Cross-Culture study of Biases in Location Judgments

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Abstract. This paper examined cultural impacts on absolute and relative location estimates of 12 Eastern China cities, based on questionnaires of each city's latitude and distances between city pairs. Linear regression analysis of the latitude estimates revealed that estimated latitude of a city is significantly related to its actual latitude. MDS analysis of the distance estimates revealed the gap that divided Eastern China into two regions and cultural-related causation of the gap was explained in detail. In particular, the Chinese language and its impact on spatial cognition were addressed. Results were compared with North America comparison was made to conclude important features of spatial cognition in common: the categorical storage of spatial information and the absolute-relative location reasoning process.

Keywords: cultural differences; location judgments; global scale; MDS analysis; latitude estimates; distance estimates.

1 Introduction

1.1 Cultural characteristics of China

Culture is defined as a body of knowledge and beliefs that is more or less shared between individuals within a group and transmitted across generations [1]. Cultural difference and its impact on geographic regions is a traditional topic in Geographical Information Science. It reflects language differences and their impact on spatial cognition [1], [2], [3]. There are three important cultural characteristics of China that influence the geographical cognition process:

1. China is divided mainly into two dialect regions: Northern (including Mandarin, the official language of China.) and Southern. As shown in Figure 1.1, all three Northern dialects in red have one same generation thus widely understandable, while

southern dialects have diverse generations and locally understandable. These language differences may reflect in the result of regional division.

Fig. 1.1. Dialect Map of Eastern China (http://www.sinolect.org)

2. Traditional geography divides Eastern China into three regions: Northeastern, North Hua and South Hua. The border between North and South Hua is “Qinling Mountain-Huai River” (Q-H border). It is also the border of North and South Climate region, where the mean temperature of January is 32ºF. Q-H border plays an important administrative role that regions south of Q-H border are mandated not to install central heating systems. Thus people experience significantly different winter climate in North Hua and South Hua, although the natural climate doesn’t change dramatically. (In South Hua the indoor temperature during winter is around 40ºF compared to 70ºF in North Hua.)

3. Chinese exclusively use absolute frames such as cardinal directions to express location at multiple scales [4], while the egocentric frames (left and right) is weak and seldom used in spatial description. For example the linguistic description of routing is mostly of the time expressed as “turn east” rather than “turn right”. Further proof is that in traditional Chinese the character for “left” also means east and sometimes even “right back” [5].

1.2 Cultural impacts on regionalization

Regionalization is one of the most distinctive characteristics when individuals make geographical estimates because geographical knowledge and perspectives are related to national region [6]. The traditional claim says that geography is the "study of regions", in which the taxonomy of geographic regions and the formation processes reflects some of the universal characteristics of human thoughts [7], especially spatial cognition. There are four major types of geographic regions: administrative, thematic, functional and cognitive [8]. Cognitive region, formed by people's informal perceptions, will be emphasized in this paper because it best reflects the cultural differences. Administrative region, formed by legal or political action, is also studied because administrative boundary is precise compared to other three types [9] and it is peculiarly related to climate in China.

Cultural impacts regional cognition when individuals categorize space and form biases in judgments [4]. Location estimate tasks, for example, allow researchers to examine the biases quantitatively and related with geographical regions. Scholars have studied the biases for latitude estimates of European cities [10] and North American cities [11] under global scale and found three common rules of location judgments [12], [13]:

1. People use plausible reasoning during their estimate tasks based on knowledge available and the representation shows the trend of regionalization.
2. Both absolute and relative location estimates are based on the same geographic representation.
3. The participants tend to stretch cities to global landmarks during the estimating tasks. Study of North American cities reveals participants stretch North America southward toward the equator.

