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Direction and Obviation in Plains Cree: A Referent Systems Approach

Udo Klein
University of Bielefeld
udo.klein@uni-bielefeld.de

Marcus Kracht
University of Bielefeld
marcus.kracht@uni-bielefeld.de

Abstract. We present a calculus in which the variables occurring in semantic representations are associated with morphosyntactic information, and the semantic composition of two representations consists in the identification of variables with matching morphosyntactic information. Importantly, shared morphological information can lead to the identification of variables irrespective of the order of composition. This flexibility, we argue, is an important advantage in analysing the syntax-semantics interface of languages like Plains Cree, where the person and number properties of the arguments as well as the assignment of semantic roles to arguments is almost exclusively determined by the complex morphological properties of the verb.

1 Introduction

In type-driven semantics, semantic role assignment depends on the order of composition. If the denotation of *see* is $[\![see]\!] = \lambda y.\lambda x.\mathsf{see}'(x,y)$ with $\mathsf{see}'(a,b)$ iff a sees b, then the first argument to which the function applies will be assigned the semantic role of entity being seen, and the next argument will be assigned the semantic role of person seeing, so that $[\![see]\!]([\![Paul]\!])([\![Marc]\!]) = \mathsf{see}'(\mathsf{marc}',\mathsf{paul}')$ holds if Marc sees Paul. This order-dependent assignment of semantic roles works well if argument linking in a language is determined exclusively by word order. But what, if instead the assignment of semantic roles is determined by the morphosyntactic information associated with predicate and argument? To illustrate, assume for simplicity that an argument is assigned the patient-like semantic role if it is accusative, and the agent-like semantic role if nominative, as in *Videt Marcus Paulum.* ('Marc sees Paul.'). Two strategies can be pursued. First, one could assume that the role of the case morphology is to restrict the hierarchical position in which an NP can occur at the deep structure: if it is marked with accusative it can only occur as a sister of a transitive verb, if it is marked as nominative, it can only occur as a sister of a verb phrase. So despite the various possible surface orders, the deep structure is always [*Marcus* [*videt Paulum*]]. Alternatively, one can assume that the accusative morpheme denotes a function *acc*, which when applied to an NP-denotation n and a function v yields $acc(n)(v) = v(n)$, and that the nominative morpheme denotes a function:

$$nom(n)(v) = \begin{cases} v(n), & \text{if } v \text{ is unary function} \\ \lambda x.(v(x)(n)), & \text{if } v \text{ is binary function} \end{cases}$$

In the first alternative, case is interpreted as a syntactic filter on permissible constituent structure (trees), so that an accusative NP is guaranteed to be the first argument of the predicate. In the second alternative, case is interpreted as a function which essentially makes sure that the argument it applies to, i.e. the NP denotation, occurs in the appropriate position in the λ-term. So despite the fact that (word) order plays no role in the descriptive generalization underlying semantic role assignment, both strategies use the morphological information to restrict the order of application, which in turn determines the assignment of semantic roles.

The idea we shall develop in this paper is that morphosyntactic (in particular inflectional) information can determine the assignment of semantic roles directly and irrespective of the order of composition. Semantic composition consists in identifying variables with matching morphosyntactic information. Assuming that $[\![videt]\!] := \mathsf{see}'(x,y)$, and that the denotation of *Paulum* is $z = \mathsf{paul}'$, and assuming further that the morphosyntactic information associated with the variable y of *videt* matches the information associated with z of *Paulum*, we shall provide a calculus which identifies the variable y of $[\![videt]\!]$ with the variable z of $[\![Paulum]\!]$, and thus assigns the semantic role of entity seen to paul'.

As a case study we have chosen the direction and obviation system in Plains Cree, since in this language the person and number properties of the arguments as well as the assignment of semantic roles to arguments is almost exclusively determined by the complex morphological properties of the verb, and not by word order. In section 2 we sketch the direction and obviation system in Plains Cree, in 3 we introduce the theory of referent systems, in section 4 we provide the analysis of direction and obviation in terms of referent systems, and in section 5 we conclude.

2 Direction and Obviation in Plains Cree

Plains Cree is one of four dialects of Modern Cree, an Algonquian language spoken by around 60.000 people in Canada. It has a basically agglutinative structure, with a comparatively simple nominal inflection, but a formidably complex verbal inflectional system.[1] Zúñiga (2006), Dahlstrom (1986) and oth-

[1] The categories involved in the nominal system are possession, number, gender and obviation (no case), cf. Zúñiga (2006).

ers distinguish no less than nine affix positions in the verbal template of Plains Cree. Three of them (the fourth, sixth and eighth suffix) express tense, aspect and mood, whereas the others are related to the direction and obviation system, a fragment of which we present below.

