**Local Housing Market Dynamics Predict Rapid Shifts in Cultural Openness:
A Nine-Year Study across 199 Cities**

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Abstract

Accumulating evidence suggests that culture changes in response to shifting socioecological conditions; economic development is a particularly potent driver of such change. Previous research has shown that economic development can induce slow but steady cultural changes within large cultural entities (e.g., countries). Here we propose that economically driven culture change can occur rapidly, particularly in smaller cultural entities (e.g., cities). Drawing on work in cultural dynamics, urban economics, and geographical psychology, we hypothesize that changes in local housing prices – reflecting changing availability of local amenities – can induce rapid shifts in local cultures of Openness. We propose two mechanisms that might underlie such cultural shifts: selective migration (i.e., people selectively moving to cities that offer certain amenities) and social acculturation (i.e., people adapting to changing amenities in their city). Based on trait Openness scores of 1,946,752 U.S. residents, we track annual changes in local Openness across 199 cities for nine years (2006-2014). We link these data to annual information on local housing markets, an established proxy for local amenities. To test interdependencies between the time series of local housing markets and Openness, we use Panel Vector Autoregression modelling. In line with our hypothesis, we find robust evidence that rising housing costs predict positive shifts in local Openness but not vice versa. Additional analyses leveraging participants' duration of residence in their city suggest that both selective migration and social acculturation contribute to shifts in local Openness. Our study thus offers a new window onto the rapid changes of cultures at local levels.

Keywords: culture change; openness; urban amenities; social ecology; geographical psychology

Public Significance Statement

Economic development in countries prompt cultural changes that typically unfold over decades and centuries. Here, we investigate the possibility of more rapid cultural shifts in smaller entities, finding that housing market dynamics predict significant changes in city cultures within a few years. Our results highlight rising local amenities as a key driver of local cultures of Openness, which in turn affect a wide variety of political, economic, social, and health-related outcomes.

Decades of research show that culture plays a crucial role in human psychology and behavior (Cohen, 2009). Much of that research has focused on culture as a static construct, but recent years have witnessed growing interest in cultural change, including the complex interactions between cultural change and psychological processes (Greenfield, 2013; Kashima, Bain, & Perfors, 2019; Varnum & Grossmann, 2017a). What causes cultures to change, and what impact does such change have on individuals?

On a very basic level, successful adaptation to the environment appears to be a crucial demand on culture (Oishi, 2014; Kashima et al., 2019). Indeed, considerable evidence suggests that cultural change is likely to occur in response to changes in socioecological affordances (Greenfield, 2009; Varnum & Grossmann, 2016, 2017a), such as disaster frequency, disease prevalence, or urbanization (Greenfield, 2013; Grossmann & Varnum, 2015; Santos, Varnum, & Grossmann, 2017). One particularly consequential factor that substantially alters environments and evokes cultural shifts is economic development. Modernization theories dating at least as far back as Marx (1867) argue that economic development has systematic and predictable cultural consequences (Greenfield, 2009; Inglehart & Baker, 2000). Empirical evidence demonstrates that economic changes drive cultural changes (Grossmann & Varnum, 2015; Santos et al., 2017). Specifically, growing economic affluence is related to greater tolerance, self-expression, support for diversity, independence, and individualism (Greenfield, 2009, 2013; Grossmann & Varnum, 2015; Inglehart & Baker, 2000; Varnum & Grossmann, 2017b). These processes have usually been studied at the level of large cultural entities, such as countries, where economic development appears to induce slow and steady cultural changes that unfold over decades or centuries (Beugelsdijk & Welzel, 2018; Jackson, Gelfand, De, & Fox, 2019; Varnum & Grossmann, 2017a). For example, in the United States, time-lagged analyses have shown that over the past 150 years, increasing socioeconomic status was followed by consistent shifts towards more individualist cultural practices, such as

higher frequency of individualist themes in published books, more unique baby names, smaller family sizes, more people living alone, and more divorces (Grossmann & Varnum, 2015).

In the present work, we make two main contributions to this literature. First, we develop and test the hypothesis that the impact of economic changes on cultural change at more localized levels is not necessarily a lengthy process. Second, we propose two theoretically derived mechanisms that might link economic and cultural changes within cities and provide a tentative empirical test of them.

Regarding the temporal horizon of culture change, we argue that smaller culture entities, such as cities, can experience much faster changes in their economic conditions than larger entities like countries and, as a consequence, can also show more rapid cultural shifts. Consider the recent economic, social, and cultural history of Pittsburgh. Formerly a booming industrial center that accounted for up to half of the nation's steel production in the 1950s, "Steel City" was hit hard by the collapse of the American manufacturing industry in the 1970s and 1980s and lost nearly 50% of its labor force population in the process (Beissel, Giardina, & Neman, 2014). Forced to reinvent itself, Pittsburgh has undergone what some have labeled the transition from *rust belt* to *brain belt* (Parkin & Hardcastle, 2019). Indeed, in the span of just a few years, by 1985, Pittsburgh's profound transformation resulted in the city – famously reputed to be a dirty, industrial place – being named the "Most Liveable City" in the USA (Beissel et al., 2014). Accompanying its emerging economic identity as a hub for medicine, higher education, and environmental sustainability, culturally Pittsburgh shifted from a smoky, industrial, blue-collar city to a green, service-oriented, high-tech city. Today, Pittsburgh, with its thriving art galleries, cultural centers, and dynamic start-up scene, continues to win accolades for its livability and attracts young and educated newcomers (Deitrick, 2015; Duryea, 2014).