1.3 The role of culture in spatial cognition

Discussion of culture and its role in geography has a long history that the most influential one is the language influences in GIS as a by-product of cultural differences [4], [14]. Importance of languages has been paid attention since then but no specific study on culture differences, and the trend was to emphasize cross-cultural differences rather than generalities. Later research focused on cultural differences and spatial cognition found that items below are the same across cultures: differential treatment of spatial information in memory, reasoning, language, as a function of scale; categorical and hierarchical organization of regions [1], [15]. As influential as the conclusion became, the study of cultural differences in spatial cognition became less noticed.

Yet the role of culture in spatial cognition is not fixed that previous studies are not complete in two aspects: first, it only studied spatial cognition under such small scale (e.g., cross–culture study of cartography of villages [16]) that cultural differences are not significant at all. Second, previous scholars seldom select oriental cultures for comparison. It is likely that all dated back to ancient Greek-Rome, western cultures tend to be similar thus on spatial cognition the differences do not even appear.

Cultural differences under large scale and between oriental and western civilizations are still important research topics in spatial cognition. Under small scale the comparative study of Japanese and American city guide books is conducted, which intended to find the influence of the distinctive oriental city pattern and address system on people's use of maps. Result shows that "the contents of linguistic information were entirely influenced by socio-cultural factors rather than environmental conditions such as the street pattern regularity" [17]. This study showed the influence of cultural differences on spatial languages, especially the pictorial information and linguistic description of maps.

This paper focuses on location judgments of Chinese cities under national scale and it is based on the same experiment (the stimuli are changed to Chinese cities) by European and North American scholars to eliminate the difference caused by experiment design. Both latitude and distance estimates of 12 selected cities are investigated and the result is analyzed using Multidimensional Scaling method. It is expected this modified experiment will reveal the characteristics of Chinese cognitive pattern, which should be different from previous North American and European characteristics considering cultural influences. Still cultural universals are expected to be found, especially those related to categorical organization of regions.

2 Objectives

The first objective is to study the influences of culture, especially languages on spatial cognition. According to the Sapir-Whorf Hypothesis [18] that a cultural group's language determines the way members perceive and think about the world, significant differences are expected to be found in China because the language is based on hieroglyphic characters whereas Latin is based on pronunciation-determined alphabet. Although Whorf hypothesis is being criticized these days, the influence of Chinese language is still not ignorable [19]. As a socialistic and developing country, it is also expected influences caused by ideological and economic differences exist.

The second objective is to find cultural universals by comparative study based on the same experiment. It is agreed that many important aspects of spatial cognitive structures and processes are universally shared by humans everywhere [1]. Thus in China despite its distinctive culture what aspects are still universal and how they influence spatial cognition are of high importance.

3 Method

The study of geographical judgments is based on a survey of latitude and distance estimates of 12 cities selected from Eastern China. Volunteers answer a series of questions requiring their geographical knowledge of the cities. Plausible reasoning process is also needed to answer the question in order to provide data for advanced analysis of spatial cognition [20].

3.1 Participants and design

Participants of the experiment are 60 volunteers from three sources:

(a) 21 undergraduate students from the class: “Introduction to Cartography”;

(b) 10 undergraduate students majoring in Geographical Information System;

(c) 29 graduate students majoring in physics (Number=6) and earth sciences (Number=23).

Of the 60, 43 provided valid questionnaires; the rest questionnaires were eliminated due to data integrity (i.e., 13 participants didn’t finish the questionnaires were not finished because participants claimed to have limited geographical knowledge; 4 participants provided invalid data by providing numbers in sequence). For the 43 who accomplished the 30-minute questionnaire (36 males, 7 females), there’s no extra credit gained.

All the participants are students of Peking University and had lived in Beijing at least for one year and a half. Up to 85% of the participants are from Eastern China. The mean age of participants was 22.1, ranging from 18 to 24. 90% of the participants had solid background in geography.

3.2 Stimuli

Twelve cities are selected from Eastern China. Each city is the capital city of a province (except Nanyang) to make sure participants have abundant knowledge so they can make reasonable estimates to provide valid data. The cities’ longitude ranged from 112.3 ˚E to 126.3 ˚E to reduce the distances cause by longitude differences therefore better connect latitude estimates with distance estimates.

