Research article

PUS

Public Understanding of Science
1–21

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DOI: 10.1177/09636625241245030
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A 30-nation investigation of lay heritability beliefs

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Abstract
Lay beliefs about human trait heritability are consequential for cooperation and social cohesion, yet there has been no global characterisation of these beliefs. Participants from 30 countries (N = 6128) reported heritability beliefs for intelligence, personality, body weight and criminality, and transnational factors that could influence these beliefs were explored using public nation-level data. Globally, mean lay beliefs differ from published heritability (h^2) estimated by twin studies, with a worldwide majority overestimating the heritability of personality and intelligence, and underestimating body weight and criminality. Criminality was seen as substantially less attributable to genes than other traits. People from countries with high infant mortality tended to ascribe greater heritability for most traits, relative to people from low infant mortality countries. This study provides the first systematic foray into worldwide lay heritability beliefs. Future research must incorporate diverse global perspectives to further contextualise and extend upon these findings.

Keywords
culture, genetic determinism, genetics, knowledge translation, public understanding of science

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1. Introduction

The past two decades have delivered stunning scientific progress into the genetic basis of human attributes (Abdellaoui et al., 2023; Polderman et al., 2015; Venter et al., 2001; Visscher et al., 2017). Meta-analyses of human trait heritability show point estimates for tens of thousands of traits with increasing confidence (Polderman et al., 2015). What remains unclear is how exactly this new knowledge permeates into lay perception of how genes contribute to human traits (Dar-Nimrod et al., 2021), especially at an international scale.

Global lay beliefs about the magnitude of trait heritability are informative for scientists, educators and policy makers, because such beliefs reveal the extent to which transformational genomic discovery has entered public understanding. Lay heritability beliefs represent people's understanding of how human traits are acquired and passed on intergenerationally, and imply whether these attributes may be seen as amenable to change through human agency or effort (Lynch et al., 2019).

However, existing cross-national research on heritability beliefs has been limited, and samples from middle and low socioeconomic countries have been neglected. Previous research has tended to apply an individualised lens to the concept of lay heritability beliefs, leaving a gap in our understanding of between-country differences in these beliefs, and what factors shape heritability beliefs worldwide. In particular, no studies have examined cross-national determinants of global lay heritability beliefs – country-level factors that transcend national borders such as resource scarcity, uncertainty avoidance or infant mortality. Addressing these research gaps, this study presents survey data from 30 countries to (1) measure lay heritability beliefs around the world and (2) explore cultural explanations for why people may vary in these beliefs.

Literature review

Defining and contextualising heritability (h^2). Traits are human qualities that vary in the extent to which they can be attributable to genes (e.g. eye colour, personality or vulnerability to disease). Trait heritability can be numerically described using the term h^2, which reflects the proportion of trait variance attributable to genetic factors derived from family studies and genome-wide association studies (Owen and Williams, 2021). Exponential progress in technological and analytic capabilities has delivered broader understandings of the genetic basis of a wide range of human characteristics (Claussnitzer et al., 2020; Polderman et al., 2015). However, there remain ongoing concerns within the genetics community about 'Eurocentric bias' in genetic data and research (Martin et al., 2019; Sirugo et al., 2019), and relative neglect of non-European descent samples. These biases risk reducing the accuracy and predictive value of genetic markers and may exacerbate entrenched disparities in health access and outcomes. Repeating this pattern of exclusion with respect to research on lay heritability beliefs is undesirable and avoidable.

Social consequences of lay heritability beliefs. Understanding global patterns and correlates of lay heritability beliefs is important because such lay beliefs have social consequences (Dar-Nimrod and Heine, 2011; Heine et al., 2017; Keller, 2005). Research in primarily WEIRD samples (white, educated, industrialised, rich and democratic; Henrich et al., 2010) has found that overgeneralisation of genetic explanations for human traits is associated with harmful attitudes towards outgroups (Byrd and Ray, 2015; Lebowitz & Ahn, 2014); pessimism, inaction or fatalism towards health problems (Chapman et al., 2019; Dar-Nimrod et al., 2014; Wang and Coups, 2010); as well as lower attribution of individual criminal responsibility but greater expectations for recidivism (Cheung and Heine, 2015). Therefore, these lay beliefs have the potential to be socially impactful in domains across human society.

To the extent that people do overestimate heritability, such biases are the psychological foundation for genetic determinism, or the notion that genes primarily or solely determine human characteristics (Dar-Nimrod and Heine, 2011; Lynch et al., 2019). Genetic determinism goes well beyond scientific consensus about the contribution of genes in explaining human traits, and may diminish human agency in solving problems such as malnutrition, disease and inequality, since these outcomes are considered natural and immutable (Alper and Beckwith, 1993).

Acquiring genetic knowledge. Outside experts in the field of genetics, knowledge about the genetic basis of human traits is minimal, even among the well-educated (Chapman et al., 2019; Christensen et al., 2010). As the pace of genomic discovery increases, gaps between frontier scientific discoveries and traditional education curricula have widened (Boerwinkel et al., 2017; Bowling et al., 2008; Dougherty, 2009). In fact, while other sources of knowledge transmission, such as print, online and social media, have increased in volume alongside technological advances (Eyck and Williment, 2003; Lee et al., 2020; Morosoli et al., 2024), research consistently shows that media content often ascribes causality to genes in a manner lacking fidelity to scientific findings (Brechman et al., 2009; Carver et al., 2012). For example, Brechman et al. (2009) detected biologically deterministic and overly simplistic language in press releases about genetics research. Together, the literature paints a picture of increasing scientific complexity and advancement against a backdrop in which people's genetic literacy tends to be low overall.

Genetic knowledge and the deficit model. The deficit model of scientific understanding posits that non-scientific attitudes and beliefs – from anti-vaxx conspiracy theories to climate scepticism – stem from a lack of scientific knowledge. As such, the deficit model proposes that the primary barrier between scientific consensus and public opinion is information – that once supplied with the correct facts, people will shift their views to align with the science (Hornsey, 2020). However, there is now ample evidence to suggest that education and scientific literacy have only limited impacts on people's attitudes to a range of science-related concepts (Hornsey et al., 2018b, 2023), including genetics and trait heritability (Morosoli et al., 2019). This is not to suggest that educational efforts are futile – some evidence suggests that specific forms of genetics instruction can buffer some people against holding beliefs based on genetic essentialism (Donovan, 2022; Donovan et al., 2021) – but that its effectiveness is qualified. In a randomised controlled trial with US high school biology students, an intervention that supported students to refute essentialist thinking led to lower (more accurate) endorsement of a genetic basis for racial differences; but this was only the case for students in the intervention condition who already had relatively strong knowledge (Donovan et al., 2021).

Moreover, other knowledge-based interventions have had only modest or even backfire effects (see Donovan, 2022 for a review), and it remains the case that most people have poor genetic literacy (Chapman et al., 2019; Christensen et al., 2010). This insufficient genetic literacy does not prevent members of the public from holding beliefs about trait heritability. There is reason to expect that such lay beliefs are informed by non-scientific influences, since heritability beliefs tend to be inconsistently (Parrott et al., 2003, 2012; Singer et al., 2007) or only weakly (Gericke et al., 2017) associated with genetic literacy and genetic education.

As a counterpoint to the deficit model, many researchers have examined how processing of scientific evidence is affected by underlying psychological variables; ideological worldviews and group identities that form lenses through which people engage with science (i.e. 'attitude roots', such as ideological worldview, identity needs, fears and phobias; Hornsey and Fielding, 2017). These 'attitude roots' reflect deeply held schemas about the world, self and others; are generally resistant to explication; and may be latent factors underpinning people's expressed or surface beliefs and attitudes about science and scientific evidence generally (Hornsey, 2020), including lay heritability beliefs. Rather than emerging in isolation, these beliefs are considered to be developed and maintained in context-dependent ways. Therefore, this study aims to characterise these lay heritability beliefs around the world, and explore cultural factors that might explain patterns in people across countries.

The rationale for a worldwide study. Despite the possible impacts of lay heritability beliefs, global research on these beliefs and their cultural correlates is minimal. Supplemental Table S1 provides a summary of multi-national research on lay heritability beliefs, which we unpack in the following section. Prior research has examined international lay heritability beliefs, but has tended to be limited in geographical and methodological scope. Notably, existing multi-nation research on heritability beliefs (see Supplemental Table S1) oversamples middle and high socio-economic countries (Chapman et al., 2019); or assesses participants' qualitative sentiments about genetics (Castera and Clemen, 2014; Hong, 2019; Schnittker, 2015) rather than assessing numerical estimates that can provide a statistical basis for global characterisation.

