The effect of topography on language and cognition in Isthmus Zapotec

Randi Moore & Juergen Bohnemeyer, University at Buffalo

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Geographic Grounding: Place, direction and landscape in the grammars of the world

Copenhagen, Denmark
Synopsis

Introduction

MesoSpace

Topography in MesoSpace

Space and topography in Diidxa za

Cultural mediation: ethnophysiography

Conclusions
Introduction

does topography influence language & cognition

test case: spatial frames of reference

previous qualitative work: Wassman & Dasen 1998; Polian & Bohnemeyeyer 2011; Palmer 2015

Figure 1. Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698)
does topography influence cognition? (cont.)

- preliminary quantitative evidence: MesoSpace
  - (Bohnemeyer et al 2014, 2015, ms.)

- second part of the talk: the role of culture
  - inter-community variation in the Isthmus of Tehuantepec
Synopsis

• Introduction
• MesoSpace
• Topography in MesoSpace
• Space and topography in Diidxa za
• Cultural mediation: ethnophysiology
• Conclusions
MesoSpace

- NSF award #BCS-0723694 “Spatial language and cognition in Mesoamerica”
- 15 field workers
- 13 MA languages
  - Mayan
    - Chol (J.-J. Vázquez)
    - Q’anjob’al (E. Mateo Toledo)
    - Tzeltal (G. Polian)
    - Yucatec (J. Bohnemeyer)
  - Mixe-Zoquean
    - Ayutla Mixe (R. Romero Méndez)
    - Soteapanec (S. Gutierrez Morales)
    - Tecpatán Zoque (R. Zavala Maldonado)
  - Oto-Manguean
    - Otomí (E. Palancar; N. H. Green; S. Hernández-Gómez)
    - Juchitán Zapotec (G. Pérez Báez)

Tarascan
- Purepecha (A. Capistrán)

Totonacan
- Huehuetla Tepehua (S. Smythe Kung)

Uto-Aztecan
- Cora (V. Vázquez)
- Pajapan Nawat (V. Peralta)
3 non-MA “controls”
- Seri (C. O’Meara)
- Mayangna (E. Benedicto, A. Eggleston in collaboration with the Mayangna Yulbarangyang Balna)
- Mexican Spanish (R. Romero Méndez)

2 (interrelated) domains
- frames of reference and meronyms (labels for entity parts)

Figure 4. Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)
MesoSpace Ib

Spatial language and cognition beyond Mesoamerica

NSF award #BCS 1053123, 2011 – 2016

new languages

- Jahai (Mon-Khmer; N. Burenhult)
- Japanese (isolate; J. Olstad)
- Mandarin (Sino-Tibetan; H. Hsiao)
- Taiwanese (Sino-Tibetan; H. Hsiao)
- Vietnamese (Mon-Khmer; J. Lovegren)
- Wan (Mande; T. Nikitina)
- Yurakaré (isolate, Bolivia; R. van Gijn and V. Hirtzel)

continuing languages

- additional data collected from speakers of
  - Isthmus Zapotec; Tseltal, and Yucatec Maya; Mayangna and Spanish

objectives

- collect further data on linguistic vs. environmental determinants of reference frame use
frames of reference: alternative classifications and subtypes

Figure 5. Reference frame types and their classification (A - 'away from', B - 'back', D - 'downriver', F - 'front', L - 'left', R - 'right', T - 'toward', U - 'upriver'; Bohnemeyer & Levinson ms.)
Tasks used by MesoSpace to study reference frames

- Ball & Chair (photo stimuli, referential communication task)
- Talking Animals (3-D toy animal stimuli, referential communication task)
- New Animals (3-D toy animal stimuli, recall and recreate array of animals)

Figure 7. One of four Talking Animals trials

Figure 8. Two of the Ball & Chair photos, featuring an intrinsic contrast

Figure 9. Animals-in-a-Row: design (Levinson 2003)
Evaluating possible contributing factors - independent variables in mixed effect regression models (GLMMs)

