



HAL
open science

Comparison of French and Estonian students' conceptions in genetic determinism of human behaviours

Jérémy Castéra, Tago Sarapuu, Pierre Clement

► To cite this version:

Jérémy Castéra, Tago Sarapuu, Pierre Clement. Comparison of French and Estonian students' conceptions in genetic determinism of human behaviours. *Journal of Biological Education*, 2013, 47 (1), pp.12 - 20. 10.1080/00219266.2012.716779 . hal-01766301

HAL Id: hal-01766301

<https://hal.science/hal-01766301v1>

Submitted on 30 Mar 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Comparison of French and Estonian students’ conceptions in genetic determinism of human behaviours

Jérémy Castéra (*, **), Tago Sarapuu & (*) Pierre Clément (**)

(*) Science Education Centre, University of Tartu, Estonia

(**) S2HEP, University Lyon 1, France

Jérémy Castéra

University of Tartu

Science Education Centre

Tähe 4-312, Tartu 51010

Estonia (Eesti)

e-mail: jeremycastera@gmail.com

Acknowledgements

We particularly thank the teachers who gathered data in Estonia and in France and all the students who filled in the questionnaire. Special thanks also to Alain Abadie, Martine Choltus, Valérie Machon, and Andréa Slepcevic who actively helped us to gather the data. We are particularly grateful to all the other Biohead-Citizen participants for their methodological contributions.

This work has been supported by ERMOS (Estonian Research Mobility Scheme) in conjunction with the FP7 Marie Curie COFUND ‘People’.

Abstract: Innatism is the belief that most of the human personality can be determined by genes. This ideology is dangerous, especially when it claims to be scientific. The present study investigates conceptions of 1,060 students from Estonia and France related to genetic determinism of some human behaviours. Factors taken into account included students' religion, gender, parents' education level and the school curriculum. The data analysis used χ^2 for single comparisons but also multivariate analyses as between-class analysis and the Monte Carlo test to differentiate samples. The difference in the answers from students of the two countries is strongly significant, Estonian students' answers being more innatist and linked with more intolerant attitudes than French ones, although in both cases the majority is tolerant. For each country, very few factors differentiate students: only gender in France for the question on sexism and schools in Estonia. These findings show how sociocultural context is important for questions containing values interacting with scientific knowledge. The interpretation of the results infers significantly different trends among Estonian and French students' conceptions about the determinism of human behaviours and performance.

Keywords: determinism, human behaviours, genetics, students' conceptions, innatism

Introduction

Evolution of conceptions about genetic determinism in occidental societies

The debate on nature versus nurture is an old and persistent one (Meaney, 2001), albeit scientifically outdated, because the two concepts are in strong interaction, and not in opposition or addition. Jacquard (1981) developed an analogy: trying to measure if bricks or cement contribute more to a wall is pointless, because without interaction between both there is no wall. When the debate is in favour of nature, this dominant belief is called 'innatism' and history reminds us that innatism is an ideology with serious consequences for our societies. Indeed, in the early twentieth century, French research in genetics led to the foundation of institutes of genetics and eugenics and in the US to the American Eugenics Society (Aubert-Marson, 2005). Eugenic laws were

passed in some countries: 400,000 people were sterilized in Germany, 60,000 in Sweden, 50,000 in the US, inter alia, in order to avoid the transmission of so-called hereditary diseases such as mental disability, prostitution, alcoholism, crime, epilepsy, etc. (Garland, 1997). Moreover, in Germany innatism was at the base of the Nazi ideal of a 'pure' race. After the Second World War, although these practices were fortunately abandoned, implicit innatist ideology is still propagated by the mass media (Nelkin and Lindee, 1995). In fact, a simplistic method is often used by media to explain behaviours: one of the most famous was the supposed chromosome of crime in the 1970s (Clément et al., 1980). Today, with the development of genetic sequencing, the press has latched on to 'the smart gene', although scientists do not use this expression (e.g. *The Times* article titled 'Smart genes?'; see Tang et al., 1999). Nevertheless, at least in France, several scientists (e.g. Jacquard, 1981; Testart, 1997; Atlan, 1999; Kupiec and Sonigo, 2000; Jacquard and Kahn, 2001) and philosophers (the most famous being Sartre and de Beauvoir, but also, more recently, Stengers, 1997; Fox Keller, 2010) have alerted the public about these reductionist and dangerous ideas. They explain that we cannot reduce a complex behaviour to a simple genetic explanation: genes code for proteins and do not code directly for a behaviour which is always a complex interaction between a person and his/her surroundings in a precise situation. Today, different words are used to designate such conceptions: *genetic essentialism* (Nelkin and Lindee, 1995), *geneticism* (Dambrun et al., 2009), *hereditarianism* (Forissier and Clément, 2003), and also the classical term *innatism* (Castéra and Clément, 2010).

Conceptions of determinism in education

Forissier and Clément (2003) as well as Resnik and Vorhaus (2006) and other researchers noticed that belief in a strong genetic determinism is often used to justify fatalism on the ground that behaviours are dictated by genes and consequently we are

not responsible for our own acts. Moreover, psychologists such as Dambrun et al. (2009) in France and Keller (2005) in Germany showed that this innatism is linked with intolerant attitudes to several human groups (e.g. sexism, racism), genetic or biological differences being used for instance to justify belief in the superiority of some human groups (Brun and Maurel, 2005). That is why teaching genetics for better citizenship is a great challenge. One of the aims of the BIOHEAD-Citizen Project (Biology, Health and Environmental Education for Better Citizenship, FP6, 2004-2008, European Community CIT2-CT 2004-5006015) was to analyse conceptions of genetic determinism of teachers of 19 nationalities with a questionnaire (Castéra and Clément, 2008, 2010; Castéra, 2010). The results showed a strong tendency to group teachers by country according to their answers about genetic determinism. The findings indicate the presence of different trends of conceptions according to country. Estonian teachers tend to be a little more innatist than French teachers.

