Technical Report
Debate Post-Hoc Analysis

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1 Introduction

The usage of the terms *nature* and *nurture* in explaining human behaviour dates back over 100 years to Galton's *Hereditary Genius* where he speculated on which was more important.[1] While people have tried to understand each other since before antiquity, it was this publication that set forth the multi generational debate of *nature vs nurture* in those terms.

The early twentieth century was saturated with uncertainty about how much any given facet of human behaviour was attributed or dominated by his or her nature or nurture.[2] From the 1920s-1960s the school of thought known as purist behaviourism was formed and solidified.[3]

The 1970s-1980s was a contest between ideological groups such as the Marxists who favoured behaviourism against genetic and biological determinism.[4] This was a period of time that was more oriented around whether it was politically and ethically acceptable to talk about "modernist facts" than about a genuine public interest in the science of behaviour.[5]

While there are still debates outside of behavioural biology departments and journals, ever since the 1990's the debate among relevant researchers has been over. From a culture perspective this was due to famed publications like *The Nurture Assumption: Why Children Turn Out the Way They Do* by Judith Harris[6] and *The Blank Slate: The Modern Denial of Human Nature* by Steven Pinker.[7] However, it was before these publications that twin studies became easier and techniques in molecular biology and biochemistry allowed probing genes and genetic markers. *The Human Genome Project* was published in 2001[8], which led to an explosion of research that followed after that searched for correlations and mechanisms between the genome and behaviour.

While the debate of nature vs nurture is essentially over in its broadest form, there remains questions about how, where, and when each matter. Modern courses on behavioural biology strongly emphasize that it is a complex interplay between biology and environment, and not one or the other being more important, that is the best way to understand the origins of behaviour.[9] One of the emphases of modern behavioural biology is that we must look at various timescales and contexts from genes, molecular machines, cells, tissues, organ systems, organisms, populations, communities, ecosystems precisely right now all the way back hundreds of millions of years.[10]

2 Main Arguments

This section will look at the main arguments that my side made during the debate, as well as those from the other side for which I was able to collect notes on during the debate.

My team and I focused on demonstrated that environment had an influence on behaviour by formally defining there to be a statistical relationship, while our opponents focused on arguing that biology was more important than environment. These are not the same claim, but what we tacitly agreed upon was that both environment and biology had an influence. To that extend, they tacitly conceded our point.

2.1 Biological and Environmental Influence

It is not controversial that either of biology or environment influence behaviour, and it has not been so for decades. There is an enormous literature demonstrating various biological and environmen-

tal influences, including the operant conditioning and conformity studies that my team used in the debate. I'll briefly recap what those points were here, and then broaden to some general findings of the literature.[1]

The studies we presented in our debate are all classics from the psychology literature. The first study we presented was the little Albert study in where an infant was startled while in the presence of white and fuzzy things such as a rabbit, and this repeated stimulation conditioned the child to generalize to be fearful of other animals that are white and fuzzy. While it is unclear whether this generalized to the full equivalence class of mutually white and fuzzy animals, it was an example of environment instilling broader implications for behaviour than just responding to an immediately stimulus with fight or flight responses.

The second and third study both looked at aspects of conformity. The Asch experiment had involved a lineup of confederates who pretended to be participants, and measuring how often the participant conformed to the confederates when they were instructed to lie vs give the true answer.[11] This experiment showed a statistically and practically significant result of conformity.[11] The Baron experiment came later, and explored the how task difficulty and task importance interact to influence conformity.[12] If the task was not manipulated in importance and the task was easy, then we saw similar results to the Asch experiment.[12] When the task was easy but the importance increased, then subjects were less likely to conform. That initially shows us some confidence in our autonomy, but when the task was difficult and important then people deferred to the opinions of others.[12] Both studies show how our social environment can affect our behaviour, and the latter study additionally showed that our perceptions of task difficulty and importance can conditionally make us more likely to conform.

Now, let's return to the bigger picture. There's an excellent paper called *Top 10 Replicated Findings from Behavioural Genetics* by Plomin et al. that nicely summarizes what the last few decades of research can say about the influence of biology on behaviour.[13] I will summarize these points here.

The first finding is that *all psychological traits show significant and substantial genetic influence.*[13] Humans are biological systems, and we can't avoid the fact that genes heavily influence what we are. This study emphasizes heritability, acknowledges that genome-wide-associations are lower, but doesn't delve into the implications.[2]

The second finding is that *no traits are 100% heritable*, and are typically found in the 30-50% range.[13] This again affirms the important point that biology almost always matters, but also that biology doesn't explain everything about the variation in almost any trait. Even individual differences in human height are 90%, not 100%, heritable.[13]

The third finding was that *heritability is caused by many genes of small effect.*[13] This claim is slightly problematic because they do not fully address what they mean by *causality*, but they do emphasize the role of controls. On this point they return to genome-wide association studies, giving examples such of diagnosable schizophrenia and years of schooling as traits with surprisingly low explained variance in terms of SNPs.[13] In case of years of schooling, only 0.0002 of its variance was

[1] Our opponents focused on some studies that emphasize the 'importance' of biology over environment, which I address in later sections. Their claim about biological influence on behaviour was its evolutionary precedent.

