ENVIRONMENTALLY BASED PERCEPTION OF SPACE

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Abstract

Many population groups on the island of Borneo developed a river-based civilization that included a river-based habitat (facilitated by so-called longhouses) and a river-based livelihood. These tribes restricted their activities almost entirely to the river and riverbanks. They penetrated the land only to extract sago and other forest products, which were abundant along the riverbanks anyway. Such a 'linear' living space of people imposed by the environment was supported by the one-dimensional astronomical referenced events (an east–west line corresponding to the rising/setting sun). This linear notion was strengthened by the lack of a calendar and the concept of a year, month, or week. It is claimed that the environmental restrictions forced the population to develop a different way of thinking and to perceive space as linear in nature.

Teaching three-dimensional (3D) subjects such as Geographic Information Systems (GIS) or cartography to descendants of people whose world was a one-dimensional (1D) plane is an interesting and challenging experience because, in spite of the tremendous advance of civilization that has positioned Brunei Darussalam in the rank of developed countries, the country's students still exhibit a tendency to lock their vision of the world into 1D. Possible causes of this outlook could be related to an indoor lifestyle, work that is done exclusively in offices, and use of dimensionless devices such as mobile phones and the Internet.

Using an interviewing technique, we studied two independent groups of students taking cartography courses at the University of Brunei Darussalam and the Wroclaw University of Environmental and Life Sciences in Wroclaw, Poland. Significant disparities in their spatial awareness and spatial quantitativeness were identified, which, in our opinion, present important and far-reaching consequences, not only for teaching 3D courses, but also for cartography and map designing in a wider context. This paper summarizes these investigations and draws a few conclusions. A suggestion is also made to form a study group within the International Cartographic Association (ICA) devoted to research and discussion on the environmentally based perceptions of space, maps and other related issues. Also, more similar studies in the topic area are strongly encouraged.

Introduction

There is a general consensus that humans are well equipped – in particular, our visual, sound, and smell perception systems – to efficiently operate in 3D space (Sommer, 1969). These sensors are

continuously feeding data about our surroundings to our central processing unit—the brain, which appears to have sufficient processing power to handle the prescribed tasks. On top of that, the brain is able to generate, interpret and understand abstract objects, such as maps (Cutting, 1989; Sekuler & Blake, 2005). These remarks are a simplified characterisation of the "bio-intellectual" fundamentals of cartography as it is normally understood. Some imperfections of these fundamentals are known, and relevant procedures are in place to mitigate potential problems. For example, special maps required for visually impaired users, or cartograms showing transportation system for visitors to a city, or simple instructions on "how to get there," are illustrations of specific cartographic solutions for people of special needs or who are in certain situations.

Yet there are situations in which the human perception potential is not used to its full capacity. This can happen in a simplified world in terms of its spatial organization, whereby the majority of natural processes follow a linear spatio-temporal path. For people roaming that linear space, such a 1D living regime imprints itself onto parts of their culture and customs. Hence, for convenience, a reference to the environmentally based perception of space will be used. The consequence of that may be a dysfunctional understanding of the 3D world and a partial or restricted ability to resolve abstract objects such as maps. An individual who was brought up in such a dimension-reduced space will most likely exhibit this deficiency when transferred to a "normal" 3D space. All aspects associated with adaptation to a 3D space could be the most intriguing and epistemologically charged experience.

There are signs that such an unusual linear perception of the 3D world can be found among some of the communities on Borneo long after the original living conditions have ceased to exist. For example, many communities on Borneo developed and used rivers and their banks as the world and even the universe in which they spent their entire lives (Beccari, 1991). No elevated points existed, only trees to climb, an activity that was practiced not in order to learn more about their world, but rather to gain food. The line of the horizon was very near and was constituted by the banks and bands of rivers. The sky did not provide much useful information either: it was simply a source of light and signal to commence/conclude another day (Binchin, 1988). These environmental determinants were also reflected in the organization of life. Dwellings were built on poles over rivers or along their banks. Multigenerational families occupied houses that, when needed, were extended in length. Even today these houses, known as longhouses, are still used by some of the ethnic groups along Borneo's rivers. Travel involved longboats, and traffic took place up or down the river. Distance was measured in terms of the river's turns, and the same method was used as a navigation aid (Binchin, 1988). Many local tribes used the rivers for their livelihood almost exclusively. The banks were exploited as a source of sago, which is abundant along the rivers. No agricultural activities were performed, such as those performed on the 2D fields. The river as the only available reference system, the abundance of food and safety imposed a linear perception of the world among locals.