To elaborate, one quantitative multi-country study examined lay heritability beliefs with respect to three mental health diagnoses (i.e. alcohol dependence, depression and schizophrenia) across United States, Australian and United Kingdom samples (Morosoli et al., 2021). They found that people's heritability estimates for alcohol dependency and depression were higher in the United States than in Australia and the United Kingdom, but this same pattern did not hold for schizophrenia. Another multi-country study, with a majority Russian sample (65%), found that heritability beliefs for eight traits significantly differed across countries, professions, education levels and religious affiliations (Chapman et al., 2019). The authors surmised that heritability underestimation was most pronounced for traits that were ostensibly under conscious control: in this case, weight, motivation and school achievement. A further multi-country study considered beliefs about the causes of health, including genetic explanations, and found that country was the largest determinant of these beliefs, over and above religion, education and exposure to healthcare (Schnittker, 2015). Meanwhile, no studies provided numerical evidence of lay heritability beliefs that included low-income countries and their cultural correlates.

In sum, a systematic worldwide account of lay heritability beliefs is necessary and timely. Despite the pace of genetic discovery, relatively little is known about how and whether these genetic advances are translating worldwide in terms of people's beliefs about human trait heritability. Therefore, this research provides a multi-country examination of lay heritability beliefs with people worldwide, spanning all inhabited continents, to understand these beliefs and their cultural correlates.

This research and hypotheses

In this study, we examined lay heritability beliefs about four basic human traits – intelligence, personality, body weight and criminality – in 30 countries. These four traits were selected given substantial attention in genomic research (Buniello et al., 2019) and for being among the top 10 most frequently investigated traits from 50 years of twin studies (Polderman et al., 2015).

The study research questions (RQs) and hypotheses are set out in Table 1 and explained further below. Given the absence of prior global research, we did not hypothesise specific differences between country means with respect to lay heritability beliefs. We examined national means for lay heritability beliefs with respect to intelligence, personality, body weight and criminality (RQ1); and the distribution of worldwide lay heritability beliefs relative to published heritability estimates (h^2) for these traits (RQ2).

Table 1. Summary of research questions and exploratory hypotheses for global lay heritability beliefs.

Objective	Elaboration/prediction
Global characterisation	
Research question 1 – National means	What are the national means for lay heritability beliefs with respect to intelligence, personality, body weight and criminality?
Research question 2 – Proportions relative to published h^2	What is the distribution of worldwide lay heritability beliefs relative to published heritability estimates (h^2) for intelligence, personality, body weight and criminality?
Exploration of cultural correlates	
Exploratory hypothesis 1 – resource scarcity	Nation-level resource scarcity would be associated with higher heritability beliefs, because resource scarcity reduces the ostensible and actual scope and impact of human intervention to provide optimal environmental conditions
Exploratory hypothesis 2 – infant mortality	Infant mortality would be associated with higher heritability estimates, because conditions of high infant mortality make differential offspring fitness salient, trigger a need for psychological accommodation, and genetic heritability offers a psychological pathway to make causal sense of basic human traits; therefore, human traits may seem more explicable by genes when infant mortality is high
Exploratory hypothesis 3 – individualism–collectivism	Individualistic cultures would be associated with lower trait heritability beliefs than collectivist cultures, because individualistic cultures tend to emphasise personal responsibility, free will and individual differences; and high heritability implies lower personal responsibility and free will
Exploratory hypothesis 4 – uncertainty avoidance	Nation-level uncertainty avoidance would be associated with higher estimates of heritability, attributing human traits to genes provides a firm putative biological cause, provides closure and alleviates uncertainty given the explanatory power that genetic accounts of human traits provide
Exploratory hypothesis 5 – holistic–analytic orientation	Holistic cultures would be associated with lower heritability estimates than analytic cultures, because holistic cultures that are predominantly influenced by Buddhism, Confucianism, Hinduism, Jainism or Taoism, are thought to more readily accommodate contradiction, interconnectedness and flux

Country-level predictors. To provide a cross-national account of factors that might explain lay heritability beliefs, we assembled a small panel of five cultural predictors: resource scarcity, infant mortality, individualism–collectivism, uncertainty avoidance and holistic–analytic culture. Pivoting from a purely 'deficit' frame, we sought to examine theory-informed contextual factors that could provide cultural context for variability in lay heritability beliefs across countries. Country-level data for the five cultural predictors were extracted from publicly available databases. These predictors are necessarily exploratory given the dearth of prior research; we set out the theoretical rationale for each factor with respect to heritability below (and summarised in Table 1).

Resource scarcity varies across countries and can be quantified using national gross domestic product. We considered nation-level resource scarcity could be associated with higher heritability beliefs (H1), because resource scarcity reduces the ostensible and actual scope and impact of human intervention to provide optimal environmental conditions (Selita and Kovas, 2018). We also wanted to test the effect of resource scarcity due to competing ideas in the literature about the extent to which true heritability can change due to human intervention. One perspective considers that heritability will be maximised in low-intervention, high-stressor environments that increase development of particular traits in high-risk individuals – the 'diathesis-stress model' (Rende and Plomin, 1992). This model posits that trait heritability is masked when protective factors are put in place to reduce or buffer risk exposure. An alternative perspective considers that heritability is maximised in high-intervention, enriched environmental conditions – the 'bioecological model' (Bronfenbrenner and Ceci, 1994). This model posits that trait heritability is masked when environmental stressors are high (Giangrande and Turkheimer, 2021).

Infant mortality is defined as the number of deaths during the first year of life per 1000 live births (World Bank, 2021a). Global infant mortality is in decline, but substantial differences between countries reflect multi-factor impacts, including poverty, access to public health, gender equality and specific advances in maternal–foetal and paediatric medicine. We tentatively considered that conditions of high infant mortality make salient differential offspring fitness (Trivers, 1974). Infant death results in grief processing and requires psychological accommodation (Currie et al., 2019; Vig et al., 2021), and genetic heritability offers a psychological pathway to make causal sense of basic human traits (Dar-Nimrod and Heine, 2011; Heine et al., 2017). Therefore, we reasoned that human traits may seem more explicable by genes when infant mortality is high, and therefore that infant mortality would be associated with higher heritability beliefs (H2).

Individualism–collectivism (Hofstede et al., 2010) refers to a general preference for loosely knit versus tightly knit social frameworks ('I' or 'we'). Unlike collectivistic cultures, individualistic cultures tend to emphasise personal responsibility, free will and individual differences (Grossmann et al., 2016; Heine and Buchtel, 2009). High heritability implies lower personal responsibility and free will (Willoughby et al., 2019). Therefore, we hypothesised that individualistic cultures would be associated with lower heritability beliefs than collectivist cultures (H3).

Uncertainty avoidance describes discomfort with ambiguity (Hofstede et al., 2010). We theorised that attributing human traits to genes provides a firm biological cause, affords closure and alleviates uncertainty (Keller, 2005). On that basis, uncertainty avoidance could produce higher heritability beliefs (H4), given the explanatory power that genetic accounts of human traits provide.

Holistic–analytic orientation describes the cultural accommodation of contradiction, change and nonlinearity, such as complementarity of opposites (see Grossmann et al., 2016: 896) and reliance on dialectical reasoning (Nisbett et al., 2001). Holistic cultures that are predominantly influenced by Buddhism, Confucianism, Hinduism, Jainism or Taoism, are thought to more readily accommodate contradiction, interconnectedness and flux (Nisbett et al., 2001). Therefore, we expected lower heritability beliefs in holistic versus analytic cultures (H5).

2. Methods

We sampled 30 countries from all inhabited continents: Asia ($k=11$), North America ($k=2$), South America ($k=5$), Europe ($k=5$), Africa ($k=5$) and Oceania ($k=2$).

Participants

Target sample size was 30 countries with $n=200$ per country, which was necessarily exploratory given the absence of comparable prior research. We surveyed 6128 people (50.5% male, $M_{age}=39.98$ years) from 30 countries ($n>200$ for all countries, see Table 2). Based on power calculations with a significance level of .05 and a model containing five predictors (see model specification in 'Design' section below), our sample size offers >90% power to detect a medium effect size (Faul et al., 2009).

Participants were recruited by the online data collection company, Dynata, which was engaged by members of the research team. Participants were recruited by the company through advertising and partnerships, and data were collected between May and June 2020. Participants were subjected to quality control and response quality monitoring as part of Dynata procedures, and allocated a unique digital fingerprint to prevent repeat survey completions. Participants were paid by the company for their time with amount varying by region to ensure equitable and equivalent compensation across countries relative to domestic economic conditions, as is the convention in multi-nation research (Hornsey et al., 2018a). A very small number of participants were removed from the dataset ($n = 17$) who identified as non-binary gender; these responses were removed only to omit the need for complex logistic modelling, and especially noting the inability for a subsample this size to statistically influence the direction of quantitative findings. Subsample results are not reported separately to avoid any possibility of re-identification given the small subsample size. The study received ethical review and approval from the University Ethics Review Committee (#1700001041).

