A set-based semantics for obviation and animacy

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Abstract This paper provides an analysis of the semantics of obviation and animacy through a case study of Ojibwe (Central Algonquian). I develop a lattice-based characterization of possible person, obviation, and animacy categories, showing that the addition of two binary features, [±Proximate] and [±Animate], captures the six-way distinction of Ojibwe. These features denote first-order predicates formed from subsets of an ontology of person primitives, with composition and interpretation defined by (i) the functional sequence of the nominal spine, (ii) the denotation of feature values, and (iii) the theory of contrastive interpretations. I show that alternative accounts based in lattice actions or feature geometries cannot capture the partition of Ojibwe, and offer extensions of the proposed system to noun classification in Zapotec, Romance, and Bantu.

Keywords: obviation, animacy, person, noun classification, gender, φ-features

1 Introduction

Languages show constrained, but rich, variation in how categories related to person are distinguished and conflated. At the core of all person systems is the possibility to refer to the author of an utterance, the addressee, and various non-participants — all languages, and indeed all humans, appear to have access to these fundamental concepts. The major point of variation is how these concepts are accessed, encoded, and manipulated by the grammar. The view taken in this paper is that the author, addressee, and others are PRIMITIVES of a mental ontology that is manipulated and accessed by morphosyntactic FEATURES. These features, in turn, give rise to CATEGORIES that allow reference to the primitives. The current state-of-the-art (e.g. Harbour, 2016; Ackema and Neeleman, 2018) accounts for variation with the *core* person categories (e.g. FIRST, SECOND, and THIRD). The goal of this paper is to understand how other categories closely related to person, namely PROXIMATE, OBVIATIVE, ANIMATE, and INANIMATE, arise from features and allow access to the ontology of person primitives.

The main line of inquiry is a case study on how person, animacy, and obviation distinctions are made within Ojibwe, a Central Algonquian language spoken in the land area extending mostly north from the Great Lakes of North America. As schematized in (1) with strong pronouns, Ojibwe makes distinctions between EXCLUSIVE (author + others), INCLUSIVE (author + addressee + others), SECOND (addressee + others), and THIRD (others) within the core persons. In the parlance of Harbour (2016), it shows a *quadripartition*—a four-way split in person categories.

(1) *Core person categories in Ojibwe as evidenced by strong pronouns*

niinawind	=	EXCLUSIVE
giinawind		INCLUSIVE
giinawaa		SECOND (PL)
wiinawaa		THIRD (PL)

However, the strong pronouns alone do not reveal the full set of possible distinctions. The THIRD person category can be further divided three ways through animacy-based noun classification and obviation. Informally, animacy divides the "others" into categories containing living (ANIMATE) versus non-living (INANIMATE) things, while obviation distinguishes the single most discourse prominent animate third person (PROXIMATE) from all others (OBVIATIVE). With animate nouns, encoding an obviation status is obligatory—animate nouns cannot lack obviation. The default status is proximate, which appears, e.g., when there is just one animate noun in the discourse (intuitively, being the *only* animate noun necessarily makes it the most prominent).

Evidence for these cuts abounds in the patterns of agreement and marking on regular nominals. Consider the patterns of plural marking in (2), where obviation is contrasted between the animate noun *ikwe* in (2a) and (2b), with the inanimate noun *ziibi* in (2c) showing a third type of marker (all in bold).

(2) a. ikwe **-wag**
woman **-PROX.PL**
'women (PROX)'

b. ikwe **-wa'**
woman **-OBV.PL**
'women (OBV)'

c. ziibi **-wan**
river **-INAN.PL**
'rivers (INAN)'

Similarly, the patterns of agreement with intransitive verbs show a three-way distinction between proximate, obviative, and inanimate, as shown in (3). While the argument in each case is *pro*, the underlying cuts are apparent from the "peripheral" agreement slot (in bold).

(3) a. misko -zi **-wag** *pro*
red -BE.ANIM **-PROX.PL** PRO.PROX.PL
'They (PROX) are red'

b. misko -zi **-wa'** *pro*
red -BE.ANIM **-OBV.PL** PRO.OBV.PL
'They (OBV) are red'

c. miskw -aa **-wan** *pro*
red -BE.INAN **-INAN.PL** PRO.INAN.PL
'They (INAN) are red'

Putting all the pieces together, the resulting partition that emerges is shown in (4), where the generic THIRD person category is replaced by PROXIMATE (proximate other + animate others), OBVIATIVE (animate others), and INANIMATE (inanimate others). We can refer to this six-way distinction as a *hexapartition*.

(4) *Animacy, obviation and person categories form a hexapartition in Ojibwe*

EXCLUSIVE
INCLUSIVE
SECOND
PROXIMATE
OBVIATIVE
INANIMATE

The main objective is to understand how these distinctions are encoded in Ojibwe. However, we also want to understand the parameters of variation across languages—needless to say, not all languages are like Ojibwe in making a six-way cut. This variation is present on a number of levels: languages might distinguish ANIMATE and INANIMATE, but not PROXIMATE and OBVIATIVE, or languages might distinguish INCLUSIVE and EXCLUSIVE, but not ANIMATE and INANIMATE. But this variation is not entirely free. The general puzzle at hand, which can ultimately be traced back to Zwicky (1977), is known as the *partition problem* (Harbour, 2016). Zwicky observed that languages with a three-way distinction between person categories (e.g. English) treat "you and us" (the INCLUSIVE) as a form of "us" (i.e. a type of FIRST) rather than a form of "you" (i.e. a type of SECOND). These two partitions are schematized in (5).

(5) *Example of attested (left) and unattested (right) partitions (as first observed by Zwicky)*

EXCL INCL	FIRST (PL)
SECOND	
THIRD	

EXCL	
INCL SECOND	SECOND (PL)
THIRD	

Such lumping goes beyond mere surface-level morphophonological *syncretism*—two categories that are otherwise distinguished in a language sharing a common form in some corner of a paradigm. It is instead a *conflation* of categories, in which a language erases a distinction that other languages may permit (e.g. McGinnis, 2005). Carful studies of possible partitions (e.g. Harley and Ritter, 2002; Cysouw, 2003; Bobaljik, 2008; Harbour, 2016) have revealed that there are far fewer patterns of conflation than we might reasonably imagine: only five of the fifteen logical possibilities are attested. These patterns will be explored in due course.

The first part of the paper (§2) introduces the lattice-based formulation of the partition problem of Harbour (2016) and extends it to understand obviation and animacy in Ojibwe. In §3 I adopt the theory of contrastive interpretations (Dresher, 2009; Cowper and Hall, 2019) to model restrictions and interactions between feature/value combinations, then apply the system in §4 to capture person, animacy, obviation, and number in Ojibwe. I then turn to evaluating alternative accounts including Harbour's proposal and the feature geometry in §5. In §6 I consider extensions of the proposed system to noun classification in Zapotec, Romance, and Bantu before concluding in §7.

2 The extended partition problem

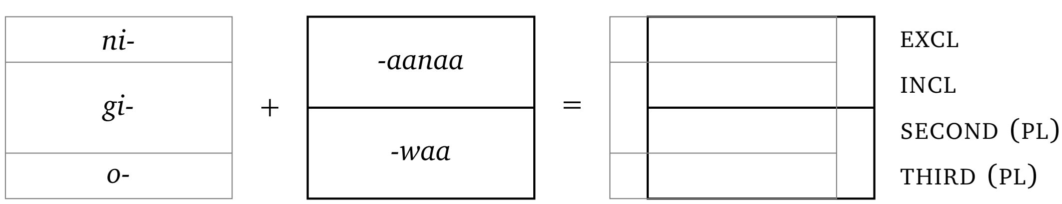
2.1 Superposition

The initial goal is to motivate the underlying distinctions related to person, obviation, and noun classification. Gaining a meaningfully abstracted perspective on patterns of conflation, and distinguishing them from mere syncretism, is a challenging empirical task. The basic form of the challenge is that our primary data—paradigms of agreement, pronouns, dietetic elements, and so on—are obscured by accidental homophony, as well as systematic morphophonological processes. The solution to this challenge has long been to compare *across* paradigms of pronouns and agreement within a language, rather than relying on the categories revealed by a single paradigm. The question being: what is the full set of possible distinctions a language makes? While by no means the first study to undertake such a program (see, e.g. Cysouw, 2003), this has recently been productively formalized through the *superposition* method of Harbour (2016).

2.1.1 The basics of superposition

By way of introduction, I begin with what superposition reveals about the *core* person categories related to the author, addressee, and generic others. The basic form of the method is shown in (6), where each of the boxes on the left side of the "equation" are two of the agreement slots found with transitive matrix verbs in Ojibwe (specifically, forms from the "independent order VTA" paradigm). For expositional purposes, just the plural variants of each category are shown (EXCL(USIVE), INCL(USIVE), SECOND plural, and (proximate) THIRD plural). The first paradigm from the left is for the person prefix, and the second is for the central agreement marker. The right side of the equals sign shows the result of superposition, which derives the underlying *partition*. The two paradigms are slightly offset from one another to preserve the visibility of the original cuts, and are shaded to more clearly reveal the correspondences between the left and right sides.

(6) *Superposition with Ojibwe transitive person prefix and central agreement*



Observe that neither of the slots alone realizes distinctions between all four categories. In other words, there are *syncretisms*. The person prefix shows a syncretism between INCLUSIVE and SECOND; the central agreement slot shows two syncretisms: between INCLUSIVE and EXCLUSIVE, and SECOND and THIRD. If we were to consider the person prefix alone, we might conclude that Ojibwe exemplifies an exception to Zwicky's observation that INCLUSIVE and SECOND are never conflated when a three-way distinction is being made. The method shows this would be misguided: when the two paradigms are superimposed, a four-way split emerges, and we can surmise that the pattern in the person prefix is a morphophonological artifact, and not directly indicative of the underlying "partition" of persons.

What is meant by *partition*? Couched in familiar terminology, a partition is the pattern of *conflation* between the possible person categories of natural language. In the coming sections, a formal definition will emerge as the lattice-based representation is introduced. Continuing to ignore the distinctions introduced by obviation, number, and noun classification, Ojibwe shows a *quadripartition*: a four-way distinction between EXCL, INCL, SECOND, and THIRD. English, on the other hand, shows a three-way distinction between a generic FIRST (which conflates EXCL and INCL), SECOND, and THIRD, known as the *standard tripartition*. This is schematized in (7).

(7) *Standard triparition in English nominative pronouns*

we	EXCL, INCL	FIRST (PL)
y'all	SECOND (PL)	
they	THIRD (PL)	

An empirical question emerges: What are the possible patterns of conflation that can arise?

2.1.2 The original five partitions

We can now begin to formulate the *partition problem* for the core persons, a generalized form of the question that arises from Zwicky's classic observation: Why are only some of the logically possible patterns of conflation attested in natural language? In an extended exposition with a large sample of languages, Harbour shows that only 5 of the 15 possible partitions are attested (see Chapter 2 of Harbour, 2016). So far, we have discussed only two of the five possibilities—the quadripartition and the standard tripartition. The full set is given in (8). From left to right, these are referred to as the monopartition, participant bibartition, author bipartition, and the already familiar tripartition and quadripartition.

(8) *Attested person partitions (without obviation and animacy)*

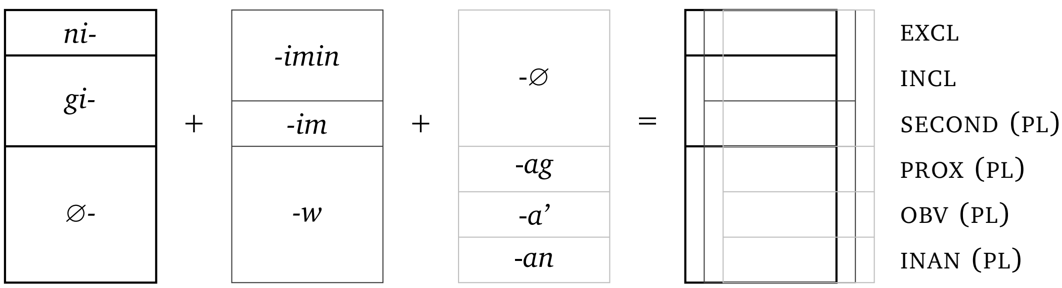
EXCL INCL SECOND THIRD	EXCL INCL SECOND	EXCL INCL	EXCL INCL	EXCL
	THIRD	SECOND THIRD	SECOND	INCL
			THIRD	SECOND
				THIRD

In this system there is a maximum of four *partition elements*, corresponding to the categories EXCLUSIVE, INCLUSIVE, SECOND, and THIRD. The partition problem can be framed as a question of why certain partition elements are attested, while others are unattested. In the next section, I complicate the picture further by considering partitions produced by obviation and animacy, setting the stage for the main contribution of the present paper.

