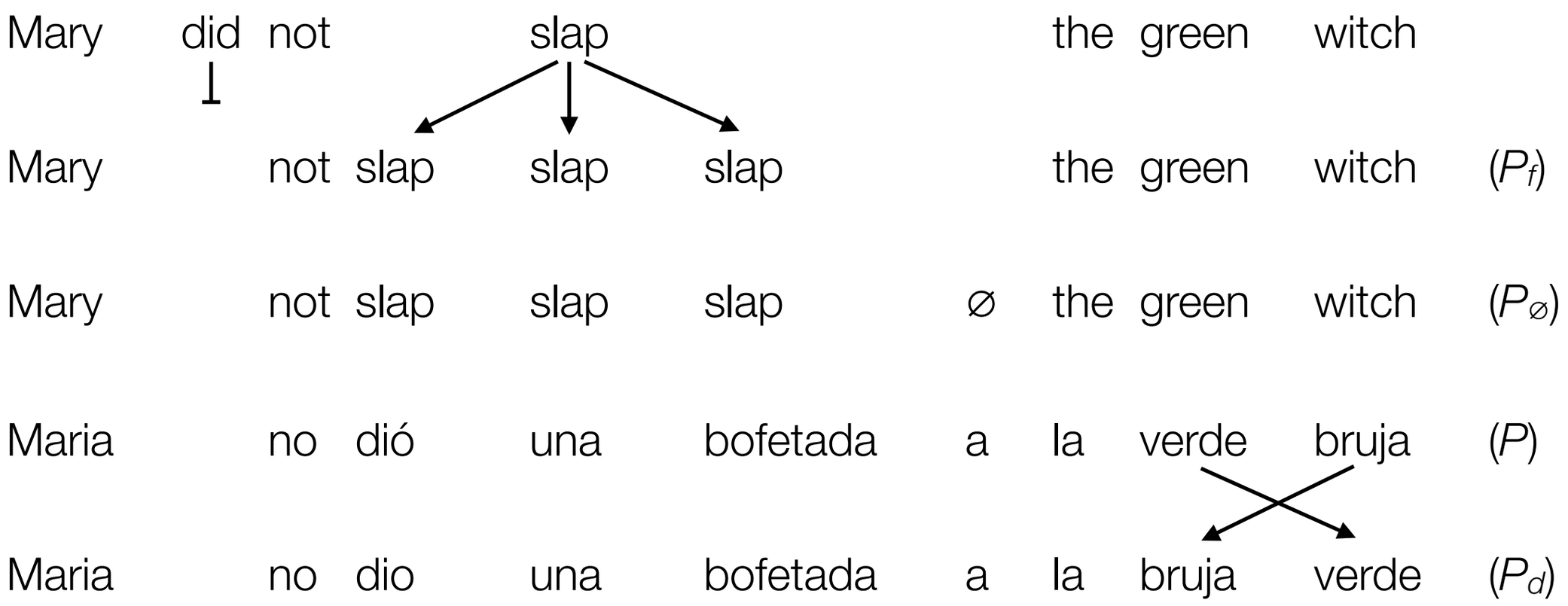
MACHINE TRANSLATION II: NOW WITH 100% MORE SYNTAX

CS 562/662: Natural Language Processing

2015-03-05

IBM MODEL III

MODEL III



[h/t: Kevin Knight]

$P_f(n \mid s)$: target token s aligns to n source tokens

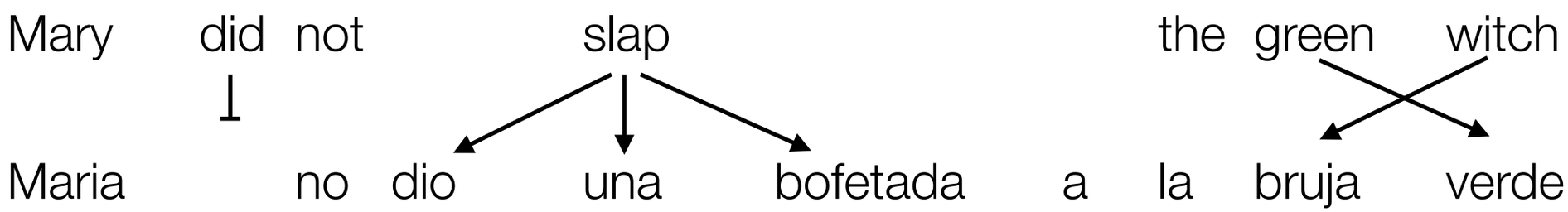
$P(t \mid \varnothing)$: a target token t aligns to no source token

