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Research Article

Genetic study of gifted individuals reveals individual variation in genetic contribution to intelligence

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Abstract: The present study, conducted by the Genetic Intelligence Project (GIP), investigated the relative contributions of genetic and environmental factors to the expression of intelligence in individuals with high intelligence quotients (IQ). The sample consisted of 150 volunteers with IQs ranging from 110 to 160, who underwent validated cognitive assessments and genomic analyses. The study aims to determine how the interaction between genetic predisposition and environmental influences affects the development of intelligence, taking into account variables such as substance use, neurodivergent conditions (ADHD and autism) and specific behavioral characteristics, such as adaptive perfectionism. Robust methods, including GWAS data, family analyses and genome sequencing, were used to assess how these variables modulate the balance between environment and genetics. This study reinforces the complexity of gene-environment interactions and their importance in the manifestation of intelligence, contributing to the advancement of cognitive genetics.

1. Introduction

Human intelligence is widely recognized as a complex polygenic trait resulting from the dynamic interaction between genetic predispositions and environmental factors throughout development. Heritability studies indicate that, on average , between 50% and 60% of the phenotypic variance in intelligence can be explained by genetic factors [1]. However, such estimates do not fully account for the genetically mediated influence of environmental factors, suggesting that the effective contribution of genes HYPERLINK "https://consensus.app/"may be even more significant when these interactions are considered .

The Genetic Intelligence Project (GIP) aims to further this discussion by investigating how environmental factors and genetic predisposition modulate intelligence in individuals with above-average IQs . The sample includes participants who undergo rigorously validated cognitive tests and comprehensive genomic analyses . The study examines conditions such as substance use , neurodivergences such as Attention Deficit Hyperactivity Disorder (ADHD) and autism, and adaptive behaviors such as perfectionism, which may favor or restrict the expression of genetic potential .

Furthermore , the role of brain plasticity and compensatory mechanisms will be analyzed as key elements in the adaptive process in the face of adverse influences . Neuroscience suggests that factors such as neurogenesis and synaptic reorganization play a critical role in the brain 's ability to compensate for deficits or maximize gene expression in favorable contexts . Using methods such as GWAS studies, family analyses and whole genome sequencing, the GIP seeks to understand how genetic and environmental variations interact to shape intelligence .

This study aims to provide a robust and in-depth analysis of the relative contribution of genetic and environmental factors , presenting new perspectives on the manifestation of human intelligence . By integrating genomic and contextual approaches , the GIP reinforces the importance of multidisciplinary models in the study of cognitive genetics and in understanding the biological bases of intelligence .

2. Development

Intelligence is a highly complex phenotypic trait characterized by a polygenic architecture with significant contributions from environmental factors. Recent studies indicate that approximately 60% of the variation in intelligence across populations can be attributed to genetic factors , although this value varies according to socioeconomic and cultural conditions . For example, research conducted in populations of twins shows that the heritability of intelligence increases with age, while the effects of the shared environment decrease significantly over the course of development [2,3].

Studies on gene-environment interactions reveal that the socioeconomic context modulates the impact of genetic factors . In environments of low socioeconomic status , a reduction in the expression of heritability is observed , while environmental factors have a greater influence on the variability of intelligence . On the other hand, in contexts of high socioeconomic status , genetic factors have a greater prevalence in determining IQ , reflecting a dynamic interaction between genetic predisposition and environment [4]. These findings reinforce the perspective that intelligence is the product of continuous interactions between genetic and environmental factors , both of which are essential contributions to understanding its phenotypic manifestation .

The meta- analysis conducted by Polderman et al. (2015) included 17,804 human traits derived from 2,748 publications , totaling 14,558,903 twin pairs [1]. The study revealed that, on average , the heritability of human traits is 49% (± 0.004), while shared environmental effects represent approximately 17% (± 0.004). These results were obtained using a random- effects meta- analytic model , allowing for incorporation of heterogeneity across studies. Furthermore , it was observed that 69% of the analyzed traits presented correlations consistent with a simple additive model, in which the phenotypic variation is mostly explained by additive genetic factors, with minimal influence of the shared environment. This extensive study provides robust evidence on the predominance of genetic factors in determining complex traits , establishing the basis for future research in genetic mapping .

