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

   b. hu haya **mi-taxat la-bayit/ha-bayit**. Hebrew, Botwinik-Rotem 2008a
   
   he was from-bottom to DEF-house/DEF-house

   c. **S-pered-i ot dom-a rosol derevo**. Russian, Mitrofanova and Minor 2013
   
   A tree grew in front of the house.

(2) Maria **a-mami ì-gûrû ri-a metha**. Kîîtharaka, Muriungi 2006

   1.Maria SM1-sleep 5-top 5-AS 9.table
   
   Maria is sleeping/lying on top of the table.


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) **Ì-gûrû i-ri ciat-ir-w-e.** Kîîtharaka, 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

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.

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
   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
       to+the.PL surroundings.PL of the city
       around the city
   b. La casa está a orillas del río.
      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 EIGN 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:
(11) a. in (#the) front of the car
b. at *(the) foot of the bed

(12) a. au/*à pied du lit
to.DEF.M/to foot.M of.DEF.M bed
at the foot of the bed
b. à/#au côté de chez Swann
to/to.DEF.M side.M of at Swann
by the Swann’s house

This is very similar to what happens with bare weak definites, like in bed (Ross 1996, Stvan 1998, 2007, Carlson and Sussman 2005, Aguilar Guevara and Zwarts 2010, 2013, Aguilar Guevara 2014, etc.), where the presence or absence of the article is intimately linked to the choice of the noun.

Further support: similar restrictions on syntax (Ross 1996): modification, pronominalization, pluralization and preposing are equally broadly impossible with both, and the presence of an outer preposition and its rigid choice is a further indication of this similarity.

2.6. Summary

AxParts have nominal distribution and axial complexes may contain an axial DP

Assuming AxParts are nouns explains a number of facts:

- the presence of the article and its variable absence
- gender agreement on it
- idiosyncratic axial parts
- connection to axial objects

Needs to be explained:

- the semantics of AxParts and axial objects
- the weak definite connection
- non-prepositional axial complexes (north of the border)

Core proposal: semantic decomposition of an axial complex:

(13) INST₁ ( DEF₁ ( NOM₁ ( PROJECT ( INST₂ ( DEF₂ ( NOM₂ ( AXIS ( GROUND ))))))))

Key intuitions: the projective component and the variable entity/region denotation

3. Proposal: Composition

Cross-linguistic evidence points towards a source component in axial complexes (14) that is not expected under any standard assumptions:

(14) a. El libro está de.lante 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 DIR+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.

There is no obvious reason why Place in Svenonius’ structure should be lexicalized as source, or why this lexicalization systematically targets AxParts.
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’:

\[(15)\]  
\[
\begin{align*}
\text{a. } & \text{ mimul *(le) batim gvohim ve- atikim} \\
& \text{Hebrew, Botwinik-Rotem 2008a} \\
& \text{opposite (to) houses tall and old} \\
& \text{opposite tall and old houses}
\end{align*}
\]

\[
\begin{align*}
\text{b. } & \text{ me’al/mitaxat (le) batim gvohim ve- atikim} \\
& \text{above/under (to) houses tall and old} \\
& \text{above/under tall and old houses}
\end{align*}
\]

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**:

\[(16)\]  
\[
\begin{align*}
& \text{he rolled to from/bottom the-table} \\
& \text{Hebrew, Botwinik-Rotem 2008b} \\
& \text{It/he rolled under the table.}
\end{align*}
\]


\[(17)\]  
\[
\begin{align*}
& \text{PathP} \\
& \text{Path} \\
& \text{PP} \\
& el P AxP \\
& mi AxPart DP \\
& taxat ha-šulxan
\end{align*}
\]

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

\[(18)\]  
\[\text{Vector-space approach to projective axial complexes}\]

**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)

\[(19) \quad \text{TOP} = \lambda x \in D_e \cdot \lambda u \in D_v \cdot \text{START} (u) = \text{CENTER} (x) \text{ and END} (u) \in \text{BOUNDARY} (x) \text{ and UP} (u) \]

the primitives START, END, BOUNDARY, etc., are defined as in Zwarts and Winter 2000

\[(20) \quad \text{Maria a-mami ì-gûrû ri-a metha.} \quad \text{Kîtharaka, Muriungi 2006} \]