What are conceptions?

According to Clément (2006, 2010) conceptions are models of reference which enable the learner to understand concepts. Clément analyses conceptions according to three influences:

- Scientific knowledge (K): knowledge published and identified as scientific by the scientific community at a precise moment: usually current, but sometimes several years ago.
- Values (V): what we use for our decision-making. They justify opinions, ideologies or beliefs. For instance, innatism is a value because it is the belief that only genetics determines human features without scientific knowledge (or with some outdated knowledge).

- Social practices (P): this pole represents all individual or collective social practices, whether professional, religious, political, or other.

Clément explains that in order to analyse a conception of a person about a precise topic, it is necessary to place this person in different situations related to this topic (in this paper the different questions of a questionnaire). This enables us to mobilize several facets of their conceptions: several situated conceptions. From these it is possible to formulate hypotheses about trends of conceptions related to the specific topic (Clément 1994, 2010). In this way it is possible to analyse the trends of conception differences in a group of subjects such as nations, religious groups, etc.

Goal and research questions

Students' conceptions were not taken into account in the BIOHEAD-Citizen Project, which only analysed teachers' conceptions on the determinism of human behaviours and performance. The goal of this study is to investigate the trends of students' conceptions on this topic. Clearly, we would hope not to find eugenic conceptions like those of the early twentieth century described earlier, but possibly a trace of innatism values as found in the mass media. The present work, conducted in France and Estonia, analyses students' conceptions on determinism of human features. These students' conceptions are then compared with the known teachers' ones.

- (1) What are the main conceptions of Estonian and French students relating to the genetic determinism of some human behaviours? Are some of these conceptions dominated by values such as innatism? Are they correlated with other values such as intolerant values (e.g. sexism)?
- (2) Are these students' conceptions correlated with other parameters apart from nationality?

- (3) Are these students' conceptions coherent with teachers' conceptions (according to previous studies)?

Methods

Questionnaire

The questionnaire used in the present study is derived from the one designed for the BIOHEAD-Citizen project. The aim of this project was to analyse how aspects of citizenship can be promoted through biology, health and environmental education, taking into account the renewal of scientific knowledge as well as the social and affective dimensions. The project was structured by two main axes: a critical analysis of curricula and school textbooks and an analysis of in-service and pre-service teachers' conceptions from their answers to a questionnaire. The teams of 19 countries associated with this project, are composed by researchers with competencies in biology, health or environment and in human and social sciences, mainly in science education. We took two full years to design the BIOHEAD-Citizen questionnaire collectively (more details in Clément and Carvalho 2007; Munoz et al., 2009). In the present study, the questionnaire is used to analyse students' conceptions thanks to five questions related to the possible biological/genetic determinism of some human behaviours. Some personal information was also asked of students: their gender, age, religion, degree to which they believed in God, and the education level of their parents.

Questions were structured in such a way as to analyse conceptions about genetic determinism of human behaviours as interactions between K (knowledge on genetics), V (mostly innatism, sexism and racism) and P (social practices). In the present work, we used the five questions which were the most important to differentiate teachers' conceptions in the BIOHEAD-Citizen Project (Castéra and Clément, 2008): see Table I.

Table I: Five questions related to genetics and determinism of some human features.

Q1	Ethnic groups are genetically different and that is why some are superior to others.	I agree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I don't agree
Q2	There are genetic factors in parents that predispose their children to be good in school.	I agree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I don't agree
Q3	The human genome contains more genes than the genome of any other living being.	I agree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I don't agree
Q4	It is for biological reasons that women more often than men take care of housekeeping.	I agree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I don't agree
Q5	There are genetic factors in parents that predispose their children to become very good violinists.	I agree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	I don't agree

These five questions are based on a Likert scale: each student had to tick one of the four boxes from 'I agree' to 'I don't agree'. Q2 and Q5 convey only innatism ideology; scientists have never found clear evidence of music or intelligence genes. Some journals have claimed the existence of such genes but most scientists agree that there is no proof of the genetic heredity of complex human behaviours. If Q1 and Q4 are linked to innatism ideology, they are also linked to intolerant attitudes like racism (Q1) or sexism (Q4). Indeed, according to the Oxford English Dictionary (<http://oxforddictionaries.com/>), racism is the belief that all members of a race possess characteristics, abilities, or qualities specific to that race which distinguish it as inferior or superior to another race. Sexism is defined by prejudice, stereotyping, or discrimination, typically against women, on the basis of gender. In the BIOHEAD-Citizen questionnaire, five questions deal with a possible biological argument justifying some gender differences; we observed a very strong correlation between the answers to these five questions and that is why we decided to keep only one of them in the present work. Q3 is linked to knowledge related to genome size, but can also be influenced by innatism: the belief that typically human performance is explained by a superior number of genes. We know that the number of human genes is approximately the same as those of the mouse, a few more than in a nematode, and twice as few as those in rice or roses,

and human performances are correlated with the number and organization of neurones and synapses (cerebral epigenesis: Edelman, 1987; Fernando et al., 2008).

