

Inheritance and Genetic Engineering of Intelligence

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1. Preface

Why does the person next to me learn faster than me, why remember more than me? These questions and whether intelligence is determined by factors in our environment or its origin lies within our genes were discussed among our group of peers. Although those disputes were most often from a philosophical point of view we took this paper as an opportunity to discuss the issue with actual, research based arguments. Even in our group we discovered several opinions, which made us curious to what our research might suggest in the end.

If your father was a serial killer, how does that affect your life? A practical question because it is known that family relations are often used as comparisons as in: You look just like your father but you got your mothers eyes. One will always be associated with his relatives, may it be a celebrity or as told in the more unpleasant example a serial killer. At first glimpse such associations are no big deal. After all we have got our genes from our parents but what if these genes would hold more than only the information whether your hair is light or dark, what if it would also determine how intelligent you will be, what if it would determine even more?

All the so far mentioned questions are about a long discussed debate topic, which is called the nature vs. nurture debate. It deals with the ancient idea whether someone's characteristics are determined by one's environment or one's genetic makeup. Following some recent studies we are going to search for the answer curious of what we might find.

2. Introduction

Our chosen topic deals with the search for and the use of a gene which determines the intelligence of a human being. Since there is no practical intelligence related genetic engineering done nowadays, we will take a closer look at the preconditions which have to be achieved to allow genetic engineering in this field.

2.1 Definition of Intelligence

At first we have to acquire general knowledge about the term intelligence. We will start right away with the question "What is intelligence?"

Some people define it as "*the capacity of a mind*" other people call it "*the ability to learn about, to learn from, to understand and to interact with ones environment*". Our first problems already start with the definition. Another part of this problem is the measurement of intelligence. The most common way to do this is an IQ Test. But is the IQ an adequate way to measure intelligence in scientific researches or is it just a number without meaning? This is another heavily discussed topic within this field of research since the IQ is provided by different tests, which only measure specific selected abilities and competences of a person. Because there is still no standardized definition and therefore no clear view which abilities should be tested to indicate the level of intelligence it's not clear in which extend the IQ tests deliver a representative result.

As we can see there are a lot of problems concerning the definition and the application of the term intelligence. Therefore we have to agree on a specific view on this term for our paper. We assume that intelligence is a characteristic of an individual which determines his talent in a certain field and his success in learning new things. We also approve of the IQ system although we think that it doesn't show the absolute value of a person's intelligence but in our opinion it is an adequate approximate value which can be used for scientific means.

2.2 Genetic Relationship of Intelligence

It has always been an important question whether intelligence is related to a gene or not and still there has not been found a clear answer yet. Of course this is the main basis to make genetic engineering on this field possible at all. The search for such a gene has been an ongoing process in the last couple of decades, but why has there been made so small success?

A main point which hindered the success in this research field was the assumption that there was a master gene determining intelligence. Today we know that most individual characteristics such as behavior or intelligence are expressed by a group of genes rather than a master gene.

However during the long story of chasing after the “intelligence-gene” scientists have been successful in the recent time. In fact there have been 47 gene parts discovered which show a relationship to a person’s intelligence development. But there is to mention that those genes only show a very small correlation to intelligence. The six most influencing genes together only make up about 1 % of the development of an individual's intelligence. But scientists assume that there are many more such genes.

Another fact which supports the genetic relationship of intelligence is that some genes have a strong influence on the development of a human brain. Since it has been verified that intelligence is related to some brain regions a genetic relationship would also be supported.