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)

\[(22) \quad \text{Axial derivatives} \]

3.2. Deriving the axial part noun

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

\[(23) \quad \text{TOP}_{\text{PART}} = \lambda x \in D_e \cdot \text{OBJECT} (\text{TOP} (x)) \]

- 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:

\[
\text{FRONT} = \lambda x \in \mathbb{D}_x . \lambda u \in \mathbb{D}_y . \text{START}(u) = \text{CENTER}(x) \text{ and END}(u) \in \text{BOUNDARY}(x) \text{ and FORWARD } (u, x) \]

Adding the projective component:

\[
\text{PROJECT} = \lambda f \in \mathbb{D}_{(y, 0)} . \lambda u \in \mathbb{D}_y . \exists w [f(w) \text{ and START } (u) = \text{END } (w) \text{ and DIR } (u) = \text{DIR } (w)]
\]

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.

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.

\[
\text{PROJECT } (\text{the-front-of-the-car})
\]

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* 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 some thing 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:

(32) a. \[ PP \quad \] on \[ NP \quad \]
    b. \[ NP \quad \]
    c. \[ PP \quad \]

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

a. Maria a-mami ñ-gûrû ri-a metha.  
   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.  
   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  
    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) \[ \text{INST}_1 (\text{DEF}_1 (\text{NOM}_1 (\text{PROJECT} (\text{INST}_2 (\text{DEF}_2 (\text{NOM}_2 (\text{AXIS} (\text{GROUND})))))))) \]

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. \( A \rightarrow B \rightarrow A \)  
    b. set of vectors \( \rightarrow \text{NOM} \rightarrow \text{entity} \rightarrow \text{INST} \rightarrow \text{set of vectors} \)

This problem is, however, an illusion:
- there is no \( \text{INST} \left( \text{DEF} \left( \text{NOM} () \right) \right) \) sequence in syntax: we have \( \text{NOM}^* \text{AXIS} \) and \( \text{NOM}^* \text{PROJECT} \) in the lexicon
- the realization of \( \text{NOM}^* \text{PROJECT} \text{de} \) in Romance does not require that \( \text{PROJECT} \) 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 Kĩtharakana *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.  
   b. \[ \left[ \text{front} \right] = \text{NOM}^* \text{PROJECT}^* \text{FRONT AXIS} \]

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) \[
\begin{align*}
\text{\textit{front}}_{\text{PROJ}} & = \text{NOM } \ast \text{PROJECT } \ast \text{FRONT} \\
\text{with } \ast & \text{ indicating function composition}
\end{align*}
\]

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) \textit{delante del coche} ‘in front of the car’

a. \[
\llbracket \text{ante} \rrbracket = \lambda x \in D_e . \text{NOM (FRONT (} x \text{))}
\]
   (lexical meaning of ante, a “nominalized” axis)

b. \[
\llbracket \text{ante del coche} \rrbracket = \text{NOM (FRONT (THE-CAR))}
\]
   (result of application to the car)

c. \[
\llbracket \text{I ante del coche} \rrbracket = \text{DEF (NOM (FRONT (THE-CAR)))}
\]
   (definite article giving uniqueness)

d. \[
\llbracket \text{de l ante del coche} \rrbracket = \text{PROJECT (INST (DEF (NOM (FRONT (THE-CAR)))))}
\]
   (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 \textit{delante} as a syntactic terminal, defined as the function composition of PROJECT \ast FRONT if the article-like \textit{l} is disregarded. Otherwise we need the full combination of the pieces identified above: PROJECT \ast INST \ast DEF \ast NOM \ast FRONT

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

We observe the following elements in \textit{au-delà}:

(42) \textit{à} ‘at, to’ + le ‘the’ + de ‘of, from’ + là ‘there’

Preferable solution: lexical construction of \textit{delà} given that là by itself only means ‘there’

If not, the following semantic composition for \textit{au-delà du pont} ‘beyond the bridge’