- Participants’ age, education, L2 use, reading and writing frequency
  - Self-reported via demographic survey

Population Geography

- Population density based on Google Earth area of municipality and population from census (INEGI 2010)

Local Topography

- In Mexico: Classification of geomorphological regions (Hernández Santana et al. 2007)
- World-wide: Improved Hammond Classification of landforms (ESRI. 2011; ArcGIS software)
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Topography in MesoSpace

- Two classifications have been used to represent local topography in multivariate statistical analyses
  - Geomorphological regions (New Atlas of Mexico, Hernández Santana et al. 2007)
  - Improved Hammond classification of landforms (ESRI 2011 ArcGIS)
    - Moore et al. ms.
Geomorphological regions (New Atlas of Mexico, Hernández Santana et al. 2007)

**Figure 10.** (left) Mapa NA III_1. From Hernández Santana et al. 2007

**Figure 11.** (above) Modified 5-way classification used in previous MesoSpace classifications
Figure 12. World Landforms – Improved Hammond Method (ESRI 2011) (http://www.arcgis.com/home/item.html?id=cd817a746aa7437cbd72a6d39cda4559)
findings I: Ball & Chair

1. Geomorphological classification of field sites

B&C study (N = 53 x 2 participants)

<table>
<thead>
<tr>
<th>Locality</th>
<th>Geomorphological Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chacoma, Chiapas</td>
<td>orogenic belt</td>
</tr>
<tr>
<td>Yaxley, Quintana Roo</td>
<td>continental shelf</td>
</tr>
<tr>
<td>Felipe Carrillo Puerto, Quintana Roo</td>
<td>continental shelf</td>
</tr>
<tr>
<td>San Pedro y San Pablo Ayutla, Oaxaca</td>
<td>orogenic belt</td>
</tr>
<tr>
<td>San Ildefonso Tuletepec, Queretaro</td>
<td>volcanic belt</td>
</tr>
<tr>
<td>La Ventosa, Oaxaca</td>
<td>coastal basin</td>
</tr>
<tr>
<td>Santa Fe de la Laguna, Michoacan</td>
<td>volcanic belt</td>
</tr>
<tr>
<td>El Desemboque (de los seris), Sonora</td>
<td>coastal basin</td>
</tr>
<tr>
<td>Rosita, Región Autónoma del AtlánticoNorte</td>
<td>coastal basin</td>
</tr>
<tr>
<td>San Miguel Balderas, Mexico State</td>
<td>volcanic belt</td>
</tr>
<tr>
<td>Chimalacatlan, Tlaquiltenango, Morelos</td>
<td>orogenic belt</td>
</tr>
<tr>
<td>Rosita, Región Autónoma del AtlánticoNorte</td>
<td>coastal basin</td>
</tr>
<tr>
<td>Barcelona, Spain</td>
<td>coastal basin</td>
</tr>
</tbody>
</table>

Table 2. Summary of the four regression models of B&C responses using reading frequency to estimate literacy. Models that include L1-Spanish speakers exclude L2 use as a predictor variable. (Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’)

<table>
<thead>
<tr>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1-Spanish Speakers Included</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOCENTRIC</td>
<td></td>
</tr>
<tr>
<td>RELATIVE</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effects</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANGUAGE GROUP</td>
<td>***</td>
</tr>
<tr>
<td>L2-Spanish use</td>
<td></td>
</tr>
<tr>
<td>LITERACY</td>
<td></td>
</tr>
<tr>
<td>TOPOGRAPHY</td>
<td>*</td>
</tr>
<tr>
<td>POPULATION DENSITY</td>
<td></td>
</tr>
</tbody>
</table>

Bottom line
- More relative frame use in coastal basins
- More geocentric frame use in volcanic belts
- Population density positively correlated with egocentrism, negatively w/ geocentrism
## findings II: Talking Animals