The rich inflectional system of the verb is instrumental in expressing (i) the person and number properties of the verbal arguments, as well as (ii) the linking between verbal arguments and the semantic roles of the predicate. The argument linking in Plains Cree can be characterized by three basic features. First, some of the affixes (the prefix and the fifth suffix) impose restrictions on the person and number features of the verbal arguments irrespective of the particular semantic role of the argument or the number of arguments of a verb. Secondly, the link between semantic roles and arguments is established by the direction suffix (the second suffix) which adds the person and number information about the agent-like and patient-like arguments. When the predicate involves third person arguments, the direction suffix also adds information about which of the arguments is proximative (and which obviative). Finally, overtly realized third person noun phrases are morphologically marked as proximative or obviative, so that the semantic composition of noun phrase and verb is determined not by word order or position in hierarchical structure, but by sharing the same morphological feature.

To begin with, consider the following minimal pair:[2,3]

(1) a. Ki-pimipahtā-n.
2-run-SAP.SG
'You (sg) run.'
b. Ni-pimipahtā-n.
1-run-SAP.SG
'I run.'

The prefix indicates whether the participants in the relation denoted by the predicate include a speech act participant, according to the following generalization:

(2) FIRST PREFIX GENERALIZATION (based on Zúñiga (2006: 73)):
a. *ki-* is used whenever the addressee or a group containing the addressee is an argument; else:
b. *ni-* is used whenever the speaker or a group containing the speaker is argument; else

[2] All examples are quoted from Zúñiga (2006).
[3] Glossing: 1, 2, 3: first, second, third person; SAP: speech act participant; SG, PL: singular, plural; EXCL, INCL: exclusive, inclusive; DIR, INV: direct, inverse; PROX, OBV: proximative, obviative.

c. ∅-, i.e. if no SAP is an argument

The final affix *-n* also encodes information about the person and number of the participants, as illustrated by the following examples:

(3) a. Ni-pimipahtā-nān.
1-run-SAP.PL.EXCL
'We (excluding addressee) run.'
b. Ni-pimipahtā-n.
1-run-SAP.SG
'I run.'

The fifth suffix in the verbal template adds information about person and number of the participants according to the following generalization:

(4) FIFTH SUFFIX GENERALIZATION (based on Zúñiga (2006: 78)):
a. if one participant is 1 exclusive plural, then *-nān*; else
b. if one participant is 1 inclusive plural, then *-nānaw*; else
c. if one participant is 2 plural, then *-nāwāw*; else
d. if one participant is 3, then *-w*; else
e. (if 1SG or 2SG, then) *-n*

We briefly mention four important aspects of these two generalizations. First, they have an IF-THEN-ELSE structure, or put differently, they involve hierarchies, and secondly, the hierarchies involved differ from one another (and can therefore not be reduced to one hierarchy).

(5) Hierarchies involved:

Slot	**Description**	**relevant hierarchy**
prefix	**highest participant**	**2 > 1 > 3**
2. suffix	**direction**	**SAP > 3prox > 3obv > 3f.obv**
5. suffix	**person/number**	**1p > 12/2p > 3anim > sSAP > 3inan**

Thirdly, these two generalizations are insensitive to the number of arguments a predicate has. To see this note that the transitive verb *pēhtaw* ('hear') in (6):

(6) Ki- pēhtaw -i -n.
2- hear -DIR(2→1) -SAP.SG
'You$_{SG}$ hear me.'

and the intransitive verb *pimipahtā* ('run') in (1a) are both prefixed by *ki-* and suffixed by *-n*. And fourthly, the generalizations do not make any reference to (specific or generalized) semantic roles, so that first prefix and fifth suffix are fixed by the person and number properties of the arguments irrespective of their semantic roles, which can be illustrated by the following minimal pair:

(7) a. Ki- pēhtaw -i -n.
2- hear -DIR(2→1) -SAP.SG
'You$_{\text{SG}}$ hear me.'
b. Ki- pēhtaw -iti -n.
2- hear -INV(1→2) -SAP.SG
'I hear you$_{\text{SG}}$.'

The link between arguments and semantic roles is established by the so-called direction suffix (the second suffix). The only morphosyntactic difference between these sentence pairs is the so-called direction suffix *-i* in (7a) and *iti* in (7b), which correlates with the difference in semantic role assignment. In (7a) the addressee is the person hearing, and the speaker the person heard, whereas in (7b) the semantic role assignment is reversed.

Together, the three affixes impose restrictions on the person and number of the arguments, but only the direction suffix provides information about the link between arguments and semantic roles. Different participant configurations call for different direction suffixes. The local configuration, illustrated above, involves only speech act participants (or groups containing speech act participants). In the mixed configuration, in which one argument is a SAP and another one is not, the respective direction suffixes are *-ā* and *-ikw*.

(8) a. Ki- sēkih -ā -w
2- frighten -DIR(2→ 3) *-3*
'You (sg) frighten him/her.'
b. Ki- sēkih -ikw -w
2- frighten -DIR(3 → 2) *-3*
'He/she frightens you (sg).'

And finally, in the non-local configuration, where neither argument is a SAP, the direction suffixes are *-ē/-ā* and *-ikw*.

(9) a. ∅- sēkih -ē -w
3- frighten -DIR(3.PROX → 3.OBV) *-3*
'He (prox) frightens him/her/them (obv).'
b. ∅- sēkih -ikw -w
3- frighten -DIR(3.OBV → 3.PROX) *-3*
'He/she/they (obv) frighten(s) him/her (prox).'