2.1.3 The hexapartition of Ojibwe

We can use the superposition method to motivate the existence of the hexapartition of Ojibwe introduced in the introduction, which includes distinctions based in both obviation and animacy. This time, I have chosen to use the paradigm of intransitive matrix verbs with plural arguments (referred to as the independent order VAI or VII paradigm in the Algonquianist literature). In the left side of the equation, the leftmost paradigm gives the forms for the person prefix, the center paradigm the forms for the central agreement slot, and the rightmost paradigm the peripheral agreement slot. The figure on the right side of the equation is the superposition of these three cuts, again offset slightly and coded with shading.

(9) *Superposition with Ojibwe intransitive prefix, central, and peripheral agreement*



The primary goal is to capture this additional partition, while not losing the ability to derive the original partitions. This amounts to treating the generic THIRD person partition element as a *conflation* between the PROXIMATE, OBVIATIVE, and INANIMATE partition elements. The system thus must be able to generate a maximum of six partition elements given the addition of Ojibwe.

At this point, it is necessary to address a potential complication for the proposed relationship between animacy and obviation. The starting point is to consider the patterns of agreement in embedded clauses in (10). When the embedded subject is obviative, as in (10a) where the matrix subject is proximate, an obviative agreement marker *-ni-* is obligatory. When the embedded subject is proximate, as in (10b) where the matrix subject is now local, this agreement is ungrammatical.[1]

(10) a. o-waabam-aa-n *pro* inini-wan ozhitoo*(-ni)-d jiimaan
3-see-DIR-3′ PROX man-OBV build-3′-3 canoe.INAN
‘S/he (PROX) sees the man (OBV) building a canoe’

b. ni-waabam-aa *pro* inini ozhitoo(*-ni)-d jiimaan
1-see-DIR FIRST.SG man.PROX build-3′-3 canoe.INAN
‘I see the man (PROX) building a canoe’ [NJ 08.30.19]

[1] A cognate morpheme *-yi-* in Plains Cree (Central Algonquian) has been argued by Muehlbauer (2012) to be a *switch-reference* marker rather than obviative agreement. At least for Ojibwe, such an analysis runs into issues with the example in (10b), where the matrix and embedded subjects are different, but *-ni-* is ungrammatical.

While Ojibwe does not show overt obviative morphology on inanimate nouns, obviative *agreement* appears with inanimate nouns under similar conditions to what was seen in (10). Obviative agreement marker is obligatory in the context of another animate third person (11a), while it is ungrammatical when there is no animate third person present (11b).

(11) a. o-waabandaan ikwe jiimaan gaa-michaa*(-ni)-g
3-see.VTI woman.PROX canoe.INAN REL-big-3′-0
'The woman sees a canoe that is big'

b. ni-waabandaan jiimaan gaa-michaa(*-ni)-g
1-see.VTI canoe.INAN REL-big-3′-0
'I see a canoe that is big' [NJ 08.30.19]

There is, however, still a fundamental asymmetry between animate and inanimate nouns in how they relate to obviation. An animate noun can clearly alternate between proximate and obviative in the context of another animate noun. This is shown with the Ojibwe example in (12), with the classic direct-inverse alternation characteristic of all Algonquian languages, where either animate noun can be associated with the proximate and obviative categories.

(12) a. o-gii-waabam-aa-n ikwe-wan gwiiwizens
3-PAST-see-3-OBV woman-OBV boy
'The boy (PROX) saw the woman' (OBV)'

b. o-gii-waabam-igoo-n gwiiwizens-an ikwe
3-PAST-see-INV-OBV boy-OBV woman
'The boy (OBV) saw the woman' (PROX)' (Hammerly, 2021b)

In contrast, inanimate nouns either show a *lack* of proximate/obviative status, or show evidence of being (covertly) obviative. This is perhaps most directly evidenced by the fact that in languages with overt proximate marking such as Blackfoot (Plains Algonquian), proximate-marked inanimate nouns are ungrammatical (Bliss, 2005, 2013; Ritter, 2014). The sentence in (13a) provides a baseline where the animate noun is marked proximate and the inanimate noun obviative marked. Such a sentence is grammatical. In contrast, (13b) shows that the reverse relationship—marking the inanimate noun proximate and the animate noun as obviative—is ungrammatical.

(13) a. An-a imitáá-wa ná-ówatoo-m-a an-i í'ksisako-yi
DEM-PROX dog-PROX PAST-eat-DIR-PROX DEM-OBV meat-OBV
'The dog ate the meat'

b. *An-a í'ksisako-wa ot-ówatoo-ok-a an-i imitáá-yi
DEM-PROX meat-PROX OBV-eat-INV-PROX DEM-OBV dog-OBV
Intended: 'The meat was eaten by the dog' (Bliss, 2005, p. 14)

A similar situation arises in Ojibwe, though since inanimate nouns are not themselves marked for obviation the contrast is less stark. In short, when animate and inanimate nouns are co-arguments of a verb, the inanimate noun cannot trigger obviative marking on the animate noun (14b)—an unmarked (by all indications, proximate) animate noun is grammatical (14a).

(14) a. o-gii-biinitoon onaagan ikwe
3-PAST-clean plate.INAN woman.PROX
'The woman (PROX) cleaned the plate'

b. *o-gii-biinitoon onaagan ikwe-wan
3-PAST-clean plate.INAN woman-OBV
Intended: 'The woman (OBV) cleaned the plate' [NJ 08.18.19]

We can therefore maintain a fundamental asymmetry between ANIMATE and INANIMATE nouns in how they relate to obviation, though the system is active in both cases to some degree. ANIMATE nouns show clear alternations between PROXIMATE and OBVIATIVE, which is triggered (in some sense) by the presence of another THIRD PERSON ANIMATE noun. INANIMATE nouns show alternations between being unmarked for obviation and showing evidence of being OBVIATIVE, but do not ever seem to be PROXIMATE per se. Given this, I continue to treat the core contrast made by obviation as a property of ANIMATE nouns, setting aside inanimate obviation for future work.

2.2 Ontological commitments

With the categories of person, obviation, and animacy established for Ojibwe, the road to a solution starts with understanding the underlying ontology of "person", broadly construed. Following Harbour (2016), we can begin with a model with a single author, i, a single addressee, u, and multiple others, o, o', o'', etc. While the assumption is not strictly necessary, Harbour provides an extended argument in favor of a minimal, egocentric ontology over alternatives that allow the possibility of multiple speakers and/or hearers (i.e. i', i'', etc; or u', u'', etc). Particularly convincing is that there is no evidence that any language differentiates between a would-be choric *we* denoting a set of authors, and the run-of-the-mill *we* denoting an author plus others. The existence of such a partition would falsify the minimal ontology, but typological surveys have failed to uncover such a case (e.g. Cysouw, 2003; Bobaljik, 2008).

I propose two extensions to the ontology of the "others" in the face of animacy-based noun classification and obviation: the addition of the *inanimate others* and the *proximate other*. The inanimate others will be represented by a sequence of r's (i.e. r, r', r'', etc.) and the proximate other by p.[2] In turn, the sequence of o's will be reserved for (non-proximate) animate others. The existence of an animacy split in the ontology is assumed in Harbour's original account (see pg. 67), but the properties and consequences are not explored. Intuitively, the line that is drawn between animate beings versus inanimate things is far less strict than the one drawn between the author versus addressee and the participants versus non-participants. Some entities such as humans

[2] A point of motivation for the notation: I have chosen r as a shortening for *res*, meaning 'thing' in Latin. I opted not to use t (would-be for *thing*) in order to avoid any potential confusion with truth values; furthermore i (would-be for *inanimate*) is already used for the first person, and should not do double duty.

and animals are almost universally treated as animate; others such as plants and supernatural, environmental, and biological forces trend towards animate, but vary from language to language (or culture to culture); yet other languages will include many things with animate-like properties that are biologically non-living, such as cars or dolls, but these are especially in the eye of the beholder. Ojibwe shows these types of "anomalies", such as *asin* 'stone', *aagim* 'snowshoe', and *opin* 'potato' being classified as grammatically animate. What is relevant here is that a distinction between animate versus inanimate entities is being made, not so much which entities fall on one side of the line or the other. In a similar vein, this paper has nothing to say about how a given animate noun/referent is selected to be proximate versus obviative. The goal is to define the categories that allow reference to these concepts, but I do not precisely define their meaning.

Consideration of additional noun classification systems in §6 precipitates the adoption of further ontological categories. A key question that comes to the fore, which is already coming into view at this point, is whether a single *universal* ontology of "person" should be posited. I believe that the evidence converges against such a view. It seems clear enough that all humans distinguish an author, an addressee, and others, so that these particular primitives may be universal; but beyond this, there is a great deal of variability and innovation. Do we want to attempt to maintain that all possible distinctions that languages *could* make are ontologically present, but that not all languages activate the features to linguistically encode these contrasts? The existence of esoteric noun class distinctions suggests that the variation stems from differences in the ontology itself, rather than solely with the features that gate access to it.

2.3 A lattice representation for the core persons

We can now come to a more formal definition of partitions by organizing the ontology into lattices. The motivation for the shift is to refer directly to how the ontological space of person is organized, rather than the opaque and imprecise categories of INCLUSIVE, EXCLUSIVE, and so on (though, it is difficult to get away from these labels entirely). We have our ontology of the author i, the addressee u, and all other (animate) persons o, o', o'', and so on (the inanimate r's and the proximate p are momentarily set aside). Partitions are the lumping together of these primitives into different lattices, which are referred to as *partition elements*. These are semantically interpreted and create restrictions on reference familiar to each category.

The EXCLUSIVE is represented with i_o.[3] i_o can be re-written as a set that includes the singleton $\{i\}$, the dyads $\{i, o\}$, $\{i, o'\}$, $\{i, o''\}$, ..., the triads $\{i, o, o'\}$, $\{i, o', o''\}$, $\{i, o, o''\}$, ..., and continuing increases in cardinality from there. Similarly, the SECOND person u_o includes the singleton $\{u\}$, the dyads $\{u, o\}$, $\{u, o'\}$, $\{u, o''\}$, ..., the triads $\{u, o, o'\}$, $\{u, o', o''\}$, $\{u, o, o''\}$, ..., and so on. The INCLUSIVE iu_o differs in that the minimal set is the dyad $\{i, u\}$, but from there it increases in a similar fashion from triads $\{i, u, o\}$, $\{i, u, o'\}$, $\{i, u, o''\}$, ..., on up. The generic THIRD person o_o does not have a unique minimal element. It starts with the singletons $\{o\}$, $\{o'\}$, $\{o''\}$, ..., then to the dyads $\{o, o'\}$, $\{o, o''\}$, $\{o', o''\}$, ..., again continuing from there.

[3]This "subscript" notation is taken from Harbour (2016), and the reader is referred to pg. 72 for formal details.