City locations and their dialect regions are shown in Figure 3.2.1:

Harbin: 46 ˚N Changchun: 44 ˚N Shenyang: 42 ˚N Dalian: 39 ˚N;
Beijing: 40 ˚N Jinan: 36.4 ˚N Zhengzhou: 34.5 ˚N Nanyang: 33 ˚N;
Nanjing: 32 ˚N Ningbo: 30 ˚N Fuzhou: 26 ˚N Kaosiung: 22.4 ˚N.

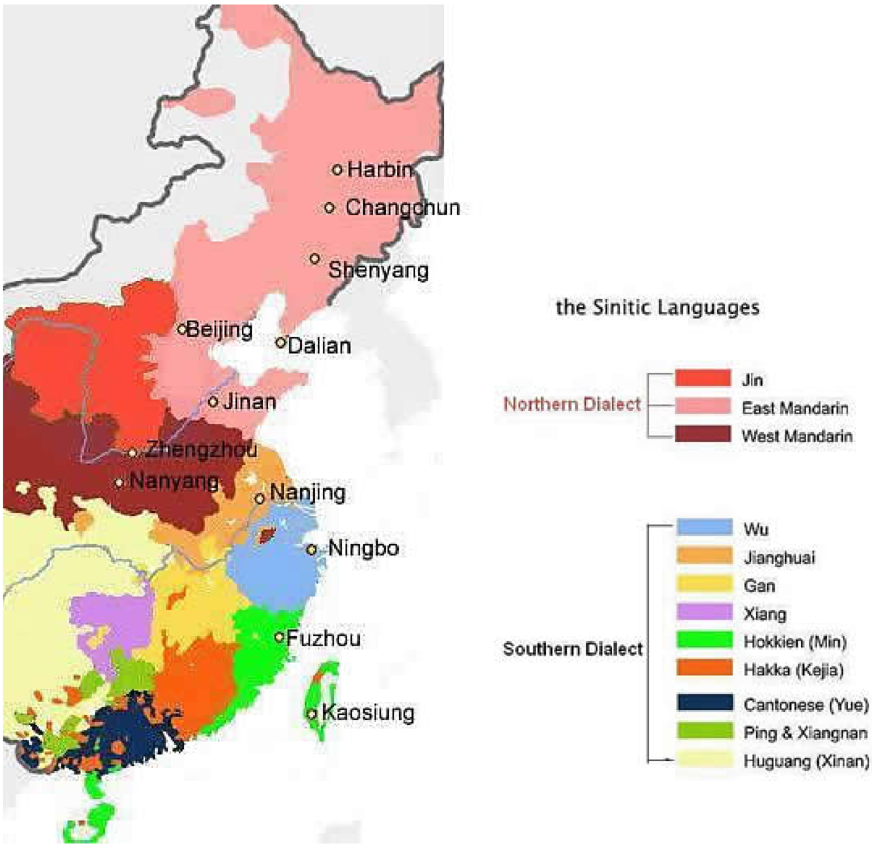

Fig.3.2.1. Selected stimuli cities and their location.

3.3 Procedure

Participants are asked to finish questionnaires including three parts: personal information, latitude estimates with knowledge rating and distance estimates. Participant may quit without any punishment or sign the agreement on the cover page which guarantee the researchers to use the information collected for scientific purposes. After signing, participants provide their personal information (i.e., sex, age and major).

For latitude estimates participants are asked to give their knowledge rate of each city on a scale from 0 (none) to 6 (quite familiar). Each city's latitude is asked to be reasonably estimated due to one's related knowledge. For distance estimates participants are asked to estimate distances of 66 pairs of cities. All the tasks are asked to be done individually and instinctually. To avoid giving estimates in sequences, the order of city pairs is totally random. To make sure latitude task and distance task are done individually, on 30 type “A” questionnaires the distance task comes first, on the remaining 30 type “B” the latitude task comes first. The possibility of each type a participant will have is 50%.

