# From Lexical Semantics to Probabilistic Pragmatic Modelling

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# Russian verbal prefixation system

Russian verbal prefixation system ingredients:

- Aspect: perfective and imperfective
- Prefixes: large inventory, polysemous, can stack, almost always change aspect to perfective
    - According to Švedova (1982), there are 23 productive prefixes in Russian.
    - Up to different 11 usages per prefix
- Imperfective suffix: polysemous, attaches before or after prefixation, changes aspect to imperfective

(1)  pisat'$^{IPF}$ – kupit'$^{PF}$
     to write – to buy

(2)  pisat'$^{IPF}$ $\rightarrow$ zapisat'$^{PF}$ $\rightarrow$ perezapisat'$^{PF}$ $\rightarrow$ perezapisyvat'$^{IPF}$
     to write     to record     to rerecord          to (be) rerecord(ing)

# Contributions of prefixes: *po-*

Švedova (1982, pp. 364–365) names the following five types of situations the verbs prefixed with *po-* can refer to:

1. to do something with low intensity, sometimes also gradually: *poprivyknut'* 'to get somehow used';
2. to do something repeatedly, with many or all of the objects or by many or all of the subjects: *povyvezti* 'to take out many/all of something';
3. to do something for some (often short) time: *pobesedovat'* 'to spend some time talking';
4. to start the action: *pobežat'* 'to start running';
5. to complete the action: *poblagodarit'* 'to thank'.

# Contributions of prefixes: *na-*

Švedova (1982) provides the following list of usages:

1. to direct the action denoted by the derivational base on some surface: *nakleit'* 'to paste';
2. to accumulate something by performing the action denoted by the derivational base: *navarit'* 'to cook a lot';
3. to perform the action intensively: *nagladit'* 'to iron thoroughly' (colloquial);
4. to perform the action denoted by the derivational base weakly, lightly, on the go (non-productive): *naigrat'* 'to strum' (colloquial);
5. to learn something or acquire some skill: *natrenirovat'* 'to train until some level';
6. to perform the action until the result: *nagret'* 'to heat up', *namočit'* 'to make wet', *napoit'* 'to give something to drink'.

# Question

Just seen: 5 usages of the prefix *po-*, 6 usages of the prefix *na-*.

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Components:

- Semantic representations that interact with each other;
- Competition between various prefixed verbs to cover the relevant domain.

# Outline

- Data
    - Contributions of prefixes: *po-* and *na-*
    - Variability of interpretations for different verbs
- Proposal
    - General idea
    - RSA implementation
- Conclusion and future work

# Contributions of prefixes: *po-*

Švedova (1982, pp. 364–365) names the following five types of situations the verbs prefixed with *po-* can refer to:

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2. to do something repeatedly, with many or all of the objects or by many or all of the subjects: *povyvezti* 'to take out many/all of something';
3. **to do something for some (often short) time:** *pobesedovat'* 'to spend some time talking';
4. to start the action: *pobežat'* 'to start running';
5. to complete the action: *poblagodarit'* 'to thank'.

## Prefix *po-*: Semantic contribution

Filip (2000, pp. 47–48): "[t]he prefix *po-* contributes to the verb the [...] meaning of a small quantity or a low degree relative to some expectation value, which is comparable to vague quantifiers like *a little, a few* and vague measure expressions like *a (relatively) small quantity / piece / extent of.*"

(3)  Ivan poguljal       po     gorodu.
     Ivan po.walk.PST.SG.M around town

     'Ivan took a (short) walk around the town.'

                                          = example (9c) in Filip 2000

(4)  Ivan po-el        jablok.
     Ivan po-eat.PST.SG.M apple.PL.GEN

     'Ivan ate some (not many) apples.'

                                   = example (3) in Kagan 2015 (p. 46)

## Prefix *po-*: Delimitative?

(5) Znat', **mnogo** po svetu pobrodil,      vsjakogo raznogo
     know, **a lot** on world po.wander.PST.SG.M, all      different
     uspel    naslušat'sja   - nasmotret'sja.
     have time na.hear.INF.refl   na.look.INF.refl

     'You know, he wandered a lot around the world, he had time to see
     and hear all kinds of different things.'

                         Marija Semenova. *Volkodav: Znamenie puti* (2003)

(6) Kogda do   stolicy ostavalos' tridcat' kilometrov, našël stolovuju
     when until capital was left    thirty    kilometers found canteen
     i     očen' plotno po-el [. . .]
     and very   tight   po-eat.PST.SG.M

     'When I was about 30 km away from the capital, I found a canteen
     and had a very good meal [. . .]'