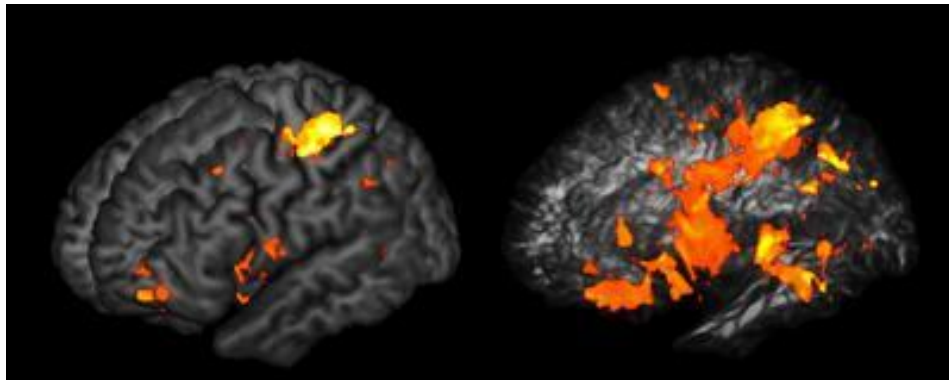


Figure 1: Intelligence related brain activity (Left : Regions ; Right : Connections)

About 30 years ago, researches lead to the discovery of an important process, the regulation of gene expression. This means that various genes in our body may be expressed and some might not. There are different processes regulating gene expression. The first ones are already starting during the transcription of a DNA sequence. This process of gene regulation is quite important, since there are external influences which determine the activity of a gene. These influences may be all of different types e.g. Nutrition, movement, ecological quality etc. This means, that the activity of the specific genes and therefore the expression of the intelligence is probably determined partly by outside circumstances.

2.3 Nature vs. Nurture

This leads us again to the main point of this conflict: Is intelligence limited to one's genetic basis or is it a product of environmental influences?

The opinion, that most of our traits are mainly affected by genes is supported by the “Minnesota Study of Twins Reared Apart”. This study indicates that two twins who were separated after birth and raised up in different families show big similarities in characteristics like interests, attitudes and personality. In one case twins’ wives even shared the same name, drove the same car and both were chain smokers. In the majority of the cases, the correlation of the IQ of the two

separated twins was very high. Overall average IQ correlations of the examined twins ranged from 0.64 to 0.75. This would mean that the IQ is about 70% genetically determined. Such twin studies are often used in today's genetic researches and the debates of genetic influence vs. environmental influence. The problem on this example of twin study is that twins which were separated after birth and find their way again back to the opposite twin, is extremely rare. And therefore one could say that we can't use such studies as a representative for the whole population. Another point is that in this study, it is not clear in which extent the environments of the separated twins differed from each other. For the 70% inheritance rate of the IQ, it was assumed that there were no environmental similarities between the raising places of the two twins. And this assumption we consider as quite unrealistic. Therefore a bigger environmental influence cannot be excluded.

3. Engineering Techniques

3.1 Genetic Engineering related to Human Intelligence

Genetic Engineering is the manipulation of an organism's genome with the aim that different procedures in the body can be controlled and directed. This is done by replacing or inserting different genes into an existing DNA sequence.

For our topic this would mean that the genome of a person can be modified in such a way, that the person becomes more intelligent. How discussed on the page before, it is not clear in which extent genes determine intelligence. Fact is that intelligence is partly genetically determined. With this knowledge we can proceed to the questions of applying engineering techniques on the field of human intelligence.

Although genetic engineering has been done very often and successful till this day, there has no success been made in the field of human intelligence. There are several factors we have to take in consider to understand the main causes of this problem:

- The search for genes which have a clear and considerable influence on a human's intelligence is still going on (The correlation of the today known "intelligence genes" is way too small to be used for engineering)
- The intelligence is probably not determined by one or a few genes but more likely by a lot of complex genes. This makes it harder to tell if a gene is somehow related to intelligence.
- The processes of implementation of a gene sequence into a host genome would be hindered by the assumed number and complexity of these genes.
- The genetic modification of human individuals is an extreme controversy and questionable part of today's science.
- The disadvantages and the outcome of gene modification is difficult to evaluate and can end devastating.

As we can see, the genetic modification of human's intelligence is a very difficult field. However scientists were able to achieve some success in boosting the intelligence of mice: They added a gene called NR2B to the genome of a mouse. During different experiments they observed that they improved their learning and remembering abilities. In this case, only one single

gene was enough to significantly boost the intelligence. Because of the factors mentioned before, it's not possible to boost our intelligence by one single gene. Also there are less ethical problems experimenting with mice.

