

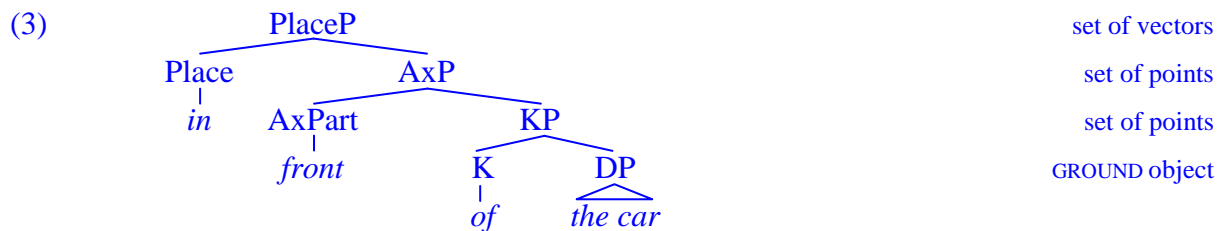
**AXES TO GRIND**  
GLOW 41, April 10-14, 2018

**1. BACKGROUND**

**Axial prepositional complexes** are widespread cross-linguistically:

- (1) a. El libro está **de-l-ante** **de la** **mesa**. Spanish, Fábregas 2007  
 the book is from-the-front of the table  
*The book is in front of the table.*
- b. hu haya **mi-taxat** **la-bayit/ha-bayit**. Hebrew, Botwinik-Rotem 2008a  
 he was from-bottom to.DEF-house/ DEF-house  
*He was under the house.*
- c. **S-pered-i** **ot** **dom-a** roslo derevo. Russian, Mitrofanova and Minor 2013  
 down.from-front-LOC from house-GEN grew tree  
*A tree grew in front of the house.*
- (2) Maria a-mami **î-gûrû ri-a metha**. Kĩitharaka, Muriungi 2006  
 1.Maria SM1-sleep 5-top 5-AS 9.table  
*Maria is sleeping/lying on top of the table.*

Svenonius 2006, 2010, etc.: axial elements (AxParts) are regarded as **purely functional**:



Lots of followers (Pantcheva 2006, Muriungi 2006, Svenonius 2006, 2010, Fábregas 2007, Takamine 2007, Botwinik-Rotem 2008a, Roy and Svenonius 2009, Romeu 2014, etc.)

**2. PROBLEMS**

Core issue: axial elements seem to be lexical

**2.1. Axial objects**

For the majority of axial elements a corresponding noun exists showing nominal syntax and a clearly related lexical meaning:

- (4) a. A hat is **on top of your head**. AxPart  
 b. Your forehead is **at the top of your head**. noun
- (5) **Î-gûrû i-rî** ciat-ir-w-e. Kĩitharaka, Muriungi 2006  
 5-top F-SM5 sweep-PERF-PASS-FV  
*The top [of something] was swept.*

Natural question: what is the syntactic and semantic **connection between an AxPart and the corresponding lexical noun**?

**2.2. Axial nouns may show case morphology**

Russian: the locative vs. directional interpretation of some PPs is encoded by the case on the NP (cf. Bierwisch 1988, den Dikken 2003, 2010, Zwarts 2005, 2006, Caha 2010):

- 
- (6) a. Marina bežit v gorod. Russian  
Marina runs in city.ACC  
*Marina is running to the city.*
- b. Marina bežit v gorode.  
Marina runs in city.LOC  
*Marina is running in the city.*

The same can be observed with axial complexes:

- (7) a. Marina bežit v.perëd. Russian  
Marina runs in.front.ACC  
*Marina is running forward.*
- b. Marina bežit v.peredi.  
Marina runs in.front.LOC  
*Marina is running in front.*

### 2.3. Non-axial AxParts

AxParts can be highly idiosyncratic and semantically conditioned by the ground:

- (8) a. There is a defibrillator **on board this train/aircraft/spaceship/#theater.**
- b. Les fleurs poussent **au pied de l'arbre.**  
the flowers grow at.the foot of the.tree  
*Flowers grow at the foot of the tree. [i.e., on the soil around the tree]*

### 2.4. Nominal properties of AxParts

The presence of a **definite article** in axial complexes is unexpected if they are functional, and the article agrees for **gender** and undergoes the *en/au* alternation (cf. Cornulier 1972, Zwicky 1987, Miller, Pullum and Zwicky 1997, Matushansky 2015) in French:

