Linguistic and Cultural Universality of the Concept of Sense-of-Direction

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Abstract. We analyze self-reported sense-of-direction in samples of people from Santa Barbara, Freiburg, Saarbrücken, Tokyo, and Beijing. The Santa Barbara Sense-of-Direction Scale (SBSOD) by Hegarty and colleagues primarily assesses survey spatial abilities in directly-experienced environments. It was translated into German, Japanese, and Mandarin Chinese. Results suggest sense-of-direction is a unitary and meaningful concept across the five samples and four languages. In four of the samples, males report significantly better sense-of-direction than do females. Some variations are found across the five samples in overall level of sense-of-direction and in response patterns across the 15 items. Because it is strongly related to the survey spatial thinking that primarily underlies sense-of-direction, and because it can be counted in a relatively straightforward manner, we specifically examine thinking in terms of cardinal directions as a component of sense-of-direction, including conducting a count of cardinal-direction words from Internet corpora in the four languages. We find support for sense-of-direction as a coherent concept across the four languages and as a useful tool to measure individual differences in sense-of-direction. We also consider linguistic/cultural variations in sense-of-direction, especially with respect to variations in physical environments.

Keywords: Sense-of-direction, cross-linguistic, individual differences, spatial corpora.

1 Introduction

Psychologists, educators, and others have attempted to characterize and measure spatial abilities (spatial intelligence) for well over a century, and over a hundred such tests have been devised and made publicly available [1, 2]. The great majority of these psychometric tests have attempted to measure spatial abilities with small, flat pictures that depict shapes, arrows, mazes, matrices of dots, and the like. Factor analytic studies have suggested that pictorial spatial abilities can be classified into two or three major factors, variously labeled by such terms as spatial visualization, spatial orientation, and spatial perception. However, this apparent diversity aside, conceptual and empirical considerations have inspired several researchers to question the adequacy of psychometric pictorial tests for describing and measuring spatial thinking

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abilities across the full range of everyday and specialized real-world tasks that people perform [3, 4, 5, 6].

Perhaps the spatial task that has been of greatest interest to researchers of human spatial cognition, including psychologists, geographers, linguists, neuroscientists, and information scientists, is navigation, particularly wayfinding. Wayfinding involves thinking and decision-making with information about environmental spaces, particularly distal places and features, and often requires combining orientation to one's local surroundings with orientation to these distal places and features [7]. Wayfinding tasks include route choice and planning, pointing to nonvisible places, and creative navigation (such as shortcutting). Directly acquired environmental spatial information is learned as part of perceptual-motor experiences moving about actual environments, whether built or natural; they include buildings, neighborhoods, parks, and cities.

Although it is plausible that pictorial spatial abilities would predict wayfinding abilities in directly-experienced environmental spaces, several attempts to demonstrate this have failed or been modestly successful at best [8, 9, 10]. More successful at predicting performance on environmental wayfinding tasks has been self-reported sense-of-direction (SOD). Kozlowski and Bryant [11] found that answers to a single 7- or 9-point rating scale item "How good is your sense of direction?" predicted error in pointing to cardinal directions, nonvisible campus landmarks, and locations within a large public building, with correlations around .5. Subsequently, others found similar results with single-item [12, 13] and multi-item assessments [9, 14]. These researchers also found that self-report scales, like actual environmental performance measures, correlated only weakly with traditional psychometric spatial tests.

1.1 Santa Barbara Sense-of-Direction Scale (SBSOD)

Hegarty and her colleagues [15] at the University of California, Santa Barbara, developed a self-report instrument they named the *Santa Barbara Sense-of-Direction Scale* (SBSOD). Their express purpose was to develop a predictive test of environmental spatial skills, including wayfinding and learning the layouts of new environments. The scale includes 15 items in which respondents express their degree of agreement or disagreement (i.e., Likert-scale format) on a 7-point scale with statements about environmental spatial abilities, activities, and preferences. Besides "My 'sense of direction' is very good," items refer to giving directions, judging distances, thinking in terms of cardinal directions, enjoyment of reading maps, getting lost, and so on. A total score is typically expressed as an average of the answers to the 15 items, with positively-worded items reverse scored so that a high score (close to 7.0) reflects a good self-reported sense of direction, and a low score (close to 1.0) reflects a poor self-reported sense of direction. The scale is reprinted in Appendix A.

Details of the development, reliability testing, and validation of the SBSOD are found in [15]. Hegarty et al. reported the scale to have an internal consistency reliability of .88, and a test-retest reliability of .91 based on a retesting interval of 40 days. They also reported several content validation studies. One showed that the SBSOD correlated more highly with respondents' errors in pointing to campus landmarks than in pointing blindfolded to objects in the room where they were standing. Another showed good correlations with blindfolded pointing to the origin of a walked route. Another showed stronger correlations with a directly experienced environment than one learned from a video or desktop virtual environment. A final study showed higher correlations with estimating directions between campus landmarks than with estimating directions between U.S. cities on a map. And correlations were just as high in this last study whether respondents filled out the scale before or after the criterion task, suggesting that sense of direction is a somewhat enduring trait and not just based on self-perceptions of recent performance; see [16]. The authors interpreted their findings to indicate that SOD primarily taps into environmental-scale spatial knowledge directly acquired via perceptual-motor experience in real environments. It does not predict map-acquired knowledge or that acquired in a desktop virtual environment as well, but it is likely to predict performance fairly well in more immersive virtual environments. Evidence also suggests that respondents interpret the phrase "sense of direction" somewhat literally, to refer especially to the ability to orient oneself so that a current or imagined heading in a real or imagined environment is coordinated with allocentric spatial knowledge, such as the locations of landmarks or absolute reference systems, including cardinal directions [17]. SOD does not correlate as strongly with performance on distance estimation or map sketching, although its predictive power there is likely to exceed .3 or .4, e.g., [18]. So it is fairly clear that SOD is about the ability to perform survey spatial tasks, not route tasks; see also [12, 13, 19, 20].

