

Chernoff survey in Argentine and Hungarian schools

José Jesús Reyes Nuñez, Anita Rohoncz, István Klinghammer, Cristina E. Juliarena de Moretti, Ana María Garra, Carmen Alicia Rey, María V. Alves de Castro, Anabella S. Dibiase, Teresa A. Saint Pierre, Mariana A. Campos

Abstract: In 2008 and 2009 a Hungarian-Argentine project was developed under “The possible uses of the Chernoff faces for data visualisation in school cartography”. This research was divided into two parts. First the international experiences using the statistical method known as Chernoff faces in thematic cartography were studied by analyzing the results of investigations completed during the last 15 to 20 years. In the second part the possibilities of this method were investigated in a more specific cartographic field: the thematic representation in school atlases and maps, trying to find answers to questions related to the possible use of this method in thematic maps published for school pupils, organizing a survey with the participation of pupils from elementary and secondary schools in both countries. The data were stored in digital format and the results of the analysis were presented using charts and were placed on the website of the project.

Keywords: Chernoff faces, school cartography, children, survey, visualization, pictograms

Jose Jesus Reyes Nuñez, PhD
(jesus@ludens.elte.hu)
Istvan Klinghammer, PhD
(klinghammer@ludens.elte.hu)
Eotvos Lorand University
Department of Cartography and
Geoinformatics
Pazmany P. set. 1/A
H-1117 Budapest, Hungary
Tel: 36 1 372 2975 Fax: 36 1 372 2951

Anita Rohoncz
Cartographia Tankönyvkiadó Kft.
Fehérvári út 89-95.
H-1119 Budapest, Hungary
Tel: 36 1 463 9010 Fax: 36 1 463 9011
rohoncziani@freemail.hu

Cristina Esther Juliarena de Moretti
(lic_geografia@hotmail.com)
Ana María Garra
(agarr@indec.mecon.gov.ar)
Consejo Superior de Educación Católica
(CONSUDEC) – Instituto del Profesorado
“Septimio Walsh” (V-5)
Esmeralda 759 – Piso 4
Buenos Aires, Argentina
Tel/Fax: 54 11 4326 3834

Carmen Alicia Rey
(carmerey@yahoo.com)
María Victoria Alves de Castro
(v_aar@yahoo.com.ar)
Anabella Soledad Dibiase
(asd_ani@yahoo.com.ar)
Teresa Alejandra Saint Pierre
(tesapi@hotmail.com)
Mariana Alesia Campos
(alesia_76@yahoo.com.it)
Centro Argentino de Cartografía
Av. Cabildo 381 – Buenos Aires,
Argentina
Tel: 54 11 4576 5576 / 184
Fax: 54 11 4502 6799

1. INTRODUCTION TO THE CHERNOFF FACES AND THE RELATED CARTOGRAPHIC RESEARCH

In 1973, Hermann Chernoff (Figure 1) created his method for the graphic representation of statistical data, which was explained in the article entitled „The use of faces to represent points in k -dimensional space graphically”, published in the Journal of the American Statistical Association.

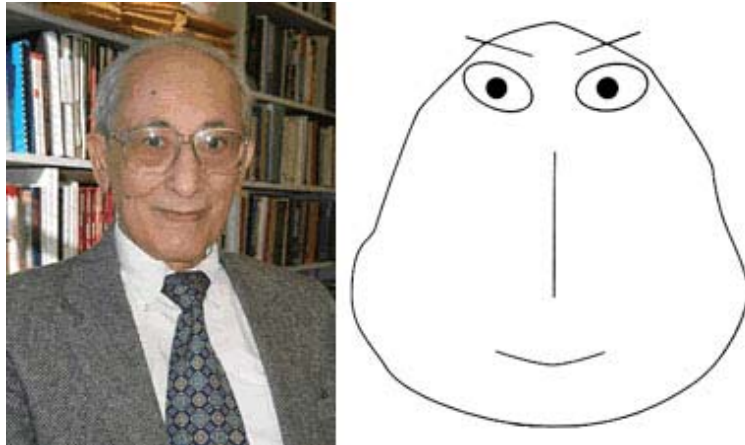


Figure 1. Herman Chernoff in 2008 and the original face from 1973

He decided to use a human face as a symbol (called multivariate symbol), on which its features (eyes, ear, nose, mouth etc) can be used to represent different variables, changing the specific characteristics (parameters) of each feature depending on the values of these variables. Chernoff (1973) affirmed that up to 18 different themes or variables can be differentiated using a wide cast of features of a human face.