The sample

In total, 1,060 students (average aged 16–18) from the last two grades of upper secondary school filled out the questionnaire:

- Five hundred and fifteen in France, collected in four schools chosen to represent four different geographical areas (one rural, one urban, one suburban, and one combining all three in a medium-sized town). In two schools our data came from scientific, economic and literature classes, in one school from only technical and scientific classes and in one other school only from a scientific class. In scientific classes there are more lessons in biology than in others.
- Five hundred and forty-five in Estonia collected randomly in 17 different schools. Five schools come from rural and 12 from urban area, as it is not possible to differentiate more areas in Estonia. In the Estonian school system, there is no big difference between schools as in France. For instance, the number of biology lessons is the same in all schools – the only difference is in some optional courses. Nevertheless, few special schools introduce deeper foreign languages and cultures (e.g. British, German, French). One French orientated school is presented in our sample. In this school, students have to learn French language as well as French history, philosophy and culture since the first grade of elementary school (from the age of 6).

Procedure

The questionnaire was distributed to the students by the teachers during lessons. They

generally needed between 10 and 15 minutes to answer the questions. The teachers ensured that the process was totally anonymous, collected the completed questionnaires immediately, and sent them to the researcher.

Data analyses

All computations were performed with the statistical software R with the multivariate analysis package *ade4*. Traditional χ^2 tests were used with Bonferroni correction in order to avoid type I errors (when there is a chance difference owing to the multiple comparisons). Multivariate statistical methods were also used, mainly between-class analyses (Dolédec and Chessel, 1989), to discriminate between groups of individuals (countries, gender, religions, etc.) according to the five questions together, in order to analyse which trends of conceptions differed the most between these groups. A Monte-Carlo permutation test (Romesburg, 1985) implemented in the *ade4* libraries was then used to test the statistical significance of the difference between groups from the five instrumental variables (the five questions).

Results and discussion

Comparison of Estonia and France

Figures 1 to 3 show the distribution of the students' answers to the five questions in France and in Estonia. Q5 and Q2 (Figure 1) concern the possible heritability of being good at school or at music. In both cases the difference between the Estonian sample and the French sample is clearly significant (Q5: $\chi^2 = 90.7$, $df = 3$, $P < 0.001$ and Q2: $\chi^2 = 203.4$, $df = 3$, $P < 0.001$). Estonian students agree or rather agree with the genetic heredity of these performances more than French students (Q5: 46% in Estonia and 24% in France; Q2: 63% in Estonia and 27% in France). The same trend for these two

questions was found in the teachers' answer in both countries (Castéra and Clément, 2010; Castéra 2010).

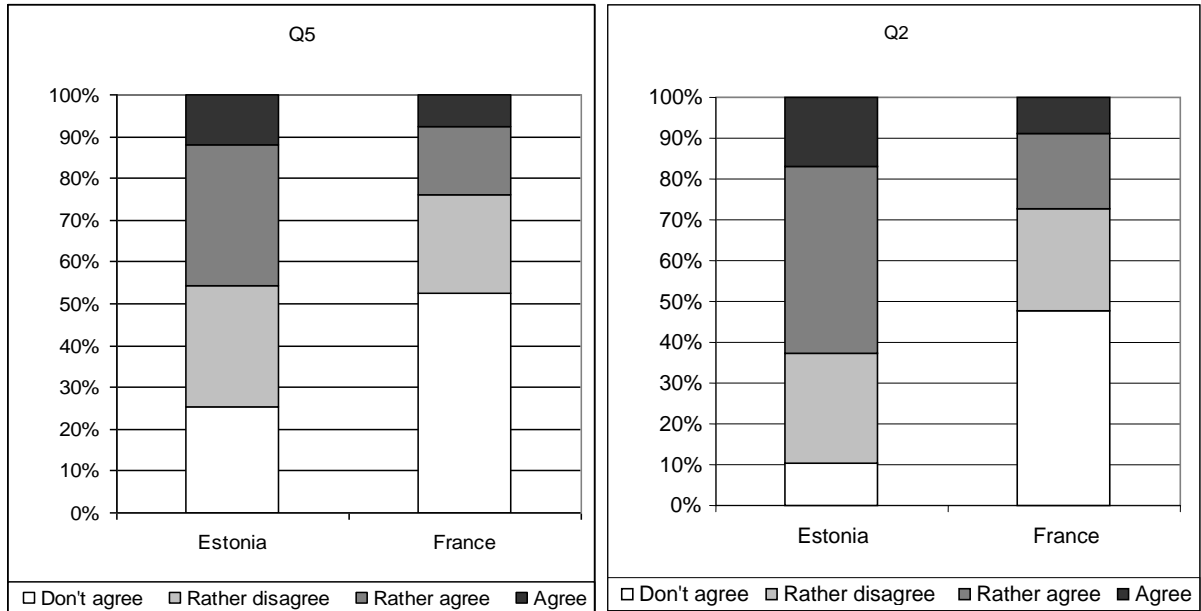


Figure 1: Comparison between Estonian and French students' answers about:

Q5 - Genetic factors and becoming very good violinists.

Q2 - Genetic factors and being good at school.

The result is quite similar for Q4 and Q1 (Figure 2). In Estonia, 40% of students agree or rather agree that : *It is for biological reasons that women more often than men take care of housekeeping* and 32% agree or rather agree that: *Ethnic groups are genetically different and that is why some are superior to others*. French students agree or rather agree to the same degree (10%) for both questions. The difference between French and Estonian students is strongly significant (Q4: $\chi^2 = 209.1$, $df = 3$, $P < 0.001$; Q1: $\chi^2 = 150.3$, $df = 3$, $P < 0.001$).