$P(t \mid s)$: target token t is generated by aligned source token s

$P_d(j \mid i, |S|, |T|)$: target token t appears in position j when it is generated by aligned source token in position i and the source and target are $|S|$ and $|T|$ long, respectively

$P(t_0 \ldots t_{|T|})$: the target consists of $t_0 \ldots t_{|T|}$

WORD ALIGNMENT DATA STRUCTURE



MODEL III PARAMETER ESTIMATION

- One candidate alignment:

$$f_d(8 \mid 5, 7, 9) = f_d(8 \mid 5, 7, 9) + 1 \ldots$$

- Two candidate alignments:

$$f_d(8 \mid 5, 7, 9) = f_d(8 \mid 5, 7, 9) + 1/2$$
$$f_d(8 \mid 6, 7, 9) = f_d(8 \mid 6, 7, 9) + 1/2$$

- But, the set of possible alignments grows *very fast*

MODEL I: TRANSLATION MODEL ESTIMATION VIA THE E.M. ALGORITHM

1. Compute $f(t \mid s)$, the conditional frequency of s co-occurring with t

2. Normalize $f(t \mid s)$ to get $P(t \mid s)$, the maximum likelihood conditional probability distribution

3. Let $a = 0$, $T = 0$ for all arguments.

4. For n iterations:

    1. For all s, t, let

        $a(s, t) = a(s, t) + P(t \mid s)$
        $Z(t) = Z(t) + P(t \mid s)$.

    2. For all s, t, let

        $P(t \mid s) = a(s, t) / Z(t)$

        then renormalize $P(t \mid s)$.

