A Vector Space Semantics for frames of reference in Yucatec

Overview

- intro: the argument
- the lexical analysis of FoRs
- the indexical analysis of FoRs
- Vector Space Semantics
- FoRs in VSS
- FoRs in Yucatec
- extensions
- summary

Intro: the argument

- two kinds of place functions (Jackendoff 1983)
  - i.e., functions from reference entities into regions
    - topological (Piaget & Inhelder) – perspective=frame-free
    - means in practice independent of the orientation of the ground,
      the observer, and the figure-ground array (the configuration)

(1.1) The apple is on the skewer
(1.2) The band aid is on the shin
(1.3) The earring is in the ear (lobe)

Intro: the argument (cont.)

- alternative classifications and subtypes

Figure 1. Some configurations that might be described in terms of topological place functions

Intro: the argument (cont.)

- projective – framework-dependent
  - the place function returns a region defined in a coordinate system centered on the reference entity
  - the axes of the coordinate system are derived from an anchor
    - in intrinsic frames, the anchor is the reference entity
    - in relative frames, it is the body of an observer
    - in absolute frames, it is some environmental entity/feature

The man is on the side of the tree.
The man is to the right of the tree.
The man is east of the tree.

Figure 2. The three types of spatial FoRs distinguished in Levinson 1996, 2003

Intro: the argument (cont.)

- great amount of crosslinguistic variation
  - in terms of both availability and preferences

Bohnemeyer & Levinson ms.)

Figure 4. Reference frame use in small-scale horizontal space across languages (Bohnemeyer & Levinson ms.)
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Intro: the argument (cont.)

but what do semanticists have to say about FoRs?

  • treats FoRs as part of the meanings of the relators
– my objectives today
  • show that the lexical analysis is inadequate
  • argue that all projective relators are indexicals
    – correcting and generalizing the classic analysis by Bühler 1934
  • develop a model-theoretic treatment in the framework of Zwarts & Winter’s (2000) Vector Space Semantics
  • apply this treatment to the analysis of FoRs in Yucatec
  • sketch extensions of the analysis to landmark-based FoRs

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The lexical analysis of FoRs

• Levinson (1996, 2003)
  – frames are a lexical property of spatial relators
  – the anchor is a semantic argument of extrinsic relators, but not of intrinsic ones
    • intrinsic relators are binary, relative ones are ternary
  – Levinson’s definitions
    • R – the meaning of the spatial relator
    • F – the figure – the entity to be located/oriented
    • G – a reference entity or ground
    • X – the origin of the coordinate system
    • A – an anchor point
    • V – the viewpoint of an observer
    • S = “‘Slope’ of a fixed bearing system, with infinite parallel lines across environment (Levinson 2003: 39)

The lexical analysis of FoRs (cont.)

• problem I: ambiguity
  – intrinsic and relative descriptions are systematically ambiguous between the two interpretations

The lexical analysis of FoRs (cont.)

“An intrinsic spatial relator R is a binary spatial relation, with arguments F and G, where R typically names a part of G. The origin X of the coordinate system is always on the volumetric center of G. An intrinsic relation R(F; G) asserts that F lies in a search domain extending from G on the basis of an angle or line projected from the center of G, through an anchor point A (usually the named facet ‘R’), outwards for a determined distance.” (Levinson 2003: 42-43)

“An absolute relator R expresses a binary relation between F and G, asserting that F can be found in a search domain at the fixed bearing R from G. The origin X of the coordinate system is nearly always centered on G, and the system of terms anchored by reference to a conceptual ‘Slope’ S.” (Levinson 2003: 50)

• absolute relators are treated as binary b/c the environmental “slope” argument S is assumed to be fixed
  • S, V and A are all treated as properties of the anchor in the analysis developed below

Figure 5. Truth conditions of intrinsic and relative descriptions of Ball & Chair 3.9 (left) and 3.12

The lexical analysis of FoRs (cont.)

– Levinson’s account entails that this is polysemy
  – this seems implausible prima facie in view of the fact that the pattern is apparently w/o exceptions
  – moreover, it fails standard polysemy tests
    • (2.1) (uttered wrt Figure 6) does not seem zeugmatic

(2.1) The ball is in front of both chairs. It is relatively in front of the first chair and intrinsically in front of the second chair.
The lexical analysis of FoRs (cont.)

- (2.2) and (2.3) seem to be contradictory

(2.2) # The ball is not in front of the picture, it's between the observer and the picture

(2.3) # The ball is not in front of the picture, it's near the intrinsic front of the picture

- for comparison, a bona-fide case of polysemy:

(2.4) That's not a cow, that's a bull

- the same argument can be advanced for the geocentric family of frames

- where similar ambiguities arise b/w geomorphic or landmark-based and abstract absolute interpretations

The lexical analysis of FoRs (cont.)

