Towards Identifying Hindi/Urdu Noun Templates in Support of a Large-Scale LFG Grammar

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The situation

- Spoken and written Hindi/Urdu: heavy, *productive* use of complex predicates (CPs) across domains

- Different types of CPs:
  - Aspectual V+V CPs: *gīr par* ‘suddenly fall’ (lit. ‘fall fall’)
  - Permissive V+V CPs: *jane de* ‘let go’ (lit. ‘go give’)
  - N+V CPs: *yad kar* ‘remember’ (lit. ‘memory do’)

- In other languages:
  - *take a bath* (≈ ‘bathe’)
  - *give a stir* (≈ ‘stir’)
  - *in Betracht ziehen* ‘consider’ (lit. ‘in look-at pull’)

Most of these are restricted in use and/or much less productive than South Asian CPs.
The challenges

- General problem in deep and shallow parsing methods for Hindi/Urdu (and other South Asian languages): proper treatment of complex predicates
  - Automatic distinction of CPs from simplex verbs
  - Extraction of subcategorization frames
  - Semantic role labeling
  - Drawing semantic inferences

Research questions:

What existing resources may be employed to explore CP usage?
Can we confirm/reject existing theoretical hypotheses of N+V CPs?
How far can clustering algorithms take us?
How “good” / “coherent” are the resulting classes?
How can our LFG grammar benefit from the results?
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1 Hindi/Urdu Noun-Verb Complex Predicates

2 Corpus study

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Theconstruction

- Combination of noun and light verb to form a single predicational unit
- Noun contributes main predicational content (including argument(s)), light verb dictates case marking and expresses subtle lexical semantic differences
- Highly productive constructions
- [Ahmed and Butt, 2011]: proposal for different classes of N+V CPs based on a small case study of 45 nouns and 3 light verbs (kar ‘do’, ho ‘be’, hu- ‘become’)

| N+V type | light verb | analysis | example N |
|----------|------------|----------|-----------|
| CLASS A  | +          | +        | psych predications |
| CLASS B  | +          | -        | only agentive |
| CLASS C  | +          | +        | subject not an undergoer |

Table: Classes of nouns identified by [Ahmed and Butt, 2011]
Goals of the investigation

- How do the proposals by [Ahmed and Butt, 2011] hold up towards a larger empirical basis (i.e., bigger corpora)?
- Extend the set of light verbs
- Apply different strategies of acquiring knowledge about CPs:
  - “Brute-force” statistical approach, based on bigram extraction, collocation analysis and clustering [Butt et al., 2012]
  - “Seed list” approach, using knowledge amassed from treebanks and clustering, and evaluate clusters (this paper)
- Come up with noun templates:
  - Nouns using one template will behave in a coherent way with respect to the light verbs they may occur with
  - Of great use for Hindi/Urdu grammar: extend noun lexicon/coverage
  - May inform further work on semantic classification of CPs
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In a recent corpus study on Hindi\(^1\), we used the approach below:

1. Collect corpus of 21 million words harvested from BBC Hindi website, Hindi wikipedia, and the Hindi-Urdu Treebank (HUTB) [Bhatt et al., 2009]
   - POS tagged, lemmatized using a state-of-the-art Hindi tagger [Reddy and Sharoff, 2011]
2. Look at a set of seven light verbs: *kar* ‘do’, *ho* ‘be’, *de* ‘give’, *le* ‘take’, *rak\(^h\)* ‘put’, *lag* ‘be attached’, *a* ‘come’ (seven most frequently occurring light verbs)

\(^1\) The corresponding Urdu study is pending.
Methodology

3. Make use of the annotations in the HUTB [Bhatt et al., 2009]
   - Includes dependency annotation scheme
   - Employs label *pof* (for *part of*) to annotate complex predicates
   - Extract all items that are tagged as nouns and carry *pof* label
     → “Seed list” of nouns that we know take part in N-V CPs

4. Extract bigrams of pattern *seed list noun item + light verb lemma* from corpus
   - Assume that noun occurs right next to verb [Mohanan, 1994]
   - Cases where noun is removed from verb are rare (∼1% in HUTB)

5. Apply cutoff value $c$ (noun occurrences across all light verbs)
   - Initial value $c = 50$: make statements about well-attested nouns
   - Also applied cutoff of $c = 3$ for comparison purposes
Compute relative frequencies of nouns combined with light verbs 
\( (c = 50: \ 522 \ \text{nouns}; \ c = 3: \ 987 \ \text{nouns}) \)