The direction suffixes for the different participant configurations are summed up below:

(10) The DIRECTION.SUFFIXES (for transitive verbs with animate objects):

	local		mixed		non-local	
DIR	*-i*	2→1	*-ā*	SAP→3	*-ē*	3_{PROX}→3_{OBV}
INV	*-iti*	1→2	*-ikw*	3→SAP	*-ikw*	3_{OBV}→3_{PROX}

The proximative-obviative distinction is realized not only in the verbal system but also in the nominal system. If a third person argument is overtly realized as a noun phrase, then it is morphologically marked either as proximative or as obviative.

(11) O- wīcēwākan **-a** ∅- miskaw -ē -w **awa** nēhiyaw.
3POSS- *companion* **-OBV** *3- find* -DIR *-3* **DEM:PROX** *Cree*
'The Cree$_{prox}$ found his comrades.'

(12) Tāpwē **awa** iskwēw ∅-pakamahw-ē-w ēsa **ōhi** wīhtiko-**wa**.
truly **DEM:PRO** *woman 3-strike*-DIR-*3* REP **DEM:OBV** *windigo*-**OBV**
'Truly the woman struck down that windigo.'

For space reasons we introduced only a fragment of the actual direction and obviation system in Plains Cree. First, we focused on only three out of six affixes relevant for direction and obviation. And secondly, we ignored a number of other morphosyntactic categories which are known to be relevant for direction marking on the verb in Plains Cree. To mention only two, the affixes encoding direction in Plains Cree depend further on (i) the type of clause,[4] and (ii) the animacy of the patient-like argument. If the argument is inanimate, as in (13a), then the direction suffix *-ē* must be used instead of *-ā*, which in turn must be used in (13b), since the argument is animate.

(13) a. Ni- wāpaht -ē -nān.
1- see -DIR(SAP→3.INAN) -1PL.EXCL
'We (excl.) see it.'

b. Ni- sēkih -ā -nān.
1- frighten -DIR(SAP→3.ANIM) -1PL.EXCL
'We (excl.) frighten him/her.'

The linking of arguments and semantic roles by means of the direction and ob-

[4] The forms introduced here are basically restricted to independent clauses (belonging to the independent paradigm), whereas dependent clauses require forms from a different so-called conjunct paradigm.

viation system poses an important challenge to the theory of semantic composition, in particular to type-drive composition, because the assignment of the semantic roles to arguments is not determined by the order of composition but by shared morphological information, namely agreement in proximative/obviative features.[5] If the direction suffix is DIR(3.OBV→3.PROX), then a proximate noun phrase denotation will be assigned the patient-like argument, if the direction suffix is DIR(3.PROX→3.OBV), then it will be assigned the agent-like argument. The analysis of the contribution of first prefix and fifth affix poses an additional challenge, since these affixes impose (semantic) restrictions on the person and number of the arguments of a predicate, but they do this irrespective of the semantic role of the arguments. In section 4 we provide an analysis which meets both these challenges in terms of referent systems, which we introduce in section 3.

3 The Theory of Referent Systems

3.1 Semantic Composition by Renaming of Variables

The semantic structure of lexical items will be analyzed in terms of pairs $\langle U, C\rangle$ consisting of a set of referents U and a set of conditions C, i.e. by means of discourse representation structures (DRSs).[6] Returning to our example (11), we want the composition of the DRSs for the noun phrase *o-wīcēwākan-a* ('his comrades$_{\text{OBV}}$') and the verb *miskawēw* ('find') to result in:

/o-wīcēwākan-a/

x
comrades′(x)

•

/∅-miskaw-ē-w/

e
find′(e) p.finding′(e) ≐ x e.found′(e) ≐ y

=

/o-wīcēwākan-a ∅-miskaw-ē-w/

e, y
find′(e) p.finding′(e) ≐ x e.found′(e) ≐ y comrades′(y)

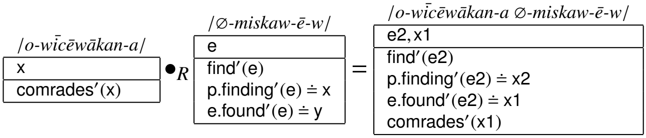
Where the referent x of the NP DRS is identified with the referent y of the verb DRS, which gets assigned the role of entity being found.[7] This result can be achieved by (i) renaming the variable x of the first DRS into x1, (ii) renaming the variables e,x,y in the second DRS into e2,x2,x1 respectively, and (iii) by conjoining the sets of renamed referents and renamed conditions respectively. Put in a nutshell, the semantic composition of two DRSs consists in conjunc-

[5] This is not to say that it is impossible to provide an analysis of semantic role assignment in Plains Cree within a type-driven approach to semantic composition.

[6] Thus, we adopt an algebraic approach to DRT, cf. Zeevat (1989), as opposed to the procedural approach of Kamp & Reyle (1993).