Design

The study involved data from people nested within countries, therefore a nested cross-sectional design was implemented with persons (level 1) within countries (level 2) – see more information under Analytic Strategy below. Person-level variables included lay heritability beliefs (intelligence, personality, body weight, criminality) and demographics (age, gender, years of education). Country-level variables included the five cultural predictors: resource scarcity, infant mortality, individualism–collectivism, uncertainty avoidance and holistic–analytic culture (see 'Measures' section below).

Measures

Person-level variables. Person-level variables were measured as part of a large cross-cultural survey on emerging technologies. All survey items were prepared in English, then translated and back-translated for fidelity (see 'Procedure' section below). A bespoke measure of lay heritability beliefs was developed in light of identified methodological shortcomings in prior research (see 'Literature Review' section and Supplemental Table S1). In the measurement of lay heritability beliefs, participants were asked to rate heritability for each trait (intelligence, personality, body weight and criminality) with the following question: 'Any human characteristic could be due to genetics (DNA), life experiences (e.g. parenting, life decisions, culture) or a combination of both. Please answer below how much you think the following traits can be explained by genetics versus life experiences'. Participants then used a continuous slider to indicate any value from 0 (i.e. 0% genetics, 100% life experiences) to 100 (100% genetics, 0% life experiences). Items were randomised in presentation within block. The initial position of the slider was 'inactivated' at the centre of the scale. Participants were required to actively click on the slider to activate the item and provide an answer, and were prompted but not forced to respond. Reliability and measurement invariance were not tested because the four outcome measures were single-item measures (Leitgöb et al., 2023).

Participants provided demographic information including age, gender, years of education as well as number of years residing in, and whether they identified as a citizen of their country (not explored further).

Country-level variables. The individual-level survey data were enriched with publicly available country-level data on resource scarcity, infant mortality, individualism–collectivism, uncertainty avoidance and holistic–analytic orientation.

Table 2. Summary national data for 30 countries: sample size, infant mortality rate and lay heritability beliefs (intelligence, personality, body weight, criminality).

Nation	*n*	Infant mortality[a]	Lay heritability belief[b] (*M*, ±95% CI)											
			Intelligence			Personality			Body weight			Criminality		
			M	Lower limit	Upper limit	*M*	Lower limit	Upper limit	*M*	Lower limit	Upper limit	*M*	Lower limit	Upper limit
Australia	202	3.05	57.22	54.17	60.27	50.50	47.45	53.56	53.22	49.93	55.70	34.32	30.81	37.83
Brazil	206	12.45	58.50	54.98	62.02	53.28	50.13	56.43	55.91	47.40	53.31	28.05	23.93	32.17
Canada	205	4.25	59.69	57.05	62.33	49.54	46.78	52.31	52.96	50.14	55.77	31.83	28.26	35.41
Chile	205	5.97	60.86	57.68	64.05	48.21	45.31	51.11	55.19	57.55	64.58	32.76	28.50	37.03
China	205	6.76	60.76	57.99	63.53	55.00	52.33	57.67	46.87	48.64	54.16	30.21	26.59	33.83
Colombia	206	11.84	61.44	58.16	64.72	54.38	51.20	57.55	58.86	50.70	55.75	31.60	27.74	35.46
Greece	204	3.31	62.22	59.41	65.04	43.32	40.39	46.25	50.36	49.30	54.64	34.90	30.93	38.87
Hungary	205	3.03	54.86	51.42	58.29	49.01	46.35	51.67	55.32	51.09	57.07	36.67	32.75	40.59
India	205	28.26	66.29	63.27	69.31	62.07	58.94	65.21	61.06	52.03	58.26	40.86	36.49	45.24
Indonesia	203	20.24	64.73	61.61	67.85	55.10	52.23	57.97	58.02	55.19	61.58	34.47	30.40	38.54
Japan	203	1.8	52.13	48.78	55.49	47.12	44.17	50.08	47.75	52.87	58.96	37.00	32.83	41.16
Kenya	204	31.87	56.24	52.34	60.14	53.86	50.35	57.38	54.14	52.15	58.22	32.75	28.36	37.13
Mexico	205	12.2	59.49	56.02	62.96	49.24	45.85	52.62	55.60	43.65	50.10	34.32	30.12	38.52
Morocco	205	18.34	58.21	54.87	61.54	50.62	47.34	53.90	51.22	52.52	58.12	40.73	36.35	45.11
New Zealand	207	3.94	58.56	55.63	61.49	46.61	43.64	49.58	51.40	54.90	61.14	34.82	30.99	38.65
Nicaragua	201	14.31	62.74	59.05	66.43	51.12	47.88	54.36	54.70	44.74	50.75	23.02	19.01	27.03
Philippines	203	21.63	61.55	58.47	64.62	52.60	49.52	55.68	56.55	52.43	58.77	30.25	26.06	34.43
Russia	202	4.93	53.50	50.13	56.88	50.04	47.07	53.02	52.06	53.46	59.64	43.21	39.49	46.94
Saudi Arabia	208	5.69	60.70	57.48	63.93	51.31	48.23	54.39	53.64	52.22	57.63	37.41	33.64	41.19
Singapore	204	2.05	58.01	55.08	60.95	50.11	47.36	52.87	51.97	50.07	55.97	32.85	29.20	36.50
South Africa	203	27.52	65.66	62.50	68.82	52.82	49.58	56.05	54.08	47.60	53.11	28.87	24.73	33.01
Spain	208	2.60	60.62	57.48	63.75	50.44	47.24	53.65	54.92	50.69	57.59	27.82	24.08	31.55
Sweden	203	2.08	60.21	57.08	63.34	49.37	46.68	52.07	53.02	51.24	58.15	36.31	32.35	40.27
Tunisia	204	14.49	58.92	55.90	61.95	50.06	47.11	53.01	53.50	52.14	58.59	39.48	35.23	43.72
Uganda	202	33.44	68.08	64.68	71.48	56.14	53.33	58.96	58.39	55.54	62.17	31.16	27.20	35.13
Ukraine	205	7.18	51.34	48.04	54.63	41.81	39.08	44.53	53.10	50.91	56.38	31.26	27.76	34.77
United Arab Emirates	203	6.40	62.50	59.34	65.67	53.94	50.80	57.08	55.14	50.58	56.42	34.89	31.02	38.76
United Kingdom	204	3.67	58.59	55.62	61.56	48.03	45.30	50.77	52.82	50.04	56.16	34.96	31.43	38.48
United States of America	202	5.56	59.12	55.88	62.37	51.45	48.46	54.44	50.36	49.22	54.89	33.18	29.66	36.71
Vietnam	206	15.88	62.95	59.67	66.22	49.38	45.62	53.15	55.37	47.93	54.51	36.54	32.15	40.94
Global sample	6128	11.14	59.85	59.26	60.44	50.88	50.32	51.44	53.92	53.37	54.47	33.89	33.17	34.61

CI: confidence interval.
[a]Death before 12 months old per 1000 live births.
[b]Scale from 0% to 100%.

Resource scarcity. We used GDP–PPP (gross domestic product – purchasing power parity) as an index for nation-level resource scarcity. This GDP per capita metric utilises a purchasing power parity adjustment so that an 'international dollar' has the same purchasing power over GDP as a US dollar has in the United States of America, where GDP is the gross sum of value from all resident producers in a country's economy (World Bank, 2020, 2021b). We extracted 2019 GDP–PPP data for each of the 30 countries in the sample.

Infant mortality. We extracted nation-level infant mortality data from a global dataset from 2019, which ranged from 1.8 (Japan) to 31.9 (Kenya) deaths per 1000 live births (World Bank, 2021a).

Individualism–collectivism and uncertainty avoidance. National scores were obtained from replications and extensions of Hofstede's original cross-cultural measurements (Hofstede et al., 2010). National scores were unavailable for Uganda and Nicaragua, leaving $k=28$ countries for these variables ($N=5725$, 7% missing data).

Holistic–analytic orientation. Consistent with the approach taken by Hornsey et al. (2018a), countries were categorised as holistic if predominantly culturally influenced by Buddhism, Confucianism, Hinduism, Jainism or Taoism. Five countries from our sample met this criterion – China, India, Japan, Singapore and Vietnam – while the remaining 25 countries were classified as non-holistic (analytic).