                         Anatolij Azol'skij. *Lopušok* (1998)

# Prefix *po-*: My answers

- All usages can be unified.
- Underspecified semantics: the prefix relates the initial and final stages of the event with some points on the scale.
- Some selections of scales lead to additional restrictions on the initial and final stages of the event.
- Delimitative interpretation appears due to pragmatic competition.

# Contributions of prefixes: *na-*

Švedova (1982) provides the following list of usages:

1. to direct the action denoted by the derivational base on some surface: *nakleit'* 'to paste';

2. **to accumulate something by performing the action denoted by the derivational base:** *navarit'* 'to cook a lot';

3. **to perform the action intensively:** *nagladit'* 'to iron thoroughly' (colloquial);

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6. to perform the action until the result: *nagret'* 'to heat up', *namočit'* 'to make wet', *napoit'* 'to give something to drink'.

# Prefix *na-*: Semantic contribution

- Filip (1999, p. 183) writes that the prefix *na-* "adds to a verb the meaning of a sufficient or large quantity, or a high degree measured with respect to a certain contextually determined scale and with respect to some standard or subjective expectation value."

(7) Maša napekla     pečenja.
    Masha na.bake.PST.SG.F cookie.SG.GEN

    'Masha baked a significant amount of cookies.'

## Prefix *na-*: Problems

- Exceed the standard?

  (8) Nemnogo pribrala    doma,  prigotovila    syrnyj sup s
      a bit      tidy.PST.SG.F at home prepare.PST.SG.F cheese soup with
      krabovym mjasom, napekla      **nemnogo** ovsjanyx
      crabb   meat    na.bake.PST.SG.F **a bit**     oatmeal.PL.GEN
      blinčikov.
      pancake.PL.GEN

      'I tidied up the house a bit, cooked a cheese soup with crab
      meat, baked some oatmeal pancakes.'

                                                    www.diary.ru

# Proposal: Pragmatic competition

- Idea: Competition between various prefixed verb derived from the same base.
- Semantic contributions of prefixes are flexible not only with respect to scale insertion, but also with respect to identifying the final stage of the event with respect to the scale.
- Proposed prefix semantics:
    - *po-*: event initial and final stages are related to some degrees on the scale;
    - *na-*: event initial stage stage is related to the minimal degree on the scale and event final stage is related either to the maximal degree (closed scale) or to a point at or above the contextual standard (open scale).
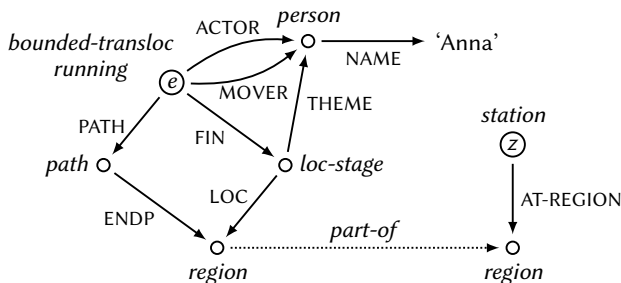
# Frame semantics

- Framework: a combination of frame semantics (Fillmore, 1982) and Lexicalized Tree Adjoining Grammars (LTAG, Joshi and Schabes 1997, Frank 1992, Abeillé 2002) as described by Kallmeyer and Osswald (2013).
- Why:
    - transparent syntax-semantics interface;
    - numerous factorisation possibilities within the lexicon;
    - cognitive plausibility;
    - explicit constraints on types allow to restrict possible derivations.

# Frame semantic modelling

**Basic assumptions**

- **Attributes** (features, functional roles/relations) play a central role
  in the organization of semantic and conceptual knowledge and
  representation (Barsalou 1992; Löbner 2014).
- Semantic components (participants, subevents) can be (recursively)
  addressed via **attributes** (from some "**base**" node).
  - ⤳ inherently **structured representations** (models); composition by
    **unification** (under **constraints**) (Kallmeyer/Osswald 2013). .