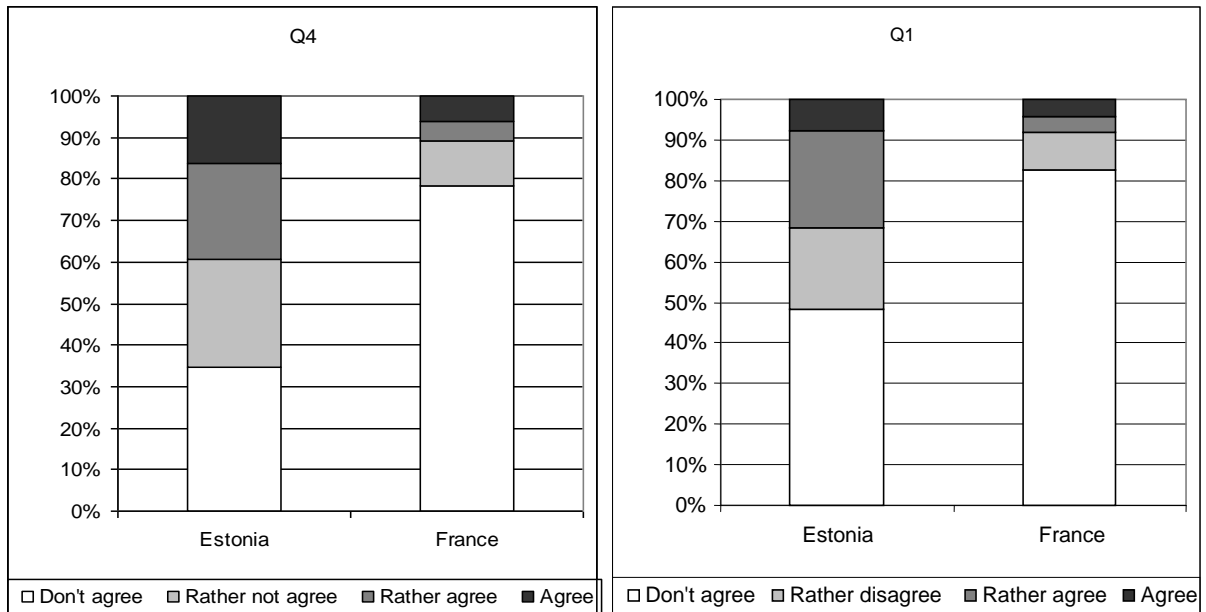


Figure 2: Comparison between Estonian and French students' answers about:

Q4 - Biological reasons why women take care of housekeeping.

Q1 - Ethnic groups are genetically different and superior to others.

Q3 (Figure 3) concerns the number of genes in the human genome. Figure 3 shows that 34% of French students versus 50% of Estonian students agree or rather agree that: *The human genome contains more genes than the genome of any other living being*. This difference is also strongly significant ($\chi^2 = 38.3$, $df = 3$, $P < 0.001$). Although this result could show a lack of knowledge about the number of genes in some species, it also shows that the idea of genetic determinism is stronger in Estonia. At the beginning of the Human Genome Project, researchers expected to find 100,000 to 150,000 genes in the human genome. Nevertheless, today we know that it contains fewer than 25,000 genes while some other species contain more genes. This information is more known or accepted by French (2/3) than by Estonian (1/2) students.

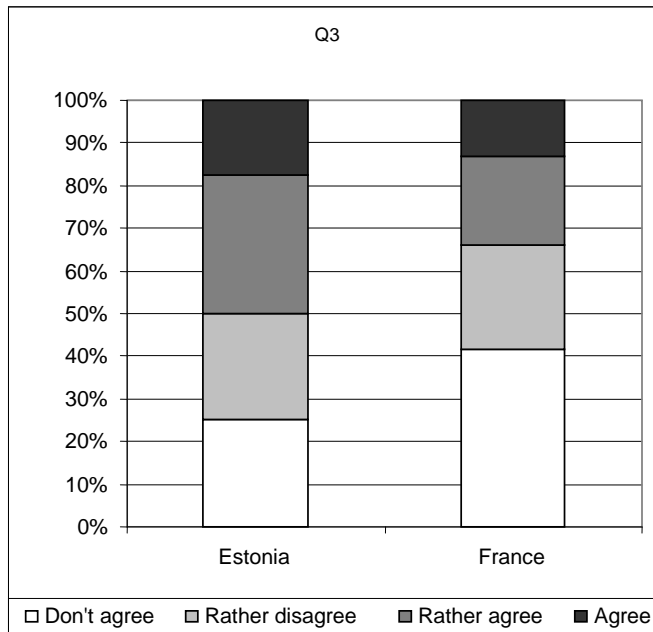


Figure 3: Comparison between Estonian and French students' answers about:

Q3 - The human genome contains more genes than any other living being.

In summary, the differences between the two countries are significant for the five questions, related to innatism (being a good violinist, Q2, or good at school, Q5; or thinking that human beings have more genes than other living beings, Q3), racism (Q1) and sexism (Q4). Moreover, between-analysis, followed by a Monte-Carlo test, showed very significant ($P < 0.001$) difference between French and Estonian students when questions were tested all together. This analysis also reveals a strong correlation between the answers to these five questions, Estonian students being more innatist than French ones. In consequence, our findings confirm a clear association of innatism with intolerant attitudes (like sexism and racism), as already shown by other researchers (e.g. Keller, 2005; Dambrun et al., 2009). An intolerant answer was given (Q1) by 10% of French students and 32% of Estonian students. A preceding survey showed that only 5% of Estonian teachers and 3% of French teachers agreed or rather agreed with the same racist affirmation Q1 (Castéra, 2010). In both countries, the difference between

teachers' and students' answers is significant for Q1, showing a possible generational effect or an effect of education level.

As regards Q4, sexism is more present in Estonian students' answers (40%) than in French students' (12%), and even more present in Estonian teachers' answers (47%) than in French teachers' (3%), as shown in earlier works (Castéra and Clément, 2010; Castéra, 2010). In Estonia, the difference between teachers and students is not significant, but in France students are significantly more sexist than teachers when answering this question (12% v. 3%). There is an influence of age and, more probably, of the level of instruction. We discuss below the differences among Estonian and French students' answers.