Only four years after the publication of the article written by Chernoff, this method of representation began to be introduced also to cartography abroad, using the human faces to represent data on a map according to the traditional methods of thematic representation. The first and more famous (today considered a classic) example is the map entitled "Life in Los Angeles, 1970", designed by Eugene Turner (Figure 2) and drafted by Richard Doss from the Geography Department at the California State University in 1977. Eugene Turner wrote about this map: "*It is probably one of the most interesting maps I've created because the expressions evoke an emotional association with the data. Some people don't like that.*" (Turner, 2004).

From the 90's mainly two names are related to research on the map use of Chernoff faces:

- Danny Dorling, who beginning the decade finished his PhD research on the theme of visualization of spatial structure, combining his cartograms with Chernoff faces to represent the results of data analysis about elections in Great Britain (Dorling 1991).
- Elizabeth S. Nelson, who from the second half of the 90's began to research on specific aspects of this theme, as feature salience and natural correspondence on faces and the exam of search process when information is represented on a map using Chernoff faces (Nelson 1997-2007).

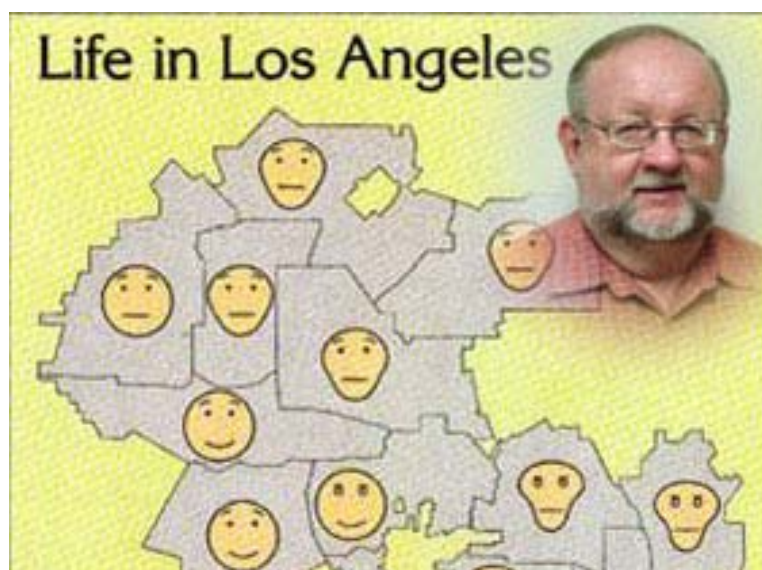


Figure 2. Eugene Turner and a fragment of his map

2. ORGANIZATION OF THE INTERNATIONAL PROJECT

Coordinators of this project have been organizing joint research from 2004, under the scope of the bilateral agreement signed by the Argentine and Hungarian governments for the support of scientific research. Present research can be considered the continuation of the project entitled „Map reading by children in school age: Cartographic education and practice in Hungary and Argentina”, developed between 2004 and 2005. One of the conclusions drafted in this project emphasized the need of further research in the field of thematic cartography. The present theme (the possible uses of the Chernoff faces in thematic cartography with special attention to school cartography) kept on this appointed line of research.