**Example**

# Frame semantic modelling

**Example** (cont'd)
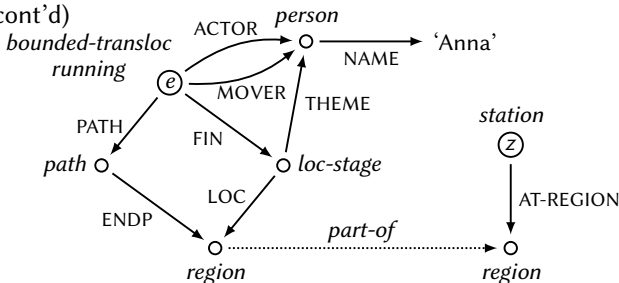

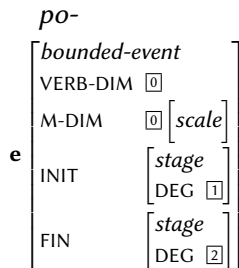
**Descriptive elements** ($\leadsto$ **signature**)

- Attributes (functional relations): ACTOR, MOVER, PATH, AT-REGION, . . .
- Type symbols: *locomotion*, *person*, *path*, *running*, *region*, . . .
- Relation symbols: *part-of*, *precedes*, . . .
- Node labels (variables/constants): *e*, *x*, *y*, . . .

**Model requirement**

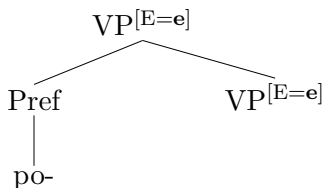- Every node is reachable from some labeled ("base") node via attributes.

# Frame semantics: Example

- Frame and tree representations for the prefix *po-*

*po-*

$$\mathbf{e}\begin{bmatrix} \textit{bounded-event} \\ \text{VERB-DIM } \boxed{0} \\ \text{M-DIM } \boxed{0}\begin{bmatrix} \textit{scale} \end{bmatrix} \\ \text{INIT} \begin{bmatrix} \textit{stage} \\ \text{DEG } \boxed{1} \end{bmatrix} \\ \text{FIN} \begin{bmatrix} \textit{stage} \\ \text{DEG } \boxed{2} \end{bmatrix} \end{bmatrix}$$

$\langle \boxed{1}, \boxed{0} \rangle$ : *member*

$\langle \boxed{2}, \boxed{0} \rangle$ : *member*

$\langle \boxed{1}, \boxed{2} \rangle$ : *less*

$$\text{VP}^{[\text{E}=\mathbf{e}]}$$

$$\text{Pref} \qquad \text{VP}^{[\text{E}=\mathbf{e}]}$$

$$\text{po-}$$

# Combining *po-* with a motion verb

*begat'*

$$
\mathbf{e}
\begin{bmatrix}
\textit{transloc} \\
\text{MANNER} \quad \begin{bmatrix} \textit{run} \end{bmatrix} \\
\text{ACTOR} \quad \boxed{1} \\
\text{TRACE} \quad \begin{bmatrix} \textit{trace} \end{bmatrix}
\end{bmatrix}
$$

*po-*

$$
\mathbf{e}
\begin{bmatrix}
\textit{bounded-event} \\
\text{VERB-DIM} \quad \boxed{1} \\
\text{M-DIM} \quad \boxed{1}\begin{bmatrix} \textit{scale} \end{bmatrix} \\
\text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{2} \end{bmatrix} \\
\text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{3} \end{bmatrix}
\end{bmatrix}
$$

*pobegat':*

$$
\mathbf{e}
\begin{bmatrix}
\textit{bounded-event} \wedge \textit{transloc} \wedge \textit{scale} \\
\text{MANNER} \quad \begin{bmatrix} \textit{run} \end{bmatrix} \\
\text{ACTOR} \quad \boxed{1} \\
\text{TRACE} \quad \begin{bmatrix} \textit{trace} \end{bmatrix} \\
\text{VERB-DIM} \quad \mathbf{e} \\
\text{M-DIM} \quad \mathbf{e} \\
\text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{2} \end{bmatrix} \\
\text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{3} \end{bmatrix}
\end{bmatrix}
$$

# Combining *po-* with a motion verb

*bežat'*

$$\mathbf{e} \begin{bmatrix} \textit{transloc} \\ \text{MANNER} \quad \begin{bmatrix} \textit{run} \end{bmatrix} \\ \text{ACTOR} \quad \boxed{1} \\ \text{TRACE} \quad \begin{bmatrix} \textit{trace} \end{bmatrix} \\ \text{PATH} \quad \boxed{2} \begin{bmatrix} \textit{path} \end{bmatrix} \\ \text{VERB-DIM} \quad \boxed{2} \\ \text{M-DIM} \quad \boxed{2} \end{bmatrix}$$