3.4 Data Analysis

The spatial structure of the distance estimates was analyzed using Multidimensional Scaling (MDS). MDS is a set of data analysis techniques that display the structure of distance-like data as a geometrical picture [21]. Psychologists used MDS to study the category of a set of objects by their distances, similarities or proximity rankings. It is then introduced in cartography to study the spatial structure of mental maps. Here classical MDS is used for the reason that according to the mathematical definition of Classical MDS, if the original distances matrix is entered, the result will represents the actual locational relations.

The data are entered into latitude estimates and distance estimates datasheets. Data of distances between cities are entered into a 12*12 matrix, where the element A[m,n] is the distance estimate between city m and city n. The MDS software is introduced to analyze the distance matrix and generate the structure map of city distances using Classical MDS [22]. The software selected is SPSS 11.0 (Statistical Program for Social Sciences 11.0).

To make a comparison, the actual distances matrix is also analyzed by MDS following the same procedure. The actual distances data are from http:// www. geobytes.com / CityDistanceTool. Htm by calculating the distance of two points on the sphere according to each point’s longitude and latitude.

4 Result

4.1 Latitude estimates

The latitude estimates were examined for three features: (1) how cities are sorted by region; (2) whether gaps among regions are discernable [11]. To better evaluate the biases in latitude estimates, figure 4.1.1 is made by displaying each city’s actual latitude and estimate latitude according to its location.

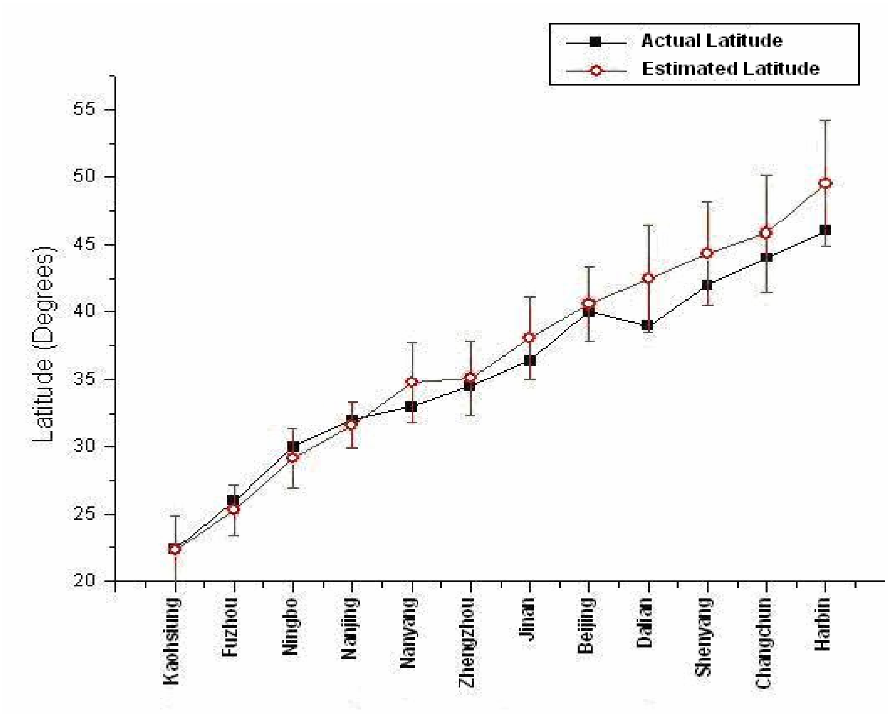

Fig.4.1.1. Latitude estimates result and comparison.

As shown in Figure 4.1.1, Cities located north of 35° N are northward estimated (represent in the figure that the estimated value is above actual value). However, regionalization is not typical in Figure 4.1.1.