The project was developed in two years, during 2008 and 2009. Our objectives were:

- Study of cartographic antecedents similar to the Chernoff method, their actual uses in thematic cartography and the possible use of Chernoff faces in school cartography.
- Drafting of principles and general lines for the cartographic use of this method.
- Design and making of sample maps and their test in educational institutions.
- Analysis of the results of the test, drafting proposals about the use of this method in school publications.
- Accessibility of the results across the Web, which assures the fast accessing by specialists from other countries.

3. DESIGN OF THE QUESTIONNAIRE

In the first year (2008) we followed theoretical research about this method, and the results were described in a paper presented in the 24th International Cartographic Conference held in Santiago de Chile in November of 2009 (Reyes, 2009).

Based on the results obtained during the theoretical research, the colleagues began to plan the tests to be applied for pupils in both countries. Considering the specific characteristics of each educational system and our interest to apply the questionnaire for pupils with some experience using maps and school atlases, our decision was to execute the survey for pupils of grades 7 and 8 (13, 14 and 15 years old) in Hungarian Elementary Schools, and for pupils of 1st grade in Argentine Secondary Schools.

In the interest of planning a cheap survey we decided that the test should be printed in a A5 format, with a maximum of four questions designed in black and white. This was important because the Argentine specialists did not have any kind of financial support to execute the survey in their country and the bilateral agreement finances only the exchange of specialists between both countries. We had to word the questions taking into account these limitations, because the absence of colours could not mean an obstacle to understand the information represented in the maps.

After numerous consultations, the four questions of the test were penned after the following principles:

Question using “traditional” Chernoff faces

Specialists decided to include a question representing a theme with the original method created by Hermann Chernoff, keeping its two main characteristics: only the shape of a face can be changed to represent data, and all the faces should be kept unfilled or filled with the same colour or tone. The decision was taken to determine how difficult it was to read the represented data if only the shape was changed while the size of the faces remained the same (Figure 3). This graphic solution does not take into account some of the principles drafted by Bertin (1983) in his “Graphic semiology”, where he affirmed that the change of size of the same symbols allows the readers to identify more easily the quantitative differences between the represented values.

The data represented using this solution was the number and volume of dumps in the suburbs of Buenos Aires in the Argentine test, and the relationship between the expectancy of life and medical services in some East European countries in the Hungarian test.

Question with Chernoff faces applying cartographic principles

The next step was to use Chernoff faces designed with some cartographic modifications. In both countries the shape of the faces (circle) was not changed, only the size varied according to the represented data. The Hungarian specialists also

decided to change the fill of the faces to represent other variable, a solution used habitually in thematic cartography, but excluded by Chernoff in the original version of his method.

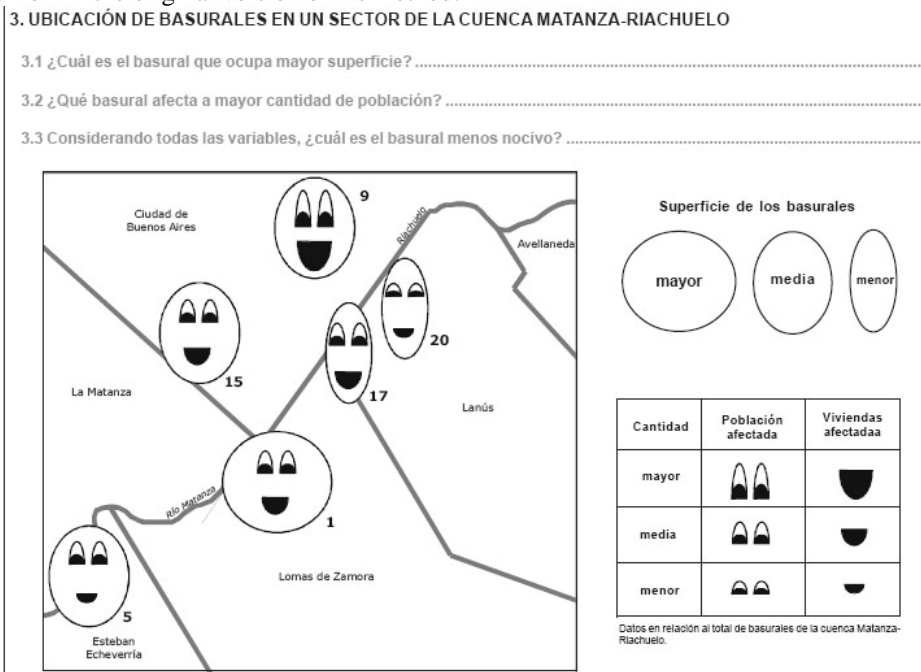


Figure 3. Question using the original Chernoff faces in the Argentine questionnaire