### 3. Field sites of the TA study by pop. density and geomorphology \((N = 343 \times 2)\)

<table>
<thead>
<tr>
<th>Language</th>
<th>Locality</th>
<th>Country</th>
<th>Density</th>
<th>Density Log Scale</th>
<th>Topographic Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese</td>
<td>Setagaya</td>
<td>Japan (Mainland)</td>
<td>15551</td>
<td>4.19</td>
<td>flat</td>
</tr>
<tr>
<td>Taiwanese Southern Min Chinese</td>
<td>Taipei</td>
<td>Taiwan</td>
<td>9949</td>
<td>4.00</td>
<td>flat</td>
</tr>
<tr>
<td>Japanese</td>
<td>Naha</td>
<td>Japan (Okinawa)</td>
<td>8244</td>
<td>3.92</td>
<td>hills</td>
</tr>
<tr>
<td>English</td>
<td>Buffalo</td>
<td>United States</td>
<td>2569</td>
<td>3.41</td>
<td>flat</td>
</tr>
<tr>
<td>Japanese</td>
<td>Yomitan</td>
<td>Japan (Okinawa)</td>
<td>1200</td>
<td>3.08</td>
<td>hills</td>
</tr>
<tr>
<td>Taiwanese Southern Min Chinese</td>
<td>Tainan</td>
<td>Taiwan</td>
<td>855</td>
<td>2.93</td>
<td>flat</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>Long Mũy</td>
<td>Vietnam</td>
<td>406</td>
<td>2.61</td>
<td>flat</td>
</tr>
<tr>
<td>Japanese</td>
<td>Fujinomiya</td>
<td>Japan (Mainland)</td>
<td>339</td>
<td>2.53</td>
<td>low mountains</td>
</tr>
<tr>
<td>Japanese</td>
<td>Aizuwakamatsu</td>
<td>Japan (Mainland)</td>
<td>321</td>
<td>2.51</td>
<td>low mountains</td>
</tr>
<tr>
<td>Japanese</td>
<td>Nago</td>
<td>Japan (Okinawa)</td>
<td>293</td>
<td>2.47</td>
<td>low mountains</td>
</tr>
<tr>
<td>Japanese</td>
<td>Miyakojima</td>
<td>Japan (Okinawa)</td>
<td>268</td>
<td>2.43</td>
<td>hills</td>
</tr>
<tr>
<td>Japanese</td>
<td>Yonaguni</td>
<td>Japan (Okinawa)</td>
<td>58</td>
<td>1.76</td>
<td>hills</td>
</tr>
<tr>
<td>Japanese</td>
<td>Shisho</td>
<td>Japan (Mainland)</td>
<td>49</td>
<td>1.69</td>
<td>low mountains</td>
</tr>
<tr>
<td>Zapotec</td>
<td>La Ventosa</td>
<td>Mexico</td>
<td>5</td>
<td>0.70</td>
<td>flat</td>
</tr>
<tr>
<td>Zapotec</td>
<td>Juchitán de Zaragoza</td>
<td>Mexico</td>
<td>5</td>
<td>0.70</td>
<td>flat</td>
</tr>
<tr>
<td>Yaxley</td>
<td>Mexico</td>
<td>2</td>
<td>0.30</td>
<td>flat</td>
<td></td>
</tr>
<tr>
<td>Felipe Carillo Puerto</td>
<td>Mexico</td>
<td>2</td>
<td>0.30</td>
<td>flat</td>
<td></td>
</tr>
</tbody>
</table>
## findings II: Talking Animals (cont.)