1.2 Linguistic and Cultural Similarities and Differences in Self-reported SOD

The original Santa Barbara SOD scale is written in American English. A persistent question of interest to researchers in spatial cognition concerns the degree to which spatial cognition is similar or different across different languages and different cultures [21, 22, 23, 24, 25]. If we grant that sense-of-direction is a coherent and meaningful concept in American English, we can ask whether it is a coherent and meaningful concept in other languages and cultures. This addresses theoretical questions about the cultural variability or universality of spatial cognition, such as questions about the innateness of spatial cognition, the role of language in spatial cognition, the role of culturally specific experiences other than language in spatial cognition, the role of the natural and built environment in spatial cognition, and so on. But it also addresses the practical issue of whether translations of the Santa Barbara SOD would be useful instruments for measuring individual differences in what the Santa Barbara version apparently measures fairly reliably. In this paper, we investigate how well and how the concept of sense-of-direction translates into some other languages. This also allows us to evaluate prospects for translating the Santa Barbara SOD Scale into useful measures of sense-of-direction in other languages.

It would not be an exaggeration to say that a concern about the proper theoretical relationship between language and non-linguistic cognition, or even whether a concept like "non-linguistic cognition" is coherent, looms as a key issue throughout the history of philosophy, as well as the social and behavioral sciences [26, 27, 28, 29, 30, 31]. Within the past decade or two, some of the most important work on these issues has centered on spatial language and spatial cognition [23, 32, 33]. In particular, most of the cross-linguistic and cross-cultural research of the last decade and a half has focused on systems (often called "frames") of reference used by different languages, and how this might affect spatial thinking. Several different conceptual frameworks for understanding spatial reference systems in cognition have been proposed over the last several decades (even earlier in the case of Piaget's work); e.g., [34, 35, 36].

A framework proposed by Levinson [37], specifically in the context of spatial language, has proven very influential. The framework overlaps with previous frameworks, of course, although it concerns only directional and not distance relations (such as "next to"). It includes three types of reference systems: absolute, relative, and intrinsic. Absolute linguistic systems code direction with respect to stable and global origins and axes that could be based on macroscopic features like mountain chains or celestial bodies. They also include systems based on the abstract coordinates of technologically developed societies, such as the latitude-longitude graticule, which Levinson does not explicitly discuss. Cardinal directions are a common example of an absolute system found in many languages. Relative linguistic systems code direction with respect to a person's heading or facing direction. They are dynamic as people change heading, and they rarely if ever apply to orientation statements over very large areas of space. Left and right are a common example of relative systems in many languages. Intrinsic linguistic systems code direction with respect to the heading of an asymmetric environmental feature, which is stable insofar as the feature does not move, but also tends to apply only to orientation statements over relatively small areas around the origin feature. The front of a building would be an example of an intrinsic system, as long as "front" referred to the fixed side of the building with a feature like the entrance.

Notable work by Levinson and his colleagues, summarized in [38] and [39], has led these researchers to propound a fairly strong form of linguistic relativity (the Whorfian hypothesis) in the domain of language involving spatial reference systems. They have studied groups of hunter-gatherers and simple agriculturalists who usually or always employ absolute reference systems, no matter the scale of space involved. That is, a modest number of language communities apparently rarely if ever employ relative reference. Native speakers of, for example, Guugu Yimithirr and Tzeltal use absolute reference to indicate directions, and according to these researchers, think about spatial directions with an absolute system, whether the spatial tasks are explicitly linguistic or not. Thus, "language can play a central role in the restructuring of human cognition" [39] and "language influences how people think, memorize, and reason about spatial relations and directions" [38].

Of course, cultural differences need not be due to language differences. Any variable that differs systematically with cultural-group membership could potentially cause differences in spatial thinking, including differences in spatial language itself. One candidate example of culturally-correlated variation that has frequently been hypothesized to influence spatial cognition and language is systematic differences in environmental activities and experiences. Indeed, such differences might explain cultural variation, sex-related variation, or even individual variation. Potential pertinent examples of such activities include independent travel away from home, map use, particular types of toy play, and video gaming [24, 40, 41, 42, 43, 44].

A second candidate that has frequently been hypothesized to influence spatial cognition and language is systematic differences in environmental structure and layout [45]. Specific examples that have been proposed include variations in the presence of vista-obstructing features [46], the presence of macroscopic features nearby (oceans, mountain chains) [47], and the presence of grid (rectilinear) versus radial versus irregular (organic) road layouts [48]. Notice that these are not entirely independent; the presence of mountains can provide a global reference, obstruct vistas, and impose curvilinear roads.