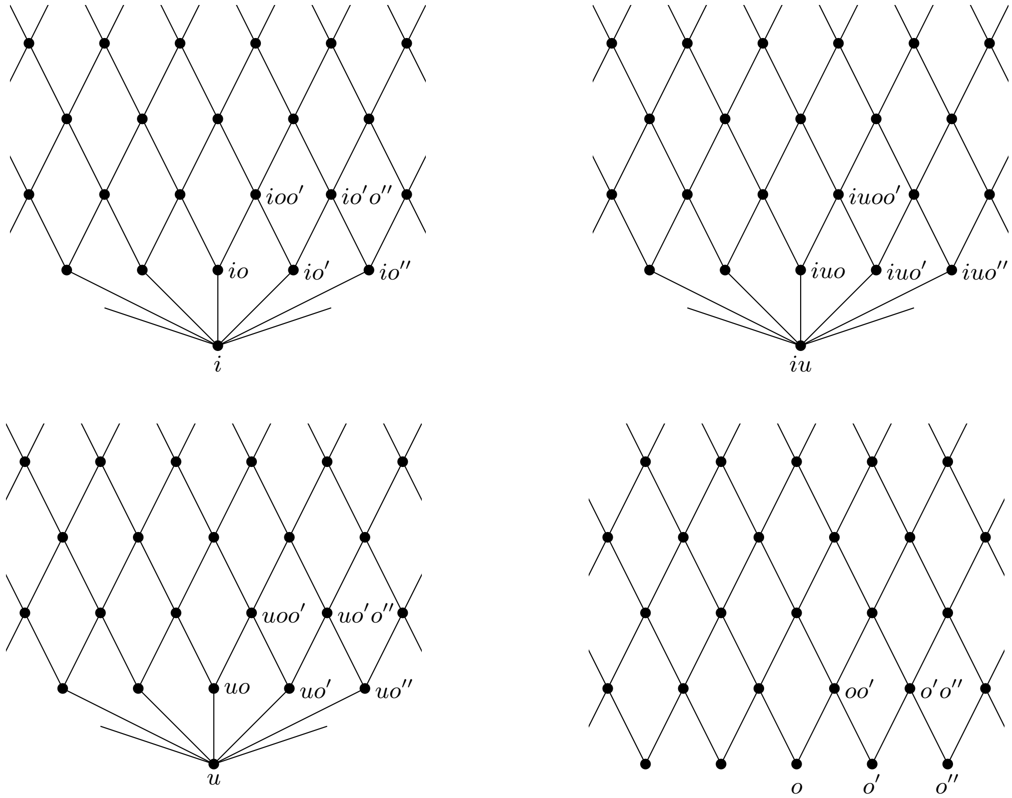


Figure 1: Hasse diagrams for EXCLUSIVE (i_o; top left), INCLUSIVE (iu_o; top right), SECOND (u_o; bottom left), and THIRD (o_o; bottom right).

It is worth introducing what I think is a more intuitive way (for the visually inclined) to represent the lattices denoted by the four elements discussed above: Hasse diagrams. The diagrams for each of the four persons are shown in Figure 1, and become particularly useful in the discussion of number in §4.5. The rows in the diagram are organized, from bottom to top, in increasing cardinality. The minimal element(s) being on the bottom row, and increasing by one in each ascending row. Each point in the diagram represents an element of the lattice, and the lines that link the points show where subset-superset relationships hold. Because the number of other persons (o, o', o'', etc) is unbounded, full Hasse diagrams are not shown for any of the lattices. Instead, an abbreviated representation is given, where incompleteness is indicated by partially extending lines to the left, right, and upper boundaries. Furthermore, only a sample of nodes are labeled—just enough to allow the pattern of the diagram to emerge.

Note that when put together in a single lattice rather than represented separately, the four partition elements exhaust the possible sets that can be formed from an ontology consisting of i, u, and the o's (in other words, combined, they are the *power set* of $\{i, u, o, o', o'', \ldots, \}$). The difference between languages is how this space is carved up. Returning to the figures used in the discussion of superposition, we can replace the category labels with subscript notation, as in (15).

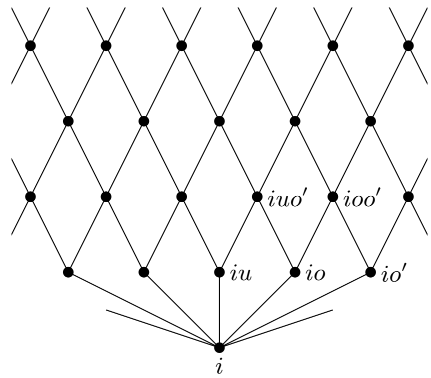


Figure 2: Hasse diagram for the generic FIRST (i_o + iu_o = i_{uo}).

(15) *Attested person partitions with subscript notation (ignoring obviation/animacy)*

<table>
<tr><td rowspan="4">i_o
iu_o
u_o
o_o</td><td rowspan="3">i_o
iu_o
u_o</td><td rowspan="2">i_o
iu_o</td><td rowspan="2">i_o
iu_o</td><td>i_o</td></tr>
<tr><td>iu_o</td></tr>
<tr><td rowspan="2">u_o
o_o</td><td>u_o</td><td>u_o</td></tr>
<tr><td>o_o</td><td>o_o</td><td>o_o</td></tr>
</table>

To take a concrete example of what collapses between the partitions look like, consider the Hasse diagram for the generic FIRST person of the standard tripartition in Figure 2, which combines the EXCLUSIVE and INCLUSIVE lattices from Figure 1.

2.4 Lattice representations for obviation and animacy

The distinctions in obviation and animacy in Ojibwe can be captured within the lattice-based representation with the extended ontology. The core function of animacy and obviation is to divide the numerous "other" persons (r's, o's, and p). The INANIMATE category allows reference to the r's, the PROXIMATE category necessarily *includes* reference to the proximate other p but also can include the o's, while OBVIATIVE necessarily *excludes* reference to p while referencing the o's.

In terms of the subscript notation, p_o is the desired partition for PROXIMATE, o_o is the desired partition for OBVIATIVE, and r_r the desired partition for INANIMATE. The PROXIMATE partition element p_o abbreviates the singleton $\{p\}$, the dyads $\{p, o\}$, $\{p, o'\}$, $\{p, o''\}$, $\ldots$, the triads $\{p, o, o'\}$, $\{p, o, o''\}$, $\{p, o', o''\}$, $\ldots$, and so on. The key is that every set includes the proximate p. The OBVIATIVE partition element o_o is the same as the generic THIRD person in the previous section. Finally, the INANIMATE partition r_r, like the OBVIATIVE and generic THIRD, does not have a unique minimal element. It starts with the singletons $\{r\}$, $\{r'\}$, $\{r''\}$, $\ldots$, then the dyads $\{r, r'\}$, $\{r, r''\}$, $\{r', r''\}$, $\ldots$, and continues from there.

These sets can be visually represented with the Hasse diagrams in Figure 3. The PROXIMATE lattice includes a unique bottom element, p. As a result, all further sets in the ascending rows

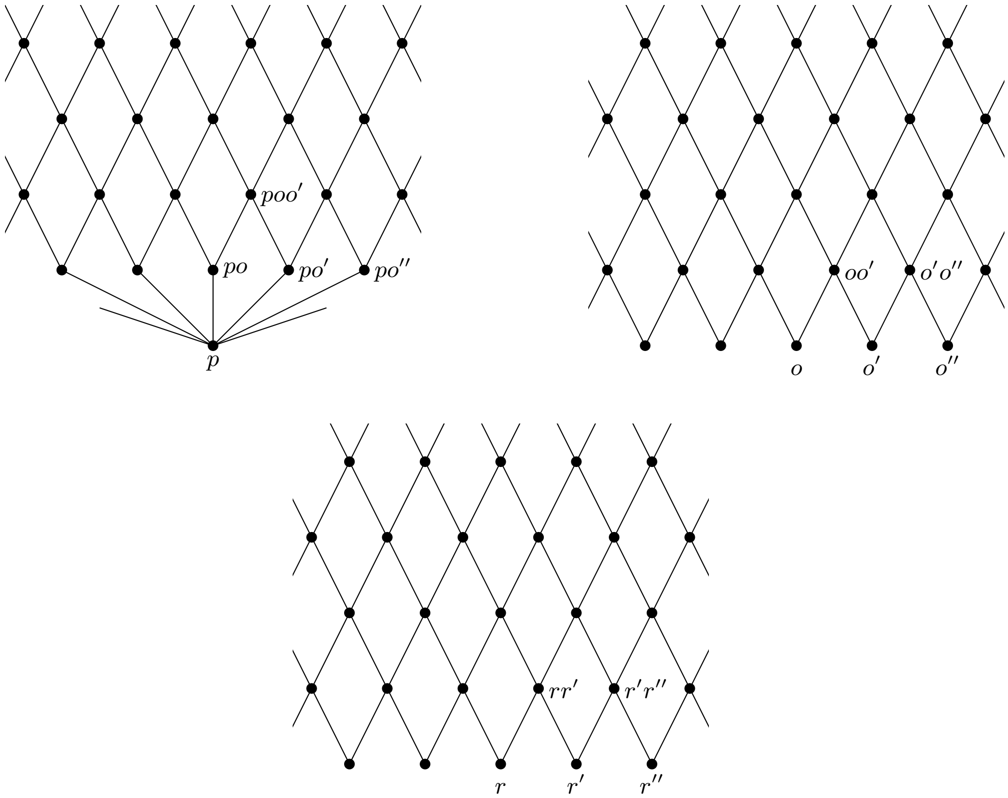


Figure 3: Hasse diagrams of the proposed PROXIMATE (p_o; upper left) and OBVIATIVE (o_o; upper right), and INANIMATE (r_r; bottom) lattices

also include this element. The OBVIATIVE lattice is analogous to the generic THIRD person lattice in Figure 1, as is the INANIMATE lattice (but with r's rather than o's).

We can now replace the category labels from (4) with the lattices denoted by the subscript notation, as shown in (16). Note that the partitions related to EXCLUSIVE, INCLUSIVE, and SECOND now include the proximate p in the subscript. This allows these categories to refer to collections that include p (alone, or in combination with the o's).

(16) *Animacy, obviation and person categories in Ojibwe in subscript notation*

i_{po}
iu_{po}
u_{po}
p_o
o_o
r_r

3 Representing and composing features

The goal of this section is to show how reference to the ontology via various categories can be derived through the composition of morphosyntactic features. I begin by proposing denotations for the root node (φ) and the features related to person, obviation, and animacy. I then introduce the theory of contrastive interpretations (Dresher, 2009; Cowper and Hall, 2019) and show how it accounts for the original partition problem, providing a novel formalization. This sets the stage for the extension of the account to capture obviation and animacy in §4.

3.1 Organizing the ontology and defining features

The ontology, represented here by φ, provides the primitives for reference. The denotation of φ is derived from the set in (17).

(17) *Set containing the full ontology*
$\{i, u, p, o, o', \ldots, r, r', \ldots\}$ $\dashv [\![\varphi]\!]$

φ denotes the *power set* (the set of all possible sets) of the entire ontology, denoting the φ *lattice* ($\mathscr{L}_\varphi$), as shown in (18). The derivation, which is rather involved, can be found in Appendix A. Additionally, φ introduces a variable over this lattice.

(18) *Denotation of the full ontology for Ojibwe*

a. $\mathscr{L}_\varphi = \{i_{po}, i_{pr}, i_{or}, u_{po}, u_{pr}, u_{por}, iu_{po}, iu_{pr}, iu_{por}, p_o, p_r, p_{or}, o_o, or, r_r\}$
b. $[\![\varphi]\!] = \lambda x.\, x \in \mathscr{L}_\varphi$

Partitions are formed by the composition of various features with φ. The core person features are derived by composition with sets containing the author alone (19a), the [Author] feautre, and/or the author and the addressee (19b), the [Participant] feature (Harbour, 2016; Cowper and Hall, 2019). The new proposal defended in this paper is the addition of two features: (i) the [Proximate] feature, which includes the author, addressee, and proximate person (19c), and (ii) the [Animate] feature, which includes all of the animate persons (19d).

(19) *Subsets of the ontology as denotations of features*

a. $\{i\}$ $= [\![\text{[Author]}]\!] = S_{au}$
b. $\{i, u\}$ $= [\![\text{[Participant]}]\!] = S_{pt}$
c. $\{i, u, p\}$ $= [\![\text{[Proximate]}]\!] = S_{px}$
d. $\{i, u, p, o, o', \ldots\}$ $= [\![\text{[Animate]}]\!] = S_{an}$

On the current account, it is not necessary to form lattices by taking the power set of these sets (cf. Harbour, 2016, see §5.1.1 for further discussion). Therefore the features denote a simple set, rather than sets of sets. These sets will be referred to as S_{au}, S_{pt}, S_{px}, and S_{an}, as shown above. With these denotations established, the task is to define how these features *compose* to restrict φ and give rise to our categories via a partition of the person space. This is accomplished by giving denotations for the binary feature values $+$ and $-$.

3.2 Contrastive interpretations

In this section, I introduce the theory of *contrastive interpretations* (Dresher, 2009), which provides a principled means to restrict the composition of features with φ. I first review the work of Cowper and Hall (2019), who show the theory of contrastive interpretations is capable of deriving the original five partitions of the core persons, and provide a novel formalization of their insights. §4 is then devoted to showing how the additional partition of Ojibwe with obviation and animacy is captured with the system.

Given that Cowper and Hall are only concerned with the core persons, the head π represents the entire relevant portion of the ontology. This is shown in (20).