MODEL III: ALIGNMENT MODEL ESTIMATION VIA THE E.M. ALGORITHM

1. For n iterations:

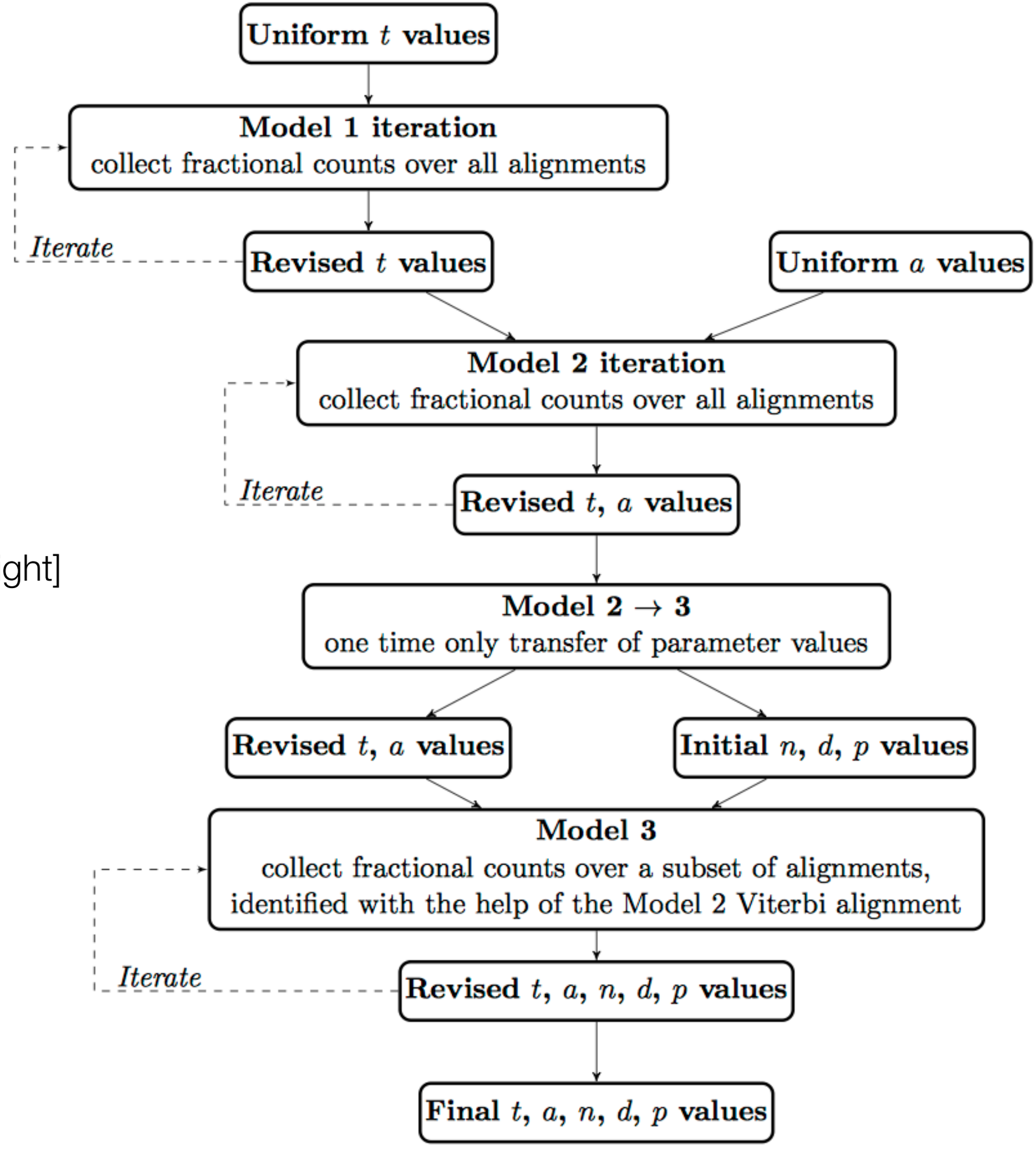
   A. For all s_i, t_j, let

   $a(s_i, t_j) = a(s_i, t_j) + P(t_j \mid s_i)\, P_d(j \mid i, |S|, |T|)$
   $Z(t_j) = Z(t_j) + P(t_j \mid s_i)\, P_d(j \mid i, |S|, |T|)$.

   B. For all s_i, t_j, let

   $P(t_j \mid s_i) = a(s_i, t_j) \,/\, Z(t_j)$

   then renormalize P and P_d



[h/t: Kevin Knight]

PHRASE-BASED TRANSLATION

BASIC PHRASE-BASED TRANSLATION MODELS

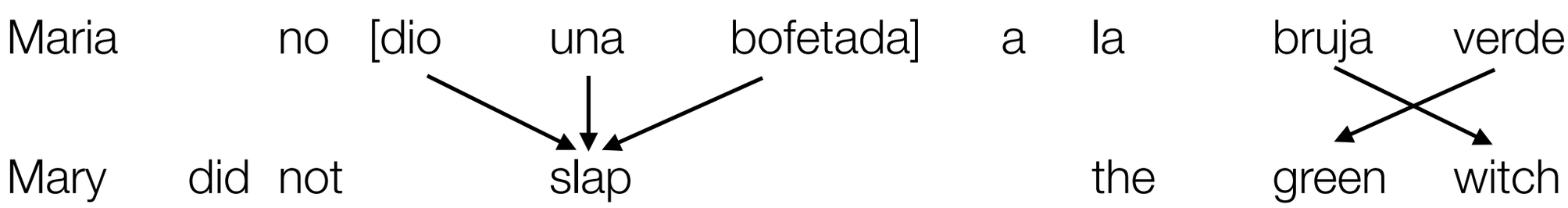
1. Segment source S into phrases $s_1 \ldots s_N$

