Assessing and Improving Geographic Belief: A Cognitive Approach

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Over the past several years, we have conducted numerous experiments designed to assess what people know about world geography and to determine how new facts affect prior knowledge. Typically, participants first estimate the latitudes or longitudes of cities in different parts of the world. Next, they are given information about the actual location of a small number of these cities and provide a second set of estimates. These location estimates are converted to representations, called location profiles, which convey information about estimation accuracy, the subjective division of continents and countries into regions, biased beliefs about the location of these regions, and beliefs about the relations between regions both within and between continents. In addition, differences between the first and second estimates indicate how representations of global geography are updated when people learn new location information about individual cities. This article provides an introduction to this research, and summarises its main findings.

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In this article, we review an on-going laboratory-based research program that has provided new methods for assessing and improving geographical knowledge (Friedman & Brown, 1999 in press a, in press b). The approach has three key elements: (a) a task – the absolute location judgement task, (b) a representation – the location profile, and (c) a form of intervention – seeding the knowledge base (Brown & Siegler, 1993, 1996). In the typical experiment, subjects are presented with a set of city names and are required to estimate either the latitude or the longitude of each city in the set. Next, they are presented with information about the actual location a small number of cities – usually just one or two – called "seed cities." Finally, they provide a second set of estimates for the cities. The pre-seeding judgements are used to construct one location profile and the post-seeding estimates to construct a second. The profiles constructed from the first set of judgments convey information about estimation accuracy, the subjective division of continents and countries into regions, beliefs about the relative and absolute location of these regions, and beliefs about the relations between regions, both within and between continents. Importantly, these pre-seeding profiles reveal the extent and nature of pre-existing biases in geographical knowledge. Thus, differences between pre-seeding and post-seeding profiles can be examined to determine how representations of global geography are updated when people learn new location information about individual cities.

ABSOLUTE LOCATION JUDGEMENTS AND LOCATION PROFILES

In our research program, we have made heavy use of absolute location judgements. In most of these experiments, participants are required to estimate, as accurately as possible, the latitude or the longitude of the all cities in the stimulus set. To our knowledge, this research program is the first to collect these estimates in a systemic manner. Of course, a number of other methods have been used to study subjective geography. These include: map reproductions (Hirtle & Jonides, 1985; Saarinen, 1987; Tversky, 1981); compass-bearing estimates (Glicksohn, 1994; Tversky, 1981), in which people indicate the location between two geographical reference points; distance judgments (Holyoak & Mah, 1982); area estimation (Kerst & Howard, 1978); comparative location estimates (Lloyd, 1989; Maki, 1981); and travel time estimates (Montello, 1989). These methods have specific problems associated with them that absolute location judgments do not. For example, map reproductions are limited by people's ability to draw. Obviously, drawing ability is irrelevant to producing location estimates.

There is also a fundamental problem with distance estimates, bearing estimates, travel-time estimates, and comparative location judgments. Because all these tasks require knowledge of at least two cities, it is difficult, and at times impossible, to attribute performance unambiguously to a single source. In contrast, the location judgement task yields an individual numerical estimate for each test city. Thus, accuracy and bias can be assessed on a city-by-city basis, as well as at more global level, using conventional statistical methods. For example, the mean signed error (signed latitude error = estimated latitude – actual latitude) and the mean absolute error (absolute latitude error = |signed latitude error|) can be computed for each city, and compared to determine which cities elicit accurate, unbiased estimates and which do not. It is also possible to take means over cites within a region and to compute the correlation between estimated and actual location for these same cities. These measures indicate whether regional membership affects accuracy and bias, and whether participants have a good sense of the relative location of cities within a given region.

Aggregate measures computed over absolute location judgments are instructive, and lend themselves to inferential statistics. However, the main advantage of this approach is that it provides the estimates that are necessary for constructing location profiles. An example of a location profile is presented in Figure 1. The data presented in this figure were collected from 60 Canadian university students who were required to estimate the latitude of 30 New World cities and 30 Old World cities (see Friedman & Brown, 1999 in press b, Experiment 2, for further details). In this figure, latitude is represented on the ordinate and the names of the test cities along the abscissa, with the New World cities presented on the left side of the figure and the Old World cities on the right side. Within each panel, the cities are ordered according to actual latitude, with the most northern city in each set (i.e., Saskatoon and Oslo) listed at the far left and the most southern city in each set (i.e., Acapulco and Nairobi) listed at the far right. Each small marker indicates a city's actual latitude and each large marker, its mean estimated latitude (and the standard error of those estimates). For example, it is clear from this figure that Tijuana is actually located at 33° north and believed to be located at 4° north, and that the corresponding coordinates for Naples are 41° north and 23° north.

