .00]	.086	8%
Population density	-.01	[-.04, .03]	.718	0%
Ethnic minority	-.04	[-.07, -.01]	.008	9%
Total variance explained	37%			
	Collectivism (Col1)			
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.01	[-.03, .05]	.562	0%
Residential mobility	-.10	[-.19, -.00]	.042	25%
Modernization	.02	[-.07, .11]	.641	0%
Ethnic minority	.04	[.01, .07]	.017	22%
Total variance explained	68%			
	Collectivism (Col2)			
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.00	[-.05, .00]	.906	0%
Residential mobility	-.08	[-.23, .01]	.297	9%
Modernization	.03	[-.12, .01]	.704	0%
Ethnic minority	-.00	[-.04, .00]	.937	0%
Genetic I	-.02	[-.07, .00]	.360	0%
Islam	.00	[-.04, .00]	.905	0%
Total variance explained	55%			
	Interdependence (Inter)			
	Standardized γ	95% CI	p value	Unique variance explained
Population density	-.00	[-.04, .03]	.888	0%
Residential mobility	-.13	[-.25, -.01]	.031	13%
Rice farming	-.06	[-.17, .04]	.201	2%
Modernization	.06	[-.05, .18]	.237	2%
Ethnic minority	-.00	[-.04, .03]	.767	0%
Genetic I	-.06	[-.14, .01]	.075	8%
Linguistic I	.08	[-.03, .20]	.133	3%
Islam	.02	[-.01, .05]	.256	2%
Total variance explained	92%			
	Interdependence (Close)			
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.01	[-.03, .05]	.634	0%
Rice farming	-.02	[-.15, .11]	.725	0%
Modernization	.01	[-.03, .05]	.083	4%
Ethnic minority	.01	[-.03, .05]	.535	0%
Genetic I	-.16	[-.27, -.05]	.008	16%
Linguistic I	.09	[-.09, .27]	.288	2%
Buddhism	.02	[-.04, .09]	.488	0%
Islam	.00	[-.03, .03]	.833	0%
Total variance explained	83%			

Holistic thinking (Hol1)				
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.02	[-.01, .05]	.264	2%
Residential mobility	-.04	[-.13, .04]	.272	2%
Modernization	-.03	[-.12, .05]	.408	0%
Ethnic minority	.03	[.01, .06]	.015	19%
Buddhism	.04	[.01, .07]	.023	4%
Total variance explained	77%			
Analytic thinking (Analy)				
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.00	[-.02, .03]	.900	0%
Residential mobility	-.00	[-.08, .03]	.416	0%
Fishery economy	.00	[-.02, .06]	.293	0%
Herding economy	-.00	[-.04, .02]	.424	0%
Modernization	.00	[-.04, .09]	.453	0%
Ethnic minority	-.00	[-.04, .01]	.138	0%
Total variance explained	99%			
Stranger trust				
	Standardized γ	95% CI	p value	Unique variance explained
Ethnic minority	.02	[.01, .04]	.013	14%
Islam	.01	[-.00, .03]	.090	12%
Total variance explained	59%			
Moral tolerance				
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.02	[-.06, .09]	.675	0%
Residential mobility	.05	[-.13, .24]	.551	4%
Modernization	.08	[-.09, .24]	.353	0%
Ethnic minority	-.05	[-.11, .01]	.075	9%
Total variance explained	53%			

Note. For markers that can be significantly predicted by more than one socioecological/population factor (Table 2), we regressed each of these markers on all significant factors simultaneously while controlling for personal demographic covariates. Ind = Individualism (Triandis & Gelfand, 1998); Col1 = Collectivism (Triandis & Gelfand, 1998); Col2 = Collectivism (Van de Vliert et al., 2013); Inter = Interdependence; Close = Relational closeness (IOS) to family members; Hol1 = Relational reasoning; Analy = Internal attribution; Moral tolerance = The reported justifiability of non-traditional personal-sexual practices. Genetic I = Genetic relatedness to Southerners (vs. Northerners); Linguistic I = Linguistic relatedness to Southerners (vs. Northerners). The table reports standardized regression coefficients, 95% CIs, raw p values, unique provincial-level explained variance for a given marker (the column name), and total provincial-level explained variance. We utilized the variance partitioning method for multilevel regression as developed by Rights and Sterba (2019).

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of each significant predictor, we regressed each marker onto all significant predictors simultaneously (see Table 3). In terms of the unique versus total explained variance, the majority of provincial variation in interdependence was explained by the collective effect of relevant socioecological and population factors.

Regional Variations in Holistic-Analytic Thinking Style

Spatial Pattern. Longitude significantly predicted all three markers in this domain. Specifically, the holistic tendencies, as manifested in relational reasoning (“Hol1”) and external attribution (“Hol2”), were lower in higher-longitude (i.e., Eastern) provinces (“Hol1”: $\gamma = -.00$, $t [29]$

$= -4.26, p < .001, r = -.62$; “Hol2”: $\gamma = -.00, t [29] = -2.42, p = .027, r = -.41$); the analytic tendencies, as manifested in internal attribution, were higher in Eastern provinces compared to Western provinces (“Hol2”: $\gamma = .01, t [29] = 4.69, p < .001, r = .66$; Table 2). Meanwhile, no marker was significantly predicted by latitude.

Socioecological Predictors. No marker was predicted by physical factors. By contrast, five social factors each predicted at least one marker (see Table 2). Consistent with the mobility account and the modernization account, holistic thinking (“Hol1”) was less prevalent, and analytic thinking (“Analy”) was more prevalent in provinces with higher residential mobility (“Hol1”: $\gamma = -.28, t [29] = -2.64, p = .029, r = -.44$; “Analy”: $\gamma = .45, t [29] = 3.47, p = .004, r = .54$) or more progressed modernization (“Hol1”: $\gamma = -.03, t [29] = -4.74, p < .001, r = -.66$; “Analy”: $\gamma = .05, t [29] = 4.31, p < .001, r = .62$). Inconsistent with the population-density account, the holistic tendencies were weaker (“Hol1”: $\gamma = -.03, t [29] = -4.74, p < .001, r = -.66$) and the analytic tendencies were stronger in more densely populated provinces (“Analy”: $\gamma = .05, t [29] = 3.23, p = .008, r = .51$).