[7] We want these two referents to be identified irrespective of the actual variable name chosen for the NP referent, in order to account for the fact that the choice of variable name for the NP referent is actually immaterial.

tion relative to a renaming R of variables



where $R = \langle\{\langle \mathsf{x}, \mathsf{x1}\rangle\}, \{\langle \mathsf{e}, \mathsf{e2}\rangle, \langle \mathsf{x}, \mathsf{x2}\rangle, \langle \mathsf{y}, \mathsf{x1}\rangle\}\rangle$. So the renaming of variables identifies some variables (irrespective of their actual names), and keeps all other variables distinct (even if they have the same names) in order to avoid accidental identification of referents.

Definition 3.1 *A **referent** $\mathsf{x}^\frown\sigma$ consists of the variable symbol* x *followed by a sequence $\sigma \in \{1, 2\}^*$. Let R be the set of such referents.*

Convention 3.1 To ease readability we use also the symbols $e, f, g, h, x, y, z, u, v, w, \ldots$ standing for referents.

Definition 3.2 *A renaming $r \subset R^2$ is an injective function which suffixes its argument either with a 1 or with a 2. r is a renaming of a referent system $\alpha = [\mu_1, \ldots, \mu_n]$ iff the domain $D \subset R$ of r is the set of referents $\{\mathbf{ref}(\mu_i) : 1 \leq i \leq n\}$.*

Definition 3.3 *Let $\Delta_1 = \langle U_1, C_1\rangle$, and $\Delta_2 = \langle U_2, C_2\rangle$ be two DRSs, where Δ_1 contains the variables $x_1, \ldots, x_m$ and Δ_2 contains the variables $y_1, \ldots, y_n$. Then $\bullet(\Delta_1, \Delta_2, \langle r_1, r_2\rangle)$ is defined iff (i) the domain of r_1 is the set of variables in Δ_1, and (ii) the domain of r_2 is the set of variables in Δ_2. In this case*
$\bullet(\langle U_1, C_1\rangle, \langle U_2, C_2\rangle, \langle r_1, r_2\rangle) = \langle r_1[U_1] \cup r_2[U_2], r_1[C_1] \cup r_2[C_2]\rangle$, where

(i) $r_1[U_1] = \{r_1(x_i) : i \leq m\}, r_2[U_2] = \{r_2(x_j) : j \leq n\}$
(ii) $r_1[C_1] = \{\phi_i[r_1] : \phi_i \in C_1\}, r_2[C_2] = \{\phi_j[r_2] : \phi_j \in C_2\}$
(iii) *$\phi[r]$ is the result of replacing every variable x in ϕ by $r(x)$*

The renaming of variables is determined by the morphosyntactic information associated with each variable, to be presented in the next subsection.

3.2 Morphosyntactic Structure

The basic idea of the calculus of referent systems, first introduced in Vermeulen (1995) and then extended in Kracht (1999), is that the way in which variables are to be renamed is decided by the morphosyntactic information associated with each variable, and stored in so-called referent systems. Since semantic composition of two DRSs proceeds relative to the renaming dictated by the morphosyntax, the renaming of variables provides the interface between morphosyntax and semantic composition.

Every variable in a DRS is associated with morphosyntactic information relevant for the identification of this variable. There are three types of information relevant for the identification of variables, namely hierarchical, linear and categorial information. Hierarchical information is encoded by the following vertical diacritics: (i) $\triangledown$ (the referent is a functor with respect to merge) (ii) $\vartriangle$ (the referent is an argument with respect to merge), (iii) $\lozenge$ (the referent is an adjunct), and (iv) $-$ (the referent cannot identify any further). The linear information is encoded by the following horizontal diacritics: (i) ⧁ (referent expects argument to the right), (ii) ⧀ (referent expects argument to the left), (iii) ⦶ (referent expects argument either to the left or to the right), and (iv) ○ (no expectations). The categorial information is encoded by a finite number of **simple names** (which are essentially feature values over a certain namespace) or **transformer names** (which transform the value of a feature):

$$\begin{bmatrix} \text{PER} & : 3 \\ \text{NUM} & : \mathsf{sg} \\ \text{CASE} & : - \end{bmatrix} \begin{bmatrix} \text{PER} & : 3 \\ \text{NUM} & : \mathsf{sg} \\ \text{CASE} & : - \to \mathsf{acc} \end{bmatrix}$$

Definition 3.4 *A **vertical diacritic** vd is a subset of* $\{\vartriangle, \triangledown\}$. *A **horizontal diacritic** hd is a subset of* {⧀,⧁}.

Convention 3.2 For ease of readability, we use the following conventions for representing vertical and horizontal diacritics:

	definition	convention
vd	$\varnothing$	$-$
	$\{\vartriangle\}$	$\vartriangle$
	$\{\triangledown\}$	$\triangledown$
	$\{\vartriangle, \triangledown\}$	$\lozenge$

	definition	convention
hd	$\varnothing$	○
	{⧁}	⧁
	{⧀}	⧀
	{⧀,⧁}	⦶

Definition 3.5 *A **diacritic** d is a pair $\langle vd, hd\rangle$ consisting of a vertical diacritic vd and a horizontal diacritic hd. A diacritic $\langle vd, hd\rangle$ is a **legal diacritic** iff* $(\triangledown \in vd \vee \blacktriangledown \in vd) \leftrightarrow hd \neq \varnothing$. *The diacritic $\langle \varnothing, \varnothing\rangle$ is called **trivial**.*

The categorial information will be represented by so called names.