- problem III: compositionality

- functors of different arity fulfilling the same semantic function creates a headache

- for compositional treatments

- requiring fixes via type raising operations

- all spatial relators are standardly assumed to be binary regardless of reference frame

- in both mentalist (Jackendoff 1983) and model-theoretic treatments

- e.g., Kracht 2002, Zwarts 2005, Zwarts & Winter 2000

- this suggests that reference frames are not a part of the meaning of spatial relators

- calling for a compositional and/or pragmatic analysis of the interaction b/w relators and frames

The indexical analysis of FoRs

- that relative relators are indexicals has been known since at least Bühler 1934

"Und wenn eines von den derart orientierten Lebewesen, nämlich der Mensch, den Mund auftut und deiktisch zu sprechen anfängt, so sagt er z.B. dort! muß der Bahnhof sein, und nimmt dabei vorübergehend die Haltung eines Wegweisers an. Das Lexikon von Wörtern, die aus demselben Orientierung ihre Feldwerte erhalten, ist mit dem dort noch keineswegs erschöpft. Wenn derselbe Mensch Wörter wie vorn-hinten, rechts-links, oben-unten verwendete, so wird er eine neue Tatsache offenbar, die Tatsache nämlich, daß er in Relation zu seiner optischen Orientierung auch seinen Körper verspürt und zeigend einsetzt.

And when one of the creatures so oriented, man, opens his mouth and begins to speak deictically, he says, e.g., there! must be the train station, and temporarily assumes the bearing of a signpost. The lexicon of words that derive their field values from the same sense of orientation is by no means exhausted with there. When the same person uses words such as front-back, right-left, above-below, a new fact is revealed, namely the fact that he senses his body in relation to his optical orientation as well and uses it for pointing.'

(Bühler 1934: 129; emphasis and translation JB)

Figure 7. Karl Bühler (1879 – 1963) http://www.dasrotewien.at

The indexical analysis of FoRs (cont.)

- the false equation deixis with egocentricity

- Bühler’s notion of indexicality – deixis – is inherently egocentric

"Zwei Striche auf dem Papier, die sich senkrecht schneiden, sollen uns ein Koordinatensystem andeuten, O die Origo, den Koordinatenausgangspunkt [cf. Figure 8; JB]. Ich behaupte, daß drei Zeigwörter an die Stelle von O gesetzt werden müssen, wenn dieses Schema das deiktische Feld der menschlichen Sprache repräsentieren soll, nämlich die Zeigwörter hier, jetzt, und ich.

"Two lines on the paper, intersecting at right angles, shall stand for a coordinate system and O the origin, the coordinates of the starting point [cf. Figure 8; JB]. I argue that three deictic words must take the place of O if this scheme is to represent the deictic field of human language, namely the deictic words here, now, and I.' (Bühler 1934: 102; emphasis and translation JB)

- this may have prevented him from realizing that allocentric relators are just as indexical

- the literature building on Bühler subsequently codified the false equation deixic/indexical = egocentric


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Figure 8.
The indexical analysis of FoRs (cont.)

- Bühler meets Kaplan:
  - the indexicality of projective relators
    - Kaplan (1989) defines indexicality in terms of two properties: context-dependence and character
    - “What is common to the words or usages in which I am interested is that the referent is dependent on the context of use and that the meaning of the word provides a rule which determines the referent in terms of certain aspects of the context. The term I now favor for these words is ‘indexical.’” (Kaplan 1989: 490; emphasis JB)
    - “The second kind of meaning, most prominent in the case of indexicals, is that which determines the content in varying contexts. The rule, ‘I’ refers to the speaker or writer is a meaning rule of the second kind. ... Let us call the second kind of meaning character. The character of an expression is set by linguistic conventions and, in turn, determines the content of the expression in every context.” (Kaplan 1989: 505; emphasis JB)

- The anchor is reference • Bühler meets Kaplan:
  - the indexicality of projective relators
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The meaning of above (Zwarts & Winter 2000: 181)

- A ranges over sets of points, \( v \) over vectors
- \( \text{ext}(v, A) \) requires \( v \) to be connected to \( A \), the region occupied by the ground
- \( v \) denotes the projection of \( v \) on a suitable axis orthogonal to the axis picked out by \( u_p \)

The angle \( \Theta \) for modeling FoRs

- the axis with respect to which the region is defined depends precisely on the frame of reference
- this axis is derived from an axis of the anchor via translation \( \pm \) rotation