With the change of fill we wanted to determine if this kind of representation can or cannot have any indirect influence when reading the other data represented by the change of size.

The selected data were the comparison of different agricultural products in Hungary (Figure 4) and the number of houses counting with public services in the suburbs of Buenos Aires, Argentina.

Question applying the Chernoff principle on pictograms

This was a more interesting question for the participant specialists, because a new proposal was tested combining traditional cartographic pictograms and the principle used by Chernof to create his faces. The detailed presentation of this idea was made in the session dedicated to Cartography and Children during the 24th ICC in Santiago de Chile (Reyes, 2009).

2. A térképen ábrázolt adatok alapján válaszolj a következő kérdésekre:

1. Csehországban vagy Ausztriában természetnek több almát az ábra alapján?

2. Melyik országban legnagyobb a búzatermesztés?

- (A) Ausztria
- (B) Magyarország
- (C) Csehország
- (D) Szlovákia
- (E) Lengyelország

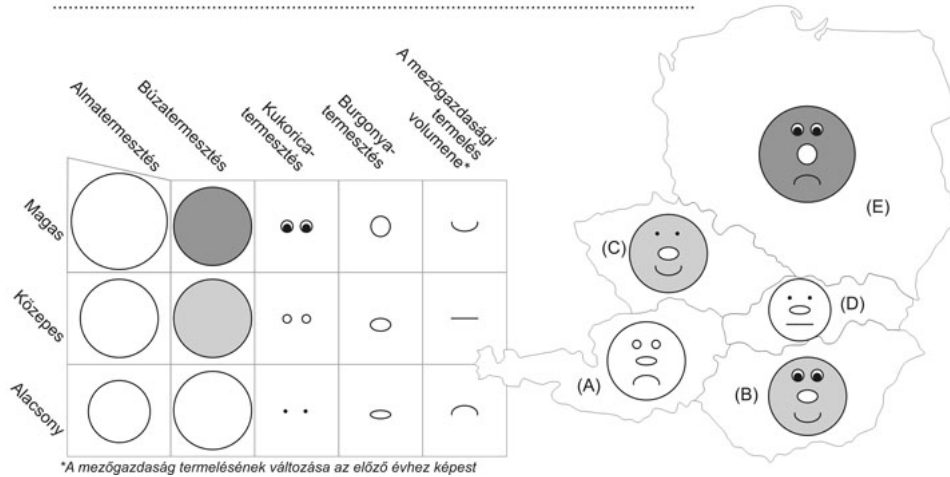


Figure 4. Question presenting a more cartographic version of Chernoff faces in the Hungarian questionnaire

3. A térképen láthatod a különböző citrusfélék termelését Spanyolország déli tartományaiban.

- Melyik tartományban a legmagasabb az összes citrusféle termelése?
- Melyik tartományban a legkevesebb a mandarin termelése?
- Melyikben a legnagyobb a citromtermelés?