It is found estimate error $\Delta Lati$ is significantly related with that city's actual latitude. Estimate error of a city is defined as

$$\Delta Lati = Lati_{est} - Lati_{actual} . \quad (1)$$

, where $Lati_{est}$ is the estimated latitude, and $Lati_{actual}$ the actual latitude of the city.

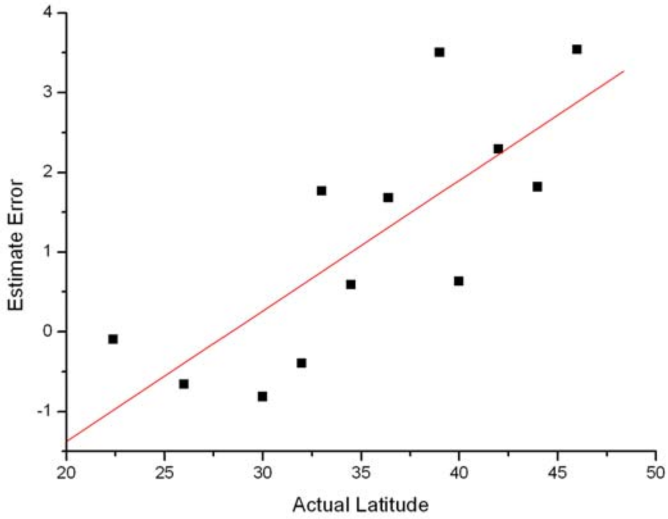

Fig.4.1.2. Linear regression of actual latitude and estimate error.

The linear regression of $\Delta Lati$ and $Lati_{actual}$ results in:

$$\Delta Lati = 0.16377 * Lati_{actual} - 4.65053 . \quad (2)$$

The correlation coefficient R of $\Delta Lati$ and $Lati_{actual}$ is 0.778. According to the significance R-test at the probability level p =0.01 (the lowers the p-level, the more significant the relationship) and degrees of freedom 10, r=0.7079<0.778, which means that the relationship is significant.

A city’s estimated latitude can be deduced from its actual latitude based on equation 2:

$$Lati_{est} = 1.16377 * Lati_{actual} - 4.65053 \quad (3)$$

Equation 3 shows a strong categorization of cities into two regions: northward estimated cities and southward estimated cities. Generally the farther north the city is located, the more north-stretched it is to be estimated. Cities south of certain latitude (in the studied case it is 28.4 ° N) will be southward estimated that its estimated latitude is below the actual latitude.

4.2 Distance estimates

The output of both actual and estimated MDS is re-scaled and rotated (the relative location of each points not changed) to be projected to the administrative map of Eastern China. Fig.4.2.1 shows the comparison of actual MDS (on the left) and estimated MDS (on the right). Actual MDS and its projection on the maps is the same as locations of the cities in real world, while estimated MDS could be considered the cognition map of those cities. Moreover, to assure the comparison, estimated MDS has the same re-scale and rotating angle as actual MDS.

