Height, human capital, and economic outcomes

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Motivation

- Height is positively correlated with income
  - 1-inch ↑ in height $\Longrightarrow$ ~1.4-2.9% ↑ earnings (Case Paxson, *JPE* 2008)
- Height is also positively correlated with cognitive performance (CP)
  - $r \approx 0.15 - 0.20$ (e.g., Beauchamp et al, *BG* 2011)
- ~80-90% of the variation in height is due to genetic factors

- 3 possible explanations for the (genetic) correlation:

i. **Assortative mating (AM):** taller females mate smarter/high-earning males, and/or vice-versa

ii. **Pleiotropy due to "social" model**:

↑height $\Longrightarrow$ ↑confidence $\Longrightarrow$ ↑human capital invest.$\Longrightarrow$↑income

- E.g., Persico et al. (*JPE* 2004) argue that boys who are taller during adolescence engage in sports, etc, which helps build human capital

iii. **"Biological" pleiotropy**: the causal effects of genes for height are correlated to those of genes for EA (even under zero AM)

Distinguishing between the 3 models

- **AM vs. pleiotropy:**
  Beauchamp et al. (*BG* 2011) show:
  - The cross-trait BF correlation between 2 traits can be influenced by both AM and pleiotropy
  - The cross-trait WF correlation is only affected by pleiotropy

- **Pleiotropy due to social model vs. biological pleiotropy:**
  - Under social model (and/or AM), genes that increase height by 1 cm should all have the same "effect" on income/human capital—regardless of where they're located in the genome
  - With biological pleiotropy, we should expect uneven genetic correlations between height and income/human capital throughout the genome

Exercise 1: comparing the cross-trait WF and BF correlations

- Correlations vary substantially between and within families
  - Height-EA: $\hat{r}_{BF} = 0.15;\ \ \hat{r}_{WF} = 0.06$
  - Height-CP: $\hat{r}_{BF} = 0.13;\ \ \hat{r}_{WF} = 0.07$
- Regressing EA on polygenic score of height in BF and WF regressions:
  - BF coefficient on score of height ~2.8 times larger than WF coefficient

$\Longrightarrow$ This suggests AM accounts for an important part of the correlation between height and EA/CP

Exercise 2: Do "genes for height" have uniform effects on EA throughout the genome

- Data from the UK Biobank (Bycroft et al. 2018)
- Use SNP-level annotations to different cell-type categories (Finucane et al. *NG* 2018) to create 3 polygenic scores of height:
  - (1) Using SNPs annotated to the Central Nervous System (CNS)
  - (2) Using SNPs annotated to Musculoskeletal-Connective (MSC) tissues (but not to the CNS)
  - (3) Using all other SNPs

- Regress $Y_i = \beta_0 + \beta_1 CNS_i + \beta_2 MSC_i + \beta_3 Other_i + \beta_4 Controls_i + \epsilon_i$
  - Y_i is either EA or CP or Income
  - $Controls_i$ include sex-specific birth year, top 20 PCs
  - Each polygenic score is normalized such that a 1-unit increase in the polygenic score increases height by 1 cm

Exercise 2: Do "genes for height" have uniform effects on EA throughout the genome

- Recall: $Y_i = \beta_0 + \beta_1 CNS_i + \beta_2 MSC_i + \beta_3 Other_i + \beta_4 Controls_i + \epsilon_i$

- Null hypothesis: under the social model only, $\beta_1 = \beta_2 = \beta_3$
  - Since each coefficient captures the effect of a 1cm increase in height on *Y*
  - Alternative models suggest these coefficients are unlikely to be the same