[2] I will return to this point later

explained by SNPs in a sample size of 120 000 individuals.[14] This is a stark contrast to the early results of Gregor Mendel that seemed to support a strict genetic determinism between genotype and phenotype.

The fourth finding was that *phenotypic correlations between psychological traits show significant and substantial genetic mediation.*[13] By *mediation*, they are not necessarily referring to *mediated causation* discussed in the causal inference literature.[15] Rather, they are referring to type of partial covariance where the genetic factors are influencing the association itself between the psychological traits. This should serve as a reminder that the collection of dependencies and conditional independences between behaviour and biology can be complicated, and even counterintuitive.

The fifth finding was that the *heritability of intelligence increases throughout development.*[13] While this point is evidently specific to intelligence, it establishes a proof of concept that we should be mindful of when considering other traits: heritability can change with age. The literature summarized here seems to suggest that genetically influenced factors such as dementia affect measures of intelligence indirectly.[13] This point is yet another example of conditional independence in how biology affects behaviour.

The sixth point is conceptually similar to the last, that age-to-age stability (of traits) is mainly due to genetics.[13] The authors claim that longitudinal studies show this to be the case, with the implication that genes keep coding for the same traits (in the complex way that they do) throughout a person's life.[13] While the fifth finding about intelligence had an identifiable biological basis in age-related cognitive decline, most changes in behaviour throughout a lifetime (after accounting for biological development before adulthood) are due to environmental conditions.[13]

The seventh point is counter-intuitive at first: *most measures of the 'environment' show significant genetic influence.*[13] You should be wondering, "how can measures of the environment itself be heritable?". This strange result is made sense of by understanding that humans themselves select, modify, and create environments **through their behaviour**. This finding illustrates how coupled the concepts of environment, biology, behaviour and heritability are.

The eighth finding is that *most associations between environmental measures and psychological traits are significantly mediated genetically.*[13] Much of what I discussed in the previous findings carries over to this one. We find that there is partial association between environmental measures and psychological traits that depends as a function of genetics. Like in the 7th point, we cannot fully separate these broad concepts of environment, biology, behaviour and heritability.

The ninth finding is that *most environmental effects are not shared by children growing up in the same family.*[13] Which is to say, that just because two siblings ostensibly growing up in the same environment in terms of the same house, parents, rooms, school, etc, doesn't mean that their environments are identical in every way. Their bedrooms may be different. Their genders may change influence how they are socially treated. Their individual experiences within or beyond their shared environment can be different. In summary, there are many things that can actually differ in the environment of individuals that are not measured (and may not be measurable).

The final and tenth finding is *abnormal is normal.*[13] There has been research that looks at whether various psychological traits diagnosed as conditions are qualitatively different than normal traits, and that perhaps these conditions are quantitative extremes instead of environment and

genetic factors rather than fundamentally different. This tacitly speaks to the notion that there is a latent space induced by environmental and biological variables, and that some of the diseases and mental disorders we observe may just be outside of the 'typical region' that most people exist within.

What should be clear from summarizing the previous ten reproduced research findings is that the interactions between biology, environment, and behaviour are coupled together. As shown in Figure 2.1, we should be expecting these factors to be influenced each other, rather than any one being universally more important.[3]

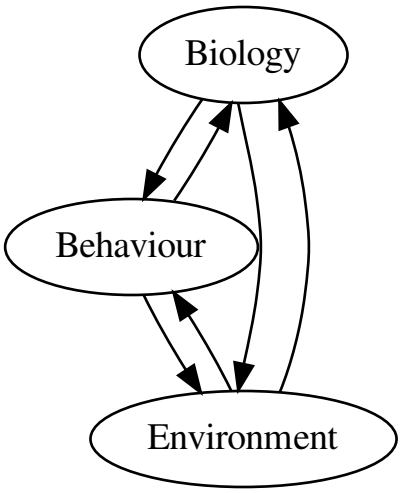

Figure 1: A directed graph illustrating how behaviour, biology, and environment are reciprocally influencing each other.

2.2 Ultimate Contingency

One might frame behaviour as intrinsically contingent on the biological system that performs those behaviours, while variation in behaviours are partly explainable by environmental factors. From this perspective, one might say that biology is the more important cause of behaviour. However, this argument can be flipped upside down by the deeper history of Earth. During the existence of life on this plant, natural selection has shaped organisms down to the level of their genomes to be compatible with the environment. So on an evolutionary timescale, the biology itself is partly a function of environment.

What about the very first genes? Well, the first organisms (with genes or not) were generated by early environmental chemistry. Even life itself is fundamentally contingent on environmental conditions, right back to the beginning.

[3]Note that this is not a valid causal model.

So if behaviour is contingent on biology, and biology is ultimately contingent on environment, then behaviour itself is ultimately contingent on environment. However, as discussed in the previous section about influence, I don't feel that this is the best way to look at things.