Table: Relative frequencies of co-occurrence of nouns with light verbs

| ID | noun              | kar ‘do’ | ho ‘be’ | de ‘give’ | le ‘take’ | rak\(^h\) ‘put’ | lag ‘attach’ | a ‘come’ |
|----|-------------------|----------|---------|-----------|-----------|----------------|--------------|----------|
| 1  | tanav ‘tension’   | 0.115    | 0.562   | 0.058     | 0.058     | 0.000          | 0.000        | 0.207    |
| 2  | bhag ‘part’       | 0.149    | 0.365   | 0.119     | 0.253     | 0.000          | 0.000        | 0.115    |
| 3  | ag ‘fire’         | 0.110    | 0.251   | 0.087     | 0.000     | 0.055          | 0.443        | 0.055    |
| 4  | mazuri ‘sanction’ | 0.000    | 0.000   | 0.757     | 0.243     | 0.000          | 0.000        | 0.000    |
| 5  | dhava ‘attack’    | 1.000    | 0.000   | 0.000     | 0.000     | 0.000          | 0.000        | 0.000    |
| 6  | kripa ‘mercy’     | 0.409    | 0.486   | 0.000     | 0.000     | 0.105          | 0.000        | 0.000    |
Apply clustering algorithm to the data
- Clustering the nouns based on their occurrence patterns with light verbs
- $k$-means and GVM clustering\(^2\) applied

→ Problem: how to evaluate?
- We already know that our combinations ($seed$ list noun item + light verb lemma) form legitimate CPs.
- What we don’t know is how semantically coherent the clusters are.
- We also don’t know which $k$ and $c$ values give us the best (i.e. most expressive/semantically most coherent) clusters.

\(^2\)Greedy Variance Minimization, http://www.tomgibara.com/clustering/fast-spatial/
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Preliminary evaluation using WordNet

- Hindi WordNet publicly available [Bhattacharyya, 2010]
- Follow the technique described by e.g. [Van de Cruys, 2006] for each $k = 2, ..., 10$ and for $c = \{3; 50\}$
  1. Extract synonyms, hypernyms and hyponyms for every noun in a cluster
  2. Choose cluster centroid: noun with most semantic relations with every other noun in cluster
  3. Extract co-hyponyms, i.e. the hyponyms of the hypernyms (sisters in the ontology tree), for each centroid from WordNet (along with their synonyms, hypernyms and hyponyms)
  4. Calculate coherence for each cluster: count number of nouns that overlap with nouns in centroid’s relations & divide by number of words in cluster
  5. Maximize coherence across $k$ and $c$
## Preliminary evaluation using WordNet

| Size of $k$ | $c = 3$ | $c = 50$ |
|------------|---------|---------|
|            | GVM     | $k$-means | GVM     | $k$-means |
| 5          | 0.049   | 0.060   | 0.107   | 0.122   |
| 6          | 0.066   | 0.055   | 0.121   | 0.119   |
| 7          | 0.089   | 0.056   | 0.104   | 0.110   |
| 8          | 0.084   | 0.089   | 0.108   | 0.109   |
| 9          | 0.082   | 0.081   | 0.095   | 0.097   |

**Table:** Semantic coherence values for $k = 5 - 9$

→ Most coherent clusters according to evaluation with $k = 5$, $c = 50$ using $k$-means algorithm
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Figure: Cluster visualization for $k = 5$, $c = 50$ (using tool by [Lamprecht et al., 2013])

Cluster description:

- Cl. 1 (light green): *kar* ‘do’
- Cl. 2 (dark blue): *ho* ‘be’
- Cl. 3 (pink): *de* ‘give’
- Cl. 4 (dark green): alternating between *rakh* ‘keep’, *lag* ‘attach’, *a* ‘come’
- Cl. 5 (light blue): *le* ‘take’
Observations:

- Continuum between cl. 1/2: $kar/ho$ alternation, psych predication [Ahmed and Butt, 2011]
- Continuum between cl. 1/3: $kar/de$ alternation, “transfer”
- “Isolated” clusters 4/5: lexicalized *incorporated idioms* [Davison, 2005]

Figure: Cluster visualization for $k = 5, c = 50$ (using tool by [Lamprecht et al., 2013])
**Productivity**

| Light verb | Gloss | Relative frequency |
|------------|-------|--------------------|
| *de*       | ‘give’ | 0.75               |
| *kar*      | ‘do’   | 0.08               |
| *le*       | ‘take’ | 0.06               |
| *ho*       | ‘be’   | 0.06               |
| *a*        | ‘come’ | 0.02               |
| *rakʰ*     | ‘keep’ | 0.02               |
| *lag*      | ‘attach’ | 0.01              |