Figure 1 is an objective profile; we use this term because the test cities are ordered by their actual latitudes (and hence the curve connecting the cities' actual latitudes decreases monotonically from left to right in each half of the figure). Objective location profiles can be suggestive. In the present case, two things are clear: First, the rough correspondence between actual latitudes and estimated latitudes indicates that participants had some knowledge of the relative locations of the test cities in both hemispheres. Second, for most cities, the estimated latitude fell below the actual latitude. This indicates

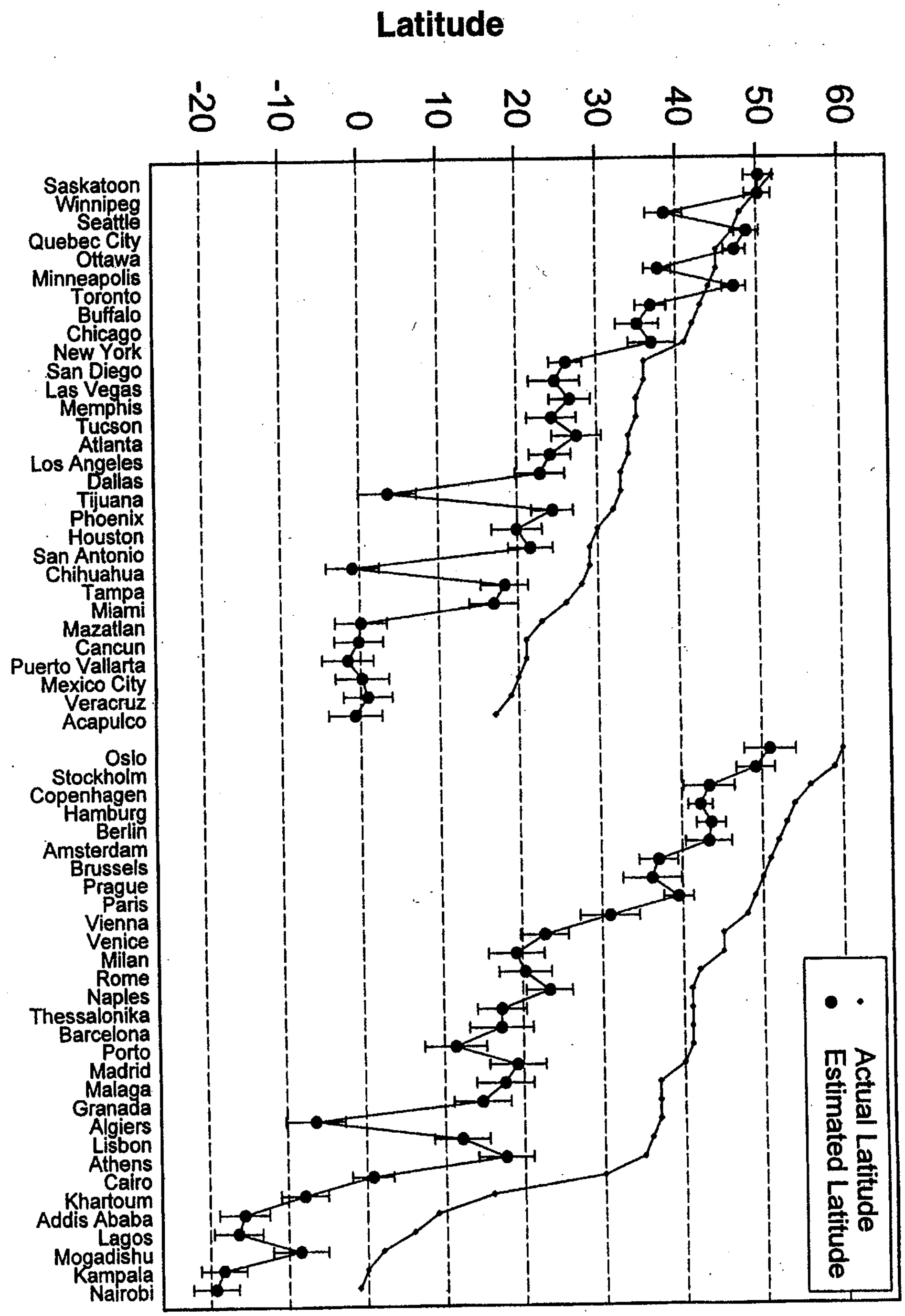

Figure 1. Objective latitude location profile for New World cities and Old World Cities (right panel). Data are ordered by the actual latitudes of the test cities.