In the 25 years since its independence, Brunei Darussalam has experienced remarkable progress and prosperity, which has facilitated the migration from a river-based civilization to a modern one. In spite of this change, traces of the linear perception of the world can still be found among descendants of the river civilization. One reason for that is the lifestyle adopted after settlement on land. Important characteristics from that perspective are: 1) maintenance of the multigenerational family living under one roof, which helps to cultivate many relics of the past; 2) spending most of their free time indoors, which diminishes discovery of the 3D space; 3) movement of people still takes place along roads, which are like rivers; 4) the transportation network is supported by long jalans (roads) which contain many short dead-end simpangs (side streets) on both sides of jalans; 5)

underdeveloped outdoor recreational facilities; and 6) use of the Internet (chats, etc.) and mobile phones, among others.

In our opinion the term “culture” refers to a phenomenon that is developed upon a few fundamentals of the human cognition processes. We believe that one of the fundamentals is the way the pure geometric 3D space is perceived, modelled, interpreted and used by human beings. The main concern we highlighted in the manuscript is that there are environments in which the full nature of the 3D space is obscured from or *denied* to human beings by natural or anthropogenic factors. For example, it might be suspected that a person who spent all of his or her life on an unusually narrow piece of land without external references might have *natural* difficulties interpreting a 3D space that almost all humans are accustomed to. Naturally, such a person would develop a system of values, and custums - elements of culture – within what was available to him or her.

Following argumentation by Ingold (2008), our work may be classified as being ethnographically related, in that it provides documentation of culturally relevant field observations. But at the same time, we put forward a body of evidence in an attempt to build a link between space as a “neutral box” (Rohkrämer & Schulz, 2009) and the very first human perceptions and impressions on which the framework of culture and civilisation is founded.

Our main idea, however, is that the human cognition potential is not only restricted by the human imagination, which may be perceived as a derivative of a complex human ecological adaptation, but also by the fact that the cognition process is restricted by environmental conditions including those which actually determine on the perception of dimensionality of the space the individual is exposed to.

Our prime goal for the research was to document such a phenomenon, arguably uncommon, which may present potential problems; for example, for map design. We are not attempting to find a solution or explanation for what we have observed. We are trying merely to point out possible sources of that behavior and potential consequences for cartography in anticipation of certain means being found to tackle the problem of the environmentally based perception of space.

Using an interviewing technique, we studied a group of students taking cartography courses at the University of Brunei Darussalam. To reference the results obtained in Brunei, a similar questionnaire was distributed among students from the Wroclaw University of Environmental and Life Sciences in Wroclaw (WUELS), Poland. We assumed that the reference group possessed a similar level of spatial awareness and quantitativeness considering their age group, contemporary lifestyle, and exposure to the latest technological gadgets such as laptop computers, the Internet, and mobile phones. We also assumed that both groups followed a cultural universal such as identified by Stea *et al*., 1996, and Blaut *et al*., 2003, two almost identical essays titled “Mapping as a Cultural Universal.” In these essays, the authors suggested that (1) mapping is a cultural universal of humans appearing in all humans from early in life; (2) that maps have been made since the very early days of human civilization; and (3) that all cultures across the world make maps.

However, as far as we know, the population groups living exclusively along the rivers of Borneo never produced nor used maps – 2- or 3D models of a macro environment (ibid) - because they did not require them! Also, mapping a 1D world into a 2- or 3D model appears to be a quite abstract and unnecessary activity.

