The Environmental Determination of Complex Behaviour: Evidence From Language, Education, Religion, Emotion and Machine Learning

A. C. Applebee[a] and L. N. Combe[a]

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Abstract

Nobody thinks Australians speak English for genetic reasons, yet justice systems treat anger, violence and addiction as chosen or inborn. This paper asks whether language is an exception or the clearest case of a general rule: capacity is partly heritable, expression is environmental. We review natural experiments that separate genes from environment (international adoption, twins reared apart, immigrant generations) and test the rule in two further domains with public data. In 2022 US census microdata for California (209,607 adults aged 25 to 65), people born in the US held a bachelor's degree more often than people of the same ancestry born abroad: 25.4% vs 10.7% for Hispanic and Latino ancestry (+14.7 points, $t = 45.9$, $p < .001$), and being US-born added 7.3 points after controlling for ancestry (OLS $b = 0.073$, $t = 30.8$). A sensitivity analysis using the Census code book's region labels and person weights gives the same coefficient (0.074) and gaps of +13.9 (Hispanic and Latin American) and +10.3 (East and Southeast Asian). Among immigrants of the same ancestry, those who arrived as children sat between those who arrived as adults and the US-born (14.9% vs 9.0%; 60.3% vs 55.6%): the longer the exposure, the larger the shift. Where immigration selects for education (European, Sub-Saharan African, South Asian ancestry) the gap reverses, as selection predicts. In the 2022 General Social Survey (3,452 US adults), two in three hold the religion they were raised in (66.6%, kappa 0.52), and the young move away from it most, towards the secular environment they grew up in. Emotional display rules, cultural values and the "values" of AI language models trained on English text follow the same pattern. Environment should be the default explanation for complex behaviour until evidence shows otherwise.

Keywords: environmental determination | nature and nurture | immigrant education | nativity | religious transmission | emotional display rules | AI cultural bias | criminology

Significance. The law treats some learned behaviours as environment (language, religion, culture) and others as choice (crime). Public census and survey data show the same signature in education and religion that language shows: same ancestry, different environment, different outcome, with the size of the shift tracking the length of exposure. The double standard has no evidential basis.

Introduction: two plates

At a Greek wedding, guests smash plates. The act expresses *kefi*, a spirited joy that overflows into the body. In an Anglo-Australian kitchen, the same act is property damage, perhaps a police matter. The movement is the same and the feeling may be the same. The meaning is reversed, and the person doing it chose neither frame any more than they chose the language they speak. Greece's own military government made plate smashing a crime in the late 1960s, then ruled it no offence if the people present accepted it (Wikipedia, 2026): the act was the same; the room decided.

In a companion paper we showed that language, among the most complex things humans learn, follows the environment completely: children adopted from abroad speak the language of the home that raised them, as reliably as children born to it (Applebee & Combe, 2026). That result is, on its own, unremarkable. Nobody thinks Australians speak English for genetic reasons.

It becomes remarkable when set beside how we treat other behaviour. Criminal justice rests on the premise that antisocial behaviour is chosen in a way language is not. Anger is a character defect; English is an acquisition. Yet both are learned the same way: long immersion in an environment that models the behaviour, with no explicit instruction, no conscious decision and no moment at which the learner could have chosen otherwise.

This paper asks whether language is the exception or the clearest example of a general rule. The rule, from twin research, is short:

> *Capacity is heritable. Expression is environmental.*

Every behavioural trait is heritable to some degree (Turkheimer, 2000), and some people are more verbally fluent than others in any language (Stromswold, 2001). No one is genetically predisposed to speak Greek rather than Swahili. We test the rule in four further places: natural experiments that separate genes from environment, educational attainment, religious affiliation, and emotional and cultural expression; and we look at an unplanned experiment, the cultural "values" of AI language models.

Natural experiments that separate genes from environment

International adoption. International adoption separates genetic ancestry from linguistic environment completely. Adults born in Korea and adopted by French families in childhood do no better on Korean than French people who never heard it, and their brains show no special response to it (Pallier et al., 2003). In Sweden, the adopted country's language replaces the first (HYLTENSTAM

et al., 2009). Children adopted from China into American families mostly score in the average range or above on English measures as preschoolers (Roberts et al., 2005), and a meta-analysis of internationally adopted children finds language mostly within normal limits, with some lag at school age (Scott et al., 2011). None of this research reports a child who spontaneously spoke the language of their birth family without hearing it.