Population Predictors. Two population factors each predicted at least one marker. Consistent with the conventional wisdom, the holistic tendencies were stronger (“Hol1”: $\gamma = .16, t [29] = 6.71, p < .001, r = .78$; “Hol2”: $\gamma = .36, t [29] = 4.42, p < .001, r = .63$) and the analytic tendencies were weaker (“Analy”: $\gamma = -.31, t [29] = -3.64, p = .001, r = -.56$) in provinces inhabited by more ethnic minorities; holistic thinking also was more prevalent in provinces inhabited by more Buddhist believers (“Hol1”: $\gamma = .13, t [24] = 3.39, p = .013, r = .57$).

Partitioning the Contribution of Relevant Predictors. To examine the unique contributions of factors that could significantly explain regional differences in the same markers of thinking style, we regressed each marker onto all significant predictors simultaneously (see Table 3). In terms of the unique versus total explained variance, the variations in relational reasoning/holistic thinking (“Hol1”) and internal attribution/analytic thinking (“Analy”) were primarily explained by the combined effect of relevant socioecological and population factors.

Regional Variations in Stranger Trust

Spatial Pattern. Neither longitude nor latitude significantly predicted the levels of stranger trust (Table 2).

Socioecological Predictors. Similar to spatial factors, none of the 12 physical and social factors significantly predicted stranger trust in a linear way (Table 2).

Population Predictors. Two population factors each significantly predicted stranger trust. Inconsistent with how cultural orientations, self-construals, and/or cognitive styles differed across China, higher stranger trust, a marker of individualism (vs. collectivism), was found in provinces inhabited by more ethnic minorities ($\gamma = .38, t [29] = 3.76, p = .001, r = .57$) and more Islamic believers ($\gamma = .70, t [29] = 3.26, p = .028, r = .52$).

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of factors that could significantly explain regional differences in stranger trust, we regressed the marker of stranger trust onto two significant predictors simultaneously (see Table 3). In terms of the unique versus total explained variance, the variation in stranger trust was primarily explained by the combined effect of relevant population factors.

Regional Variations in Moral Tolerance

Spatial Pattern. Longitude significantly predicted moral tolerance: Participants from higher-longitude (i.e., Eastern) provinces accepted non-traditional personal-sexual practices more ($\gamma = .02$, $t [29] = 4.27$, $p < .001$, $r = .62$), suggesting that participants in Eastern regions were more individualistic than their counterparts in Western regions. Meanwhile, latitude did not significantly predict this marker.

Socioecological Predictors. No physical factor significantly predicted moral tolerance (Table 2). By contrast, three social factors each explained the variation of interest: Consistent with the mobility account and the modernization theory, moral tolerance was higher in provinces with higher residential mobility ($\gamma = 3.59$, $t [29] = 3.81$, $p = .004$, $r = .58$) and higher modernization ($\gamma = .29$, $t [29] = 6.11$, $p < .001$, $r = .75$). Inconsistent with the population-density account, however, moral tolerance was also higher in more densely populated provinces ($\gamma = .27$, $t [29] = 5.47$, $p < .001$, $r = .71$).

Population Predictors. Among the eight population factors, only ethnicity significantly predicted moral tolerance: Consistent with the findings in other domains, moral tolerance was weaker in provinces inhabited by more ethnic minorities ($\gamma = -1.16$, $t [29] = -4.42$, $p < .001$, $r = -.63$).

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of factors that could significantly explain regional differences in moral tolerance, we regressed the marker onto all significant predictors simultaneously (see Table 3). In terms of the unique versus total explained variance, the variation in moral tolerance was mainly explained by the combined contribution of relevant socioecological and population predictors.

Discussion

In this study, we conducted a comprehensive analysis of the variation in psychological markers of individualism and collectivism across different regions within China. The study yielded several key findings.

First, we found that the cultures of individualism and collectivism in China primarily vary along the East-West axis, rather than the North-South axis. Longitude significantly predicted 9 out of the 11 markers we investigated, while latitude did not predict any of them. Furthermore, most of the predictive socioecological and population factors were related to longitude, with only a few, such as rice farming, related to latitude.

Second, our diverse markers converged to indicate the prevalence of individualism in the Eastern regions and a dominance of collectivism in the Western regions. Compared to individuals in the Western regions, those in the Eastern regions demonstrated higher levels of individualistic orientation, analytic thinking style, and moral tolerance. However, they exhibited lower levels of collectivism, interdependent self-construal, and holistic thinking style. We found no significant differences in independence and trust in strangers.

Third, the cultural variation in individualism and collectivism could be attributed to many social factors (25 out of 77 associations were significant) and population factors (21 out of 88 associations were significant), but only a few physical factors (1 out of 55 associations was significant). Among the seven social factors, population density, residential mobility, and modernization exhibited the strongest predictive ability (with 10, 6, and 7 out of 11 associations being significant, respectively). While all associations for modernization and residential mobility aligned with theoretical expectations, all associations for population density contradicted them, with higher levels of population density, modernization, and residential mobility being

associated with stronger individualism. Rice farming predicted 2 out of 11 outcomes, but in a direction contradicting the theory: More rice farming was associated with a lower level of interdependence. Among the eight population predictors, ethnic minority (10 out of 11 associations were significant) and Islamic population (4 out of 11 were significant) demonstrated the strongest predictive ability. Except for stranger trust, associations with all other outcomes converged to indicate that a high population of ethnic minorities and Islamic believers was associated with a high level of collectivism.

Lastly, very few predictors demonstrated unique predictive power. Instead, most of them operated in conjunction with other factors, suggesting that cultural phenomena are mostly the result of the combined influences of multiple factors.

In summary, our findings lend support to most theories and explanatory factors: the modernization theory, the mobility account, the parasite-stress theory, as well as the potential influences of fishery economies, religion, ethnic minorities, and genetic and linguistic factors. However, the two theories that are commonly used to explain within-country cultural variations in China, namely the rice theory and the climato-economic theory, did not receive any support.

Interestingly, population density was highly predictive, but in the opposite direction of what was expected. This may be due to its significant overlap with modernization. This overlap is evidenced by the fact that all independent predictions from both factors were in the same direction and that when population density and modernization were considered simultaneously, neither emerged as predictive. A possible explanation for this overlap is that favorable life conditions foster both population growth and societal modernization. Overall, cultural phenomena are best understood as the collective outcome of multiple socioecological factors.

Study 2

Study 2 aimed to examine whether the primary findings of Study 1 could be replicated with a large community sample when intersubjective perceptions of individualism-collectivism were examined (e.g., how much participants believe that individualist or collectivist behaviors and values are widely endorsed).