3.2 Implementation of a Gene into a Host Genome

But if we would find genes with a significant high correlation to intelligence and the application of genetic engineering on the field of intelligence would be possible, how would such a procedure of gene implementation into a host genome look like?

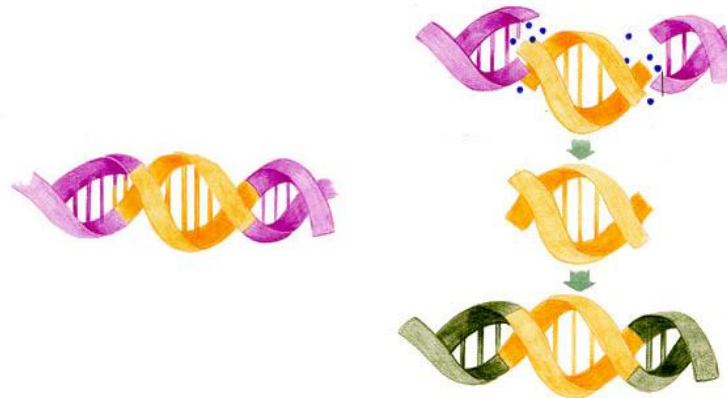


Figure 2: Isolation of a gene and the creation of a DNA construct

Firstly the requested gene has to be isolated. This is done by using specific enzymes. After the gene has been isolated, it's possible to amplify the number of it, by using polymerase chain reaction (PCR). In this method a gene transcription by the polymerase is established by heating up the gene sections. During heating up, the DNA strands separate into two complementary single strands. After this the DNA polymerase automatically starts DNA transcription. With this method, the requested genes can be amplified exponentially.

After that, a DNA construct has to be built. This means that the gene has to be combined with other genes to work properly. The constructs usually contain a promoter and terminator part to control the transcription process afterwards. There is also a selectable marker needed to determine which cells are transformed with the new gene.

Afterwards we have to insert the gene into the host genome. In animals, this is often done by injecting the DNA directly into the nucleus by microinjections directly through the nuclear envelope.

How mentioned before, such a manipulation of a genome with the aim to boost one's intelligence is not possible yet. However a possible technique in the future will obviously lead to a heavy debate, whether it is legitimate to manipulate one's intelligence to improve it. In the discussion part we want to take a closer look at the ethical aspects by comparing pro and contra views.

4. Interview with Prof. Bharat Chattoo



Figure 3: Prof. Bharat Chattoo

“Bharat Chattoo is a Professor at the Department of Microbiology and Biotechnology Centre, and Director, Genome Research Centre at M.S. University of Baroda, Baroda. He received his Ph.D. from the University of Delhi, for a thesis in the field of Microbial Genetics. Subsequently, he worked at the University of Rochester Medical Centre in the area of Yeast Genetics. He was on staff as a scientist at the Centre for Cellular & Molecular Biology, Hyderabad, and also worked at the Friedrich Miescher Institute, Switzerland and has been at M.S.University since 1986. His current research interests are in functional genomics of fungal pathogens, host-pathogen interactions and microbial diversity.”¹

1. How would you define intelligence from your point of view?

This is the most difficult of your questions. The experts have debated the definition of intelligence for a long time and we can discuss it as well. However, I would like to define intelligence as the ability of an organism to learn and adapt from it’s environment. As I said, many people may not agree with this definition, but we can use it as a basic formulation. The reason I would like to define it in this way is because the ability to sense, monitor and adapt to the environment is a characteristic that we can see in practically all forms of life. Therefore, it is not necessarily a quality only of humans. If we use this definition, it also becomes a bit easy to think of how to study it say in an experimental organism.

2. Do you think it is a justifiable consideration that intelligence might be genetically inherited to a certain extend? Why or why not?

Yes, it is reasonable to think that intelligence is inherited. However, it would be too simplistic to think that there is one or a few genes that control a hugely complex behavioural trait such as intelligence. It would be reasonable to think that intelligence as defined above is a complex, heritable trait that involves many genes. This is not to say that the environment does not have any effect. We should also remember that there is now more evidence that several traits are influenced by what are also called as epigenetic factors. It is ,therefore, important to recognize the complexity of the problem and use several different approaches to dissect it in a scientific objective manner.

