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Author/s:

Bohnemeyer, J;Danziger, E;Lum, J;Alshehri, A;Benedicto, E;Blythe, J;Cerqueglini, L;Donelson, K;Eggleston, A;Gaby, A;Lin, YT;Moore, R;Nikitina, T;Stoakes, H;Yulbarangyang Balna, M

Title:

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Date:

2022-01-01

Citation:

Bohnemeyer, J., Danziger, E., Lum, J., Alshehri, A., Benedicto, E., Blythe, J., Cerqueglini, L., Donelson, K., Eggleston, A., Gaby, A., Lin, Y. T., Moore, R., Nikitina, T., Stoakes, H. & Yulbarangyang Balna, M. (2022). Reference frames in language and cognition: cross-population mismatches. *Linguistics Vanguard*, 8 (S1), pp.175-189. <https://doi.org/10.1515/lingvan-2021-0091>.

Persistent Link:

<https://hdl.handle.net/11343/297491>

Reference frames in language and cognition: Cross-population mismatches

1. Introduction - In recent decades, numerous studies have found evidence that a speech community's referential practices in discourse are predictive of its members' behavior in nonverbal tasks, especially in recall and recognition memory studies (Bohnemeyer et al 2014, 2015; Haun et al 2011; Pederson et al 1998; Levinson 2003; Mishra et al 2003; Wassmann & Dasen 1998; inter alia). This research has focused on so-called **spatial frames of reference**, cognitive axis systems used to project directions and regions in space. Figure 1 gives an overview of frame types among which previous typological research has found it useful to distinguish.

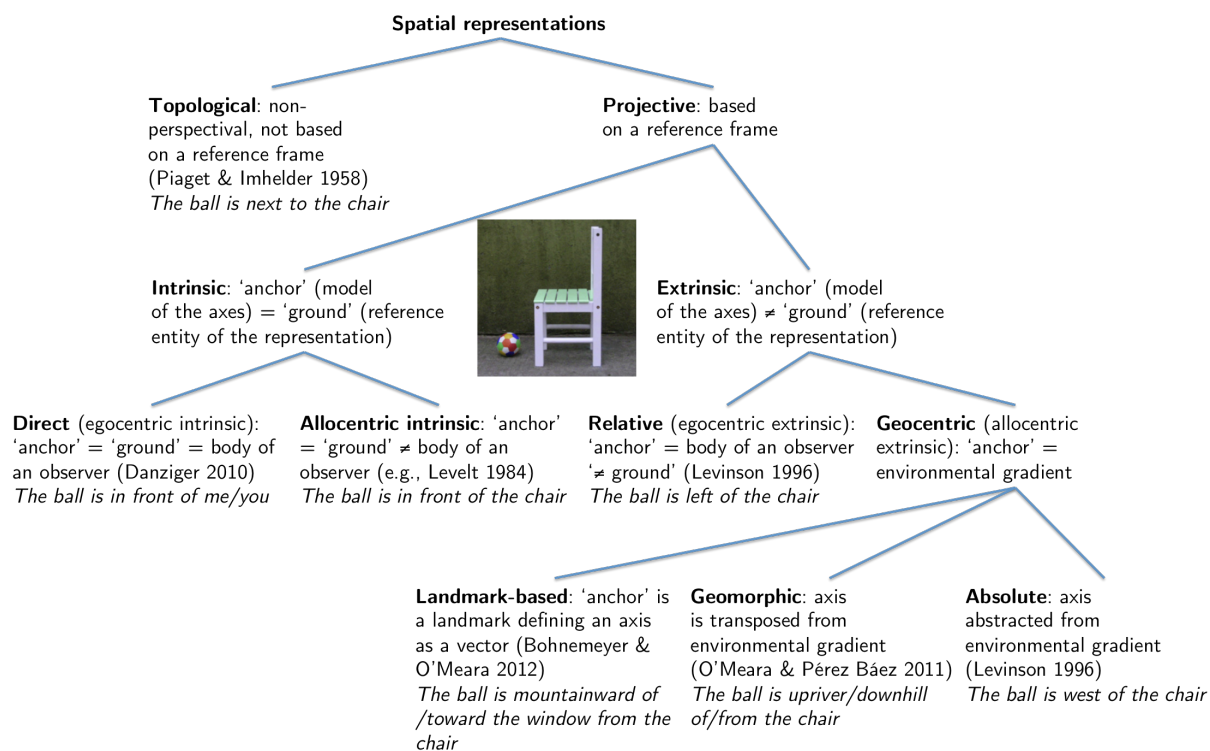


Figure 1. A fine-grained classification of spatial representations in terms of the underlying reference frame types (cf. O'Meara & Pérez Báez 2011; Bohnemeyer et al. 2015)

In this article, we discuss a series of exceptions to the much-discussed alignment between verbal and nonverbal frame use preferences. Whereas studies showing alignment between verbal and nonverbal preferences have dealt with language varieties where either relative or geocentric frame use is dominant in discourse, in the communities of the present study, the linguistic pattern is different. In these communities, when discourses refer to small-scale space, either intrinsic frame use is dominant (very little extrinsic frame usage), or both relative and geocentric frames are used frequently in addition to intrinsic frames. In none of our study populations does an extrinsic frame type account for the largest percentage of uses in our linguistic data. In such

cases, there is no clear prediction for either relative or geocentric frame use in solving cognitive tasks (Danziger 2001). While these cases have been pointed out individually, they have not been discussed in conjunction with one another. Consequently, the striking commonality across the findings of these studies has gone unnoticed: in nine of eleven documented cases across Asia, Central and North America, Europe, and Oceania which lack an overall community-level linguistic bias toward either geocentric or relative frame use in discourse, geocentric nonverbal coding is more common than relative nonverbal coding in tasks that involve stationary stimulus configurations. In the remaining two populations, there is evidence suggesting only limited extrinsic coding in both verbal and nonverbal tasks. We discuss to what extent this distribution can be accounted for by the hypothesis of a weak innate geocentrism bias in primates which is subject to ‘cultural override’ in individual human populations (Haun et al. 2006). While this hypothesis offers a potential explanation for the prevalence of geocentric strategies in nonverbal cognition in most of our study populations, the absence of a parallel linguistic preference for geocentrism in these groups points to the desideratum of a model of the cultural transmission of cognitive practices. Moreover, the lack of evidence of robust geocentrism in both language and cognition in two of the groups in our sample calls into question to what extent any extrinsic reference frame use in humans can exist independently of cultural transmission.