*po-*

$$\mathbf{e} \begin{bmatrix} \textit{bounded-event} \\ \text{VERB-DIM} \quad \boxed{1} \\ \text{M-DIM} \quad \boxed{1} \begin{bmatrix} \textit{scale} \end{bmatrix} \\ \text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \quad \boxed{2} \end{bmatrix} \\ \text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \quad \boxed{3} \end{bmatrix} \end{bmatrix}$$

*pobežat'*:

$$\mathbf{e} \begin{bmatrix} \textit{bounded-event} \wedge \textit{transloc} \\ \text{MANNER} \quad \begin{bmatrix} \textit{run} \end{bmatrix} \\ \text{ACTOR} \quad \boxed{1} \\ \text{TRACE} \quad \begin{bmatrix} \textit{trace} \end{bmatrix} \\ \text{PATH} \quad \boxed{2} \begin{bmatrix} \textit{path} \end{bmatrix} \\ \text{VERB-DIM} \quad \boxed{2} \\ \text{M-DIM} \quad \boxed{2} \\ \text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \quad \boxed{3} \end{bmatrix} \\ \text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \quad \boxed{4} \end{bmatrix} \end{bmatrix}$$

# Frame semantics: *po-* + verb that specifies a scale

The verb *gret'* 'to heat' operates on the temperature scale

$$
\mathbf{e}\begin{bmatrix}
\textit{change-of-state} \\
\text{MANNER} \quad \begin{bmatrix} \textit{heat} \end{bmatrix} \\
\text{ACTOR} \quad \boxed{1} \\
\text{THEME} \quad \boxed{2} \\
\text{VERB-DIM} \quad \boxed{3}\begin{bmatrix} \textit{temperature} \end{bmatrix} \\
\text{M-DIM} \quad \boxed{3}
\end{bmatrix}
$$

$$
\mathbf{e}\begin{bmatrix}
\textit{bounded-event} \\
\text{VERB-DIM} \quad \boxed{1} \\
\text{M-DIM} \quad \boxed{1}\begin{bmatrix} \textit{scale} \end{bmatrix} \\
\text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{2} \end{bmatrix} \\
\text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{3} \end{bmatrix}
\end{bmatrix}
$$

$$
\mathbf{e}\begin{bmatrix}
\textit{bounded-event} \wedge \textit{change-of-state} \\
\text{MANNER} \quad \begin{bmatrix} \textit{heat} \end{bmatrix} \\
\text{ACTOR} \quad \begin{bmatrix} \textit{entity} \end{bmatrix} \\
\text{THEME} \quad \begin{bmatrix} \textit{entity} \end{bmatrix} \\
\text{VERB-DIM} \quad \boxed{1}\begin{bmatrix} \textit{temperature} \end{bmatrix} \\
\text{M-DIM} \quad \boxed{1} \\
\text{INIT} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{2} \end{bmatrix} \\
\text{FIN} \quad \begin{bmatrix} \textit{stage} \\ \text{DEG} \ \boxed{3} \end{bmatrix}
\end{bmatrix}
$$

# Frame and tree representations for the prefix *na-*

$$
\mathbf{e}\begin{bmatrix}
\textit{bounded-event} \\
\text{C-DIM} \quad \boxed{3} \\
\text{VERB-DIM} \quad \boxed{3} \\
\text{M-DIM} \quad \boxed{3}\begin{bmatrix}\textit{scale} \\ \text{MIN} \quad \boxed{1} \\ \text{THRESHOLD} \quad \boxed{2}\end{bmatrix} \\
\text{INIT} \quad \begin{bmatrix}\textit{stage} \\ \text{DEG} \quad \boxed{1}\end{bmatrix} \\
\text{FIN} \quad \begin{bmatrix}\textit{stage} \\ \text{DEG} \quad \boxed{4}\end{bmatrix} \\
\boxed{2} \leq \boxed{4}
\end{bmatrix}
$$

$$
\begin{array}{c}
\text{VP}^{[\text{E}=\mathbf{e}]} \\
\diagup \quad \diagdown \\
\text{Pref} \qquad \text{VP}^{[\text{E}=\mathbf{e}]} \\
| \\
\text{na-}
\end{array}
$$