To understand how economic changes in cities are associated with changes in local culture, it is important to consider the mechanisms that might link the two. Drawing on research in sociology and economics, we argue that local amenities, such as restaurants, museums, opera houses, sports venues, urban green space, neighborhood safety, and good schools (Clark, Lloyd, Wong, & Jain, 2002; Glaeser, Kolko, & Saiz, 2001) represent a key factor that connects economics and culture across cities. Indeed, there is a broad literature linking housing prices, as a manifestation of local economic development, to local amenities. Here, frameworks such as hedonic pricing theory (Rosen, 1979) and spatial equilibrium models (Roback, 1982) have long argued that housing stock valuation is directly linked to the provision of local amenities. According to these accounts, differences in housing prices between areas are best explained and justified by the availability of local amenities and buyers' willingness to pay a premium to access them. Consistent with this idea, empirical studies have provided ample evidence that housing prices are directly and dynamically associated with the availability of local amenities (Couture, Gaubert, Handbury, & Hurst, 2019; Diamond, 2016). For example, longitudinal research has shown that increasing housing prices in the U.S. are accompanied by the formation of new amenities such as hip coffee shops, progressive restaurants, and wine bars and vice versa (Glaeser, Kim, & Luca, 2018).

Against this backdrop, a cultural dimension that might be particularly susceptible to rapid changes in economic development, and thus local amenities, is psychological Openness. Openness is defined by intellectual curiosity, creative imagination, and aesthetic sensitivity (John & Srivastava, 1999), and open-minded places are characterized by a climate of cultural looseness (Harrington & Gelfand, 2014) and tolerance (Florida, 2014b; Rentfrow, Gosling, & Potter, 2008). There are at least two basic mechanisms through which rising levels of economic development and local amenities might affect local Openness: selective migration

(Rentfrow et al., 2008; Rentfrow, 2010) and social acculturation (Götz, Stieger, Gosling, Potter, & Rentfrow, forthcoming; Kitayama, Conway, Pietromonaco, Park, & Plaut, 2010).

Selective migration

The selective migration hypothesis suggests that open people should be especially likely to move to affluent cities because the cultural and psychological affordances of these places are likely to satisfy their psychological needs. Indeed, research has shown that in deciding where to live, individuals do not focus exclusively on economic factors but also consider a broad variety of lifestyle factors (Florida, 2014b), including local amenities, community aesthetics, and social offerings (Florida, Mellander, & Stolarick, 2011). Individuals high in Openness are prone to seek out opportunities for psychological stimulation and are therefore attracted to areas rich in cultural entertainment and aesthetic experiences (Falck, Fritsch, & Heblich, 2011; Rentfrow, 2010; Rentfrow, Jokela, & Lamb, 2015). In line with this pattern, relatively open individuals are more likely to move to affluent areas (Jokela, 2020), derive greater happiness from living in such places (Jokela, 2020; Jokela, Bleidorn, Lamb, Gosling, & Rentfrow, 2015), and use cultural amenities regularly (e.g., frequenting museums, art galleries, and theatres; Schwaba, Luhmann, Denissen, Chung, & Bleidorn, 2018). Thus, as more expensive cities offer more cultural amenities (Florida & Mellander, 2010; Glaeser et al., 2001), open individuals might be more willing to pay this amenity-premium to satisfy their psychological needs (Glaeser & Gottlieb, 2006). At the same time, open individuals may not only be more willing but also more able to pay the higher housing prices that come with such amenities (Florida, 2014a; Glaeser et al., 2001) because Openness is positively related to educational attainment (McCrae, 1996), higher income (Boudreau, Boswell, & Judge, 2001), and career success (Eby, Butts, & Lockwood, 2003).

Improved local amenities may not only create opportunities and experiences that attract open-minded people to that city but might also push out people who are unable to afford

to live in such increasingly expensive areas (Couture et al., 2019; Glass, 1964; Hamnett, 1991). Furthermore, changing urban environments that increasingly offer amenities attractive to open people might, at the same time, become less appealing to residents who are low in Openness. Consequently, less open people might move away, even if they are financially secure, due to diminished person-environment fit (Ebert, Gebauer, Talman, & Rentfrow, 2020; Götz, Ebert, & Rentfrow, 2018; Jokela et al., 2015; Motyl, Iyer, Oishi, Trawalter, & Nosek, 2014).

Social acculturation

Just as individuals might selectively move to particular places, so too might they adapt to aspects of an area. The social acculturation hypothesis suggests that people living in cities with rising economic development might become more open (Kitayama et al., 2010). From an evolutionary psychological perspective, greater affluence allows individuals to prioritize their interests without consulting with or relying on others for support (Grossmann & Varnum, 2015; Santos et al., 2017; Varnum & Grossmann, 2017a). Indeed, in an economically flourishing environment, a promotive openness mentality, which emphasizes diversity, creativity, liberty, and autonomy appears adaptive. In contrast, in an environment subject to economic pressure, a preventive closed mentality, which emphasizes uniformity, discipline, hierarchy, and authority, seems more adaptive (Beugelsdijk & Welzel, 2018; Pepper & Nettle, 2017). This line of reasoning converges with nation-level research showing that rising economic affluence is related to greater tolerance (Varnum & Grossmann, 2017b) and self-expression (Inglehart & Baker, 2000; Santos et al., 2017), as well as by research showing that neighborhood affluence in Australia has fostered increasing levels of Openness (Jokela, 2020). It, therefore, seems plausible that more material and physical safety (as a central amenity that rises with economic development; Glaeser et al., 2018) might enable individuals

to exercise their intellectual curiosity, creative imagination, aesthetic sensitivity, and wide interests, all of which are defining characteristics of Openness (John & Srivastava, 1999).