### Table 4. Regression models of the Talking Animals data: summary of effects

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Literacy variable</th>
<th>Independent variables (fixed effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing</td>
<td>Reading</td>
<td>L1</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>***</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>**</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>***</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>***</td>
</tr>
</tbody>
</table>

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

### Figure 14. One of four Talking Animals trials

![Image of a toy animal](image14)

### Figure 15. Design of the Talking Animals task (adapted from Pederson et al. 1998: 562)

![Image of the Talking Animals task design](image15)
findings III: New Animals

Table 5. Participants whose responses were included in the analysis, by language, age, and sex

<table>
<thead>
<tr>
<th>Language</th>
<th>Male</th>
<th>Female</th>
<th>≥30</th>
<th>&lt;30</th>
</tr>
</thead>
<tbody>
<tr>
<td>American English</td>
<td>12</td>
<td>8</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Japanese</td>
<td>33</td>
<td>15</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Mandarin Chinese</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Mixe</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Otomí</td>
<td>1</td>
<td>4</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Spanish</td>
<td>11</td>
<td>21</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Sumu Mayangnga</td>
<td>4</td>
<td>21</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Taiwanese Southern Min</td>
<td>2</td>
<td>19</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Tarascan</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Tzeltal</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>4</td>
<td>2</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Yucatec</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Istic Zapotec</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 16. Animals-in-a-Row: design (Levinson 2003)
findings III: New Animals (cont.)

Figure 17. Response type frequency by L1
MesoSpace (cont.)

findings III: New Animals (cont.)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Literacy variable</th>
<th>Independent variables (fixed effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egocentric</td>
<td>Writing Yes</td>
<td>Reading No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Regression models of the New Animals data: summary of effects (Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1)

Bottom line
• Field sites featuring hilly topography show sig. less egocentric use than flat regions
• Population density positively correlated w/ egocentrism
discussion

- both population density and topography confirmed as independent factors influencing reference frame use in both discourse and recall memory

- by hypothesis, the effect of population density is primarily mediated by infrastructure
  - egocentrism more efficient for navigating urban roadways

- the effect of topography has been hypothesized to be mediated by the availability of salient potential 'anchors'
  - such as physiogeographic gradients and natural landmarks
  - cf. Polian & Bohnemeyer 2011; Li & Gleitman 2002

questions

- what is the role of culture in these geographic effects?
- at what level of granularity do such effects begin to matter?
Synopsis

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- Space and topography in Diiddxa za
- Cultural mediation: ethnophysiography
- Conclusions
Space and topography in Diidxa za

- **Diidxa za (Isthmus Zapotec)**
  - Otomanguean, VSO, tonal, ~100,000 speakers (INEGI 2010 census)

- **Reference frame use in Isthmus Zapotec**
  - Pérez Báez (2011) reference frame use in recall and discourse
    - 2-D stimuli in La Ventosa
    - Strong geocentric preference, based on prevailing winds
  - Moore (2016) frame use in recall and discourse
    - 3-D stimuli in La Ventosa and Juchitán
    - Confirmed geocentric preference
    - Significant variation exists between communities
    - Variation also exists in degree of preference for geocentric over egocentric encoding in memory
Isthmus Zapotec field sites
- La Ventosa
- Juchitán de Zaragoza
- Santa María Xadani

Figure 18. Oaxaca, Mexico, and three field sites in the Isthmus of Tehuantepec
Distribution of frame type responses in discourse by Community

Figure 19. Frame use in discourse. Responses to Talking Animals (Moore 2016) (N = 23 x 2 participants)
Generalized linear mixed-effects models (Lme4 package in R)

Factors included in Models
- Education level
- Reading and writing frequency
- Frequency of L2 use (Spanish)
- Community membership

Dependent Variables
- L2, Education, Reading, Writing, Community membership

Independent Variables
- Reference frame types

Community membership only significant factor in predicting frame use
<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Literacy variable</th>
<th>Independent variables (fixed effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Writing</td>
<td>Reading</td>
</tr>
<tr>
<td>Geocentric</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Relative</td>
<td>Yes</td>
<td>No</td>
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<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Absolute</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Direct</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>‘Landmark-based’</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Table 8.** Regression models of the Talking Animals Zapotec data: summary of effects

*(Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1)*

(model details in Appendices)
Figure 20. Frame use in recall memory. Responses to New Animals. (N = 28 participants)
Large-scale topographic classifications don’t capture the variation in local landscape throughout the Isthmus

- All three are coastal (Hernandez et al) or flat (ESRI)

Yet, variation in frame use in discourse and memory exists between communities
Synopsis

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- Conclusions
The impact of the environment on cognition is mediated by culture.