Procedure

Participants responded to an invitation from the third-party company to complete a survey entitled 'Perspectives on Society'. Participants completed items on their beliefs about heritability of human traits as part of a larger 155-item survey on emerging technologies. Participants were asked to rate heritability for each trait (intelligence, personality, body weight and criminality) and provided demographic information.

For any sites where the country survey was delivered in a language other than English, an extensive four-stage translation process was undertaken. First, the recruitment company Dynata arranged a translation of the original English survey. Second, we arranged for an independent English back-translation of the translated survey, which was reviewed by the project team for any deviations in meaning from the original English survey. Third, any changes were marked on the back-translation and sent for review to colleagues who were proficient in both English and the non-English language in question. Upon receiving the back-translation, the colleagues provided responses to the suggested changes, including whether the identified issues did indeed deviate from the original meaning, or was simply an artefact of the back-translation process. Fourth, these responses were again reviewed by Dynata's translation service before final clearance was given to begin local data collection.

Data preparation

Data were prepared for analysis using SPSS, R and Excel software packages (see https://osf.io/v62j4 for complete code). Publicly available country-level data were extracted from the source databases and merged with our person-level survey data to create a long-format dataset. Missing data were assessed at $<7\%$ by variable and treated with pairwise deletion (see Table 2 for n values).

Analytic strategy

We calculated country means with confidence intervals for each trait from the raw data and ranked countries from highest to lowest. We obtained published h^2 for each of the four traits from reputable twin studies and meta-analysis (Kendler et al., 2015; Polderman et al., 2015), then examined deviation from these values by calculating the percentage of people across the pooled global sample who selected a response greater than or less than the published h^2.

To test the exploratory cultural hypotheses, we used a type of linear regression called mixed effects modelling. We did so because our survey data are grouped or 'nested' in structure.

Traditional linear regression tests relationships between variables, but these analyses generally assume that all data points are independent. This creates potential problems for grouped or nested datasets (also called ‘hierarchical’), where data will be non-independent because they come from within groups. A classic example is the school results of children (level 1) within classrooms (level 2) within schools (level 3). In application to this research, our survey data are grouped data because they were collected from people grouped within countries. In short, we used mixed effects modelling to account for this nested structure of the data: people (level 1) within countries (level 2).

Mixed effect models were tested and *p*-values and the proportion of variance explained (R^2) estimated using R packages lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2020) and r2glmm (Jaeger, 2017). Visualisations were prepared with R packages ggplot2 (Allen et al., 2021; Wickham et al., 2021) and highcharter (Kunst et al., 2020). Mixed effects models were tested with maximum-likelihood estimation and *p*-values using the Satterthwaite method, and we then calculated marginal and conditional R^2 values for fixed and random effects (Nakagawa and Schielzeth, 2013). These R^2 values provide an estimate of the effect size for the whole model as well as each predictor, on each of the outcome variables.

For each trait, we estimated the fixed effect of person-level (demographics) and country-level (cross-national) predictors with a random effect of country. This allowed us to focus on the specific contributions of the measured or ‘fixed’ components, while accounting for unmeasured or ‘random’ contributions of the grouping variable (country). For model stability, we tested the panel of cross-national predictors in separate serial models, rather than combined in a single model.

To further test our models containing infant mortality (i.e. after detecting the infant mortality effect), we processed a more stringent post hoc model, in which GDP–PPP was added as a level 2 fixed effect. We did so to separate out shared variance given the known relationship between national economic performance and population health outcomes. In other words, we added GDP–PPP to create a more stringent test and to rule out the possibility that infant mortality was only a proxy measure for resource scarcity, since these variables are highly correlated (Ensor et al., 2010; O’Hare et al., 2013; Schady and Smitz, 2010). We examined the model coefficients for the fixed effects of interest, along with R^2 values and confidence intervals, to determine which cultural predictors, if any, were significantly associated with the four lay heritability belief outcomes.

3. Results

We first addressed our RQs with respect to global characterisation of lay heritability beliefs. With respect to RQ1, averaging across traits, the five countries that most strongly attributed traits to genetic factors were India (M=57.6%), Uganda (53.4%), Indonesia (53.1%), United Arab Emirates (51.6%) and Colombia (51.6%), while the lowest heritability values were found in Ukraine (M=44.4%), Japan (46.0%), Greece (47.7%), New Zealand (47.9%) and Nicaragua (47.9%; see Figure 1, Supplemental Figure S1). Table 2 presents all national means for each of the traits.

With respect to RQ2, relative to published heritability estimates (h^2) from twin studies (see Figure 2), a majority of participants overestimated the heritability of personality, with 74% of the global sample endorsing heritability of $>$ .44 (Polderman et al., 2015), and to a lesser extent, intelligence, with 58% of the sample estimating heritability at $>$ .51 (Polderman et al., 2015). In contrast, most people underestimated the heritability of body weight, for which 70% of the sample endorsed heritability of $<$ .63 (Polderman et al., 2015), and criminality, for which 63% estimated $<$ .46 (Kendler et al., 2015).

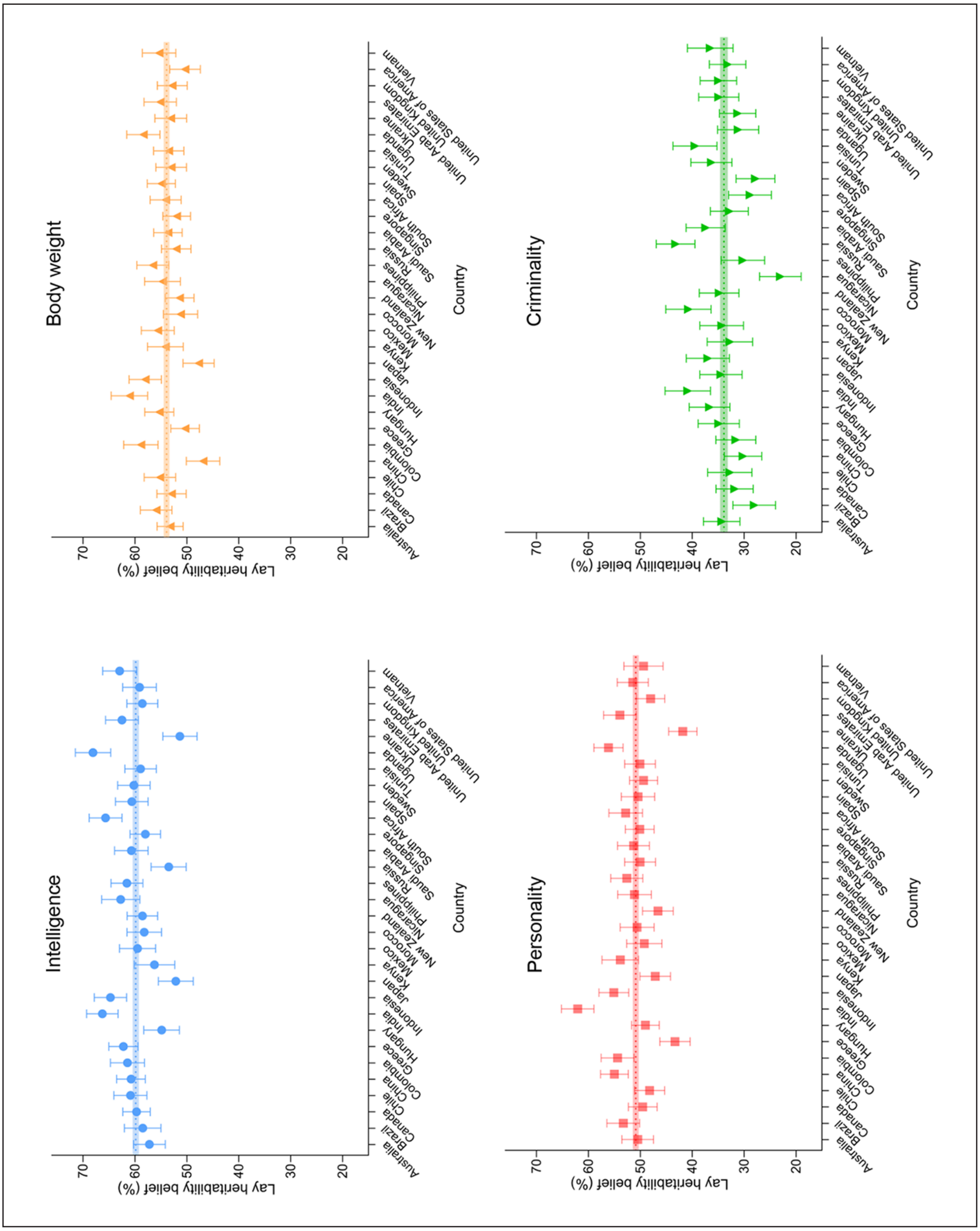

Figure 1. National means, 95% confidence intervals (CI) and global mean comparators for lay heritability beliefs. Dotted line is global mean with 95% CI.