There are good reasons to believe that these environmental variables influence cognition and language. Brown [49] compiled data from 127 globally distributed languages and reported variations in the preferred spatial reference system used in each language. His explanation for these variations was that if most members of a society live within circumscribed territories, geographic features—especially global features such as big mountains—will be used when references to direction in the environment are made. For instance, maintaining orientation in grids is easier than on oblique or curved road systems [50, 51]. Data reported by [52] and [53] on cardinal-direction usage in American English suggests that such terms are more common in regions of the U.S. that are less mountainous; at least in most areas west of the Appalachians, this also means the road and property layouts are more rectilinear. To the degree that features like these differ systematically in the environments of different cultural groups, one might expect some corresponding variation in spatial cognition and language [54].

2 Study 1: Cross-Linguistic/Nationality Comparison of the SBSOD

In this study, we compare responses to versions of the SBSOD that were translated into German, Japanese, and Mandarin Chinese. We evaluate the similarities and differences in responses to the scale across datasets consisting of responses by native speakers of each language.

2.1 Methods

2.1.1 Respondents

Comparisons in this paper are based on five separate datasets, collected from respondents who were university students in one of four countries (Table 1). The respondents were speakers of one of four different languages: English, German, Japanese, or Mandarin Chinese. Although some multilingualism undoubtedly exists among the respondents, we believe it to be modest, and that nearly all respondents filled out the SBSOD in their native language.

Table 1. Respondent characteristics in the five datasets

City	Language of SOD Scale	Number of Respondents (Sex)	Age in Years (Range)
Santa Barbara	English	106 (48 F, 56 M, 2 ?)	19.9 (18-37)
Freiburg	German	90 (49 F, 41 M)	21.4 (19-31)
Saarbrücken	German	115 (93 F, 22 M)	22.0 (19-40)
Tokyo	Japanese	137 (86 F, 51 M)	21.7 (18-58)
Beijing	Mandarin	102 (29 F, 73 M)	18.5 (18-23)

At the time of filling out the scale, respondents were residing in Santa Barbara (CA), U.S.; Freiburg, Germany; Saarbrücken, Germany; Tokyo, Japan; and Beijing, China. All datasets consisted primarily of young adults of typical college age; the average age of the respondents in each dataset was between 18 and 22 years. Two respondents (one from Santa Barbara, one from Freiburg) were removed from the datasets because they did not respond to five or more items on the SOD scale.

2.1.2 Survey Instruments

The original SBSOD developed by [15] and written in American English consists of 15 Likert-scale items. Each item asks respondents to rate their degree of agreement with a statement about their abilities or preferences at environmental spatial skills or tasks that relate to sense-of-direction. Ratings are on a 7-point scale with 1 being 'strongly agree' and 7 being 'strongly disagree.' As shown in Appendix A, seven items are stated positively (agreeing with the item reflects a good sense-of-direction) and eight are stated negatively.

The English-language SBSOD was translated into German, Japanese, and Mandarin Chinese by a native speaker of the language into which the scale was translated; he or she was also a competent speaker of English as a second language. Translators attempted to translate the entire instructions and the content of each item as accurately as possible. The German version of the scale, known as the "Freiburg SBSOD," was translated by S. Münzer and C. Hölscher; for comparison and discussion, and recognizing the many German speakers in the COSIT community, the German version is presented in Appendix B. The Japanese version, known as the "Tokyo SBSOD," was translated by T. Ishikawa. The Mandarin version, known as the "Beijing SBSOD," was translated by the second author. All versions are available from the authors of the present manuscript.

2.1.3 Procedure

All data collection efforts were conducted by native speakers of the scale's language. Each version of the scale presented the items to respondents in the same fixed order as in the original SBSOD. Respondents in Santa Barbara and Beijing completed the scale in a single group session during an introductory geography class (the respondents were mostly not geography students, however). Respondents in Tokyo and the German cities were recruited and filled out the scale individually. All respondents read the instructions and a consent statement before completing the scale.

2.2 Results and Discussion

2.2.1 Overall Responses Pattern

As is customary with the SBSOD, we present the data in this paper by reverse-scoring positively-stated items so that a high score (close to 7.0) indicates a good sense-of-direction. Table 2 presents the means and standard deviations of responses to each item in all five datasets.

Table 2. Means and standard deviations of responses to each item in all five datasets, reverse-scored so that higher scores reflect better sense-of-direction