2.3 Explained Variance

One of the frequently used measures of a model's explanatory power is its coefficient of determination, and it is used in studies looking at the main effects and interactions among variables that include behavioural genetics. One of the first difficulties in the interpretation of this measure is that it is not truly a single concept, and it would be useful to briefly outline them. The first definition should be familiar to students that have undertaken a course in introductory statistics, which gives the coefficient of determination to be the square of Pearson's product-moment correlation coefficient given in 1.[4]

$$R^2 = \left[\frac{\sigma_{x,y}}{\sigma_x \sigma_y}\right]^2 = \left[\frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})}\sqrt{\sum_i (y_i - \bar{y})}}\right]^2 \tag{1}$$

This definition can also be thought of as squaring the ratio of covariance between two variables by the product of their standard deviations. We can assume that this is the ratio of explained variance of one variable given another when we assume a simple linear relationship with a fitted intercept, but further generalization is possible. The generalization that works on multivariate and non-linear models is defined as

$$R^2 = 1 - \frac{SS_{res}}{SS_{total}} = 1 - \frac{\sum_i (y_i - f_i)^2}{\sum_i (y_i - \bar{x})^2}$$

where SS_{res} is the sum of square errors between a model f, and SS_{total} is the sum of square errors of the total sample. This definition can be used with a variety of different model structures from simple linear regression to artificial neural networks, and can work with different optimizers like limited-memory Broyden-Fletcher-Goldfarb-Shanno or the various forms of gradient descent. This generalization has a price in that it is possible for a model to make worse predictions than the 'baseline' of predicting the average, so negative values are technically possible. However, most models thoughtfully selected by a researcher will perform better than simply predicting the average value.[5]

Now that we've considered a general understanding of the coefficient of determination, I want to return to one of modelling assumptions that researchers often make. In the overwhelming majority of studies in both the biological and psychological literature, linearity is assumed. There are arguments to be had for and against linear models. On the positive, they are straightforward to specify, parameterize and interpret. As a negative, real-world variables are not always linear and a non-linear model would have greater representational capacity. A typical counterargument to this is that linear models are relatively simple, which helps avoid overfitting and get acceptable fit. A counter to this counterargument is that there are regularization techniques like elasticnet, optimal stopping, and cross-validation to reduce overfitting. Furthermore, a linear model can achieve acceptable fit until hypothesis testing and not be the optimal model. These arguments can be further branched, but hopefully this gives the flavour the debate. The issue for using regression models

[4] Note that the degrees of freedom have cancelled out.

[5] I've trained a lot of different models, and I have never found one to perform worse than predicting each value to be average.

to calculate coefficients of determination is that researchers may not be using the best available models, and as a result the coefficients of determination found in the literature may not be as accurate as they could be.

Leaving the mathematical grievances aside, there is an empirical issue observed when considering explained variance of behavioural traits in terms of genetic traits. One common type of study in this area are genome-wide association studies. Since these are based null-hypothesis tests with a large number of tests being performed, family-wise error rate is a concern. What tends to be found in genome-wide association studies of human behaviour is that many markers are significantly correlated with the trait, but often weakly. For example, variation in homosexual vs heterosexual mate choice in humans seems to be explained by at most 8 to 25% of the total variation among measured single nucleotide polymorphisms (SNPs).[16] This immediately implies the compliment, that 75 to 92% of the variation was *not* explained by SNPs. While SNPs are not the only form of genetic variation, they provide particularly valuable information. They are the highest-resolution form of genetic variation since they occur at only a single nucleotide, and they are the most common form of variation making them comparable across multiple people or taxa.

2.4 Twin Studies and Heritability

Our opponents focused on twin studies, which are a research approach that attempts to decide how heritable a trait is. Twin studies include one or both of monozygotic and dizygotic twins, which have different implications. Monozygotic twins nominally share all of their genes due to originating from the same initial zygote (i.e. the first cell), whereas dizygotic twins involved concurrent fertilization of separate eggs that result in separate zygotes.[17]

During the cross-examination they emphasized the heritability of the Big Five personality traits. Let's linger on this a moment to understand what this model it. The Big Five is a latent factor model that finds 5 groups of latent variables called *openness*, *conscientiousness*, *extroversion*, *agreeableness*, and *neuroticism*.[18] Each of these latent variables is a linear combination of the original variables which are survey responses, and from a linear algebra perspective it finds a change in basis such that the covariance is minimized while the variance is left out of the objective function.[19, 20] These survey responses are self-reported descriptions of how a person sees themselves, and therefore there is an aspect of subjectivity to the measurements. It is a limitation of latent factor analysis, at least in practice, that it assumes linearity without much precedent. Given that it explains over half of the variance in survey responses, it should be granted that it has psychometric validity[6] even if its external validity is more difficult to justify.