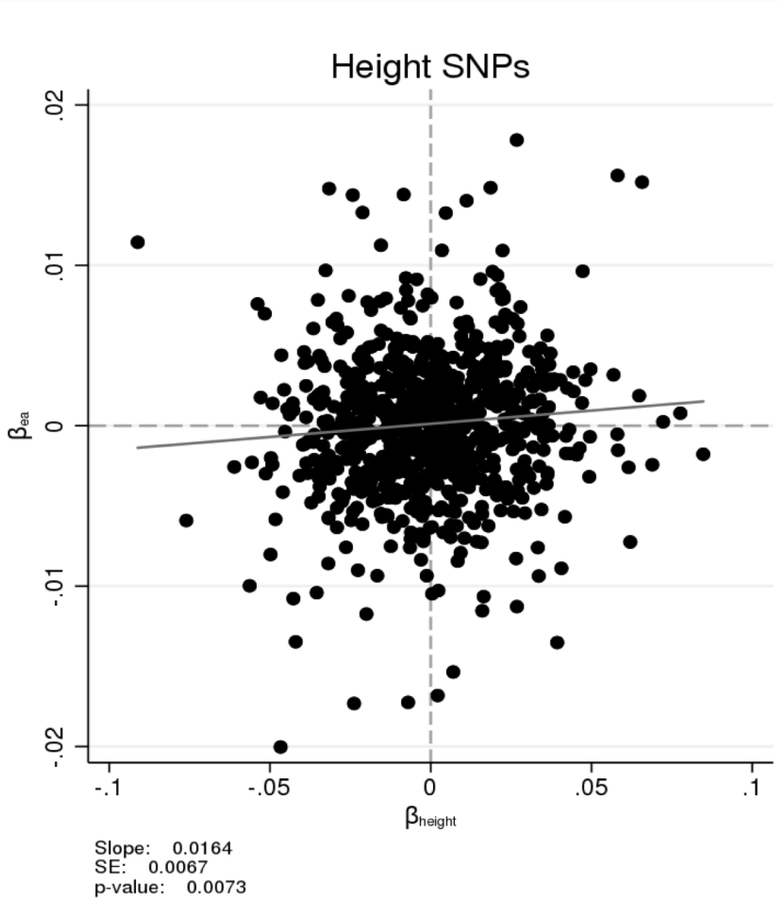
- Preliminary results for *Y*=*EA*:
  - BF regression: reject null that the coefficients are equal ($P = 0.02$)
  - WF regression: do not reject within families ($P = 0.80$)

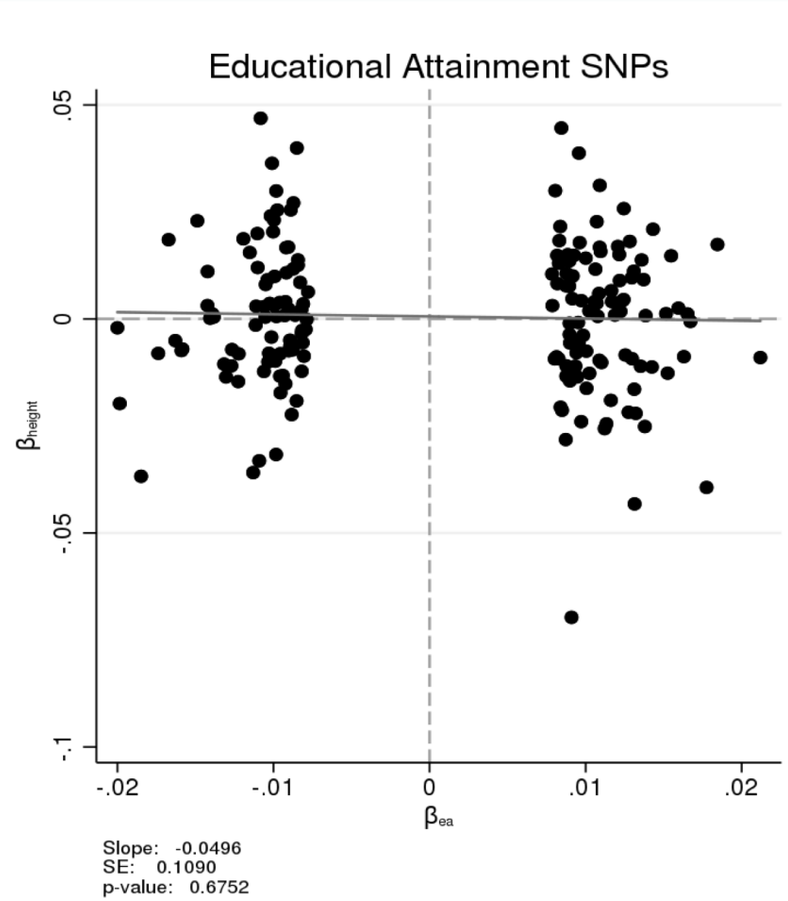
$\Longrightarrow$ BF result suggests biological pleiotropy matters (not only AM and social model)

Exercise 3: "Pickrell" Analysis

- Inspired by Pickrell et al. (*NG* 2016):
  1. For the height lead SNPs, regress the EA beta's on the **WF** height beta's;
  2. For the EA lead SNPs, regress the **WF** height beta's on the EA beta's
  - ➢ A positive slope for (1) but not for (2) suggests that height causes EA (but EA does not cause height)

- Preliminary results – using **WF** height sumstats: from Robinson et al. (*NG* 2015) and (levels) EA sumstats from Lee et al. (*NG* 2018)
  - ➢ Compatible w. "height causes EA" (and not "EA causes height")
  - ➢ But relative likelihood of a causal model over a non-causal model is only $r = 0.424$





Conclusion

- Preliminary results suggest a role for both AM and “biological” pleiotropy
- Aspirational next steps: quantify relative role of AM, biological pleiotropy, and pleiotropy due to social model

Thank you

This research has been conducted using the UK Biobank Resource under Application Number 11425