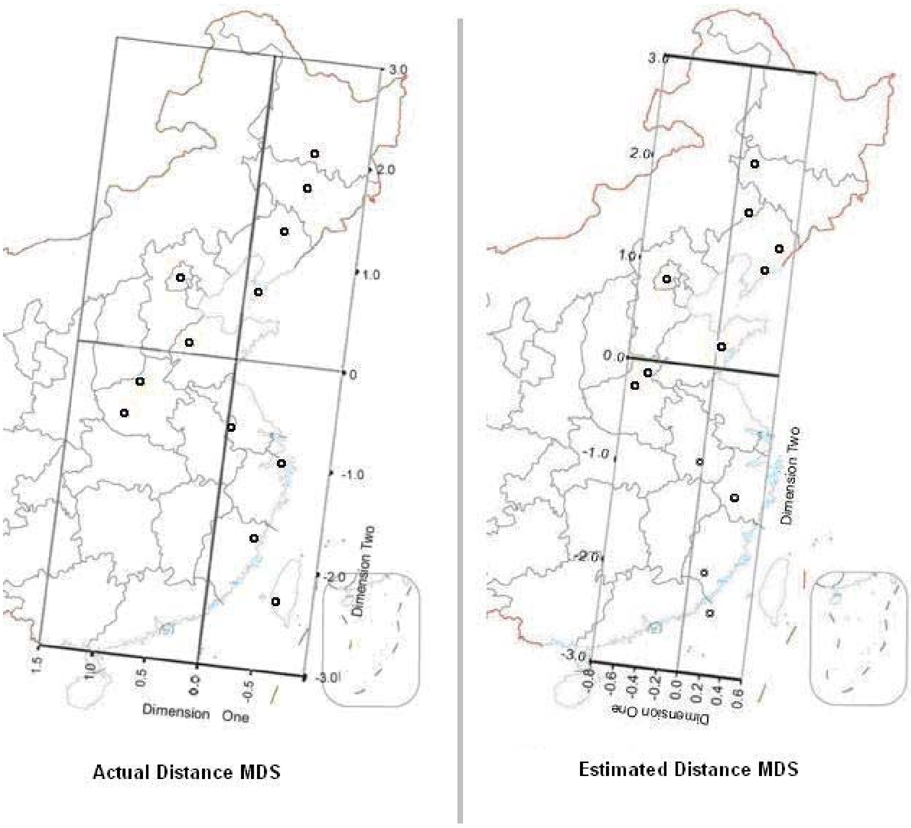

Fig.4.2.1. Actual MDS and estimated MDS.

Estimated distance MDS shows that a gap forms from 32° N to 33° N, which divides cities largely into two groups: northern cities and southern cities. The north-south discrimination of distance estimates is also accordant with the latitude estimates. This phenomenon is best explained by regulation-related climate factor because the gap is where the Q-H border is located. Furthermore, only cities near Q-H border are significantly stretched away because their experienced-climates are more influenced by the Q-H border. Especially the city Nanyang, although it is on the Q-H border and belongs to the South Hua geographically, it is also in a typical North Hua province thus has heating for winter. It is concluded that the gap between two cognitive regions of Eastern China is mainly influenced by regulation-related climate difference.

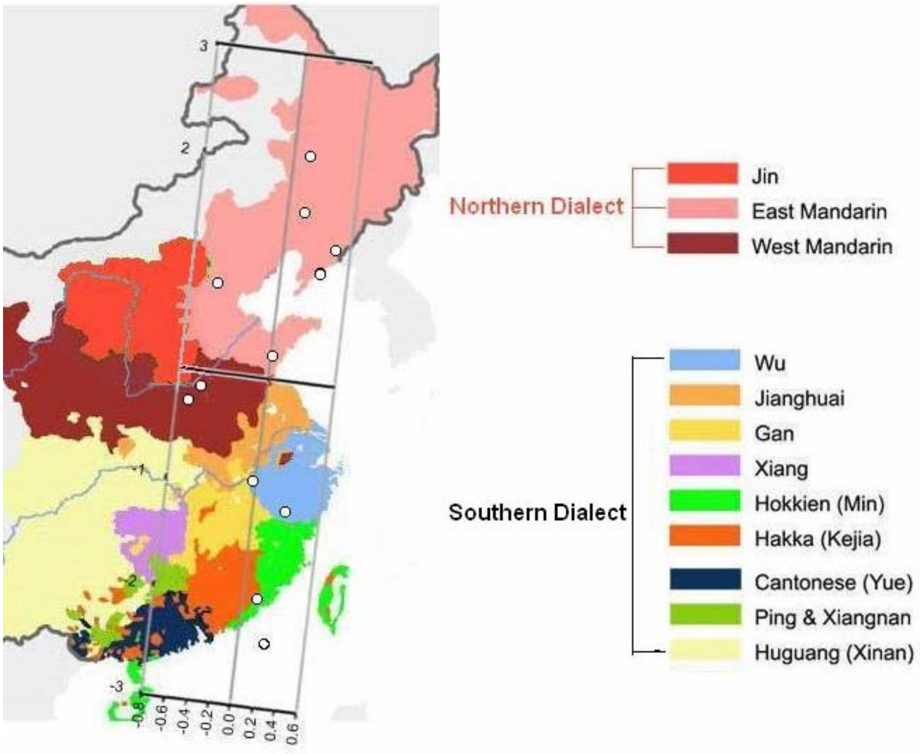

Fig.4.2.2. Estimated MDS and its projection on dialect map.