	Santa Barbara, USA	Freiburg, Germany	Saarbrücken, Germany	Tokyo, Japan	Beijing, China
1 giving directions	4.8^{a} (1.6)	4.4^{a} (1.4)	4.4^{a} (1.5)	3.5^{b} (1.5)	4.4^{a} (1.9)
2 memory for things	4.3^{ab} (1.9)	4.5^{a} (1.9)	4.7^{a} (1.8)	3.3^{c} (1.7)	3.8^{bc} (2.1)
3 judging distances	4.4^{a} (1.6)	3.9^{ab} (1.6)	3.3^{b} (1.8)	3.4^{b} (1.7)	4.1^{a} (1.7)
4 sense of direction	4.8^{a} (1.9)	4.5^{ab} (1.8)	4.2^{ab} (1.8)	3.3^{c} (1.7)	4.0^{b} (2.1)
5 cardinal directions	3.6^{a} (2.3)	2.6^{b} (1.5)	2.0^{b} (1.6)	2.4^{b} (1.8)	3.9^{a} (2.6)
6 easily get lost	4.0^{a} (1.6)	4.5^{a} (1.7)	4.1^{a} (1.9)	3.9^{a} (1.9)	4.0^{a} (2.1)
7 enjoy reading maps	4.2^{a} (2.0)	4.6^{b} (1.9)	3.8^{b} (2.0)	4.0^{b} (2.1)	5.6^{b} (2.0)
8 understand directions	5.1^{a} (1.6)	4.9^{ab} (1.4)	5.0^{ab} (1.4)	3.6^{ab} (1.8)	4.8^{c} (2.0)
9 good reading maps	5.0^{a} (1.6)	4.9^{ab} (1.6)	4.4^{b} (1.8)	3.7^{c} (1.8)	5.2^{a} (1.8)
10 remember routes	4.1^{a} (2.1)	3.6^{a} (2.0)	3.4^{a} (2.0)	3.5^{a} (1.9)	3.5^{a} (2.0)
11 giving directions	4.0^{ab} (1.7)	4.3^{ab} (1.8)	3.9^{ab} (1.9)	3.6^{b} (1.6)	4.5^{a} (1.8)
12 important to know	6.0^{a} (1.4)	5.2^{bc} (1.7)	5.3^{bc} (1.6)	5.1^{c} (1.5)	5.7^{ab} (1.8)
13 someone navigate	4.4^{a} (2.1)	4.6^{a} (2.0)	4.2^{a} (2.2)	4.0^{a} (2.0)	4.0^{a} (2.1)
14 remember routes	5.0^{a} (1.7)	4.4^{ab} (1.9)	4.3^{b} (1.9)	3.3^{c} (1.6)	4.4^{ab} (1.9)
15 good mental map	5.3^{a} (1.8)	4.5^{b} (1.8)	4.6^{b} (1.8)	3.7^{c} (1.6)	4.5^{b} (2.0)
Overall Mean	4.6^{a} (1.1)	4.4^{ab} (1.0)	4.1^{b} (1.1)	3.6^{c} (1.1)	4.4^{ab} (1.0)

^{abc}Within each row, cities with mean scores that do not share a superscript are significantly different from each other. For example, for item #1, the means for Santa Barbara, Freiburg, Saarbrücken, and Beijing all have only an 'a' superscript and do not significantly differ from each other. Tokyo's mean has only a 'b' superscript and is significantly less than the means of each of the other datasets.

A multivariate approach to repeated measures was used to test the significance of differences in responses to the 15 items across the five datasets. The scores significantly differed as a function of dataset, $F(4, 541) = 16.18$, $p<.0001$. Post-hoc comparisons suggest that respondents from Santa Barbara, Freiburg, and Beijing form a group rating themselves best; respondents from Freiburg, Saarbrücken, and Beijing form a group rating themselves intermediately (i.e., Freiburg and Beijing ratings were poorer than Santa Barbara but not significantly, and they were better than Saarbrücken but not significantly); and respondents from Tokyo form a group rating themselves most poorly. However, the pattern of overall mean differences interacted with the 15 items, $F(56, 2056) = 6.14$, $p<.0001$. Simple effects tests revealed that all items differed significantly across the datasets except items #6 (I very easily get lost in a new city), #10 (I don't remember routes very well while riding as a passenger in a car), and #13 (I usually let someone else do the navigational planning for long trips). Table 2 uses subscripts to indicate which datasets did or did not differ significantly for a particular item.

In sum, mean SOD scores varied significantly across the language/ethnicity datasets, and more importantly, these differences varied in different ways across the 15 items of the scale. These results are quite ambiguous in and of themselves. We carried out several more analyses in an attempt to understand better the nature of similarities and differences in self-reported sense-of-direction across the datasets.

2.2.2 Sex Differences

Males commonly report having a better sense-of-direction than do females, e.g., see [12, 55]. We examined potential sex differences in the five datasets. As Table 1 shows, the proportion of female and male respondents is quite variable across the five datasets, so we did not perform an omnibus significance test involving dataset, items, and sex as factors. Instead, we compared the average scores of females to those of males within each dataset. As Table 3 shows, in fact, males reported significantly better sense-of-direction in all datasets except Freiburg, where it was virtually identical for the sexes and did not significantly differ.

Table 3. Mean SOD scores for female and male respondents in each dataset

City	Female Scores (n)	Male Scores (n)
Santa Barbara	4.3 (48)	4.9 (56)*
Freiburg	4.4 (49)	4.3 (41)
Saarbrücken	4.0 (93)	4.6 (22)*
Tokyo	3.3 (86)	4.2 (51)*
Beijing	4.0 (29)	4.6 (73)*

*Means differ significantly at the p<.05 level or better.

Mean scores were better for males than for females, except in the Freiburg dataset. In the other four datasets, the mean difference favoring males is .6 of a scale point for Santa Barbara, .6 for Saarbrücken, .9 for Tokyo, and .6 for Beijing. The recurring pattern of similar sex-related differences across the datasets supports the idea that sense-of-direction is a coherent concept in German, Japanese, and Chinese. We have no explanation for the lack of sex differences in the Freiburg dataset; it cannot be anything linguistic or ethnic per se, as the Saarbrücken dataset shows sex differences like the other three datasets.