2. Methods - This article presents a metastudy comparing findings of eleven individual studies carried out with distinct though overlapping instruments. In this section, we briefly introduce those instruments, discussing nonverbal cognition tasks before discourse tasks.

2.1. Recall/recognition tasks - The instruments which we summarize here were used in the studies of cultural and individual variation in reference frame use in nonverbal cognition. All rely on a combination of two elements: participants first commit a stimulus configuration to memory, and then, after having undergone rotation (most commonly, by 180 degrees), they identify it from among a range of options or they reconstruct it from materials provided. The rationale is that if the participants memorize the configuration geocentrically, with respect to the environment, then under rotation, the configuration’s orientation will remain constant relative to the environment, but change relative to the participants’ body. In contrast, if participants memorize the configuration egocentrically, with respect to their own body, then under rotation, the configuration’s orientation will remain invariant with respect to their body, but change in orientation with respect to the environment. Table 1 summarizes the task protocols used in the studies we compare here. Note that while we present all the available non-verbal task data from our 11 populations in Section 3 and in the supplemental materials, we limit our statistical tests in Section 4 to orientation data from the *Animals-in-a-row* and *New Animals* tasks for maximal comparability across the sample.

Table 1. *Recall/recognition tasks used in the studies reported on*

Task	Citations	Stimuli	Rotation	N test trials	Task
Animals-in-a-row	Levinson & Schmitt (1993); Levinson (2003: 154-159); Pederson et al. (1998)	Array of 3 toy animals (participants asked to memorize correct 3 out of a set of 4)	180 degrees (b/w Table 1 and Table 2)	5 (chosen by the researcher from out of a set of options)	Recall and reconstruction
New animals	Pérez Báez (2008); Bohmeyer et al. (2015)			6 (fixed)	
Chips recognition	Levinson et al. (1993); Levinson (2003:159-160)	2 sets of 5 identical playing cards showing two circles or squares of distinct colors		4 or 8 ¹	Recognition (4 test cards are rotated at 90-degree intervals from one another)
Steve's mazes	Levinson (1993)	Simple schematic maps (1/trial) with incomplete paths drawn on them; three test cards per map that show potential completions: 1 geocentric, 1 relative, 1 distractor		5	Inference and recognition

The instructions given to the participants are deliberately vague so as to avoid any bias toward a particular strategy: e.g., in the case of *Animals-in-a-row* and *New Animals*, ‘Make it again!’. Li & Gleitman (2002) argue that this vagueness invites fallback on subvocal verbal encoding; cf. Levinson et al. (2002) for a response. However, Li & Gleitman’s alternative design type targets ability rather than preference, fundamentally altering the research question.

2.2. Referential communication tasks - All studies we compare here relied primarily on the same type of instrument for profiling populations in terms of their preferred strategies for spatial reference in discourse: so-called ‘referential communication tasks’, in which dyads of participants verbally coordinate on identical copies of nonverbal stimuli without sharing a visual field (Clark & Wilkes-Gibbs 1986). Typically, a screen, placed between the participants, blocks visual access to the stimulus configurations. It is generally acknowledged that this type of task is of low ecological validity. In particular, it suppresses discourse that relies on deictic

¹ The relevant instructions in Levinson et al. (1993: 111): “Number of trials: 4 per axis (Do left/right, front/back optional -- do the same for all subjects).”

demonstration (Danziger 2010). To compensate for this weakness, researchers rely on spontaneous observation and tasks such as local history narratives and procedural descriptions. The rationale for referential communication designs is that they force participants to be as explicit in their reference acts as is required to resolve whatever ambiguities are built into the stimulus configurations. Table 2 compares the referential communication tasks in the studies we draw on below.

Table 2. *Referential communication tasks used in the studies reported on*

Task	Citations	Stimuli	N test trials	Task
Men and tree (original version)	Levinson et al. (1992); Pederson et al. (1998)	2 x 4 x 12 photographs featuring dyadic configurations of toys (men, trees, balls) ²	4 (each involving one set of 12 photos)	Participants instruct one another to match the photos
Ball and chair	Bohnmeyer & Pérez Báez (2008: 29-32); Bohnmeyer et al. (2015)	2 x 4 x 12 photographs featuring dyadic configurations of a ball and a chair		
Man and Tree (Senghas version)	Senghas (2000); Terrill & Burenhult (2008)	2 x 16 photographs featuring dyadic configurations of a toy man and toy tree	1 or 2 (each involving a set of 16 photos)	Participants instruct one another to match the photos
Talking animals	Bohnmeyer (2012)	4 identical sets of toy animals; stimulus configurations built by researcher for 1 participant according to schematic drawings	4 (each with a unique configuration)	Participants instruct one another to rebuild the stimulus configuration

² Levinson et al. (1992: 7) comment as follows: “Note that ‘Men and Tree’ is a notation for the full set of 4 photo-photo matching games which explore these questions. There is one training game in the set (game 1) and there are distractor photos -- intended to make the game more fun to play -- within games 2, 3 and 4 of the set. This means that all photos in the ‘Men and Tree’ set do not necessarily depict a man or a tree. It also means that there is one entire game (game 1) of the ‘Men and Tree’ set in which not a single man or a single tree appears.”

3. The individual studies - Table 3 provides basic information about the eleven study populations.

Table 3. *Language populations, field sites, and researchers of the studies under comparison*

Language	ISO 639-3	Family	Genus or proximal major sub-branch	Population	Fieldsite	Studies
Aṣ-Šāniṣ Arabic	ajp	Afro-Asiatic	Arabic	20,000 (estimate Cerqueglini)	Lakiya (Negev, Israel)	Cerqueglini (2015, 2019, this issue); unpublished work by Cerqueglini
Hijazi Arabic	acw	Afro-Asiatic	Arabic	14.5 million (2011)	Asir (Saudi Arabia)	Alshehri et al. (2018); unpublished work by Alshehri
Bashkir	bak	Turkic	Kipchak	1.2 million (2010)	Bashkortostan (Russia)	Nikitina (2018)
Dhivehi	div	Indo-European	Indo-Aryan	335,000 - 410,000 (Gnanadesikan 2017)	Laamu Atoll, Maldives	Lum (2018); Palmer et al. (2017)
L2 Mandarin (L1 Min Nan)	cmn	Sino-Tibetan	Sinitic	13.8 million (2010 Population and Housing Census)	Keelung, Taichung, Tainan, Taipei (Taiwan)	Lin (2017, this issue)
Mopan	mop	Mayan	Yucatecan	9,000-12,000 (2008; Hofling 2011)	San Antonio, Toledo district, Belize	Danziger (1996, 1999, 2001, 2011)
Murrinhpatha	mwf	Southern Daly	N/A	3,000 (Mansfield 2019)	Wadeye (Australia)	Blythe et al. (2016); Gaby et al. (2016)
Rural Mexican	spa	Indo-European	Romance	≥ 20 million ³	San Miguel Balderas,	Bohnemeyer et al. (2014,

³ 2020 Mexican census data shows a population of 126,014,024. 6.2% were identified as speakers of indigenous languages aged 3 or older (<https://www.inegi.org.mx/temas/lengua/>, last accessed 06/16/2021). 80.7% of the population lived in urban communities (www.cia.gov).