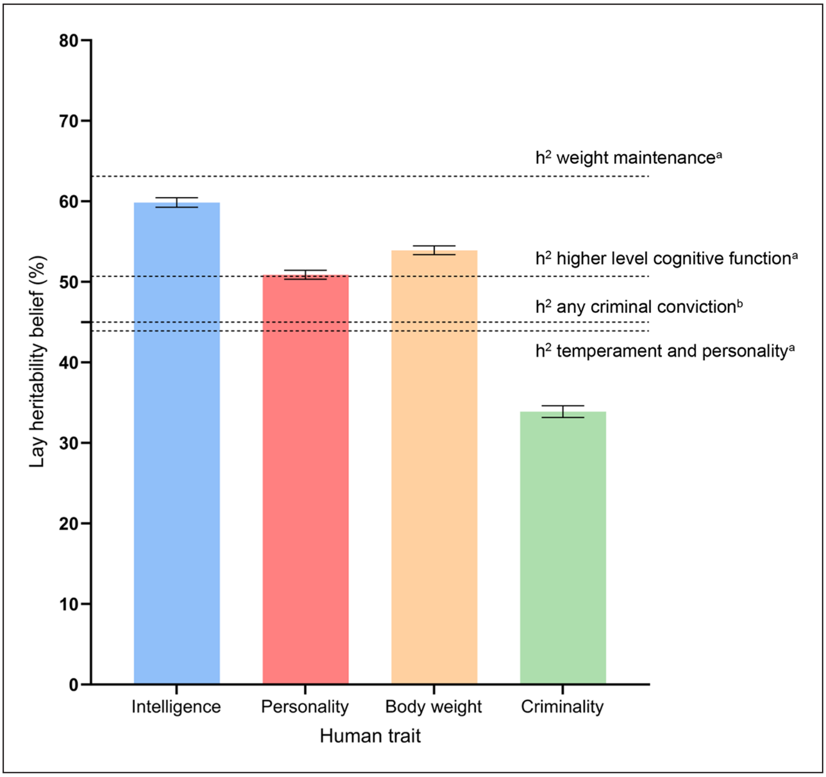

Figure 2. Global mean public heritability estimates with h^2 comparators. Error bars are 95% confidence intervals. Dotted lines are h^2 estimates.
[a]Polderman et al. (2015).
[b]Kendler et al. (2015).

Overall, criminality was seen as less attributable to genes than the other traits, with a global mean estimate of 33.9% heritability (95% confidence interval (CI): 33.16, 34.61), and a worldwide modal response of 0 (see Figure 1, Supplemental Figure S2). Lay estimates for criminality were nearly half the mean global estimate for intelligence (59.9% heritability, 95% CI: 59.26, 60.44).

We then tested the exploratory cultural hypotheses (H1–H5) examining whether cultural factors might explain observed patterns in lay heritability beliefs. Using linear mixed-effects regression, we ran a series of models in which we estimated the fixed effect of person-level (demographics) and country-level (cross-national) variables on lay heritability beliefs, and included a random effect of country in each of the models. The data do not support an association between lay heritability beliefs and resource scarcity (H1), individualism–collectivism (H3), uncertainty avoidance (H4) or holistic–analytic orientation (H5).

However, we identified a modest effect of infant mortality (H2) on lay heritability beliefs about intelligence, personality, and body weight, but not criminality (see summary in Table 3). Specifically, people from countries with high infant mortality tend to ascribe higher genetic heritability for these traits than do people from low-infant mortality countries (see Figure 3).

We also processed more stringent post hoc models, in which GDP–PPP was added as a level 2 fixed effect. With the addition of person- and country-level covariates (age, gender, education, country, infant mortality, GDP), the infant mortality models explained between 1.6% and 3.5% of

Table 3. Summary of mixed-effect models of lay heritability beliefs for intelligence, personality, body weight and criminality.

Outcome	Predictor	Fixed effect	*SE*	*t*	*p*	R^2	Upper CI	Lower CI	Model R^2m	Model R^2c
Model 1										
Intelligence									1.6%	3.0%
	Infant mortality	0.31	0.09	3.67	.001	.8%	0.014	0.004		
	GDP (PPP)	0.23	0.39	0.59	.560					
	Age	0.14	0.02	6.73	.000	.8%	0.013	0.004		
	Gender	1.01	0.60	1.68	.093					
	Education	−0.04	0.06	−0.78	.437					
Model 2										
Personality									2.3%	3.5%
	Infant mortality	0.38	0.08	4.94	.000	1.3%	0.02	0.008		
	GDP (PPP)	0.43	0.35	1.25	.223					
	Age	0.12	0.02	6.13	.000	.6%	0.011	0.003		
	Gender	1.25	0.57	2.21	.027					
	Education	−0.28	0.05	−5.11	.000	.4%	0.008	0.002		
Model 3										
Body weight									.8%	1.6%
	Infant mortality	0.17	0.07	2.62	.014	0.3%	0.006	0.001		
	GDP (PPP)	−0.21	0.30	−0.70	.489					
	Age	0.05	0.02	2.45	.014					
	Gender	0.70	0.57	1.24	.215					
	Education	−0.12	0.05	−2.19	.029					
Model 4										
Criminality									1.0%	2.6%
	Infant mortality	0.01	0.11	0.10	.920					
	GDP (PPP)	−0.22	0.50	−0.45	.659					
	Age	0.19	0.03	7.45	$<.001$	0.9%	0.015	0.005		
	Gender	1.05	0.74	1.43	.154					
	Education	−0.09	0.07	−1.30	.195					

CI: confidence interval; GDP: gross domestic product; PPP: purchasing power parity.

global variance in lay heritability beliefs (see Table 3). We also found small effects of age on heritability beliefs ($R^2 < .009$, see Table 3), with older participants estimating higher heritability for all traits except body weight.

4. Discussion

Scientific debate has long transcended the nature–nurture dichotomy in favour of a more interactive model. In 1874, Sir Francis Galton (1874) had already underlined this nuance in *English Men* [sic] *of Science: Their Nature and Nurture*, observing that '. . . the highest natural endowments may be starved by defective nurture, while no carefulness of nurture can overcome the evil tendencies of an intrinsically bad physique, weak brain, or brutal disposition' (p. 13). Adopting modern parlance, and a rather more global frame of reference, this study provides a worldwide characterisation of lay heritability beliefs about body weight, intelligence, personality

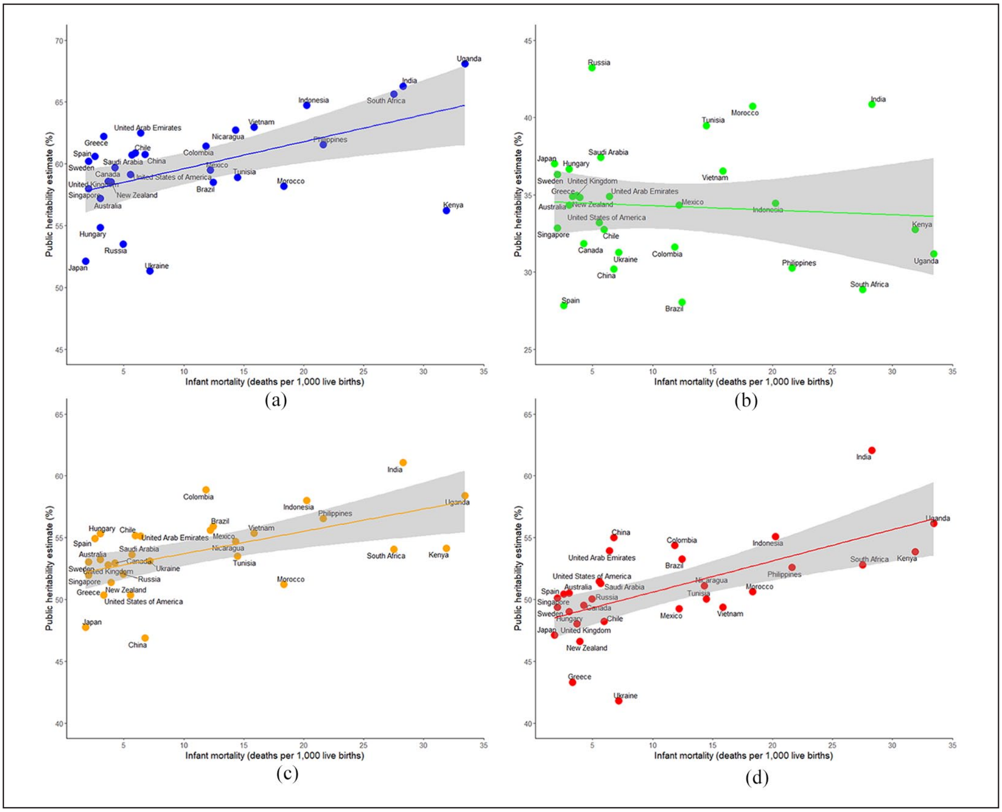

Figure 3. Scatterplots of national infant mortality by lay heritability beliefs. Single-level regression line with standard error band. (a) Intelligence, (b) Criminality, (c) body weight and (d) personality.

and criminality; and undertakes a novel exploration into the cultural correlates of lay heritability beliefs.