(20) a. $\mathscr{L}_\pi = \{i_o, iu_o, u_o, o_o\}$
 b. $[\![\pi]\!] = \lambda x.\, x \in \mathscr{L}_\pi$

Cowper and Hall posit two binary-valued person features, which combine to partition the head π. They treat these features as first-order predicates, as in (21).

(21) *Person features as first-order predicates (Cowper and Hall, 2019)*
 a. ⟦[+Author]⟧ = includes the speaker
 b. ⟦[−Author]⟧ = does not include the speaker
 c. ⟦[+Participant]⟧ = includes at least one participant
 d. ⟦[−Participant]⟧ = does not include a participant

With the sets S_{au} and S_{pt} defined in the previous section, I advance a formal definition of feature values to generalize the informal statements in (21).

The formulas in (22) define the composition of the root lattice with person features (this also applies to obviation, but different definitions will be necessary for number and noun classification). Positive composition of F with G, shown formally in (22a), results in a lattice consisting of all elements within $\mathscr{L}_G$ that *contain at least one member* of S_F. Negative interaction of F with G, given formally in (22b), results in a lattice consisting of all elements within $\mathscr{L}_G$ that *do not contain any members* of S_F.

(22) a. $[\![+F(G)]\!] = \{g : \exists f \in g\ [g \in \mathscr{L}_G \wedge f \in S_F]\}$
 b. $[\![-F(G)]\!] = \{g : \neg\exists f \in g\ [g \in \mathscr{L}_G \wedge f \in S_F]\}$

In the coming derivations of each partition, I use $\oplus$ to denote positive interactions between sets and lattices, and $\ominus$ to denote negative interactions, as shown in (23).

(23) a. $[\![+F(G)]\!] = \mathscr{L}_G \oplus S_F$

b. $[\![-F(G)]\!] = \mathscr{L}_G \ominus S_F$

The order of composition of features is commutative, as shown in (24). This property is particularly relevant when evaluating Harbour's original account of feature composition/lattice interaction (see §5.1), where the order of composition of features is a matter of parameterization that must be extrinsically fixed within a given language.

(24) $[\![\pm H(\pm F(G))]\!] = [\![\pm F(\pm H(G))]\!]$

The major boon is that this property frees the account of a need to stipulate extrinsic parameters or constraints to organize the composition of features on a head. This allows the feature set to be a truly unordered bundle, providing a more parsimonious representation, and as a consequence simplifying the mapping between syntax the LF interface. Here, heads (and, by extension, the functional sequence) are the sole locus of restrictions in the order of composition — a fact that has been widely noted and well-established in current theories of the syntax-semantics interface, where phrase-structure hierarchies guides semantic composition (e.g. Heim and Kratzer, 1998). There is no need for additional mappings to be established to guide the composition of features.

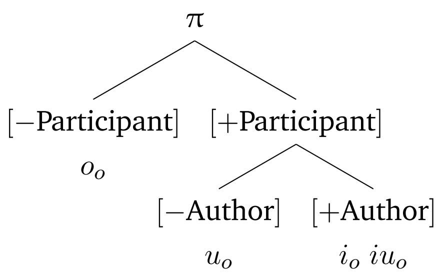
3.2.1 Solving the original partition problem

Cowper and Hall (2019) show the derivations of the monopartition, author bipartition, and participant bipartition utilize the same basic inventory of features as proposed by Harbour, despite the noted differences in how feature composition is conceived. If there are no person features specified on π, then no partitions are made and the monopartition is derived. If the language uses only [±Author], then a split is made between a partition with all sets that include the speaker (i_o, iu_o) with the positive value, versus those that do not include the speaker (u_o, o_o) with the negative value. Similarly, the participant bipartition is derived for languages that only utilize the [±Participant] feature, dividing π between those that include at least one discourse participant (i_o, iu_o, u_o) with the positive value, and those that do not (o_o) with the negative value.

Of particular interest here is in the derivation of the tripartition and quadripartition, where more than one feature is involved. In these cases, the relative *contrastive scope* of features determines both the possible partitions that a feature can make as well as the particular interpretation that a feature receives. It is important to emphasize that "contrastive scope" relations are with respect to the contrastive hierarchy rather than the phrase structure hierarchy (I use the bipartite term "contrastive scope" to avoid confusion). The determination of contrastive scope relationships occurs over the course of acquisition, when a learner is faced with generating a particular person partition given a set of grammatical primitives (heads and features). This is discussed further in §3.2.2.

Consider the tripartition first, with the relevant contrastive hierarchy shown in (25). The inventory of π is first split by [±Participant], making a division between the first and second persons versus the third persons. The further split introduced by [±Author] then only serves to separate the members on the [+Participant] side of the divide, separating the sets that include i from those that lack it. This allows for a partition that makes a distinction between second and first person, but lacks a clusivity distinction.

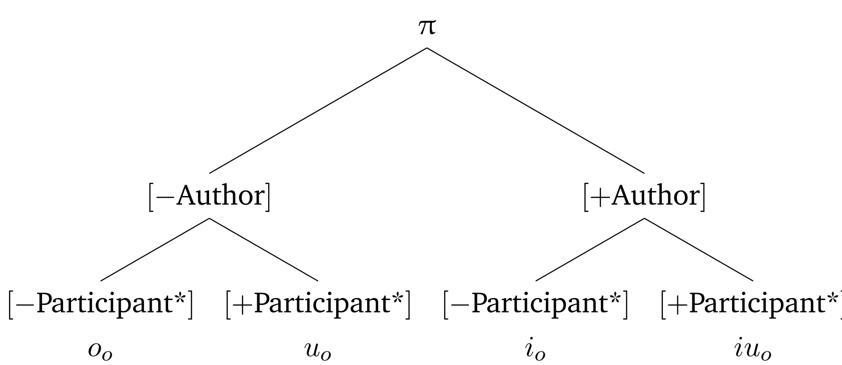
(25) *Contrastive hierarchy for the tripartition*



It is worth spelling out in more detail why [±Author] only makes further cuts when [+Participant] has applied, but not [−Participant]. In short, [−Participant] creates a partition that completely excludes any discourse participant. As a result, there is *no further contrast* for the feature [±Author] to make (i.e. there are no sets that include i). As a result, any application of the author feature would be entirely vacuous—the generic third person partition element is derived regardless. In contrast, on the [+Participant] side, [±Author] can further partitions the sets into those that include versus exclude the author, thus providing a relevant contrast to derive first versus second person.

The quadripartition exemplifies a second way in which the notion of being contrastive affects the representation of person, as schematized in the hierarchy in (26).

(26) *Contrastive hierarchy for the quadripartition*



The key difference is that [±Author] now takes contrastive scope above [±Participant]. The first contrast is therefore between those elements of the π lattice that include the author (i_o, iu_o) versus those that exclude the author (u_o, o_o). In the latter case, [±Participant] makes further a division between the sets that exclude a participant (the third person o_o) and those that include a participant (the second person u_o). The division made on the [+Author] side is more subtle, and crucially relies on the notion that features introduce some relevant contrast. In particular, Cowper and Hall (2019) propose the feature is narrowed to mean 'includes/does not include a discourse participant *other than the speaker*'. This recasts the feature as marking a contrast between those sets that include versus exclude the addressee (u), allowing the contrast between the inclusive and exclusive persons to be derived. I represent the narrowed version of this feature as [Participant*].

To bring the notion of contrast further into relief, imagine if the contrastive principles did not apply. On the [−Author] side, this would leave open the possibility that the predicate denoted by [−Participant], which semi-informally means "does not include a discourse participant", becomes redundant with [−Author] by simply excluding the elements that include i, thereby failing to create a cut between the third and second person elements. By the same token, the positive variant [+Participant] could create a contradiction with [−Author] by denoting a predicate that requires the presence of i. The issues are analogous on the [+Author] side, where the combination of [−Participant] could in principle give rise to a contradiction, while [+Participant] might fail to create the relevant cut. In short, a system without the contrastive interpretation of features would be far too unconstrained.

Short of conceiving of the absence of a feature as *complete* narrowing, a further property of the system is that the author feature will never have an alternative interpretation. Since this feature only contains a single element i, [Author] is as narrow as a feature can be while still being present at all. This means that we have now exhausted all of the possibilities of feature combinations and contrastive meanings under the current two feature system, and have thus derived all and only the five original partitions—we have provided a solution to the original partition problem.

3.2.2 Generating contrastive hierarchies

The reader may wonder about the representational status of contrastive hierarchies. In short, they are schematic devices — it is not the case that features are literally organized into such hierarchies. As a result, the contrastive hierarchies should not be construed mental representations per se, but a way of showing the contrastive scope relationships between features, which allows the particular interpretation of the features to be established. This marks an important conceptual difference from alternatives such as the feature geometric approach, where a (geometric) hierarchy is directly represented and manipulated by the grammar (e.g. Harley and Ritter, 2002; Preminger, 2014).

What, then, gives rise to contrastive scope relationships? Following the work of Dresher (2009, 2018) on the derivation of phonological contrasts, these properties can be derived from the Successive Division Algorithm in (27), which ultimately is active over the course of acquisition. I eschew the formal details to focus on the principles behind the theory.

(27) *Successive Division Algorithm (SDA), informally*
Assign *contrastive features* by successively dividing an inventory until every member has been distinguished.

The idea is general enough to apply to any number of domains where an inventory must be divided into some number of categories. In phonology, it is applied to allow for the inventory of phonemes in a given language to be distinguished. For the present purposes, it is applied to allow the inventory of person partitions to be distinguished. For an inventory of person categories, the initial state is one in which there are no divisions between the persons. In other words, the monopartition created by the presence of π. The necessary contrasts (i.e. the patterns of distinction and conflation between partition elements) to be derived are determined by the primary input to the learner, and features are added, further dividing the inventory, until the proper number of partition elements are derived.

There are two major tenants of the theory. The most fundamental, adapted from Clements (2001) and given in (28), is the notion of *Feature Activity*. This limits the specification of features to only those that play a role in deriving the inventory—these features are thus considered "active" in a given language.

(28) *Feature Activity*
A feature is *active* if it plays a role in the derivation of the inventory.

The second tenant adapted from Hall (2007) is given in (29), and provides further clarification on Feature Activity: only features that provide the means to generate a contrast are active.

(29) *The Contrastivist Hypothesis*
The derivation of an inventory only operates with those features that are necessary to distinguish the members of the inventory.

In the case that the hypothesis in (29) holds, then the principle in (30) also holds.

(30) *Corollary to the Contrastivist Hypothesis*
If a feature is active, then it must be contrastive.

The Contrastivist Hypothesis and its corollary provide the means to capture the two restrictions seen in the the derivation of the tripartition and quadripartition. First, it prevents [±Author] from combining with [−Participant] in tripartition languages, as there is no further contrast that can be marked by the author feature in this context—all participants are partitioned off in these cases, leaving author nothing to divide. While no harm would come from including these features in terms of deriving the final inventory, the learner lacks evidence to drive the addition of these features, and is assumed to adopt the most parsimonious representation consistent with the input. Second, the theory derives restrictions on [±Participant] when it is in the contrastive scope of [±Author]—i.e. it distinguishes between sets the include and exclude u.

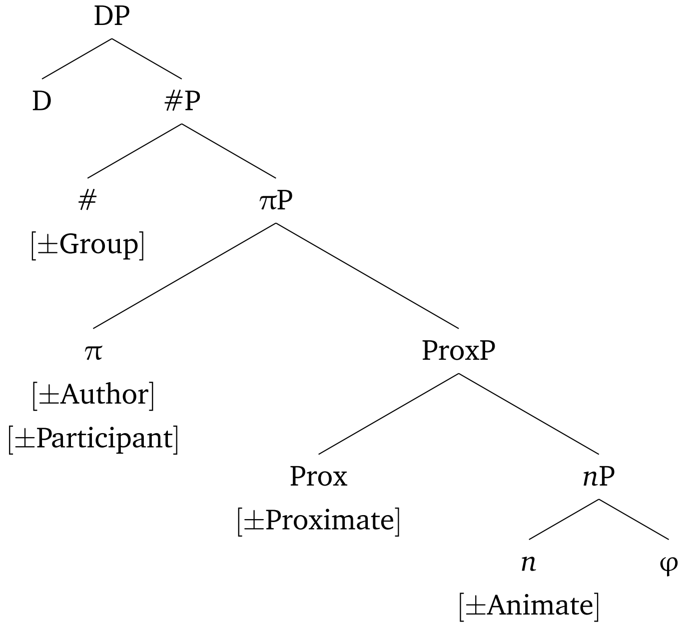
4 Deriving the Ojibwe partition

In this section, I return to consideration of the animate and proximate features and to deriving the hexapartition of Ojibwe in the context of the theory of contrastive interpretations.