that these Canadian subjects tended to believe that most test cities lie south of their actual locations. Consistent with these observations, the mean correlation between estimated and actual latitude was .83 for the 30 New World Cities, and the mean signed error was -11°; comparable figures for the Old World cities were .76 and -19°.

Figure 1 data are re-presented in Figure 2. In this subjective profile, cities are sorted by the latitude estimated by the subjects rather than actual latitude. Here, for each hemisphere, the test city that yielded the most northerly mean estimate is listed furthest to the left, and the one that yielded the most southerly mean estimate is listed furthest to the right. Like the objective profile, the tendency for estimated latitudes to fall below actual latitudes indicates that these subjects were biased to locate most cities south of their actual locations. More importantly, the sharp discontinuities apparent in these estimate curves (but not those in Figure 1) can be interpreted as boundaries between psychologically distinct regions and subregions. As a result, subjective location profiles can be used to identify subjective regions empirically, to determine whether these subjective regions are located correctly, and to infer the existence and the nature of between-region relations both within and between hemispheres.

More concretely, we interpret Figure 2 as follows. First, for our subjects, North America was composed of four correctly ordered regions: Canada, the Northern United States, the Southern United States, and Mexico. Second, these participants divided Europe into a Mediterranean region and a north-central region, and they drew a clear distinction between Europe and Africa. Third, there was a tendency to place warm regions (the southern US, Mexico, Mediterranean Europe, and Africa) far to the south of their actual locations. Fourth, there appeared to be a between-hemisphere correspondence between regions, with Canada and the northern United States aligning with north-central Europe, the southern US aligning with Mediterranean Europe, and Mexico with the Mediterranean Ocean. The general division of hemispheres into regions and subregions and the alignment of regions across hemisphere have been replicated a number of times (Friedman & Brown, 1999 in press a, in press b). In addition, we have been able to use a bearing judgment task and variety seeding manipulations to obtain converging evidence for these claims (Friedman, Brown, and McGaffey 1999).