This study captures global patterns in people's beliefs about trait heritability and identifies a cross-national association with infant mortality. Globally, mean lay beliefs are generally not in lockstep with h^2 as estimated by twin studies, with a majority of people overestimating the heritability of personality, and to a lesser extent intelligence, while underestimating the heritability of body weight and criminality. The findings indicate that people tend to estimate heritability differently depending on the nature of the referent trait, which is generally consistent with single-nation and otherwise restricted sample studies (Willoughby et al., 2019). In particular, criminality was perceived as less heritable than the other traits, with the global mode response for criminality being zero. Possible explanations relate to the fact that criminality is a negatively valenced (i.e. antisocial) trait. Evidence from exclusively US samples identifies an asymmetry in trait genetic attributions – to the extent people are motivated to punish antisocial characteristics like criminality, they tend to reject genetic explanations in favour of non-heritable causes such as personal responsibility (Lebowitz et al., 2019). This asymmetry could explain why criminality has attracted lower heritability beliefs globally, but is less instructive with respect to the absence of an infant mortality effect for this outcome measure, which future research may explore.

We found that people from countries with high infant mortality tend to ascribe higher genetic heritability for these traits than do people from low-infant mortality countries. Furthermore, the effects of infant mortality remained statistically reliable after the addition of covariates, namely, individual demographic variables of age, sex, education and national GDP. We reason that the tragic conditions of high national infant mortality highlight differential offspring fitness within kinship groups (Trivers, 1974), require psychological accommodation (Currie et al., 2019; Vig et al., 2021) and may give genetic explanations psychological utility in explaining human traits that are important for survival (Dar-Nimrod and Heine, 2011; Heine et al., 2017).

While gender and education were not associated with lay heritability beliefs, we did identify small effects of age, whereby older respondents were more likely to attribute higher heritability for all traits except body weight. These small effects of age on lay heritability beliefs are consistent with previous research, which has shown endorsement of genetic explanations for human traits are positively associated with age (Ashida et al., 2011; Gericke et al., 2017).

Implications

This study is the first to comprehensively address the prior oversampling of high- and middle-income countries in lay heritability beliefs research. Confidence in the findings comes from multi-nation sampling of several thousand individuals across 30 countries in all inhabited continents, and our use of nested modelling to account for person- and country-level variance simultaneously. This research is part of a broader movement responding to concerns about failures in representation within genetics research itself, and has aimed to include the voices of people from the Global South alongside more frequently sampled populations. The study makes an important contribution to this literature by quantifying lay beliefs in countries that are typically neglected in social science research, creating an evidence base for the generation of future research questions and hypotheses. It also provides a worldwide baseline against which future studies can investigate changes over time, or test the impact of interventions with respect to genetic beliefs, knowledge and education.

The study also illuminates the challenges inherent in the deficit model of science communication, which assumes differences between lay heritability beliefs and published heritability estimates are the result of deficits in scientific knowledge. More broadly, comparison of lay heritability beliefs with published estimates in the scientific literature is conceptually and technically complex. The comparison depends not only on dissemination of scientifically established concepts and knowledge, but also in part on the reliability and representativeness of heritability estimates themselves, which are constantly being refined in light of new data, methodologies and applications (Adeyemo et al., 2021; Claussnitzer et al., 2020; Harden, 2021; Plomin and von Stumm, 2018; Polderman et al., 2015; Savage et al., 2018; Visscher et al., 2017; Yang et al., 2015), and which vary across the lifespan (Bergen et al., 2012; Elks et al., 2012; Haworth et al., 2010; Polderman et al., 2015), populations and cultures (Martin et al., 2019; Sirugo et al., 2019). This sets a high bar for lay members of the public in terms of acquiring and maintaining 'accurate' beliefs about the heritability of traits. This is especially fraught given disparities in access to genetics education and representation in genetics databases and repositories themselves.

Unfortunately, the paucity of global research into lay heritability beliefs reflects broader under-representation of diverse global samples within genomic research (Martin et al., 2019; Sirugo et al., 2019). Bias in genetic sample composition reduces the accuracy and predictive value of genetic markers and creates a barrier for underrepresented groups to benefit from clinical applications (Adeyemo et al., 2021; Martin et al., 2019). This study serves as a reminder of the risks and challenges associated with concepts of 'accuracy' with respect to lay heritability beliefs. Underrepresentation in original genetic databases generates a ripple effect of inequality, and hinders global comparison of lay beliefs with trait h^2, because the true extent to which trait heritability varies is not accurately known for all populations. Therefore, diverse cultural perspectives are needed to build a stronger global understanding of how genomic findings translate into public perceptions and concerns (Schnittker, 2015; Wauters and Van Hoyweghen, 2016), and the extent to which genomic findings reflect true trait heritability at culturally relevant levels of analysis.

Limitations and future directions

Our data are cross-sectional and cannot illuminate directionality of relationships, or a time course for the development or maintenance of lay heritability beliefs. Measurement strategy meant that most variables were assessed with single-item measures, which provides efficient quantification and minimises participant burden, but necessarily compromises on depth. Consistent measurement of lay heritability beliefs across studies would also support meta-analysis as the area of research further matures. Together, this would strengthen the evidence base from which specific and justified recommendations for science communicators could be developed and tested.

With respect to the cultural models, causal inferences are theoretically justified but should be substantiated with other research designs, including qualitative and longitudinal quantitative studies. The posited relationship with infant mortality is exploratory, modest and requires replication. Other latent explanatory variables such as national health infrastructures and education systems may play a role in shaping people's lay beliefs about trait heritability. The addition of country GDP–PPP and individual demographic variables such as education goes some way to addressing such concerns, but does not rule out or confirm a mechanism.

Future research that takes local granularities into account would also be beneficial – while most country-level factors examined in this study did not play a significant role, their impacts are not experienced the same by all citizens within a country. This disparity may reflect the operation of hidden (unmeasured) moderators at a local or regional level, which future research could investigate. Global perspectives are needed to elaborate these findings, qualitatively and quantitatively. For instance, data from semi-structured interviews could enhance quantitative findings with respect to how lay heritability beliefs are conceptualised, shared or disputed.

5. Conclusion

Worldwide lay beliefs about the magnitude of trait heritability are informative for science communicators, educators and policy makers, because lay heritability beliefs reveal whether, and the extent to which, transformational genomic discovery has translated and disseminated around the world. The scientific debate has long transcended nature versus nurture dichotomy (Barlow, 2019; Jayaratne et al., 2009), and this study's findings show global public appreciation for this, given that the modal response is 50% heritability for three of the four traits studied. The infant mortality effect suggests that contextual cross-national factors are associated with people's lay beliefs about heritability. This research offers a pioneering foray into how culture and heritability beliefs intersect, and provides an international baseline from which future research can extend. Alongside its contribution to science communication research, investigators at the genomic frontier can use this information to consider how their scientific output translates to impact worldwide beliefs about fundamental aspects of humanity.

Acknowledgements

We thank Dr Samuel Pearson for input into the development of data visualisations.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funded in part by an Australian Research Council Discovery Project grant (grant no. DP180100294) awarded to Mathew Hornsey and Taciano Milfont.

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Supplemental material

Supplemental material for this article is available online.

References

Abdellaoui A, Yengo L, Verweij KJH and Visscher PM (2023) 15 years of GWAS discovery: Realizing the promise. *American Journal of Human Genetics* 110(2): 179–194.

Adeyemo A, Balaconis MK, Darnes DR, Fatumo S, Granados Moreno P, Hodonsky CJ, et al. (2021) Responsible use of polygenic risk scores in the clinic: Potential benefits, risks and gaps. *Nature Medicine* 27: 1876–1884.

Allen M, Poggiali D, Whitaker K, Marshall TR, van Langen J and Kievit RA (2021) Raincloud plots: A multi-platform tool for robust data visualization. *Wellcome Open Research* 4: 63.

