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REGIONAL DIFFERENCES IN SPATIAL FRAME OF REFERENCE SYSTEMS FOR PEOPLE IN DIFFERENT AREAS OF CHINA [1]

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Summary.—Levinson defined spatial frame of reference systems into three types and found that people who spoke different languages all over the world had different habits in the use of these systems. Some quasi-experimental designed research in China suggested that Chinese people in various areas had different preferences for frame of reference systems in nonlinguistic spatial tasks. In this study, a newly designed and strictly controlled laboratory experiment was conducted to measure performance on linguistic spatial tasks. Response times of two groups of participants, respectively selected from the north (10 men and 12 women; *M* age = 24 yr., *SD* = 4) and south (11 men and 12 women; *M* age = 24 yr., *SD* = 3) of China, were compared on processing of spatial terms used in different systems: absolute (e.g., east) versus relative (e.g., right). To reduce the effect of living experience, the Northern participants with less than 4 yr. living experience in the south of China were included, and vice versa. Analysis showed that Southerners, but not Northerners, differed in response times to terms between absolute and relative systems. This finding suggests that speed of processing spatial terms differs among people who speak the uniform language Mandarin but live in geographically distinct home areas in China and use different frame of reference systems.

Spatial Frame of Reference Systems

Frame of reference system is a key concept in spatial cognition. It was proposed firstly by Gestalt theorists as a "coordinate system used to compute and specify the location of objects with respect to other objects" (e.g., Koffka, 1935). The concept of a spatial frame of reference system has been used in psychology, neurocognition, linguistics, and elsewhere (Majid, Bowerman, Kita, Haun, & Levinson, 2004).

Levinson defined frame of reference systems into three types: intrinsic, relative and absolute. Intrinsic system involves an object-centered coordinate system, wherein the coordinate is determined by the "inherent features,"

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such as sidedness or facets of the object to be used as the ground or relatum. Relative system is based on viewer's viewpoint, seems generally to be based on the planes through the human body, giving an "up"/"down," "back"/"front" and "left"/"right" set of half-lines. An absolute system "refers to the fixed direction provided by gravity," and "such a system requires that persons maintain their orientation with respect to the fixed bearings at all times" (Levinson, 2003). Cardinal directions, such as "north"/"south"/ "east"/"west" are used frequently in that system.

Cross-cultural Comparisons About Spatial Language Use

Spatial languages employ one or more frame of reference systems for spatial descriptions (Levinson, 1996a). The frequency and range of application of these systems change across languages and cultures all over the world. For example, English and Dutch speakers use terms in relative system to describe spatial relations in "table-top space"—that means nongeographic space (Majid, *et al.*, 2004), but they restrict the use of the terms in an absolute system to large-scale, geographical descriptions. In contrast, speakers of Guugu Yimithirr in Australia use only the terms in an absolute system, even when they describe the location of an object on a body part. Levinson and his colleagues have developed several experimental paradigms and used them to show that use of frames of reference in spatial language and cognition varied around the world (e.g., Brown & Levinson, 1993; Levinson, 1996b, 1997, 1998, 2000; Burenhult & Levinson, 2008; Levinson, 2008). They also mentioned that all languages used at least one frame of reference, and there were different preferred frames of reference in different cultures (see Levinson, 2003).

Almost all of Levinson's comparisons were carried out across different countries, and there were also some comparisons within a given country or language. For example, Pederson (1993) observed urban and rural Tamil speakers in India and found significant differences in their use of frames of reference.

There is a similar situation in China, but the differences in use habits occur between the north and south of China divided by Qin Mountain and Huai River. In China, most people speak the uniform language Mandarin. Although people in some areas of China use different kinds of dialects such as Cantonese and Min Nan, there are terms in absolute and relative systems in all kinds of dialects and these terms have the same meaning as in Mandarin. It is, however, commonly observed that people in the North of China use east, west, north, and south to indicate the directions usually, while people in the South of China use left, right, front, and back to indicate the directions usually.

Comparisons on spatial cognition in different areas have been carried out in some provinces in China. Levinson's rotation paradigm and "animal" recall task (1997) were adopted and carried out in Shandong Province in North of China and Guangdong Province in South of China. A significant difference between these two groups of participants was found in their observation: Southerners were inclined to use a relative frame of reference on these nonlinguistic tasks, while Northerners were inclined to use an absolute frame of reference (Liu, Zhang, & Wang, 2005; Zhang & Liu, 2007; Zhang, Liu, & Shi, 2008). Besides nonlinguistic comparisons, there are also linguistic comparisons about use of spatial terms and phrases. In Liu and colleagues' quasi-experimental designed research (2005), when using spatial language to describe different experimental scenarios, more Northerners used absolute frame of reference phrases than Southerners did. Yang (2007) asked the participants to judge the spatial relation of two points presented on the screen and then speak out the corresponding spatial terms in Chinese or English. He drew conclusions that the mean speed of verbal production of spatial terms in a relative system was faster than that of terms in an absolute system, and the process of verbal expressions of spatial relation was improved by the familiarity of the spatial terms.