# Frame semantics: *na-* + gret'

# One more ingredient

- In order to show the proposed competition in action, let us add one more ingredient: the prefix *pere-*.
- We will be looking at open scales and in this case *pere-* (the most polysemous prefix according to the grammars) has an 'excess' contribution.
- Semantic contributions of prefixes are flexible not only with respect to scale insertion, but also with respect to identifying the final stage of the event with respect to the scale.

| base verb | translation | "excess" | "neutral" | other competing verbs |
|-----------|-------------|----------|-----------|------------------------|
| *xvalit'* | 'to praise' | *perexvalit'* | *poxvalit'* | |
| *žarit'* | 'to fry' | *perežarit'* | *požarit'* | *nažarit'* 'to fry a lot of' |
| *gret'* | 'to heat' | *peregret'* | *nagret'* | *pogret'* 'to heat' |
| *kormit'* | 'to feed' | *perekormit'* | *nakormit'* | *pokormit'* 'to feed' |
| *trenirovat'* | 'to train' | *peretrenirovat'* | *natrenirovat'* | *potrenirovat'* 'to train for some time' |

Proposed prefix semantics:

- *po-*: event initial and final stages are related to some degrees on the scale;
- *na-*: event initial stage stage is related to the minimal degree on the scale and event final stage is related either to the maximal degree (closed scale) or to a point at or above the contextual standard (open scale).

# Rational Speech Act Framework

Rational Speech Act model (RSA, Goodman and Frank 2016):

- literal listener (interprets everything according to literal semantics)
- pragmatic speaker (reasons about the literal listener)
- pragmatic listener (reasons about the pragmatic speaker)

Input to the model:

- competing utterences,
- world model,
- world priors,
- utterance priors.

## Example: *zimovat'*

The OSLIN database[1] of verbal aspect provides the following list of the verbs derived from *zimovat'*:

1 vyzimovat' 'to survive the winter' (usually about the plants),

2 *dozimovat'* 'to spend the rest of the winter',

3 *zazimovat'* 'to stay for the winter',

4 *otzimovat'* 'to finish spending the winter',

5 *perezimovat'* 'to spend the winter',

6 *pozimovat'* 'to spend some winter time',

7 *prozimovat'* 'to spend the winter time'.

---

## Examples

Out of these seven verbs only four are commonly used in contemporary texts, as evidenced by the data in Russian National Corpora[2]

(9) Ix     by k  nam na severa,          čtoby pozimovali    v svoix
    they   to us  on north.PL.PREP, that  po.winter.PST.PL in their
    kartočnyx domikax.
    card       house.PL.PREP
    'I would like to see them spending winter time here in the north in
    their houses of cards.'                    (doskapozorakomi.ru)

(10) Èkspedicija        zazimovala      na Novoj   Zemle.
     expedition.SG.NOM za.winter.PST.SG.F on Novaya Zemlya
     'The expedition stayed on the Novaya Zemlya for the winter.'
                                                    (Ušakov 1935-1940)

---

[2]Available online at ruscorpora.ru.

# Examples

(11) Dozimuem na korable vo l'dax.
do.winter.PRES.PL.1 on ship in ice.PL.PREP
'We will spend the rest of the winter on a ship in the ices.'
(Ušakov 1935-1940)

(12) Perezimovat' v derevne.
pere.winter.INF in village.SG.PREP
'To spend the winter in a village.' (Ušakov 1935-1940)

## *Zimovat'*: set of situations

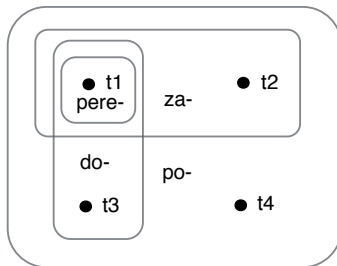What is special about the verb *zimovat'*?

1 refers to a specific scale – the scale of spending winter time

2 this scale has a clear structure: it is a closed scale with two distinguished points (winter start and winter end)

Due to this, a natural set of situations that one may want to refer to with respect to spending winter time contains four elements:
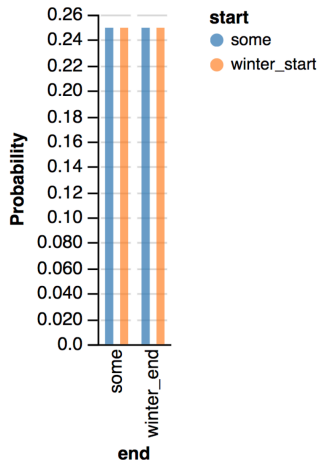
1 spending one whole winter ($t_1$);

2 spending an initial part of the winter ($t_2$);

3 spending a final part of the winter ($t_3$);

4 spending some time of the winter without bounding the event duration to the duration of the winter ($t_4$).