Community-specific practices evolve around salient environmental gradients.

Inter-community variation such as witnessed in the Isthmus is the result of this.

Another example: Bali (Wassman and Dasen 1998).

**Figure 21.** Three neighboring villages on the North-East peninsula of Bali using the same set of geocentric terms each based on different local conventions (Bohnemeyer et al. ms, based on a detail from Wassman & Dasen 1998: 698).
studying the cultural mediation of environmental forces: ethnophysiology

cf. Bohnemeyer 2002; Burenhult & Levinson 2008; Johnson & Hunn 2010; Mark & Turk 2003; Mark et al 1999; O’Meara 2010; Smith & Mark 2003; inter alia
one salient environmental feature that’s not directly captured in a topographic classification: prevailing winds

- the Isthmus of Tehuantepec has year-round prevailing north winds
- these are indirectly shaped by the relief, in that a gap in the North American cordillera creates a giant wind tunnel

Figure 22. Diagram of Tehuantepecer winds (https://i.kinja-img.com/gawker-media/image/upload/hvttkme469ebgy6l1mhb.png)
these winds provide the Isthmus with a salient geocentric cue that is readily accessible outdoors

although this cue is available throughout the region, it appears to play a more prominent cultural role in La Ventosa

as reflected in the name (‘the windy one’) and the ubiquity of wind farms, which are a source of great public controversy.

Figure 23. La Ventosa windfarms, taken from the Sierra Sur foothills
evidence from ethnopsysiographic elicitation confirms this

data sources

Lexical inventory/salience of features
- Considerable variation exists between communities (Listing task: 10 speakers, 3 communities, avg. 12 terms/person)

Landmarks in direction-giving
- Route description task: 5 pairs per community

Landmarks/environmental features used in descriptions of small-scale space (Talking Animals)
- Is there significant variation between communities in
  (i) extent of Geocentric use
  (ii) type of Geo use (local/manmade landmark, environmental landmark, absolute/cardinal system)?
- If so, this variable in a statistical model could independently predict use (in discourse & recall)
  vs. community membership, or other factors
Findings

Most frequent responses to a landscape term listing task (items that occurred 5+ times)

- Prompt words were: dani, guiigu, guiixhi

<table>
<thead>
<tr>
<th>La Ventosa</th>
<th>Juchitán de Zaragoza</th>
<th>Santa María Xadani</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yaga ‘tree’ (13)</td>
<td>Yaga ‘tree’ (12)</td>
<td>Nisa do’ ‘sea’ (10)</td>
</tr>
<tr>
<td>Dani ‘hill’ (13)</td>
<td>Guiigu ‘river’ (9)</td>
<td>Dani ‘hill’ (9)</td>
</tr>
<tr>
<td>Bi ‘wind’ (12)</td>
<td>Dani ‘hill’ (9)</td>
<td>Guiixhi ‘forest/jungle’ (7)</td>
</tr>
<tr>
<td>Mani’ ‘animal’ (9)</td>
<td>Mani ‘animal’ (8)</td>
<td>Ranya ‘milpa’ (6)</td>
</tr>
<tr>
<td>Nisa ‘water’ (7)</td>
<td>Yuu ‘house’ (5)</td>
<td>Guiigu ‘river’ (6)</td>
</tr>
<tr>
<td>Guiigu ‘river’ (7)</td>
<td>Nisa ‘water’ (5)</td>
<td>Bize* ‘well’ (6)</td>
</tr>
<tr>
<td>Nisa do’ ‘sea’ (5)</td>
<td>Guixi ‘trash’ (5)</td>
<td>Esteru ‘marsh/swamp’ (5)</td>
</tr>
<tr>
<td>Guie ‘rock/soil’ (5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Listing task responses by community.
Synopsis

- Introduction
- MesoSpace
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Conclusions

confirmed: geography influences spatial language & cognition

- MesoSpace has found evidence of effects of population density and topography
  - as independent factors influencing reference frame use in both discourse and recall memory
- by hypothesis, these effects are primarily mediated by infrastructure and the local availability of potential salient anchors
Conclusions (cont.)