Twins reared apart. The Minnesota Study of Twins Reared Apart found identical twins raised separately alike on many measures (Bouchard et al., 1990). Every pair spoke the language of the place that raised them. Twin research separates the two questions this paper keeps apart: genes account for a substantial share of differences in language *ability* and disorder (Stromswold, 2001), and for none of the difference in *which* language, because rearing fixes that in every sample.

Immigrant generations. Ancestry stays constant across the generations of an immigrant family; exposure does not. By the third generation most grandchildren of immigrants in the United States speak only English at home (Alba et al., 2002), and our analysis of the 2022 census shows the same within one generation: across six ancestries, people born in the US were 30 to 69 percentage points more likely to speak only English at home than people of the same ancestry born abroad (Applebee & Combe, 2026). The earlier the move, the more complete the change (Hakuta et al., 2003).

The original version of this section offered a "statistical synthesis" with assumed counts (about 25,000 Korean adoptees, none speaking Korean, $\chi^2 = 50{,}000$) and a table of adoptee totals by country. Those figures were estimates, not data, so they are not reported here as findings; the companion paper's census test replaces them with measured counts.

Study 1: same ancestry, different birthplace, different education

Language is arbitrary: no language is biologically correct. A sceptic can grant language and hold out for outcomes where genetic arguments have a long history. Educational attainment is the obvious test.

Method. US Census Bureau American Community Survey, 2022 1-year public microdata for California (U.S. Census Bureau, 2023): 209,607 adults aged 25 to 65. Outcome: a bachelor's degree or higher. Ancestry is the first ancestry reported (ANC1P), grouped into world regions; environment is birthplace (born in the US or abroad) and, for immigrants, age at arrival. The test is simple: within one ancestry, does birthplace change the outcome?

The headline analysis (February 2026, Variant A) groups ancestry codes in blocks of one hundred by world region, tests US-born against foreign-born within each block with *t*-tests, and estimates the nativity effect across blocks by regression. It is reported unchanged. As a sensitivity analysis (Variant B), we regroup the same codes using the region names in the Census Bureau's code book, which labels several blocks differently (for example, it lists codes 700 to 799 as East and Southeast Asian ancestries, 300 to 399 as Caribbean and non-Hispanic South American, and 500 to 599 as Sub-Saharan African), add person weights, and add age at arrival. The people in each block are identical in both variants; only the names and weights differ.

Results.

Table 1. Bachelor's degree or higher, adults 25 to 65, ACS 2022 California, weighted. Variant B (sensitivity). The headline Variant A gives +14.7 points for Hispanic and Latino ancestry (25.4% vs 10.7%, unweighted, *n* = 55,812). Source: `studies/01-ancestry-education`.

Ancestry (code-book region, sensitivity analysis)	Born in US	Born abroad	Difference
Hispanic and Latin American	23.8% (n = 28,237)	9.8% (n = 27,575)	+13.9
East and Southeast Asian	66.4% (n = 9,200)	56.1% (n = 19,338)	+10.3
North African and Middle Eastern	66.5% (n = 1,156)	54.0% (n = 2,758)	+12.6
Caribbean and non-Hispanic South American	48.0% (n = 227)	46.3% (n = 408)	+1.8
South and Central Asian	75.3% (n = 696)	77.9% (n = 4,725)	−2.6
European	52.9% (n = 48,088)	62.4% (n = 4,538)	−9.5
Sub-Saharan African	35.6% (n = 573)	62.7% (n = 601)	−27.1

The headline result: for Hispanic and Latino ancestry, the largest group, being born in the US goes with a 14.7-point higher degree rate (25.4% vs 10.7%, $p < .001$), and across all ancestry groups being US-born adds 7.3 points ($b = 0.073$). The sensitivity analysis agrees: +13.9 and +10.3 points in the two largest non-European groups (both $p < .001$) and $b = 0.074$ (robust $z = 31.6$).

The reversals are the selection signature. Immigrants from most countries are more educated than the people who stay behind, some groups strongly so (Feliciano, 2005). A foreign-born Nigerian or Indian adult in California is not a random draw from Nigeria or India. That is why the headline analysis treats the reversals as selection. Under the code-book labels the largest reversal is among Sub-Saharan Africans, a small group here (1,174 adults) whose immigrants hold degrees at nearly twice the rate of the US-born of the same ancestry.