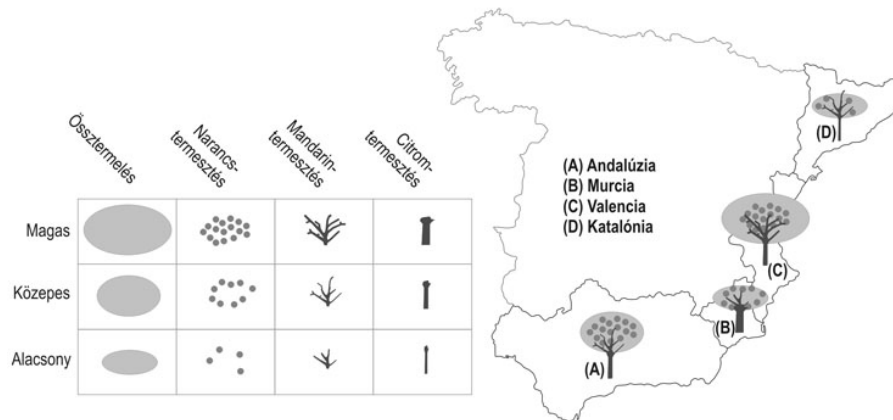


Figure 5. Question applying the Chernoff principle on pictograms in the Hungarian questionnaire

Shortly: a pictogram can be divided into its more relevant and graphically better recognizable elements (components, features), and each of these elements can represent a specific variable (data set). By this solution we try to improve the traditional use of symbols in (school) cartography: for centuries symbols were used to represent only one theme, changing the size (proportional symbols) and/or the shape of the symbol to express how a theme can change depending on a value. Sometimes other graphic parameters of a symbol (e. g. fill colour) were also changed to represent another theme. But using the Chernoff principle other graphic parameters can be changed within a symbol (in this specific case a pictogram), growing automatically the number of themes that can be represented on one thematic map only.

Argentine and Hungarian colleagues selected two different themes (range of parks and squares in some districts of Buenos Aires, and the production of citrus in the southern provinces of Spain), but both themes were presented using the same pictogram (a tree) and changing similar parameters: leafage, trunk, etc (Figure 5).

Question to draw thematic data on an outline map using Chernoff faces

The last question of the test included an outline map with a table containing basic data and a legend to give pupils the choice of creating their own Chernoff map. In Argentina, data about the level of educational attainment in some provinces were used, while in Hungary, the data were about the different religions in some provinces (Figure 6).



Figure 6. Question to make a Chernoff map in the Argentine questionnaire

4. SURVEY IN BOTH COUNTRIES

This survey was applied between March and June of 2009. The Argentine organizers faced some difficulties to collect their data at a national level: the large extent of the country (the province of Buenos Aires is equivalent to the whole territory of Hungary), and the difficult communication with the remote regions represented a serious obstacle, adding that they made and distributed the tests without any financial support. Finally, they succeeded in collecting answers from 8 schools placed in the province of Buenos Aires. In Hungary a total of 12 schools participated from three provinces, but the majority of the answers arrived from Budapest.

In Hungary, a total of 1038 pupils answered the questions of the test, while in Argentine a total of 818 pupils participated in the survey (Juliarena et al, 2009). The major part of the Hungarian pupils (42.1%) was 14 years old and 33.7% was 13 years old. In Argentina 66.4% of the participants were 13 years old.

5. GENERAL RESULTS AND ANALYSIS OF SOME ANSWERS

The general results of the survey are presented by questions and countries in Table 1.

MAIN RESULTS OF THE SURVEY						
QUESTIONNAIRE	ARGENTINA			HUNGARY		
	Right answers	Answers with one or more errors	No answer	Right answers	Answers with one or more errors	No answer
Question using “traditional” Chernoff faces	493	325	-	828	207	3
Question with Chernoff faces applying cartographic principles	285	533	-	665	367	6
Question applying the Chernoff principle on pictograms	294	524	-	908	123	7
Question to draw thematic data on an outline map using Chernoff faces	540	278	-	798	211	29

Table 1. General results of the survey

Together with the general results presented in the table, specialists also calculated the partial results by each question, which are presented by different diagrams on the website of the project. Based on these diagrams we can have more genuine background information about the results of the survey.

A characteristic example is the analysis of the partial results in the question about the use of Chernoff faces applying cartographic principles in the Argentine survey. According to the general results, only 35% of participants answered correctly the three items of this question. But consulting the results in the more detailed diagram (Figure 7), it can be seen that the percent of pupils with only one error in their answer is very similar (34%, 281 pupils), and both categories together constitute nearly 70% of the participants.