Moreover, the increasing availability of local cultural amenities may also affect individual Openness. Indeed, the social and cultural institutions in a place can influence residents' behavior by shaping the range of opportunities and experiences available to them (Cohen, 1996; Rentfrow et al., 2008). For example, living in a city where fine-dining restaurants, jazz clubs, and artsy coffee shops start springing up increases the opportunities for residents to try those new amenities (Ebert, Götz, Gladstone, Müller, & Matz, 2020), which, if satisfying, might lead to further exploration of their new tastes, thereby boosting their Openness.

Social influence might similarly promote heightened Openness. For instance, if there is a high prevalence of local amenities that enable behaviors typically associated with Openness, such as exotic restaurants and theatres, these behaviors might gain higher social value, become generally more accepted, and ultimately evolve into a sociocultural norm (Huggins & Thompson, 2019) that, in turn, affects all individuals living in that city through the mechanisms of social influence (Oishi, 2014).

The present research

Taken together, we believe that there are good reasons to assume that changes in a city's local amenities are associated with changes in that city's cultural Openness and that this association might be driven by selective migration and social acculturation processes. To test our hypothesis, we adopt an ecological approach (Santos et al., 2017; Varnum & Grossmann, 2017a) and analyze temporal differences in the prevalence of trait Openness among local populations. Overall, our approach is guided by the assumption that aggregated personality profiles allow ethnographic interpretations of which emotional, cognitive, and behavioral features characterize cultures (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950; Hofstede & McCrae, 2004). Specifically, we use trait Openness scores of 1,946,752 U.S.

residents. Based on these individual-level data, we create a time series data set that allows us to track annual changes in local Openness across 199 cities for nine years. We then link these annual city-level Openness data with annual city-level housing market indicators, which we use to capture changes in local amenities.

Data & Methods

Individual Openness data. To measure local cultures of Openness across cities, we used trait Openness scores from participants of the Gosling-Potter Internet Personality Project (GPIPP; Gosling, Vazire, Srivastava, & John, 2004). The GPIPP is a non-commercial website, which participants could find in various ways (e.g., via links on websites or search engines). Participants gave their consent to take part by proceeding to the study by clicking on a link. Ethical approval for the GPIPP was obtained from the institutional review boards of the University of Texas at Austin and the University of California, Berkeley.

Within the GPIPP, Openness was assessed via 10 items of the Big Five Inventory (BFI; John & Srivastava, 1999). Each item contains a short phrase based on a prototypical marker of Openness (e.g., “Is original, comes up with new ideas”, “Is curious about many different things”, or “Values artistic, aesthetic experiences”). Participants reported the degree to which they agreed with each item on a 5-point Likert scale ranging from 1 (*disagree strongly*) to 5 (*agree strongly*). After completing the survey, participants received a customized evaluation of their personality. The psychometric suitability of the GPIPP personality data for cross-regional research has extensively been demonstrated elsewhere (Ebert, Gebauer, et al., 2019; Rentfrow et al., 2008).

For the present investigation, we included only participants who reported living in the U.S. when they completed the survey, provided a valid postal code of their location, were between 15 and 70 years of age, completed the personality measure, and participated between 2006 and 2014 (i.e., those years for which the GPIPP provides best data coverage). After

applying these selection criteria, the sample included 1,946,752 participants. As is typical for online convenience samples (Gosling et al., 2004; Götz, Bleidorn, & Rentfrow, 2020; Jokela et al., 2015), the demographic composition of this sample was skewed towards females (65.01%) and younger people ($M_{Age} = 27.33$, $SD_{Age} = 11.90$).

Openness in cities across time. Our research aimed to track temporal changes in a city's local culture of Openness. Therefore, we aggregated individual Openness scores to the city-level using two pieces of temporal and spatial information.

First, we used *temporal* information provided by the time stamp of participation to assign each observation to a calendar year between 2006 and 2014. Based on this temporal information, we then formed nine annual subsets of data (e.g., all persons who filled out the survey in 2008). We grand-mean centered Openness scores separately in each yearly subsample. To illustrate, an Openness score of 1 in the subsample for 2008 now indicates that a person scored one unit higher than the average of all participants in 2008. As such, we removed the *national* Openness time trend from our data (e.g., a nationwide declining Openness trend due to more widespread internet access) while leaving *within-city* time trends unaffected¹.

Second, we used *spatial* information provided by a person's postal code of residence to assign each participant to one of the 392 U.S. Metropolitan Statistical Areas (MSA). MSAs are geographical units consisting of an urban core with at least 50,000 people and an adjacent hinterland that shows strong economic and social ties with this urban core² (Office of Management and Budget, 2010).

¹ Our analysis period (2006 - 2014) coincides with a period in which internet access became much more widespread, with the share of American adults with internet access growing from 71% to 85% over that period (PEW Research Center, 2015). Therefore, we needed to make sure that we measured true changes in local cultures of Openness and not changing self-selection processes into our online sample (e.g., open people being particularly likely to be among early internet users).

²MSAs are functional geographical units consisting of several counties. They are demarcated based on commuting flows between counties. By capturing the area in which employees both live and work, MSAs represent the interaction space that is available to the regional population on a daily basis.