4.1 The functional sequence

A keystone of the proposal is the functional sequence in (31). I have included projections up to DP, noting that nominals of different types may vary in how much functional structure they contain (see Déchaine and Wiltschko, 2002).

(31)

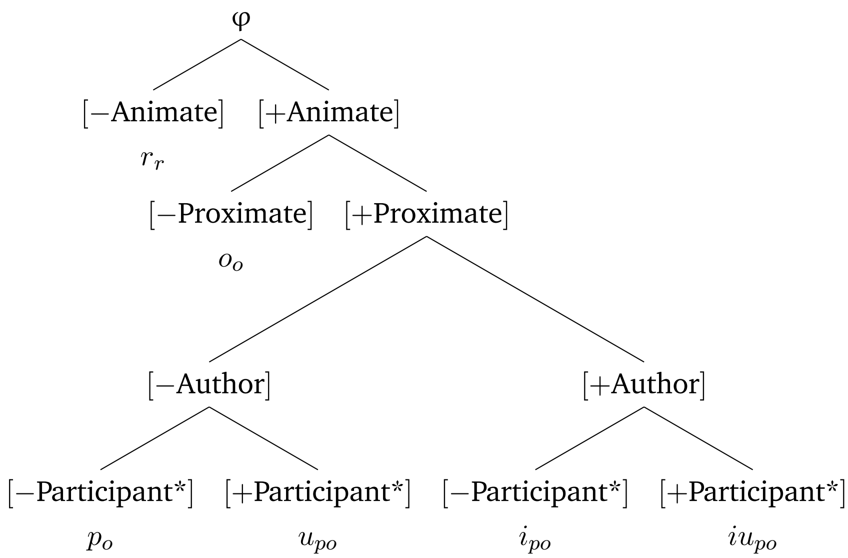


The structure is in line with decades of cross-linguistically informed work on the functional sequence of nominal projection (e.g. Ritter, 1991, 1993; Picallo, 1991; Kramer, 2014, 2015), with noun class occupying the lowest position on *n*, followed by obviation heading its own projection, then the two person features on π, and finally number in the highest position, labelled #. The present account utilizes the hierarchy of functional heads both to restrict the order of composition and the possible contrastive scope relations: noun classification will always compose first and take contrastive scope over everything; obviation composes next and takes contrastive scope over person and number; person is next, taking contrastive scope over number alone, which composes last.

4.2 A contrastive hierarchy for Ojibwe

The addition of animacy and obviation requires an extension of the contrastive hierarchy. Given the functional sequence in the previous section, the following hierarchy can be obtained:

(32) *Contrastive hierarchy for the Ojibwe hexapartition*



Like the quadripartition, the contrastive scope relation between [Author] and [Participant] lead to the winnowed feature [Participant*]. Furthermore, analogously to the split made by [−Participant] in the tripartition where the [±Author] feature was not composed, there is no further possible partition that can be gained through an interaction with [±Proximate], [±Participant], or [±Author] following [−Animate]. Similarly, no further partitions can be made by [±Participant] nor [±Author] following [−Proximate]. Since the application of these features would be vacuous at best, under the SDA the features are not posited by the learner.

The lattice for φ, the root of the nominal spine, is repeated in (33) for reference.

(33) $\mathscr{L}_\varphi = \{i_{po}, i_{pr}, i_{or}, u_{po}, u_{pr}, u_{por}, iu_{po}, iu_{pr}, iu_{por}, p_o, p_r, p_{or}, o_o, or, r_r\}$

4.3 The composition of [±Animate]

The first feature to compose with φ is [±Animate]. What partitions should be made by this feature? Put in plain language, the aim is for [+Animate] to pick out a lattice that excludes all sets containing the r's (or only sets containing i, u, p, or at least one of the o's). In turn, the aim of [−Animate] is to pick out a lattice with only those sets including the r's (or excluding i, u, p, and any of the o's). Neither variant should include a mixture of r's with i, u, p or the o's (i.e. $i_{pr}, i_{or}, u_{pr}, u_{por}, iu_{pr}, iu_{por}, p_r, p_{or}, or$). This requires a re-thinking of the semantics of the feature values for [Animacy].

Recall the definition of values for person features, repeated in (34) for reference (these will also be the denotations used for [±Proximate]).

(34) *Denotation of values with person and obviation (repeated from (22))*

a. $[\![+F(G)]\!] = \{g : \exists f \in g\ [g \in \mathscr{L}_G \wedge f \in S_F]\}$

b. $[\![-F(G)]\!] = \{g : \neg\exists f \in g\ [g \in \mathscr{L}_G \wedge f \in S_F]\}$

The positive variant is particularly problematic for animacy: it picks out the members of G that contains at least *some* member of the set denoted by F. This is not restrictive enough. To derive the desired partitions, it must pick out the members of G that *only* contain members of the set denoted by F. A denotation that accomplishes this restriction is given in (35).

(35) *Denotation of values with animacy*

a. $[\![+F(G)]\!] = \{g : g \in \mathscr{L}_G \wedge y \in g \wedge y \in S_F\}$

b. $[\![-F(G)]\!] = \{g : g \in \mathscr{L}_G \wedge y \in g \wedge y \notin S_F\}$

That the values associated with person versus animacy have distinct denotations is not taken to be problematic: as distinct features on separate functional heads, it is not surprising that they do not perfectly align. As we will see, number will also require a separate formulation for the values. That said, the denotations share a common core: the negative variant simply introduces logical negation compared to the positive variant (either before the existential operator or with set membership).

This allows for the derivation of our first category: INANIMATE. This is derived by the composition of the negatively valued [−Animate] feature with φ, as shown in (36).

(36) *Derivation of* INANIMATE

$[\![-\text{Animate}(\varphi)]\!]$
$= \mathscr{L}_\varphi \ominus S_{an}$
$= \{i_{po}, i_{pr}, i_{or}, u_{po}, u_{pr}, u_{por}, iu_{po}, iu_{pr}, iu_{por}, p_o, p_r, p_{or}, o_o, or, r_r\} \ominus \{i, u, p, o, o', \ldots\}$
$= \{r_r\}$

The notation makes the derivation somewhat opaque. While the denotation of [Animate] includes, for example, i_{po}, it does not include i_{pr} or i_{or}. Why should these latter two be excluded by negative action of [Animate] on φ? The reason is that, in all three cases, the implied sets necessarily include i; in turn, negative action of [Animate] excludes all sets that include i (or u, p or an o, the other members of S_{an}). Therefore, despite i_{pr} and i_{or} *including* the inanimate r's, negative action by [Animate] dictates their removal. The only element that is not "contaminated" by one of the animate primitives is r_r, the INANIMATE partition element.

The composition of φ with [+Animate] is the first step for the derivation of the remaining five categories. The result this composition is shown in (37).

(37) *Result of [+Animate] acting on* φ

$[\![+\text{Animate}(\varphi)]\!]$
$= \mathscr{L}_\varphi \oplus S_{an}$
$= \{i_{po}, i_{pr}, i_{or}, u_{po}, u_{pr}, u_{por}, iu_{po}, iu_{pr}, iu_{por}, p_o, p_r, p_{or}, o_o, or, r_r\} \oplus \{i, u, p, o, o', \ldots\}$
$= \{i_{po}, u_{po}, iu_{po}, p_o, o_o\}$

In this case, only the sets in $\mathscr{L}_\varphi$ that contain some collection of i, u, p, or the o's are preserved. None of the sets can include r, as this is not a member of S_{an}. This means that, like the negative variant, elements like i_{pr} and i_{or} are removed. Despite the fact that they necessarily include animate primitives, the fact that they also include the inanimate r's means they are excluded. Notice that we are left with the five partition elements associated with the five remaining categories. The composition of the remaining features [±Proximate], [±Animate], and [±Participant*] will pick out each of these elements.

4.4 The composition of [±Proximate] and the core persons

The next category we can derive is OBVIATIVE, represented by the partition element o_o. This is derived by the result of (37) composing with [−Proximate], as shown in (38). Note, the denotations for feature values with [±Proximate] are the same as those for the core person features (i.e. *not* the same as [±Animate]).

(38) *Derivation of* OBVIATIVE

$$\begin{aligned}
&[\![-\text{Proximate}(+\text{Animate}(\varphi))]\!]\\
&= ((\mathscr{L}_\varphi \oplus S_{an}) \ominus S_{px})\\
&= \{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \ominus S_{px}\\
&= \{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \ominus \{i, u, p\}\\
&= \{o_o\}
\end{aligned}$$

This removes any set that contains an i, u, or p, leaving only those consisting of the o's.

The derivation of PROXIMATE in (39) is more complex. This involves composition first with [+Animate], already seen in the derivation in (37), followed by [+Proximate], which removes the o_o partition element, then [−Author], removing both i_{po} and iu_{po}, and finally [−Participant*], leaving only p_o remaining.

(39) *Derivation of* PROXIMATE

$$\begin{aligned}
&[\![-\text{Participant*}(-\text{Author}(+\text{Proximate}(+\text{Animate}(\varphi))))]\!]\\
&= ((((\mathscr{L}_\varphi \oplus S_{an}) \oplus S_{px}) \ominus S_{au}) \ominus S_{pt*})\\
&= (((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus S_{px}) \ominus S_{au}) \ominus S_{pt*})\\
&= (((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus \{i, u, p\}) \ominus \{i\}) \ominus \{u\})\\
&= ((\{i_{po}, u_{po}, iu_{po}, p_o\} \ominus \{i\}) \ominus \{u\})\\
&= \{u_{po}, p_o\} \ominus \{u\}\\
&= \{p_o\}
\end{aligned}$$

As with the derivation of the original partition problem, the composition of these features is commutable. In particular, there is nothing crucial in the order of composition of the two core person features, which are specified on a single head. There is therefore no need to specify an extrinsic parameter on composition order for these cases.

The second person, shown in (40), takes positive values for the proximate and author features as in (39), but differs in that the participant* feature positively composes, leaving only u_{po}.

(40) *Derivation of* SECOND

$[\![+\text{Participant*}(-\text{Author}(+\text{Proximate}(+\text{Animate}(\varphi))))]\!]$

$= ((((\mathscr{L}_\varphi \oplus S_{an}) \oplus S_{px}) \ominus S_{au}) \oplus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus S_{px}) \ominus S_{au}) \oplus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus \{i, u, p\}) \ominus \{i\}) \oplus \{u\})$

$= ((\{i_{po}, u_{po}, iu_{po}, p_o\} \ominus \{i\}) \oplus \{u\})$

$= \{u_{po}, p_o\} \oplus \{u\}$

$= \{u_{po}\}$

The derivation of EXCLUSIVE in (41) again includes positive composition of the proximate feature. Additional positive composition of the author feature selects those sets containing i, and negative interaction by participant* removes those containing u, leaving only the desired exclusive element i_{po}.

(41) *Derivation of* EXCLUSIVE

$[\![-\text{Participant*}(+\text{Author}(+\text{Proximate}(+\text{Animate}(\varphi))))]\!]$

$= ((((\mathscr{L}_\varphi \oplus S_{an}) \oplus S_{px}) \oplus S_{au}) \ominus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus S_{px}) \oplus S_{au}) \ominus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus \{i, u, p\}) \oplus \{i\}) \ominus \{u\})$

$= ((\{i_{po}, u_{po}, iu_{po}, p_o\} \oplus \{i\}) \ominus \{u\})$

$= \{i_{po}, iu_{po}\} \ominus \{u\}$

$= \{i_{po}\}$

Likewise, INCLUSIVE is derived by positive composition of the proximate and author features, leaving only sets that include i. In contrast to the exclusive, positive composition of participant* selects sets that include u, leaving only the inclusive element iu_{po}.

