Evidence from a large-scale study

The Cultural Transmission of Spatial Cognition

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Synopsis

• the Linguistic Transmission Hypothesis
• the test case: spatial frames of reference
• frame use in discourse: the Ball & Chair study
• frame use in recall memory: the New Animals study
• discussion
The Linguistic Transmission Hypothesis

- the Linguist Relativity Hypothesis (LRH): strong vs. weak interpretations

The strong (deterministic) orthodox interpretation of the LRH:
“The structure of anyone’s native language strongly influences or fully determines the world-view he will acquire as he learns the language.”

The weak (non-deterministic) neo-Whorfian interpretation of the LRH:
“Structural differences between language systems will, in general, be paralleled by nonlinguistic cognitive differences, of an unspecified sort, in the native speakers of the two languages.” (Brown 1976: 128)

- the recent neo-Whorfian debate has focused on the weak interpretation
  - i.e., on the existence of language-on-thought effects
- there are to our knowledge no contemporary proponents of the strong interpretation
The Linguistic Transmission Hypothesis (Cont.)

- a new take:

the Linguist Transmission Hypothesis (LTH)

Linguistic Transmission Hypothesis (LTH) – abstract formulation:
“Using a language or linguistic variety may facilitate the acquisition of cultural practices of nonlinguistic cognition shared among the speakers of the language.”

– more concretely:

Linguistic Transmission Hypothesis (LTH) – concrete formulation:
“The comprehension of utterances may provide clues to the cognitive practices involved in their production, and both the comprehension and the production of utterances may afford habituation to these cognitive practices. The cognitive practices so acquired may or may not subsequently be extended beyond the domain of speech production.”
The Linguistic Transmission Hypothesis (Cont.)

• the LTH compared to the LRH
  – the LTH entails cognitive effects of language *use*, but does not entail effects from the lexicon or grammar
  – it is compatible with, but does not entail, the weak interpretation of the LRH
  – it emphasizes the role of language as a potential conduit
    • in the transmission of cultural “styles” or “practices” of cognition
    • a role it shares with other types of perceivable behavior
      – e.g., co-speech gesture (Haviland 1979; Le Guen 2011); agricultural and religious practices (Bohnemeyer 2011)
• The LTH is not a new idea
  – a precursor: Levinson (2003: 315-325)
  – closely related: Slobin’s (1996, 2003) work on Thinking-for-Speaking (TfS) effects
  • the LTH unilaterally entails the existence of TfS effects
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The test case: spatial frames of reference

• spatial frames of reference
  – cognitive axis ("coordinate") systems used to interpret ‘projective’ (Piaget & Inhelder 1956) spatial relations
  • in representations of location, motion, and orientation
The test case: spatial frames of reference (Cont.)

• **classifying frames**

**Table 1.** A classification of frame types based on Danziger (2010)

- **egocentric:** axes “anchored” to the body of the observer
  - *The ball is in front of me*
    - **Direct** (Danziger 2010)
  - *The ball is in front of the chair*
    - **Object-centered** (Carlson-Radvansky & Irwin 1993)

- **allocentric:** axes independent of the body of the observer
  - *The ball is right of the chair*
    - **Relative** (Levinson 1996)
  - *The ball is downriver of the chair*
    - **Geocentric**

**intrinsic:** centered on the anchor (the model of the axes)

**extrinsic:** transposed from the anchor
The test case: spatial frames of reference (Cont.)

• reference frames and the LTH
  – reference frames are not part of the grammars or lexicons of natural languages
  – they stand in a many-to-many relationship with respect to the spatial relators that tap into them

<table>
<thead>
<tr>
<th>The ball is in front of the chair</th>
<th>relative</th>
<th>intrinsic</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ball is left of the chair</td>
<td>intrinsic</td>
<td>relative</td>
</tr>
</tbody>
</table>

true in which type of FoR?

Figure 1. Truth conditions of intrinsic and relative descriptions of Ball & Chair 3.9 (left) and 3.12
The test case: spatial frames of reference (cont.)