The heritability of intelligence , estimated at between 50% and 60%, represents the proportion of phenotypic variance attributable to genetic factors . However , this estimate does not capture the complex interaction between genes and environment, which shapes the expression of intelligence in a dynamic and multifaceted manner. Considering that every phenotypic manifestation has an underlying genetic basis , it is plausible to assume that all environmental factors are also, directly or indirectly, under genetic influence .

To illustrate this proposition , we can perform a hypothetical calculation : if we assume that 50% of the environmental contribution (which corresponds to the remaining 40-50% of the variance in intelligence) is genetically mediated, the effective genetic share in intelligence could reach 70-75 %.

Here's how we arrived at that number :

- Heritability: 50-60%
- Environmental influence : 40-50%

Genetic influence on environmental factors: 50% of (40-50%) = 20-25%

Adding heritability to the genetic influence on environmental factors, we have:

- 50% (heritability) + 25% (genetic influence on environment) = 75%
- 60% (heritability) + 20% (genetic influence on the environment) = 80%

Although speculative, this exercise highlights the difficulty of separating genetic and environmental contributions in a simply additive manner. This perspective is corroborated by longitudinal and twin studies, such as that of Tucker-Drob and Briley (2013), which demonstrated the increasing influence of genetic factors on cognition in more advantaged socioeconomic contexts [5]. This finding suggests a transaction effect, in which genetic predispositions guide the selection of environments, which, in turn, reinforce cognitive traits.

The Genetic Intelligence Project (GIP) evaluated genetic data from 150 volunteers with intelligence quotients (IQ) above 110, concentrated mainly in the range of 130 to 160. The research used volunteers with validated and supervised protocols for intelligence assessment . Preliminary results revealed significant variations in the relative influence of genetic and environmental factors . While some

participants showed up to 80 % of variation attributable to genetic factors, others demonstrated a reduced genetic contribution , around 60 %, with greater influence from environmental factors. These findings reflect the complexity of gene-environment interactions and corroborate previous studies indicating that the heritability of IQ tends to be higher in advantaged socioeconomic contexts , while less advantaged environments increase environmental influence by restricting genetic potential [4,5].
Furthermore, the GIP results highlight that brain plasticity and compensatory mechanisms modulate the expression of intelligence. Brain plasticity allows the brain to reorganize itself in response to environmental stimuli, facilitating or limiting the manifestation of genetic predispositions, especially in critical periods of development. These effects are most evident during childhood and adolescence, when environmental influences can amplify or suppress genetic traits [5].
Finally, longitudinal studies reinforce that genetic influence on intelligence increases with age, while the impact of the shared environment progressively decreases. This trend is explained, in part, by the greater autonomy of older individuals to select environments that reinforce their genetic predispositions , characterizing the phenomenon of gene type -environment correlation [6].
compensatory effect describes the brain's ability to mitigate deficiencies in certain functions by activating genetic mechanisms or strengthening other neural regions . For example, genes associated with increased synaptic density or neurogenesis in the hippocampus may attenuate the effects of less favorable genetic variants related to intelligence. This dynamic-adaptive genetic interaction not only contributes to brain plasticity but also to the wide phenotypic variability observed in human intelligence. Recent research continues to explore these gene-environment interactions, elucidating the mechanisms underlying cognitive development and revealing new horizons for understanding the biological bases of intelligence [5,6].