However, Yang's experiments did not compare the differences between Northerners and Southerners in use of spatial terms. The current study focused on this comparison by using a strictly controlled experiment in the laboratory. The main purpose of this experiment was to find out whether speed of processing spatial linguistic terms in different frame of reference systems would vary among participants from different areas of China. The experimental task involved converting the spatial terms into a common set of directional symbols, represented by the arrow keys on a computer keyboard. Participants' response patterns, which reflected their familiarity with different terms, were compared to discriminate between groups from the two areas. It was predicted that participants from the North and South of China would have significantly different response patterns to terms used in a relative and an absolute frame of reference systems, respectively.

Method

Participants

Two groups of participants were in this experiment—Northerners and Southerners. Their judgments of two sets of characters used in different frames of reference were measured.

The participants in the experiments of Liu, *et al.*, (2005), Zhang and Liu (2007), and Zhang, *et al.* (2008) were from Shandong and Guangdong as representatives of Northerners and Southerners, respectively. These authors noted significant differences in participants' use of spatial frames of reference. In the present experiment, participants born in these two provinces were included. But there were few Cantonese in Beijing, so participants born and raised in Zhejiang, Hubei, Jiangsu, Sichuan, Guangxi, Jiangxi, Fujian, Hunan Province, and Chongqing City were added as Southerners. These provinces and cities are all in the south of China, and their topographic conditions are similar to those in Guangdong Province. As this experiment was carried out in Beijing, in the north of China, for the purpose of reducing the effect of living experience, the Northern participants with less than four years of living experience in the south of China and the Southern participants with less than four years living experience in the north of China were included. The reason for setting four years as a standard was that four years was the length for an ordinary undergraduate to earn a bachelor's degree in China. Moreover, four years was considered to be long enough for someone to know a city.

Northerners.—Twenty-two undergraduates (10 men, 12 women) born and raised in the north of China participated in the experiment with monetary compensation. They studied in the Chinese Agricultural University, Beijing Forestry University and Chinese Academy of Sciences in Beijing. Their ages ranged from 18 to 35 years, with a mean age of 24 yr. ($SD=4$). The average time of living in South of China was 1 yr. ($SD=2$). They all reported normal eyesight or corrected eyesight.

Southerners.—Twenty-three undergraduates (11 men, 12 women) born and raised in the south of China participated in the experiment with monetary compensation. They studied in the Chinese Agricultural University, Beijing Forestry University, University of Technology and Science Beijing, and Chinese Academy of Sciences in Beijing. Their ages ranged from 18 to 27 years, with a mean age of 24 yr. ($SD=3$). The average time of living in North of China was 3 yr. ($SD=2$). One male participant reported his eyesight was too bad to distinguish the Chinese characters "left" and "right," so he quit the experiment and his data were discarded.

Materials and Apparatus

Twelve testing objects were used, one group of arrows and two groups of spatial terms in Chinese. The arrow group consisted of four pictures of arrows, the length of each arrow being 5 cm. The stimuli were used to establish baselines that measured the time span from recognizing the spatial-visual information (arrow) to key pressing. Each spatial term group consisted of four Chinese characters. One group was used in the relative system (cf. Fig. 1), front, back, left, and right, while the other group was used in the absolute system north, south, west, and east. The type size for all characters was 40 point.

A Dell compatible computer, running E-PRIME 1.1 software, controlled the presentation of stimuli, timing operations, and data collection.

English words indicating the directions	Front	Back	Left	Right	North	South	West	East
Corresponding Chinese characters	前	后	左	右	北	南	西	东

FIG. 1. Chinese characters used in the experiment

Stimuli were presented on a 17-in. LCD color monitor and the resolution was 640×480 pixels. Each participant sat on a chair facing north and viewed the monitor from a distance of 60 cm in a dimly lit room. The visual angle between the center of stimuli and the central fixation was approximately 5°. A standard keyboard with 104 keys was applied for participants' responses. All participants were required to respond using the arrow keys in the numpad area.

Procedure

In this experiment, participants responded to the three blocks one by one with one-minute breaks between every two blocks. The order of presentation of the three blocks was counterbalanced among participants. Because the judging tasks were very simple, there was a short practice phase with only three trials (an arrow, a character used in relative system, and a character used in absolute system) before the formal experiment. Participants were required to finish all the trials correctly, or they repeated this phase until their responses were correct.