Methods

Respondents. In several online surveys, Chua et al. (2019) have measured perceptions of cultures of the 31 provinces among a large Chinese community sample. We reanalyzed their data (collected in 2014 and 2017), involving 8,167 respondents (53% males) who completed at least one intersubjective measure of current interest. Their ages ranged from 18 to 69 years ($M_{\text{age}} = 31.66$, $SD = 8.96$), with 57% bachelor's degree holders or currently enrolled university students. According to self-reports, they had stayed in a given province for 4–68 years ($M_{\text{age}} = 22.47$, $SD = 12.56$). Importantly, Chua et al.'s analysis indicated that non-local respondents (who had stayed for more than 3 years) reported intersubjective perceptions similar to local respondents.

Intersubjective Perceptions of Provincial Cultures. Respondents were asked to report intersubjective perceptions on a variety of cultural constructs (e.g., tightness-looseness, power distance, traditional Chinese values, etc.). Among these measures, we found three markers conceptually similar to what was assessed in Study 1: Two of them tapped into general orientation towards collectivism, and one tapped into moral tolerance (individualism).

Collectivism. Relational and group collectivism, two forms of collectivism that have been well distinguished in previous research (House et al., 2004; Realo et al., 2008), were assessed in Chua

et al.'s study. While relational collectivism refers to the culture that fosters pride and loyalty between family members, group collectivism refers to the culture that promotes collective cohesion and welfare.

In terms of established questionnaires (House et al., 2004), respondents reported their perceptions of collectivism in the province where they currently lived. Sample items include “*In this society, children take pride in the individual accomplishments of their parents*” for relational collectivism, and “*In this society, leaders encourage group loyalty even if individual goals suffer*” for group collectivism ($1 = \text{Strongly agree}$; $7 = \text{Strongly disagree}$). Original items were written in English and were translated into Chinese by Chua et al. When necessary, ratings were reversely coded so that higher scores indicate stronger collectivism. We calculated mean scores across items for relational collectivism ($\alpha = .71$, 4 items) and group collectivism ($\alpha = .63$, 4 items), respectively.

Moral Tolerance. In response to a single item (“*To what extent are people in your province tolerant towards lesbians, gays, bisexuals, and transgender*”), respondents reported their perceptions of a province’s moral tolerance towards non-traditional personal-sexual practices on a 6-point scale ($1 = \text{Not at all}$, $6 = \text{To a great extent}$).

Provincial Predictors and Analytic Strategies. We used the same analytic strategies as in Study 1. Each province’s spatial, socioecological, and population predictors were identical to those in Study 1. We performed a series of two-level multilevel regressions to examine how provincial factors, individually and collectively, predicted each of the three intersubjective markers, with three available demographic covariates (i.e., gender, age, and educational attainment) and the False-Discovery Rate (FDR) controlled for. For more details, please refer to the SI Appendix (pp. 6–7).

Transparency and Openness. All R codes and outputs were deposited at Science Data Bank (<https://doi.org/10.57760/sciencedb.07672>).

Results

Regional Variations in Collectivism

Spatial Pattern. Only longitude significantly predicted the marker of collectivism (Table 4): Respondents perceived lower collectivism, as manifested in group collectivism ($\gamma = -.01$, $t [29] = -3.49$, $p = .005$, $r = -.54$), in Eastern than Western provinces. The results are consistent with what we found in Study 1.

Socioecological Predictors. Two physical factors significantly predicted markers in this domain: Consistent with the parasite-stress theory as well as the natural disaster account, the perceived collectivism was stronger in provinces with higher pathogen prevalence (as manifested in group collectivism: $\gamma = .01$, $t [29] = 3.01$, $p = .016$, $r = .49$) or with higher stress of natural disasters (as manifested in relational collectivism: $\gamma = 1.05$, $t [29] = 4.11$, $p < .001$, $r = .61$). Meanwhile, five social factors each significantly predicted at least one marker (Table 4): Consistent with the mobility account, the subsistence (fishery economies) perspective, and the modernization theory, the perceived collectivism was weaker (as manifested across both markers) in provinces with higher residential mobility, a higher prevalence of fishery economies, or higher modernization. Inconsistent with the population density account and the rice theory, however, the perceived collectivism was weaker in provinces with higher population density (as manifested in both markers) or a higher prevalence of rice farming (as manifested in group collectivism). The results, in general, replicated the main findings in Study 1.

Table 4. Effect Sizes (r) for Spatial, Socioecological, and Population Factors that Significantly Predict Regional Variations in Intersubjective Perceptions of Individualism-Collectivism in Study 2.

	Collectivism		Moral tolerance
	Relational	Group	
Spatial factors			
Latitude			
Longitude		-.54**	.39*
Physical factors			
Climatic harshness			
Climate by wealth			
Climate by rains			
Pathogen prevalence		.49*	
Natural disasters	.61***		
Social factors			
Population density	-.64***	-.50**	.66***
Residential mobility	-.60***		.76***
Relational mobility			
Rice farming		-.55**	
Fishery economies	-.47*	-.64***	.43*
Herding economies			
Modernization	-.68***	-.45*	.83***
Population factors			
Ethnic minority		.47*	
Genetic I			
Genetic II		-.48*	
Linguistic I			
Linguistic II			
Buddhism			
Christianity			
Islam		.60**	

Note. Each marker was regressed on a given provincial factor separately. The table only presents effect sizes for significant associations after controlling for the False Discovery Rate (FDR; adjusted $p < .05$) in multiple testing. Missing cells indicate no significant associations between the predictor and the marker.

Relational = The perceived descriptive norms of relational collectivism; Group = The perceived descriptive norms of group collectivism; Moral tolerance = The perceived tolerance towards LGBT groups.

Genetic I = Genetic relatedness to Southern Chinese (vs. Northern Chinese); Genetic II = Genetic relatedness to Western Chinese (vs. Eastern Chinese); Linguistic I = Linguistic relatedness to Southern Chinese (vs. Northern Chinese); Linguistic II = Linguistic relatedness to Eastern Chinese (vs. Western Chinese).

* $p < .05$, ** $p < .01$, *** $p < .001$ (denoting the significance level of corresponding regression coefficients).

Population Predictors. Three population factors each significantly predicted one marker of collectivism: Consistent with the conventional wisdom in China and the view on Eastern religion, the perceived collectivism, as manifested in group collectivism, was stronger in provinces inhabited by more ethnic minorities ($\gamma = .39$, $t [29] = 2.90$, $p = .021$, $r = .47$) or more Islamic believers ($\gamma = .88$, $t [29] = 4.03$, $p = .001$, $r = .60$). Meanwhile, the perceived group collectivism was weaker in Southern (vs. Northern) populations in terms of linguistic relatedness ($\gamma = -.14$, $t [26] = -2.77$, $p = .030$, $r = -.48$). The findings conceptually replicated what we found in Study 1.