The fact that the proportion of the two sexes is so variable across the five datasets (i.e., dataset and sex are confounded), and the fact that males rate themselves as having a better sense-of-direction in most of the datasets, suggests that we exercise caution in interpreting comparisons across the datasets. The poor overall scores for the Tokyo SBSOD can partially be accounted for by the large proportion of female respondents in that dataset. In fact, not only does the Tokyo dataset include a large proportion of female respondents, but the females in that dataset reported an exceptionally poor overall SOD, considerably poorer than males in the Tokyo data, as well as poorer than female and male respondents in the other four datasets. The Saarbrücken dataset has an even higher proportion of female respondents than the Tokyo dataset does, and its overall mean SOD score was second poorest after the Tokyo dataset.

To help further disentangle dataset differences due to language, ethnicity, or culture from sex differences, we repeated our comparisons across the datasets, but separately within each sex. In fact, scores differed significantly for both sexes as a function of dataset and the interaction of dataset by item: for female respondents, dataset $F(4, 298) = 11.96$, $p<.0001$; dataset by items $F(56, 1110.8) = 4.02$, $p<.0001$; for male respondents, dataset $F(4, 236) = 3.89$, $p<.01$; dataset by items $F(56, 869.6) = 2.95$, $p<.0001$. We do not pursue further analysis of the pattern of item differences across datasets for each sex, but the point is clear that the dataset differences in overall SOD we find can only partially be attributed to a difference in the proportion of the two sexes in each dataset.

2.2.3 Factorial Structure and Internal Consistency

Factor analysis was used to examine the factorial structure of each dataset (i.e., the analyzed matrix had item communalities on the diagonal, not 1.0 as in PCA). Eigenvalues express the variance accounted for by each factor; at a minimum, useful factors should have eigenvalues > 1.0, as otherwise, a multivariate factor does not even improve on the descriptive power of one of the original items from the scale. As Table 4 shows, the first factor extracted in each dataset accounts for a clear majority proportion of the variance making up the factors extracted (i.e., this is not the total variance of the original items): 79% for Santa Barbara, 73% for Freiburg, 76% for Saarbrücken, 82% for Tokyo, and 68% for Beijing. For each dataset, the next largest factor is largely irrelevant, with eigenvalues less than 1.0.

Table 4. Exploring the unidimensionality of the SOD scale in each of the five datasets via factor analysis and internal consistency

City	Cases[1]	Eigenvalue of First Factor Extracted	Eigenvalue of Second Factor Extracted	Internal Consistency[2]
Santa Barbara	106	5.30	0.69	.88
Freiburg	89	4.60	0.85	.84
Saarbrücken	114	5.26	0.89	.87
Tokyo	137	5.92	0.79	.89
Beijing	101	3.81	0.78	.80

[1]The number of respondents who provided responses to all 15 items in the scale.
[2]Cronbach's α

Examining the pattern matrix of factor loadings for each item reveals that in all datasets, all 15 items loaded positively on the first factor. In fact, a strong majority of items in each dataset had loadings greater than .40 on the first factor, and only the Tokyo and Beijing datasets had even one item with a loading <.20. Furthermore, the pattern matrices for the first factor were rather similar across datasets. In each dataset, item #4 had nearly the strongest loading on the first factor of all the items, and it was the highest loading item on the Freiburg, Saarbrücken, and Beijing scales. Conversely, item #2 had the weakest loading on the first factor in all datasets except Beijing, where it had the third weakest loading. To compare the loading patterns across the datasets more systematically, we calculated correlation coefficients for each dataset in comparison to the Santa Barbara dataset by using items as the unit of analysis and correlating the 15 pairs of loadings from the datasets taken two at a time (thus, N=15 for each correlation). The pattern of loadings across the 15 items for the Santa Barbara dataset correlated substantially with the pattern for each of the other datasets: .49 with Freiburg, .62 with Saarbrücken, .61 with Tokyo, and .57 with Beijing.

Finally, we examined the unidimensionality of the various datasets by examining the internal reliability of each. Table 4 shows that all five datasets have similarly high internal consistency, as reflected in Cronbach's α values between .80 and .90. Thus, all language versions of self-reported SOD, administered in all places, have good internal consistency. By itself, this suggests relatively strong unidimensionality.

Our examination of the factorial structure of the five datasets provides relatively strong evidence in favor of the coherence of sense-of-direction and the likely feasibility of translated versions of the Santa Barbara SOD as a useful tool in German, Japanese, and Mandarin Chinese. In each case, the scale has one very strong factor and no second factors of appreciable magnitude that would normally be considered in need of interpretation by guidelines common in factor analysis. The pattern of factor loadings is rather similar to the pattern for the original Santa Barbara scale for each of the non-English datasets, in each case sharing around 25% or more variance. All five datasets have internal consistency of .80 or better. The SOD scale measures mostly one thing in each dataset.