Each test object was repeated 20 times during the experimental program, and the objects in the same group were presented in the same block. There were 80 experimental trials in each block, so there were 240 trials in total for each participant. On each trial, a fixation point was presented in the center of the screen for 1,000 msec. Then an arrow or a Chinese character was presented in the center of the screen. The participants were required to press the corresponding key in the numpad area of the keyboard as quickly and correctly as possible with the right index finger. Fig. 2 gives the correct key responses to the stimuli. The stimulus would disappear after the response was made. If no response was made, the stimulus would disappear after 10,000 msec.

RESULTS

Forty-four participants' response time data were analyzed. Incorrect responses (.7% of trials), and response times less than 300 msec. and more than 1,300 msec. (2.1% of trials) were excluded.

Each participant's mean response time to arrows was subtracted from

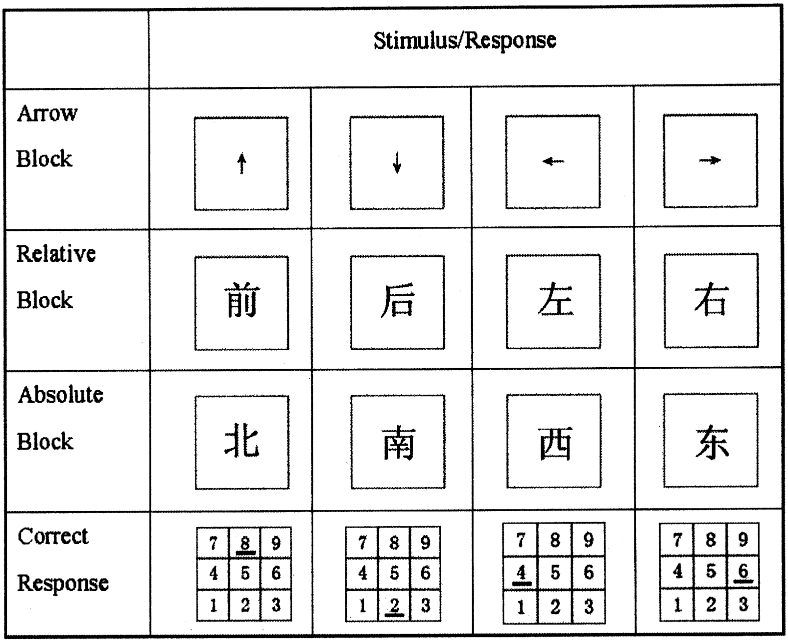

FIG. 2. The corresponding responses to stimuli in the experiment. (Underlined numbers indicate the correct key responses to the stimuli.)

the response time of spatial terms used in absolute or relative frames of reference, and the result of that calculation was defined as the required time for converting the linguistic information into spatial-visual information. The converting times (the response time of spatial terms used in relative or absolute system minus the response time to arrows) of the remaining trials were analyzed by analysis of variance, with one between-subjects factor (Areas: North vs South) and one within-subject factor (Frame of Reference System Types: terms used in relative system vs terms used in absolute system); cf. Table 1.

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR RESPONSE TIMES OF TWO AREA GROUPS (MSEC.)

Area Group	Arrows	Relative	Absolute	Relative -Arrows	Absolute -Arrows
Northerners					
M	534.5	691.0	671.2	156.5	136.7
SD	128.3	161.9	153.8	59.3	71.1
Southerners					
M	524.0	655.7	688.7	131.7	164.7
SD	148.4	164.9	189.7	58.2	99.0

The interaction between Areas and Frame of Reference System Types was significant ($F_{1,42} = 6.39$, $p < .02$; $\eta_p^2 = .13$, cf. Fig. 3). For the Northerners, there was no significant difference between their converting time of the spatial terms used in relative system and absolute system ($F_{1,21} = 2.12$, $p = .16$; $\eta_p^2 = .09$). For the Southerners, the converting time of terms used in absolute system was significantly longer than that of the terms used in relative system [mean RT increase was 33 msec. ($F_{1,21} = 4.34$, $p < .05$; $\eta_p^2 = .17$)], however, no significant main effects were found for Areas ($F_{1,42} = .02$, $p = .89$; $\eta_p^2 = .001$), and Frame of Reference System Types ($F_{1,42} = .38$, $p = .54$; $\eta_p^2 = .01$).