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of factors that could significantly explain regional differences in the two markers, we regressed each marker onto all significant predictors simultaneously (see Table 5). In terms of the unique versus

Table 5. Regressing Intersubjective Markers of Individualism-Collectivism on Relevant Socioecological and Population Predictors in Study 2.

Collectivism (Relational)				
	Standardized γ	95% CI	p value	Unique variance explained
Natural disasters	.05	[-.04, .14]	.275	1%
Population density	-.06	[-.16, .04]	.248	2%
Residential mobility	-.02	[-.13, .09]	.681	0%
Fishery economy	-.02	[-.09, .05]	.596	0%
Modernization	-.02	[-.19, .14]	.762	0%
Total variance explained		62%		
Collectivism (Group)				
	Standardized γ	95% CI	p value	Unique variance explained
Pathogen prevalence	.02	[-.11, .06]	.583	0%
Population density	.02	[-.07, .11]	.599	0%
Rice farming	-.08	[-.21, .06]	.266	1%
Fishery economy	-.08	[-.16, -.01]	.034	12%
Modernization	-.02	[-.11, .07]	.618	0%
Ethnic minority	-.01	[-.09, .06]	.728	0%
Linguistic I	.07	[-.08, .21]	.334	2%
Islam	.10	[.01, .19]	.024	14%
Total variance explained		90%		
Moral tolerance				
	Standardized γ	95% CI	p value	Unique variance explained
Population density	.01	[-.08, .10]	.805	0%
Residential mobility	.05	[-.05, .16]	.303	1%
Fishery economy	-.01	[-.07, .06]	.789	0%
Modernization	.15	[.01, .29]	.031	5%
Total variance explained		72%		

Note. For markers that can be significantly predicted by more than one socioecological/population factor (Table 4), we regressed each of these markers on relevant factors simultaneously while controlling for personal demographic covariates.

Linguistic I = Linguistic relatedness to Southern Chinese (vs. Northern Chinese).

The table reports standardized regression coefficients, 95% CIs, raw p values, unique provincial-level variance in a given marker (the column name) explained by a single provincial predictor, and total provincial-level variance explained by relevant predictors.

total explained variance, the variations in the two markers were mainly explained by the combined contribution of relevant socioecological and population predictors.

Regional Variations in Moral Tolerance

Spatial Pattern. Longitude but not latitude significantly predicted moral tolerance (Table 4): Consistent with Study 1, the perceived moral tolerance was higher in Eastern (vs. Western) provinces ($\gamma = .01$, $t [29] = 2.31$, $p = .043$, $r = .39$).

Socioecological Predictors. No physical factor significantly predicted moral tolerance. By contrast, four social factors each significantly predicted this marker (Table 4): Similar to regional differences in collectivism, the perceived moral tolerance (individualism) was higher in provinces with higher residential mobility ($\gamma = 3.71$, $t [29] = 6.33$, $p < .001$, $r = .76$), a higher prevalence of fishery economies ($\gamma = 1.44$, $t [29] = 2.56$, $p = .015$, $r = .43$), and higher modernization ($\gamma = .25$, $t [29] = 8.01$, $p < .001$, $r = .83$). Moral tolerance was also stronger in more densely populated provinces ($\gamma = .20$, $t [29] = 4.75$, $p < .001$, $r = .66$), which contradicted the population density account.

Population Predictors. Unlike in Study 1, no population factor significantly predicted the perceived moral tolerance (Table 4).

Partitioning the Contribution of Relevant Predictors. To examine the unique contribution of factors that could significantly explain regional differences in moral tolerance, we regressed the marker of moral tolerance onto all significant predictors simultaneously (see Table 5). In terms of the unique versus total explained variance, the variations in moral tolerance was primarily explained by the combined effect of relevant socioecological factors.

Summary and Discussion

Study 2 replicated the primary findings of Study 1 with a large community sample when intersubjective perceptions of individualism and collectivism were examined. Firstly, as in Study 1, regional variations on perceived individualism and collectivism predominantly exhibited East-West differences, rather than North-South differences. Secondly, numerous factors were predictive in directions like those in Study 1. These include pathogen prevalence, population density, residential mobility, fishery economies, modernization, ethnic minority, linguistic relatedness, and Islamic religion.

Interestingly, while climate did not predict any outcomes, rice farming predicted group collectivism in a direction contrary to what is expected according to the rice theory. Additionally, many of the predictors functioned in conjunction with others, rather than independently, suggesting the complex interplay of multiple factors in shaping cultural phenomena.

These findings support the modernization theory, the mobility account, the parasite-stress theory, and the potential influences of fishery economies, religion, ethnic minorities, and linguistic relatedness, among which modernization emerged as the most potent predictor. However, they do not support the climato-economic theory, the rice theory, and population-density account. Overall, the main findings from Study 1 were successfully replicated in Study 2.

Study 3

The first two studies yielded consistent findings on the regional variations in individualism and collectivism as well as their sources within China. However, both studies examined cultural variations during normal circumstances. An intriguing question arises as to whether these findings would remain similar when one or more potential sources suddenly become extremely salient due to catastrophic events such as an infectious disease outbreak. Given that catastrophic events have the potential to reshape regional cultural variations (Borkowska & Laurence, 2021; Gelfand et al., 2017; Kara et al., 2021; O'Shea et al., 2022), any findings that withstand these catastrophic events would undoubtedly gain increased robustness.

The COVID-19 pandemic provided researchers with unique opportunities to study human cultural psychology amidst an unprecedented crisis. During the early stages of the COVID-19 outbreak, we initiated a large-scale online survey in Mainland China, incorporating some of the same subjectivist measures used in Study 1. We utilized this data to investigate whether the primary findings from Study 1 remained true during the COVID-19 pandemic.

Methods

Respondents. Respondents were recruited by advertisements posted on Chinese social media. The advertisement received lots of attention from teachers across various colleges, which in turn attracted numerous college students to complete the survey. All respondents finished the survey online as volunteers. Data collection took place between 31st January and 12th February 2020, with 35,549 respondents completing the whole survey. After excluding unqualified responders (6% were under-aged [<18 years] or failed to input a valid year of birth), careless responders (12% failed to pass our quality-check question⁷; 9% completed our survey too fast [<300 s] or too slow [$>36,000$ s]), and inter-provincial migrants (about 14%), 20,590 respondents (38% males) were included in the analyses. Their ages ranged from 18 to 77 years ($M = 25.33$, $SD = 8.26$), with about 93% being Han Chinese. Their occupational backgrounds were diverse: 60% were currently enrolled university students, while 40% were white- and blue-collar workers, farmers, self-employed workers, professionals (e.g., lawyers, doctors, and teachers), business managers, and public servants. Their urban versus rural residences were fairly balanced, with 52% urban residents. Their home provinces covered 31 provinces in Mainland China. For more detailed descriptive statistics for each provincial sample's demographic background, please refer to Table S4 in the SI Appendix.