- (9) a. à la tête du train Roy 2006  
to the.F head.F of.the train  
*in the front section of the train*
- b. en tête du train  
in head of.the train  
*in the front section of the train*

Plural AxParts are possible if rare:

- (10) a. aux alentours de la ville French  
to+the.PL surroundings.PL of the city  
*around the city*
- b. La casa está a orillas del río. Spanish, Romeu 2014  
the house is to riverside.PL of.the river  
*The house is at the river side.*

KP is moreover generally possessive (with some exceptions), yet in Roy and Svenonius 2009 K is supposed to lexicalize the EIGEN function (which is also problematic because regions do not have the wherewithal to determine what their front is)

### 2.5. Connection to weak definites

The choice of the AxPart determines the presence of the article:



In Romance the putative source component *de* could be analyzed as possessive (*de* is also the genitive ‘of’)

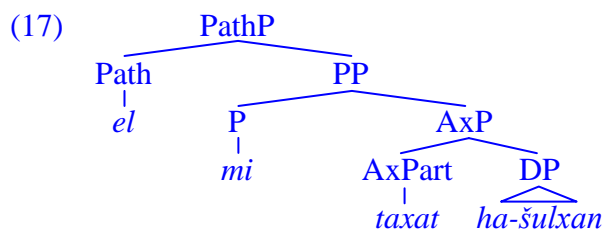
But in Hebrew, it is identical to the **directional preposition** *mi-* ‘from’:

- (15) a. **mimul** \*(le) batim gvohim ve- atikim Hebrew, Botwinik-Rotem 2008a  
 opposite (to) houses tall and old  
*opposite tall and old houses*
- b. **me'al/mitaxat** (le) batim gvohim ve- atikim  
 above/under (to) houses tall and old  
*above/under tall and old houses*

This source element is compatible with a higher directional (allative) layer, showing that **the meaning of the axial complex PP** (*mi.taxat ha-šulxan*) **is locative**:

- (16) hu hitgalgel el mi.taxat ha-šulxan. Hebrew, Botwinik-Rotem 2008b  
 he rolled to from.bottom the-table  
*It/he rolled under the table.*

Adding the directional component PathP (cf. Jackendoff 1983, Koopman 2000):



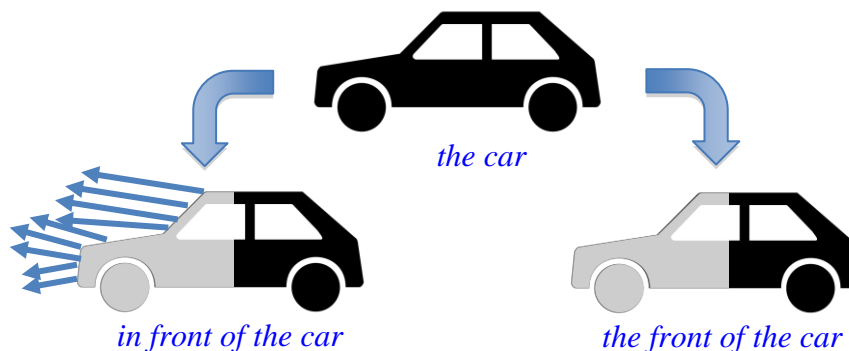
How come that a source preposition like *mi-* is used to describe a location?

Answer: axial complexes describe locations through **projection** away from a ground

The semantic component unifying projective axial complexes and source Ps: directions, either **vectors** or **paths**, pointing **away from** the ground

Botwinik-Rotem 2008a: *mi-* is semantically vacuous. Unlikely: *dedans* ‘inside’, etc., in French, *delante* ‘in front of’, etc., in Spanish (which also has *alante* ‘in front of’), but also a source component in *99 miles from LA*

(18) Vector-space approach to projective axial complexes



**Projective axial complexes** (*in front of the car*) have a component that is absent from axial part objects (*the front of the car*):

- *in front of the car* denotes a set of vectors, which is the denotation of locative PPs in vector-space semantics (Zwarts and Winter 2000)
- *the front of the car* denotes an object, which is the denotation of referential DPs

As we will see below, this is not true for all axial complexes (cf. *on top of the car*)

### 3.1. The axial starting point

Core principles of spatial language and cognition (cf. Herskovits 1986 and many others) allow for the assignment of **axes** (like tops and fronts) to an object on the basis of its shape, function, the position of the perspective holder, etc.