(42) *Derivation of* INCLUSIVE

$[\![+\text{Participant*}(+\text{Author}(+\text{Proximate}(+\text{Animate}(\varphi))))]\!]$

$= ((((\mathscr{L}_\varphi \oplus S_{an}) \oplus S_{px}) \oplus S_{au}) \oplus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus S_{px}) \oplus S_{au}) \oplus S_{pt*})$

$= ((((\{i_{po}, u_{po}, iu_{po}, p_o, o_o\} \oplus \{i, u, p\}) \oplus \{i\}) \oplus \{u\})$

$= ((\{i_{po}, u_{po}, iu_{po}, p_o\} \oplus \{i\}) \oplus \{u\})$

$= \{i_{po}, iu_{po}\} \oplus \{u\}$

$= \{iu_{po}\}$

The above derivations derive all and only the six categories found in Ojibwe (excluding number). Crucially, this particular feature combination does *not* predict a distinction between proximate and obviative outside of the animate third person—the local persons do not alternate on this dimension, and instead show the profile of a typical quadripartition. Finally, the original five partitions retain their analysis. Lacking evidence of a contrast in animacy and obviation, these languages do not make use of [Animate] or [Proximate], and therefore conflate these categories into a generic third person. As such, all six partitions discussed—the five original plus the hexapartition of Ojibwe—have been derived.

4.5 Interactions with number

The final piece is to define the interactions with a number feature. Number in Ojibwe makes a cut between atomic/non-group (singular) and non-atomic/group (plural) sets. In his theory, Harbour makes use of a feature [±Atomic] to make this distinction. Informally, the feature creates a partition between atomic sets (i.e. sets with a cardinality of one) and non-atomic sets (i.e. sets with a cardinality of greater than one). Harbour treats atomicity as a basic concept, simply denoting it as a predicate $atom(x)$. In (43), I provide a formal definition of the predicate in terms of set notation.

(43) $[\![\text{[Atomic]}]\!] = \{g : |g| = 1 \wedge g \in \mathscr{L}_\varphi\}$

More precisely, the feature denotes the subset of the φ lattice with a cardinality equal to one. This is shown in (44).

(44) $\{i, u, p, o, o', o'', \ldots, r, r', r'', \ldots, \}$

In many theories of number, such as those based in the feature-geometric approach, the number feature in singular/plural type languages has been thought to make a split based on *group* rather than *atomicity*. Arguments for such a [Group] feature are generally based in the fact that plural is morphologically marked, while singular unmarked. Given that these theories use privative features (i.e. features that lack values), morphological markedness is encoded by representational markedness, with singular being the default interpretation of the number node # (the interpretation of # when it is unmarked for features). While these sorts of arguments strictly based in markedness are less directly relevant for the current system, where features are bivalent and both singular and plural are equally marked in the representation, other factors such as agreement might be considered. Number agreement uniformly targets plural goals over singular goals (e.g. Nevins, 2011). In order to define an agreement probe that prefers plural over singular (i.e. groups over atoms), a [Group] feature is necessary (Hammerly, 2020).

With all of this in mind, it is perfectly possible to define a group feature in terms of sets, as shown in (45).

(45) $[\![\text{[Group]}]\!] = \{g : |g| > 1 \wedge g \in \mathscr{L}_\varphi\}$

The difference between the group and atomic features is that group includes all sets with a cardinality of greater than 1, rather than all sets with a cardinality equal to 1. As such, the group feature defines a lattice that is the complement of that defined by [Atomic], with respect to the full φ-lattice. As a result, in terms of deriving the proper partitions, the two turn out to be equivalent.

To see this, consider the proposed denotations of feature values for number, shown in (46). The positive value in (46a) is equivalent to set intersection between the lattice denoted by the number feature F (either borne of the atomic or group feature) and the lattice denoted by G (for our purposes, the lattice produced following composition with noun classification and person). The negative value in (46b) is relative complementation or set difference. This produces a partition of the lattice denoted by G with only those elements *not* found in the lattice denoted by F (i.e. the complement of the lattice denoted by F).

(46) *Feature values as lattice interactions with number*

a. $[\![+F(G)]\!] = \{g : g \in \mathscr{L}_G \wedge g \in \mathscr{L}_F\}$

b. $[\![-F(G)]\!] = \{g : g \in \mathscr{L}_G \wedge g \notin \mathscr{L}_F\}$

Returning to the contrast between [Atomic] and [Group], both produce the same two partitions, but with opposite correspondences the feature values. With [Atomic], the positive value picks out the "singular" sets, and negative value the "plural" ones. With [Group], the positive value picks out the "plural" sets, and the negative value the "singular" ones. I frame the singular-plural number contrast in terms of [Group] rather than [Atomic], though nothing hinges on this choice.

Again, the denotation of values with number differs from person/obviation and noun classification, but all share a core similarity in that the negative value is associated with logical negation. Number is simply intersection (with the positive value) or complementation (with the negative value) between $\mathscr{L}_G$ and $\mathscr{L}_F$. Again, the existence of these differences is not problematic—despite all of these features serving to create partitions of lattices, the various features exist on different functional heads and create partitions based on different properties, thus we should not necessarily expect their semantics to be uniform.[4]

4.5.1 Application to Ojibwe

I turn now to showing the derivation of number contrasts in Ojibwe with respect to the six person categories derived in §4. The most straightforward way of representing the partitions made by [Group] is through the use of the Hasse diagrams. These are given in Figure 4, with the cut by [Group] represented by the dashed line. For the PROXIMATE, OBVIATIVE, and INANIMATE lattices, the group feature makes a cut between the singleton elements on the bottom row (e.g. p, o, o', r, r'), and everything else. For EXCLUSIVE and SECOND, whose bottom elements are respectively the singleton sets $\{i\}$ and $\{u\}$, are similarly partitioned with these bottom elements on the [−Group] side, and everything else falling into the [+Group] partition. In the case of INCLUSIVE, none of the

[4]As a point of reference, the semantics of values and lattice action/interaction is not uniform in Harbour (2016) either. Harbour takes positive and negative values on person to represent pairwise addition and cumulative subtraction, respectively (see §5.1.2 for details), while negative values on number features to be logical negation of the predicate denoted by the number feature (and positive values to be the absence of negation with the predicate). From this point of view, to the degree that unifying the denotation of values across features should be a goal, the current account satisfies this desideratum with negative values on person, number, and noun classification all denoting logical negation.

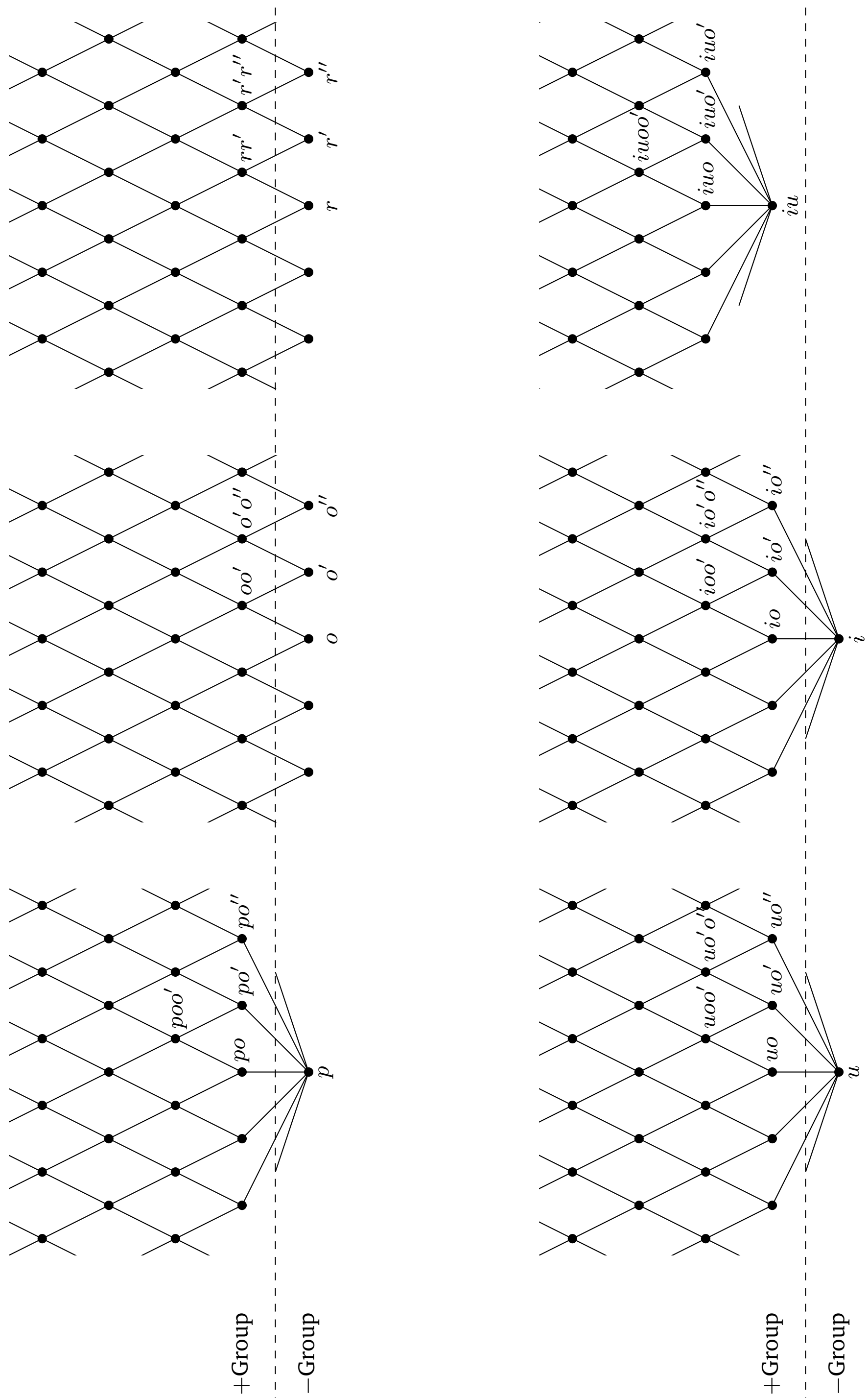


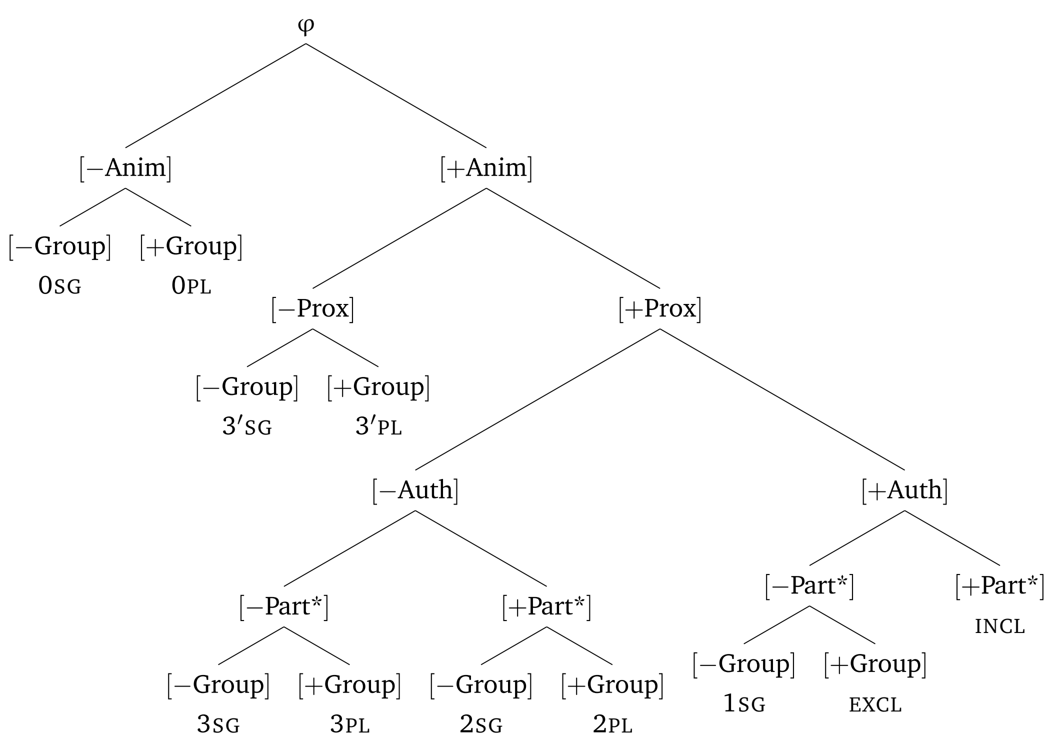
Figure 4: Lattices for each partition with singular-plural number distinction.

elements are atomic: the bottom element is the dyad $\{i, u\}$, so no element in that lattice falls into the [−Group] partition. As a result, on the theory of contrastive interpretations, we should expect the inclusive person in Ojibwe to be unmarked for number: The group feature (and also, for the record, the atomic feature) fails to make a contrast in these cases, and thus is not expected to be active.