Individual-Level Measures of Cultural-Psychological Markers. The survey included several identical measures as we used in Study 1 to assess overall orientation towards individualism-collectivism, independence-interdependence self-construal, holistic-analytic thinking style, and tendency of stranger trust. Specifically, the Horizontal and Vertical Individualism and Collectivism Scale (Triandis & Gelfand, 1998) was used to assess individualistic orientation ($\alpha = .78$) and collectivistic orientation ($\alpha = .86$) separately; the IOS Scale (Aron et al., 1992) was used to assess relational closeness to family members (1 item⁸), with higher scores reflecting higher interdependence (lower independence); the Triad Categorization Task (Ji et al., 2004) was used to assess thinking style ($\alpha = .92$), with high scores indicating high analytic (vs. holistic) tendencies. The single-item measure of stranger trust (Welzel, 2010) was used to assess trust, with high scores reflecting high levels of individualistic (vs. collectivistic) tendency.

Provincial Predictors and Analytic Strategies. Spatial, socioecological, and population predictors were identical to those in the first two studies. Analytic strategies also followed the practices in Study 1. The level-1 regression included gender, age, education level, family SES, and rural-urban residence as covariates. We did not consider respondents' fields of study and affiliated universities because the survey included a much broader population beyond students.

Transparency and Openness. The study protocol was pre-registered at <https://aspredicted.org/blind.php?x=hg52wu>.⁹ Data and survey materials are available upon reasonable request. All R codes and outputs were deposited at Science Data Bank (<https://doi.org/10.57760/sciencedb.07672>).

Results

Tables 6 and Table 7 display the main findings of Study 3. Compared with the main findings of Study 1 in Table 2, Table 6 showed that there were much less significant associations in Study 3

Table 6. Effect Sizes (r) for Spatial, Socioecological, and Population Factors that Significantly Predict Regional Variations in Psychological Manifestations of Individualism-Collectivism in Study 3.

	Individualism-Collectivism		Interdependence (vs. independence)	Analytic (vs. holistic)	Stranger trust
	Ind	Col			
Spatial factors					
Latitude					
Longitude					.52*
Physical factors					
Climatic harshness					
Climate by wealth					
Climate by rains					
Pathogen prevalence					-.46*
Natural disasters					-.46*
Social factors					
Population density					
Residential mobility					
Relational mobility					
Rice farming					
Fishery economies					
Herding economies					
Modernization	.47*		-.44*	.45*	.59**
Population factors					
Ethnic minority					
Genetic I					
Genetic II					
Linguistic I					
Linguistic II	.44*		-.57**		
Buddhism					
Christianity					
Islam			.46*		

Note. Each marker was regressed onto a given provincial factor separately. The table only presents effect sizes for significant associations after controlling for the False Discovery Rate (FDR; adjusted $p < .05$) in multiple testing. Missing cells indicate no significant associations between the predictor and the marker.

Ind = Individualism (Triandis & Gelfand, 1998); Col = Collectivism (Triandis & Gelfand, 1998); Interdependence (vs. independence) = Relational closeness (IOS) to family members; Analytic (vs. holistic) = Relational reasoning (reversely coded).

Genetic I = Genetic relatedness to Southern Chinese (vs. Northern Chinese); Genetic II = Genetic relatedness to Western Chinese (vs. Eastern Chinese); Linguistic I = Linguistic relatedness to Southern Chinese (vs. Northern Chinese); Linguistic II = Linguistic relatedness to Eastern Chinese (vs. Western Chinese).

* $p < .05$, ** $p < .01$ (denoting the significance level of corresponding regression coefficients).

than in Study 1: While 56 out of 242 associations were significant in Study 1, only 10 out of 110 associations were significant in Study 3. Overall, the discrepancy suggested that COVID-19 pandemic might have wiped off or dwarfed many regional variations of individualism and collectivism as well as impacts of diverse socioecological and population factors on them. Nevertheless, several main findings of Study 1 were still replicated.

First, similar to Study 1, latitude did not predict anything, whereas longitude significantly predicted stranger trust ($\gamma = 0.01$, $t [29] = 3.31$, $p = .012$, $r = .52$), with higher levels of stranger trust found in Eastern provinces compared to Western provinces.

Table 7. Regressing Markers of Individualism-Collectivism on Relevant Socioecological and Population Predictors in Study 3.

	Individualism (Ind)			Unique variance explained
	Standardized γ	95% CI	p value	
Modernization	.04	[.01, .06]	.010	24%
Linguistic II	.03	[.00, .06]	.021	21%
Total variance explained		47%		
	Interdependence (IOS to family members)			Unique variance explained
	Standardized γ	95% CI	p value	
Modernization	-.04	[-.00, -.08]	.031	14%
Linguistic II	-.05	[-.01, -.10]	.014	22%
Islam	.02	[-.00, .05]	.099	0%
Total variance explained		46%		
	Stranger trust			Unique variance explained
	Standardized γ	95% CI	p value	
Natural disasters	.01	[-.03, .05]	.606	0%
Pathogen prevalence	-.03	[-.06, -.00]	.025	8%
Modernization	.06	[.01, .10]	.018	15%
Total variance explained		48%		

Note. For markers that can be significantly predicted by more than one socioecological/population factor (Table 6), we regressed each of these markers on relevant factors simultaneously while controlling for personal demographic covariates.

Ind = Individualism (Triandis & Gelfand, 1998).

Linguistic II = Linguistic relatedness to Eastern Chinese (vs. Western Chinese).

The table reports standardized regression coefficients, 95% CIs, raw p values, unique provincial-level variance in each marker (the column name) explained by a single provincial predictor, and total provincial-level variance explained by relevant predictors.

