Socioeconomic Context, Polygenic Scores for Educational Attainment, Cortical Structure and Neurocognitive Skills in Children and Adolescents

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Introduction

- Genome-wide polygenic scores for educational attainment (PGS-EA) and socioeconomic factors are correlated with each other (Plomin et al., 2016)
- Both are associated with academic achievement and general cognitive ability in children and adolescents (Judd et al., 2020)
- The independent associations of PGS-EA and socioeconomic factors with brain structure and neurocognitive skills are not well understood.
- We examined the unique contributions of PGS-EA and parental education to cortical thickness (CT), cortical surface area (SA), and neurocognitive skills in children and adolescents.

Methods

Participants

- Data for this study came from the Pediatric Imaging, Neurocognition, and Genetics (PING) study (Jernigan et al., 2016)
- N = 391
- Age range: 3-21 years, 53% male

Measures

Polygenic Score for Educational Attainment

- Summary data from genome-wide association study (GWAS) of educational attainment (Lee et al., 2018).

Neurocognitive Skills

- National Institute of Health (NIH) Toolbox Cognition Battery.
  - Vocabulary, working memory, inhibitory control, attention, episodic memory

Image Acquisition and Preprocessing

- Imaging data were collected using 3-Tesla scanners manufactured by General Electric, Siemens, and Philips
- Preprocessing of publicly shared raw imaging data followed CIVET processing pipeline (https://mcin.ca/technology/civet/)
- Covariates in vertex-wise analyses were age, age^2, gender, scanner, principal components 1-10, and total brain volume

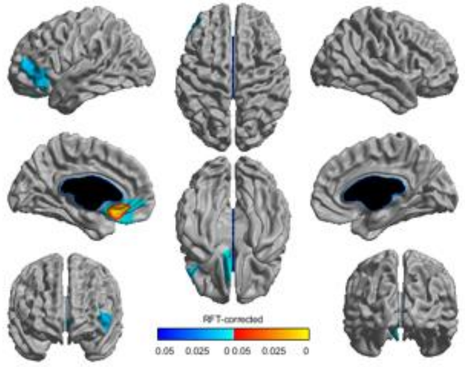
PGS-EA and parental education were independently associated with SA but were not associated with CT

- Higher PGS-EA was significantly associated with greater SA in left medial orbitofrontal and inferior frontal regions after adjusting for parental education
- Higher parental education was significantly associated with greater SA in the parahippocampal gyrus after adjusting for PGS-EA

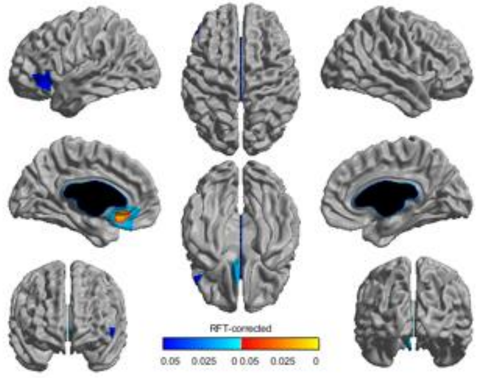
PGS-EA and parental education were independently associated with vocabulary and attention outcomes

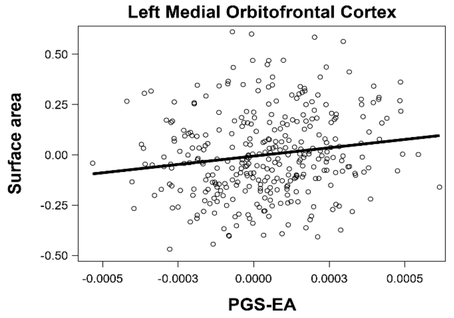
- PGS-EA was significantly associated with vocabulary, attention, and episodic memory after adjusting for parental education
- Parental education was significantly associated with inhibitory control, working memory, sustained attention, and vocabulary after adjusting for PGS-EA

Higher PGS-EA were associated with greater SA in orbitofrontal and inferior frontal regions



These associations were attenuated but remained significant after additionally adjusting for parental education





Discussion

- Higher parental education was significantly correlated with higher PGS-EA in children and adolescents which may reflect a gene-environment correlation (rGE).
- Higher PGS-EA and parental education were independently associated with greater SA in children and adolescents; however, these associations were attenuated when the other was accounted for.
  - Genetic associations with SA could arise, in part, from rGE between participants' PGS-EA and environments associated with their socioeconomic background.
- PGS-EA may impact SA in the medial OFC, which leads to greater inhibitory control in motivationally-salient contexts and in turn higher academic achievement
- PGS-EA impacts on SA in the left inferior frontal gyrus may underlie associations between PGS-EA and language skills
- These findings add new insights into how genetic and environmental factors may contribute to cortical structure in children and adolescents.

References

Jernigan, T. L., Brown, T. T., Hagler Jr., D. J., Akshoomoff, N., Bartsch, H., Newman, E., Thompson, W. K., Bloss, C. S., Murray, S. S., Schork, N., Kennedy, D. N., Kuperman, J. M., McCabe, C., Chung, Y., Libiger, O., Maddox, M., Casey, B. J., Chang, L., Ernst, T. M., … Dale, A. M. (2016). The Pediatric Imaging, Neurocognition, and Genetics (PING) Data Repository. *NeuroImage*, 124, Part B, 1149–1154.

Judd, N., Sauce, B., Wiedenhoeft, J., Tromp, J., Chaarani, B., Schliep, A., Noort, B. van, Penttilä, J., Grimmer, Y., Insensee, C., Becker, A., Banaschewski, T., Bokde, A. L. W., Quinlan, E. B., Desrivières, S., Flor, H., Grigis, A., Gowland, P., Heinz, A., … Klingberg, T. (2020). Cognitive and brain development is independently influenced by socioeconomic status and polygenic scores for educational attainment. *Proceedings of the National Academy of Sciences*, *117*(22), 12411–12418.

Lee, J. J., Wedow, R., Okbay, A., Kong, E., Maghzian, O., Zacher, M., Nguyen-Viet, T. A., Bowers, P., Sidorenko, J., Karlsson Linnér, R., Fontana, M. A., Kundu, T., Lee, C., Li, H., Li, R., Royer, R., Timshel, P. N., Walters, R. K., Willoughby, E. A., … Cesarini, D. (2018). Gene discovery and polygenic prediction from a genome-wide association study of educational attainment in 1.1 million individuals. *Nature Genetics*, *50*(8), 1112–1121.

Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2016). Top 10 replicated findings from behavioral genetics. *Perspectives on Psychological Science*, 11(1), 3–23.

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The data used in the study are publicly-available through the Pediatric Imaging, Neurocognition, and Genetics (PING) study: http://pingstudy.ucsd.edu/. A complete listing of PING investigators can be found online.

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