4.6 Summary

In this section, the interaction of the representation of person with noun classification and number was considered for Border Lakes Ojibwe. This amounted to creating a partition of the φ lattice based on the noun classification feature [±Animate], followed by the obviation feature [±Proximate], then the two person features [±Author] and [±Participant*], and finally the number feature [±group]. The composition order of noun classification first, obviation/person in the middle, and noun classification last is motivated by the association of the features with different projections in the functional sequence. The overall result can be summarized with the contrastive hierarchy in (47). I have reverted to category labels for the terminals rather than the subset notation for clarity (number contrasts are difficult to represent with the notation), but emphasize that the hierarchy represents the derivation of partition elements rather than the categories per se.

(47) *Final contrastive hierarchy for Ojibwe*



The hierarchy produces 11 non-overlapping partitions of the lattice denoted by the root node φ, which restrict the range of the variable introduced by this head, thereby determining the overall denotation of each of the categories.

5 Evaluating alternative accounts

This section draws out two alternative solutions to the (extended) partition problem, giving way to a critical discussion. The first is that based in the proposal of Harbour (2016). While his account provides a solution for the original partition problem, I show his theory of feature composition is unable to derive the partition of Ojibwe, where only the third persons, and not the local persons, show a distinction in obviation. The second is the feature geometry (Harley and Ritter, 2002; Béjar, 2003; Oxford, 2019). Here, the system has the means to derive the partition of Ojibwe, but at the cost of losing the possibility of explaining how languages that lack obviation might conflate these categories.

5.1 Harbour's solution

5.1.1 Features as lattices

In Harbour's (2016) analysis features denote *lattices*. This differs from the proposal in the present paper, where features denoted simple sets and only the heads φ or π denoted a lattice. These lattices are derived from the same subsets as the current account. Harbour's original analysis included only [Author] and [Participant], and aimed only to derive distinctions in the core persons. For the purposes of introducing the system, I stick to these features only. In §5.1.5 I provide an extension of the proposal to [Proximate].

(48) *Subsets of the ontology, used to create the denotation of features*

a. $\{i\}$ $\dashv$ ⟦[Author]⟧
b. $\{i, u\}$ $\dashv$ ⟦[Participant]⟧

To arrive at a lattice representation for the features we can form the power sets for each of the subsets in (48). The power set of any given set, represented here by the function $\mathcal{P}$, is a set of all possible subsets, including the empty set. I show the result for each of the features in (49).

(49) *Power sets of each ontological subset*

a. $\mathcal{P}(\{i\})$
$= \{\{i\}, \{\}\}$
b. $\mathcal{P}(\{i, u\})$
$= \{\{i\}, \{i, u\}, \{u\}, \{\}\}$

We can then make the move of treating the objects in (49) in *lattice-theoretic* terms (as lattices of sets), rather than in *set-theoretic* terms (as sets of sets). Here, the move is purely notational: by re-writing the sets in (49) as lattices, we can exclude curly braces, as shown in (50). Additionally, the empty set is removed. These will be referred to as the *author lattice* ($\mathscr{L}_{au}$) and the *participant lattice* ($\mathscr{L}_{pt}$).

(50) *Power sets re-written in lattice-theoretic terms*

a. $\{i\}$ $= \mathscr{L}_{au}$

b. $\{i, iu, u\}$ $= \mathscr{L}_{pt}$

5.1.2 Values as operations

A second key difference between the adopted proposal and Harbour's original system is then in the composition of features. In the system Harbour proposes, lattices combine via *operations* defined by the positive (+) or negative (−) values. That is, features compose with the head π via function application rather than function modification (for discussion, see Harbour, 2016, p. 66). Semi-informally, the + value joins every possible duo of elements in a pair of lattices. The formal definition is shown in (51).

(51) $[\![+F(G)]\!] = \{g \sqcup f : f \in \mathscr{L}_F, g \in \mathscr{L}_G\}$

As written, F is *positively acting on* G. But the addition operation is commutative (as in regular arithmetic addition; $1 + 2 = 2 + 1$).

The − value cumulatively subtracts every element in one lattice from every element in the other. This operation can be simplified, because each of the sets that will come into play have a *unique maximal element*. Subtracting the maximal element of F from each element of G renders any further subtraction redundant since all other elements are subsets of the maximal element.

(52) $[\![-F(G)]\!] = \{g \backslash max(\mathscr{L}_F) : g \in \mathscr{L}_G\}$

Analogously to the positive value, $-F(G)$ is *negative action* of F on G. Therefore the maximal element of F is subtracted from each element of G. This operation is critically non-commutative (again, as in arithmetic subtraction; $1 - 2 \neq 2 - 1$). This marks a key difference between the proposed account, where features are freely ordered, and the account of Harbour, where features are strictly ordered. This requires the setting of extrinsic parameters, detailed in the next section.

5.1.3 The parameters of π

Since Harbour's account focuses on the core persons alone, only the slice of the ontology containing i, u, and the o's is relevant. The head π is therefore taken to denote a lattice formed from the powerset of a set containing these elements, repeated in (53).

(53) $[\![\pi]\!] = \mathscr{L}_\pi = \{i_o, iu_o, u_o, o_o\}$

Features then compose with the head to restrict the lattice and generate partitions. Harbour proposes that the features on π are parameterized on two basic dimensions: (i) a feature can either be present or absent (an assumption shared with the adopted account); and (ii) if two (or more) features are present, then the order that the features compose with π must be set (an assumption that is critically *not* necessary with the proposed theory). These parameters are given in (54).

(54) *Parameters of π from Harbour (2016)*

a. The author feature is (not) present.
b. The participant feature is (not) present.
c. The author/participant feature composes first.

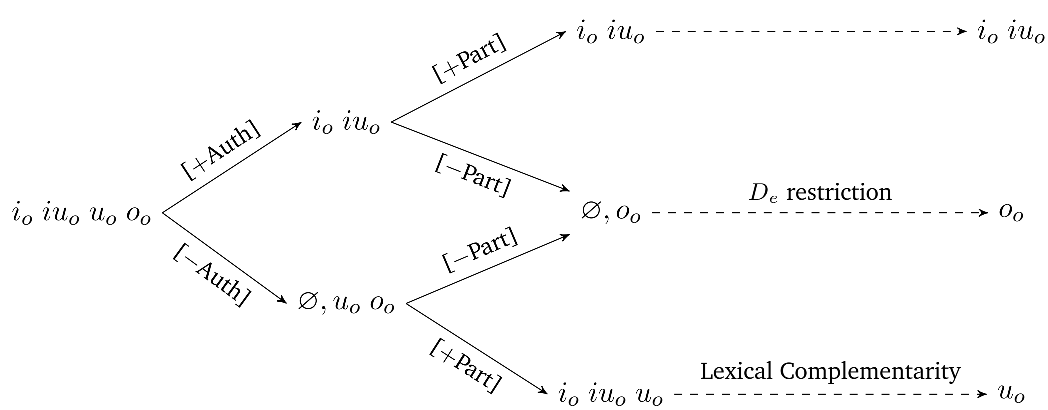
This gives rise to five possible feature specifications and composition orders, corresponding to the five attested partitions. In the next section, I walk through the derivations for each case.

5.1.4 Capturing the original five partitions

The details of how the lattice operations give rise to a particular output in each step is not critical—the reader is referred to Harbour's book for a step-by-step exposition of the derivations. The following figures, which summarize the essence of the derivations for the tripartition and quadripartition, are reproduced from Cowper and Hall (2019).

I begin with the tripartition in (55), where the composition of [±Author] precedes [±Participant]. The solid arrows show the result of the composition (lattice action) of each feature. The dashed arrows show the output follow two additional restrictions proposed by Harbour (2016).

(55) *Derivation of the tripartition (Harbour, 2016)*



First, empty sets are introduced by negative actions between lattices. The presence of the empty set serves an important role over the course of the derivation, but causes problems in the final partition. Recall that these features create sets that restrict the set of entities that can be referenced by particular person categories. The presence of the empty set implies that it should be possible to make reference to nothing or no one—a possibility that is not attested. Harbour proposes adding a constraint to the domain restrictor D_e introduced by φ so that it cannot include the empty set.

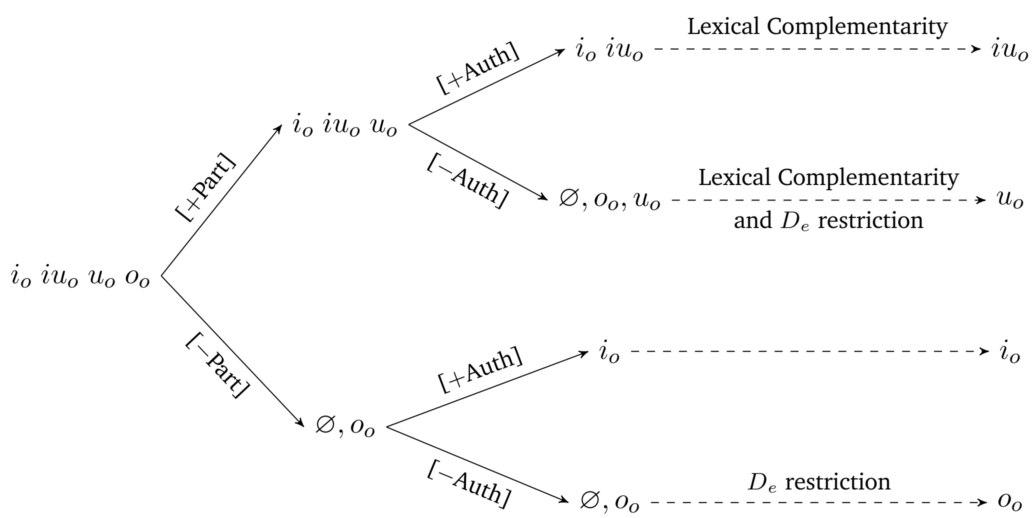
Second, see that [+Author]([+Participant](π)) gives rise to i_o, iu_o, while the output of [−Author]([+Participant](π)) is i_o, iu_o, u_o. The issue here is that none of the feature combinations pick out the second person partition element u_o on its own—they fail to derive the second person category in the tripartition. The proposed solution comes from the principle of *Lexical Complementarity*. This is invoked when two distinct feature outputs stand in a subset-superset relationship, and is used to eliminate the overlap between the two denotations. The result is that the feature combination with the larger denotation is restricted to only those elements that are not already covered by the feature combination with the smaller denotation. In formal terms:

(56) *Lexical Complementarity (Harbour, 2016, p. 80)*
Let F and G be feature specifications where $[\![F(\pi)]\!] \subset [\![G(\pi)]\!]$. Then use of $[\![G(\pi)]\!]$ is restricted to $[\![G(\pi)]\!] \backslash [\![F(\pi)]\!]$.

The two overlapping feature combinations of the tripartition stand in a subset-superset relationship. Therefore Lexical Complementarity can be applied to restrict the [−Author]([+Participant](π)) feature combination such that it only includes the second person element u_o.

The same issue arises in the quadripartition, shown in (57). Lexical Complementarity applies in two cases: (i) to restrict the [+Participant]([+Author](π)) combination to only the exclusive element iu_o; and (ii) to restrict the [+Participant]([−Author](π)) combination to only the second person element u_o.

(57) *Derivation of the quadripartition (Harbour, 2016)*



The final three partitions — the monopartition, the author bipartition, and the participant bipartition — do not require the application of Lexical Complementarity. The monopartition is simple: there are no features specified, and the output is exactly the lattice denoted by π. The author and participant bipartitions are derived by the composition of the author and participant features with π, respectively. These derivations do require the application of the restriction on D_e to remove the empty set, but otherwise the feature combinations themselves produce the desired results.

Harbour's proposal therefore provides the means to derive all and only the five possible core person partitions. The immediate question is whether the system that Harbour proposes to solve the partition problem is capable of capturing the further distinctions in the third person introduced by the addition of obviation.

5.1.5 Harbour and the proximate feature

To evaluate how the proximate feature could fit into Harbour's theory, let us first make a number of assumptions that mirror the adopted proposal.