# *Zimovat'*: set of situations and interpretations

|       | event start = winter start | event end = winter end |
|-------|:--------------------------:|:----------------------:|
| $t_1$ | +                          | +                      |
| $t_2$ | +                          | -                      |
| $t_3$ | -                          | +                      |
| $t_4$ | -                          | -                      |

# *Zimovat'*: RSA output
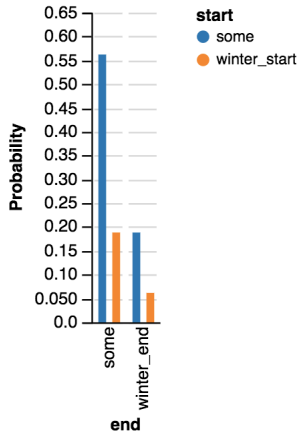
# Example: Heat

- 3 prefixed verbs:
    - *peregret'* 'to overheat',
    - *nagret'* 'to warm up' (to the standard),
    - *pogret'* 'to warm up' (to some extent).
- Possible situations: reaching the standard – exceeding it – below the standard,
- On the semantic side:
    - *pere-* (*peregret'*): excess interpretation only;
    - *na-* (*nagret'*): standard or above;
    - *po-* (*pogret'*): any.

# Pragmatic listener's interpretation
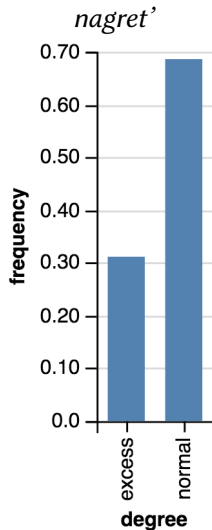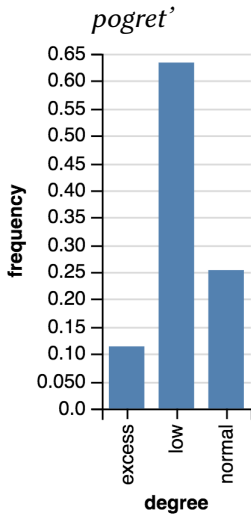
# Example: Fry

- 3 prefixed verbs:
  - *perežarit'* 'to fry too much',
  - *nažarit'* 'to fry a lot of',
  - *požarit'* 'to fry'.
- Possible situations:
  - focus on the quantity: normal or excess;
  - focus on the degree: normal or excess;
- On the semantic side:
  - *pere-* (*perežarit'*): excess interpretation with respect to degree only;
  - *na-* (*nažarit'*): standard or excess quantity;
  - *po-* (*požarit'*): any.

# Pragmatic listener's interpretation
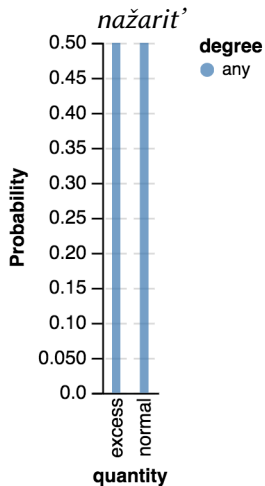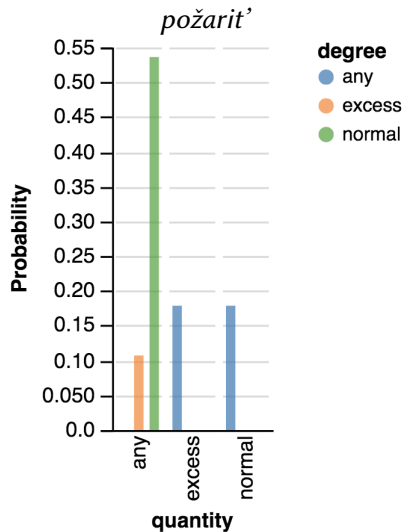
# Summary

- I have proposed how to predict prefix contributions on the basis of underspecified semantics and pragmatic modelling.
- Such an approach not only reduces the number of representations, but also allows to deal with facts challenging the traditional approaches.
- Challenges:
    - modelling possible situations;
    - selecting competing verbs;
    - setting the prior.
- Further question: does this competition happen online?

# Thank you very much
# for your attention!

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