- the challenge of topographic classification
  - there is as yet no universally agreed upon system of variables
    - that jointly capture the morphology of the Earth’s crust everywhere
  - MesoSpace has successfully pioneered the application of the Improved Hammond Classification
    - for the search of cognitive effects of geography
Conclusions (cont.)

- studying cultural mediation between environment and cognition/behavior: ethnophysiography
- community-specific practices evolve around salient environmental gradients
Thank you!

Xquixe pe’ laatu!

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Advisors and committee
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The UB Semantic Typology Lab

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Selected References


Selected References

Selected References


Selected References


Selected References


Appendices:
Model print outs for Zapotec Talking Animals
Geocentric, Write -> Community Membership

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial  ( logit )
Formula: GEOJ ~ CD + L2D + EdD + WriteD + (1 | ID)
Data: mydata

AIC       BIC     logLik deviance df.resid
444.1 471.3    -216.0  432.1      682

Scaled residuals:
          Min       1Q  Median       3Q      Max
-3.9080  0.1834  0.2125  0.3154  0.9009

Random effects:
  Groups   Name         Variance  Std.Dev.
  ID       (Intercept)  0.9783    0.9891
Number of obs: 688, groups: ID, 89

Fixed effects:
                              Estimate Std. Error  z value Pr(>|z|)
(Intercept)                    1.54690    0.51832   2.9840 0.002841 **
CDLAV                           1.61751    0.42981   3.7630 0.000168 ***
L2D                              0.20254    0.30456  -0.6650 0.506043
EdD                             -0.16145    0.28222  -0.5717 0.567270
WriteD                          0.04705    0.20213   0.2330 0.815957

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
                             (Intr)  CDLAV  L2D  EdD  WriteD
CDLAV     -0.211            
L2D       -0.573  -0.429  
EdD        0.110   0.063 -0.250
WriteD    -0.467   0.205 -0.042 -0.457
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']

Family: binomial  ( logit )
Formula: GEOJ ~ CD + L2D + EdD + ReadD + (1 | ID)
Data: mydata

AIC      BIC   logLik deviance df.resid
443.9    471.1 -215.9  431.9     682

Scaled residuals:
          Min     1Q  Median     3Q    Max
-4.0174  0.1844  0.2050  0.3090  0.9058

Random effects:
 Groups   Name         Variance  Std.Dev.
   ID     (Intercept)  1.001     1.001
Number of obs: 688, groups: ID, 89

Fixed effects:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)       1.7078    0.5047  3.3844  0.000715 ***
CDLAV             1.5518    0.4295  3.6133  0.000303 ***
L2D               0.1581    0.3154  0.5010  0.616193
EdD               0.2426    0.2712  0.8942  0.371115
ReadD             0.1133    0.2172  0.5220  0.602014

---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
         (Intr) CDLAV L2D  EdD
CDLAV    -0.199
L2D      -0.493 -0.450
EdD      0.035  0.097 -0.184
ReadD   -0.408  0.184 -0.248 -0.363
Relative, Write -> Community Membership

Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']
family: binomial  ( logit )
formula: RELJ ~ CD + L2D + EdD + WriteD + (1 | ID)
data: mydata

AIC BIC logLik deviance df.resid
458.3 485.5  -223.2  446.3  682

scaled residuals:
Min 1Q Median 3Q Max
-3.4189 -0.2983 -0.2002 -0.1796  3.7679

Random effects:
Groups Name Variance Std.Dev.
ID (Intercept) 1.313  1.146
Number of obs: 688, groups: ID, 89