We used this temporal and spatial information to calculate average Openness scores for each year in each MSA. To ensure that yearly Openness estimates are reliable across the entire analysis period, we retained only those cities with at least 100 observations for each year (Hoover & Dehghani, 2019). Our final sample comprised 1,946,752 individual observations from 199 cities. With a total population of over 210 Million inhabitants in 2014, these 199 cities are home to roughly two-thirds of the entire U.S. population. Online Supplement 1 provides a list of all included cities and their sample sizes. To ease interpretation, we z-standardized city-level Openness scores after aggregation.

Figure 1 visualizes the resulting data structure by depicting Openness trajectories in three major U.S. cities. The data indicate, for example, that New York's Openness score was .93 SD above average in 2006 and rose consistently over time, reaching 1.3 SD above average in 2014. By comparison, Chicago's Openness score was .40 SD higher than average in 2006, then rising to .62 SD above average in 2010, at which point it leveled off.

Figure 1. Smoothed (LOWESS) Openness and Housing Cost trajectories from 2006 to 2014 in three major U.S. cities (New York, Chicago, San Francisco).

Local amenities across time. Our theoretical framework builds upon the argument that changing local amenities drive changes in a city's culture of Openness. However, *directly* measuring changing local amenities (e.g., number of coffee shops, thrift shops, art venues) across hundreds of cities at yearly intervals is virtually impossible. To circumvent this problem, we followed previous research (Freeman, 2005) by using housing-market indicators to capture changes in local amenities. Empirical evidence demonstrates that housing prices are a valid proxy for local amenities: they are conceptually and empirically related to *the availability* of local amenities (Diamond, 2016; Rosen, 1979; Roback, 1982), and *the formation* of new amenities is directly associated with increasing housing prices (Glaeser et al., 2018). Therefore, we approximated the development of local amenities by yearly changes in a city's median monthly housing costs between 2006 and 2014. The monthly housing costs comprise both tenants' gross rents and homeowner costs (United States Census Bureau, 2020a).

To illustrate, Figure 1 depicts how New York's monthly housing costs were at a level of 1,250 USD in 2006 and constantly rose to a level of 1,450 USD by 2014. By contrast, Chicago's monthly housing costs started at 1,150 USD in 2006, peaked in 2008 at 1,250 USD, and decreased to 1,150 USD in 2014.

Panel Vector Autoregression. Our data structure covers yearly housing costs and Openness between 2006 and 2014 across 199 cities. Figure 1 already hints at potential interdependencies between these two time series. Specifically, the figure not only shows that cities with generally higher housing costs feature generally higher Openness levels (San Francisco > New York > Chicago), but also that cities with rising housing costs (New York and San Francisco) feature increasing Openness relative to other cities.

To analyze interdependencies between both time series, we applied *Panel Vector Autoregression* (PVAR). Vector autoregressive models are a flexible modelling tool for

analyzing multiple equations systems (Holtz-Eakin, Newey, & Rosen, 1988; Sims, 1980). Vector autoregression models can be viewed as an extension of conventional autoregressive models in which one variable is treated as the outcome that is explained by the temporal development of one or more predictor variables (such as panel regressions). By contrast, the key feature of vector autoregressive models is that all variables are treated as endogenous and enter the model in the same way (i.e., there is no a priori specified outcome variable). Specifically, each variable is modelled by an equation consisting of its own lagged values, the lagged values of the other variables, as well as an error term. As such, vector autoregressive models account for all possible interactions between the included time series. Consequently, vector autoregressive models allow researchers to disentangle bidirectional relationships between variables (in our case, whether economic change predicts cultural change or vice versa) and thus, keep theoretical restrictions imposed on the model to a minimum. Due to these advantageous characteristics, PVAR models with regional data are widely used in regional economics (e.g., Eberle, Brenner, & Mitze, 2019). However, we are not aware of any study that has used PVAR models in geo-psychological research.

Like other time series approaches, PVAR requires data *stationarity*. The properties of the time series should be constant over time and not follow a specific trend. To ensure data stationarity, we applied *first-order differencing* to both time series (i.e., computing the differences between two consecutive observations). While grand-mean centering across years removed *national* Openness trends from our data, first-order differencing adjusts *city-level* time-series for their inherent trend (i.e., generally rising or falling housing costs or Openness in a city). For example, if a city's average level of Openness was 1.1 SD above average in 2007 and 1.2 SD above average in 2008, this would equal a first-order difference of .1 SD in 2008. Accordingly, the reported estimates indicate whether a *change* in housing costs is associated with a *change* in a city's relative Openness ranking (and vice versa). Unit-root tests

suggested that both first-order differenced time series were stationary (Levin-Lin-Chu unit-root tests rejected non-stationarity at $p < .001$; Levin, Lin, & Chu, 2002). We used Akaike's information criterion to determine the lag structure that best fits our data, which suggested a lag length of $t-1$.

Finally, we wanted to ensure that our results are tied to changes in a city's housing cost and not driven by some other city development trajectory running in parallel. Therefore, we added first-order-differenced population density as an additional endogenous variable. Population density is often viewed as a *catch-all* variable that represents various city characteristics such as the availability of infrastructure or the size of the labor market (Ebert, Götz, Obschonka, Zmigrod, & Rentfrow, 2019; Obschonka et al., 2015). In addition, we also accounted for differences in the composition of our local personality samples by adding the size, average age, and gender ratio of a city's yearly personality sample as exogenous covariates (so-called PVARX model).³

To ease interpretation, we transformed the housing cost and population density indicator so that one unit represents 50 USD or 10 inhabitants per square mile, respectively. Note that an annual increase of 50 USD in housing costs per year is roughly one standard deviation above the average annual change in housing costs. As such, a housing cost increase of 50 USD or higher is a realistic and frequently occurring scenario (i.e., in around 15% of all years). All estimations were conducted using the *pvar* package in Stata (Abrigo & Love, 2016), and the corresponding analysis scripts are available from our project page on the Open Science Framework (<https://osf.io/9akc8/>).