3. Do you believe in future advances concerning the genetic engineering of genes relative to the capacity of remembering, the power of concentration, or even a master gene of intelligence itself?

Since we do not understand the basis of this rather complex phenomenon in purely genetic terms, we shall have to wait before we can answer questions as to how one may be able to increase the power of concentration etc. It is almost for sure that intelligence is not controlled by a single master gene. However, there are examples in the literature that mice could be made to increase their ability to learn by inserting a gene that codes for a protein in brain cells known to be associated with memory. However, one must also appreciate that

¹ http://www.fbae.org/2009/FBAE/website/governing-body_bharat_chattoo.html

the biological basis of memory by itself is not clearly understood. I believe that all these are exciting questions and their study will lead towards a better understanding of how cells and organisms work.

4. When you analyze characteristics of an organism (e.g. plant) and you find one (e.g.: a resistance) that you would like to implant another organism how would you go about trying to find the gene responsible for this exact characteristic?

We now have fairly standard techniques available to isolate and study the function of specific genes. In case of a gene for resistance in a plant, one could think of isolating such a gene from a plant that is resistant and then transfer it to another plant of the same or another species, which may not be resistant to a given disease. If the recipient plant now becomes resistant, it would indicate that the gene that was isolated is indeed capable of conferring the desired characteristic (resistance in this case). Once you have identified and isolated a given gene, it is fairly straightforward to determine its sequence. Subsequently, one can now disrupt or inactivate such a gene and show that the characteristic of resistance is lost. A variety of different approaches can be used and I shall be happy to discuss them in greater detail with you if you are interested.

5. How do you feel about the ethical issue of medical trials on humans and would they be justified if it would serve a greater good?

One needs to recognize that the clinical trials in humans can be allowed only if a particular drug has been shown to have not adverse effects in animal experiments. Again, even after obtaining data on the possible adverse effects of a drug in animal studies, one proceeds very carefully to clinically trials. Although rats and mice are used more commonly, but depending on the nature of the trial, one may also have to use other animals. All the ethical issues are considered in specific committees constituted for this purpose and these committees have not only experts in the field, but also social worker etc. involved as members. Most countries have a very elaborate procedure in place that must be followed before a drug can be tested in humans for efficacy.

6. Would you ever consider genetic engineering on humans? (e.g.: designer babies)

For me, The answer is a clear No

7. Is there anything else you came to think of while answering our questions you would like to add here?

I believe that Biology has reached a very exciting stage. You are blessed to be young and to be studying Biology at this time. There are a lot of fundamental questions that can be addressed now in a more precise way than was possible before because of the advances in a number of techniques in Genetics and Molecular Biology, but also in Analytical chemistry and Other physical sciences. Implications of studies in Biology are significant not only for gaining a better understanding of fundamental questions, but also for applications in agriculture, industry and environment.

What might the future be holding? The topic of this paper is an uncertain one which leads to the fascination but also the problematic of it all: we don't know how or even if the proposed techniques are going to be put to use within the next few years. Today's knowledge suggests that genetic engineering with human DNA sounds promising. It is already practiced to some extent as most of us know the designer baby controversy. If this is possible the only problems hindering the genetic manipulation of human DNA to also change characteristics such as intelligence are the missing gene and moral ones. The first part of the discussion will deal with the future possibilities and usage of techniques which might be developed out of today's research. The second part will deal with the moral problems resulting from the firstly discussed possibilities.