Our observations and conclusions present important and far-reaching consequences for teaching 3D courses, but also for cartography and map designing in a wider context. A deficient spatial awareness and quantitativeness among students requires a unique approach to convey the concept, properties, and navigation in the 3D space, and to train such students in using a map, which is a highly abstract facility, unknown and, perhaps, even unnecessary to river-based or similar civilizations.

Geographic and Cultural Background

Negara Brunei Darussalam (about 5,765 km^2) is a country located on the island of Borneo in Southeast Asia. It borders the South China Sea from the north and the Malaysian state of Sarawak from all other directions (Figure 1). The climate is described as wet tropical, with the monthly average temperature between 26.7^{o}C and 27.7^{o}C, and the monthly average rainfall 375 mm. The area is influenced by two monsoons: weaker south-west (April–August) and stronger north-east (October–January). The topography of the country is mainly dominated by low, slightly undulating features with the southeastern part described as mountainous: the Temburong Mountain Range, with the highest point at Bukit Pagon (1850 m). A significant part of the western part of the country is covered by peat swamp. Current geomorphology was formed during the last significant sea-level subsidence some 5,000–6,000 years ago. The country is drained by four major rivers, including the Belait River (209 km), Tutong River (137 km), Temburong River (98 km), and Brunei River (41 km) (Figure 2). The eastern part of Brunei—the Temburong District—is detached from the rest of the territory by the Malaysian valley of the Limbang River. Some 48% and 28% of the total country area is covered by primary and secondary forest, respectively.

Figure 1. Brunei Darussalam in the Southeast Asia geographical context.

The population of Brunei is about 383,000 people (2006), which includes about 30,000 temporary residents. There are four major urban centers, with Bandar Seri Begawan—the capital city—being the largest. Seventy percent of the total population resides in the Brunei Muara district, where the capital city is located. All centers are localized in the vicinity of the above-mentioned major rivers. The ethnic composition of the population is dominated by Malay, 66.7%, followed by Chinese, 11.1%, and others, 22.2%.

The so-called water village (kampong ayer), consisting of houses built upon poles over a river, is a traditional Malay way of living. Even today water villages are seen on the Bornean rivers, and this

tradition is so strong among the local population that many refuse to move to the houses provided by the Brunei government. For those who refused to settle in the land-based housing, the government developed two modern water villages constructed of concrete and equipped with modern amenities. Living in houses built over a river has many advantages over land-based houses: easy sanitation, safety (from snakes, insects), a handy source of food, and relief from the daytime heat.

The development of the land-based settlements in Brunei Darussalam began in 1906 and was initiated and encouraged by the first British Resident, Malcolm Stewart Hannibal McArthur (1872-1934). The Sultan also moved to a land-based residence in 1909. This was followed by the development of government and commercial facilities and even some private houses on the reclaimed land on the banks of the Brunei River.