Definition 3.6 *A **name space** $\mathbf{N}$ is a triple $\langle A, V, f\rangle$, where A is a finite non-empty set of attributes, V is a finite non-empty set of values disjoint from A, and $f : A \to \wp(V)$ is a valuation function assigning every attribute in A a subset of V.*

Definition 3.7 *A **simple name** N (over a name space $\mathbf{N} = \langle A, V, f\rangle$) is a feature structure over $\mathbf{N}$. A **transformer name** $\mathfrak{N}$ is a pair $\langle N, N'\rangle$ of simple names.*

We shall use the more compact notation:

$$\begin{bmatrix} \text{CAT} & : & \mathsf{v} \\ \text{PRE} & : & - \\ \text{SUFF} & : & - \to + \end{bmatrix} \text{for} \left\langle \begin{bmatrix} \text{CAT} & : & \mathsf{v} \\ \text{PRE} & : & - \\ \text{SUFF} & : & - \end{bmatrix}, \begin{bmatrix} \text{CAT} & : & \mathsf{v} \\ \text{PRE} & : & - \\ \text{SUFF} & : & + \end{bmatrix} \right\rangle$$

Let $n.a$ be the value of the simple name n for the feature a. The unification $n_1 \sqcap n_2$ is defined if for all attributes $a \in A$ it holds that $n_1.a \cap n_2.a \neq \emptyset$. Then $n_1 \sqcap n_2 = \{[a : v_1 \sqcap v_2] : [a : v_1] \in n_1 \wedge [a : v_2] \in n_2\}$.

We can now put together the information relevant for the identification of a referent, by defining so-called argument identification statements:

Definition 3.8 *A triple $\alpha = \langle x, \langle vd, hd \rangle, n \rangle$ is an **argument identification statement** (AIS) iff (i) x is a referent, $\langle vd, hd \rangle$ a legal diacritic with $|vd| < 2$, and n a simple name (over a name space $\mathbf{N}$), or (ii) x is a referent, $\langle vd, hd \rangle$ a legal diacritic with $vd = \{\triangle, \triangledown\}$, and n a transformer name. Further, let $\mathbf{ref}(\alpha) = x, \mathbf{vd}(\alpha) = vd, \mathbf{hd}(\alpha) = hd, \mathbf{n}(\alpha) = n$.*

Definition 3.9 *A list of argument identification statements $[\mu_1, \ldots, \mu_m], m \geq 1$, is called a **referent system**.*

Before providing the definition for the merge of referent systems, we illustrate this operation by discussing the merge of the referent system of *miskaw-ē* ('find') with the referent system of the fifth suffix *-w*:

$$\underset{/miskaw\text{-}\bar{e}/}{\boxed{\begin{array}{l} \mathsf{e} : \triangle\bigcirc : \begin{bmatrix} \text{CAT} : \mathsf{trv} \\ \text{PRE} : - \\ \text{SUF} : - \end{bmatrix} \\ \mathsf{x} : \triangle\bigcirc : \begin{bmatrix} \text{PER} : 3 \\ \text{PROX} : + \end{bmatrix} \\ \mathsf{y} : \triangle\bigcirc : \begin{bmatrix} \text{PER} : 3 \\ \text{PROX} : - \end{bmatrix} \end{array}}} \bullet \underset{/\text{-}w/}{\boxed{\begin{array}{l} \mathsf{f} : \lozenge \oslash : \begin{bmatrix} \text{CAT} : \mathsf{trv} \\ \text{PRE} : - \\ \text{SUF} : - \to + \end{bmatrix} \\ \mathsf{u} : \lozenge \oslash : \begin{bmatrix} \text{PER} : 3 \end{bmatrix} \\ \mathsf{v} : \lozenge \oslash : \begin{bmatrix} \text{PER} : 3 \end{bmatrix} \sqcup \begin{bmatrix} \text{PER} : 1 \\ \text{NUM} : \mathsf{sg} \end{bmatrix} \sqcup \begin{bmatrix} \text{PER} : 2 \\ \text{NUM} : \mathsf{sg} \end{bmatrix} \end{array}}} = \underset{/miskaw\text{-}\bar{e}\text{-}w/}{\boxed{\begin{array}{l} \mathsf{e1} : \triangle\bigcirc : \begin{bmatrix} \text{CAT} : \mathsf{trv} \\ \text{PRE} : - \\ \text{SUF} : + \end{bmatrix} \\ \mathsf{x1} : \triangle\bigcirc : \begin{bmatrix} \text{PER} : 3 \\ \text{PROX} : + \end{bmatrix} \\ \mathsf{y1} : \triangle\bigcirc : \begin{bmatrix} \text{PER} : 3 \\ \text{PROX} : - \end{bmatrix} \end{array}}}$$