Exposure, not just birthplace. If environment drives the gap, immigrants who arrived as children, and so spent their schooling years in the US, should sit between adult arrivals and the US-born. They do. Among Hispanic and Latin American Californians, 9.0% of those who arrived at 18 or older hold a degree, 14.9% of those who arrived aged 0 to 12, and 23.8% of the US-born. Among East and Southeast Asian Californians: 55.6%, 60.3% and 66.4% (child vs adult arrivals, both $p < .001$). The dose-response runs the way an environmental account predicts.

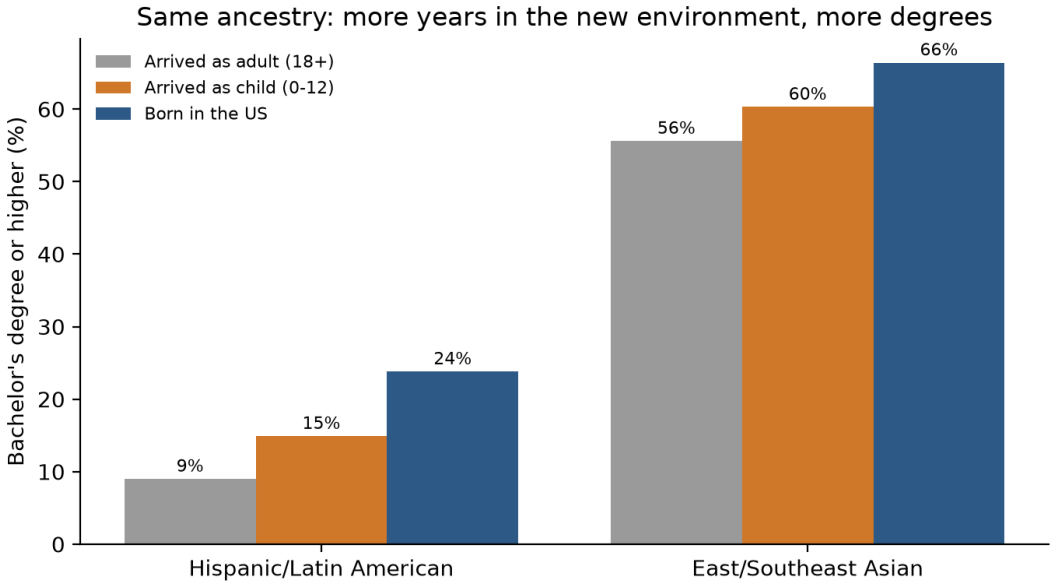


Fig. 1. College degree by exposure to the US environment, same ancestry. Grey: arrived as an adult. Orange: arrived as a child. Navy: born in the US.

The language comparison. The February 2026 analysis coded LANX = 1 as English at home and found a "language paradox": English speakers less often held degrees (33.1% vs 44.8%; 34.2% vs 45.2% in our rerun on the same analysis sample), which it explained by immigrant selection. The Census code book defines LANX = 1 as speaking a language other than English; read that way, the comparison runs the other way (only English at home 43.6%, another language 31.5%) and needs no selection explanation. We report both readings and leave the coding for the authors to confirm; the nativity results above do not use this variable.

Study 2: religion follows upbringing

Method. The General Social Survey (GSS) asks a national sample of US adults their religion now and the religion they were raised in at 16 (Davern et al., 2023). We used the 2022 survey: 3,452 adults answered both questions. Retention is the weighted share whose religion now is the religion they were raised in; agreement beyond chance is Cohen's kappa.

Results. Two in three US adults (66.6% weighted; 66.0% unweighted, 95% CI 64.4 to 67.6) hold the religion they were raised in, against 30.3% expected if current religion were independent of upbringing (kappa = 0.52; $\chi^2(132) = 12{,}398$, $p < .001$). Among those raised Protestant, 68.5% remain Protestant; Catholic, 63.1%; Jewish, 86.5% (n = 55); raised with no religion, 73.5% remain without one.

The departures are environmental too. Of adults raised in a religion, 21.8% now have none, and the share rises steeply as the cohort gets younger: 12.5% of those aged 60 or over, 19.5% of those aged 40 to 59, 32.4% of those aged 18 to 39. Retention falls from 74.1% to 58.7% across the same groups. The younger cohorts did not deliberate their way out one by one; they grew up in a more secular America, and they took on its religion, which is increasingly none. Families remain the main channel of transmission (Bengtson et al., 2013), immigrants' religious lives reshape around their new country (Cadge & Ecklund, 2007), and the religious composition of a country is overwhelmingly that of its majority faith (Pew Research Center, 2012).