For the sake of simplicity we abstract away from the complications added by the frame of reference (intrinsic *at the top of the truck* vs. relative *to the left of the tree* vs. absolute *north of the border*), cf. Levinson 1996a, b

These axes can be represented in terms of **sets of vectors** (combining shape and orientation)

(19)  $TOP = \lambda x \in D_e . \lambda u \in D_v . START(u) = CENTER(x)$  and  $END(u) \in BOUNDARY(x)$   
 and  $UP(u)$ ,  
 the primitives  $START, END, BOUNDARY$ , etc., are defined as in Zwarts and Winter 2000

(20) Maria a-mami **î-gûrû ri-a metha.** Kĩitharaka, Muriungi 2006  
 1.Maria SM1-sleep 5-top 5-AS 9.table  
*Maria is sleeping/lying on top of the table.*

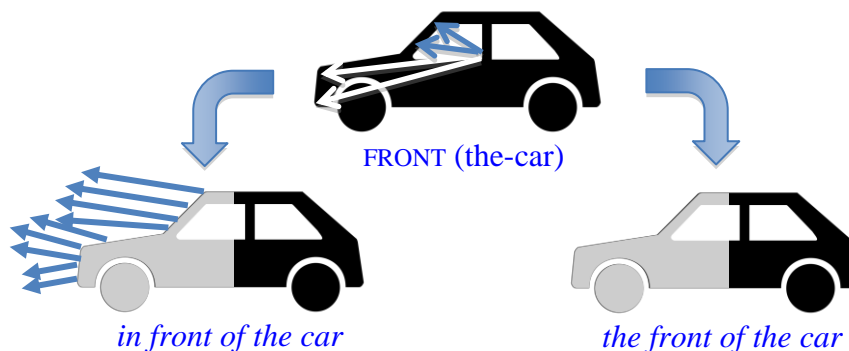
Such **topological** axial complexes are not compatible with measure phrases or modifiers:

- (21) a. \*twenty meters on top of the house  
 b. \*diagonally on top of the house

Spatial core of *top*: a function  $TOP$  that maps an object  $x$  to the **set of vectors** starting from its center, ending at the boundary and directed upward

From this spatial core we can define the **axial part object** (the object that occupies the space defined by (24)) and the **axial projection** (the space outside the ground directed away from the axial object)

(22) Axial derivatives



### 3.2. Deriving the axial part noun

Object part meaning of *front* (in *the front of the car*, for instance)

- (23)  $[[top_{PART}]] = \lambda x \in D_e . OBJECT(TOP(x))$
- $TOP$  maps an object  $x$  to its top axis (the set of vectors pointing from the center of  $x$  to the top boundary of  $x$ , as in (24))
  - $OBJECT$  maps an axis  $A$  to the unique object corresponding to it
  - The uniqueness of the axial part object explains the regular definite article

Important:  $OBJECT$  does not seem to be a compositional part of *top* either syntactically or in the lexicon (as an affix); it is merely a shorthand description permitting to identify the spatial core

The **diachronic derivation** is obviously from the concrete part to the axial noun (see Appendix)

### 3.3. Deriving the axial projection

Projective meaning of *front* (for *in front of the car*, for instance)

Starting with the front axis:

(24)  $FRONT = \lambda x \in D_e . \lambda u \in D_v . START(u) = CENTER(x) \text{ and } END(u) \in BOUNDARY(x) \text{ and } FORWARD(u, x)$

Adding the projective component:

(25)  $\llbracket front_{PROJ} \rrbracket = \lambda x \in D_e . PROJECT(FRONT(x))$  vector-based semantics for *front*

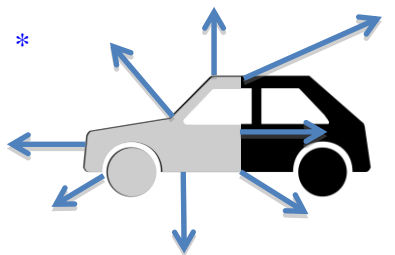
- FRONT maps  $x$  to its front axis
- PROJECT maps an axis  $A$  to the set of vectors that extend it

Unlike axial objects, which are defined relative to the ground (intrinsic frame of reference), axial projections can be defined relative to the ground, relative to the viewer or absolute. While this is a further reason not to derive the latter from the former, the need to parameterize FRONT for the frame will be left as a topic for the future.