Spanish					Mexico	2015); Eggleston (2012)
Rural Nicaraguan Spanish				2.4 million ⁴	Rosita, Nicaragua	
Sumu- Mayangna	yan	Misumalpan	N/A	≈10,000 (Benedicto et al. 2016)	Las Minas area, RAAN, Nicaragua	Eggleston et al. (2011); Eggleston (2012)
Yucatec	yua	Mayan	Yucatecan	774,755 (2020) ⁵	Rural communi- ties in central Quintana Roo, Mexico	Bohnemeyer & Stolz (2006); Bohnemeyer (2011); Le Guen (2011); Bohnemeyer et al. (2014, 2015)

The bar charts below summarize the quantitative results of the studies on reference frame use in discourse and nonverbal cognition by population. Unless otherwise noted: (i) the unit of observation is propositions for the linguistic data (where a single description of a stimulus item may comprise multiple propositions, each potentially relying on a distinct frame) and trials for the recall memory data; (ii) data from array reconstruction tasks was coded for the orientation of the animals. More detailed information can be found in the supplemental materials.

Based on these numbers, one can safely estimate the number of rural Spanish speakers to lie upwards of 20 million.

⁴ For Nicaragua, at a population of 6,200,000 in 2020, with 95.3% Spanish speakers in 2005 and 59% urban population in 2020 (all www.cia.gov), the comparable estimate yields upward of 2.4 million rural Spanish speakers.

⁵ <https://www.inegi.org.mx/temas/lengua/>, last consulted 06/16/2021.

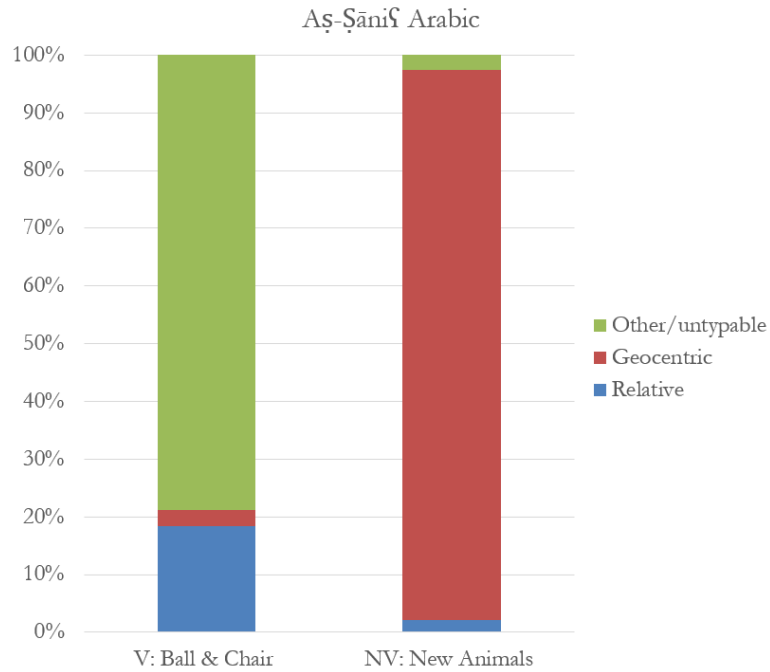


Figure 2. *Quantitative results of the aṣ-Ṣāniʿ Arabic studies (V: verbal studies; NV: nonverbal studies)*

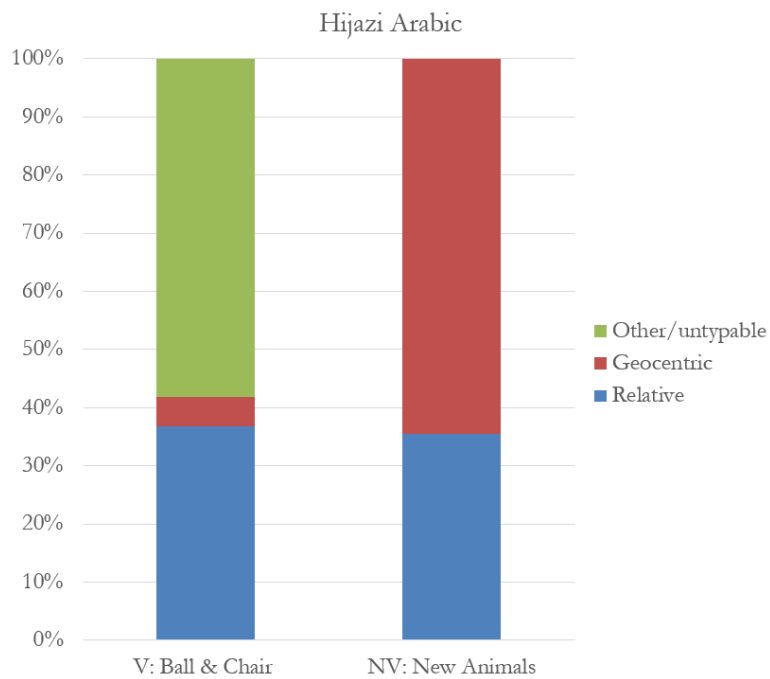


Figure 3. *Quantitative results of the Hijazi Arabic studies (V: verbal studies; NV: nonverbal studies)*