These findings show trends of conceptions (all questions together) more innatist in Estonia than in France. Consequently, in comparison with our earlier work, it is possible to see strong similarities between students and teachers in both countries, even though some small differences can be found, with an effect of the level of instruction.

Sociocultural explanation

Do the results reflect a possible influence of media on the conceptions related to genetic determinism of human behaviours (Nelkin and Lindee, 1995; Dambrun et al., 2009)? There is probably a difference between French and Estonian media in these terms. In France, several scientists and philosophers regularly warn that genetic determinism can be used as a justification for social fatalism regarding political or religious issues. An interesting example is the strong reaction of the scientific community to Nicolas Sarkozy's assumption of the genetic determinism of some human behaviours, e.g. juvenile violence or suicide, during the French presidential campaign in 2007 (Philosophie Magazine, 2007).

We note also that philosophy is an obligatory course in the last grade of French secondary school. The curriculum specifies that students have to learn the concept of determinism. This notion is studied in association with human liberty and free will. For instance, in 2011 the final national examination (the Baccalauréat) at the end of secondary school asked students to discuss this question: *La culture dénature-t-elle l'homme?* (Does culture change the nature of human beings?). To answer this question, students had to discuss the inseparable concepts of culture and nature (nature and nurture) and to support their argument by showing that we cannot be satisfied with simple genetic determinism. In Estonia, philosophy is only optional and depends on the school specialty. Even when schools choose this course, however, the concept of determinism is not under consideration. This difference between curricula can also partly explain the variation in answers between French and Estonian students, which are more generally anchored in the specific culture and history of the two countries.

The French sample

No difference between French schools

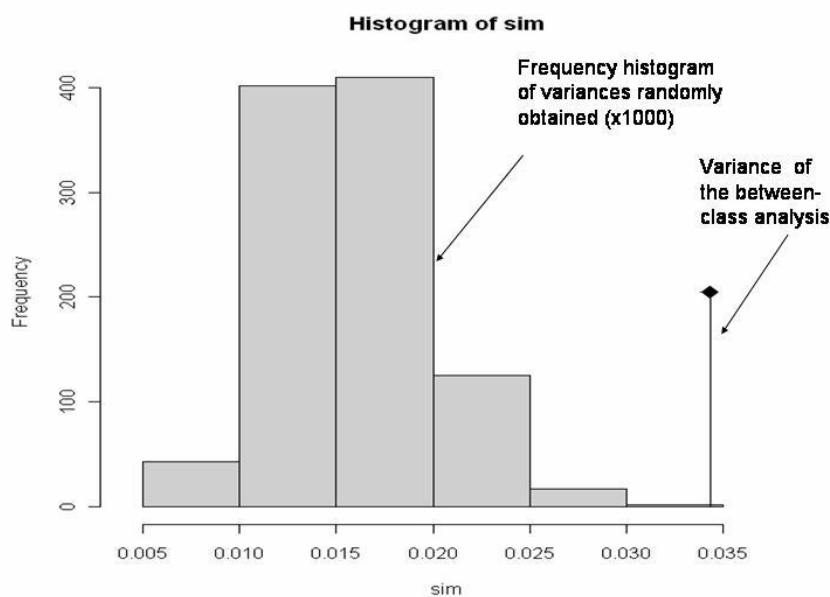


Figure 4: Monte Carlo permutation test on the variation between French schools. The test is not significant because the variation could be obtained by chance.

In France, the between-class analysis shows no significant difference between the schools: in the Monte Carlo test, the variance of the sample is no different from 1000 variances obtained randomly (Figure 4). The French sample is very homogeneous, which is why in a subsequent test (Figure 6) we can compare the different Estonian classes with the French sample (without differentiating between French classes).

Factors distinguishing students in France

The between-class analyses and Monte Carlo permutation test do not show any difference between the religions (Muslims, Catholics, Protestants and agnostics/atheists) or between levels of religious practice and belief in God. There is also no significant difference according to the socio-professional categories of students' parents. Students following scientific curricula (with more knowledge on biology) do not differ from other students.

The gender of students is the only parameter significantly differentiating the students' answers according to the Monte Carlo test. The difference only relates to Q4: *It is for biological reasons that women more often than men take care of housekeeping* (Figure 5). The difference between female and male students in France is strongly significant ($\chi^2 = 42.7$, $df = 3$, $P < 0.001$).

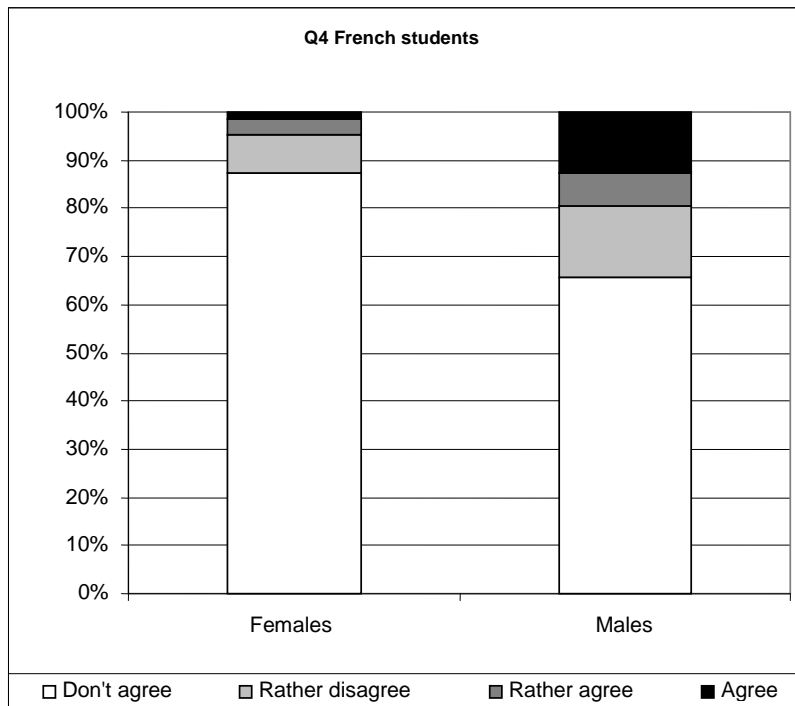


Figure 5: Comparison between female and male students' answers about:

Q4 - Biological reasons why women take care of housekeeping.