**Table:** LV properties of cluster 3, measured at centroid

- Frequencies: *likelihood* of nouns in group to co-occur with LVs
- Productive patterns *more likely* to be valid CPs, less productive patterns *more likely* to be non-CP combinations [Butt et al., 2012]
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Grammar integration

Noun templates

| Light verb | Gloss  | Relative frequency |
|------------|--------|--------------------|
| *de*       | 'give' | 0.75               |
| *kar*      | 'do'   | 0.08               |
| *le*       | 'take' | 0.06               |
| *ho*       | 'be'   | 0.06               |
| *a*        | 'come' | 0.02               |
| *rak*<sup>h</sup> | 'keep' | 0.02       |
| *lag*      | 'attach' | 0.01             |

Table: LV properties of cluster 3, measured at centroid

*Could* define grammar templates that model “absolute” choices:

```
NVGROUP3 = { NV-CP-VERB = dE
            | NV-CP-VERB = kar
            | ~ NV-CP-VERB
            }.
```

iSArA NOUN @NVGROUP3.  

*signal (give/do)*
Even better: noun templates with optimality choices

| Light verb | Relative frequency |
|------------|---------------------|
| de         | 0.75                |
| kar        | 0.08                |
| le         | 0.06                |
| ho         | 0.06                |
| a          | 0.02                |
| rak h      | 0.02                |
| lag        | 0.01                |

Table: LV properties of cluster 3

Advantages:

- Do not make strict assertions about CP formation
- Rather, model statistical preferences over analyses
- Boost grammar coverage, robustness

Or: grammar templates that model preferences, via marks inspired by Optimality Theory (OT):

\[
\text{OPTIMALITYORDER } \text{cp-dispref } \text{non-cp-dispref} \\
\text{ +cp-pref } \text{ +non-cp-pref}. \\
\]

\[
\text{NVGROUP3} = \{ \text{NV-CP-VERB} = \text{dE} \\
\text{ OT-MARK cp-pref} \\
\text{ VERB = dE} \\
\text{ \sim NV-CP-VERB} \\
\text{ OT-MARK non-cp-dispref} \\
\text{ \sim \ldots} \\
\text{ NV-CP-VERB = \text{lag}} \\
\text{ OT-MARK cp-dispref} \\
\text{ VERB = lag} \\
\text{ \sim NV-CP-VERB} \\
\text{ OT-MARK non-cp-pref} \\
\}
\]

\[iSArA \text{ NOUN } @\text{NVGROUP3}. \quad \text{signal (give/do)}\]
Summary

- Some nouns heavily lexicalized towards a peculiar semantic configuration (i.e., compatible with a smaller subset of light verbs)
- Others may occur with a wider range of light verbs
- In dire need of further theoretical linguistic work to (possibly) link “noun templates” defined here with semantic classes

→ Use for grammar development?
  - Lexicon development
  - Can define templates, based on classification
  - Handle new coinages/borrowings, predict their usage

- Future work:
  - Apply method to Urdu data
  - Refine/narrow down clusters (using more data/more features/more light verbs)
Thank you all for your attention!
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In Proceedings of the Sixteenth Computational Linguistics in Netherlands (CLIN), pages 17–32.
Background — the Hindi/Urdu ParGram Grammar

- Computational LFG grammar in development in Konstanz
- Aim: large-scale LFG grammar for parsing Urdu/Hindi
- Overview publications are e.g. [Butt and King, 2007], [Bögel et al., 2009]
- Grammar is part of the ParGram project
  - Collaborative, world-wide research project
  - Development of parallel, linguistically well-motivated LFG grammars for a variety of languages
  - Features and analyses are kept parallel for easy transfer between languages
- Languages involved: English, German, French, Indonesian, Japanese, Norwegian, Welsh, Georgian, Hungarian, Turkish, Chinese, Urdu/Hindi
- Overview publications are e.g. [Butt et al., 2002], [Sulger et al., 2013]
Background — the Hindi/Urdu ParGram Grammar

Example parse:

kīsan \( \text{ṭrekṭar}=\text{ko} \) \( \text{bec-ta} \) \( \text{he} \)
farmer.M.Sg.Nom tractor.M.Sg.Obl=Acc sell-Impf.M.Sg be.Pres.3.Sg

‘The farmer sells the tractor.’