Figure 12. Absolute \( (u_{\text{REL}}) \), relative \( (u_{\text{ABS}}) \), and intrinsic \( (u_{\text{INT}}) \) vertical axes of a chair in a given situation (based on Levelt 1996: 90)

Figure 13. An analysis of (4.2) in VSS

- the eigenspace function \( \text{loc} \) maps entities into the regions they inhabit and is supplied by type raising
- the 'antilocation' function \( \text{loc}^- \) maps sets of vectors to the set of entities "contained" in the set of their endpoints

(4.3) \( \text{loc}^- := \lambda W<v,t>. \lambda p \in \text{loc}(x) \exists v \in W \{ e\text{-point}(v) = p \} \)

(Zwarts & Winter 2000: 175)

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FoRs in VSS

- the proposal
  - all 'projective' (non-topological) functions of type \(<<p,t>, <v,t>>\) are indexicals

- implementation
  - the axis function
    - replace the axis constant in the denotation of the projective function...
      - \(up\) in the case of \(above'\)
      \[
      \text{above'} := \lambda A. \lambda v. \text{ext}(v, A) & c(up, v) > |v_{up}|
      \]
    - ... with a function that maps the anchor into a unit vector of the relevant kind
    - e.g., \(up\) maps the anchor into a vertical axis
      - where verticality is interpreted differently depending on the nature and identity of the anchor and thus the FoR

- model theory
  - \([anchor]_{M^0.g.c} = c_o\)
  - \([up(\text{anchor})]_{M^0.g.c}\) denotes for each context
    - the ordered pair of the selected anchor and its vertical axis projected onto the origin of the reference frame

- example
  - \(\forall p \in \text{loc}(\text{the\_cup}) \exists v \in \text{above'}(\text{loc}(\text{the\_table})) | e\text{-point}(v) = p\)
    - \((5.2)^{M^0.g.c} = 1\)
      - if the table is in canonical vertical orientation
        - and the closest vectors pointing from the table to the cup form an acute angle with the gravity vector
      - but also if the table is standing on one side
        - and the closest vectors pointing from the table to the cup form an acute angle with the table's intrinsic vertical axis

- the assignment function
  - assume an “anchored” model \(M^0 = <C, D_o, D_v, D_p, \text{I}, g>\)
    - a set of contexts \(C\)
    - the domains of individuals, points, and vectors
    - the interpretation function
    - and a variable assignment

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- the axis function is part of the meaning of the projective relator (see, e.g., (5.1))
  - expand Zwarts & Winter's object-centric \(up, \text{front}, \text{and right}\) and their negative counterparts
    - with a set of geocentric axes selected by \(upriver, uphill, \text{north, east} etc.\)
    - and their negative and orthogonal partners
  - each type of frame comes with its own unique set of axis functions
  - the anchor constant
    - let a constant \textit{anchor} pick out the anchor
      - the denotation of \textit{anchor} is fixed by the interpretation function

- FoRs in VSS (cont.)
  - a ground phrase headed by a projective relator
    - denotes the set of endpoints of vectors connected to the hull of the ground that form an acute angle...
    - ...with a vector based in the volumetric center of the ground and codirectional with the axis of the anchor
      - picked out by the axis function
      - see, however, below re. the codirectionality requirement
    - a locative description is true iff
      - the eigenspace of the figure is included in the region designated by the ground phrase

- model theory
  - \([\text{anchor}]_{M^0.g.c} = c_o\)
  - \([\text{up(\text{anchor})}]_{M^0.g.c}\) denotes for each context
    - the ordered pair of the selected anchor and its vertical axis projected onto the origin of the reference frame

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    - and their negative and orthogonal partners
  - each type of frame comes with its own unique set of axis functions
two important wrinkles
– two subtypes of relative frames
  • the projection of the selected axis from the anchor onto the ground involves
    – translation + rotation in English-style relative frames
    – translation only in Hausa-style relative frames (Hill 1982)

Figure 17. English- and Hausa-type relative frames

English-style relative frames: the ground as a metaphorical mirror image of the observer
Hausa-style relative frames: the ground as a metaphorical avatar of the observer

absolute frames
– the axes of absolute frames are abstracted from concrete geomorphic and landmark-based systems
  – cf. Levinson 2003: 47-50
– in this case, the anchor does not change with context
– in absolute frames and English-type relative frames
  • the axis from which the designated region is projected is not simply codirectional with the selected axis of the anchor
  – these cases can be dealt with in terms of specialized axis functions