³ To ensure that controlling for population density is not overly conservative we additionally fitted a model without population density that led to identical results (see Online Supplement 2). In addition, we also tested for the presence of curvilinear relationships between housing costs and Openness but did not find any (see non-significant quadratic terms in Online Supplement 3).

Results

Changing housing costs and Openness. Table 1 provides the results of the PVAR model. We found that changes in housing costs were significantly associated with subsequent changes in local Openness, while changes in Openness were not associated with subsequent changes in housing costs. In other words, housing costs were useful for predicting future values of Openness (so-called *Granger-causality*; Granger, 1969), while Openness did not predict (i.e., did not *granger-cause*) future housing costs. In addition, we found that positive changes in population density *granger-caused* rising housing costs and vice versa.

Table 1. Results from Panel Vector Autoregression with Housing Costs, Openness and Population Density Predicting Each Other.

	Housing Costs	Openness	Population Density
Housing Costs (t-1)	-0.02 [-0.13,0.09]	0.17*** [0.07,0.27]	0.02* [0.00,0.04]
Openness (t-1)	-0.01 [-0.06,0.05]	-0.36*** [-0.42,-0.30]	-0.01 [-0.02,0.00]
Population Density (t-1)	0.93* [0.12,1.74]	0.27 [-0.27,0.80]	0.32* [0.03,0.61]
Sample Size	0.00 [-0.00,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]
Sample Gender Ratio	4.18 [-0.69,9.05]	0.62 [-5.33,6.57]	0.71 [-0.14,1.55]
Sample Average Age	-0.02 [-0.13,0.09]	0.05 [-0.06,0.16]	0.01 [-0.01,0.03]

N = 1,194 yearly spells across 199 cities.

Note. City-level sample size, city-level gender ratio and city-level average age are control variables only; 95% confidence intervals in brackets / * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients indicate how housing cost changes of 50 USD, changes in Openness of 1 SD, and changes in population density of 10 people per square mile affect each other.

Based on the results of this equation system, we used *Generalized Impulse-Response Functions* (Pesaran & Shin, 1998) to forecast how a change in one variable (*Impulse*) predicts the development of another variable (*Response*) when considering all direct and indirect effects between variables. The left-hand panel of Figure 2 shows that an increase of 50 USD in a city's housing costs predicted a positive change of .17 SD (relative to other cities) in that city's Openness after one year. By contrast, the flat line in the right part of Figure 2 suggests that changes in local Openness did not predict any subsequent changes in a city's housing costs. Online Supplement 4 provides a full overview of Impulse-Response Functions for all variable pairings. Taken together, these findings support our hypothesis that changes in local amenities (as measured by changing housing costs) predict rapid changes in local cultures of Openness.

Figure 2. Impulse-Response Functions for housing costs and Openness. Dashed lines represent means of impulse-response. Left: Change in Openness (one unit = 1 SD) following an increase in housing costs of 50 USD. Right: Change in housing costs (one unit = 50 USD) following an increase in Openness of 1 SD. Grey bands depict 95% confidence intervals based on 200 Monte Carlo simulations.

Disentangling Processes. In our theoretical framework, we identified two mechanisms through which changing local amenities might lead to changes in local cultures of Openness: selective migration and social acculturation. Therefore, in the next step, we tried to disentangle how each of these processes contributed to the previously observed finding. To do so, we used an additional survey item provided in the GPIPP data asking participants how long they have already lived at their current place of residence.

Based on this information, we split the personality data into two subsamples. The first subsample comprises the *established* population in a city (i.e., those people who have already lived at a place before the beginning of our analysis window in 2006⁴). The second subsample comprises the *newcomer* population in a city (i.e., those who relocated to a new place during our analysis window 2006-2014). The selective migration perspective would be supported if rising housing costs predicted increased Openness among the newcomer population (relative to other cities). In contrast, the social acculturation perspective would be supported by increased relative Openness among the established population (relative to other cities). The two processes are not mutually exclusive and can operate at the same time.

Unfortunately, the aforementioned survey item is not specific about what constitutes a person's place of residence. As such, we are not able to convincingly disentangle across- from within-city relocations. This inability is not too problematic for testing the social acculturation perspective within the established population (i.e., people who have not moved since 2006 have clearly lived in the same city since that year). However, the lack of specificity creates problems for testing the selective migration perspective within the newcomer population: First, we may misclassify some people as newcomers to a city although they belong to the established population⁵. Second, this misclassification might not be randomly distributed but could be more common in cities with rising housing costs. For example, under rising housing costs, people might frequently be priced out from their locations, forcing them to relocate to other parts of their city (Couture et al., 2019; Freeman, 2005; Glass, 1964; Hamnett, 1991).

⁴ We also tested a more conservative threshold for established residents (i.e., only including people who already lived in the city five years prior to our analysis period) and found conceptually identical results. Please note that by focusing only on people that lived in the city for at least five years, we had to exclude more city-year Openness estimates that did not meet our general inclusion criterion of 100 observations. Due to the resulting smaller sample size, the effect for established Openness was only significant at the 10% level. However, when we increase the sample size by relaxing the criteria to also include city-year Openness estimates with at least 50 (instead of 100) observations, the effect again was significant at the 1% level (see Online Supplements 5a and 5b).