3. Discussion

In the Genetic Intelligence Project (GIP), cases were identified in which individuals with a high genetic predisposition for intelligence presented below-expected results on IQ tests. In subsequent analyses, these participants reported a history of use of psychoactive substances, such as marijuana and crack, and taking the tests during or after periods of addiction, suggesting that drug use significantly compromised their cognitive abilities, as documented in studies that associate chronic substance use with deficits in memory , attention , and executive function [7,8].
Furthermore, cases of neurodivergent conditions, such as autism and Attention Deficit Hyperactivity Disorder (ADHD), have been observed, which corroborate the predominance of environmental factors in the phenotypic variation of intelligence, especially in contexts of adverse development. On the other hand, participants with adaptive perfectionism showed greater coherence between genetic predisposition and IQ scores, reflecting less environmental interference and greater genetic influence.
genetic data of 90% of the volunteers demonstrated a strong correlation with the results of IQ tests and personality assessments. However, in the remaining 10%, discrepancies associated with factors such as drug use, double exceptionality and the possibility of influence of previous training in IQ tests were identified. The hypothesis of error in the tests or in the genetic imputation was also considered, leading to the performance of additional analyses with whole genome sequencing, in some cases, for greater precision.
The study incorporated family analyses and observation of siblings in 5 % of cases, in addition to using GWAS data and the main studies available in the literature on the genetics of intelligence. These references include fundamental areas such as brain morphology, synaptic connectivity, cognition, extreme intelligence, neurodevelopment, breastfeeding, childbirth, creativity, language, neurodivergences and neurotransmitters. Finally, the GIP consolidates a robust compilation of the most important existing studies, complemented by a proprietary database. Following ethical and methodological research standards, internal data are not published to preserve the privacy of participants and protect sensitive information, and are used exclusively for internal analyses and rigorous methodological verification. In the GIP report, some SNPs were identified with a higher incidence among individuals with high IQs when compared to those with IQs close to normal, highlighting them both for their frequency in the study and for their impact on cognitive and creative abilities already documented by other authors. These findings reinforce the significant genetic contribution of specific SNPs in determining high levels of intelligence and cognitive abilities, indicating that specific genetic variations, in synergy with environmental factors, modulate the development of intelligence in

individuals with higher IQ. These SNPs are just a few chosen to illustrate this study, and may vary in the future according to the increase in sample size.

4. Final considerations

Studies indicate that the genetic heritability of intelligence is, on average, 60%. This implies that the remaining 40%, on average, cannot be attributed exclusively to environmental factors, since all phenotypic expression is based on a genetic precursor. In other words, gene expression is regulated by both genetic and environmental factors, but always with an underlying genetic component. Thus, the manifestation of the gene is determined by the interaction between the initial genetic programming and the influences of the environment, whose origin is also genetically mediated. The GIP - Genetic Intelligence Project study analyzed genetic tests of 150 volunteers with IQs ranging from 110 to 160 points, with the majority in the range of 130 to 160 points. All IQ tests were supervised, valid and scientifically proven. To date it has been found that the relative impact of genetic and environmental factors varies between individuals. In other words, there are those with a greater genetic predisposition and less environmental influence , while others present greater environmental significance , remaining within the 40% standard established by previous studies. It is important to consider that studies with twins offer a more consistent basis due to greater genetic similarity, but they do not take into account the compensatory effect. This effect refers to the development of brain subregions or the expression of genes that compensate for possible discrepancies in development, such as genes that promote greater intelligence by compensating for deficiencies in other less expressive areas. In addition, certain genes may be more determinant of intelligence, acting as drivers of cognitive performance. To illustrate with a fictitious analogy, imagine an individual whose genes favor greater synaptic density and an enlarged hippocampus, while other genes related to intelligence have less significant expression and do not contribute positively. In this case, the genes that increase synaptic density and the hippocampus could compensate for the limitations of the others, promoting high intellectual development, even with the presence of less favorable genetic factors. In this study, it was possible to create a hypothetical model that considers the results consolidated in the literature, indicating that the average heritability of intelligence varies between 50% and 60%. However, when interpreting that genes not only express, but also act as precursors of all phenotypic manifestations, it is suggested that the 40-50% traditionally attributed to the environment may be partially genetically mediated. Thus, hypothetically, the environmental contribution could be adjusted to approximately 25%, while the genetic influence would reach 75%. The GIP, however, emphasizes that the relationship between genetic and environmental predisposition varies significantly among individuals, being modulated by factors such as neuroplasticity, compensatory systems and the presence of SNPs (single nucleotide polymorphisms) with greater or lesser impact on the regulation of genetic networks. Furthermore, the study highlights that some genes have a more significant determining potential, while others play a modulating role, depending on the interactive context in which they are inserted, reinforcing the complexity of the gene-environment interaction.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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