2. Reorder each s_i according to distortion model P_d

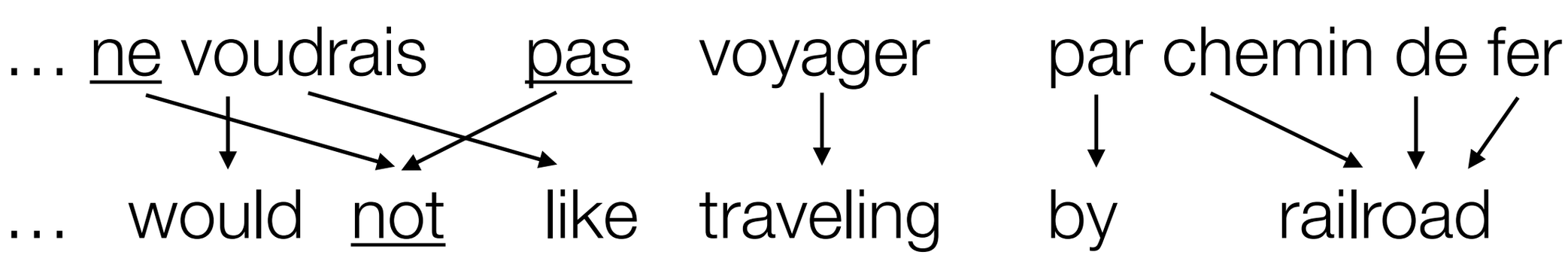
3. Translate each s_i according to phrasal translation model P

[Och & Ney 2004]

PHRASAL ALIGNMENTS



PHRASAL ALIGNMENT TEMPLATES WITH GAPS



[Bansal et al. 2011]

SYNTAX-BASED TRANSLATION

HIERARCHICAL PHRASAL ALIGNMENT

he adores [listening [to music]$_j$]$_i$

kare ha [[ongaku wo]$_j$ kiku]$_i$ no ga daisuki desu

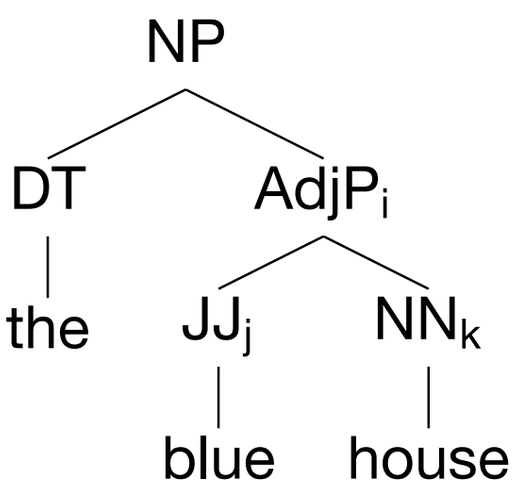
[Knight & Yamada 2001, Chiang 2005]