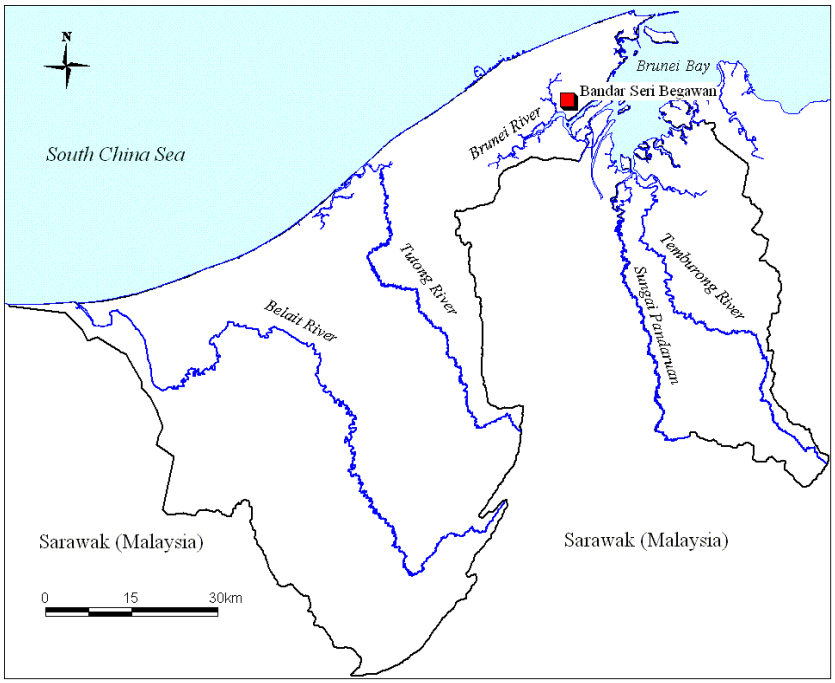


Figure 2. The major rivers of Brunei Darussalam. They are the spatial origins of contemporary Brunei Darussalam. Even today, many water villages are seen along the banks of the rivers, especially in their upstream sections.

The urbanization of the country was and still is very much an organic process in the sense that it tends to resemble a river system, with major roads serving the role of a river. The major roads are poorly interconnected. Houses are built on short dead-end streets, known as simpangs, along the major roads. This furthers the impression that this system is a river-like village.

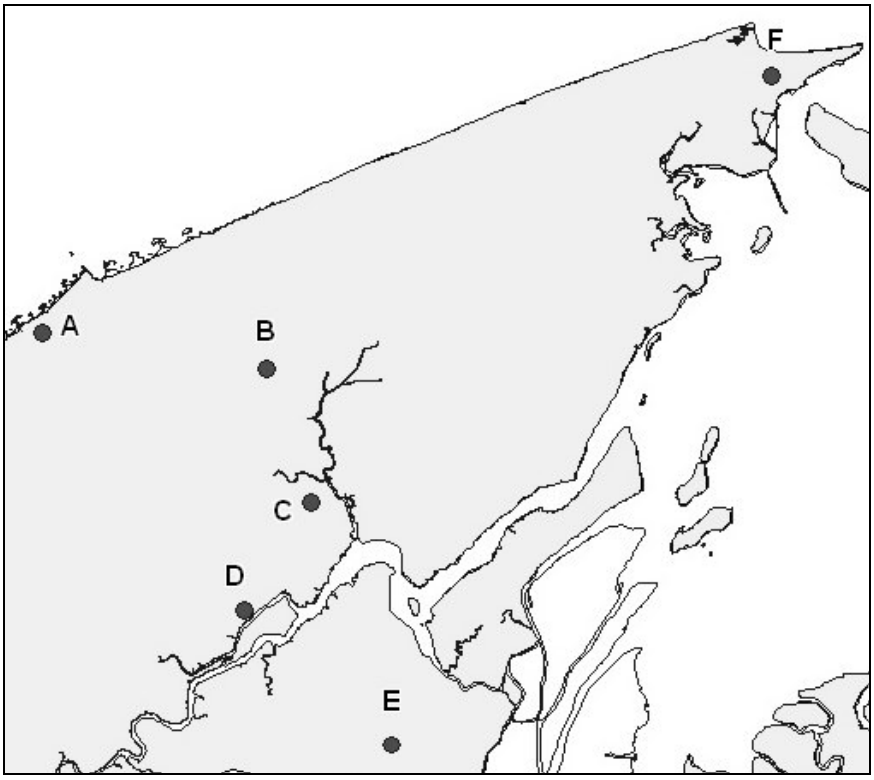
Data Collection and Analysis

An attempt to capture some of the disparities in perception of space between people belonging to two significantly different cultures was carried out using a questionnaire. As the investigations were considered to be preliminary, we used a qualitative approach that should be sufficient to capture and illustrate the first glimpses of our hypothesis.