Second, modernization was still the most powerful predictor. It significantly predicted all four markers of individualism and collectivism in the expected direction: A higher level of modernization was associated with greater individualistic orientation ($\gamma = .05$, $t[29] = 2.88$, $p = .016$, $r = .47$), stronger analytic thinking tendency ($\gamma = .18$, $t[29] = 2.69$, $p = .016$, $r = .45$), and higher stranger trust ($\gamma = .09$, $t[29] = 3.94$, $p = .002$, $r = .59$), but a lower level of interdependence ($\gamma = -.09$, $t[29] = -2.65$, $p = .016$, $r = -.44$). Moreover, as shown in Table 7, when modernization was considered together with other alternative predictors, it still manifested significant unique predictive power on all markers.

Third, other socioecological and population factors such as pathogen prevalence, natural disasters, linguistic relatedness, and Islamic religion, were also predictive of some markers: Higher pathogen prevalence and more natural disasters were associated with lower levels of stranger trust ($\gamma = -.00$ and $-.53$, $t[29] = -2.77$ and -2.79 , $p = .048$ and $.046$, $r = -.46$ and $-.46$, respectively). Linguistic relatedness to Eastern (vs. Western) Chinese predicted higher levels of individualism ($\gamma = .14$, $t[26] = 2.50$, $p = .047$, $r = .44$) but lower levels of interdependence ($\gamma = -.37$, $t[26] = -3.55$, $p = .007$, $r = -.57$); a larger population of Islamic believers was associated with higher levels of interdependence ($\gamma = .82$, $t[29] = 2.79$, $p = .046$, $r = .46$). Note that all these associations were in the expected direction.

Finally, the provincial variation in stranger trust is more effectively explained by the combined contributions of relevant predictors compared to their unique contributions (Table 7), consistent with Study 1's finding that relevant predictors often worked in tandem.

Discussion

By examining a large sample of the Chinese population during the COVID-19 pandemic, we roughly replicated the main findings of Study 1: The cultural variation of individualism and collectivism primarily manifested as East-West differences; Modernization emerged as the most potent predictor, and multiple predictive factors appeared to operate collectively.

Meanwhile, we also identified some discrepancies. Many impactful factors identified in Study 1 became statistically non-significant, such as population density, residential mobility, and the population of ethnic minorities. This reduction in heterogeneity may have resulted from the pandemic, as existential threats often strengthen social unity and conformity, making it easier for societies to coordinate and tackle collective challenges (Fog, 2017; Gelfand et al., 2017; Gelfand et al., 2021). For instance, individuals from various regions have become more similar in their overall collectivist orientations in Study 3 compared to Study 1. However, we do not rule out the possibility that other factors may also contribute, such as unbalanced sampling¹⁰. Regardless of the reasons for the diminished effects, it is obvious that the impacts of COVID-19 pandemic are not the same on all predictive relationships, suggesting that different markers and relationships may be differentially sensitive to the pandemic or other situational influences.

Interestingly, the results from Study 3 on stranger trust diverged from those of Study 1. Study 1, which involved university students before the COVID-19 pandemic, found that stranger trust had limited regional variations and was not significantly influenced by most socioecological and population differences. In contrast, Study 3, conducted during the pandemic with a more inclusive sample that included working adults, revealed that individuals in Eastern and more modernized regions reported higher levels of stranger trust than those in Western and less modernized regions. Additionally, existential threats, such as pathogen prevalence and natural disasters, were negatively correlated with trust.

Several factors may account for the discrepancies regarding stranger trust. First, the pandemic heightened the salience of existential threats. Compared to other psychological markers, stranger trust may be more susceptible to these threats. After all, trust—the willingness to accept one's vulnerability during social cooperation—entails high-stake consequences, such as suffering economic or affective losses (Wang et al., 2017). These risks are especially relevant during the pandemic because trusting unfamiliar others increases the likelihood of being infected (Fincher & Thornhill, 2012). By contrast, endorsing individualistic or collectivistic values, as well as being analytic or holistic thinkers, is more distantly related to social interaction during risky situations and thus less consequential.

Second, the heightened existential insecurities may also make regional disparities in institutional strength and modernization more impactful. Eastern and more modernized regions, with their superior institutional support and infrastructure, are better equipped to alleviate existential anxieties. This, in turn, could have weakened inter-group boundaries and promoted trust among unfamiliar individuals (Hruschka & Henrich, 2013; Welzel & Delhey, 2015). The increased importance of institutional strength in alleviating existential threats might explain why modernization, compared to other provincial factors, became more prominent in shaping regional-cultural variations across various markers in the present study.

Third, the more diverse sample in Study 3, which included individuals from occupations that frequently interact with strangers, may more accurately reflect real-world trust dynamics than the university student sample in Study 1. Lastly, people's psychological responses to crises can vary: Some individuals become more cautious (i.e., less trusting of strangers) during crises,

while others may respond with increased trust and cooperation, especially in well-supported environments. These findings indicate that cultural patterns such as stranger trust are context-dependent and can change in response to societal disruptions.

General Discussion

Over recent years, academic interest has surged in extending cross-country research to within-nation cultural variations and their sources. A within-country investigation has its advantages, as it reduces many potential confounds in cross-country research (e.g., language, sociopolitical system, religion, genetic makeup, and reference-group effect) and serves as a more stringent test of the origins of cultural variation. As a nation with rich socioecological, population, and subcultural variations, China is a unique site for such investigations. In this large-scale research, we examined how cultures of individualism and collectivism varied across regions (provinces) in contemporary China and explored factors that might account for such regional differences. By controlling for relevant personal demographic factors and examining an unprecedentedly rich collection of outcome measures and explanatory factors, we obtained converging results. These results shed light not only on regional cultural-psychological variations in China and their sources but also on many issues about cultural psychology in general.

Main Findings

First, individualism and collectivism primarily vary along the East-West axis, which corresponds to longitude and variations in socioecological/population factors such as modernization; in contrast, the North-South axis, associated with latitude and disparities in climatic harshness, rice farming practices, and so forth, plays a secondary role. People in Eastern regions tend to exhibit stronger individualistic tendencies and weaker collectivist tendencies compared to those in Western regions. This is evidenced in various markers, including individualistic and collectivistic orientations (Studies 1, 2, and 3), interdependent self-construal (Studies 1 and 3), holistic and analytic thinking styles (Studies 1 and 3), stranger trust (Study 3), and moral tolerance (Studies 1 and 2). Meanwhile, as indicated by the associations between cultural-psychological markers and latitude-related socioecological factors (e.g., rice farming), Northern Chinese, when compared to Southern Chinese, tend to exhibit higher interdependence (Study 1) and perceive a higher prevalence of group collectivism (Study 2).