Alper JS and Beckwith J (1993) Genetic fatalism and social policy: The implications of behavior genetics research. *Yale Journal of Biology and Medicine* 66(6): 511–524. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2588854/

Ashida S, Goodman M, Pandya C, Koehly LM, Lachance C, Stafford J, et al. (2011) Age differences in genetic knowledge, health literacy and causal beliefs for health conditions. *Public Health Genomics* 14(4–5): 307–316.

Barlow FK (2019) Nature vs. nurture is nonsense: On the necessity of an integrated genetic, social, developmental, and personality psychology. *Australian Journal of Psychology* 71(1): 68–79.

Bates D, Mächler M, Bolker BM and Walker SC (2015) Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67(1): 1–48.

Bergen SE, Gardner CO and Kendler KS (2012) Age-related changes in heritability of behavioral phenotypes over adolescence and young adulthood: A meta-analysis. *Twin Research and Human Genetics* 10(3): 423–433.

Boerwinkel DJ, Yarden A and Waarlo AJ (2017) Reaching a consensus on the definition of genetic literacy that is required from a twenty-first-century citizen. *Science & Education* 26(10): 1087–1114.

Bowling BV, Huether CA, Wang L, Myers MF, Markle GC, Dean GE, et al. (2008) Genetic literacy of undergraduate non–science majors and the impact of introductory biology and genetics courses. *BioScience* 58(7): 654–660.

Brechman JM, Lee CJ and Cappella JN (2009) Lost in translation? A comparison of cancer-genetics reporting in the press release and its subsequent coverage in lay press. *Science Communication* 30(4): 453–474.

Bronfenbrenner U and Ceci SJ (1994) Nature-nurture reconceptualized in developmental perspective: A bioecological model. *Psychological Review* 101(4): 568–586.

Buniello A, MacArthur JAL, Cerezo M, Harris LW, Hayhurst J, Malangone C, et al. (2019) The NHGRI-EBI GWAS Catalog of published genome-wide association studies, targeted arrays and summary statistics 2019. *Nucleic Acids Research* 47(D1): D1005–D1012.

Byrd WC and Ray VE (2015) Ultimate attribution in the genetic era: White support for genetic explanations of racial difference and policies. *The ANNALS of the American Academy of Political and Social Science* 661(1): 212–235.

Carver RB, Rødland EA and Breivik J (2012) Quantitative frame analysis of how the gene concept is presented in tabloid and elite newspapers. *Science Communication* 35(4): 449–475.

Castera J and Clemen P (2014) Teachers’ conceptions about the genetic determinism of human behaviour: A survey in 23 countries. *Science & Education* 23(2): 417–443.
Chapman R, Likhanov M, Selita F, Zakharov I, Smith-Woolley E and Kovas Y (2019) New literacy challenge for the twenty-first century: Genetic knowledge is poor even among well educated. *Journal of Community Genetics* 10(1): 73–84.
Cheung BY and Heine SJ (2015) The double-edged sword of genetic accounts of criminality: Causal attributions from genetic ascriptions affect legal decision making. *Personality and Social Psychology Bulletin* 41(12): 1723–1738.
Christensen KD, Jayaratne TE, Roberts JS, Kardia SLR and Petty EM (2010) Understandings of basic genetics in the United States: Results from a national survey of black and white men and women. *Public Health Genomics* 13(7–8): 467–476.
Claussnitzer M, Cho JH, Collins R, Cox NJ, Dermitzakis ET, Hurles ME, et al. (2020) A brief history of human disease genetics. *Nature* 577(7789): 179–189.
Currie ER, Christian BJ, Hinds PS, Perna SJ, Robinson C, Day S, et al. (2019) Life after loss: Parent bereavement and coping experiences after infant death in the neonatal intensive care unit. *Death Studies* 43(5): 333–342.
Dar-Nimrod I and Heine SJ (2011) Genetic essentialism: On the deceptive determinism of DNA. *Psychological Bulletin* 137(5): 800–818.
Dar-Nimrod I, Cheung BY, Ruby MB and Heine SJ (2014) Can merely learning about obesity genes affect eating behavior? *Appetite* 81: 269–276.
Dar-Nimrod I, Kuntzman R, MacNevin G, Lynch K, Woods M and Morandini J (2021) Genetic essentialism: The mediating role of essentialist biases on the relationship between genetic knowledge and the interpretations of genetic information. *European Journal of Medical Genetics* 64(1): 104119.
Donovan BM (2022) Ending genetic essentialism through genetics education. *Human Genetics and Genomics Advances* 3(1): 100058.
Donovan BM, Weindling M, Salazar B, Duncan A, Stuhlsatz M and Keck P (2021) Genomics literacy matters: Supporting the development of genomics literacy through genetics education could reduce the prevalence of genetic essentialism. *Journal of Research in Science Teaching* 58(4): 520–550.
Dougherty MJ (2009) Closing the gap: Inverting the genetics curriculum to ensure an informed public. *The American Journal of Human Genetics* 85(1): 6–12.
Elks C, Den Hoed M, Zhao JH, Sharp S, Wareham N, Loos R, et al. (2012) Variability in the heritability of body mass index: A systematic review and meta-regression. *Frontiers in Endocrinology* 3: 29.
Ensor T, Cooper S, Davidson L, Fitzmaurice A and Graham WJ (2010) The impact of economic recession on maternal and infant mortality: Lessons from history. *BMC Public Health* 10(1): 727.
Eyck TAT and Williment M (2003) The national media and things genetic: Coverage in the New York Times (1971–2001) and the Washington Post (1977-2001). *Science Communication* 25(2): 129–152.
Faul F, Erdfelder E, Buchner A and Lang AG (2009) Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods* 41(4): 1149–1160.
Galton F (1874) *English Men of Science: Their Nature and Nurture*. Macmillan & Co. Available at: https://galton.org/books/men-science/pdf/galton-men-science-1up.pdf
Gericke N, Carver R, Castéra J, Evangelista NAM, Marre CC and El-Hani CN (2017) Exploring relationships among belief in genetic determinism, genetics knowledge, and social factors. *Science & Education* 26(10): 1223–1259.
Giangrande EJ and Turkheimer E (2021) Race, ethnicity, and the Scarr-Rowe hypothesis: A cautionary example of fringe science entering the mainstream. *Perspectives on Psychological Science* 17: 696–710.
Grossmann I, Huynh AC and Ellsworth PC (2016) Emotional complexity: Clarifying definitions and cultural correlates. *Journal of Personality and Social Psychology* 111(6): 895–916.
Harden KP (2021) ‘Reports of my death were greatly exaggerated’: Behavior genetics in the postgenomic era. *Annual Review of Psychology* 72: 37–60.
Haworth CMA, Wright MJ, Luciano M, Martin NG, de Geus EJC, van Beijsterveldt CEM, et al. (2010) The heritability of general cognitive ability increases linearly from childhood to young adulthood. *Molecular Psychiatry* 15(11): 1112–1120.

Heine SJ and Buchtel EE (2009) Personality: The universal and the culturally specific. *Annual Review of Psychology* 60: 369–394.

Heine SJ, Dar-Nimrod I, Cheung BY and Proulx T (2017) Essentially biased: Why people are fatalistic about genes. In: Olson JM (ed.) *Advances in Experimental Social Psychology* (Vol. 55). Cambridge, MA: Academic Press, pp. 137–192.

Henrich J, Heine SJ and Norenzayan A (2010) The weirdest people in the world? *Behavioral and Brain Sciences* 33(2–3): 61–83.

Hofstede G, Hofstede GJ and Minkov M (2010) *Cultures and Organizations: Software of the Mind*, 3rd edn. New York, NY: McGraw-Hill.

Hong SJ (2019) Cross-cultural differences in the influences of spiritual and religious tendencies on beliefs in genetic determinism and family health history communication: A teleological approach. *Journal of Religion and Health* 58(5): 1516–1536.

Hornsey MJ (2020) Why facts are not enough: Understanding and managing the motivated rejection of science. *Current Directions in Psychological Science* 29(6): 583–591.

Hornsey MJ and Fielding KS (2017) Attitude roots and Jiu Jitsu persuasion: Understanding and overcoming the motivated rejection of science. *American Psychologist* 72(5): 459–473.

Hornsey MJ, Bierwiaczonek K, Sassenberg K and Douglas KM (2023) Individual, intergroup and nation-level influences on belief in conspiracy theories. *Nature Reviews Psychology* 2: 85–97.

Hornsey MJ, Greenaway KH, Harris EA and Bain PG (2018a) Exploring cultural differences in the extent to which people perceive and desire control. *Personality and Social Psychology Bulletin* 45(1): 81–92.