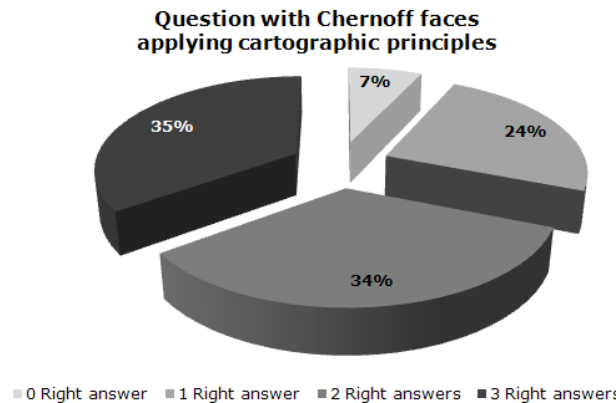


Figure 7. Diagram presenting the percentage of answers to the question about the use of Chernoff faces applying cartographic principles in Argentina

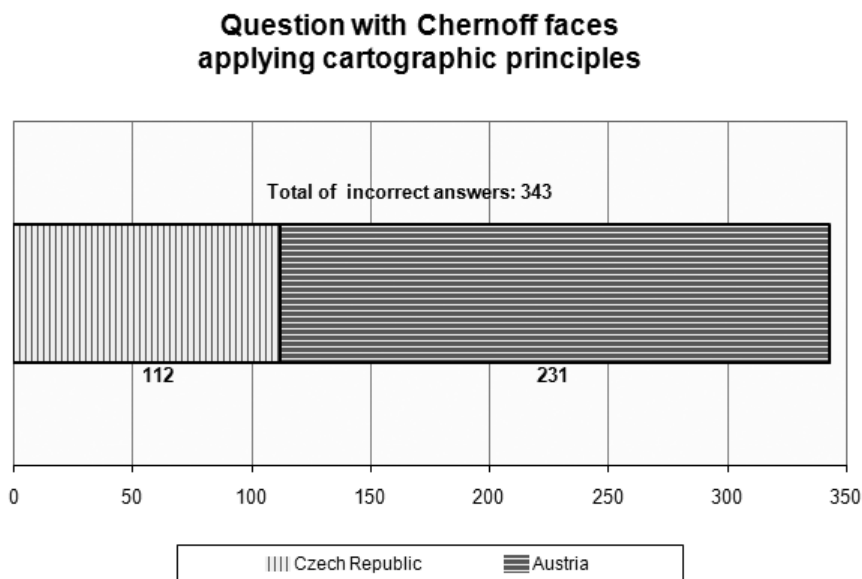


Figure 8. Diagram presenting the percentage of answers to the question about the use of Chernoff faces applying cartographic principles in Hungary

An unforeseen result can be also appreciated in the similar question of the Hungarian survey (Chernoff faces designed following cartographic principles), representing agricultural data from five Central European countries (Austria, Czech Republic, Slovakia, Hungary and Poland). In this case the size of the faces was changed to represent a data set (production of apples), and the fill was also changed depending on the production of wheat (Figure 4). The first question was directly focused to compare the size: *which country has a larger production of apples: Czech Republic or Austria?*, and the correct answer is *both countries*, because the size of the faces is the same. But the face representing Czech Republic was also filled with a darker grey tone (to represent a larger production of wheat) and it was also smiling (to symbolize a larger volume of agricultural production too). We were interested to check if these attributes could have or not any influence when the pupils compared only the size of the faces. A total of 367 answers were wrong, and in 343 incorrect answers only one of these countries was indicated. The diagram in Figure 8 shows us that only 112 pupils selected the Czech Republic over Austria, so we can affirm that neither the fill nor the smile was determinant during their analysis to answer this question.