⁵ Official statistics (United States Census Bureau, 2020b) suggest that among those young age-groups that are included in our sample, more than half of all relocations are across county borders (i.e., potentially include a change of city). As such, we expect that a considerable share of the people who indicated a recent relocation are indeed new to a city.

Given these limitations, the findings for the selective migration perspective are presented as tentative evidence until supported by future research.

We fitted two PVAR equation systems that model the interdependencies between the time series of housing costs and established/ newcomer Openness. We ensured that in both models only city-year Openness estimates based on at least 100 observations were included in the model. First-order differenced time series satisfied the stationarity condition, and a lag structure of t-1 again best fitted our data. Tables 2 and 3 provide the results of these PVAR models. We found that changes in housing costs predicted changes in both established Openness and newcomer Openness. There were no effects of established or newcomer Openness on housing costs.

Table 2. Results from Panel Vector Autoregression with Housing Costs, Established Openness and Population Density Predicting Each Other.

	Housing Costs	Established Openness	Population Density
Housing Costs (t-1)	0.07 [-0.06,0.21]	0.18** [0.05,0.31]	0.02 [-0.00,0.05]
Established Openness (t-1)	-0.02 [-0.08,0.04]	-0.37*** [-0.43,-0.31]	-0.01 [-0.02,0.00]
Population Density (t-1)	0.49 [-0.21,1.19]	0.34 [-0.29,0.97]	0.33* [0.02,0.64]
Sample Size	0.00 [-0.00,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]
Sample Gender Ratio	9.34** [2.56,16.12]	1.42 [-6.49,9.32]	0.85 [-0.27,1.98]
Sample Average Age	0.08 [-0.03,0.20]	0.04 [-0.08,0.17]	0.01 [-0.01,0.03]

N = 1,085 yearly spells across 192 cities.

Note. City-level sample size, city-level gender ratio and city-level average age are control variables only; 95% confidence intervals in brackets / * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients indicate how housing cost changes of 50 USD, changes in established Openness of 1 SD, and changes in population density of 10 people per square mile affect each other.

Table 3. Results from Panel Vector Autoregression with Housing Costs, Newcomer Openness and Population Density Predicting Each Other.

	Housing Costs	Newcomer Openness	Population Density
Housing Costs (t-1)	0.05 [-0.17,0.27]	0.22** [0.07,0.37]	0.03 [-0.01,0.07]
Newcomer Openness (t-1)	0.04 [-0.05,0.13]	-0.28*** [-0.36,-0.19]	-0.01 [-0.02,0.01]
Population Density (t-1)	3.70 [-2.78,10.18]	1.75 [-1.85,5.35]	-0.12 [-1.23,0.98]
Sample Size	0.00 [-0.00,0.00]	0.00 [-0.00,0.00]	-0.00 [-0.00,0.00]
Sample Gender Ratio	7.74 [-1.37,16.84]	-2.28 [-8.89,4.33]	1.41 [-0.19,3.01]
Sample Average Age	0.04 [-0.39,0.47]	-0.03 [-0.29,0.24]	0.04 [-0.03,0.11]

N = 661 yearly spells across 177 cities.

Note. City-level sample size, city-level gender ratio and city-level average age are control variables only; 95% confidence intervals in brackets / * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients indicate how housing cost changes of 50 USD, changes in newcomer Openness of 1 SD, and changes in population density of 10 people per square mile affect each other

Figure 3 depicts the Impulse-Response Functions for housing costs with established and newcomer Openness (see Online Supplement 6 for full overviews of all variable pairings). The left-hand panel shows how an increase in monthly housing costs of 50 USD is associated with positive changes in established and newcomer Openness after one year, but not in later periods. The right-hand panel shows that there were no effects of established or newcomer Openness on housing costs. Taken together, these findings suggest that rising housing costs are associated with positive changes in Openness (relative to other cities) among the established local population as well as newcomers to the local population. Accordingly, and in line with our theoretical framework, both processes – selective migration and social acculturation – seem to contribute to the observed shifts in local cultures of Openness.

Figure 3. Impulse-Response Functions for housing costs and Openness among established residents (upper panel) and newcomer residents (lower panel). Dashed lines represent means of Impulse-Response. Left: Change in established/ newcomer Openness (one unit = 1 SD) following an increase in housing costs of 50 USD. Right: Change in local housing costs (one unit = 50 USD) following an increase in established/ newcomer Openness of 1 SD. Grey bands depict 95% confidence intervals based on 200 Monte-Carlo simulations.

Robustness Tests. To scrutinize the robustness and validity of our results, we conducted several robustness checks. First, we sought to ensure that our results are not driven by (a) unreliable local Openness estimates or (b) a selective inclusion of only a few cities. Therefore, we raised (to 150) and lowered (to 50) the original local sample inclusion criteria of 100 participants in each year between 2006 and 2014. Raising the inclusion criteria boosted the measurement precision of local Openness at the cost of reducing the number of included cities (from 199 to 165). By contrast, lowering the inclusion criteria boosted the geographical coverage (from 199 to 317 cities) at the cost of reducing the measurement precision of local Openness. For both lowered and raised inclusion cut-offs, we again found that rising housing costs predict shifts in local Openness, but not vice versa (see Online Supplements 7 and 8).