Survey research puts religious retention at about 80% (Pew Research Center, 2015; Sherkat, 2014). Our 2022 measure, a stricter one (the same broad religion at 16 and now, in a year of fast secularisation), is 66.6%. The pattern still holds: upbringing predicts religion far beyond chance, and the main movement away from it tracks the surrounding culture.

What is heritable is *religiousness*, how intensely a person engages, and even that ran mostly on shared family environment in childhood in a study of reared-together twins, with genetic influence growing in adulthood (Koenig et al., 2005). Which god, which text and which rituals is set by environment. Capacity and expression again.

Cultural and emotional expression

Emotional expression is not obviously arbitrary, and still follows culture. Display rules, the norms for which emotions may be shown to whom, vary systematically across 32 countries and track individualism and collectivism (Matsumoto et al., 2008). Values

cluster by country (Hofstede, 2001). Immigrants' emotional patterns move towards those of their new culture with exposure and contact (De Leersnyder et al., 2011).

Table 2. The same physical behaviour, opposite social meanings.

Behaviour	Meaning in one culture	Meaning in another
Smashing plates	Celebration, *kefi* (Greek)	Aggression, property damage (Anglo)
Loud argument at dinner	Normal family engagement (Italian, Greek)	Hostile conflict (Northern European)
Direct eye contact	Respect, honesty (Western)	Disrespect or challenge (many East Asian and Aboriginal Australian contexts)
Vertical head nod	"Yes" (most cultures)	"No" (Bulgaria)
Standing close in conversation	Normal (Mediterranean, Latin American)	Intrusive (Northern European)

The capacity to feel intensely, to need physical release, is plausibly heritable; some people run hotter than others. Whether that heat comes out as plate-smashing at a wedding or a fist through a wall is shaped by the culture that taught what the act means. Behaviours we classify as pathological or criminal can be the same capacity as behaviours we celebrate, through a different template.

An unplanned experiment: AI language models

Large language models learn entirely from their training text, with no genes, no childhood and no decisions. If environment installs worldview, models trained mostly on English text should carry English-speaking cultural frames. They do. ChatGPT's answers to cultural-values surveys align most closely with American respondents (Cao et al., 2023). A model's opinions on global survey questions most resemble those of people in the USA and a handful of Western countries, even when asked in other languages (Durmus et al., 2023). A model trained to make ethical judgments reproduces the judgments embedded in its training labels (Talat et al., 2022). Multilingual models appear to route meaning through an English-like internal representation even when working in other languages (Wendler et al., 2024). The old question of whether language shapes thought (Wolff & Holmes, 2011) gets a new kind of evidence: a system that learned only from exposure acquired the cultural frame of what it was exposed to.

The comparison is an analogy, not a causal test of human learning; gradient descent is not childhood. Its value is narrow and clear: cultural bias can be installed purely by exposure to patterned data, without any of the things (genes, trauma, choice) usually invoked to explain human difference.

Discussion

The pattern across domains.

Table 3. Capacity and expression across domains.

Domain	Same environment, same expression?	Change the environment	Heritable part
Language	72% to 98% by country (Applebee & Combe, 2026)	Adoptees replace the first language	Fluency, not which language
Education	Same ancestry, US-born +10 to +14 points	Child arrivals sit between	Not tested here
Religion	66.6% keep their upbringing's religion	Young cohorts follow a secular shift	Religiousness, not which faith
Emotional display	Rules track culture across 32 countries	Immigrants' emotions move to the host culture	Intensity, not its form
AI models	Values match the training text	(no genes by construction)	none

The asymmetry. We do not imprison people for speaking the wrong language. We do not punish adherence to a religion learned in childhood. We do not hold people culpable for their culture's display rules. We do imprison people for behavioural patterns learned in exactly the same way.

This is not an argument against responding to harm. Some behaviour hurts people whatever its origin, and a society must answer it. It is an argument against the explanatory frame beneath most criminal justice, the rational actor who weighs costs and benefits and can be deterred by punishment. Across these domains, most complex behaviour is not chosen; it is acquired. The useful question is not "why did this person choose this?" but "what environment installed this pattern, and how can it be updated?"