First, leftward merge $\alpha \bullet_l \beta$ of two referent systems α and β is defined if (i) α is saturated (i.e. with $\triangledown \notin \mathbf{vd}(\alpha)$ for all AISs in α) and (ii) at least one leftward merge of AISs is defined. A leftward merge $\mu \triangleleft \nu$ of two AISs μ and ν is defined if (i) the horizontal diacritic of ν contains $\oslash$, (ii) the vertical diacritic of μ is $\triangle$ or $\lozenge$, (iii) the vertical diacritic of ν is $\triangledown$ or $\lozenge$, and (iv) the names of μ and ν can be unified. In our example, the leftward merge of the AISs of the referents e and f is defined, since (i) the horizontal diacritic of f is $\oslash$, (ii) the vertical diacritic of e is $\triangle$, (iii) the vertical diacritic of f is $\lozenge$, and (iv) the first name of the transformer name of f matches (i.e. can be unified with) the simple name of e. Further, the AIS with referent u can be leftward-merged with the AIS with referent x, and the same holds for the two AISs with referents v and y.

Definition 3.10 *The **leftward merge of two AISs** $\mu \triangleleft \nu$ is defined iff (i) $\otimes \in \mathbf{hd}(\nu)$, (ii) $\triangle \in \mathbf{vd}(\mu)$, (iii) $\triangledown \in \mathbf{vd}(\nu)$, and (iv) $\mathbf{n}(\mu) \cdot \mathbf{n}(\nu)$ is defined. If defined, then:*

$$\mu \triangleleft \nu = \langle \mathbf{ref}(\mu)^\frown 1, \langle \mathbf{vd}(\mu) \cap \mathbf{vd}(\nu), \mathbf{hd}(\mu) \rangle, \mathbf{n}(\mu) \cdot \mathbf{n}(\nu) \rangle$$

*where the **resulting name** $m \cdot n$ is:*

$$\mathbf{n}(\mu) \cdot \mathbf{n}(\nu) = \begin{cases} \mathbf{n}(\mu) \sqcap \mathbf{n}(\nu), & \text{if } \mathbf{n}(\mu), \mathbf{n}(\nu) \text{ are unifiable simple names} \\ B, & \text{if } \mathbf{n}(\mu) = \langle A, B \rangle, \mathbf{n}(\nu) = C, \text{ and } A \text{ unifies with } C \\ C, & \text{if } \mathbf{n}(\mu) = A, \mathbf{n}(\nu) = \langle C, D \rangle, \text{ and } A \text{ unifies with } D \\ \text{undefined}, & \text{otherwise} \end{cases}$$

The leftward merge of referent systems is defined as follows:

Definition 3.11 *Let $\alpha = [\mu_1, \ldots, \mu_m]$ and $\beta = [\nu_1, \ldots, \nu_n]$ be two referent systems. The **leftward merge** $\bullet(\alpha,\beta,\langle r_1, r_2 \rangle)$ **of** α **and** β **relative to the renaming** $\langle r_1, r_2 \rangle$ is defined iff*

- *α is saturated*
- *there is an $i, 1 \leq i \leq n$ such that μ_1 accesses ν_i*
- *for every k with $1 \leq k \leq m$*
  - *$\mu_k \triangleleft \nu_{i+(k-1)}$ is defined*
  - *$r_1(\mathbf{ref}(\mu_k)) = r_2(\mathbf{ref}(\nu_{i+(k-1)})) = \mathbf{ref}(\mu_k)^\frown 1$, and*
- *for all j between $1 \leq j \leq n$ with $j \neq i + (k-1)$, $r_2(\mathbf{ref}(\nu_j)) = \mathbf{ref}(\nu_j)^\frown 2$*

In this case $\bullet(\alpha,\beta,\langle r_1, r_2 \rangle) = \langle [\epsilon_p : 1 \leq p \leq n] \rangle$ where:

$$\epsilon_p = \begin{cases} \mu_k \triangleleft \nu_{i+(k-1)} & \text{if } i \leq p \leq i + (m-1) \\ \langle \mathbf{ref}(\nu_p)^\frown 2, \langle \mathbf{vd}(\nu_p), \mathbf{hd}(\nu_p) \rangle, \mathbf{n}(\nu_p) \rangle & \text{else} \end{cases}$$

Definition 3.12 *Let $\alpha = [\mu_1, \ldots, \mu_m]$ be a saturated referent system and $\beta = [\nu_1, \ldots, \nu_n]$ another referent system. Then μ_1 **accesses** ν_i ($1 \leq i \leq n$) iff (i) either $\mu_1 \triangleleft \nu_i$ or $\nu_i \triangleright \mu_1$ is defined, and (ii) there is no ν_k with $i < k \leq n$ such that $\mu_1 \triangleleft \nu_k$ or $\nu_k \triangleright \mu_1$ is defined*

As it is formulated, the merge requires that the first AIS of the saturated referent system access the first AIS from the bottom of the functor referent system for which the left- or rightward merge of AIS is defined. The notion of access can be made dependent on the language, so that for example in some languages the merge requires that the first AIS of the saturated referent system can only access the last AIS of the functor referent system.

The rightward merge of argument identification statements and referent systems can be formulated analogously.