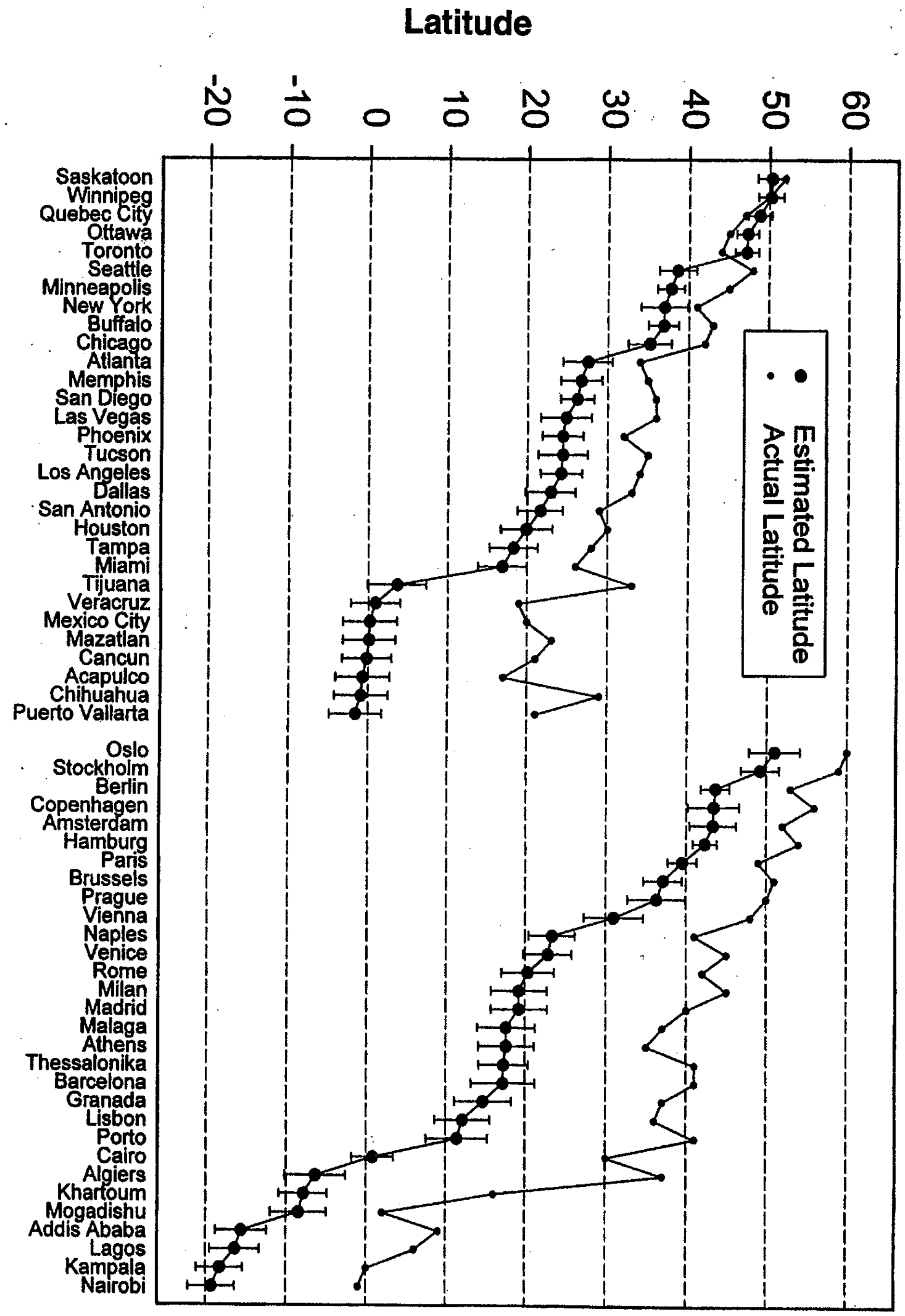

Figure 2. Subjective latitude location profile for New World cities and Old World cities. Data are ordered by the estimated latitudes of the test cities.

SEEDING LOCATION JUDGEMENTS

We have demonstrated how a location estimation task can be used to create location profiles, and how these profiles can be use to investigate subjective geography. The current research program also has demonstrated that exposure to seed facts can improve estimation accuracy, sometimes quite dramatically, and that the seeding method can also be used to probe the organization of geographical knowledge.

In this section, we present some data from a longitude estimation experiment to illustrate both points (for a complete description, see Friedman & Brown 1999 in press a, Experiment 3). In this experiment, 60 participants were first informed that the longitude scale begins at 0° in Greenwich, England, that it increases to 180° west, and that the dateline runs through the western Aleutians. Next, they were presented with the names of 13 North American cities and 15 South American cities, and were required to provide a longitude estimate for each. Following this initial estimation task, participants learned the actual longitude of one South American city, either Lima, Peru (77° west) or Rio de Janeiro, Brazil (43° west). Then, after learning one of these seed facts, participants provided a second set of longitude estimates for all test cities.

Figures 3 and 4 are the objective location profiles derived from these longitude estimates. In these figures, longitude is listed on the abscissa and the test city names along the ordinate; North American cities appear in the top panel and South American cities in the bottom panel. Within each continent, cities are ordered according to their actual longitudes, with the most westerly city appearing at the top of the panel and most easterly city appearing at the bottom. As in the prior figures, the small markers indicate a city's actual longitude and the large markers its mean estimated longitude.