5.1 Hypothetical Possibilities

Right now there is a lot going on in the field of genetic engineering. Cloning, manipulating, immunizing are only a few of the techniques used. Most of those practices are used on plants and cattle on regular basis but seldom on humans. This means there are all those possibilities and a lot of research but also big problems. Experimenting with humans or just human DNA is morally highly questionable and the follow up discussion will be exactly about problems like that, but for now it is just one of the reasons why the research is not moving as fast as it would if it would not concern humans as closely. The work with DNA is a highly complex process and although one could just try and see what happens while working with the DNA of grains this obviously can't happen with human DNA. What if these problems wouldn't matter? Many people are working hard on advancements in the field of genetic engineering and there is progress made. Will we soon be able to create more intelligent human beings just by using gene manipulation, or will we be able to go even further and create more adapted, faster and stronger beings? Will we take selection in our hands? First this could lead to an improvement but then it might take a turn for the worst. People will eventually have to manipulate the genes of their offspring so that they can succeed within our achievement-oriented society and this might lead to a decrease in bio diversity. Right now there are price winning cows being cloned because of their genes, although this still is illegal in most countries. These clones might actually survive and be as good as they were intended to be but a lower survival rate is only one of the problems of which the origin yet remains uncertain. Similar and closely related problems arise trying to manipulate genes in general and now imagine how problematic this would be with humans.

5.2 Ethical and Moral Issues

One of the most discussed topics is whether a woman should have a right to abort a baby or not. In genetic engineering there would be a lot of unborn children of whom only a few would survive and lots of them getting born with unnatural disabilities which otherwise would not have occurred. Now it is clear that theoretically genetic engineering on human beings to increase their intelligence is possible and there might be even more. What is left to find are the genes responsible for the wanted characteristics and a competent technique without the so far discussed problems. The biggest problem whatsoever would be the moral issues. It is not only that these problems are prevalent while researching but even more so after techniques would have been developed.

Assuming that genetic engineering is looking at a bright future, how would it overcome or shirk the ethical and moral barriers? Although science and religion were always in conflict to some extent

this would take their discord to a whole new level. A scientist might look at the techniques as an advancement and is certain that they will be used eventually, but he does also know that there are going to be many problems till the techniques will be elaborate enough to be used on a regular basis. People opposing this will use every incident to make public that this research does more harm than good and that nature should be allowed to run its own course. Trying to answer the question whether we should continue searching genes related to intelligence and try to manipulate the human genome or not we can look at determining factors. Will the research eventually improve the overall quality of life, or put differently will the benefits outweigh the cost? It seems like more intelligent people would benefit our society. The finding of genes connected to intelligence or other connected characteristics will boost our knowledge of human mental procedures and will help us understand and improve life in general. On the other hand arguments of the opposing party will criticize our achievement-oriented society, question whether we will actually be happier or live a better life knowing how many people had to make sacrifices to get us to this point and that we have no guarantee that the promised improvements will ever take place as it all could go terribly wrong. Arguing for or against it is a lot like having to decide whether to buy a product in a store or not on whose label it is promised in huge letters to be exactly what you need and that it will erase all your problems but you can read the side effects in the small written part.

6. Summary

In our researches we tried to find out whether intelligence is determined by a gene and if it's possible to modify an individual's intelligence by genetic engineering. There has only been made small success in this field of genetic engineering. One main reason is that intelligence is most likely determined by a complex system of different genes, rather than by a master gene. Another important reason is that the applying of genetic modifications on a human individual would oppose today's ethics.

In recent years scientists discovered 47 genes determining intelligence. But the correlation of the genes to intelligence is too small to start off with genetic engineering.

But our studies showed that we can't say intelligence is only expressed by genes. There are some who believe that the biggest part of our intelligence is determined by outside circumstances like family, colleagues and nutrition etc. Although some studies suggest a high genetic impact (e.g. Minnesota Study), it's not clear in which extend the environmental circumstances influenced the development of intelligence.

As we came to know there isn't a method to boost ones intelligence by genetic engineering yet. But one succeeded in increasing the intelligence of mice by adding a gene called NR2B to the genome of a mouse. This was only possible because one had to modify the genome of the mouse by a single gene.

In our discussion we argue about whether it is acceptable to experiment with humans to improve next generation's intelligence and if we have the right to interfere in natural selection. Do the advantages outweigh the risks which will occur surely if one experiments with the human genome? Is it morally correct if rich people will have genetically modified perfect children?

There is no answer to these questions. We have to decide by ourselves if we could bear to sacrifice other people's life for our own seek or for our offspring's and if we have the mental strength to ignore the moral aspects.

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