Second, we tested whether our findings reflect true changes in local Openness or whether they are merely a side-effect of changes in socioeconomic status (SES) among local populations. This analysis is important because SES is correlated with Openness and theories and empirical evidence in psychology and cultural studies highlight the role of SES as a driver of individual-level behavioral and psychosocial outcomes, as well as cultural change (Cohen, 2009). We accounted for SES on the individual- and city-level. At the individual level, we used a participant's educational attainment and self-reported social class (i.e., two widely used measures of SES; Kraus & Stephens, 2012) to partial out the variance that Openness shares with SES. At the city-level, we included a city's first-order differenced median income as an additional endogenous variable. Accounting for individual and city-level SES led to the same result (see Online Supplement 9), suggesting that our findings indeed reflect true changes in Openness among local populations.

Third, we wanted to ensure that our results are (a) as hypothesized specific to Openness and (b) not an artifact of our empirical design (e.g., due to some underlying general trend in the GPIPP data that provides significant results for any variable originating from that data). Therefore, we repeated our analysis for each of the four remaining Big Five personality traits (i.e., Conscientiousness, Extraversion, Agreeableness, Neuroticism). We found no associations between housing costs and the other four traits (see Online Supplement 10). This finding (a) suggests that the reported Openness-findings are not an artifact of our empirical design and (b) provides discriminant validity for the specific role of Openness in cultural change processes in cities.

Fourth, cultural differences can exist at multiple geographical levels (Cohen, 2009; Ebert, Gebauer et al., 2019). We wanted to ensure that our results (as hypothesized) reflect *local* cultural shifts and are not driven by overlapping trends at broader geographical levels. Therefore, we assigned each MSA to the state in which most of its population lives and

additionally included first-order differenced state-level Openness as an endogenous variable (see Online Supplement 11). We found no significant effects for state-level Openness, and the relationship for city-level Openness remained unchanged, suggesting that our findings indeed reflect local cultural changes.

Discussion

Modernization theories dating at least as far back as Marx (1867) have proposed that economic development leads to cultural change (Greenfield, 2009; Inglehart & Baker, 2000). In recent years, the field of cultural dynamics has provided ample empirical support for this position. Investigating economic development and changes in cultural practices across different countries for decades and often centuries, this emerging field of research has shown that growing economic affluence can induce slow but steady shifts in national culture (Greenfield, 2009, 2013; Grossmann & Varnum, 2015; Inglehart & Baker, 2000; Varnum & Grossmann, 2017b). In the current study, we expanded this work by showing that smaller cultural entities (i.e., cities) are economically and culturally nimble and can thus experience considerable cultural shifts within years rather than decades or centuries.

Specifically, building on work on improved economic conditions as a driver of culture change, we posited that local upward economic development could prompt rises in local cultures of Openness. More to the point, we proposed the growing availability of amenities, which results from economic development (Diamond, 2016; Glaeser et al., 2018), and favors rising Openness as a central mechanism tying local economic changes to cultural Openness. We suggested two mechanisms through which increased amenities in a city might contribute to higher Openness: 1) Selective migration, whereby open people will be attracted to move to cities that offer a wide range of cultural amenities (Falck et al., 2011; Rentfrow, 2010; Rentfrow et al., 2015), while less open people who do not value amenities enough to pay the rising housing costs associated with them will move elsewhere (Roback, 1982; Glaeser &

Gottlieb, 2006); 2) Social acculturation, whereby individuals living in cities with increasing amenities might become more open due to i) greater opportunities to try out new amenities and engage in prototypically open behaviors (e.g., attend theatre performances, sample exotic cuisines; Cohen, 1996; Rentfrow et al., 2008), ii) developing sociocultural norms that encourage prototypically open behaviors (Huggins & Thompson, 2019) among all residents, including among those who are low in Openness (Ebert et al., 2020; Oishi, 2014).

We were unable to measure amenities in 199 cities across multiple years directly, so we used housing cost data, which has been shown to serve as a good proxy for a wide variety of local amenities (Couture et al., 2019; Diamond, 2016; Glaeser et al., 2018). Against this backdrop, we aggregated large-scale psychological data on Openness (i.e., trait Openness scores from 1,946,752 U.S. residents) to measure annual development of local Openness across 199 cities from 2006 to 2014. We paired the resulting Openness time series with matching information on annual city-level housing costs. We then tested our hypothesis that rising local housing prices (as a proxy for the availability of amenities) would lead to an increase in the local culture of Openness. Mindful of the complexity of culture change (Grossmann & Varnum, 2015) and potential bidirectionality (Varnum & Grossmann, 2017a), we employed *Panel Vector Autoregression (PVAR)* models to account for the possibility of local Openness predicting housing prices.

Consistent with prior research on U.S. American cultural dynamics, showing that changes in occupational status prompted changes in individualism, rather than the other way around (Grossmann & Varnum, 2015), we found that rising housing costs meaningfully predicted subsequent increases in local Openness. In contrast, rising local Openness did not predict future housing costs (see Figure 2). The finding persisted across a series of robustness checks (e.g., varying inclusion thresholds for minimum city-level sample sizes; accounting for individual and city-level SES; comparisons with the remaining Big Five personality traits;

accounting for statewide-differences in Openness). In a next step, we aimed to shed some light on the respective contribution of our proposed two mechanisms as drivers of rising levels of Openness. In so doing, we replicated our *PVAR* models for established residents (i.e., people who had already lived at the same place before 2006) and newcomer residents (i.e., people who had moved to their current place since the beginning of the study timeframe in 2006). Results showed substantial effects for both groups of residents (see Figure 3).