The pre-seeding estimates, averaged over the 60 subjects (and excluding the seed cities) are the focus of Figure 3. As this figure suggests, these participants tended to locate all test cities to the west of their actual locations, though South American cities produced more biased estimates (mean signed error = 40°) than the North American cities (mean signed error = 23°). It is also clear from this figure that participants had a better sense of the relative locations of the North

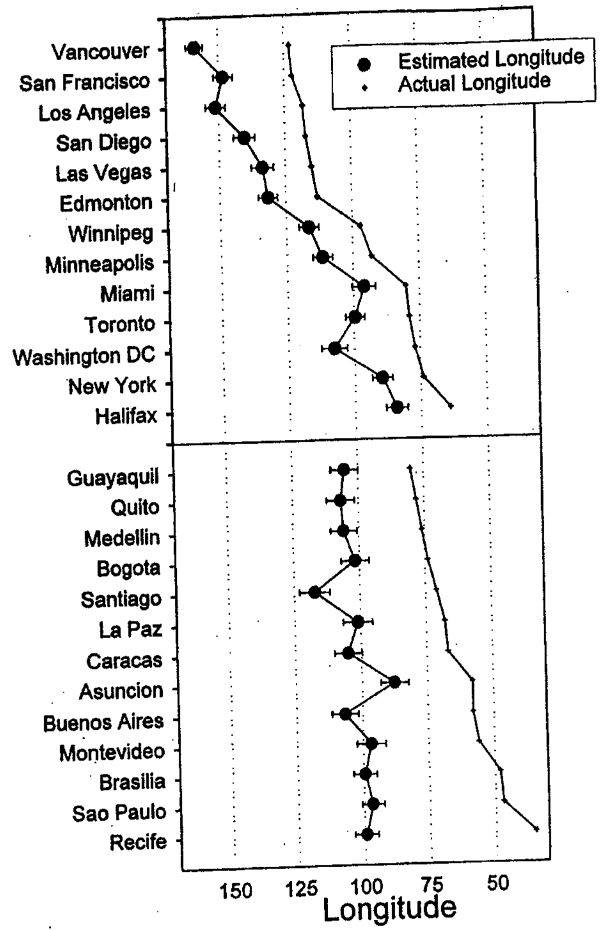

Figure 3. Objective longitude profile for North American cities and South American cities. Data are ordered by the actual longitude of the test cities.

American cities than the South American cities; the mean correlation between estimated and actual longitude was .85 for the former and .25 for the latter. Finally, it is interesting to note that that South American cities line up with the cities on the eastern seaboard of the United States. This suggests that at least these subjects mistakenly believed that South America lies due south of the eastern United States, though actually there is little horizontal overlap between the two continents (cf. Tversky, 1981).

In Figure 4 the post-seeding estimates from both the Lima group and the Rio group are presented along with the pre-seeding estimates and the actual longitudes. It is clear from this figure that even a single seed fact can have a large effect on subsequent estimates, and that

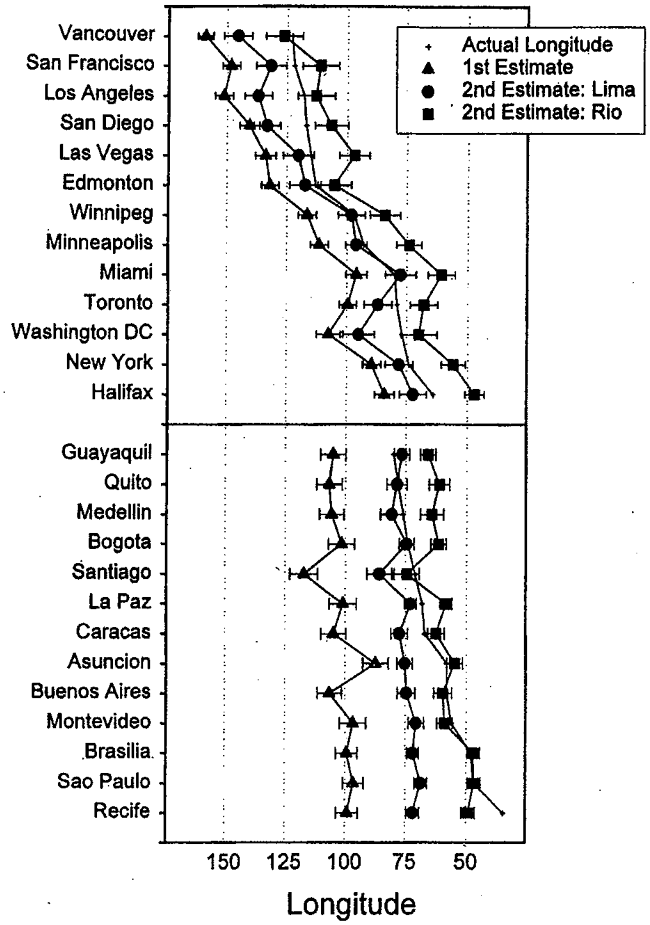

Figure 4. Objective longitude profile for North American cities and South American cities presenting actual longitudes, mean pre-seeding estimates, mean post-seeding estimates obtained from the Lima group and the Rio group. Data are ordered by the actual longitude of the test cities.