Projecting estimated MDS onto the dialect map, we will find that cities within the same dialect region are estimated to be closer. The north-south gap is also accordant with northern dialect and non-northern dialect division. It shows the influence of culture because people speaking the same dialect are more likely to share the same culture [18].

4.3 Correlations between latitude and distance estimates

If the coordinates of the MDS model points are projected to a Euclidean metric scale (distances under global-scale should be described as spherical metrics. However, assuming that participants' spatial knowledge is not precise enough to distinguish among these spherical and Euclidean metrics, distance estimates in Euclidean metric are acceptable [11]), a set of latitude values will be generated as the projection into latitude domain called indirect latitude estimates (i.e. estimates generated from latitude estimates part of the questionnaires are called direct estimates).

The Pearson correlation coefficient of direct and indirect latitude estimates is 0.998, showing a strong linear relationship. It is concluded that both latitude estimates (absolute location judgments) and distance estimates (relative location judgments) are based on a common representation at global scale.

5 Conclusion

There are four characteristics of Eastern China's location estimates: (1) participants divided Eastern China into two non-overlapping psychological regions: the north and the south; (2) there is a large gap between the north and the south; (3) a city's estimated latitude is strongly related to its location. The farther north the city is located, the more north-stretched it is to be estimated. Cities south of certain latitude will be southward estimated; (4) both latitude estimates and distance estimates are based on a common representation at global scale.

Similarly, previous researches show four characteristics of North America's location estimates: "(1) participants divided the continents into non-overlapping psychological regions that could be independently influenced by new information; (2) the regions typically had large "boundary zones" between them; (3) there was relatively little north-south discrimination among the locations of cities within most regions; (4) for both the Old and the New World, the estimates became more biased as the cities being estimated were actually located farther south; (5) Latitude estimates and distance estimates are generated from the same representation of geographical knowledge" [11].

By comparing those characteristics, three cultural universal aspects are found:

1. Categorical organization of regions.
2. The existence of relation between estimated latitudes and actual location.
3. The existence of common representation for absolute location judgments and relative location judgments [23].

Both the Chinese and the North American have the most important features of spatial cognition in common: the categorical storage of spatial information and the reasoning process. Despite the emphasis on absolute frames to express location in Chinese language, it has little influence on Chinese people's general cognitive behaviors.

However, landmarks used by the subjects during estimation are quite different between North America and Eastern China. It is assumed subjects in China use the Q-H border around 32ºN as the landmark, rather than the equator that European and North American subjects use in their experiment [11], [12], [13]. This landmark difference is purely cultural because if the restriction of central heating system were not there, people in China will live with natural climate which gradually changes from the equator to the North Pole, therefore more likely to consider equator as the landmark for location estimates.

6 Discussion

People tend to exaggerate the difference between cultures. As the process of globalization and the prevalence of English language, cultural differences become minor yet still worth paying attention to. China, as an influential Asian country which has historical traditions in many cultural aspects, approves universalities shared by human beings when facing location estimate tasks. Thus it is not surprised to see the growth of English-based GIS software such as ArcGIS in China market.

While admitting generalities of geographical estimates at global scale, there are still important dissimilarities at smaller scale that may interfere with daily geographical behaviors (e.g. navigation, [17]). The different spatial frames used by different cultures are also important when people study the way-finding or route memorizing behavior across cultures [24].

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