

Applying genetic discoveries to education

Professor Yulia Kovas, a director of several research programmes on genetic and environmental effects on learning, and **Fatos Selita**, Barrister and Director of International Business and Law Consultancy Ltd, discuss the ethical implications and potential benefits of applying genetic research to education



In September 2011, the Government of the Russian Federation awarded you a 'megagrant' to establish the Laboratory for Cognitive Investigations and Behavioural Genetics at Tomsk State University (TSU). How has this grant contributed to your research?

YK: The megagrant provided an incredible opportunity to establish this new laboratory and to integrate it into international research efforts on improving learning and education. The laboratory is truly interdisciplinary, using the latest equipment for DNA extraction and storage, measuring electrical brain activity, electrical brain stimulation studies and investigating cognitive abilities.

The megagrant also enabled the establishment of the Russian School Twin Registry (RSTR). This long-term, large-scale project will become a unique resource for conducting behavioural genetic research and a platform for multiple international research collaborations.

Are there projects underway at the laboratories?

YK: Currently, we are researching factors involved in mathematical learning. We collaborate with many schools and collect longitudinal data to establish underlying causal mechanisms. We study children's emotional, motivational and cognitive development in

different educational settings, including schools for the mathematically gifted. We also study cognitive and brain processes in thousands of British and Russian twins to gain an insight into genetic and environmental effects on learning.

You also lead genetically informative mathematics research in the Twins Early Development Study (TEDS). How does this complement your other endeavours?

YK: TEDS has followed thousands of twins from birth into adulthood. I am lucky to be associated with this amazing project. As a PhD student I was supervised by Professor Robert Plomin, the TEDS director, who continues to advise both InLab and the Tomsk laboratory. My continued collaboration with TEDS and several other major twin projects has enabled a cross-cultural research programme. Currently, we are investigating genetic and environmental factors that link mathematical ability with spatial ability, number sense, general intelligence, motivation and mathematical anxiety.

Are there potential benefits to applying genetic discoveries to education?

YK & FS: Soon, everyone's DNA is likely to be sequenced at birth. This will present incredible benefits for prediction, prevention and treatment of illnesses, learning disabilities and behavioural problems, and for optimising education for all learners.

Could you introduce the International Laboratory for Interdisciplinary Investigations into Individual Differences in Learning (InLab)?

YK: InLab conducts research into the origins of differences in learning, motivation, cognition and academic achievement. We study genetic and environmental influences on educational processes in the hope that better understanding will lead to improvement of education and learning.

InLab is a highly dynamic environment. Its core is a team of 25 undergraduate, graduate and postgraduate students, as well as interns from UK universities and international partner institutions. InLab's associate members include leading scientists from top research institutions in the UK, Russia, Kyrgyzstan, Canada, the US and China. When I started InLab in 2011, I could not imagine how fast it would grow and what an incredible environment it would become for learning, training and research.

Genome-tailored education

Behavioural genetic research at **Goldsmiths, University of London** and **Tomsk State University** aims to pave the way to genome-tailored educational strategies. In collaboration with **International Business and Law Consultancy Ltd**, the laboratories look for successful, ethical ways of implementing the rapidly developing genetic knowledge

Behavioural genetic research has shown that each child's cognitive and motivational profile results from complex gene-environment co-action, so there are no universally suitable educational methods. Understanding the causes of individual differences and using the most suitable learning environments can help individuals maximise their educational progress.

What are the ethical and legal implications of applying genetics in psychology and education?

FS: Personalised education is as desirable as personalised medicine, and genetic discoveries can help us to reach them. However, as a potential user of genetic information and as a lawyer, I can see a clear need for effective guidelines and policies related to the use of genetic information in education. Genetic information may be used in harmful ways without good understanding of it. Much work needs to be done to help scientists communicate genetic knowledge effectively to all stakeholders.

Another important issue is access to personal genetic information. The purpose of access to any personal information in an educational setting (whether it is a result of an ability test or DNA test) should be to find the most suitable educational approaches for an individual. We need to develop new policies and guidelines that keep up with the progress in genetic research, to ensure new discoveries are used efficiently to benefit all learners.

What are your hopes for the future?