The questionnaire contained 20 questions meant to identify, among other things, spatial awareness and spatial quantitativeness. Spatial awareness is understood as the ability to identify the spatial relationship between commonly recognized objects, such as the names of popular suburbs or

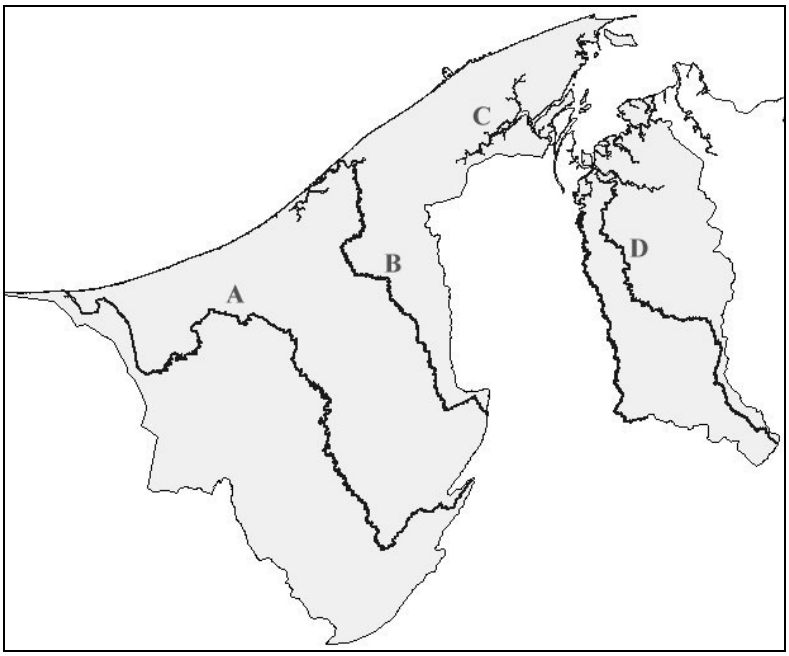
villages. Spatial quantitativeness is the ability of an individual to describe in quantitative terms the extent or size of well-known objects in 3D space. Some of the questions were specific to the particular cultural settings. Hence, they were omitted or modified to avoid confusion. But they were important for identifying variables contributing to the level of spatial awareness and quantitativeness. The spatial-sensitive or relevant questions answered by both groups of respondents are listed below.

1. What height was the tallest tree you have seen in your life? (m)
2. What is the area of your room? (m^2)
3. How far is it from your house to the University? (km)
4. How much time do you need to travel one way to the University from your residence? (minutes)
5. How far is this classroom from the coastline? (km)
6. How many metres above sea level are we now? (m)
7. What is the radius of the Earth? (km)
8. What are the approximate geographic coordinates of the University?
   Latitude /Longitude (degree)
9. Using the following drawing as a guide, draw appropriate connecting lines between locality names and the letters A–F:



[Muara] [Kiulap] [Kasat] [Jerudong] [Telanai] [Rimba]

10. Using the following drawing as a guide, draw lines connecting the letters and the appropriate river names:



[Tutong River] **[Brunei River]** **[Temburong River]** **[Belait River]**

11. Draw an arrow on one of the maps indicating a SE direction.

12. How do you spend your free time? List up to four activities.

The points of interest (popular suburbs in the Brunei-Muara district) were located within an area of about 15 km in radius. This restriction was imposed to increase the probability that respondents knew all the locations.

The first group of respondents was composed of students who attended the Cartography and Map Analysis course at the University of Brunei Darussalam. This is a course normally taken by second-year students. For geography students this is a core course, but it is also taken as an elective by students across the University. Sixty-six students – 42 females and 24 males, who ranged in age from 20–23 years – responded to the questionnaire:.

The second group was composed of students taking the Geodesy course at the Wroclaw University of Environmental and Life Sciences in Wroclaw, Poland, and consisted of 40 respondents: 20 females and 20 males, who ranged in age from 20–21 years.

The maps shown in questions 9 through 11 were relevant to the first group of respondents. The participants of the second group were presented with comparable maps relevant to them.