While I didn't obtain the precise citation that my opponents referred to, I noted that they claimed that 40% of the variation in personality (according to a twins study) were explained by biological factors while only 17% were explained by environmental factors. If 40+17=57% of the variation is accounted for by biology and environment, it is unclear what my opponents thought of the remaining 100-57=43%. This unexplained variance could further support biology, or bolster environment to explain more variation than biology. Or, it could speak to methodological issues surrounding twin studies. One study looked at the heritability of the individual personality traits, finding that 15% of the variation in neuroticism and 21% of the variation in openness were explained

[6] Which is to say, there is a statistically identifiable pattern in survey responses indicating five groupings of questions

by genetic factors, while the other three personality traits were not significantly explained by genetic factors.[20] This study did not explicitly discuss environmental factors beyond speculating that they might explain the unexplained variance.[20] An older study found that over 40% of each personality trait was explained by genetic factors using twin studies [21], however this study relied on a twin study design that did not take into account interaction effects between environment and biology as is standard in modern studies of behaviour.[13]

Heritability is itself a counter-intuitive measure, and is not well-understood by the general population. While is intuitively correct is that genetic factors have a significant influence on the development of nearly all human traits, heritability does not measure how 'genetically inheritable' the trait is, nor inform us on the causes of the trait, nor even the relative influence of the environment in developing that trait.[22] The amount of variance attributable to genetic differences based on genome-wide association studies is often much less than estimates based on comparing relatives.[23] This disparity has been termed as "missing heritability".[24, 25] A biology-favouring interpretation of missing heritability is to claim that other biological processes that are not linear functions of gene expression, while an environment-favouring interpretation would claim that perhaps more variation than originally assumed is due to environmental factors at different stages of life.

Heritability is still considered a broadly-applicable concept[26], but it remains unclear how exactly to explain the interactions between genes, environment and behaviour.[27, 28]

2.5 Bird Songs

My opponents made a claim that bird songs are genetically determined. According to a study by Ken Otter et al 2020 at the University of Northern British Columbia, songbirds have regional dialects and are capable of learning songs across an entire continent.[29] Previous works by other researchers seem to support the idea that song birds learn songs from each other socially.[30, 31, 32]

3 Learning Outcomes

This section discusses skills and knowledge that became relevant to the debate that were not themselves topics of the debate.

3.1 Listening Skills

One of the types of skills I really noticed is valuable in a debate format is listening skills. This was especially true for the questioning and cross-examination portion of the debate, for both the person asking the question and the person responding to a question. If a leading question[7] is asked, noticing it creates an opportunity for the person responding to either point out the problem with the question or give a redirected answer.

Listening to the opening remarks carefully allowed for the crafting of rebuttals, and getting their position correct from the beginning is beneficial for knowing when the other claim says *"that's not our position"* whether they are being inconsistent.

[7]Example: The literal and direct response to "*Have you stopped beating your dog? Yes, or no?*" will sound bad regardless of which answer is given.

3.2 Critical Thinking Skills and Self Knowledge

I have not studied critical thinking skills since my early 20's, but the debate quickly reminded me of the importance of the topics of cognitive biases and logical fallacies. From a truth-speaking perspective, the goal is to keep yourself and others accountable to using valid arguments, sound premises, and the consideration of alternative hypotheses or interpretations. Within a debate format, the goal of a debater is not to seek the truth but rather to defend a position. In hindsight, more preparation could have allowed me to use my opponent's biases against them in argument, as well as utilize biases of the audience.

However, there is also a philosophical divide for me here that I am first-and-foremost a truth-seeker, not a debater. I'd rather have conversations with people I disagree with rather than debate them, and that self-knowledge is important for knowing where and how I want to influence the world. This debate was a good reminder for me to brush up on critical thinking skills, and pursue the truth as I find it.

3.3 Game Theory

In this subsection I want to share how this debate led my thinking and reading into game theory and related topics.

I realized that some aspects of the debate are not well-defined, as an exact objective function. However, there were still qualitative aspects to which game theory applies. Table 3.3 shows a perceived payoff matrix indicating how I believe people behave in a debate based on how positive or negative their point is compared to the opponents. Most of their attention will be on making their side look relatively better, and thus (+,-) or (-,+) are observed the most frequently. With topics that are advantageous to both players, I believe we can expect to see conditional independence. One factor that could affect this (+,+) case is the degree to which people perceive a point already made as *belonging* to the other team, in contrast to others who would make a point of affirming that their side also benefits from the point. The (0,0) topics may be brought up simply to fill time, especially when avoiding a difficult question/cross-examination, but would not be expected if a participant had an advantageous point to make. Lastly are the (-,-) points that are disadvantageous for both sides, and I would expect are generally avoided. There is a point to be made that some players might try to make a (-,-) point if they believe that the opponent did not see that the disadvantage goes both ways, but this is definitely the most risky because you may inspire your opponent to explore the same point from the opposing perspective.

Table 1: Perceived payoff matrix for bringing up debate points that are (A)dvantagous, (N)eutral, and (D)isadvantagous between two opposing players. Blue indicates that preference toward the action will exhibit conditional independence, red indicates that the topic will be avoided, and green indicates the topic will be avoided.