YK: Attracting excellent students to this research area and providing them with training is of utmost importance. To this end, InLab has set up the MSc programme in the Science of Psychology, Genetics and Education. Students get a chance to work on research projects in international teams, collaborate with international partners and work on ethical, legal and societal implications of the research. Many students continue onto PhDs in one of our laboratories. Looking at these enthusiastic, thoughtful and hardworking young people, I have no doubt our research can lead to improvements in education and learning.

THE DECLINE IN the number of schoolchildren that elect to study science, technology, engineering and mathematics (STEM) subjects in high school and university, and ultimately enter the STEM workforce, continues to perplex governments worldwide. Initiatives to counter this decline include efforts to increase recruitment of women and minority groups who are particularly underrepresented in STEM fields; alternative or holistic approaches to teaching these subjects; and introducing basic STEM problem-solving and interpretation in a child's first years of schooling. However, the specific causal factors that determine why and how some children learn faster, retain information longer or develop an interest in or aptitude for specific subjects at school are still largely unknown.

BEHAVIOURAL GENETICS AND STEM

The premise that both genetic and environmental factors contribute to individual differences in basic intelligence, cognitive impairments, academic motivation, learning abilities and disabilities underlies the research focus of two laboratories in the UK and Russia. These laboratories are the International Laboratory into Interdisciplinary Investigations into Individual Differences in Learning (InLab) at Goldsmiths, University of London and the Laboratory for Cognitive Investigations and Behavioural Genetics at Tomsk State University (TSU) in Russia. Professor Yulia Kovas, a developmental psychologist and behavioural geneticist, heads both laboratories, and she is the co-director of the Russian-British Laboratory of Behavioural Genetics at the Psychological Institute of the Russian Academy of Education.

The field of behavioural genetics applies twin methodology and molecular genetic techniques to explore the degree to which variation in DNA and environmental conditions contribute to variation in human behaviour within a particular population. Kovas and her colleagues are currently seeking to elucidate the mechanisms of co-action between genes and environment that motivate individuals to develop skills and to succeed in STEM subjects. As part of this effort, she is



Twins at the Russian School Twin Registry (RSTR) Festival.

leading an investigation into discovering genetic polymorphisms that contribute to a person's ability in mathematics. The study relies on two twin projects: Twins Early Development Study (TEDS) at King's College London and the Russian School Twin Registry (RSTR). "Why many children continue to underachieve in mathematics, as well as why some are mathematically gifted, is poorly understood," Kovas observes. Over 18 years, TEDS has collected longitudinal data from about 13,000 pairs of twins born in England and Wales between 1994 and 1996. The data includes the children's levels of ability and motivation, behaviour, their home and educational environments and their DNA. This information has already provided a wealth of knowledge on child development, and new knowledge continues to come out of this research. The RSTR complements TEDS and provides a cross-cultural dimension to the research.

MATHEMATICAL INHERITANCE

The starting point of Kovas' research was the principle that each person's brain is wired uniquely and works differently and that their genome and environmental experiences constitute a matchless mix. Kovas has determined from TEDS and other twin studies that individuals develop motivation for and skills in mathematics under the influence of genetic and environmental factors. The research shows that there is no single 'mathematical gene', but instead many DNA markers, called quantitative trait loci (QTLs), that influence mathematical

INTELLIGENCE

INTERNATIONAL LABORATORY FOR INTERDISCIPLINARY INVESTIGATIONS INTO INDIVIDUAL DIFFERENCES IN LEARNING AND THE LABORATORY FOR COGNITIVE INVESTIGATIONS AND BEHAVIOURAL GENETICS

OBJECTIVES

- To conduct research dedicated to understanding the origins of individual differences in cognitive abilities, motivation and achievement
- To understand the complex co-action between genetic, social and cultural factors, and their effects on learning and achievement

KEY COLLABORATORS

Professor Sergey Malykh, Director of the Psychological Institute of the Russian Academy of Education and co-Director of the Russian-British Laboratory of Behavioural Genetics

Professor Robert Plomin, Director of the Twins Early Development Study (TEDS), University of London

PARTNERS

Fatos Selita, Barrister of England and Wales, Director of IBL Consultancy Ltd

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YULIA KOVAS is a developmental psychologist and behavioural geneticist. She directs the Russian School Twin Registry, coordinated by the Laboratory for Cognitive Investigations and Behavioural Genetics at Tomsk State University. She also leads the research on mathematical development in the Twins Early Development Study at King's College, University of London.