Responsibility survives. A fluent English speaker is responsible for what they say, though they never chose English. Knowing a pattern was installed does not excuse its harm; it changes the response, from punishing a choice that may never have occurred to changing the environments that keep teaching the pattern.

Limitations

Language is uniquely arbitrary, and a sceptic may say aggression is not; we answer that religion, display rules and values are as arbitrary as language and follow the same pattern, but behaviours with survival value may carry more genetic variance, and this paper does not test crime directly. Genes and environment interact: people select and evoke environments, and the clean split between capacity and expression is a working rule, not a law. Study 1 is cross-sectional, one state, one year; birthplace bundles schooling, income and discrimination, all of them environment but not separable here; and immigrant selection cuts both ways, which is why the age-at-arrival gradient within ancestry matters more than any single gap. Study 2 relies on adults' reports of the religion they were raised in, and the GSS cell for Judaism is small. The AI evidence is analogical. Population concordance does not decide individual cases.

Conclusion

Across language, education, religion, emotional display and the values of machines trained on text, the pattern repeats: the environment a person grows up in predicts the form their behaviour takes; changing the environment changes the form, more completely the earlier and longer the change; and what genes contribute is capacity, not content. The default explanation for a complex behaviour should be the environment that taught it, until specific evidence points elsewhere. Today the default runs environmental for language, faith and culture and individual for crime, aggression and addiction. The data do not support the asymmetry.

People speak the language they heard. They pray to the god they were shown. They feel the feelings they were taught. And they can learn something different, if someone teaches them.

Data and code availability

`reproduce.sh` reruns both studies from the data in `studies/` and checks each result against `expected/`. Study 1 uses a column extract of the ACS 2022 California person file (with the code book and rebuild instructions); the original February 2026 scripts are kept beside the rerun (`src/original_*.py`). Study 2 uses a five-column extract of the 2022 General Social Survey. The full statistical appendix, with confidence intervals, assumptions, power and the sceptic's questions, is `appendix/statistical-appendix.pdf`. Repository: https://github.com/vexanonus/environmental-determinism.

Appendix: statistics

Two-group comparisons of proportions (Study 1). *Why:* the question is whether birthplace changes the degree rate within one ancestry. Variant A used independent t-tests on a 0/1 outcome (equivalent to a two-proportion z-test at these sizes); Variant B uses chi-square tests on 2 × 2 tables with weighted percentages. *Assumptions:* independent observations; household clustering and the ACS sampling design are ignored, which understates standard errors somewhat. *Power:* the two main groups hold 55,812 and 28,538 people; differences of 10 points are detectable many times over. *Sceptic:* "Same ancestry is not same genes." *Answer:* ancestry is a coarse proxy, but any genetic difference between US-born and foreign-born people of the same ancestry would have to be implausibly large and would not explain the child-arrival gradient. *Sceptic:* "Selection explains everything." *Answer:* selection explains the reversals; it predicts the US-born gap in the opposite direction from what the two largest groups show, and it does not explain why child arrivals of the same ancestry sit between adult arrivals and the US-born.

OLS regression (Study 1). College (0/1) on ancestry-region dummies and US birth; a linear probability model, reported with heteroskedasticity-robust standard errors in Variant B. *Why:* gives the average within-ancestry nativity difference in percentage points. *Sceptic:* "R^2 is small (0.13)." *Answer:* R^2 measures how well the model predicts individuals, not whether the nativity effect is real; the coefficient is the finding.

Retention, kappa and chi-square (Study 2). *Effect sizes* follow Cohen's conventions (Cohen, 1988). *Why:* retention is the share keeping their upbringing's religion; kappa corrects that share for agreement expected by chance given how common each religion is; the chi-square tests independence. *Assumptions:* the GSS is a probability sample; weights (WTSSPS) adjust for design and non-response; small cells (some religions under 50 respondents) make the omnibus chi-square approximate, which does not affect a result of this size. *Sceptic:* "Retention of 66.6% is not 'determination'." *Answer:* agreed that it is not total; it is more than twice chance, and the main movement away tracks the cohort's environment, not individual deliberation.

Scripts: `studies/01-ancestry-education/src/run.py` (figure: `src/figure.py`), `studies/02-religion-retenti`

Related papers: *The Language Proof* and *Learning Distillation*.

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Author information

Affiliation: Omxus Press. All authors wrote the paper. The authors declare no competing interests. Correspondence: research@omxus.com.