Second, modernization emerges as the most robust and potent predictor, with higher levels of modernization linked to stronger individualism¹¹. Specifically, modernization is positively associated with individualistic orientation (Studies 1, 2, and 3), analytic thinking style (Studies 1 and 3), tolerance of morally debatable behaviors (Studies 1 and 2), and stranger trust (Study 3), but negatively associated with interdependent self-construal (Studies 1 and 3). In addition, across all three studies, both the Islamic population and pathogen prevalence positively predict collectivism.

Third, regional cultural variations typically originate from multiple sources, which collectively shape regional culture. In most instances, regional variation explained by a single factor is much smaller than that explained by relevant factors in combination. Last, regional cultural variations exhibit both coherence and context-dependence, as evidenced by the presence of both similarities and differences in the variation patterns of different cultural markers and in the prediction patterns of different explanatory factors.

Overall, these three studies provide consistent and robust support for the modernization theory. We also found that many other factors—mobility, pathogen prevalence, fishery economies, religions, ethnic minorities, and genetic and linguistic relatedness—are associated with certain cultural markers as theoretically assumed, although the scope of markers linked to

these factors is narrower than that associated with modernization. In contrast, we found no evidence supporting the climato-economic theory. Unexpectedly, our results contradict predictions from the rice theory and the population-density account: Rice farming and population density are positively associated with individualism rather than collectivism, contrary to prior claims (Talhelm, et al., 2014).

Strengths and Limitations

Compared to previous studies, the present research has the following strengths. First, we examined a substantially wider range of psychological markers of individualism-collectivism, ensuring that our findings are not tied to a specific perspective. Second, we employed multi-methods measurement to assess cultural-psychological tendencies. The methods included not only explicit, self-referenced measures as being traditionally used, but also implicit or intersubjective measures, suggesting that our findings are unlikely to be a product of measurement artifacts (Chiu et al., 2010; Kitayama et al., 2009). Third, we considered a much broader scope of socioecological and population factors (20 factors in total) in predicting regional-cultural variation. Importantly, we evaluated not only the gross predictability of each factor but also its unique predictability in comparison to relevant factors, thus minimizing the impacts of potential confounding or lurking variables. Fourth, we have investigated three large and diverse samples (Study 1: a student sample, $N = 18,606$; Study 2: a community sample, $N = 8,167$; Study 3: a community sample, $N = 20,584$), maximizing the generalizability of the main findings. Finally, our main findings are resistant to spatial autocorrelation (See the SI Appendix, pp. 8-9 and Supplemental Tables S5 to S7). Overall, these strengths boost our confidence about the persuasiveness of our findings (Heine et al., 2002; Triandis et al., 1990).

Yet, our research has some limitations. First, individualism and collectivism can be operationalized in various ways, using different markers, and numerous theories have been proposed to account for regional variations. Although we have considered 11 markers of individualism-collectivism and 20 explanatory factors, we acknowledge that this set is not exhausted. Future research could explore whether our findings hold true for other markers and theories, as well as other cultural-psychological dimensions such as long-term (vs. short-term) orientation and culture of honor (Leung & Cohen, 2011; Minkov, 2018). Second, in Study 1 and Study 3, convenience samples and some self-report measures were used, which may limit the generalizability of the specific findings of these studies. Future replications with representative samples are needed. Lastly, all our studies are correlational, which restrains us from making causal conclusions.

Implications for Understanding Cultural Variations in China

The Pattern and Contents of Regional Cultural Variations. Our research expands the current understanding of regional variations in individualism and collectivism in China in at least two ways. Firstly, going beyond previous studies (e.g., Talhelm et al., 2014; Van de Vliert et al., 2013), we have discovered that regional cultural variations of individualism and collectivism in China are primarily characterized by East-West differences, rather than South-North differences. This suggests that the latitude-dominant account of cultural variation (Van de Vliert & Van Lange, 2019) may not be applicable in the Chinese context. Secondly, we examined many more cultural markers or domains concurrently, including cultural orientations measured by Triandis and Gelfand's (1998) scale, self-construal measured by Singelis's (1994) scale, internal versus external attribution style (Morris & Peng, 1994), moral tolerance (Harding et al., 1986), and stranger trust (Wessel, 2010). As a result, we got a more comprehensive understanding of cultural variations in China.

The Sources of Regional Cultural Variations. Previous studies have suggested that distal (physical) or historical factors, which were fundamental for human survival in the ancient world, such as climatic harshness and rice (vs. wheat) farming, can explain regional variations in individualism-collectivism in modern China (e.g., Talhelm et al., 2014; Talhelm & English, 2020; Van de Vliert et al., 2013). However, our research found little evidence to support this. Instead, factors related to contemporary socioeconomic development, such as modernization, population density, and mobility, can substantially predict regional cultural variations across a wide range of markers. Importantly, modernization remained a significant predictor during the pandemic, while many other factors lost their predictive power. These findings confirm the potent impact of modernization on Chinese culture and psychology (Sun & Ryder, 2016) and underscore the usefulness of the modernization theory in understanding cultural variations in modern society (Greenfield, 2009; Welzel, 2013).

Beyond previous studies that have largely overlooked population-related factors, we discovered that the population of ethnic minorities, religion (e.g., Islam), and ancestry relatedness (as indicated by genetic and linguistic relatedness) significantly predicted diverse markers in a coherent manner. These findings support the notion that population-related factors form the normative pillars that preserve a region's unique cultural traditions (Kara et al., 2021). They also suggest that culture and population characteristics can shape each other and co-evolve (Berry, 2018; Lu et al., 2021).

Importantly, we discovered that environmental and population factors often collectively explain China's regional-cultural differences, an aspect that has been largely overlooked in previous research. This finding supports the environment-culture-person interplay account (Berry, 2018; Smith & Bond, 2019) and underscores the importance of considering environmental and population factors concurrently when examining the sources of cultural variations (Bromham, et al., 2018).

Implications for Understanding Cultural Variations in General

Our research offers several insights into cultural and cross-cultural psychology more broadly. Firstly, we observed a notable degree of coherence across the diverse manifestations of individualism and collectivism. Although these cultural manifestations have long been considered multifaceted yet coherent (House et al., 2004; Triandis, 1995), in recent years, some researchers have questioned the coherence of these manifestations and whether individualism and collectivism can be used as umbrella concepts to understand cultural differences (Krys et al., 2022; Oyserman et al., 2002). Some have even proposed that individualism and collectivism should be narrowed to the domain of general orientation or value endorsement (e.g., Krys et al., 2022). Upon examining regional cultural differences within Mainland China, our research indicates that individualism and collectivism, as cultural syndromes, can coherently manifest as shared values, self-definitions, cognitive processes, and various behavioral tendencies (Triandis, 1993). However, the range and degree of this coherence may differ across contexts and psychological markers. For example, the expected pattern of variation in stranger trust, along with its correlations to various socioecological and population factors, only emerged during the pandemic (Study 3) and not prior to it (Study 1), creating a contrast with many other markers under investigation. Thus, contextual and situational factors remain indispensable when exploring individualism and collectivism.