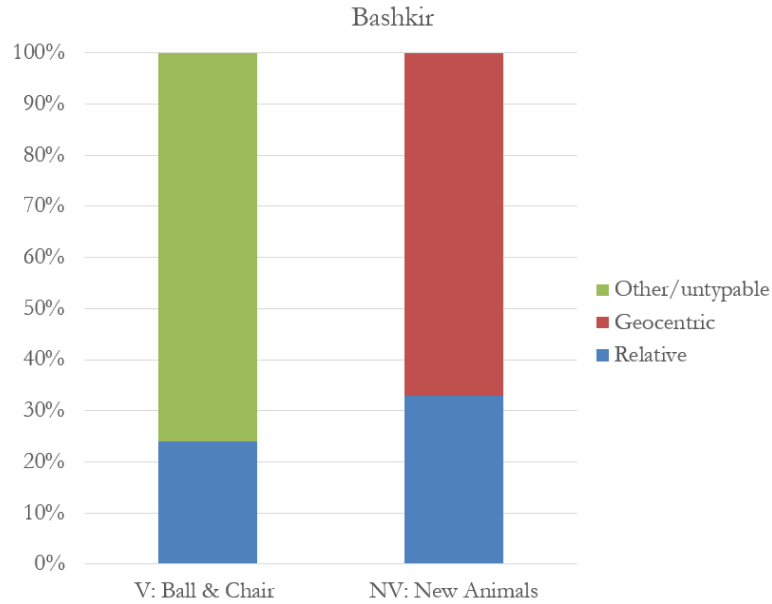


Figure 4. Quantitative results of the Bashkir studies (V: verbal studies; NV: nonverbal studies)

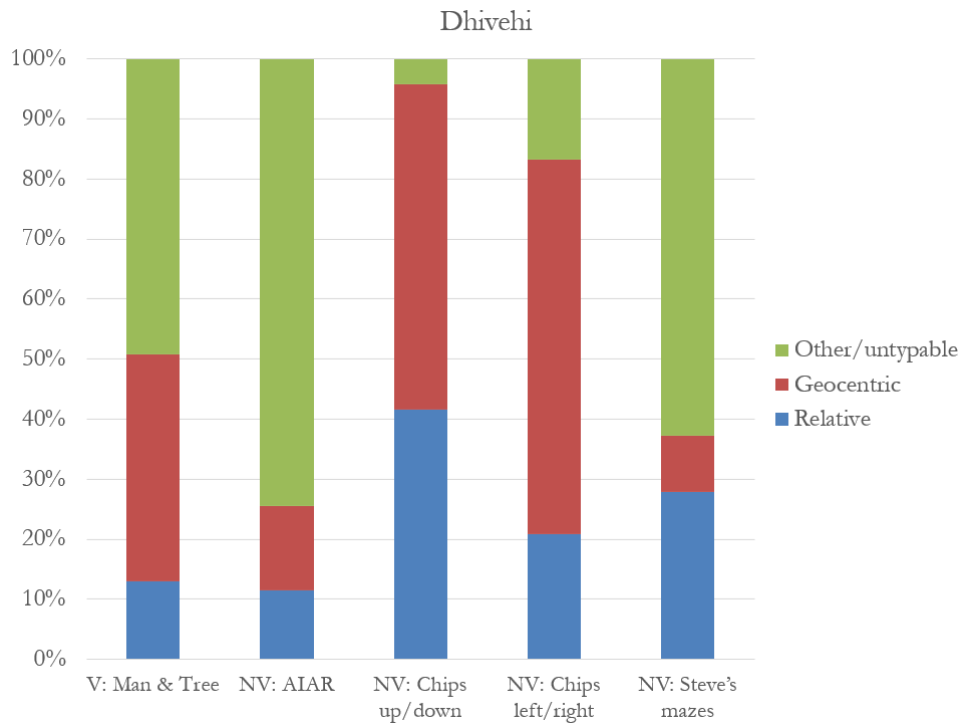


Figure 5. Quantitative results of the Dhivehi studies (V: verbal studies; NV: nonverbal studies; unit of observation for NV data: participants; AIAR data reflects both orientation and order of animals)

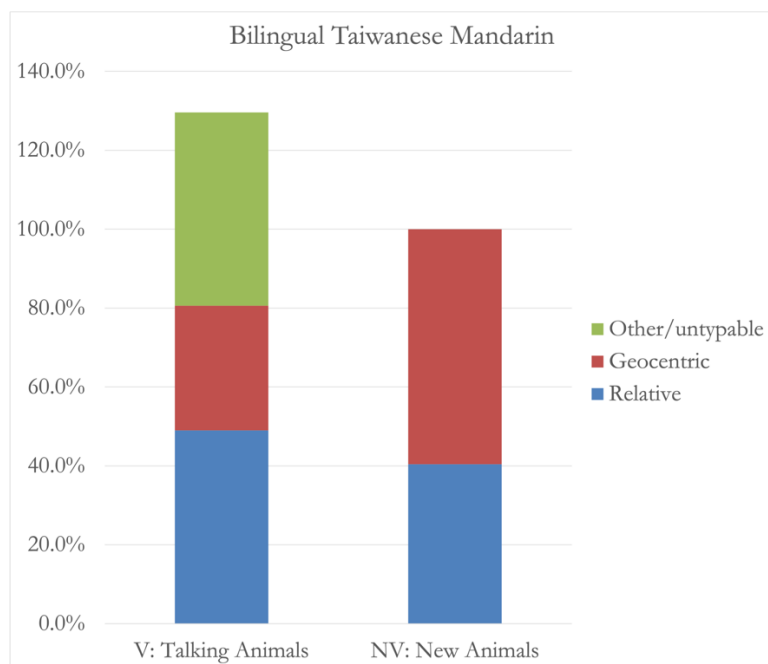


Figure 6. Quantitative results of the Bilingual L2 Taiwanese Mandarin studies (V: verbal studies; NV: nonverbal studies; unit of observation for V data: participants \times trials \times items; reported percentages of verbal responses do not sum to 100 because observations may instantiate multiple frame types simultaneously)