(43) a. \[
\llbracket \text{là} \rrbracket = \lambda x \in D_e . \text{YOND (} x \text{)}
\]
   (lexical meaning of AxPart là: the sets of vectors to the furthest boundary of x)

b. \[
\llbracket \text{là du pont} \rrbracket = \text{YOND (THE-BRIDGE)}
\]
   (DP denoting entity-correlate corresponding to ‘beyond’ axis of bridge)
c.  \[ \{\text{de là du pont}\} = \text{PROJECT} (\text{INST} (\text{YOND} (\text{THE-BRIDGE}))) \]
   (outward projection of that axis)

d.  \[ \{\text{le de là du pont}\} = \text{DEF} (\text{NOM} (\text{PROJECT} (\text{INST} (\text{YOND} (\text{THE-BRIDGE})))))) \]
   (another round of nominalization ...)

e.  \[ \{\text{à le de là du pont}\} = \text{INST} (\text{DEF} (\text{NOM} (\text{PROJECT} (\text{INST} (\text{YOND} (\text{THE-BRIDGE})))))) \]

Because \textit{au delà} ‘beyond’ is compatible with measure phrases, \textit{à} should be treated as INST

Issue: what about the potentially ground-external \textit{à la tête du train/en tête du train}? Ambiguity?

10. **APPENDIX 2: INDIVIDUAL CASES**

10.1. A projective axial noun denoting a location: \textit{north of}

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

(44) \textbf{north of the city}

a.  \[ \{\text{north}_\text{PROJ}\} = \lambda x \in D_e . \text{PROJECT} (\text{NORTH}(x)) \]
   (lexical meaning of AxPart \textit{north}, maps directly to a set of vectors)

b.  \[ \{\text{north}_\text{PROJ of the city}\} = \text{PROJECT} (\text{NORTH} (\text{THE-CITY})) \]
   (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: \textit{to the north of}

The more complex case, with an article and a preposition

This is not a complex PathP: \textit{of the city} is not path-denoting, so \textit{north} is not entity-denoting

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

(45) \textbf{to the north of the city}

a.  \[ \{\text{north}_\text{PROJ}\} = \lambda x \in D_e . \text{NOM} (\text{PROJECT} (\text{NORTH}(x))) \]
   (lexical meaning of AxPart \textit{north}, the “nominalized” variant of (44))

b.  \[ \{\text{north}_\text{PROJ of the city}\} = \text{NOM} (\text{PROJECT} (\text{NORTH} (\text{THE-CITY}))) \]
   (the singleton set consisting of the entity-correlate of the set of the vectors
   pointing north from the city)

c.  \[ \{\text{the north}_\text{PROJ of the city}\} = \text{DEF} (\text{NOM} (\text{PROJECT} (\text{NORTH} (\text{THE-CITY})))) \]
   (DP denoting the entity-correlate of the relevant external region)

d.  \[ \{\text{to the north}_\text{PROJ of the city}\} = \text{INST} (\text{DEF} (\text{NOM} (\text{PROJECT} (\text{NORTH} (\text{THE-CITY})))))) \]
   (preposition \textit{to} mapping to the set of vectors instantiating entity-correlate)

Crucial: because \textbf{to the north of is compatible with measure phrases}, the set of vectors that

INST gives us should be identical to PROJECT (\text{NORTH} (\text{THE-CITY}))

Potential objection: \textit{the north of the city} is an axial object, \textit{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: \textbf{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
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. \[ \text{[in front PROJ]} = \lambda x \in D_e . \text{NOM (PROJECT (FRONT \( x \)))} \]
   (lexical meaning of AxPart \text{front})

b. \[ \text{[in front of the car]} = \text{NOM (PROJECT (FRONT (THE-CAR)))} \]
   (the singleton set consisting of the entity-correlate of the relevant external region)

c. \[ \text{[Ø front PROJ of the car]} = \text{DEF (NOM (PROJECT (FRONT (THE-CAR))))} \]
   (DP denoting the entity-correlate of the relevant external region)

d. \[ \text{[in front of the car]} = \text{INST (DEF (NOM (PROJECT (FRONT (THE-CAR))))} \]
   (preposition \text{in} = \text{INST maps entity back to set of vectors})

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

Modulo some tweaking: only orthogonal vectors count, cf. \text{diagonally in front of}.

Unresolved issue: why is \text{in front}, but \text{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. \text{front}: MEng, \text{front} ‘forehead’). This is why axial objects always have intrinsic frames:

(48) a. The bike is on top of the car.
b. \#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) \text{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 \text{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 \text{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)

12. Bibliography