Secondly, seemingly contradictory cultural elements can coexist (Fang, 2012; Oyserman, 2015). Over the past decades, a growing body of evidence has shown that many national-cultural traditions contain both collectivistic and individualistic components (e.g., Krys et al., 2022; San Martin et al., 2018), although their prominence varies with context (Realo et al., 1997; Takano & Osaka, 2018a). Our research suggests that this may also be true for regional cultural traditions. For instance, while people from regions with a high number of minorities are generally

collectivistic, they simultaneously exhibit a relatively high level of stranger trust, a characteristic of individualistic culture. Similarly, although people in Western China are generally more collectivistic than those in Eastern China, they exhibit a similar level of independence, a typical characteristic of individualistic culture. Given this complexity, researchers should move beyond oversimplified cultural binaries and decipher cultural logics in a context-sensitive manner (Jing & Cai, 2022; Kitayama et al., 2022).

Thirdly, some existing theories regarding the sources of cultural variations might not be universally applicable. Although we found supporting evidence for most theories across a varying range of cultural-psychological markers, we found no evidence to support latitudinal psychology and the climatic theory; moreover, we even found opposite evidence for the population density account and the rice theory. Overall, while some theories may have boundary conditions, others may be questionable (i.e., the rice theory, also see McClain & Kenny, 2025; Hu & Yuan, 2015; Ruan, et al., 2015).

Fourthly, regional-cultural differences typically arise from multiple sources, which are difficult to disentangle. This is consistent with the realist theory of science (Bhaskar, 2013) and suggests that attributing all regional differences to a single source may not be appropriate (e.g., rice-farming). It also implies that when investigating the sources of regional cultural variations, it is necessary to simultaneously examine multiple potential environmental and population factors. Otherwise, spurious findings may emerge when covariates are not adequately controlled for (Bromham et al., 2018).

Our findings also carry implications for understanding cultural change and continuity. Over the past centuries, modernization has led to a general cultural shift from traditional collectivism to modern individualism worldwide (Cai et al., 2019; Santos et al., 2017), including in China (Bao et al., 2021, 2022; Cai et al., 2020). Our research reveals robust associations between modernization and diverse manifestations of individualism and collectivism, providing cross-sectional evidence for this trend. This trend, however, does not result in a complete homogenization of global culture (Kaasa & Minkov, 2020). As demonstrated in our research, the existence of population barriers, such as genetic and linguistic dissimilarities, may be a significant factor in maintaining the distinctiveness of different cultures during the process of modernization and globalization.

Conclusion

Several findings have emerged from our three large-scale studies. First, regional cultures of individualism and collectivism in contemporary China exhibit more East-West differences than North-South differences. Individuals in Eastern China exhibit higher levels of individualism than those in Western China. Second, modernization is the most potent force shaping regional cultural variations in individualism and collectivism in China, although many other socioecological (e.g., pathogen prevalence) and population factors (e.g., ancestry relatedness and religion) also contribute to these differences in certain cases. Third, regional cultural variations are typically the result of combined influences arising from multiple factors. Fourth, most existing theories are applicable in China to varying extents, with a few exceptions.

Author's Note

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Author Contributions

Huajian Cai initiated and led this project. Huajian Cai, Yiming Jing, and Li-Jun Ji designed the study. All authors contributed to survey data collection or data analysis. Yiming Jing and Han-Wu-Shuang Bao sourced socioecological and population data. Yiming Jing, Youting Wang, and Menglin He analyzed the data. Yiming Jing, Huajian Cai, and Li-Jun Ji wrote the main text. Yiming Jing, and Huajian Cai wrote the SI Appendix.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


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Data Availability

The links to preregistration protocols, computer codes, and outputs of main analyses, as well as data availability statements, are included in the method section.

Supplemental Material

Supplemental material for this article is available online.

Notes

1. Van de Vliert and colleagues constructed this scale by selecting items from a variety of classic cross-country measurements and validated the scale among Chinese respondents.
2. Two negative-worded items were excluded due to their low zero-order correlations with many other items ($r_s < .10$).
3. As a common way to control the FDR, the BH procedure usually has more statistical power than methods that control Familywise Error Rate (FWER) such as the Bonferroni correction. The FDR was controlled at .05 in all studies.
4. The effect size r for a single multilevel analysis was calculated using the t -to- r transformation (Nakagawa & Cuthill, 2007). For our data that exhibited limited intraclass correlations ($< .10$), this approach produced similar effect size estimates as did the more sophisticated approach (Nakagawa & Cuthill, 2007).
5. There are some deviations from the pre-registrations in both Study 1 and Study 3. Following recent recommendation (Willroth & Atherton, 2024), we listed these deviations in the Supplemental Appendix (Supplemental Tables S8 and S9).
6. The results thus suggest that the genetic and linguistic indexes, operationalized in the current way, better capture the differences of interest between the North and the South compared to those between the West and the East.
7. Similar to Study 1, we implemented a question, in the middle of the survey, requiring each respondent to select the option of “6” to indicate that they were paying attention to each question’s instruction.

8. Instead of measuring relational closeness with mother and father separately and averaging between them (as we did in Study 1), in this study we measured each respondent's IOS with their family members as a whole.
9. The original purpose of this pre-registered study was to examine the influences of pathogen on Chinese cultural psychology. In this paper, we were interested in the impacts of all potential factors on cultural psychological variations in China. So, we did not follow preregistered analysis strategy exactly (see Supplemental Table S9 in the (Supplemental) SI Appendix).
10. For an unbalanced data structure (e.g., provinces with varying sample sizes), the estimation algorithm of multilevel modeling discounts imprecise estimators (e.g., group means) based on small samples (Raudenbush & Bryk, 2002, pp. 107-109). Our additional analyses (based on Weighted Least Squares regression) indicated that discounting small samples substantially reduced the predictive power of population density and ethnic minority in the present study, but such effect was less pronounced for the remaining provincial factors.
11. As shown in the SI Appendix (pp. 8-9 and Supplemental Tables S5-S7), the key results remained robust after controlling for spatial autocorrelation that many cross-cultural studies failed to consider (Bromham et al., 2018; Eff, 2004).

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