More information on the Hindi/Urdu ParGram Grammar:
http://ling.uni-konstanz.de/pages/home/pargram_urdu/

More information on ParGram: http://pargram.b.uib.no/
Grammar integration

Class A: psych predications

- Occur with all three light verbs examined by [Ahmed and Butt, 2011]

(1) a. larki=ne kahani yad k-i
girl.F.Sg=Erg story.F.Sg memory.F.Sg do-Perf.F.Sg
‘The girl remembered a/the story.’
(lit. ‘The girl did memory of the story.’)

b. larki=ko kahani yad he
girl.F.Sg=Dat story.F.Sg memory.F.Sg be.Pres.3.Sg
‘The girl remembers/knows a/the story.’
(lit. ‘Memory of the story is at the girl.’)

c. larki=ko kahani yad hu-i
girl.F.Sg=Dat story.F.Sg memory.F.Sg be.Perf-F.Sg
‘The girl came to remember a/the story.’
(lit. ‘Memory of the story became to be at the girl.’)
Class B: agentive CPs

- Require an agentive (ergative-marked) subject and light verb *kar* ‘do’

(2) a. bilal=ne makan tamir ki-ya
    Bilal.M.Sg=Erg house.M.Sg construction.F.Sg do-Perf.M.Sg
    ‘Bilal built a/the house.’
    (lit. ‘Bilal did construction of the house.’)

b. * bilal=ko makan tamir he
    Bilal.M.Sg=Dat house.M.Sg construction.F.Sg be.Pres.3.Sg

c. * bilal=ko makan tamir hu-a
    Bilal.M.Sg=Dat house.M.Sg construction.F.Sg be.Perf-M.Sg
Class C: subject not an undergoer

- Exclude the light verb *hu-* ‘become’

(3) a. bilal=ne yih ḫarṭ taslim k-i
   Bilal.M.Sg=Erg this condition.F.Sg acceptance.M.Sg do-Perf.F.Sg
   ‘Bilal accepted this condition.’
   (lit. ‘Bilal did acceptance of this condition.’)

b. bilal=ko yih ḫarṭ taslim ḫe
   Bilal.M.Sg=Dat this condition.F.Sg acceptance.M.Sg be.Pres.3.Sg
   ‘Bilal accepted this condition.’
   (lit. ‘Acceptance of this condition was at Bilal.’)

c. * bilal=ko yih ḫarṭ taslim hu-a
   Bilal.M.Sg=Dat this condition.F.Sg acceptance.M.Sg be.Perf-M.Sg
[Ahmed and Butt, 2011] looked at a set of three light verbs
Extending the set of light verbs brings up new questions
Nouns that occur with *kar* ‘do’ and *de* ‘give’ (but exclude other light verbs)

(4) a. nadya=ne ləɾki=ko paramarʃ ki-ya
    Nadya.F.Sg=Erg girl.F.Sg=Acc advice.M.Sg do-Perf.M.Sg
    ‘Nadya advised the girl.’
    (lit. ‘Nadya did advice to the girl.’)

b. nadya=ne ləɾki=ko paramarʃ di-ya
    Nadya.F.Sg=Erg girl.F.Sg=Acc advice.M.Sg give-Perf.M.Sg
    ‘Nadya advised the girl.’
    (lit. ‘Nadya gave advice to the girl.’)
Nouns that occur with *kar* ‘do’ only, not with *de* ‘give’

(5) a. bilal=ne maka=na tamir=ka khi=ya
    Bilal.M.Sg=Erg house.M.Sg construction.F.Sg do-Perf.M.Sg
    ‘Bilal built a/the house.’
    (lit. ‘Bilal did construction of a/the house.’)
    [Ahmed and Butt, 2011, p. 3]

b. * bilal=ne maka=na tamir=ka dî=ya
    Bilal.M.Sg=Erg house.M.Sg construction.F.Sg give-Perf.M.Sg
Nouns that occur with *le ‘take’ only, not with any other light verb

(6) a. nadya=ne  lărki=ko  god  lý-ya
   Nadya.F.Sg=Erg girl.F.Sg=Acc lap.F.Sg take-Perf.M.Sg
   ‘Nadya adopted the girl.’
   (lit. ‘Nadya took lap to the girl.’)

b. * nadya=ne  lărki=ko  god  kî-ya
   Nadya.F.Sg=Erg girl.F.Sg=Acc lap.F.Sg do-Perf.M.Sg

c. * nadya=ne  lărki=ko  god  dî-ya
   Nadya.F.Sg=Erg girl.F.Sg=Acc lap.F.Sg do-Perf.M.Sg