	A	N	D
A	(+,+)	(+,-)	(+,-)
N	(-,+)	(0,0)	(+,-)
D	(-,+)	(-,+)	(-,-)

Another game theory aspect of this debate is that it is not an infinite, nor arbitrarily repeated, game. This would lead one to think that 'cheating' is more likely because retaliation in future debates is unlikely. However, the class is also a cohort of students that have been in the same program for years, so while the debate may or may not be repeated, the social interactions are. The web-based demonstration *The Evolution of Trust* serves as a simulation-driven argument that repeated games can change the dominating strategy in multiplayer games.[33] As the clinical psychologist Jordan Peterson has emphasized in his books on personal development, there is a hierarchy of games and that it is not as important to win every game as it is to win the 'metagame' of being allowed to play in as many games as possible.[34, 35] Jordan Peterson's views are often controversial and metaphorical, but I think a concrete notion can be extracted from this point. If we consider a metagame to be a game that concerns a collection of games, we can consider the objective function for the metagame to be a (linear or non-linear) function of the performance of the players on those games. One such metagame could include the notion of sequences of games being played by a collection of players, and that the probability of a given player being allowed to play in the next game depends on their history of 'cheating' in previous games. Even more specific to Jordan Peterson's point would be such a metagame where the goal is to be allowed to play as many games as possible, and that this long-term view justifies not being malicious in debates even from a selfish perspective.

There are two substantial limitations to interpreting our debate in terms of game theory. The first is that the objective function isn't necessarily well-defined, so the process of how to go about maximizing that objective function is also not well-defined. The second limitation ties into the first, that people are not always 'rational' in the sense of trying to optimize an objective function for a game. Researchers such as Daniel Kahneman and Amos Tversky have developed alternative concepts such as prospect theory[36] and ecological rationality[37] to explain how people's behaviour differ from classic game theory approaches that incorporate psychological heuristics and biases.

4 Feedback

Something that I think is really valuable about the debate format is that it makes learning into a social exercise. While I've spent a lot of my learning career hidden away with books and papers, there is something valuable about the real-time feedback of how other people intellectually and emotionally react to your ideas. Having to respond in real time also cultivate quick thinking, which can be valuable in real-world situations where there isn't time to write a multi-page report on the positive and negative aspects of an idea. Sometimes persuasion must be given on demand.

One of the important limitations for framing a meaningful debate are the debate topics themselves. If the two sides are not mutually exclusive, then there is a possibility of arguing past each other. In this case, the debate position *Behaviour is coded in genes (Nature)* is not mutually exclusive from *Behaviour is learned from environment (Nurture)*. When debate topics are not mutually exclusive, it is possible for well-intentioned debaters to talk past each other.

One of the difficulties I had with this debate topic was that neither position was really my own from the beginning. My understanding is that this debate is already settled by the scientific community, and I accept that both environment and biology are essential in understanding behaviour. On the one hand the constraint of defending a position I didn't agree with forced me to be creative about how to defend it, but I also experienced cognitive dissonance in trying to frame my mind to my assigned position.

There's a notion in Law that if two opposing sides give the best representation they can for a position, that the truth will emerge as a result. There's at least some truth to this because your opponents will bring up points you had not thought of, but as my consideration of game theory suggests, it is also possible for some topics to be avoided by both sides of a debate. While the audience asking questions can help with this to some extent as a third party, sometimes talking about the truth makes everyone uncomfortable.[8]

5 Notes of the Individual

I took an unorthodox approach to preparing for the debate. I read papers while at my desk, and then practising talking out the subject matter on long walks in the woods. As such, my preparation did not rely on handwritten or digital notes for the debate. I also knew that I could rely on my background in molecular biology, an advantage I knew my opponents did not have. As such, I do not have any predebate notes. However, I can provide some notes I jotted down *during* the debate. They were written in a fashion where I only needed to understand them for the next half-hour, so they may not be self-explanatory.

- Note a question of importance/precedence or quantity
  - $$R^2_{genes} >> R^2_{environment}$$
- But are the behaviours "coded" in the genes
- Identical twin studies still have unexplained variance

[8] Topics having to do with sexuality, politics, and religion often have this problem.

  - and environmental measures themselves have heritability
  - and they have shared prenatal environment
- Birds learn songs
  - Find 'bird songs go viral' paper
- Fish $\sim$ sex change triggered by social status: ciclids; environment first vs biology
- Generational knowledge?! How about learning how to use technology that never existed when our ancestors evolved the neocortex, hypothalamus, or even cerebellum for that matter!
- Heritability tends to be 30-50%
- Selection pressures $\rightarrow$ genes $\rightarrow$ (environment $\rightarrow$ biology $\rightarrow$ behaviour)

References

[1] F. Galton. *Hereditary genius.* D. Appleton, 1891.

[2] Franz Boas. *The Mind of Primitive Man.* 1911.

[3] John Watson. *Behaviourism.* 1930.

[4] Richard Lewontin. *Not in our genes : biology, ideology, and human nature.* Pantheon Books, New York, 1984.

[5] Alfie Kohn. *The brighter side of human nature : altruism and empathy in everyday life.* Basic Books, New York, 1990.

[6] Judith Harris. *The nurture assumption : why children turn out the way they do.* Free Press, New York, 1998.

[7] Steven Pinker. *The blank slate : the modern denial of human nature.* Viking, New York, 2002.