Results

A summary of the responses to the 11 questions which were asked both groups is shown in Table 1. Questions concerning cultural roots are not discussed here in detail because of the limits of space. However, a significant correlation between the results and people claiming their river-based roots and culture was identified. Full details of the results will be presented in a forthcoming investigation on the society's mindset and in forthcoming articles. A few explanatory notes are

needed to properly interpret the results beforehand. In all cases where a number was required, an average value and its standard deviation were calculated (questions 1–7). A range of answers was also provided. For questions where the correct number was known (questions 5–7), an error was calculated as an absolute value of difference between the correct value and actual value provided by the respondents. Next, the average value of the error and its standard deviation were calculated. The answers for questions 8–11 were assessed as "correct/incorrect." A ratio of correct answers versus all answers is provided. The answers for questions 3 and 4 were used to calculate the speed (distance over the travel time).

Table 1. A summary of the results of questions for both groups of respondents. UBD denotes the University of Brunei Darussalam. WUELS denotes the Wroclaw University of Environmental & Life Sciences.

Question No	UBD		WUELS	
	Avg ± σ	**Range**	**Avg ± σ**	**Range**
1	58.7 ± 80m	2 - 400m	30 ± 15m	25 – 50m
2	53.1 ± 247m^2	4 - 1296m^2	10 ± 15m^2	8 – 50m^2
3/4	75 ± 300km/h	1.5 - 1600km/h	9 ± 5 km/h	6 - 20 km/h
5	20.8 ± 82km	0 - 650km	0.5 ± 1km	0 – 5km
6	1428 ± 5028m	0 – 23980m	0 ± 12m	100 - 150m
7	45x10^6 ± 3.7x10^8km	0 – 3x106km	10 ± 8km	6370 – 6390km
8	12% correct ans.	Lat: 4-221° Lon: 2-153°	98% correct ans.	Lat: 50-51° Lon: 17-18°
9	62% correct ans.	N/A	90%	N/A
10	100% correct ans.	N/A	60%	N/A
11	65% correct ans.	N/A	30% correct ans.	N/A

Questions 1–8 were designed to test the respondents' ability to estimate in quantitative terms the dimension of elements commonly found in the 3D space. We refer to this ability as spatial quantitativeness.

The answers to question 1 (UBD) -the average tree height ~60m, very high standard deviation, and enormous range--may indicate a profound lack of spatial quantitativeness among a significant number of respondents. The answers provided by WUELS are much more realistic, which may indicate an excellent spatial quantitativeness.

The answer to questions 2–7 (UBD) are characterised by a very high level of error and equally very high standard deviation of that error. Again, this may point to the lack of spatial quantitativeness even in the case of a private space (question 2). The corresponding WUELS answers are realistic. The conclusions are similar to that of question 1. Question 8 was designed to test both spatial awareness and quantitativeness. Only 12% correct answers were recorded for UBD respondents, versus 98% for WUELS students.

The remaining three questions (9–11) tested the spatial awareness of the respondents. The answers to question 9 indicate that UBD students are well behind the WUELS students in terms of identifying spatial relations between well-known landmarks. This may be due to residual effects of the river-based way of life, which required the ability to navigate in 1D space only.

The 100% success rate in answering question 10 by UBD students may indicate their still-strong connections to rivers. Another reason could be that the four districts of the country are named after the major rivers.

Question 11 also was answered better by UBD students, most likely for reasons similar to those in question 10. Also, a contributing factor may be the common necessity to identify the direction to Mecca, as most of the UBD students are Muslims.
Question 12 tested the level of spatial experiences. Most of the UBD students named indoor activities, while WUELS students preferred to spend their free time outdoors. Again, this may be due to inherited but still-cultivated domains of limited size, as their dwellings of the past were built along river banks and became their dimensionally depleted universe. Some other factors, not necessarily related to space, may play a significant role here as well. A typical answer of a local questioned regarding their preferred way of spending time indoors is that outside is "…too hot," "there is nowhere to go," or even in some not-so-isolated cases, one heard "…there are demons in the forest."

Conclusion

The results of the questionnaires document a significant variability in spatial awareness and spatial quantitativeness between two groups of respondents with different geographical and historical roots. In our opinion, the investigations have provided a body of evidence supporting a view that the level of spatial awareness and spatial quantitativeness is linked to the river-based origin of the contemporary population of young people in Brunei Darussalam.