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FoRs in Yucatec
• ongoing research: 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, PI)
  – Mixe-Zoquean
    • Ayuitla Mixe (R. Romero Méndez)
    • Sotapapanec (S. Gutierrez Morales)
    • Tecpatán Zoque (R. Zavala Maldonado)
  – Oto-Manguean
    • Otomi (E. Palancar; N. H. Green; S. Hernández-Gómez)
    • Juchitán Zapotec (G. Pérez Báez)
    • Purepecha (A. Capistrán)
    • Totonacan
    • Huehuete Tepehua (S. Smyth Kung)

Figure 19. The MesoSpace field site

Figure 20. Meronyms in Ayoquesco Zapotec (left) and Tenejapa Tseltal (adapted from MacLaury 1989 and Levinson 1994)
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FoRs in Yucatec (cont.)

- the MesoSpace tool for studying FoRs in discourse - Ball & Chair (B&C)
  - 4 x 12 photographs of configurations of a ball and chair
  - participants match corresponding pix in two identical sets through referential communication

- B&C was conducted
  - with five pairs of Yucatec speakers
  - in the summer of 2008

- results
  - cf. Bohnemeyer in press

Figure 23. A Yucatec B&C trial

- examples: locative descriptions
  - topological
    (6.1) (...)
    DADV where IMPF-A3=sit:INCH.INC person=D2 PREP=DET=earth=D2
    hun-p'eel b'ola p'ek-ekbal
    one-CL.IN ball lie.as.if.dropped-DIS(B3SG) really
    '(...)' there where one sits, on (lit. with respect to) the ground, a ball is lying, right at its corner.'

- object-centered
  (6.2) (...)
  PREP=exists(B3SG) DET=ball PREP=DET=back
  ti'=pek-eekbal
  PREP=lie.as.if.dropped-DIS(B3SG) one-CL.IN
  'There lies a little ball, on (the chair's) side.'

- landmark-based
  (6.5) B'ól=e',
  PREP=exists(TOP) DET=ball
  ti'=yàan le=b'ola tu=pach/ab'il=lo'
  PREP=EXIST(B3SG) DET=ball PREP=A3=back:hand:REL=D2
  'But toward the [volleyball] court, there's the ball behind [the chair]'
FoRs in Yucatec (cont.)

- **landmark-based**
  
  (6.9) \( \ldots \)u=fleente tu’x k-u=kutal máak=o’,
  YUC A3=front where IMPF-A3=sit:INCH.INC person=D2
  le=kàancha=o’
  PREP:A3=straight-REL DET=court=D2
  ‘(…) its front where one sits, it’s in a straight line
  with respect to the volleyball court.

- **direct**
  
  (6.10) Tu’x k-u=nak-tal máak=o’,
  YUC where(B3SG) IMPF-A3=lean.against-INCH.INC person=D2
  estée ta=freente súut-ul
  HESIT PREP:A2=front turn\(\text{MIDDLE-INC}(B3SG)
  ‘The back (lit. where one leans against), uh,
  it’s turned towards your front.’

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**Extensions**

- the Yucatec data suggests two additional phenomena a semantics for FoRs should cover
  - orientation descriptions
  - head-anchored descriptions
- orientation descriptions are by necessity
  - projective - there are no topological orientation descriptions
  - extrinsic – there are no intrinsic/object-centered orientation descriptions

---

**Extensions (cont.)**

- making orientation descriptions work
  - the reference frame is centered on the figure
  - not on the ground as in locative descriptions
  - the axis function serves to align a suitable axis
  of the figure

  **Orientation**: any vector \( \mathbf{v} \) defines the orientation of an object if
  
  \( \text{(i)} \) the base of \( \mathbf{v} \) is the center of the object,
  \( \text{(ii)} \) \( \mathbf{a} \) is codirectional with one of the object’s axes
  and pointing outward.
  By default, \( \mathbf{v} \) is codirectional with the object’s front axis.

  ![Diagram](image)

- making head-anchored descriptions work
  - the axis function in this case defines a set of vectors whose endpoints are on the anchor
  - rather than to select an axis of the anchor,
    as in angular-anchored frames

  (7.2) The chair is facing the door/us
  (7.3) The ball is towards the door/us from the chair

  ![Diagram](image)
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Summary

• proposals argued for
  – spatial frames of reference are not a part of the lexical meaning of spatial relators
  – projective spatial relators are indexicals
  – orientation descriptions are necessarily projective and extrinsic
  – two routes to constituting a reference frame
    – in angular-anchored descriptions, an axis of the frame is “copied” from one of the anchor
      – via translation ± rotation
    – in head-anchored descriptions, an axis of the frame is defined as a vector pointing toward the anchor

References


References (cont.)