French female students are more opposed than male students to this sexist affirmation. Only 5% of French female students agree or rather agree with it whereas 20% of French male students do. In France, female students are significantly more feminist than male students (Q4).

The Estonian sample

Differences between Estonian schools: a comparison with the French sample

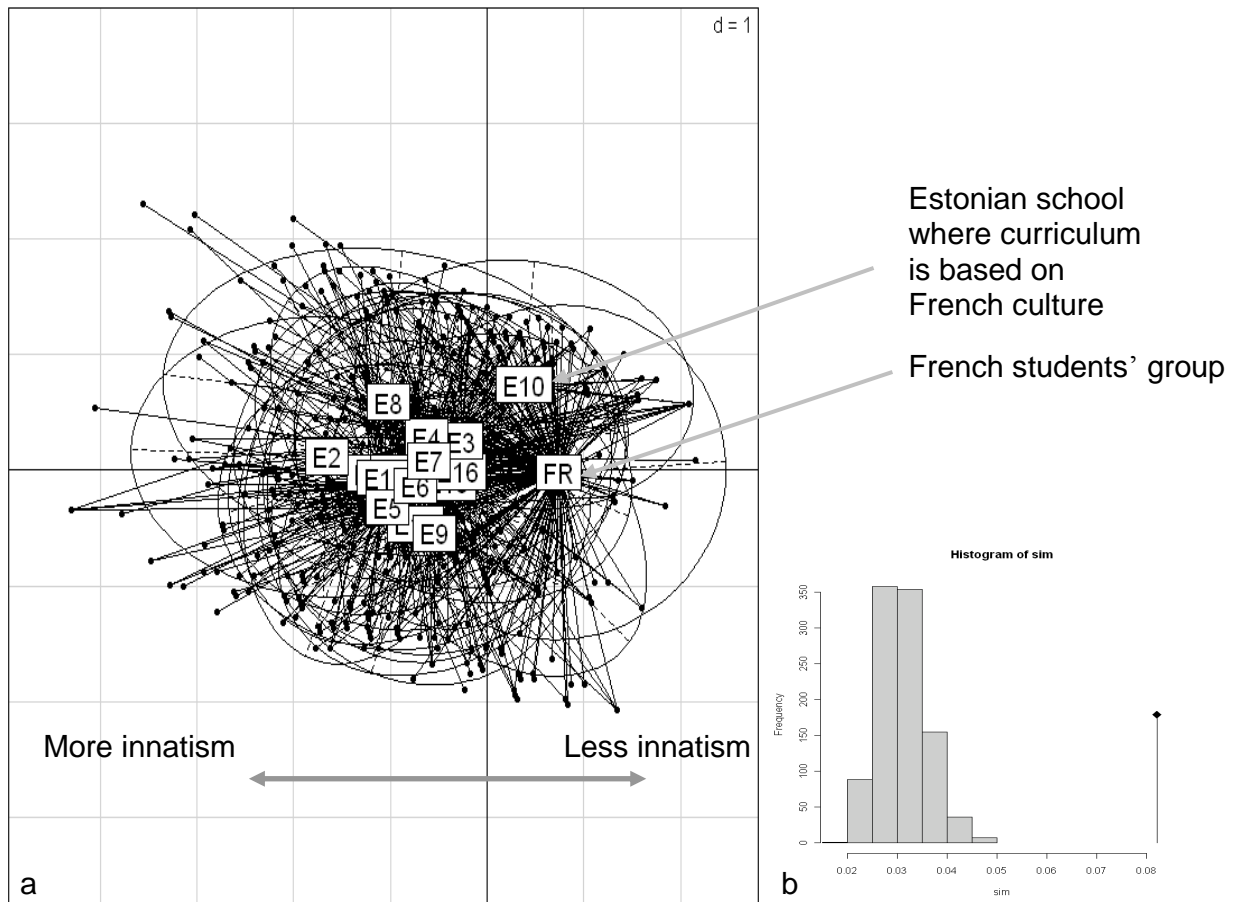


Figure 6a: Between-class analysis of Estonian schools (E1 to E17 = 545 students) and French sample (FR = 515 students from France). The vertical axis is not enough informative to be interpreted. Figure 6b: Monte Carlo permutation test of Estonian schools only.

The between-analysis based on the answers of students related to the five questions, followed by a Monte Carlo permutation test, shows a significant difference between Estonian schools (variance between only Estonian schools is different from variance obtained randomly, $P < 0.001$, Figure 6b). It means that the analysed students' conceptions differ in certain Estonian schools. The less innatist students' conceptions

are observed in school E10 (Figure 6a), where Estonian students have a curriculum oriented on French culture. These students give answers very close to the French students' answers as represented in Figure 6a. This proximity was confirmed by a between-class analysis of French students (FR) and Estonian students from school E10, which does not show any significant differences (Monte Carlo test). The students' conceptions in the E10 school also significantly differ from those in other Estonian schools (Figure 6a).