More interesting than the quantitative results was the analysis of the opinions expressed by the pupils at the end of the Hungarian questionnaire. A total of 507 pupils (49%) wrote their opinions. Beginning its analysis, our first step was to categorize the answers as positive or negative, and the result is presented in Figure 9.

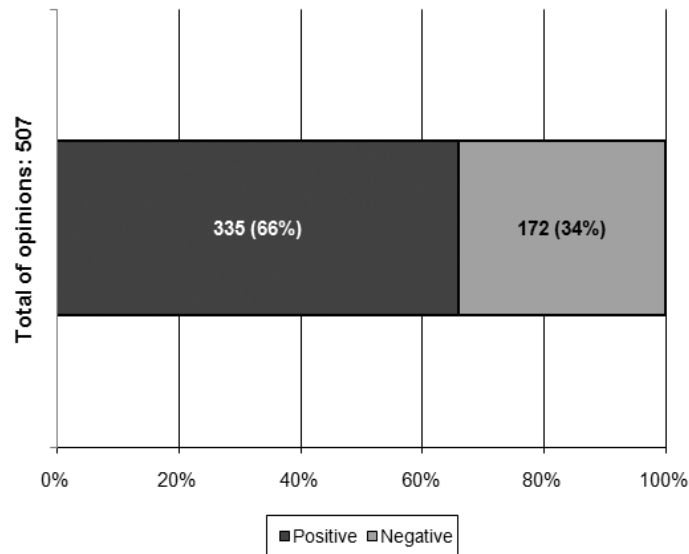


Figure 9. Proportion of positive and negative opinions about the survey

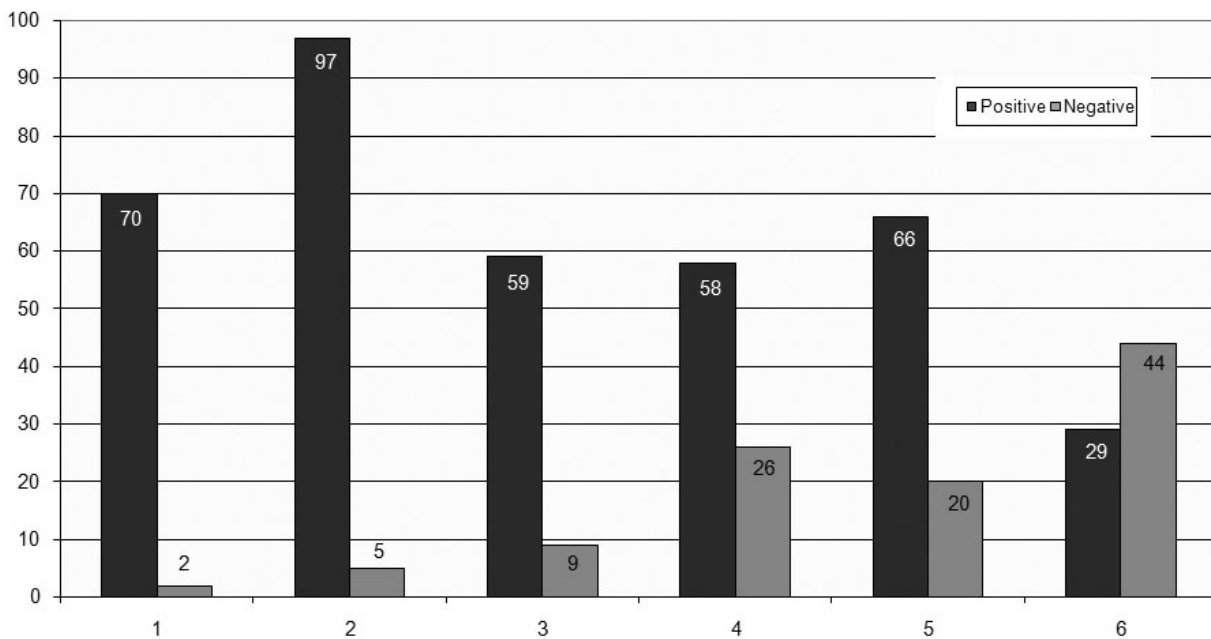


Figure 10. Diagram showing the frequency of the numbered doublets in the pupils' opinions: (1) interesting – bored, (2) good – wrong, (3) like – do not like, (4) easy – hard, (5) funny – infantile (childlike), (6) understandable, suggestive, unequivocal – incomprehensible, inexplicable