- crosslinguistic variation

**Key:**
- relative and intrinsic
- relative, intrinsic, and absolute/geocentric
- absolute/geocentric and intrinsic; relative restricted (to unfeatured grounds, loan words, and/or bilingual speakers)
- absolute/geocentric and intrinsic variation by linguistic variety (dialect) (absence of evidence of variation is represented as absence of variation)

**Figure 2. Reference frame use in small-scale horizontal space across languages (Bohnemeyer & Levinson ms.)**
The test case: spatial frames of reference (cont.)

- alignment between language and cognition – preferences for particular frame types in discourse and recall memory covary

**Table 2. Animals-in-a-Row in Levinson 2003: the large sample**

<table>
<thead>
<tr>
<th>Linguistically Relative</th>
<th>English, Dutch, Japanese, Tamil-Urban</th>
<th>Prediction: Non-verbal coding will be relative</th>
<th>N = 85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistically Absolute</td>
<td>Arrernte, Hai//om, Tzeltal, Longgu, Belhare, Tamil-Rural</td>
<td>Prediction: Non-verbal coding will be absolute</td>
<td>N= 99</td>
</tr>
</tbody>
</table>

**Figure 3. Animals-in-a-Row: design**

1. Memorize row of animals
2. Turn 180° to the recall table
3. Reconstruct the array

**Figure 4. Animals-in-a-Row: results (Levinson 2003: 184)**

- Geocentric languages
- Relative languages

% of geocentric responses
The test case: spatial frames of reference (cont.)

- two competing interpretations

**Figure 5. The mainstream vision**

**Innatist interpretation** (Li & Gleitman 2002; Li et al 2011; inter alia)
- innate knowledge of all frame types
- variation only in usage preferences
- variation caused by adaptation to the environment - topography, population geography, education, literacy
- language plays no role in the cultural transmission of practices of spatial reference

**Figure 6. The Neo-Whorfian vision**

**Neo-Whorfian interpretation** (Levinson 1996, 2003; Pederson et al 1998; inter alia)
- knowledge of some frame types is culturally transmitted
- language plays a key role in the cultural transmission of practices of spatial reference
- the adaptation to the environment happens at the phylogenetic level, not at the ontogenetic level
• the forest, the trees, and statistics
  – adjudicating between these interpretations
    • presupposes isolating the effects of language, literacy, education, topography, etc., on the use of reference frames
  – the problem: many of these factors can co-vary
    • e.g., populations that speak different languages may also differ in their levels of education and literacy
  – the solution: larger population samples and multivariate statistics

Figure 7. Seeing the forest for the trees
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Frame use in discourse: Ball & Chair

• our tool for studying the use of FoRs in discourse
  – a referential communication task: Ball & Chair (B&C)
    – replacing Men & Tree (M&T) in Pederson et al (1998) etc.
    – B&C allows us to discover selection preferences
      for any of the FoR types
        » at the in-door scale
        » M&T may for various reasons depress the use of intrinsic FoRs

Figure 8. Design of the Men and Tree task (Pederson et al. 1998: 562)

Figure 9. Two of the Ball & Chair photos, featuring an intrinsic contrast
• the data set of the present study  
  – B&C data from 11 varieties