3 Study 2: Cross-Linguistic Comparison of Cardinal Direction Words from Internet Corpora

As we discussed in the Introduction, linguistic differences in word use, particularly in the reference system used with spatial expressions, have been proposed to underlie differences in spatial thinking style and ability. Here, we present an exploratory attempt to test this idea by comparing word counts from Internet corpora developed by linguists with scores on the SOD scale. We chose to look specifically at the use of cardinal direction words in the corpora because that directly addresses the use of an absolute reference system (an abstract allocentric system [35]) in a way that can be identified and counted fairly unambiguously in corpora. Also, ability to think about space in absolute terms clearly relates to SOD overall, and, in fact, the SBSOD contains a specific item (#5) that concerns thinking in terms of cardinal directions. Although it would certainly be informative to perform broader and more general analyses of corpora for spatial terms, the other items in the SBSOD do not lend themselves to obvious word counts and do not obviously relate to spatial reference systems, widely recognized as fundamental to spatial language. Here, we examine the Internet corpora from all four languages in our datasets above: English, German, Japanese, and Mandarin Chinese.

3.1 Methods

3.1.1 Corpora

To gain further insight into the relationship between self-reported sense-of-direction and the way languages differ in expressing spatial concepts, we analyzed linguistic Internet corpora created by the "Wacky" project. This uses a Web crawler to find web sites that contain particular words or phrases in different knowledge domains. The corpora are subjected to various filtering procedures, including the removal of very small and very large pages, duplicate pages, and pornographic sites (which use long strings of machine-generated text to fool search engines). Details about the creation of the corpus are found in [56]. We used frequency counts of single words from the corpora of Internet word forms in English, German, Japanese, and simplified Chinese from the Centre for Translation Studies at the University of Leeds found at http://corpus.leeds.ac.uk/list.html.

3.1.2 Procedure

We counted the frequency of words that explicitly referred to cardinal directions in the four language corpora. Small-case and capitalized versions of words were counted separately, as long as they occurred with a frequency of at least 5 per one million words (for context, “relaxing,” “pulmonary,” and “sang” appear with a frequency of 5.00 in English). Counted words in English included North (with the greatest frequency of cardinal-direction words in English of 158.44 per one million), South, West, East; north, south, west, east; Northern, Southern, Western, Eastern; northern, southern, western, eastern; Northwest, Northeast, Southwest, Southeast; and Midwest (other relevant terms did not occur with enough frequency).

Although it might be considered more appropriate to exclude cardinal-direction words used as region names (such as “Midwest”), we realized that a count of single words in English would always include parts of region names that we could not identify and exclude (such as “North America”). Thus, we included region names in all four languages (such as “Osteuropa” in German). For the Japanese corpus, we included both kana and kanji versions of cardinal-direction words. However, we excluded single-letter references (N, S, E, W) in the four languages because we thought it would be too ambiguous as to whether they actually referred to cardinal directions or something else, like other names. In fact, we suspect that Japanese, in particular, may include substantial single-letter references to cardinal directions in its corpus.

3.2 Results and Discussion

Table 5 gives the frequency count of cardinal direction words from the Internet corpora in the four languages we examined. These are broken down by variations of north, south, east, west, and combination words like northeast. The Mandarin Chinese count was the highest at over 2,000 per million words, more than twice the count of almost 1,000 in English, the second highest. The Japanese count was lower at about 700, and the German count was even lower at about 500.

Table 5. Frequency counts per one million words of cardinal-direction words in English, German, Japanese, and Mandarin Chinese.[1]

Language	North	South	East	West	Combined	Total
English	262.20	254.22	169.77	228.66	28.61	943.46
German	73.48	87.02	158.07	165.98	15.23	499.78
Japanese	193.82	64.17	295.07	99.84	38.53	691.43
Mandarin	760.26	425.98	381.61	462.42	121.91	2152.18

[1]All versions of a given term were counted, e.g., North, north, Northern, and northern in English; Norden, Nord, nördlichen, nördlich in German.

These word counts compare rather closely to the pattern of responses to item #5 from the SOD scale that concerns whether a person thinks about his or her environment in terms of cardinal directions (reported in Table 2). Respondents from the Beijing dataset reported the strongest agreement with item #5, and the Mandarin corpora included the largest count of cardinal direction words, by far. Respondents from the Santa Barbara dataset reported the second strongest agreement with item #5, and the English corpora included the second largest count of cardinal direction words. Respondents from the Freiburg, Saarbrücken, and Tokyo datasets reported the weakest agreement with item #5 (significantly weaker than Beijing and Santa Barbara), and the German and Japanese corpora included the smallest count of cardinal direction words.

4 General Discussion

Our studies are most consistent with the conclusion that sense-of-direction is a unitary and meaningful concept across the four languages we compared: it's original American English, German, Japanese, and Mandarin Chinese. We also believe that the Santa Barbara Scale is useful as a predictive tool in all four languages, or at the least, that it deserves further investigation in these and other languages as a potentially useful tool. The strongest evidence to support these conclusions is the clear unidimensional factor structures and high internal consistency we find in all five datasets for the 15-item scale. The correlation of the factor loadings for each of the four non-English datasets with the original Santa Barbara data also supports these ideas. All items load positively on the first factor in all five datasets. In particular, item #4 that specifically mentions "sense of direction" loads the highest of all items in three of the datasets, and second highest in the other two. Similarly, item #2 has a very weak loading on the first factor in all five datasets. We also find support for the likely similarity of meaning of self-reported sense-of-direction across the datasets in the recurring pattern of sex-related differences (favoring males) across all but one of the datasets.