[8] J. Craig Venter, Mark D. Adams, Eugene W. Myers, Peter W. Li, Richard J. Mural, Granger G. Sutton, Hamilton O. Smith, Mark Yandell, Cheryl A. Evans, Robert A. Holt, Jeannine D. Gocayne, Peter Amanatides, Richard M. Ballew, Daniel H. Huson, Jennifer Russo Wortman, Qing Zhang, Chinnappa D. Kodira, Xiangqun H. Zheng, Lin Chen, Marian Skupski, Gangadharan Subramanian, Paul D. Thomas, Jinghui Zhang, George L. Gabor Miklos, Catherine Nelson, Samuel Broder, Andrew G. Clark, Joe Nadeau, Victor A. McKusick, Norton Zinder, Arnold J. Levine, Richard J. Roberts, Mel Simon, Carolyn Slayman, Michael Hunkapiller, Randall Bolanos, Arthur Delcher, Ian Dew, Daniel Fasulo, Michael Flanigan, Liliana Florea, Aaron Halpern, Sridhar Hannenhalli, Saul Kravitz, Samuel Levy, Clark Mobarry, Knut Reinert, Karin Remington, Jane Abu-Threideh, Ellen Beasley, Kendra Biddick, Vivien Bonazzi, Rhonda Brandon, Michele Cargill, Ishwar Chandramouliswaran, Rosane Charlab, Kabir Chaturvedi, Zuoming Deng, Valentina Di Francesco, Patrick Dunn, Karen Eilbeck, Carlos Evangelista, Andrei E. Gabrielian, Weiniu Gan, Wangmao Ge, Fangcheng Gong, Zhiping Gu, Ping Guan, Thomas J. Heiman, Maureen E. Higgins, Rui-Ru Ji, Zhaoxi Ke, Karen A. Ketchum, Zhongwu Lai, Yiding Lei, Zhenya Li, Jiayin Li, Yong Liang, Xiaoying Lin, Fu Lu, Gennady V. Merkulov, Natalia Milshina, Helen M. Moore, Ashwinikumar K Naik, Vaibhav A. Narayan, Beena Neelam, Deborah Nusskern, Douglas B. Rusch, Steven Salzberg, Wei Shao, Bixiong Shue, Jingtao Sun,

Zhen Yuan Wang, Aihui Wang, Xin Wang, Jian Wang, Ming-Hui Wei, Ron Wides, Chunlin Xiao, Chunhua Yan, Alison Yao, Jane Ye, Ming Zhan, Weiqing Zhang, Hongyu Zhang, Qi Zhao, Liansheng Zheng, Fei Zhong, Wenyan Zhong, Shiaoping C. Zhu, Shaying Zhao, Dennis Gilbert, Suzanna Baumhueter, Gene Spier, Christine Carter, Anibal Cravchik, Trevor Woodage, Feroze Ali, Huijin An, Aderonke Awe, Danita Baldwin, Holly Baden, Mary Barnstead, Ian Barrow, Karen Beeson, Dana Busam, Amy Carver, Angela Center, Ming Lai Cheng, Liz Curry, Steve Danaher, Lionel Davenport, Raymond Desilets, Susanne Dietz, Kristina Dodson, Lisa Doup, Steven Ferriera, Neha Garg, Andres Gluecksmann, Brit Hart, Jason Haynes, Charles Haynes, Cheryl Heiner, Suzanne Hladun, Damon Hostin, Jarrett Houck, Timothy Howland, Chinyere Ibegwam, Jeffery Johnson, Francis Kalush, Lesley Kline, Shashi Koduru, Amy Love, Felecia Mann, David May, Steven McCawley, Tina McIntosh, Ivy McMullen, Mee Moy, Linda Moy, Brian Murphy, Keith Nelson, Cynthia Pfannkoch, Eric Pratts, Vinita Puri, Hina Qureshi, Matthew Reardon, Robert Rodriguez, Yu-Hui Rogers, Deanna Romblad, Bob Ruhfel, Richard Scott, Cynthia Sitter, Michelle Smallwood, Erin Stewart, Renee Strong, Ellen Suh, Reginald Thomas, Ni Ni Tint, Sukyee Tse, Claire Vech, Gary Wang, Jeremy Wetter, Sherita Williams, Monica Williams, Sandra Windsor, Emily Winn-Deen, Keriellen Wolfe, Jayshree Zaveri, Karena Zaveri, Josep F. Abril, Roderic Guigó, Michael J. Campbell, Kimmen V. Sjolander, Brian Karlak, Anish Kejariwal, Huaiyu Mi, Betty Lazareva, Thomas Hatton, Apurva Narechania, Karen Diemer, Anushya Muruganujan, Nan Guo, Shinji Sato, Vineet Bafna, Sorin Istrail, Ross Lippert, Russell Schwartz, Brian Walenz, Shibu Yooseph, David Allen, Anand Basu, James Baxendale, Louis Blick, Marcelo Caminha, John Carnes-Stine, Parris Caulk, Yen-Hui Chiang, My Coyne, Carl Dahlke, Anne Deslattes Mays, Maria Dombroski, Michael Donnelly, Dale Ely, Shiva Esparham, Carl Fosler, Harold Gire, Stephen Glanowski, Kenneth Glasser, Anna Glodek, Mark Gorokhov, Ken Graham, Barry Gropman, Michael Harris, Jeremy Heil, Scott Henderson, Jeffrey Hoover, Donald Jennings, Catherine Jordan, James Jordan, John Kasha, Leonid Kagan, Cheryl Kraft, Alexander Levitsky, Mark Lewis, Xiangjun Liu, John Lopez, Daniel Ma, William Majoros, Joe McDaniel, Sean Murphy, Matthew Newman, Trung Nguyen, Ngoc Nguyen, Marc Nodell, Sue Pan, Jim Peck, Marshall Peterson, William Rowe, Robert Sanders, John Scott, Michael Simpson, Thomas Smith, Arlan Sprague, Timothy Stockwell, Russell Turner, Eli Venter, Mei Wang, Meiyuan Wen, David Wu, Mitchell Wu, Ashley Xia, Ali Zandieh, and Xiaohong Zhu. The sequence of the human genome. *Science*, 291(5507):1304–1351, February 2001.