(26)  $PROJECT = \lambda f \in D_{\langle v, t \rangle} . \lambda u \in D_v . \exists w [f(w) \text{ and } START(u) = END(w) \text{ and } DIR(u) = DIR(w)]$

Crucial: the projection *in front of the car* cannot be derived from the part denoted by *the front of the car*: a projection of an object would be in all directions, including the interior of the car

(27) projecting the axial object



PROJECT (the-front-of-the-car)

Possible solution: *front, bottom, top*, etc., are special objects with only one defined exterior. Factually incorrect: *under the front of the thalamus* is perfectly fine

## 4. AXPARTS AS LOCATIVES

If  $front_{PROJ}$  of the car denotes a set of vectors (a location), then why wouldn't it behave like a locative (e.g., like *home*)?

In many languages (some) axial nouns do in fact not need prepositions:

(28) Maria a-kari **ru-ngu** rw-a ndagaca. Kĩtharaka, Muriungi 2006  
 1.Maria SM1-sit 11-under 11-AS bridge.9  
*Maria is sitting under the bridge.*

(29) yeš hadaš **taxat** la-šemeš. Hebrew  
 there.is new bottom to.DEF-sun  
*There is something new under the sun.*

(30) The town is located **north of the border**.

**What is not expected:**

- the outer preposition: *in front of the car* (because a preposition requires an entity)
- the definite article: *at the foot of the bed* (because an article requires a predicate)

What do the axial projections *front of the car* and *foot of the bed* denote in such cases?

## 5. THE ROLE OF THE DEFINITE ARTICLE

Intuition: axial NPs like *front of the car* or *foot of the bed* are **weak** definites (cf. Carlson and Sussman 2005)

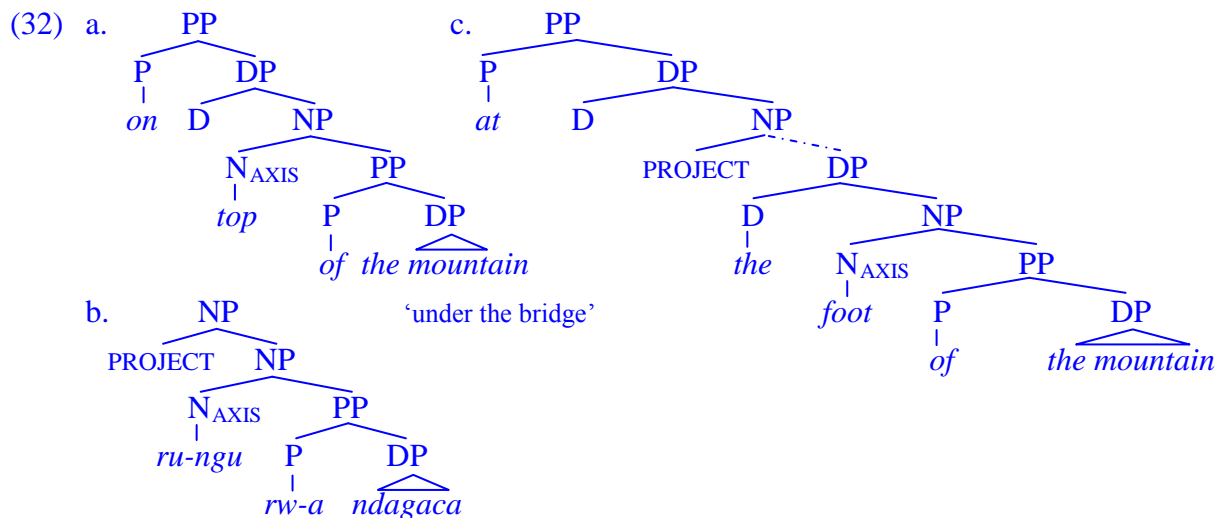
- like *school* in *at school* and *hospital* in *at the hospital*
- lexically specified presence/absence of article
- lack of modification and other restrictions
- typical occurrence in the context of (pre-determined) prepositions

(31) **Implementation: weak NPs as “kind”-referring** (Aguilar Guevara and Zwarts 2010)