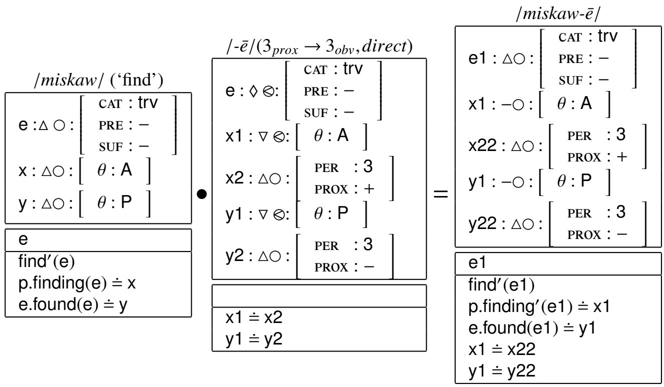
4 A Referent Systems Analysis of Direction and Obviation

In this section we provide an analysis of the direction and obviation system in terms of referent systems, and illustrate this analysis by deriving the following two sentences:

(14) a. O- wīcēwākan **-a** ∅- miskaw -ē -w **awa** nēhiyaw.
3POSS- *companion* -**OBV** *3- find* -DIR *-3* **DEM:PROX** *Cree*
'The Cree$_{prox}$ found his comrades.'

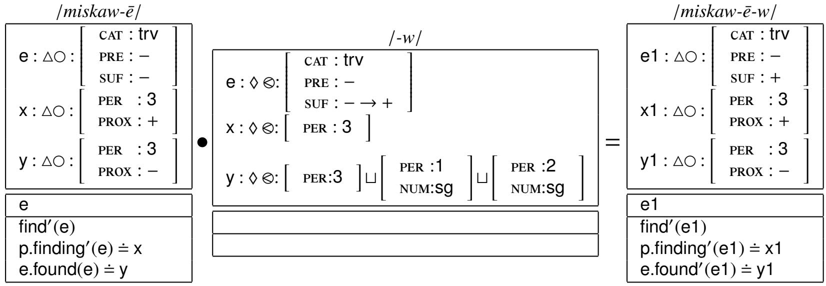
b. Ki- pēhtaw -iti -n
2- hear -INV(1→2) -SAP.SG
'I hear you (sg).'

Combining the sign *miskaw* with the direction suffix *ē* results in:

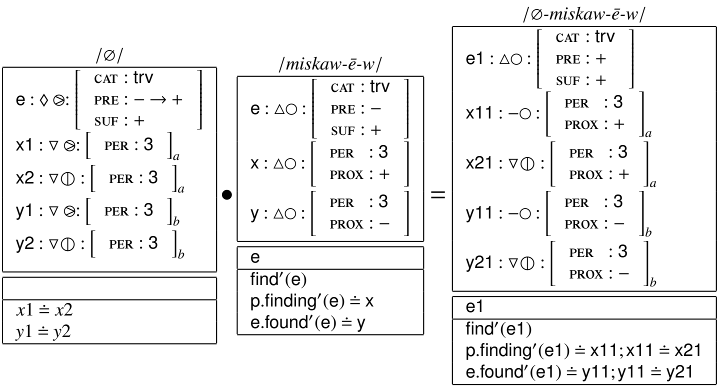


The referent system of *miskaw* contains an AIS for the event variable e, and one AIS for each argument variable x and y. Since the event variables of stem and direction suffix have matching morphosyntactic information, they get identified. Moreover, the merge of the two referent systems also identifies x and x1 (as well as y and y1), due to the matching value for the θ-role feature. As a result the variables x and x1 are both renamed to x1 (y and y1 are renamed to y1). Since the referents x1 and x2 of the direction suffix are coreferential, the two referents x1 and x22 of the referent system for *miskaw-ē* are also coreferent, which in effect means that the referent x22 is assigned the semantic role of person finding. Given its associated morphosyntactic information, this referent can only identify with 3rd person proximate noun phrases.

The attachment of the fifth suffix $-w$ to this base imposes the restriction that one referent is third person and the other is either third person or a singular SAP. Moreover, the fifth suffix transforms the suffix value from − to +, provided that the base is prefixless.



The first AIS of the zero prefix provides the morphosyntactic information associated with the event variable. This AIS can only merge with a variable whose prefix value is − and whose suffix value is +. If this is the case, it transforms the prefix value from − to +, making sure that only one prefix can attach to the base. The next two AISs of the zero prefix contain referents which are coreferential and whose categorial information is required to be identical (this is what the indices *a* and *b* are supposed to mean). The reason for this is as follows. The zero affix must be prefixed to the base, therefore the linear information associated with x1 (and y1) is ⊗. However, we would like the resulting referent to be identifiable either to the left or to the right. To achieve this, we add a coreferential referent x2 to the zero prefix, and require that it be identifiable either to the left or to the right, i.e. with ⦶.



The prefixation of the zero affix then identifies the referents e, x1, y1 of the zero affix with the referents e, x, y of the base *miskaw-ē-w*, respectively, and consequently the referents x2 and y2, renamed to x21 and y21, are assigned the semantic roles of person finding and entity found, respectively.