The next step was trying to find some doublets with more frequent occurrence in the opinions. A total of six doublets were selected, which expressed contradictory opinions like “interesting – bored”, “easy – hard”, etc. The frequency of these words in the text was summarized and the results were compared as seen in Figure 10.

6. CONCLUSIONS (AFTERWORDS)

Specialists from both countries are analyzing the results obtained during this survey. Comparing the Argentine and Hungarian results, we can note some contradictory experiences as the results related to the question applying the Chernoff principle on pictograms: the Hungarian pupils' answers were the best result between the four questions

included in the questionnaire, while it was the second worse result in the Argentine questionnaire. Other unexpected result is related to the question using the “traditional” (original) Chernoff faces, because the positive results in both countries (better than the results obtained when the authors optimized the Chernoff faces applying cartographic principles) let us deduce that the reading of data represented by changing only the shape of a face does not provoke more significant difficulties than if the representation is made changing only the size.

Project header: Proyecto intergubernamental de colaboración bilateral entre Argentina y Hungría en ciencias y tecnología. Posibles usos de las fases de Chernoff para la visualización de datos en la cartografía escolar (2^{do} año). Logos for 'Idioma húngaro' and '1^{er} año'.

Descripción	Participantes	Misiones técnicas	Investigaciones
<ul style="list-style-type: none">• Cuestionarios:<ul style="list-style-type: none">○ Cuestionario para alumnos (Hungría)○ Carta para docentes (Hungría)○ Cuestionario para alumnos (Argentina)• Resultados:<ul style="list-style-type: none">○ Tabla con los resultados de la encuesta para alumnos (Argentina)○ Tabla con los resultados de la encuesta para alumnos (Hungría)• Ponencias y publicaciones:<ul style="list-style-type: none">○ XXIV Conferencia Cartográfica Internacional de la ACI (ICC 2009) (Santiago de Chile, 15-21 de noviembre de 2009):<ul style="list-style-type: none">■ Ideas for the use of Chernoff faces in school cartography ponencia és presentación Ponencia: 24th International Cartographic Conference CD proceedings (The World Geo-Spatial Solutions), ISBN: 978-1-907075-02-05○ Centro Argentino de Cartografía:<ul style="list-style-type: none">■ Posibles usos de las fases de Chernoff para la visualización de datos en la cartografía escolar artículo Publicado en: Boletín Nro. 45 del Centro Argentino de Cartografía. Publicación semestral, año 53, Junio de 2009 (1/2009), pp.42-51, ISSN 1667-8508			

Figure 11. Website of the project (fragment)

Colleagues interested in this theme can find free access to all the databases, documents, etc related to this project visiting the following website: <http://lazarus.elte.hu/hun/dolgozo/jesus/ma0809/proyect1.htm>. All the documents are in two languages of the participant countries (Spanish and Hungarian), but we plan to translate the databases and final documents into English too (Figure 11).

The obtained results leave open some questions, and specialists are interested to follow working up and testing new solutions. This year the Hungarian colleagues plan to follow the research in collaboration with colleagues of the University of Technology in Vienna under the scope of the bilateral agreement for scientific research between Austria and Hungary. The periodical contacts with Argentine colleagues are also followed, expecting to begin new research in this and other themes related to Cartography and more specifically to Cartography for Children.

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The present research is developed in the framework of activities of the MTA-ELTE Research Group on Cartography and GIS, financed by the project ARG-3/2007 of the National Office for Research and Technology of Hungary and the project 68302 of the Hungarian Scientific Research Fund (OTKA).