The primary purpose of the current research was to empirically investigate the emergence and directionality of rapid cultural shifts within cities, but it is far more than a theoretical exercise and proof-of-concept study. To fully understand the real-world relevance of our findings, it is necessary to consider the magnitude of the observed effects and the downstream consequences of cultural Openness. Across the 199 cities included in our study, an increase of 50 USD in a city's housing costs was associated with a positive change in city-level Openness of .17 standard deviations (relative to other cities) during the following year (see Figure 2). This is noteworthy in and of itself (Funder & Ozer, 2019), as local cultural Openness is a complex phenomenon that is likely to be determined by a multitude of diverse causes, with each individual cause in turn being likely to yield only a small effect (Götz, Gosling, & Rentfrow, 2020). The practical relevance of this finding becomes even more apparent when considering the crucial macro-level outcomes that are robustly associated with local cultural Openness. Often lauded as a key driver of innovation (Rantisi, 2002; Rodríguez-Pose, 1999), Openness is related to economic resilience (Obschonka et al., 2015), human capital and social diversity (Rentfrow et al., 2015) as well as cultural looseness (Harrington & Gelfand, 2014), which is in turn related to creative capital (Jackson et al., 2019). In the political domain, Openness is strongly associated with liberal votes and attitudes (Rentfrow et al., 2015), with some empirical evidence even suggesting that higher regional Openness could have swung the Brexit vote in the 2016 U.K. referendum (Garretsen, Stoker, Soudis, Martin,

& Rentfrow, 2018). In other words, the current study not only refines our understanding of cultural dynamics *per se* but also of the emergence of spatial psychological differences. As such our study marks a crucial advance for the field of geographical psychology and has far-reaching implications for many diverse real-world outcomes.

Notwithstanding its important theoretical and practical implications, our study had several limitations that should be recognized. First, while the Openness data are a rich resource and uniquely positioned to meet the high demands on both temporal and geographical coverage necessary to conduct our study, they are not longitudinal in a strict sense. Rather, they contain time-stamped and geo-tagged cross-sectional data from 1,946,752 U.S. residents; this data structure allowed us to create yearly aggregated Openness estimates at the city level, but it did not allow us to track individuals across time. Consequently, while the resulting estimates are valid for cities as a whole, as the focal units of analysis in this study, we strongly caution the reader against drawing any inferences that concern changes in Openness within individuals (Rentfrow, 2010; Robinson, 1950). Relatedly, our study relied on an online convenience sample. Like other large-scale online convenience samples, the sociodemographic composition of our data was skewed towards females and younger people (Gosling et al., 2004; Götz, Bleidorn, et al., 2020; Rentfrow et al., 2015). As we controlled for the sample composition in our analyses, we can rule out the possibility that these skewed demographics drove our results. Nevertheless, future research should examine whether our findings also generalize to more demographically heterogeneous samples.

Second, while our paper ascribes a prominent role to local amenities as the catalyst that links economic development and rising housing prices to changes in local cultures of Openness, we were unable to measure local amenities directly. We are also not aware of any other research that has assessed amenities with the temporal and geographical scope afforded by our study. Encouragingly, recent years have seen successful first attempts to broadly

capture local amenities through data from social media, such as Yelp (Glaeser et al., 2018), Twitter (Wakamiya, Lee, & Sumiya, 2011), or Baidu Maps (Li, Wei, Wu, & Tian, 2019). Such approaches are promising and should be used and further developed in future research, but they could not be used in our study, which captured a timeframe from 2006 to 2014. Whereas Yelp has been around since 2004, albeit not at its current level of prominence, Twitter was only founded in 2006 when our study was already underway. Baidu Maps was not even available for the U.S. until 2016, two years after the end of our study's time frame. Against this backdrop, we relied on housing prices as a publicly available variable that holistically captures general trends in city-level amenity availability (Diamond, 2016; Glaeser et al., 2018).

Lastly, our study was restricted to a timeframe of nine years, which – although likely impressive from a conventional perspective in psychological science – seems rather short in comparison to recent studies in culture dynamics spanning decades (Huynh & Grossmann, 2020; Santos et al., 2017; Varnum & Grossmann, 2016) or even centuries (Greenfield, 2013; Grossmann & Varnum, 2015; Jackson et al., 2019). As more prospective and retroactive data become available, we hope that these studies can serve as role models and inspire future research that seeks to cover similarly long timespans while also maintaining the levels of resolution and geographical breadth used in the present research. Nonetheless, we believe that our study makes an important contribution by 1) showing that even if some culture changes unfold over long timeframes substantial change is still possible over much shorter periods, and 2) providing empirical insights into the underlying dynamic psychological processes. As such, we demonstrate that in smaller cultural entities like cities, substantial cultural shifts can and do occur within a couple of years.

Conclusion

Examining annual changes in local Openness and housing prices across 199 U.S. cities for nine years, we found that rising housing prices predict positive changes in Openness but not vice versa. Drawing on theory and research in urban studies and cultural economics, we suggest that this process is likely to be explained, at least in part, by local amenities, which increase with rising house prices to 1) attract open new residents (i.e., selective migration) and 2) foster greater Openness among existing residents (i.e., social acculturation). In providing preliminary empirical evidence for both processes, our study has several important implications. From a theoretical perspective, it extends previous research from cultural psychology to 1) affirm the role of economic development as a driver of culture change at the city-level, and 2) show that while cultural change in large cultural entities such as nations is typically slow, much more rapid cultural shifts can be observed in smaller cultural entities. From an applied perspective, it highlights the crucial role of economic change and local amenities in the emergence and perpetuation of local cultures of Openness, which in turn shape a broad range of important political, economic, and social outcomes.

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