As can be seen, the referent x21, which bears the role of person finding, can only identify with referents which are third person proximative, and the referent y21 bearing the role of entity found can only be identified with third person obviative referents. Now the two noun phrases can be combined (in any order). Combining first the obviative NP result in the identification of the referent x of the NP referent system with the referent y of the verb, which in turn entails that the the semantic role of entity found is assigned to the comrades:

/o-wīcēwākan-a/
x : △ ○ : [PROX : -]
x
comrades′(x)

•

/∅-miskaw-ē-w/
e : △○ : [CAT : trv, PRE : +, SUF : +]
x : ▽⦶ : [PER : 3, PROX : +]
y : ▽⦶ : [PER : 3, PROX : −]
e1
find′(e)
p.finding′(e) ≐ x
e.found′(e) ≐ y

=

/o-wīcēwākan-a ∅-miskaw-ē-w/
e2 : △○ : [CAT : trv, PRE : +, SUF : +]
x2 : ▽⦶ : [PER : 3, PROX : +]
x1 : −○ : [PER : 3, PROX : −]
x1, e2
find′(e2)
p.finding′(e2) ≐ x2
e.found′(e2) ≐ x1
comrades′(x1)

Finally, combining this verb phrase with the proximate NP results in the identification of the referent x of the proximate NP with the referent x of the verb phrase referent system, so that this referent gets assigned the semantic role of person finding.

(13)

/o-wīcēwākan-a ∅-miskaw-ē-w/
e : △○ : [CAT : trv, PRE : +, SUF : +]
x : ▽⦶ : [PER : 3, PROX : +]
y : −○ : [PER : 3, PROX : −]
e, y
find′(e)
p.finding′(e) ≐ x
e.found′(e) ≐ y
comrades′(y)

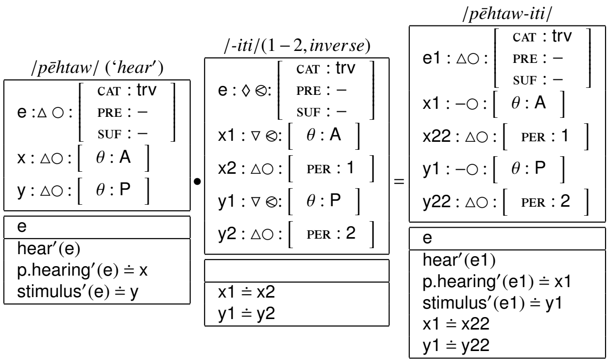
•

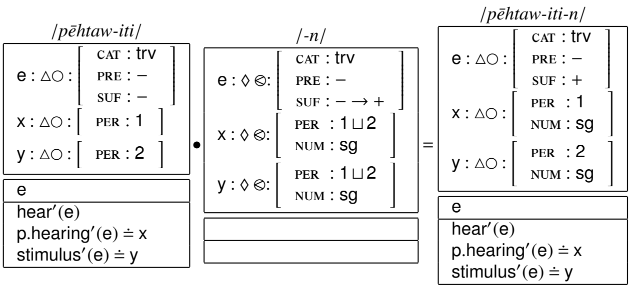
/awa nēhiyaw/
x : △ ○ : [PROX : +]
x
cree′(x)

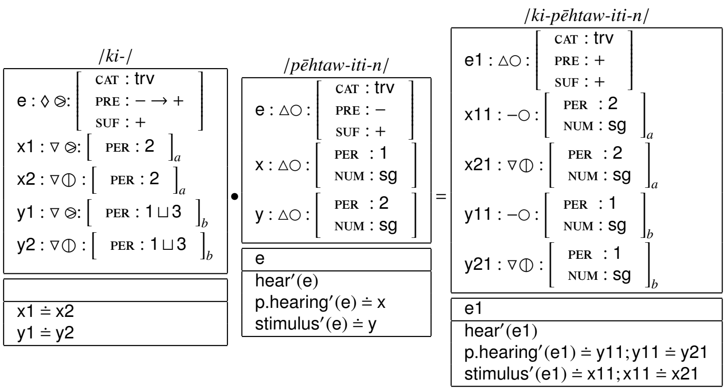
=

e1 : △○ : [CAT : trv, PRE : +, SUF : +]
x1 : −○ : [PER : 3, PROX : +]
y1 : −○ : [PER : 3, PROX : −]
e1, y1
find′(e1)
p.finding′(e1) ≐ x1
e.found′(e1) ≐ y1
comrades′(y1)
cree′(x1)

Second derivation:







5 Conclusion

Referent systems provide an interface between syntax on the one hand and semantics on the other by allowing to detail the way in which variables are being linked (i.e. identified) under merge. Certain aspects of the system have been omitted, such as parameters or quantification, in order to make the presentation focused. We have shown how referent systems allow for greater flexibility in syntax, by opening up access in argument structure. It should be fairly obvious that merge is a fairly inexpensive operation. It consists in two steps: the first is to calculate the resulting argument structure and the substitutions before merge, and the step in executing the substitutions and then merging the semantic representations. Although complete syntactic flexibility has its price in terms of combinatorial explosion, referent systems allow morphology to keep this search simple by providing clues as to how arguments have to be linked. And it seems that in practice languages do employ ways of keeping this combinatorial problem at bay.

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