Fixed effects:
                 Estimate Std. Error  z value Pr(>|z|)
(Intercept) -1.86458   0.57958  -3.217  0.00129 **
CDLAV -1.33916   0.44367  -3.018  0.00254 **
L2D   -0.03556   0.32140  -0.111  0.91189
EdD    0.06220   0.30505   0.204  0.83843
WriteD 0.16911   0.22380   0.756  0.44987

Correlation of Fixed Effects:
                 (Intr) CDLAV  L2D   EdD
CDLAV  -0.309
L2D    -0.569 -0.324
EdD    0.127  0.022 -0.232
WriteD -0.494  0.206 -0.002 -0.508

- Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Relative, Read-> Community

Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']

Family: binomial (logit)
Formula: RELJ ~ CD + L2D + EdD + ReadD + (1 | ID)
Data: mydata

AIC   BIC   logLik deviance df.resid
458.9 486.1   -223.4    446.9     682

Scaled residuals:
    Min     1Q Median     3Q    Max
-4.583  -0.2931  -0.1996  -0.1780   3.6227

Random effects:
  Groups   Name         Variance  Std.Dev.
     ID       (Intercept) 1.356    1.164

Number of obs: 688,  groups: ID, 89

Fixed effects:
            Estimate   Std. Error t value Pr(>|z|)
(Intercept) -1.63179    0.56022  -2.913  0.00358 **
CD         -1.42691    0.45228  -3.155  0.00161 **
L2D        -0.02981    0.32952  -0.090  0.92792
EdD         0.18849    0.28482   0.662  0.50811
ReadD      -0.02197    0.23043  -0.095  0.92404

---

Correlation of Fixed Effects:
       (Intr)  CDLAV  L2D  EdD
CDLAV   -0.316
L2D    -0.503  -0.362
EdD      0.018   0.042 -0.178
ReadD  -0.425   0.244 -0.185 -0.371

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']

family: binomial (logit)

formula: ABSJ ~ CD + L2D + EdD + ReadD + (1 | ID)

Data: mydata

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scaled residuals:

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Random effects:

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</table>

Number of obs: 688, groups: ID, 89

Fixed effects:

|                  | Estimate | Std. Error | z value | Pr(>|z|) |
|------------------|----------|------------|---------|---------|
| (Intercept)      | -0.23793 | 0.70073    | -0.340  | 0.734   |
| CD               | 3.47602  | 0.62308    | 5.579   | 2.42e-08*** |
| L2D              | -0.17488 | 0.43581    | -0.401  | 0.688   |
| EdD              | 0.50912  | 0.37601    | 1.354   | 0.176   |
| ReadD            | 0.04957  | 0.29669    | 0.167   | 0.867   |

Correlation of Fixed Effects:

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<th>EdD</th>
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<tr>
<td>L2D</td>
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<td>ReadD</td>
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Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']

family: binomial ( logit )
formula: ABSJ ~ CD + L2D + EdD + WriteD + (1 | ID)
Data: mydata

AIC      BIC    logLik deviance df.resid
5481.4   508.6  -234.7    469.4     682

Scaled residuals:
          Min       1Q   Median       3Q      Max
-3.29977  0.10810  0.16670  0.29160  2.28950

Random effects:
Groups   Name          Variance  Std.Dev.    Corr
    ID    (Intercept)   2.9022    1.703

Number of obs: 688, groups: ID, 89

Fixed effects:
                    Estimate Std. Error    z value  Pr(>|z|)
(Intercept)          -0.6605     0.7201  -0.91705     0.359
CDLAV                 3.6022     0.6204   5.80581  < 2e-09 ***
L2D                   0.1787     0.4164   0.42907     0.668
EdD                   0.3026     0.3824   0.79070     0.429
WriteD               -0.3723     0.2744  -1.35670     0.175

Corr(Intercept,CDLAV) -0.304
Corr(Intercept,L2D)   -0.564 -0.379
Corr(Intercept,EdD)   0.085  0.032 -0.228
Corr(Intercept,WriteD) -0.480  0.246 -0.048 -0.428