- *front of the car* and *foot of the bed* denote **spatial “kinds”**
- spatial version of Chierchia’s (1998) nominalization operator NOM maps a set of vectors to the singleton set consisting of the corresponding **entity-correlate**
- depending on the noun, there is an overt definite article to mark the uniqueness
- prepositions are there to go from the entity-correlate “back” to vectors

Prediction (apparently correct): no overtly definite axial complex without a preposition

We thus obtain a variety of compositional possibilities of varying complexity:



Important: (32) need not be the real syntactic structures – this is about semantic composition

(33) **Kĩtharaka: no prepositions necessary**

- a. Maria a-mami **î-gûrû ri-a metha.** non-projective  
 1.Maria SM1-sleep 5-top 5-AS 9.table  
*Maria is sleeping/lying on top of the table.*
- b. Maria a-kari **ru-ngu rw-a ndagaca.** projective  
 1.Maria SM1-sit 11-under 11-AS bridge.9  
*Maria is sitting under the bridge.*

(34) **English: projective options**

- a. north of the mountain
- b. in front of the mountain
- c. at the foot of the mountain

(35) **English: non-projective options**

- a. next to (?)
- b. on top of the mountain
- c. at the corner of a busy intersection (?)

## 6. THE ROLE OF THE PREPOSITION

Two issues: (a) why P and (b) why do different AxParts require different Ps?

- (36) a. in front of the house projective  
 b. to the side of the house

Two options for (b):

- the same semantics (instantiation of a spatial kind, INST) but different realizations in function of the noun they combine with
- the prepositions have their normal semantics and the choice depends on how the axial noun is conceived of (e.g., *in the ground*: *ground* is not a container but the preposition *in* is used because *ground* has a privileged way of accessing it), cf. *at school* vs. *in yeshiva*

No evidence yet for making a choice

## 7. STRUCTURE VS. LEXICON

We get the following maximal semantic structure (ignoring the possessive/genitive marking on the ground)

- (37) INST<sub>1</sub> (DEF<sub>1</sub> (NOM<sub>1</sub> (PROJECT (INST<sub>2</sub> (DEF<sub>2</sub> (NOM<sub>2</sub> (AXIS (GROUND))))))))))

This structure is motivated by

- the parts we recognize in axial complexes
- the input/output conditions we assume for each component

But as a result we get Duke of York derivations (38) and intermediate syntactic constituents that are not attested independently

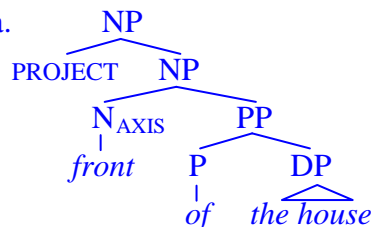
- (38) a. A → B → A  
 b. set of vectors –NOM→ entity –INST→ set of vectors

This problem is, however, an illusion:

- there is no INST (DEF (NOM ())) sequence in syntax: we have NOM ° AXIS and NOM ° PROJECT in the lexicon
- the realization of NOM ° PROJECT *de* in Romance does not require that PROJECT be there as an independent syntactic terminal
- the non-independence of intermediate syntactic constituents can result from their denotation (spatial kinds)

In other words, the English *front* (and probably the Kîtharaka *ru-ngu*) is not embedded in a syntactic structure as in (39a) with the lexical entry in (24), but has the lexical entry in (39b)

- (39) a. no



- b. [[front]] = NOM ° PROJECT ° FRONT AXIS yes

The cross-linguistic variation in the syntax of *top*, etc., is therefore derived from the lexicon

## 8. CONCLUSION AND FURTHER QUESTIONS

The usually assumed syntactic structure in (3) does not account for the observed patterns



Discussed above:

- lexical inadequacy: axial elements are lexical, not functional
- descriptive inadequacy: axial complexes do not have the same syntax

Proposed here:

- AxParts are nominal
- They have semantics based on locative notions, which may be encoded as kinds
- They necessitate the PROJECT concept, which may but need not be syntactically present
- Functional elements appearing the axial complex must be taken at face value

## 9. APPENDIX 1: CROSS-LINGUISTIC VARIATION AS ORIGINATING IN THE LEXICON

Lexical derivations above: (47a) introduces a lexically constructed AxPart:

- (40)  $[[\text{front}_{\text{PROJ}}]] = \text{NOM} \circ \text{PROJECT} \circ \text{FRONT}$   
with  $\circ$  indicating **function composition**

Natural question: must we build these structures in the lexicon?