these effects can propagate from the seeded region (i.e. South America) to an adjacent, unseeded region (i.e., North America). In this case, the post-seeding estimates for both the South American cities and the North American cities tended to be significantly less biased (as measured by signed error) and more accurate (as measured by absolute error) then pre-seeding estimates (see Table 1).

As noted above, the initial longitude estimates suggested that this set of participants behaved as if they believed that South America were located due south of the east coast of North America. The data presented in Figure 4 indicate that this belief, in conjunction with the

	Pre-Seeding Absolute Error (SE)	Post-Seeding Absolute Error (SE)
Lima Seed Fact		
North America[c*]	33.68° (2.18)	28.21°(2.26)
South America[a]	49.64° (3.63)	19.07°(1.54)
Rio Seed Fact		
North America[n.s.]	31.20°(2.17)	31.78°(2.20)
South America[a]	48.84°(4.00)	18.60°(1.73)
	Pre-Seeding Signed Error (SE)	**Post-Seeding Signed Error (SE)**
Lima Seed Fact		
North America[b]	24.88°(3.99)	9.00°(4.42)
South America[a]	38.18°(6.19)	12.57°(2.33)
Rio Seed Fact		
North America[a]	20.85°(3.83)	-11.81°(5.90)
South America[a]	40.57°(5.72)	-4.00°(3.13)

Note *: All significance levels derived from paired t-tests (df = 29).
Note a: $p < .001$
Note b: $p < .01$
Note c: $p < .05$

Table 1. Mean pre-seeding and post-seeding absolute error and signed error as a function of region and seed fact.

South American seed fact, played an important role in determining the post-seeding estimates for the North American cities. More concretely, it appears that exposure to the South American seed fact compelled participants to recognize that South America was further east than they had assumed, and provided specific numerical information that was used to correct mistaken assumptions about South America's location. Then, in order to maintain an aligned representation of the Americas, participants had to shift the Atlantic coast of North America to east. As these claims imply, the set of post-seeding estimates was aligned in the much the same way as the pre-seeding estimates, with the post-seeding estimates provided by the Rio group falling furthest to the east and the pre-seeding estimates falling furthest to the west.

In addition to the present study, we have conducted a number of experiments designed to determine whether seeding effects can be obtained with longitudes as well as latitudes, and to ascertain when and how seeding effects propagate from a seeded region to physically adjacent and/or conceptually related ones. An exhaustive review of this work is beyond the scope of this article. Nonetheless, we should note that these studies have demonstrated that seed facts can improve the accuracy of latitude judgements, that seeding effects propagate to unseeded regions only when changes are required to maintain a coherent set of geographical beliefs, and that seeding per se does not guarantee improved performance – depending on the particular seed facts, post-seeding estimates can be more accurate than, less accurate than, or identical to pre-seeding estimates (Friedman & Brown, 1999a, 1999b).

CONCLUSION

In this article, we have presented some highlights from our on-going study of subjective geography. The work completed to date has demonstrated that it is possible to use absolute location judgements, location profiles, and seeding effects to investigate the nature and accuracy of peoples' geographical knowledge. This work has also established that exposure to a small number of carefully chosen seed facts can produce a marked improvement in estimation accuracy (Friedman & Brown, 1999 in press a, in press b). Admittedly, the selection of a good set of seed facts is, at present, as much an art as a science. Moreover, long-term effects of the geographical seeding have not been assessed (but see Brown & Siegler, 1996), and there are as yet no demonstrations that teaching seed facts facilitates school learning. Clearly, additional research will be required to establish guidelines that will take the guesswork out of creating an optimal set of seed facts, to demonstrate that seeding effects are long lived, and to determine whether these effects can be produced in children as well as adults. Although much work remains, we believe that these issues are both interesting and tractable. Thus, we are optimistic that the seeding approach may one day play a useful role in the geography classroom.

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