It also appears that in spite of the tremendous development Brunei Darussalam has enjoyed over the last 25 years, the mindset of the young members of the society still exhibits strong symptoms of deficiency in spatial awareness and spatial quantitativeness. However, this may be caused by some contemporary factors such as common use of mobile phones and the Internet, which may significantly hamper the 3D experiences needed by young people for their intellectual development. For example, instead of doing business in person (necessary movement in space), many matters are settled via phone or the Internet (no 3D experience). Also, the abundance of private cars in Brunei Darussalam (probably the highest in the world per capita) takes its toll on the perception of space. This, combined with underdeveloped public land transport, and the staggering underutilisation of it by Bruneians, leads to even deeper deficiency in space awareness and space quantitativeness.

We believe this deficiency in perception of space may have many adverse consequences for both personal and societal well-being. At the personal level, the proper space perception is needed to maintain proper levels of abstract thinking and planning, which are necessary for a successful and efficient learning process. At a societal level, the proper perception of space is necessary to use available natural resources in a sustainable way. This may also include planning of spatial development. Also, effective verbal and visual communication requires an audience that is able to imagine, understand and interpret the spatial terms of reference such as 'hectare,' 'millimetres of rain,' 'kilometre', or recognize geographical shapes such as political borders or continents.

The above observations regarding the environmentally based perception of space are clearly suggesting a problem on at least a national scale. The question is how to tackle the problem. An answer may be that multidimensional and additional studies are necessary in order to develop a proper strategy to deal with these issues. However, some preliminary solutions may now be formulated.

First of all, a notion of the decline in the usefulness and applicability of maps in the epoch of GPS and navigation devices must be recognized, and proper action must be taken to fight that trend. A poor ability to identify the southeast direction by the Polish respondents is probably caused by an over-reliance on GPS and related navigation devices. Also, there are known examples that over-

reliance on navigation devices may lead to disasters. The trend toward using navigation devices for point-to-point navigation only by the majority of users was recently identified by the Mio company (http://www.mio.com/mio-technology-press-releases-22734.htm). Prompt action not only from the cartographers' community but from all sectors of the spatial sciences must be initiated to prevent further deterioration in map use.

Secondly, significant study efforts are required on map perception issues in the area of GPS and navigation devices. In our opinion, the best way would be an increased level of exposure to education in map reading and map making at all steps of education.

It is interesting to note that the link presented in this paper between an unusual environmental case and the deficiency in the spatial awareness and quantitativness among ancestors of people living in such a depleted space does not exhaust other similar both natural and anthropogenic arrangements. Without too much speculation, we point to a possible anthropogenic arrangement already at work and causing the above-outlined deficiencies among young people. In our opinion the rapid development of and easy and cheap access to mobile phone technology is locking people into a dimensionless world of text messages. Exchange of data and information using short text messages is performed without providing an explicate spatial reference and without needing to go anywhere in the real word; for example, to the post office. This "negative" spatial training will probably rapidly deplete or underdevelop the level of spatial awareness and spatial quantitativeness among young people being exposed to this technology since early childhood. The Internet and computer games work in the same direction. An analogy to the above-described cognitive mechanism may be found in the common inability among young people to efficiently perform mental arithmetic. This effect is linked to an overuse of electronic calculators.

Obviously, our study is of a preliminary nature. More studies in the determinants and sources of our knowledge of space are urgently needed to prevent further deterioration in the spatial awareness and spatial quantitativeness among the next generation. For example, the authors plan to carry out the same survey among respondents of various ethnic origins, including Chinese who were born and live in Brunei and settled on land, to confirm our conclusions. Also, some quantitative data collection and analysis methods will be deployed in the follow-up research. It is anticipated that correlating few attributes of the respondents, including their family roots (river- versus non-river backgrounds) will highlight a real source of the observed phenomena.

We invite interested colleagues to join our efforts in this area of research by conducting similar tests in their environments and/or among, for example, the mobile phone users/non-users and the Internet users.
We also believe that a coordination of such efforts from ICA is necessary and would be welcomed by many. Therefore, we call for the formulation of such a study group.

Acknowledgement

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