Hornsey MJ, Harris EA and Fielding KS (2018b) The psychological roots of anti-vaccination attitudes: A 24-nation investigation. *Health Psychology* 37(4): 307–315.

Jaeger B (2017) r2glmm: Computes R squared for mixed (multilevel) models. Available at: https://CRAN.R-project.org/package=r2glmm

Jayaratne TE, Gelman SA, Feldbaum M, Sheldon JP, Petty EM and Kardia SLR (2009) The perennial debate: Nature, nurture, or choice? Black and white Americans' explanations for individual differences. *Review of General Psychology* 13(1): 24–33.

Keller J (2005) In genes we trust: The biological component of psychological essentialism and its relationship to mechanisms of motivated social cognition. *Journal of Personality and Social Psychology* 88(4): 686–702.

Kendler KS, Maes HH, Lönn SL, Morris NA, Lichtenstein P, Sundquist J, et al. (2015) A Swedish national twin study of criminal behavior and its violent, white-collar and property subtypes. *Psychological Medicine* 45(11): 2253–2262.

Kunst J, Agostinho N, Noriega D, Hadley MJ, Flores E, Kilfoyle D, et al. (2020) highcharter: A wrapper for the 'Highcharts' library. Available at: https://CRAN.R-project.org/package=highcharter

Kuznetsova A, Brockhoff PB, Christensen RHB and Pødenphant Jensen S (2020) lmerTest: Tests in linear mixed effects models. Available at: https://CRAN.R-project.org/package=lmerTest

Lebowitz MS and Ahn W-K (2014) Effects of biological explanations for mental disorders on clinicians' empathy. *Proceedings of the National Academy of Sciences* 111(50): 17786–17790.

Lebowitz MS, Tabb K and Appelbaum PS (2019) Asymmetrical genetic attributions for prosocial versus antisocial behaviour. *Nature Human Behaviour* 3(9): 940–949.

Lee NM, Abitbol A and VanDyke MS (2020) Science communication meets consumer relations: An analysis of twitter use by 23andMe. *Science Communication* 42(2): 244–264.

Leitgöb H, Seddig D, Asparouhov T, Behr D, Davidov E, De Roover K, et al. (2023) Measurement invariance in the social sciences: Historical development, methodological challenges, state of the art, and future perspectives. *Social Science Research* 110: 102805.

Lynch KE, Morandini JS, Dar-Nimrod I and Griffiths PE (2019) Causal reasoning about human behavior genetics: Synthesis and future directions. *Behavior Genetics* 49: 221–234. Available at: https://link.springer.com/content/pdf/10.1007/s10519-018-9909-z.pdf

Martin AR, Kanai M, Kamatani Y, Okada Y, Neale BM and Daly MJ (2019) Clinical use of current polygenic risk scores may exacerbate health disparities. *Nature Genetics* 51(4): 584–591.

Morosoli JJ, Colodro-Conde L, Barlow F and Medland S (2019) Public understanding of behavioral genetics: Integrating heuristic thinking, motivated reasoning and planned social change theories for better communication strategies. *Behavior Genetics* 49: 469–477.

Morosoli JJ, Colodro-Conde L, Barlow FK and Medland SE (2021) Investigating perceived heritability of mental health disorders and attitudes toward genetic testing in the United States, United Kingdom, and Australia. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics* 186(6): 341–352.

Morosoli JJ, Colodro-Conde L, Barlow FK and Medland SE (2024) Scientific clickbait: Examining media coverage and readability in genome-wide association research. *PLoS ONE* 19(1): e0296323.

Nakagawa S and Schielzeth H (2013) A general and simple method for obtaining R2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution* 4(2): 133–142.

Nisbett RE, Peng K, Choi I and Norenzayan A (2001) Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review* 108(2): 291–310.

O'Hare B, Makuta I, Chiwaula L and Bar-Zeev N (2013) Income and child mortality in developing countries: A systematic review and meta-analysis. *Journal of the Royal Society of Medicine* 106(10): 408–414.

Owen MJ and Williams NM (2021) Explaining the missing heritability of psychiatric disorders. *World Psychiatry* 20(2): 294–295.

Parrott RL, Kahl ML, Ndiaye K and Traeder T (2012) Health communication, genetic determinism, and perceived control: The roles of beliefs about susceptibility and severity versus disease essentialism. *Journal of Health Communication* 17(7): 762–778.

Parrott RL, Silk KJ and Condit C (2003) Diversity in lay perceptions of the sources of human traits: Genes, environments, and personal behaviors. *Social Science & Medicine* 56(5): 1099–1109.

Plomin R and von Stumm S (2018) The new genetics of intelligence. *Nature Reviews Genetics* 19(3): 148–159.

Polderman TJC, Benyamin B, de Leeuw CA, Sullivan PF, van Bochoven A, Visscher PM, et al. (2015) Meta-analysis of the heritability of human traits based on fifty years of twin studies. *Nature Genetics* 47(7): 702–709.

Rende R and Plomin R (1992) Diathesis-stress models of psychopathology: A quantitative genetic perspective. *Applied & Preventive Psychology* 1: 177–182.

Savage JE, Jansen PR, Stringer S, Watanabe K, Bryois J, de Leeuw CA, et al. (2018) Genome-wide association meta-analysis in 269,867 individuals identifies new genetic and functional links to intelligence. *Nature Genetics* 50(7): 912–919.

Schady N and Smitz M-F (2010) Aggregate economic shocks and infant mortality: New evidence for middle-income countries. *Economics Letters* 108(2): 145–148.

Schnittker J (2015) The politics of health beliefs: Cross-national evidence. In: Jacobs Kronenfeld J (ed.) *Education, Social Factors, and Health Beliefs in Health and Health Care Services* (Vol. 33). Bingley: Emerald, pp. 17–42.

Selita F and Kovas Y (2018) Genes and GINI: What inequality means for heritability. *Journal of Biosocial Science* 51(1): 18–47.

Singer E, Antonucci TC, Burmeister M, Couper MP, Raghunathan TE and Van Hoewyk J (2007) Beliefs about genes and environment as determinants of behavioral characteristics. *International Journal of Public Opinion Research* 19(3): 331–353.

Sirugo G, Williams SM and Tishkoff SA (2019) The missing diversity in human genetic studies. *Cell* 177(1): 26–31.

Trivers RL (1974) Parent-offspring conflict. *American Zoologist* 14(1): 249–264. Available at: http://www.jstor.org/stable/3881986

Venter JC, Adams MD, Myers EW, Li PW, Mural RJ, Sutton GG, et al. (2001) The sequence of the human genome. *Science* 291(5507): 1304–1351.

Vig PS, Lim JY, Lee RWL, Huang H, Tan XH, Lim WQ, et al. (2021) Parental bereavement – Impact of death of neonates and children under 12 years on personhood of parents: A systematic scoping review. *BMC Palliative Care* 20(1): 136.

Visscher PM, Wray NR, Zhang Q, Sklar P, McCarthy MI, Brown MA, et al. (2017) 10 years of GWAS discovery: Biology, function, and translation. *American Journal of Human Genetics* 101(1): 5–22.

Wang C and Coups EJ (2010) Causal beliefs about obesity and associated health behaviors: Results from a population-based survey. *International Journal of Behavioral Nutrition and Physical Activity* 7(1): 19.

Wauters A and Van Hoyweghen I (2016) Global trends on fears and concerns of genetic discrimination: A systematic literature review. *Journal of Human Genetics* 61(4): 275–282.

Wickham H, Chang W, Henry L, Pedersen TL, Takahashi K, Wilke C, et al. (2021) ggplot2: Create elegant data visualisations using the grammar of graphics. Available at: https://CRAN.R-project.org/package=ggplot2

Willoughby EA, Love AC, McGue M, Iacono WG, Quigley J and Lee JJ (2019) Free will, determinism, and intuitive judgments about the heritability of behavior. *Behavior Genetics* 49(2): 136–153.

World Bank (2020) *Purchasing Power Parities and the Size of World Economies: Results from the 2017 International Comparison Program*. Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/33623

World Bank (2021a) Mortality rate, infant (per 1,000 live births) 1960-2019. Available at: https://data.worldbank.org/indicator/SP.DYN.IMRT.IN

World Bank (2021b) World development indicators: Economy. Available at: https://datatopics.worldbank.org/world-development-indicators/themes/economy.html

Yang J, Bakshi A, Zhu Z, Hemani G, Vinkhuyzen AAE, Lee SH, et al. (2015) Genetic variance estimation with imputed variants finds negligible missing heritability for human height and body mass index. *Nature Genetics* 47(10): 1114–1120.

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