The traditional French presentation of the question of determinism of human behaviours is linked to the history and the culture of the nation. Indeed, France has a long tradition of philosophical questions about the universality of human rights, egalitarianism (Montesquieu, 1749; Rousseau, 1755, etc. during the Century of Lights) and feminism (de Beauvoir, 1949). These philosophers have deeply influenced French society's thought on egalitarianism and feminism. That is probably why our results show that feminist and anti-racist positions are stronger in France than in Estonia. This finding highlights the influence of cultural heritage. Conceptions of Estonian students in the school oriented to the French culture are very close to conceptions of French students. These Estonian students learn French history, literature, etc. and this has an impact on their own conceptions. The difference between Estonian schools remains even if we suppress school E10, showing strong disparities of trends of conceptions among schools in Estonia

Other factors distinguishing Estonian students

The same factors tested in France were used in between-class analyses and Monte Carlo permutation tests. As in France, there is no significant difference in terms of religion (Orthodox, Catholics, Protestants and agnostics), the levels of religious practice and belief in God, or the socio-professional categories of students' parents.

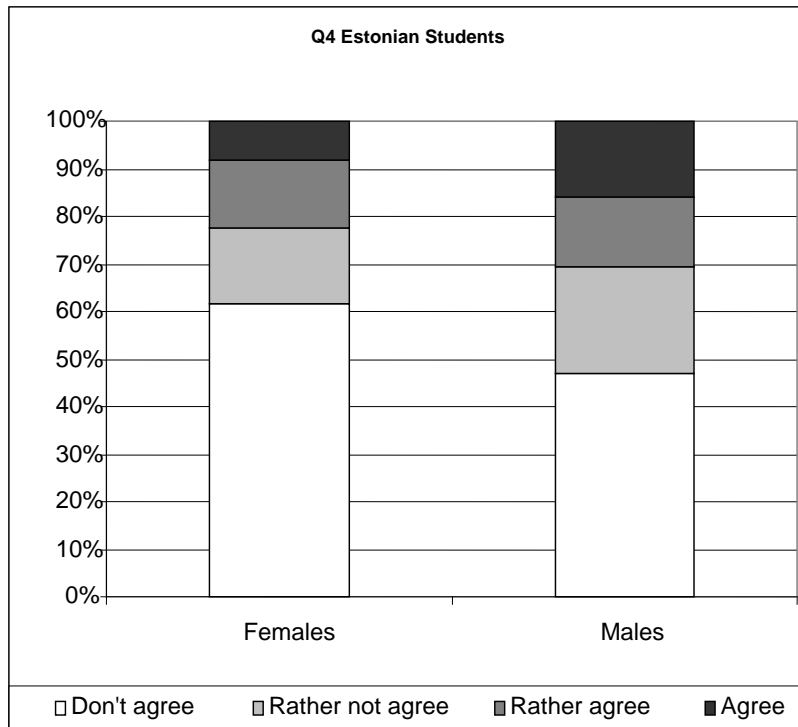


Figure 7: Comparison between answers of Estonian female students and Estonian male students about:

Q4 - Biological reasons why women take care of housekeeping.

In Estonia, the difference between male and female students' answers is not significant (from the between-analysis and Monte Carlo test), even if it is at the limit of signification for Q4 ($\chi^2 = 9.5$, $df = 3$, $P = 0.024$), where the female answers are a little less sexist than the male answers (Figure 7). Female students are more feminist than male students (Q4), significantly in France but less significantly in Estonia. This result reinforces the idea that feminist heritage in France is stronger than in Estonia, especially for French females.

Conclusion and educational implications

The results, based on the answers of students, shows that the majority of students in

both countries are not influenced by innatism, but a non-negligible proportion of answers is influenced by an innatist value. This is more important in Estonia than in France. It is shown also that students influenced by innatism agree more with sexist or racist affirmations. This finding is consistent with a structured mental model (a conception) whereby innatism can justify intolerant attitudes against some human groups. Few factors other than 'the country effect' distinguish students' conceptions on genetic determinism. These factors are always under influence of sociocultural aspects. This finding reinforces our hypothesis that the culture, history and media of each country have a very strong influence on the analysed conceptions. Interactions between science and sociocultural aspects are ubiquitous in human genetics.

We are aware that these findings relate only to answers to five questions about genetic determinism of human behaviours, but they are in total accordance with the results previously found for teachers' answers on a longer questionnaire. Similar trends of conceptions are present in Estonia and in France among students and teachers.

This work shows that, at least for one topic learnt during secondary school, the conceptions of students can differ from one European country to another. The sociocultural influence is undeniable. If we want to improve the role of schools in Europe in order to develop better citizenship, it is necessary to consider these sociocultural influences. Comparative studies are very important for European citizenship and can lead to specific teacher training and recommendations for school curricula in a particular country.

In the light of our results, we recommend introducing this epistemological and historical approach to genetics in schools. Teachers and students should learn from Garland (1997, p.77), with reference to the eugenic experiments of the past: *'There is an important lesson to learn from the past: genetic arguments are put forward to mask the*

true – social and economic – causes of human behavioural defects?. Explaining how science was used to justify ideology can help teachers and students to become aware of their own conceptions. Indeed, we suggest that epistemological genetics education can also lead to better tolerance, which is a pillar of citizenship, especially in context of the European construction. Moreover, an unclear conception of genetic determinism leads to *an inability to participate fully in social life and potentially a lack of support for new genetic technologies* (Marks, 2009, p. 1). The role of education is to give keys to citizens for their own decision-making.