Teachers of the future will be able to use new, adaptive learning technologies to tailor their methods and settings to each child's unique genetic and neural profile – to maximise each person's potential

abilities. These QTLs also influence other learning abilities, including reading and language.

Kovas' analyses show that genetic similarities account for similarities in motivation and achievement in mathematics between members of the same family. Therefore, while nurture makes a contribution to a child's attitude towards learning and achievement in mathematics, a major contribution to these traits comes from their genes. Moreover, if a child underperforms in some areas of mathematics and not others, the likely source of this discrepancy will be environmental factors. Kovas explains: "Differences in our genomes explain approximately 60 per cent of the variability in how well we can learn and use mathematics, and approximately 40 per cent of variability in how much we enjoy mathematics or feel confident in our mathematical ability". This evidence strongly suggests that education should not only be child-centred and delivered in an environment that is conducive to learning, but that a single way of teaching a particular aspect of maths is unlikely to work for all children. "In the future, we will be able to tailor methods and settings to each child's unique genetic and neural profile to maximise the individual's potential," Kovas enthuses.

CULTURAL ENVIRONMENT INFLUENCES

Kovas has found that the effects of 'mathematical genes' are not static, but change according to culture and age for three main reasons: genetic profiles, such as frequencies of varying alleles, differ across populations; common cultural norms and practices influence teaching and learning; and the influence of the same genetic variation on behaviour can vary according to environment. In countries with a centralised national curriculum and standard teaching methods, the influence of genes on children's academic achievements are more evident than in countries where teaching and curricula differ.

For these reasons, InLab and the laboratory at TSU are conducting research to explore aspects of genetic and environmental effects with respect to mathematical learning and ability in different countries in parallel, using the same protocols and assessment tools. One project is examining sources of variation in mathematical achievement. Another set of cross-cultural behavioural genetic studies aims to establish cross-cultural similarities and differences in the development of early cognitive skills and in how they affect later mathematical development. An additional project aims to discover factors that influence 16-year-olds' achievement

in mathematics and motivation to pursue STEM careers. Whereas it is commonly believed that motivation can be shaped and is heavily influenced by parents and teachers, this last study, which combined data from twins in the UK, US, Japan, Germany, Canada and Russia, has shown that interest and self-perceived ability in mathematics are not affected by family- or class-wide factors. Similarity between twins in these traits is explained by their shared genes. In other words, individual differences in mathematical motivation come from genetic and individual specific environmental factors. A further project is examining the nature of the teacher and classroom effects on children's learning. Preliminary results show that the effects are not static, but vary with age, phenotype and environmental factors such as curriculum.

APPLYING GENETIC INFORMATION TO EDUCATION

While genetic information could help children develop and use their potential more effectively, there are still many questions concerning the use of DNA data for education. "The purpose of access to any personal information in an educational setting should be to find the most suitable and effective educational approaches, to help each learner to progress best. To prevent unethical use of genetic information, new policies and regulations are needed," asserts Fatos Selita, Director of International Business and Law (IBL) Consultancy Ltd, a legal and financial consultancy based in London. As the prospect of applying genetic information to education approaches, Selita and his team at IBL are collaborating with Kovas on the legal, ethical and societal aspects.

Kovas and Selita are firm on the point that those who have access to genetic information for educational purposes will need to better understand its implications, especially that genetic effects are dynamic and non-deterministic. IBL is therefore working to help scientists communicate the complexities of the issue to all stakeholders: parents, teachers, learners, educational policy makers, the media and the concerned public.

INTERESTED IN MORE INFORMATION?

InLab – International Laboratory for Interdisciplinary Investigations into Individual Differences in Learning – www.inlab.co.uk

MSc in the Science of Psychology, Genetics & Education – www.gold.ac.uk/pg/msc-psychology-genetics-education/

Laboratory for Cognitive Investigations and Behavioural Genetics – cogbglab.tsu.ru

The Russian-British Laboratory of Behavioral Genetics – www.rbbglab.ru/en/

The Twins Early Development Study – www.teds.ac.uk/

IBL – International Business and Law Consultancy – www.inblc.com