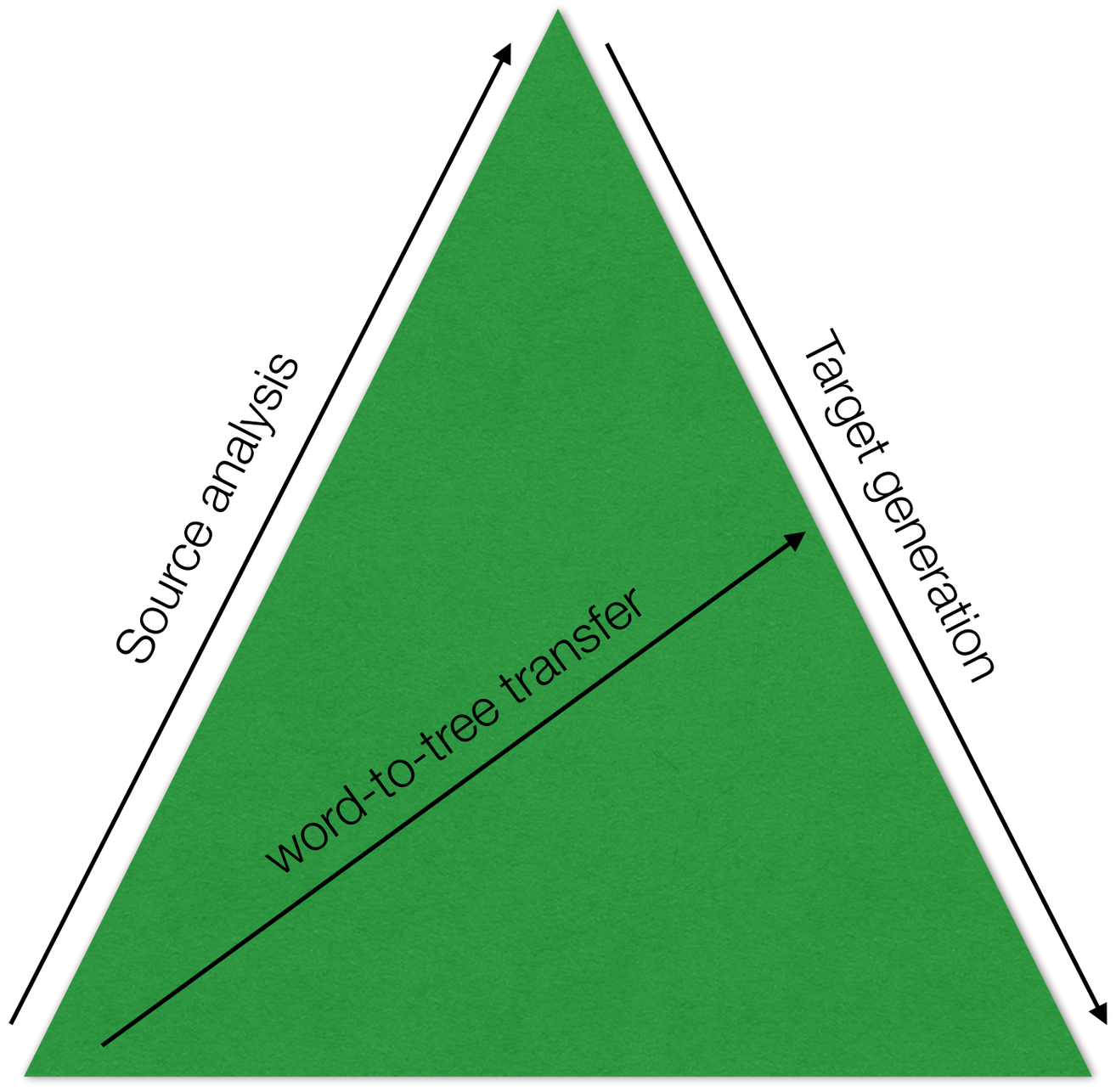
SOURCE

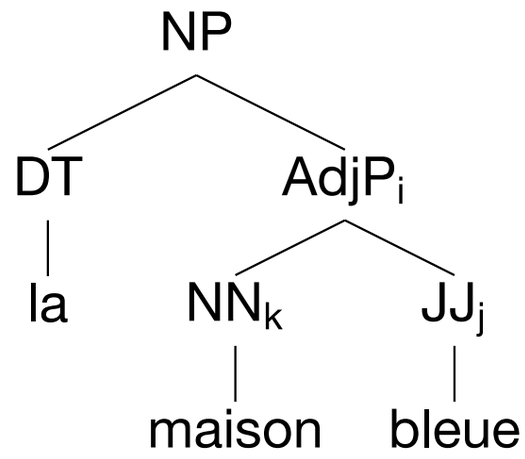
TARGET

Semantic transfer

λx. HOUSE(x) & BLUE(x)