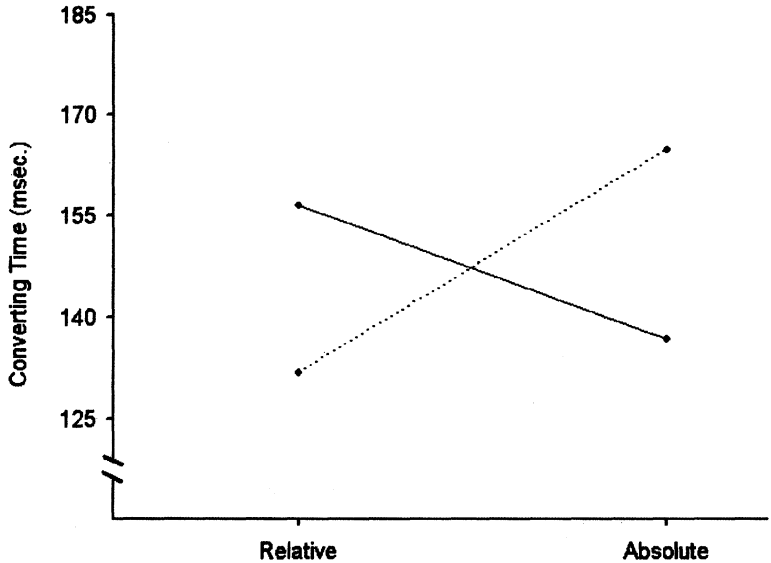

FIG. 3. Mean converting times (msec.) for Northerners (——) and Southerners (· · · ·) in different frame of reference systems

Discussion

In general, this research provided evidence for the previous results of observation about regionally preferred habits of using frame of reference systems (Pederson, 1993) in a newly designed and strictly controlled experiment carried out in China.

For the participants from the north of China, the analysis showed that frame of reference system types did not affect the converting time. The phenomenon illustrated that the familiarity of these two sets of spatial terms in different frame of reference systems was equal in Northerners' spatial cognition. This result suggested that, for Northerners, cognitive processing of spatial terms, respectively used in absolute and relative systems, could be almost equal in spatial cognition system. And, for the participants from the south of China, the response pattern was different from the one presented by the Northerners. The analysis showed that frame of reference system types affected the response time of this group of subjects. The advantage of response to spatial terms used in a relative frame of reference illustrated that Southerners were more familiar with the terms in a relative system than those in an absolute system.

Areas did not affect the mean converting time, so these two groups of participants from the north and south of China could be considered homogeneous in spatial ability during these experimental tasks.

After the experiment trials, participants talked about the situations in which they would use the two sets of frames of reference in their daily lives. There were common situations in the two groups: when they needed to describe the table-top space in words, both Northerners and Southerners would use terms in a relative system. That can explain the result found in experiments by Liu, *et al.* (2005) that more than half of the Northern participants used relative frame of reference phrases to describe the experimental scenes presented on the table before them. This finding was similar to Levinson's conclusions drawn from observation about Englishmen and Dutchmen (see Levinson, 1996a). However, when they needed to give route descriptions to others, most Northerners reported that they would prefer the absolute system to the relative system, which was different from Southerners' preference. In summary, Northerners use both absolute and relative frame of reference systems in daily life, so their familiarity with terms in these two systems is similar; and Southerners use a relative frame of reference much more frequently than an absolute frame of reference, so they are more familiar with terms in a relative system.

These use habits may be related to the geographic features of the route and the environment (Kataoka, 2005). In China, northern areas have more open plains and southern areas are more mountainous. As a result of the differences in topography, the urban planning in the north is different from that in the south of China. Most northern provinces have roads built according to the cardinal directions, whereas most southern provinces have roads built along the foot of mountains or along rivers so they do not follow cardinal directions. Therefore, it is convenient for Northerners to use terms in an absolute system to indicate the directions, and that is different from the use habit of Southerners. These situations in China are different from other cases in some countries where evolution or development would affect the preference for frame of reference (Niraula, Mishra, & Dasen, 2004; Haun, Call, Janzen, & Levinson, 2006; Gentner, 2007).

Another noteworthy point is that the southern participants in this study had all studied and lived in Beijing for one to four years. The spatial language habit in Beijing was considered completely different from that in their hometown, but only a few participants had gotten used to indicating directions with absolute frame of reference phrases which were popularly used by people in Beijing. It is still unknown how long it would take new spatial language use to replace an original frame of reference habit. This question could be examined in further studies. This finding illustrated that, to a certain extent, it might be difficult for an individual to change his preference despite being in an environment with a different use habit of frame of reference system in speech.

In conclusion, the study examined the processing of terms used in different spatial frame of reference systems. The results illustrate that the use habits of spatial frame of reference systems are different in various areas in China, although people speak the uniform language, Mandarin. Northerners had no preference in use for absolute and relative spatial frame of reference systems, while Southerners preferred using a relative frame of reference system. These conclusions can be applied in the design of the navigation systems. For example, it may be a good idea for designers to provide an option for users to select their preferred way of direction expression (Zhao, Wu, Li, Ou, & Sun, 2008).

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