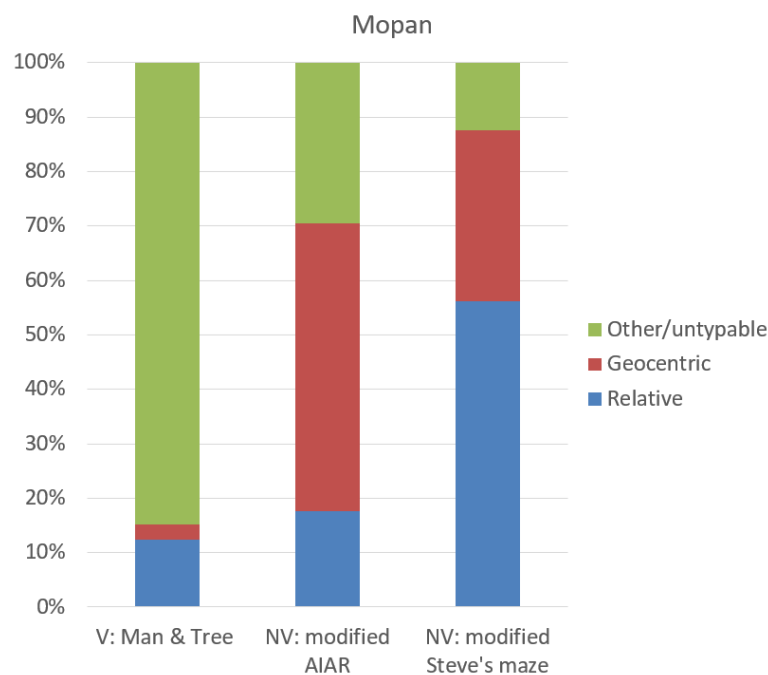


Figure 7. Quantitative results of the Mopan studies (V: verbal studies; NV: nonverbal studies; unit of observation for NV data: participants)⁶

⁶ After several attempts with the standard protocol yielded only untypable results, both the Animals-in-a-row (AIAR) and Steve's Maze task instructions were modified for Mopan speakers. Mopan participants in AIAR were told to pay attention to the animals and 'where they

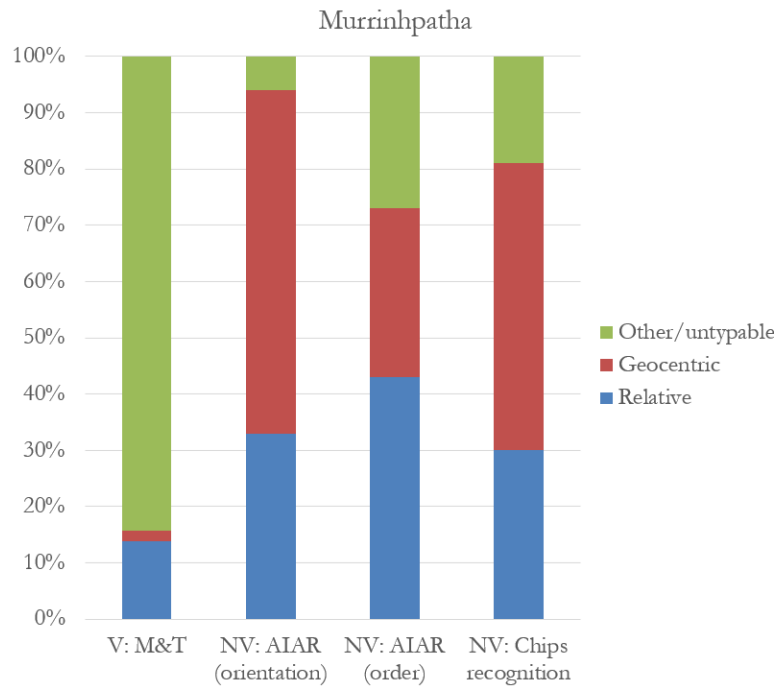


Figure 8. *Quantitative results of the Murrinhpatha studies (V: verbal studies; NV: nonverbal studies)*

are looking'. Mopan participants in the Steve's maze task were told to draw the path that they would follow onto a laminated version of the maze on the stimulus table, before being rotated to consider options on the recognition table. Reported results are from these modified versions of the tasks. See Danziger (2001) for details.

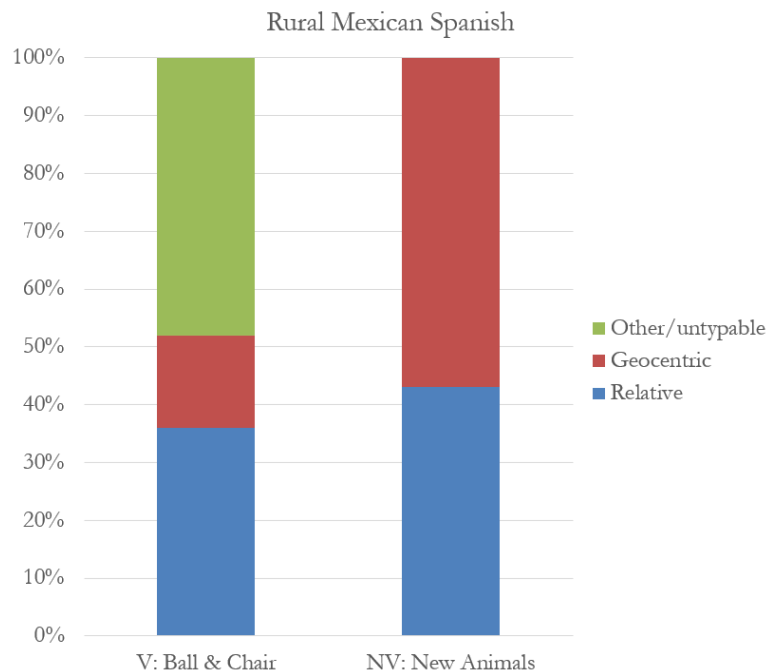


Figure 9. *Quantitative results of the rural Mexican Spanish studies (V: verbal studies; NV: nonverbal studies)*

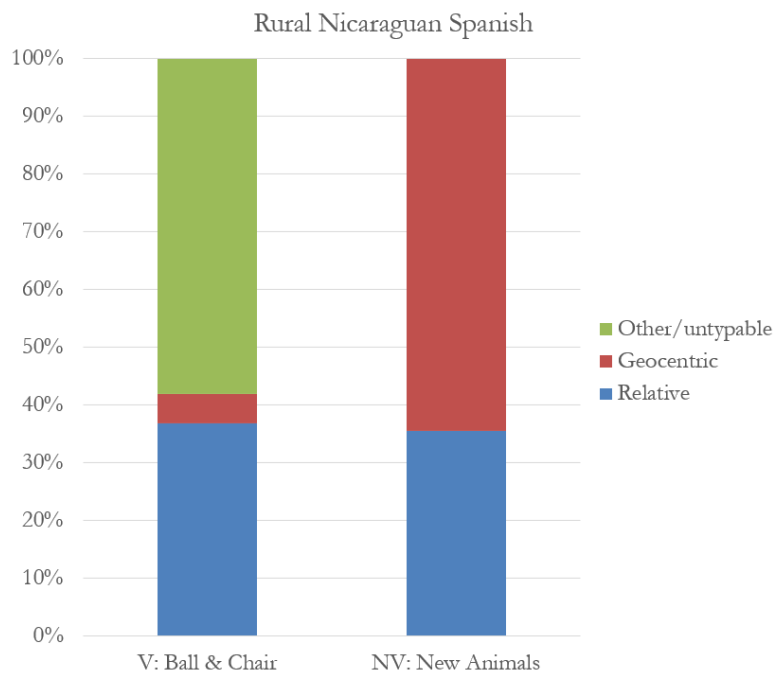


Figure 10. *Quantitative results of the rural Nicaraguan Spanish studies (V: verbal studies; NV: nonverbal studies)*