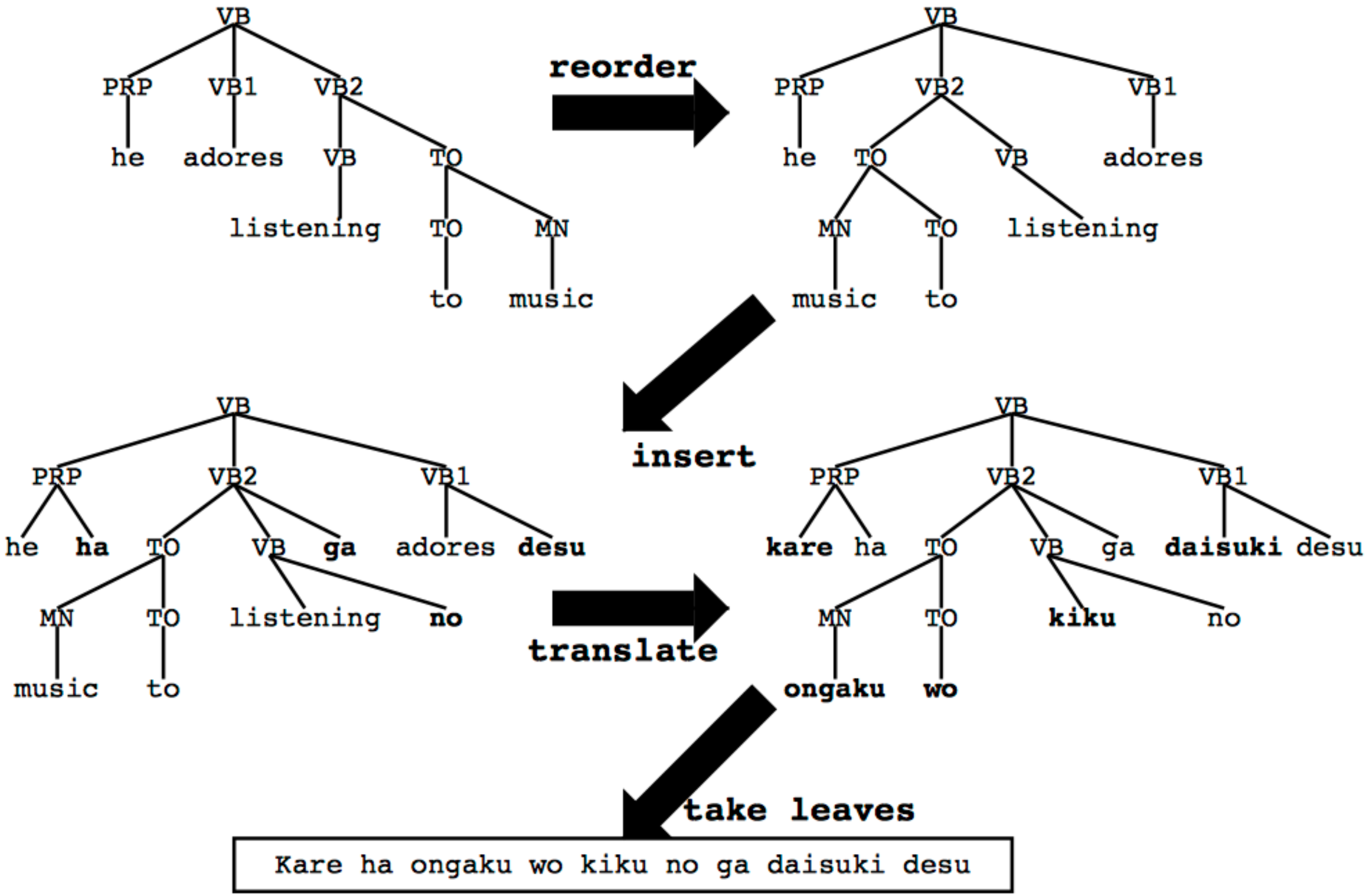
the [blue house]$_i$

la [maison bleue]$_i$

the$_i$ blue$_j$ house$_k$

la$_i$ maison$_k$ bleue$_j$

VAUQUOIS TRIANGLE



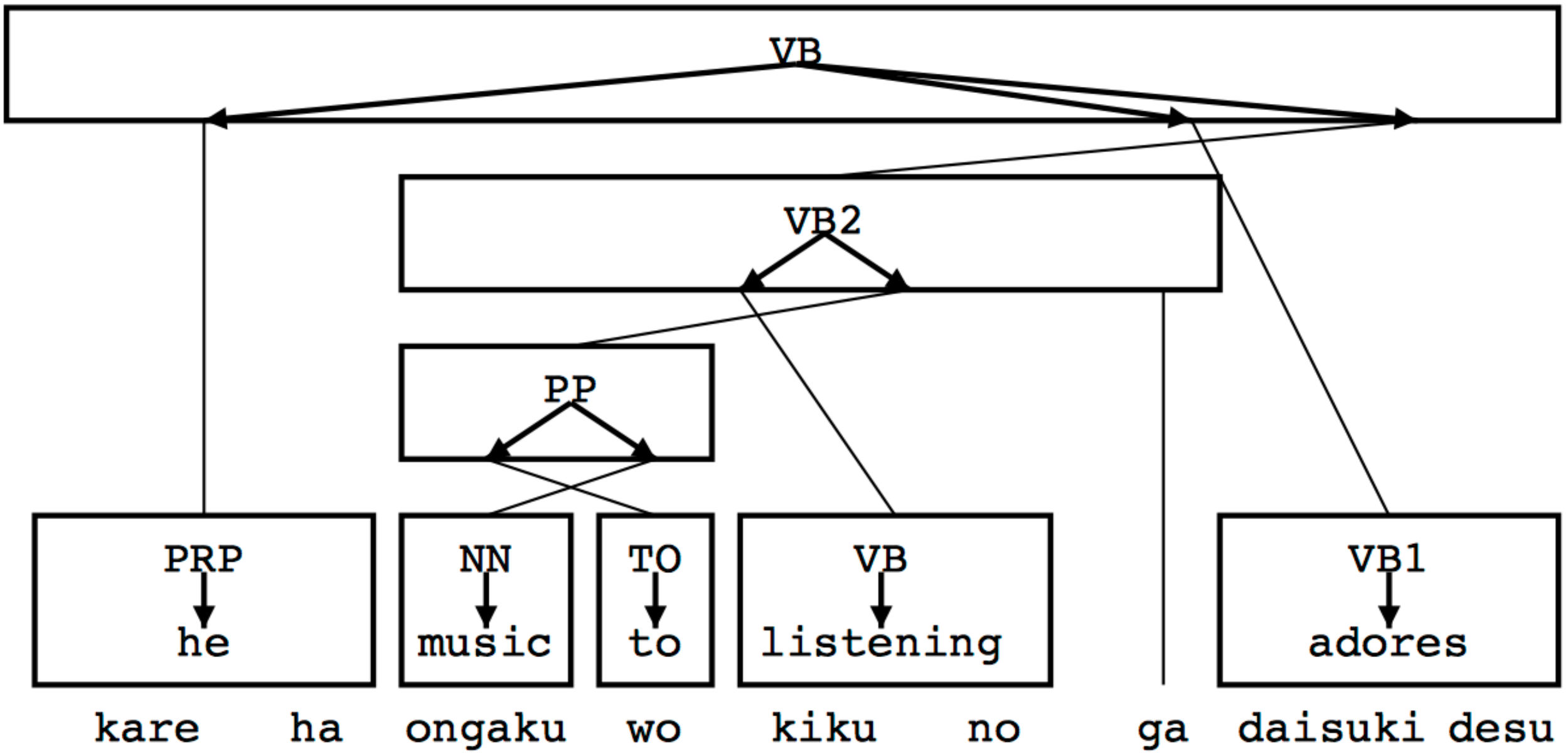
[h/t: Philipp Koehn]

DECODING AS PARSING

1. Pick target tokens *T*

2. Project pre-terminals over tokens in *T*

3. Combine pre-terminals to project higher-level non-terminal until all tokens in *T* share a root



[h/t: Philipp Koehn]