<table>
<thead>
<tr>
<th>Language group</th>
<th>Linguistic variety</th>
<th>Field site</th>
<th>Researcher</th>
<th>Dyads</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meso-American</td>
<td>Tzeltal</td>
<td>Chacoma, Chiapas</td>
<td>Polian</td>
<td>5</td>
<td>7/3</td>
<td>6/4</td>
</tr>
<tr>
<td>Yucatec</td>
<td>Yaxley, Quintana Roo</td>
<td>Bohnemeyer</td>
<td>4</td>
<td></td>
<td>2/6</td>
<td>4/4</td>
</tr>
<tr>
<td></td>
<td>Felipe Carrillo Puerto, Quintana Roo</td>
<td></td>
<td>1</td>
<td></td>
<td>0/2</td>
<td>1/1</td>
</tr>
<tr>
<td>East Highlands Mixe</td>
<td>Ayutla, Oaxaca</td>
<td>Romero-Méndez</td>
<td>5</td>
<td></td>
<td>3/7</td>
<td>3/7</td>
</tr>
<tr>
<td>Otomí</td>
<td>San Ildefonso Tultepec, Querétaro</td>
<td>Palancar, N. Hernández, S. Hernández</td>
<td>4</td>
<td></td>
<td>0/8</td>
<td>1/7</td>
</tr>
<tr>
<td>Isthmus Zapotec</td>
<td>La Ventosa, Oaxaca</td>
<td>Pérez-Báez</td>
<td>6</td>
<td></td>
<td>4/8</td>
<td>3/9</td>
</tr>
<tr>
<td>Tarascan</td>
<td>Santa Fe de la Laguna, Michoacán</td>
<td>Capistrán-Garza</td>
<td>5</td>
<td></td>
<td>4/6</td>
<td>4/6</td>
</tr>
<tr>
<td>Non-Meso-American indigenous</td>
<td>Seri</td>
<td>El Desemboque, Sonora</td>
<td>O’Meara</td>
<td>5</td>
<td>1/9</td>
<td>2/8</td>
</tr>
<tr>
<td>Sumu</td>
<td>Rosita and Siuna, RAAN, Nicaragua</td>
<td>Benedicto, Eggleston, Mayangna Yulbarangyang Balna</td>
<td>5</td>
<td></td>
<td>2/8</td>
<td>5/5</td>
</tr>
<tr>
<td>Spanish</td>
<td>Mexican</td>
<td>Chimalacatlán, Morelos</td>
<td>Romero-Méndez, H. Rodríguez, Tucker</td>
<td>5</td>
<td>6/4</td>
<td>3/7</td>
</tr>
<tr>
<td>Nicaraguan</td>
<td>Rosita and Siuna, RAAN</td>
<td>Eggleston</td>
<td>4</td>
<td></td>
<td>0/8</td>
<td>2/6</td>
</tr>
<tr>
<td>European</td>
<td>Barcelona, Cataluña</td>
<td>Eggleston</td>
<td>4</td>
<td></td>
<td>2/6</td>
<td>1/7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>53</td>
<td>31/75</td>
<td>35/71</td>
</tr>
</tbody>
</table>

Table 3. Participants by language, site, age, sex, and study (showing only those whose responses were included in the analysis)
– we also collected the participants’ self-reported …
  • ...level of education
  • ...frequency of use of Spanish as a second language (L2)
  • ...frequency of reading and writing
– we included two geographic variables capturing properties of the recording field sites
  • topography
    – a categorical variable classifying elevation and geomorphological patterns based on published map data
    – five levels: orogenic belts, volcanic belts, central high plateaus, continental shelf, and coastal basins and transgressions
  • population density
    – calculated from
      » the size of the community’s population according to census data
      » the size of the community’s area according to Google Earth
Frame use in discourse: the Ball & Chair study (cont.)

• **coding**
  
  – we coded descriptions of the location of the ball

• **distinguishing among eight categories**
  
  – allocentric intrinsic
  
  – egocentric intrinsic = direct (Danziger 2010)
  
  – egocentric extrinsic = relative (Levinson 1996)
  
  – intrinsic-relative ambiguity
    
    » i.e., the description is true of the same picture under both allocentric intrinsic and egocentric extrinsic interpretations
  
  – (horizontal) geocentric
  
  – vertical geocentric
  
  – vertical geocentric-intrinsic ambiguity
  
  – topological (no reference frame involved; Piaget & Inhelder 1956)
all of the languages in the sample have the lexical and grammatical resources for using all FoR types
– in no case does the grammar or lexicon of the language constrain the use of particular frame types
– reference frames are semantic patterns
  • which are only indirectly related to particular lexical items

<table>
<thead>
<tr>
<th>Description</th>
<th>Relative</th>
<th>Intrinsic</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ball is in front of the chair</td>
<td>relative</td>
<td>intrinsic</td>
</tr>
<tr>
<td>The ball is left of the chair</td>
<td>intrinsic</td>
<td>relative</td>
</tr>
</tbody>
</table>

**Figure 10.** *Truth conditions of intrinsic and relative descriptions of Ball & Chair 3.9 (left) and 3.12*
which of the eight dependent variables showed the greatest amount of variation?