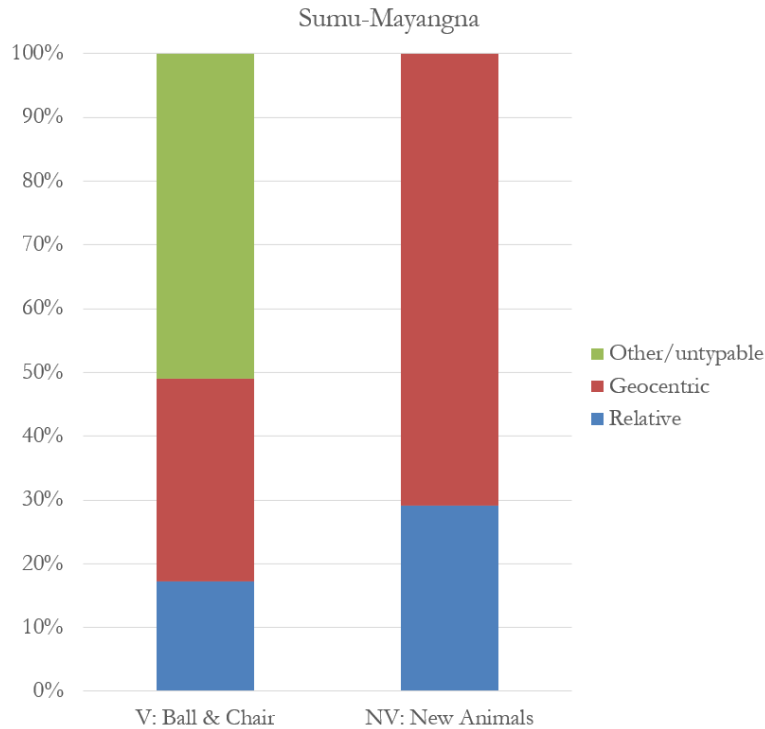


Figure 11. Quantitative results of the Sumu-Mayangna studies (*V*: verbal studies; *NV*: nonverbal studies)

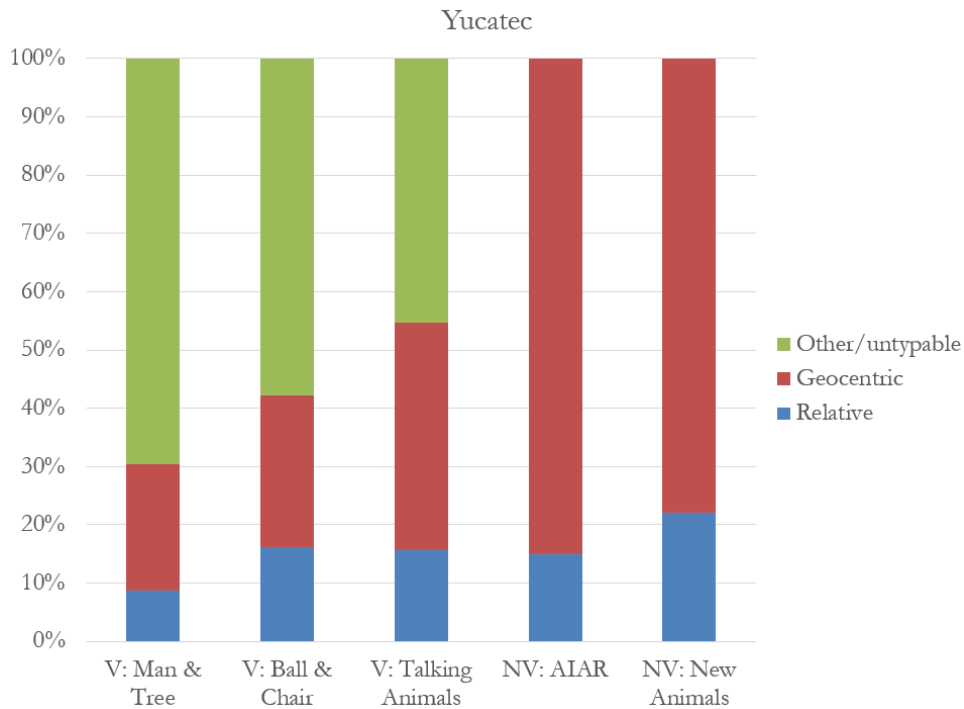


Figure 12. Quantitative results of the Yucatec studies (*V*: verbal studies; *NV*: nonverbal studies; *AIAR* data reflects both orientation and order of animals)

Before we proceed to discuss these findings, a few comments are in order. Frequency counts are represented in terms of percentages with varying denominators depending on how the individual researchers coded the data. The denominators are made explicit in the supplemental materials. In some instances, verbal frequencies are based on units that can instantiate multiple frame types simultaneously (e.g., descriptions of a particular item), so that sums of percentages may exceed 100. Examples illustrating these generalizations can be found in the supplemental materials, along with examples of preferred strategies and ethnographic background on all 11 populations.

4. Summary of Findings

Any statistical analysis of the data presented here is subject to all the usual caveats that apply to statistical tests of patterns emerging from meta-studies. In particular, the data was collected using similar, but not in all cases identical tools. It was also originally analyzed and presented in somewhat divergent ways, although we have done our best to correct for such differences here.

In view of these limitations, a maximally coarse-grained analysis that compares basic outcomes across populations seems the only feasible option. Such a test, however, presupposes a decision on a question that to our knowledge has no off-the-shelf answers: the question whether the data from the two Arabic varieties in our sample can be treated as distinct observations or should be grouped as one, and analogously for the data from the two Spanish populations. Both views are defensible. What argues in favor of grouping the varieties by language is that the speakers of the two dialects of each language behaved remarkably similarly to one another. In addition, for the purposes of statistical significance testing, grouping is the most conservative choice, as the odds of finding statistical significance increase with sample size.