[9] Robert Sapolsky. Lecture collection — human behavioural biology - youtube. https://www.youtube.com/playlist?list=PL848F2368C90DDC3D, 2011. (Accessed on 11/28/2020).

[10] Robert Sapolsky. *Behave : the biology of humans at our best and worst.* Penguin Press, New York, New York, 2017.

[11] S.E Asch. Effects of group pressure on the modification and distortion of judgments. *Carnegie Press*, pages 177–190, 1951.

[12] Robert S. Baron, Joseph A. Vandello, and Bethany Brunsman. The forgotten variable in conformity research: Impact of task importance on social influence. *Journal of Personality and Social Psychology*, 71(5):915–927, 1996.

[13] Robert Plomin, John C. DeFries, Valerie S. Knopik, and Jenae M. Neiderhiser. Top 10 replicated findings from behavioral genetics. *Perspectives on Psychological Science*, 11(1):3–23, January 2016.

[14] C. A. Rietveld, S. E. Medland, J. Derringer, J. Yang, T. Esko, N. W. Martin, H.-J. Westra, K. Shakhbazov, A. Abdellaoui, A. Agrawal, E. Albrecht, B. Z. Alizadeh, N. Amin, J. Barnard, S. E. Baumeister, K. S. Benke, L. F. Bielak, J. A. Boatman, P. A. Boyle, G. Davies, C. de Leeuw, N. Eklund, D. S. Evans, R. Ferhmann, K. Fischer, C. Gieger, H. K. Gjessing, S. Hagg, J. R. Harris, C. Hayward, C. Holzapfel, C. A. Ibrahim-Verbaas, E. Ingelsson, B. Jacobsson, P. K. Joshi, A. Jugessur, M. Kaakinen, S. Kanoni, J. Karjalainen, I. Kolcic, K. Kristiansson, Z. Kutalik, J. Lahti, S. H. Lee, P. Lin, P. A. Lind, Y. Liu, K. Lohman, M. Loitfelder, G. McMahon, P. M. Vidal, O. Meirelles, L. Milani, R. Myhre, M.-L. Nuotio, C. J. Oldmeadow, K. E. Petrovic, W. J. Peyrot, O. Polasek, L. Quaye, E. Reinmaa, J. P. Rice, T. S. Rizzi, H. Schmidt, R. Schmidt, A. V. Smith, J. A. Smith, T. Tanaka, A. Terracciano, M. J. H. M. van der Loos, V. Vitart, H. Volzke, J. Wellmann, L. Yu, W. Zhao, J. Allik, J. R. Attia, S. Bandinelli, F. Bastardot, J. Beauchamp, D. A. Bennett, K. Berger, L. J. Bierut, D. I. Boomsma, U. Bultmann, H. Campbell, C. F. Chabris, L. Cherkas, M. K. Chung, F. Cucca, M. de Andrade, P. L. De Jager, J.-E. De Neve, I. J. Deary, G. V. Dedoussis, P. Deloukas, M. Dimitriou, G. Eiriksdottir, M. F. Elderson, J. G. Eriksson, D. M. Evans, J. D. Faul, L. Ferrucci, M. E. Garcia, H. Gronberg, V. Guthnason, P. Hall, J. M. Harris, T. B. Harris, N. D. Hastie, A. C. Heath, D. G. Hernandez, W. Hoffmann, A. Hofman, R. Holle, E. G. Holliday, J.-J. Hottenga, W. G. Iacono, T. Illig, M.-R. Jarvelin, M. Kahonen, J. Kaprio, R. M. Kirkpatrick, M. Kowgier, A. Latvala, L. J. Launer, D. A. Lawlor, T. Lehtimaki, J. Li, P. Lichtenstein, P. Lichtner, D. C. Liewald, P. A. Madden, P. K. E. Magnusson, T. E. Makinen, M. Masala, M. McGue, A. Metspalu, A. Mielck, M. B. Miller, G. W. Montgomery, S. Mukherjee, D. R. Nyholt, B. A. Oostra, L. J. Palmer, A. Palotie, B. W. J. H. Penninx, M. Perola, P. A. Peyser, M. Preisig, K. Raikkonen, O. T. Raitakari, A. Realo, S. M. Ring, S. Ripatti, F. Rivadeneira, I. Rudan, A. Rustichini, V. Salomaa, A.-P. Sarin, D. Schlessinger, R. J. Scott, H. Snieder, B. St Pourcain, J. M. Starr, J. H. Sul, I. Surakka, R. Svento, A. Teumer, H. Tiemeier, F. J. A. van Rooij, D. R. Van Wagoner, E. Vartiainen, J. Viikari, P. Vollenweider, J. M. Vonk, G. Waeber, D. R. Weir, H.-E. Wichmann, E. Widen, G. Willemsen, J. F. Wilson, A. F. Wright, D. Conley, G. Davey-Smith, L. Franke, P. J. F. Groenen, A. Hofman, M. Johannesson, S. L. R. Kardia, R. F. Krueger, D. Laibson, N. G. Martin, M. N. Meyer, D. Posthuma, A. R. Thurik, N. J. Timpson, A. G. Uitterlinden, C. M. van Duijn, P. M. Visscher, D. J. Benjamin, D. Cesarini, and P. D. Koellinger and. GWAS of 126, 559 individuals identifies genetic variants associated with educational attainment. *Science*, 340(6139):1467–1471, May 2013.