Of course, although it is justified to say that the scale measures primarily one thing in each dataset, we cannot say for sure that this one thing is exactly the same in each dataset. That is, we cannot say confidently that respondents in the different datasets understand sense-of-direction in exactly the same way. In fact, we doubt they do. We would need to conduct content validation studies in the different language groups similar to those reported by [12] in order to establish that more convincingly. Even so, from what researchers have come to understand about the way natural language encodes meaning, we do not believe it is possible for the terms used in the original Santa Barbara Scale to be translated perfectly. This strikes us as a useful and interesting area for further research.

Even if we accept the unitary nature of sense-of-direction across languages and cultures, and grant that its meaning is largely similar, we do not find that respondents in the five datasets have equivalent levels of sense-of-direction. Overall mean SOD varies significantly across the five datasets, with the Santa Barbara respondents reporting the best SOD, significantly better than the Saarbrücken and Tokyo respondents. The Tokyo respondents report the poorest SOD, significantly worse than all four of the other sets of respondents. This can partially be explained by the fact that the Tokyo dataset includes a large proportion of female respondents, and female respondents report poorer SOD than male respondents in all but one of the datasets. But even when the datasets are compared within the two sexes, we find significant differences among the datasets overall and in interaction with the different items. Taken together, our data analyses support the idea that sense-of-direction is a very similar but non-identical concept across American English, German, Japanese, and Mandarin Chinese languages/cultures. They also suggest that members of different language/culture groups may in fact differ somewhat in their sense-of-direction. Of course, in the absence of validation testing, we recognize that cultural differences in modesty (self-assertion) could contribute to overall differences in mean reported sense-of-direction across respondent groups. Indeed, such a claim would be an attractive explanation for sex-related differences found within a culture, except that in the case of American respondents, evidence reported in studies such as [12, 15, 55] shows that the better SOD scores typically reported on average by males actually correspond to better performance on various survey-style spatial tasks. In any case, it bears emphasizing that cultural differences in modesty would only help explain overall mean differences and not patterns of internal consistency, factor structure, or other aspects of our data.

If the analyses do in fact provide evidence for measurable differences in sense-of-direction across the five datasets, and not just differences in reporting style, can we address why this might be so? As we reviewed in the Introduction, most of the literature on cultural differences in spatial cognition from the last couple decades has focused on the use of reference systems in different languages. Of course, all four languages we examine use all three systems (absolute, relative, intrinsic), and we presume they are similar in varying the use of different systems according to factors like the scale of space, indoor-outdoor, and so on, e.g., [33]. Thus, our results provide no particular evaluation of the claims of Levinson and his colleagues [37, 38]. They do increase our interest in attempting to assess self-reported sense-of-direction among some of the language groups studied by Levinson et al., although we anticipate that adequate translation would be much more difficult with people from much less technologically developed lifestyles. Levinson et al. have reported observations of impressively good performance by their participants on task such as maintaining orientation over long-distance travel, pointing to non-visible landmarks, and so on. This implies to us that these participants would rate themselves as better on a self-report sense-of-direction scale than our American, German, Japanese, or Chinese respondents. But given the relative nature of psychometric judgments, how much would Levinson et al.'s participants adjust their internal scales of what constitutes good or poor ability and preference to take account of their overall much better levels? One could also take Levinson et al.'s interpretations to suggest that sense-of-direction does not vary much within the groups they study, but is uniformly excellent across individuals. This is very definitely not what we and other researchers find within our samples; performance on wayfinding and learning tasks that influence assessments of sense-of-direction vary greatly among individuals, even within samples of respondents that are fairly uniformly educated and otherwise able. For some of us, this makes the results that Levinson et al. report that much more astonishing.

We do find evidence in our analysis of Internet corpora for the suggestion that respondents who speak languages referring more frequently to cardinal directions are more likely to self-report that they think in terms of cardinal directions. We also cited a couple of other studies that provide evidence for regional differences in the use of cardinal directions specifically within the U.S. [52, 53]. We are thus curious about regional comparisons within the U.S. on the SBSOD. We do recognize that the cardinal directions are just one example of the forms that absolute systems of reference can take. In many parts of the world where cultures have less modern technological sophistication (compasses, globally accurate maps, GPS units), absolute systems are often based on local environmental features like mountains or oceans that are so large, they function as global references over large portions of home territory, if not all of it.

Besides the choice of linguistic terms, as we reviewed above, people living in different parts of the world live in residential environments that are not identical. We increasingly find merit in the idea that living in flat, hilly, or mountainous terrain; living near or far from large water bodies; or living in regions with or without rectilinear roads and property lines (including whether they are aligned with cardinal directions or not) influences the ease of using different reference systems. More specifically, we think that the use of absolute systems—and the particular absolute system that is used—does depend to a considerable degree on environmental factors like these. We note that among the settings of our five datasets, Santa Barbara (and the U.S. more generally) and Beijing are most clearly organized into grid patterns of city layout. Furthermore, we accept that when meaning is habitually expressed in natural language in particular ways, people become accustomed to thinking in that way. They can think in that manner more quickly and more competently. This is an endorsement of a version of linguistic relativity but not necessarily a version that starts the nexus of causation in the language choices themselves. In other words, we would not call this a linguistic difference per se, and we are not sure if this would appropriately be called a cultural difference. This theoretical story suggests that speakers of any language from any culture might eventually come to change their spatial thought and language when moving to new environments differing in relevant properties. Research on changes in spatial cognition with changes in residential environment thus intrigues us. Also intriguing is the possibility that the role of factors like habitual language use and residential environment may vary systematically across individuals within language/cultural groups (or across homogeneous language/culture groups based on sex, age, expertise, and so on).