- we performed an MDS analysis
  - of a 53 x 53 distance matrix comparing the dyads in terms of their use of the eight strategies (see appendix)
- correlation analyses showed the use of **geocentric** and **relative** frames to correlate most strongly
  - with the first dimension of the MDS plot
    - Spearman’s Rho: 0.85 and -0.84, respectively
Frame use in discourse: the Ball & Chair study (cont.)

• which factors predict the selection of a relative or geocentric frame in response to a given item?
  – we ran linear mixed effects regressions
    – implemented using the ARM package in R (Gelman et al 2012)
  • we regressed the probability of a geocentric or relative frame being used in response to a particular scene
    – against the sum term of our six independent variables
• we ran two geocentric and two relative models
  – models that included the L2-SPANISH USE variable were based on observations that excluded the L1-Spanish speakers
    » and vice versa
• the LANGUAGE GROUP variable
  – our dataset includes too many individual languages for parsimonious modeling
  – therefore, we grouped the languages according to areal-linguistic affiliation
    • yielding a three-level variable for the 11-populations models
      – languages of the Mesoamerican *sprachbund*, Spanish, and the two non-Mesoamerican indigenous languages
    • and a two-level variable for the models that include the responses from the speakers of the indigenous languages only
      – Mesoamerican *sprachbund* languages vs. non-Mesoamerican indigenous languages (Seri and Sumu)
• **results**

  • EDUCATION made no significant contribution to any of the models

    – removing it as a variable from the models improved the AIC

**Table 4. Models using non-Mesoamerican Indigenous language type as a baseline (Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’)**

<table>
<thead>
<tr>
<th>Models</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>L1-Spanish speakers included</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Dependent variable</td>
<td>GEOCENTRIC</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RELATIVE</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Effects</td>
<td>LANGUAGE GROUP</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>L2-Spanish use</td>
<td>N/A</td>
<td>N/A</td>
<td>***</td>
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<tr>
<td></td>
<td>LITERACY</td>
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<tr>
<td></td>
<td>TOPOGRAPHY</td>
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<tr>
<td></td>
<td>POPULATION DENSITY</td>
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<td>*</td>
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</tbody>
</table>
• discussion: the role of the first language
  – we found significant LANGUAGE GROUP effects in all models
    • except the geocentric model w/o the L1-Spanish speakers
  – this contribution of L1 cannot be reduced to a combination of any of the other factors
    • to this extent contra Li & Gleitman 2002

<table>
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<tr>
<td>Sample</td>
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<tr>
<td></td>
<td>L1-Spanish speakers included ✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Dependent variable</td>
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<tr>
<td></td>
<td>GEOCENTRIC ✓ ✓</td>
<td>✓</td>
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<td></td>
<td>RELATIVE ✓ ✓</td>
<td>✓</td>
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<td>Effects</td>
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<td>LANGUAGE GROUP *** *** ***</td>
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<td></td>
<td>L2-SpanISH USE N/A N/A ***</td>
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<td></td>
<td>LITERACY</td>
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<td>TOPOGRAPHY *</td>
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<tr>
<td></td>
<td>POPULATION DENSITY</td>
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</tbody>
</table>
• discussion: language contact
  – we found a significant L2 use effect on the use of relative frames
  – the frequency of L2-Spanish use boosts the use of relative frames
• in the speakers of the indigenous languages
• providing additional support for the LTH

<table>
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<td>Dependent variable</td>
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<td></td>
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<tr>
<td>Effects</td>
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<td>***</td>
<td>***</td>
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<td>L2-SpanISH USE</td>
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<td>N/A</td>
<td>***</td>
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<td></td>
<td>LITERACY</td>
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<td>TOPOGRAPHY</td>
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<td>POPULATION DENSITY</td>
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</tbody>
</table>

Frame use in discourse: the Ball & Chair study (cont.)
Frame use in discourse: the Ball & Chair study (cont.)