Our sample is defined in terms of two criteria: (i) availability of quantitative population data on frame use in both discourse and non-verbal cognition, and (ii) absence of clear linguistic extrinsic bias. In none of the populations does either of the extrinsic frame types account for 50% or more of the linguistic observations, and in none of them does either of the extrinsic frame types represent the largest share of the linguistic observations.

We performed a multinomial test over the population outcomes. We consider there to be three possible outcomes for any population: a relative bias, a geocentric bias, or no extrinsic bias, with a one-in-three chance of each of these outcomes occurring randomly. We classify a population as showing a relative bias if under the original experimental procedure at least 50% of responses to individual trials were relative and/or at least 50% of participants performed relatively overall across their set of trials, depending on how the data were coded by the author(s) of the original study. We classify a population as showing a geocentric bias in an analogous way. If a 50% threshold for either geocentric or relative responses was not reached (under the original experimental procedure), we classify the population as showing no extrinsic bias.

4.1 Across all nonverbal tasks: dispreference for relative solutions – In nonverbal tasks, we found an overall dispreference for relative solutions among the populations in our study, which is

statistically highly significant ($p < 0.002$). We found three partial exceptions to the general dispreference for relative solutions:

- (1) Mopan speakers initially produced mostly ‘untypable’ (i.e., neither relative nor geocentric) responses in pilot implementations of two cognitive tasks. In response, Danziger chose to modify the task protocols (Danziger 2011). In the *Animals in a row* task, Danziger instructed the participants to consider ‘where the animals are looking’. Most participants responded with allocentric choices. In the *Steve’s maze* task, Danziger instructed participants to draw the inferred path onto the stimulus map prior to responding. Most participants in this case offered egocentric responses. Danziger (2001: 213) concludes: “no monolithic Mopan preference toward Absolute [i.e., geocentric] or Relative nonlinguistic strategies is identifiable.”
- (2) Dhivehi speakers produced mostly ‘untypable’ responses in two nonverbal tasks. In *Animals in a row*, most participants produced a ‘monodirectional’ pattern consistent with intrinsic coding, like the Mopan participants prior to the change in experimental procedure. In *Steve’s mazes*, most participants selected a mixture of geocentric and relative⁷ completion cards; however, of those that had a clear preference, there were more egocentric coders than geocentric coders. Note, however, that the Dhivehi participants did not display a preference for egocentric solutions in other non-verbal tasks (*Animals in a row* and *Chips Recognition*).
- (3) In *Animals in a row*, Murrinhpatha speakers ordered the animals in a relative way more frequently than in a geocentric way (e.g., the leftmost animal in the response corresponded with the leftmost animal of the stimulus array). However, they mainly oriented the animals in a geocentric way (e.g., if animals were facing north in the stimulus array, they were arranged to face north in the response array). Although this finding might be partially explainable in terms of the different affordances of orientation vs. location contexts (see the supplemental materials for further discussion), we observe that in *Chips recognition*, a task involving coding of location only, Murrinhpatha speakers performed predominantly geocentrically. We also observe that Dhivehi speakers, the only other population in our sample for which we have *Animals* order data, do not show a bias towards relative order (Lum 2018: 300-301).⁸

⁷ Or, more broadly, egocentric, as for this task, the use of frames that treat the participants’ own body as a landmark (as in ‘toward/away from me’) seems relevant. Such frames are egocentric and extrinsic, but not relative, since they don’t involve transposition of axes, representing a problem for the typology shown in Figure 1.

⁸ In most *Animals-in-a-row* studies, including most of those in our sample, only orientation data is recorded, not order data, in line with the purpose of the original experiment design (Levinson & Schmitt 1993).

We note that two of the three exceptions involve a path completion (maze) task, the only maze task data in our sample. A possible explanation for nonverbal egocentric encoding in maze tasks is that participants assume the perspective of the moving figure in the maze, thereby representing the path as a sequence of turns, each of which is either a left turn or a right turn (cf. Dasen & Mishra 2010: 132-134, Taylor & Tversky 1996). Note that this particular egocentric strategy could be understood as an intrinsic one, therefore not necessarily involving the relative frame.

4.2. Preference for geocentric solution to the array reconstruction tasks – In general, there was a significant preference across our populations for geocentric solutions to nonverbal tasks ($p < 0.002$). But a number of participants produced ‘untypable’ responses, which may reflect the fact that the nonverbal tasks were designed to distinguish between extrinsic frame encodings (geocentric versus relative), rather than to provide a clear intrinsic-frame response (Danziger 2011, Lum 2018). The one case for which strictly comparable data is not available is Mopan, where only a modified version of AIAR was implemented (experimenter instructed consultants to consider “where the animals are looking” on Table 2). The exception is an important one, since the modification was introduced precisely because in initial trials, it proved impossible to induce Mopan to make strict choices between relative and geocentric solutions (Danziger 2001). Under these circumstances, we categorize Mopan as a community in which there was neither a relative nor a geocentric preference on the standard task.

4.3. Discussion – To our knowledge, our sample includes every single population-specific or cross-population study that has ever been conducted in which both verbal and nonverbal reference frame preferences in the small-scale domain were tested, and in which either an intrinsic bias or no bias was found on the linguistic side.⁹ We can thus say with confidence that the general absence of evidence of a relative bias in all 11 populations represents an extremely strong finding. The evidence for cognitive geocentrism in nine of the eleven populations also represents a statistically improbable outcome. What can account for this significant distribution?

The prevalence of geocentrism in the AIAR/ New Animals memory tasks in nine of the eleven sample populations, along with the absence of a preference for relative solutions in any of the sample languages, initially suggests support for the proposal of an innate weak geocentrism bias that may be “overridden” by a culturally transmitted preference for relative frames in the small-scale domain. This proposal resulted from a study (Haun et al. (2006) of spatial cognition in members of all five great ape species and in preverbal human infants in Germany. Haun et al. find evidence of geocentric rather than relative encoding in all six study populations. They interpret this as evidence of a soft innate geocentrism bias that is overridden by cultural transmission of relative encoding in some modern human populations. Haun et al. (2006) do not discuss intrinsic frames.

⁹ In the supplemental materials, we briefly mention some studies that did not entirely meet the criteria for inclusion, but should be considered for future research.

Additional evidence in support of the hypothesis comes from observations (Nardini et al. 2006, Shusterman and Li 2018), of a preference for environmental over body-based cues in three-to-four-year-old English-learning children. Bohnemeyer et al. (2014) discuss the evidence from the two Spanish-speaking populations presented here as additional support for the hypothesis.