Finally, the analyses we report here highlight shortcomings of the Santa Barbara Sense-of-Direction Scale in two ways. First, the scale is not necessarily the best possible self-report scale, even in American English. For instance, if we were to revise the scale, we would not include items such as #2. It does not contribute to the scale as a whole as well as one would want, either empirically or conceptually; i.e., "having a poor memory for where you left things" is probably not strongly part of sense-of-direction when the things in question are keys or sunglasses. We also accept Sholl et al.'s [17] findings that a single-item question about sense-of-direction (i.e., our item #4) often works almost as well as the 15-item scale.

Second, we appreciate that sense-of-direction is most clearly a measure of survey spatial abilities in environmental spaces. Researchers are interested in other aspects of spatial cognitive skills and preferences, including reasoning with pictures and objects, reasoning about routes (which can be done with or without survey reasoning), reasoning with cartographic maps and other geo-information systems, giving and interpreting verbal directions, and more. Aside from continued attempts to develop valid and reliable ways to measures these other skills and preferences, we find value in continued research on cross-linguistic, cross-cultural, and cross-environmental similarities and difference.

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Appendix A. Instructions and items from the original English-language Santa Barbara Sense-of-Direction Scale, presented in this order to all respondents.

This questionnaire consists of several statements about your spatial and navigational abilities, preferences, and experiences. After each statement, you should circle a number to indicate your level of agreement with the statement. Circle "1" if you strongly agree that the statement applies to you, "7" if you strongly disagree, or some number in between if your agreement is intermediate. Circle "4" if you neither agree nor disagree.

Each item rated by circling a number on a 7-point Likert scale (provided after each item in original scale): strongly agree 1 2 3 4 5 6 7 strongly disagree

1. I am very good at giving directions.
2. I have a poor memory for where I left things.
3. I am very good at judging distances.
4. My "sense of direction" is very good.
5. I tend to think of my environment in terms of cardinal directions (N, S, E, W).
6. I very easily get lost in a new city.
7. I enjoy reading maps.
8. I have trouble understanding directions.
9. I am very good at reading maps.
10. I don't remember routes very well while riding as a passenger in a car.
11. I don't enjoy giving directions.
12. It's not important to me to know where I am.
13. I usually let someone else do the navigational planning for long trips.
14. I can usually remember a new route after I have traveled it only once.
15. I don't have a very good "mental map" of my environment.

Appendix B. Instructions and items from the German-language Freiburg Santa Barbara Sense-of-Direction Scale, presented in this order to all respondents.

Dieser Fragebogen besteht aus verschiedenen Aussagen über Ihre räumlichen Fähigkeiten, Vorlieben und Erfahrungen sowie Ihre Fähigkeiten, Vorlieben und Erfahrungen beim Finden von Wegen. Nach jeder Aussage sollen Sie einen Kreis um diejenige Zahl ziehen, die den Grad Ihrer Zustimmung mit dieser Aussage am besten ausdrückt. Markieren Sie die „1“ wenn Sie stark zustimmen, dass diese Aussage für Sie zutrifft, markieren Sie „7“ wenn Sie dies stark ablehnen oder markieren Sie eine Zahl dazwischen, wenn Ihre Zustimmung dazwischen liegt. Markieren Sie die „4“ wenn Sie weder zustimmen noch ablehnen.

Each item rated by circling a number on a 7-point Likert scale (provided after each item in original scale): stimme stark zu 1 2 3 4 5 6 7 lehne stark ab

1. Ich bin sehr gut im Geben von Wegbeschreibungen.
2. Ich kann mir nur schlecht merken, wo ich Dinge liegen gelassen habe.
3. Ich bin sehr gut im Schätzen von Entfernungen.
4. Mein „Orientierungssinn“ ist sehr gut.
5. Wenn ich über meine Umgebung nachdenke, verwende ich meist die vier Himmelsrichtungen (N,S,O,W).
6. In einer neuen Stadt verlaufe ich mich sehr leicht.
7. Landkarten lesen macht mir Spaß.
8. Ich habe Probleme, Wegbeschreibungen zu verstehen.
9. Ich bin sehr gut im Kartenlesen.
10. Als Beifahrer im Auto erinnere ich mich nicht sehr gut an die gefahrenen Strecken.
11. Ich gebe nicht gerne Wegbeschreibungen.
12. Für mich ist es nicht wichtig, zu wissen wo ich bin.
13. Normalerweise überlasse ich anderen die Wegeplanung für längere Fahrten.
14. In der Regel kann ich mich an einen neuen Weg erinnern, wenn ich ihn lediglich einmal zurückgelegt habe.
15. Ich habe keine sehr gute „innere Karte“ meiner Umgebung.