[15] Judea Pearl. *Causal inference in statistics : a primer*. John Wiley & Sons Ltd, Chichester, West Sussex, UK, 2016.

[16] Andrea Ganna, Karin J. H. Verweij, Michel G. Nivard, Robert Maier, Robbee Wedow, Alexander S. Busch, Abdel Abdellaoui, Shengru Guo, J. Fah Sathirapongsasuti, Paul Lichtenstein, Sebastian Lundström, Niklas Långström, Adam Auton, Kathleen Mullan Harris, Gary W. Beecham, Eden R. Martin, Alan R. Sanders, John R. B. Perry, Benjamin M. Neale, and Brendan P. Zietsch and. Large-scale GWAS reveals insights into the genetic architecture of same-sex sexual behavior. *Science*, 365(6456):eaat7693, August 2019.

[17] R Bortolus. The epidemiology of multiple births. *Human Reproduction Update*, 5(2):179–187, March 1999.

[18] S. Rothmann and E. P. Coetzer. The big five personality dimensions and job performance. *SA Journal of Industrial Psychology*, 29(1), October 2003.

[19] Ashis Sengupta. *Advances in multivariate statistical methods*. World Scientific, New Jersey, 2009.

[20] Keenan Pituch. *Applied multivariate statistics for the social sciences : analyses with SAS and IBM's SPSS*. Routledge, New York, 2016.

[21] Kerry L. Jang, W. John Livesley, and Philip A. Vemon. Heritability of the big five personality dimensions and their facets: A twin study. *Journal of Personality*, 64(3):577–592, September 1996.

[22] David S. Moore and David Shenk. The heritability fallacy. *Wiley Interdisciplinary Reviews: Cognitive Science*, 8(1-2):e1400, December 2016.

[23] Marcus W. Feldman and Sohini Ramachandran. Missing compared to what? revisiting heritability, genes and culture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 373(1743):20170064, February 2018.

[24] David Golan, Eric S. Lander, and Saharon Rosset. Measuring missing heritability: Inferring the contribution of common variants. *Proceedings of the National Academy of Sciences*, 111(49):E5272–E5281, November 2014.

[25] Eric Turkheimer. Still missing. *Research in Human Development*, 8(3-4):227–241, July 2011.

[26] Peter M. Visscher, William G. Hill, and Naomi R. Wray. Heritability in the genomics era — concepts and misconceptions. *Nature Reviews Genetics*, 9(4):255–266, March 2008.

[27] Eric Turkheimer. Genetic prediction. *Hastings Center Report*, 45(S1):S32–S38, September 2015.

[28] Jay Joseph. *The trouble with twin studies : a reassessment of twin research in the social and behavioral sciences*. Routledge, Taylor & Francis Group, New York, NY, 2015.

[29] Ken A. Otter, Alexandra Mckenna, Stefanie E. LaZerte, and Scott M. Ramsay. Continent-wide shifts in song dialects of white-throated sparrows. *Current Biology*, 30(16):3231–3235.e3, August 2020.

[30] Daniel J. Mennill, Stéphanie M. Doucet, Amy E.M. Newman, Heather Williams, Ines G. Moran, Ian P. Thomas, Bradley K. Woodworth, and D. Ryan Norris. Wild birds learn songs from experimental vocal tutors. *Current Biology*, 28(20):3273–3278.e4, October 2018.

[31] Douglas A. Nelson and Angelika Poesel. Does learning produce song conformity or novelty in white-crowned sparrows, zonotrichia leucophrys? *Animal Behaviour*, 78(2):433–440, August 2009.

[32] Michael D. Beecher. Birdsong learning as a social process. *Animal Behaviour*, 124:233–246, February 2017.

[33] The evolution of trust. https://ncase.me/trust/. (Accessed on 11/28/2020).

[34] Jordan Peterson. *12 rules for life : an antidote to chaos*. Random House Canada, Toronto, 2018.

[35] Jordan Peterson. *Maps of meaning : the architecture of belief*. Routledge, New York London, 1999.

[36] Daniel Kahneman and Amos Tversky. Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2):263, March 1979.

[37] A. Tversky and D. Kahneman. Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157):1124–1131, September 1974.