However, attempting to explain our data with reference to a hypothetical biological preference for geocentric cues in spatial cognition immediately runs into two problems. Firstly: how is the proposed geocentrism in nonverbal tasks to be reconciled with the absence of a similar linguistic bias in all our study populations (and in fact the near-absence of geocentric frame use in discourse in five of them)? On the innate geocentrism hypothesis, the linguistically relative populations are cognitively relative due to cultural override. It is not obvious how such cultural override has affected our populations, or what kind of cultural override has affected them. If language is a mechanism of cultural override, then has there been no cultural override in our populations, since most of them appear to be cognitively geocentric on the evidence presented here? But if there has been no cultural override, then why are our populations not linguistically geocentric?

And secondly, how can the proposed geocentrism bias be reconciled with the absence of robust evidence of geocentrism (or indeed any extrinsic preference) in the Dhivehi and Mopan participants when solving nonverbal tasks? In discussion of the Mopan results in particular, Danziger (2001) concludes that there is no evidence for a preference of geocentric or of relative coding in nonverbal tasks, and proposes that both of these extrinsic frame types must be culturally acquired across all human populations and languages.

This article is not the place to attempt a resolution of these problems. However, any such resolution will have to answer a number of further questions, to be briefly considered in the remainder of this section.

First, what aspects of geocentrism, if any, could plausibly be innate? There are many different subtypes of geocentric frames, all of which are clearly culture-specific and learned (e.g., de León 1994; Wassman & Dasen 1998; Brown & Levinson 2000; Cablitz 2002; Levinson 2003; Mishra et al. 2003; Polian & Bohnemeyer 2011; Palmer et al. 2017; Schlossberg 2018; *inter alia*). It seems likely, then, that it is not any fully-formed geocentric frame type that could be innately available (at least not in humans). The hypothetical innate bias might not be more than a preference for allocentric over egocentric *anchoring*. Such anchoring may be compatible with intrinsic rather than extrinsic frame use. Indeed, most experiments show only that human children and non-human primates are more inclined to record object locations with respect to the environment than with respect to their own bodies (Haun et al. 2006; Nardini et al. 2006, Shusterman & Li 2016).¹⁰

Secondly, how would the proposed cultural ‘override’ work? In the data of the present study, this question arises because many of our populations show some use of relative as well as

¹⁰ In Experiment 5 of their word-acquisition study, Shusterman & Li (2016) make impressive efforts to eliminate the intrinsic possibility.

of geocentric encoding in their speech, without showing substantial evidence of an ‘override’ toward relative solutions in the nonverbal tasks. The question cannot be answered without a theory of the cultural transmission of cognitive practices, including referential practices. Bohnemeyer et al. (2015) argue that the transmission of cognitive practices must rely on observable behaviors including language, gesture, and other cultural practices.¹¹

Lastly, there is in fact evidence suggesting that the use of extrinsic reference frames - including of the geocentric variety - requires more support by cultural transmission than that of intrinsic reference frames (Danziger 2001). The use of extrinsic frame types in small-scale space is more constrained typologically than the use of intrinsic frames. It seems that all adult human populations make non-marginal use of intrinsic frames (where ‘marginal’ could be defined with respect to an arbitrary threshold such as 5% of overall uses).¹²

Thus, although it appears that all reference frame types are subject to cultural transmission and learning, it seems that all human populations come up with some intrinsic solutions for close-range spatial reference. This may be due to the fact that the building blocks of intrinsic frames consist exclusively of potentially innate primitives of spatial cognition: figure-ground assignment, object mereology, and the geometry of axes and vectors. In contrast, to function reliably over time, extrinsic frame use requires habituation to an extrinsic anchoring system: in the case of geocentrism, it requires agents to learn to track their environmental bearings; and in the case of relative use, it requires them to learn not only to project their body coordinates onto the objects surrounding them, but also to translate from one person’s perspective to another. This habituation may require more support from cultural transmission than intrinsic frame use does (Danziger 2001).

5. Conclusion

Across populations, verbal practices of spatial reference are highly variable. And a group’s verbal practices tend to reliably predict its members’ preferred strategies of cognitive encoding (Pederson et al. 1998). The work presented here has identified a second, complementary pattern: populations whose members either prefer intrinsic frames for verbal representations of small-scale locative relations or make free use of all major reference frames without a clear preference, show infrequent or task-specific use of relative strategies in nonverbal cognition. Most of these groups in fact prefer geocentric solutions. We have discussed these findings in the context of the proposal of a weak, culturally malleable, innate geocentrism bias in nonverbal cognition (Haun et al. 2006). While such a bias at first appears compatible with the apparent prevalence of cognitive geocentrism in a significant majority of our populations, it is not immediately obvious

¹¹ This proposal is elaborated further in Bohnemeyer et al. (ms.), who propose a theory of the cultural evolution of referential practices.

¹² It has been claimed that Guugu Yimithirr speakers of the Australian Cape York peninsula are an exception (Haviland 1979, Levinson 1997); but this claim turns out on closer inspection to be restricted to the transverse axis (Haviland 1993:5; 1998:28-29).

how such a bias would be consistent with the absence of a linguistic preference for geocentric frames in the same populations, or with the absence of robust evidence of any nonverbal preference other than for intrinsic coding in two of our populations. It is evident, then, that much more research is needed to understand the role of both biology and culture in spatial cognition.

Acknowledgments

We wish to acknowledge the contributions of Tomasa Gomez, late member of the Mayangna Yulbarangyang Balna, who passed away in the spring of 2021 and was instrumental in the collection of the Sumu-Mayangna data presented here. We are grateful for the insightful comments and constructive criticism of Bill Palmer and one anonymous reviewer.

Funding

Our research was supported by the following grants: Australian Research Council grants DE130100399 *The acquisition of kinship terminology in a morphologically complex Australian Language* (PI J. Blythe) and DP120102701 *Thinking and talking about atolls: the role of the environment in shaping language and our understanding of physical space* (PIs B. Palmer and A. Gaby); Israeli Science Foundation grant #680/17 *Spatial Language across Generations in Negev Arabic* (PIs L. Cerqueglini and R. Henkin); National Science Foundation grants BSC-0723694 *Spatial Language and Cognition in Mesoamerica*, BSC-1053123 *Spatial Language and Cognition Beyond Mesoamerica*, BSC-1551925 *Doctoral Dissertation Research: Spatial Language and Cognition in Bilingual Minds* (PI J. Bohnemeyer). Data collection on Mopan and Yucatec was additionally supported by the Max Planck Society.

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Supplemental materials

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