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.
Direct, Write -> Community Membership

A generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']

Family: binomial ( logit )
Formula: DIRJ ~ CD + L2D + EdD + WriteD + (1 | ID)
Data: mydata

AIC BIC logLik deviance df.resid
-85.1 712.3 -336.5 673.1 682

Conditional residuals:
Min 1Q Median 3Q Max
-8.98 -0.5081 -0.3954 -0.3161 2.6862

Correlation of Fixed Effects:
 (Intr) CDLA V L2D EdD
CDLA V -0.277
L2D -0.595 -0.386
EdD 0.110 0.049 -0.231
WriteD -0.476 0.157 0.003 -0.471

Random effects:
 Groups Name Variance Std.Dev.
 (Intercept) 0.3159 0.562

Number of obs: 688, groups: ID, 89

Fixed effects:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)       -1.5203     0.3634  -4.184 2.86e-05 ***
CDLA V            -0.7802     0.2792  -2.794  0.0052 **
L2D                0.3203     0.2046   1.566  0.1174
EdD                -0.2393     0.1820  -1.315  0.1887
WriteD            -0.1923     0.1323  -1.453  0.1461

Residual standard error: 2.6862 on 682 degrees of freedom.
Multiple R-squared:  0.009399, Adjusted R-squared:  0.003574
F-statistic: 0.5718 on 4 and 682 DF, p-value: 0.6644

Diff. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Direct, Read-> Community Membership, Reading

Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']

family: binomial (logit)
-formula: DIRJ ~ CD + L2D + EdD + ReadD + (1 | ID)
-data: mydata

AIC      BIC   logLik deviance df.resid
583.0    710.2  -335.5   671.0       682

Random effects:
  Min   1Q     Median   3Q     Max
8442  -0.5047  -0.3930  -0.3201  2.7717

Correlation of Fixed Effects:
  (Intr) CDLAV  L2D    EdD
CDLAV -0.285
L2D   -0.524 -0.404
EdD   0.028  0.065 -0.160
ReadD -0.396  0.167 -0.205 -0.381

Fixed effects:
  Estimate Std. Error  z value  Pr(>|z|)
 Intercept -1.5412    0.3464    -4.449 8.64e-06  ***
   CDLAV  -0.7364    0.2784   -2.645  0.00816  **
     L2D   0.2316    0.2078    1.115   0.26498
    EdD  -0.2491    0.1736   -1.435   0.15143
   ReadD  0.2806    0.1380    2.032   0.04210  *

---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Landmark, Read -> Community Membership

Generalized linear mixed model fit by maximum likelihood (Laplace approximation) ['glmerMod']
  family: binomial  ( logit )
  formula: LANEJ ~ CD + L2D + EdD + ReadD + (1 | ID)
  Data: mydata

  AIC      BIC    logLik  deviance df.resid
388.9    416.1   -188.5     376.9     682

Random residuals:
  Min  1Q  Median   3Q  Max
5.398 -0.1700 -0.0926 -0.0536 4.2369

Random effects:
  Groups   Name        Variance Std.Dev.
          (Intercept) 4.899   2.213
  Number of obs: 688, groups: ID, 89

Fixed effects:
  Estimate Std. Error  z value Pr(>|z|)
  (Intercept) -0.4116     0.8938 -0.461   0.645
  CDLAV        -4.0363     0.8656 -4.663 3.1e-06  ***
  L2D          -0.5749     0.5807 -1.000   0.315
  EdD           0.5749     0.5807  1.000   0.315
  ReadD       -0.5531     0.3895 -1.416   0.156

Correlation of Fixed Effects:
                 (Intr)  CDLAV  L2D  EdD  ReadD
  CDLAV          -0.164
  L2D            -0.521  -0.490
  EdD            0.023   0.113  -0.196
  ReadD         -0.379   0.279  -0.216  -0.329

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 . ‘.’ 0.1 ‘ ’ 1