Putative answer: no

### 9.1. Overt evidence for entity-denotation below PROJECT: the Spanish *delante* ‘in front’

Assuming that *de* corresponds to PROJECT:

- (41) *delante del coche* ‘in front of the car’

- a.  $[[\text{ante}]] = \lambda x \in D_e . \text{NOM} (\text{FRONT} (x))$   
(lexical meaning of *ante*, a “nominalized” axis)
- b.  $[[\text{ante del coche}]] = \text{NOM} (\text{FRONT} (\text{THE-CAR}))$   
(result of application to the car)
- c.  $[[\text{l ante del coche}]] = \text{DEF} (\text{NOM} (\text{FRONT} (\text{THE-CAR})))$   
(definite article giving uniqueness)
- d.  $[[\text{de l ante del coche}]] = \text{PROJECT} (\text{INST} (\text{DEF} (\text{NOM} (\text{FRONT} (\text{THE-CAR}))))$   
(with INST as type-shift, shifting the entity-correlate of the car’s front axis back to the corresponding set of vectors, which can then be projected by PROJECT)

It is possible to treat *delante* as a syntactic terminal, defined as the function composition of PROJECT  $\circ$  FRONT if the article-like *l* is disregarded. Otherwise we need the full combination of the pieces identified above: PROJECT  $\circ$  INST  $\circ$  DEF  $\circ$  NOM  $\circ$  FRONT

### 9.2. Overt evidence for entity-denotation above PROJECT: the French *au-delà* ‘beyond’

We observe the following elements in *au-delà*:

- (42) *à* ‘at, to’ + *le* ‘the’ + *de* ‘of, from’ + *là* ‘there’

Preferable solution: lexical construction of *delà* given that *là* by itself only means ‘there’

If not, the following semantic composition for *au-delà du pont* ‘beyond the bridge’

- (43) a.  $[[\text{là}]] = \lambda x \in D_e . \text{YOND} (x)$   
(lexical meaning of AxPart *là*: the sets of vectors to the furthest boundary of  $x$ )
- b.  $[[\text{là du pont}]] = \text{YOND} (\text{THE-BRIDGE})$   
(DP denoting entity-correlate corresponding to ‘beyond’ axis of bridge)

- c.  $[[de\ là\ du\ pont]] = PROJECT\ (INST\ (YOND\ (THE-BRIDGE)))$   
 (outward projection of that axis)
- d.  $[[le\ de\ là\ du\ pont]] = DEF\ (NOM\ (PROJECT\ (INST\ (YOND\ (THE-BRIDGE)))))$   
 (another round of nominalization ...)
- e.  $[[à\ le\ de\ là\ du\ pont]] = INST\ (DEF\ (NOM\ (PROJECT\ (INST\ (YOND\ (THE-BRIDGE))))))$

Because *au delà* ‘beyond’ is compatible with measure phrases, *à* should be treated as INST  
 Issue: what about the potentially ground-external *à la tête du train/en tête du train*? Ambiguity?

## 10. APPENDIX 2: INDIVIDUAL CASES

### 10.1. A projective axial noun denoting a location: *north of*

The simple case, no article or preposition (like Kîtharaka)

(44) *north of the city*

- a.  $[[north_{PROJ}]] = \lambda x \in D_e . PROJECT\ (NORTH\ (x))$   
 (lexical meaning of AxPart *north*, maps directly to a set of vectors)
- b.  $[[north_{PROJ}\ of\ the\ city]] = PROJECT\ (NORTH\ (THE-CITY))$   
 (the set of vectors pointing north from the northern boundary of the city)

Axes not denoting cardinal points require nominal structure in English, with or without an article

### 10.2. A projective axial noun denoting a kind: *to the north of*

The more complex case, with an article and a preposition

This is not a complex PathP: *of the city* is not path-denoting, so *north* is not entity-denoting

NOM lexically combines with the projection (PROJECT) of the axis:

(45) *to the north of the city*

- a.  $[[north_{PROJ}]] = \lambda x \in D_e . NOM\ (PROJECT\ (NORTH\ (x)))$   
 (lexical meaning of AxPart *north*, the “nominalized” variant of (44))
- b.  $[[north_{PROJ}\ of\ the\ city]] = NOM\ (PROJECT\ (NORTH\ (THE-CITY)))$   
 (the singleton set consisting of the entity-correlate of the set of the vectors pointing north from the city)
- c.  $[[the\ north_{PROJ}\ of\ the\ city]] = DEF\ (NOM\ (PROJECT\ (NORTH\ (THE-CITY))))$   
 (DP denoting the entity-correlate of the relevant external region)
- d.  $[[to\ the\ north_{PROJ}\ of\ the\ city]] = INST\ (DEF\ (NOM\ (PROJECT\ (NORTH\ (THE-CITY)))))$   
 (preposition *to* mapping to the set of vectors instantiating entity-correlate)

Crucial: because **to the north of is compatible with measure phrases**, the set of vectors that INST gives us should be identical to PROJECT (NORTH (THE-CITY))

Potential objection: *the north of the city* is an axial object, *to* adds direction. Answer: not predicted to be outside

This looks like a classical Duke-of-York derivation (Pullum 1976), with a twist: there is full restoration to the input for all outputs

Reasonable objection: the preposition and the article are semantically vacuous.

We would be happy with this idea, but: **what are the conditions on their distribution** (not even the choice of a specific item, but the presence or absence of a syntactic terminal)?

Until this question is answered, we’re stuck with a semantic approach

Issue: **the choice of the preposition is determined by the noun**, as in weak definites:

- (46) a. **in** country, **at** pasture, **on** property Stvan 1998  
 b. **in** yeshiva, **at** school

But for bare weak definites **the choice is local** (no article)

### 10.3. A projective bare axial noun denoting a kind: *in front of*

As before, but with a null definite article:

- (47) *in front of the car*
- a.  $\llbracket \text{front}_{\text{PROJ}} \rrbracket = \lambda x \in D_e . \text{NOM} (\text{PROJECT} (\text{FRONT} (x)))$   
 (lexical meaning of AxPart *front*)
- b.  $\llbracket \text{front}_{\text{PROJ}} \text{ of the car} \rrbracket = \text{NOM} (\text{PROJECT} (\text{FRONT} (\text{THE-CAR})))$   
 (the singleton set consisting of the entity-correlate of the relevant external region)
- c.  $\llbracket \emptyset \text{ front}_{\text{PROJ}} \text{ of the car} \rrbracket = \text{DEF} (\text{NOM} (\text{PROJECT} (\text{FRONT} (\text{THE-CAR}))))$  DEF =  $\emptyset$   
 (DP denoting the entity-correlate of the relevant external region)
- d.  $\llbracket \text{in front}_{\text{PROJ}} \text{ of the car} \rrbracket = \text{INST} (\text{DEF} (\text{NOM} (\text{PROJECT} (\text{FRONT} (\text{THE-CAR}))))))$   
 (preposition *in* = INST maps entity back to set of vectors)

Crucial: because *in front of* is compatible with measure phrases, the set of vectors INST gives us should be identical to PROJECT (FRONT (THE-CAR))

Modulo some tweaking: only orthogonal vectors count, cf. *diagonally in front of*.

Unresolved issue: why is *in front*, but *to the left*? Is there a system? Russian seems to suggest that there isn't (but Russian axial complexes are even more complex)

## 11. APPENDIX 3: HISTORICAL DEVELOPMENT

Axial nouns are derived from the part-whole vocabulary (cf. *front*: MEng. *front* 'forehead'). This is why **axial objects always have intrinsic frames**:

- (48) a. The bike is on top of the car.  
 b.  $\neq$ The bike is on the top of the car.



In order to create an AxPart from an axial noun, it is necessary to impoverish its meaning to the corresponding spatial relation (the axis):

- (49) *front* 'forehead'  $\rightarrow$  the set of vectors starting at the center of an object and ending at that boundary of the object where its forehead stereotypically is

For this change of interpretation it is necessary to postulate a function that applies both to the function *front* and to the ground (i.e., this **cannot be achieved by function composition**)

Consequences:

- **no synchronic derivation** of the AxPart from the corresponding axial object
- **cross-linguistic variation** in the meaning of *front*, etc.: how big an object it is

- the potential for the emergence of the **absolute** frame of reference: replacing the stereotypical position of the top by the absolute direction (UP)

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