References

- Atlan H (1999) *La fin du "tout génétique"*. Paris, France: INRA.
- Aubert-Marson D (2005) Les politiques eugénistes aux Etats-Unis dans la première moitié du XXe siècle. *Medecine/Science*. 21 320-323.
- Beauvoir (de) S (1949) *Le deuxième sexe* (1986 ed.). Paris, France: Gallimard.
- Brun B and Maurel M C (2005) Introduction à l'histoire de la controverse "inné/acquis". In: *L'Inné et l'Acquis. Nouvelles approches épistémologiques*, eds Maurel M C and Brun N B pp 7-46. Aix en Provence, France: Presses Universitaires de Provence.
- Castéra J (2010) *Enjeux de l'enseignement de la génétique humaine. Ses représentations dans les manuels scolaires et chez les enseignants, dans 19 pays*. Doctoral dissertation, Université Lyon 1.
- Castéra J and Clément P (2008) A gender effect related to teachers' conceptions of biological gender differences: A survey in 14 countries. In: *Proceedings of ERIDOB (European Researchers in Didactics of Biology, 16th -20th September)* pp 343-360. Utrecht, Netherlands: University of Utrecht.
- Castéra J and Clément P (2010) Interaction entre connaissances scientifiques et valeurs dans les conceptions d'enseignants français sur le déterminisme génétique de comportements humains. *Recherches en didactique des sciences et des technologies*. 1 241-264.

- Clément P (1994) Représentations, conceptions, connaissances. In: *Conceptions et connaissances*, eds Giordan A, Girault Y and Clément P pp. 15-45. Berne, Switzerland: Peter Lang.
- Clément P (2006) Didactic transposition and the KVP Model: Conceptions as interactions between scientific knowledge, values and social practices. In: *Proceedings of Summer School ESERA* pp 9-18. Braga, Portugal: Univ. Minho.
- Clément P (2010) Conceptions, représentations sociales et modèle KVP. *Skholê*. 16 55-70.
- Clément P Blaes N and Luciani A (1980) Le mythe tenace du "chromosome du crime", encore appelé "chromosome de l'agressivité". *Raison Présente*. 54 109-127.
- Clément P and Carvalho G (2007) Biology, health and environmental education for better citizenship: teachers' conceptions and textbook analysis in 19 countries. In: *Proceedings WCCES XIII (World Council of Comparative Education Societies)* 15 pp. Sarajevo, CD-Rom.
- Dambrun M Kamiejski R Haddadi N and Duarte S (2009) Why does social dominance orientation decrease with university exposure to the social sciences? The impact of institutional socialization and the mediating role of "geneticism". *European Journal of Social Psychology*. 39(1) 88-100.
- Dolédéc S and Chessel D (1989) Rythmes saisonniers et composantes stationnelles en milieu aquatique II- Prise en compte et élimination d'effets dans un tableau faunistique. *Acta OEcologica, OEcologia Generalis*. 10 207-232.
- Edelman G (1987) *Neural Darwinism: the theory of neuronal group selection*. New York, USA: Basic Books.
- Fernando C Karishma K K Szathmáry E (2008) Copying and Evolution of Neuronal Topology. *PLoS ONE*. 3 (11) 3775.
- Forissier T and Clément P (2003) Teaching "biological identity" as genome / environmental interactions. *Journal of Biological Education*. 37(2) 85-91.
- Fox Keller E (2010) *The mirage of a space between nature and nurture*. Durham, NC, USA: Duke University Press.
- Garland E A (1997) The social and economic origins of genetic determinism: a case history of the American Eugenics Movement, 1900–1940 and its lessons for today. *Genetica*. 99 77-88.
- Jacquard A (1981) *Eloge de la différence*. Paris: Le Seuil.
- Jacquard A and Kahn A (2001) *L'avenir n'est pas écrit*. Paris, France: Bayard.

- Keller J (2005) In genes we trust: The biological component of psychological essentialism and its relationships to mechanisms of motivated social cognition. *Journal of Personality and Social Psychology*. 88 686-702.
- Kupiec J J and Sonigo P (2000) *Ni Dieu, ni gène*. Paris, France: Seuil.
- Marks N J (2009) Public Understanding of Genetics: The Deficit Model. *eLS*. (online article:<http://onlinelibrary.wiley.com/doi/10.1002/9780470015902.a0005862.pub2/full>). Last access on: 12/03/12.
- Meaney M J (2001) Nature, nurture and the disunity of knowledge. *Annals of the New York Academy of Sciences*. 935 50-61.
- Montesquieu (1749) *De l'esprit des lois* (2003 ed.). Paris, France: Flammarion.
- Munoz F Bogner F Clément P and Carvalho G S (2009) Teachers' conceptions of nature and environment in 16 countries. *Journal of Environmental Psychology*. 29(4) 407-413.
- Nelkin D and Lindee M S (1995) *The DNA mystique: the gene as a cultural icon*. New York, NY, USA: Freeman.
- Philosophie Magazine (2007) Website available on <http://www.philomag.com/article,dialogue,nicolas-sarkozy-et-michel-onfray-confidences-entre-ennemis,288.php>. Last access on: 21/11/11.
- Resnik D B and Vorhaus D B (2006) Genetic modification and genetic determinism. *Philosophy, Ethics, and Humanities in Medicine*. 26 1-9.
- Romesburg H C (1985) Exploring, confirming, and randomization tests. *Computers & Geosciences*. 11 19-37.
- Rousseau J J (1755) *Discours sur l'origine et les fondements de l'inégalité entre les hommes* (2007 ed.). Paris, France: Hatier.
- Stengers I (1997) *La vie et l'artifice : les visages de l'émergence. Cosmopolitiques VI*. Paris : La Découverte.
- Tang P Shimizu E Dube G R Rampon C Kerchner G A Zhuo M Liu G and Tsien J Z (1999) Genetic enhancement of learning and memory in mice. *Nature*. 401(6748) 63-69.
- Testart J (1997) Génétique: puissance et illusions. *Transversales Science Culture*. 44 4-7.