- discussion: other effects
  - the two environmental variables made significant independent contributions
    - to the models that included the L1-Spanish speakers
    - TOPOGRAPHY to the geocentric model,
      POPULATION DENSITY to the relative one
  - we did not find a significant effect of LITERACY

<table>
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<td>Dependent variable</td>
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<tr>
<td>GEOCENTRIC</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>RELATIVE</td>
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<tr>
<td>Effects</td>
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</tr>
<tr>
<td>LANGUAGE GROUP</td>
<td>***</td>
<td>***</td>
<td>***</td>
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<tr>
<td>L2-SPANISH USE</td>
<td>N/A</td>
<td>N/A</td>
<td>***</td>
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<td>LITERACY</td>
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Frames in recall memory: New Animals

• recall memory task: New Animals
  – a near-identical replication of the Animals In A Row (AIAR) design
    • of Levinson 1996 and Pederson et al. 1998

  -- big drawback: no intrinsic response pattern

Figure 11. Layout of the AIAR memory recognition task
  – minor differences: the toy animals used; the number of trials; ...


• participants
  – we tested b/w 11 and 28 speakers of each variety
    • the mean number was 16.8
  – data from participants with errors in more than two of the six trials was excluded from the analysis

Table 5. *Participants whose responses were included in the analysis by language, site, age, sex, and study (MA – Mesoamerican; NMA – non-Mesoamerican indigenous; Sp. – Spanish)*

<table>
<thead>
<tr>
<th>Language Group</th>
<th>Locality</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt; 30 / ≥ 30</td>
<td>M / F</td>
</tr>
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<td>Tseltal (MA)</td>
<td>Chacoma</td>
<td>NA</td>
<td>NA</td>
</tr>
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<td>Yaxley</td>
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<td>9/7</td>
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<tr>
<td></td>
<td>Felipe Carrillo Puerto</td>
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<td>7/7</td>
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<td>Mexican Sp.</td>
<td>San Miguel Balderas</td>
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Frames in recall memory: the New Animals study (cont.)

• coding
  – facing direction: egocentric vs. geocentric vs. neither
  – order of animals: egocentric vs. geocentric vs. neither
    • the analysis presented here is based on order only

• errors
  – wrong animal; wrong order
  – responses by participants who produced errors in more than two of the six trials were excluded altogether
Framed in recall memory: the New Animals study (cont.)

- **analysis**
  - regression models of the probability of egocentric and geocentric reconstructions
    - against the same set of predictor variables used in the analysis of the linguistic data

- **results**

<table>
<thead>
<tr>
<th>Models</th>
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<tr>
<td>POPULATION DENSITY</td>
<td>**</td>
<td>*</td>
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Table 6. Summary of the four regression models of the NA responses based on self-reported participant data. Models that include L2 use exclude L1-Spanish speakers (Significance codes: 0.001 ‘***’, 0.01 ‘**’, 0.05 ‘*’).
• results (cont.)

– as before, EDUCATION did not yield an effect and was eliminated to improve the AIC
– LANGUAGE GROUP effects in all models except the GEOCENTRIC model that excludes the L1-Spanish speakers
– TOPOGRAPHY and POPULATION DENSITY effects in the models that include the L1-Spanish speakers
– no L2-SpanISH use or LITERACY effects

• a possible explanation: most populations preferred geocentric responses
  – even those that did not show a linguistic bias

<table>
<thead>
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<th>3</th>
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<tr>
<td>Effects</td>
<td>LANGUAGE GROUP</td>
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<td>L2-SpanISH use</td>
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<td>POPULATION DENSITY</td>
<td>**</td>
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Synopsis

• the Linguistic Transmission Hypothesis
• the test case: spatial frames of reference
• frame use in discourse: the Ball & Chair study
  – distribution of the response variables
  – impact of the predictor variables
• frame use in recall memory: the New Animals study
• discussion
Discussion

• demonstrated for the first time here
  – L1 makes an irreducible contribution to frame choice, contra Li & Gleitman (2002)
  – L2 use predicts frame choice in the L1
    • suggesting contact diffusion of frame choice

• both findings support
  the Linguistic Transmission Hypothesis
  – language appears to be a conduit
    for the transfer of cultural practices of cognition

• only populations with a linguistic egocentric bias
  also show an egocentric bias in recall memory
  – most other populations prefer geocentric recall
    • suggesting a possible pan-simian geocentric bias
Acknowledgements

- we would like to thank
  - ... our teachers and consultants, the speakers of the languages the MesoSpace team has been studying
  - ... NSF, for the necessary resources to realize these studies
    - through award #BCS-0723694
      Spatial language and cognition in Mesoamerica
  - ... the institutions who have partnered with MesoSpace to lend us support
    - CIESAS and the Max Planck Institute for Psycholinguistics
• I would like to thank (cont.)
  – ... Eve Danziger, Matthew Dryer, Jeff Good, Marianne Gullberg, Florian Jaeger, Jean-Pierre Koenig, Steve Levinson, Jesse Lovegren, David Mark, Wolfgang Wölck
    • and the members of the UB Semantic Typology Lab, for advice
  – ... audiences at
    • CILLA V, the *International Conference on Yucatecan Linguistics*, the *Workshop on Quantitative Methods in Areal Typology*, the 87th Annual Meeting of the LSA, and BLS 39
    • for comments on previous presentations of some of the material
  – ... you!
Thank you!
References


References (cont.)


Appendix: Distribution of the response variables

– We ran a three-dimensional Multi-Dimensional Scaling (MDS) analysis of the similarity matrix
  • three dimensions produced a better goodness of fit than two
  • cf. Schiffman et al 1981

Figure 25. Plotting the first two dimensions of the MDS analysis
• the first dimension of the MDS plot correlates positively with the frequency of geocentric descriptions...  
  » Spearman’s Rho: 0.85

• ... and negatively with the frequency of relative descriptions
  » Spearman’s Rho: -0.84

Figure 26. Correlations between the first dimension of the MDS plot and the frequency of geocentric (left) and relative (right) descriptions.
Appendix: Distribution of the response variables (cont.)

- the second dimension shows a stronger correlation with the frequency of topological descriptions
  
  – Spearman’s Rho: -0.9

Figure 17. Correlations b/w the 2nd dimension of the MDS plot and the frequency of topological descriptions
Appendix: A geocentrism bias?

• An unexpected pattern in the recall memory data
  – populations that showed a linguistic egocentrism bias also showed the same bias in the recall memory study
  – all other populations showed a geocentric bias or no bias at all in the recall memory task

• even populations that did not show a linguistic bias produced evidence of a geocentric bias in the memory task

Figure 12. Frequency of response types by language in descriptions locating the ball vis-à-vis the chair

Figure 13. Frequency of response types by language in descriptions locating the ball vis-à-vis the chair
• A comparison of Spanish-speaking populations confirms this picture
  – Table 7 compares linguistic and recall memory data for **five** Spanish-speaking populations
    • including **three Mexican Spanish** ones
  – all and only those populations that preferred relative descriptions also preferred egocentric reconstructions
  – all other populations preferred geocentric reconstructions!

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Appendix: A geocentrism bias? (cont.)

• discussion (cont.)
  – a possible explanation: a pan-simian innate bias for processing geocentric information
  – supporting evidence
    • Haun et al (2006) conducted recall memory experiments with all Great Ape species and with German preschoolers
      – all populations committed more errors in egocentric than in geocentric conditions
    • developmental studies indicate early acquisition of geocentric terms in populations with a geocentric bias
      – Brown 2001; Brown & Levinson 2000, 2001; de León 1994
        » however, Cablitz 200? did not find this effect in Marquesan
  – this geocentric bias would be readily supplanted by a learned, culturally transmitted preference
    • for using egocentric frames in small-scale space
    • since the primitives for computing reference frames of any type are the same: vectors, angles, and distances