First, let us take for granted a split in animacy and define the full ontology φ to be restricted only to the lattice in (58).

(58) $\mathscr{L}_{\varphi} = \{i_{po}, iu_{po}, u_{po}, p_o, o_o\}$

Second, let us assume that the denotation of the proximate feature is derived by taking the power set of the ontological subset consisting of i, u, and p. Like the two person features, we can treat this as a lattice ($\mathscr{L}_{px}$) and perform the additional step of removing the empty set. These steps are summarized in (59).

(59) ⟦[Proximate]⟧

$$= \mathcal{P}(\{i, u, p\})$$
$$= \{\{i\}, \{i, p\}, \{u\}, \{u, p\}, \{i, u\}, \{i, u, p\}, \{p\}, \{\}\}$$
$$= \{iup, iu, ip, up, i, u, p\}$$
$$= \mathscr{L}_{px}$$

Third, let us assume that [Proximate] is specified on a separate head that composes prior to the two person on π. This restricts the possible composition orders such that only [±Participant] and [±Author] can alternate.[5]

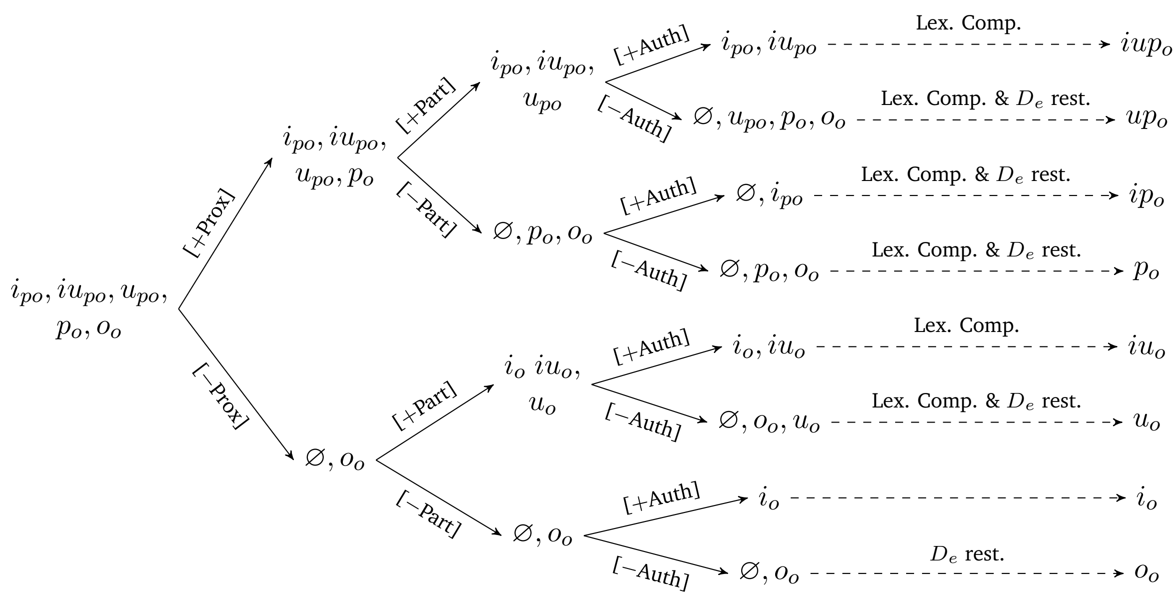
Finally, I only consider cases where both [±Participant] and [±Author] are present on π. Alternatives that lack either or both of these features can be ruled out simply because they can only generate a maximum of four contrasts. With only two features with binary values, there are only four total possible combinations of values. Having set aside animacy, the contrast between EXCLUSIVE, INCLUSIVE, SECOND, PROXIMATE, and OBVIATIVE requires a minimum of five combinations. With three features, a maximum of eight distinctions can arise. An immediate suspicion can be raised, again based simply on the number of distinctions that these combinations predict. However, this property of Harbour's account has already been observed in the prior discussion, and it does not necessarily lead to complete catastrophe. The tripartition, which fully crosses two bivalent feature, has four unique feature-value combinations. Harbour shows that this does not result in four unique partition elements, but rather two paths to deriving the third person—one where

[5] While I do not consider the additional alternatives here, the further composition orders that are allowed when the assumption is relaxed are also unable to derive the proper partitions for Ojibwe. For details, see Hammerly (2020).

the author feature takes a positive value, and one where the author feature takes a negative value. From this, we can conclude that it will not *necessarily* be the case that we will have eight distinct elements flowing from the eight feature-value combinations in a three-feature system. It is possible that some combinations will lead to identical partition elements.

With these assumptions in hand, the first derivation I consider is one where [±Participant] composes before [±Author]. This is summarized in (60).

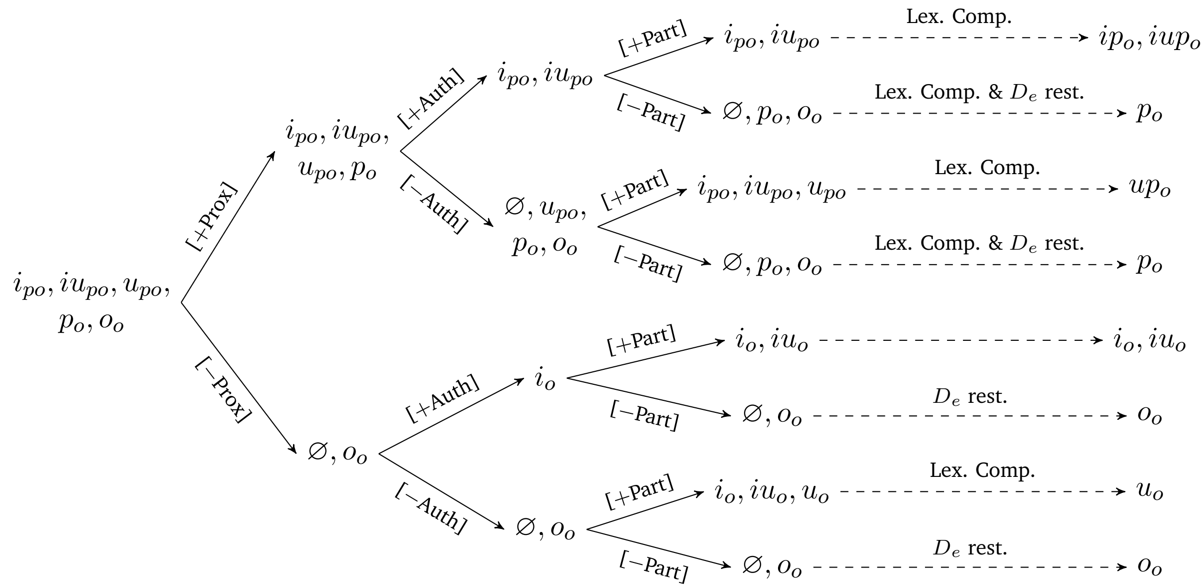
(60) *Derivation of* $[\![\pm\textit{Author}(\pm\textit{Participant}(\pm\textit{Proximate}(\varphi)))]\!]$



In this case, each value combination generates a unique partition element, for a total of eight: $iup_o, iu_o, up_o, u_o, ip_o, i_o, p_o,$ and o_o. This feature combination successfully generates a contrast between PROXIMATE and OBVIATIVE within the third persons, however, all of the local persons are also split between proximate and obviative counterparts. This is, generally speaking, not an undesirable result—Blackfoot shows a split between proximate and obviative counterparts in the local persons (Bliss, 2005, 2013; Wiltschko, Marshall, Matheson, and Vincent, 2015). That said, the immediate issue is that these partitions are not present in Ojibwe, so this combination over-generates.

The second possibility in (61) composes [±Author] prior to [±Participant].

(61) *Derivation of* ⟦*±Participant(±Author(±Proximate*(φ)))⟧



Once again, this composition order can generate the contrast in PROXIMATE versus OBVIATIVE, but also overgenerates a distinction in obviation within the local persons. Considering the unique elements, this creates a six-way contrast that is akin to the standard tripartition, but with a contrast in obviation within each category. Again, this is a case of overgeneration.

The conclusion is that it is not possible to generate the five-way split (setting aside animacy) that is characteristic of Ojibwe and nearly all other Algonquian languages, modulo Blackfoot. One objection to the above discussion is that much depends on the particular subset of the person ontology that the proximate feature denotes. It is the power set generated from $\{i, u, p\}$, which then interacts with the already established features from Harbour's original account. I argue that *there is not an alternative feature* with the ability to make these cuts, given only the machinery that Harbour proposes. The options for alternatives is rather limited. There are two types of live possibilities: One which includes *only* the proximate third person (i.e. $\{p\}$), or one that includes the proximate third person p and either i or u on its own (i.e. $\{i, p\}$ or $\{u, p\}$).

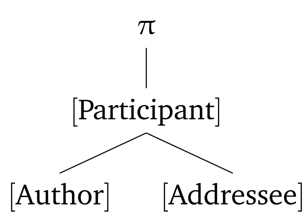
It is not necessary to consider derivations with each of these features to see why these alternatives will not provide the correct result. We are looking for a feature that creates a proximate/obviative distinction in the third persons, while leaving the local persons unchanged from the quadripartition. In terms of the lattice operations denoted by the feature values, the key is to ensure that the proximate p is removed from the third person only lattices, but retained when the lattice includes a local person as the bottom element. This requires restricting *when* the feature can apply, not which particular elements are added or subtracted. That is, we need to ensure that [−Proximate] only applies when both author and participant feature also take negative values.

This highlights one of the major differences between Harbour's theory and one based in contrastive interpretations. Short of adding restrictions on the way features combine, Harbour's account is locked in to generating the number of logical combinations given the number of features crossed by their possible values. On the other hand, the addition of contrastive interpretations creates principled limits on these combinations, so that not all possibilities are generated. For example, the author feature does not combine following a negatively valued participant feature (as seen in the tripartition), and neither author nor participant combine following a negatively valued proximate feature. This occurs because in both cases the features would fail to make a contrast.

5.2 The feature geometry

The second alternative account to consider is that based in the feature geometric representation (Harley and Ritter, 2002; Béjar, 2003). The core of this account is the claim that features have a *universal* set of implicational relationships. These relations are motivated and constrained by the conceptual relationships that hold between the features, such that more specific features entail less specific ones. In the original system, the proposed features are *privative*—they are either specified or not, and do not take a value. The figure in (62) shows the geometry related to person, as proposed by Harley and Ritter (2002).

(62) *The feature geometry for person (Harley and Ritter, 2002)*



The geometry, it must be emphasized, is not a phrase structure representation, despite its appearance as a tree. The schematic represents the aforementioned implicational relations: the subordinate (lower, more specific) features cannot be specified without also specifying all superordinate (lower, less specific) features. Harley and Ritter add one additional restriction beyond the geometry that is relevant here: [Addressee] only appears if [Author] is present.[6] With these restrictions, only the collections of features in (63) are possible.

(63) *Possible person representations under the original feature geometry*

a. {π, Participant, Author, Addressee}
b. {π, Participant, Author}
c. {π, Participant}
d. {π}

[6] This has led to alternative geometries, such as that of Béjar (2003), who proposes that [Addressee] is subordinate to [Author]. A version of this proposal is discussed further in the coming paragraphs.

The features are interpreted as first-order predicates, as shown in (64) for a language where all features are active. To get the right result, we can apply Lexical Complementarity, where the presence of a more marked form limits the interpretation of those forms that are less marked (the application of this principle is indicated by "$\equiv$"), the various possible combinations of these features can generate the contrasts characteristic of the quadripartition.

(64) *The quadripartition with the original feature geometry*

a. ⟦{π, Participant, Author, Addressee}⟧
= the set contains a person ∧ a participant ∧ an author ∧ an addressee $= iu_o$

b. ⟦{π, Participant, Author}⟧
= the set contains a person ∧ a participant ∧ an author $= i_o, iu_o \equiv i_o$

c. ⟦{π, Participant}⟧
= the set contains a person ∧ a participant $= i_o, iu_o, u_o \equiv u_o$

d. ⟦{π}⟧
= the set contains a person $= i_o, iu_o, u_o, o_o \equiv o_o$

In turn, a tripartition system can be captured by a language that does not activate [Addressee], as shown in (65).

(65) *The tripartition with the original feature geometry*

a. ⟦{π, Participant, Author}⟧
= the set contains a person ∧ a participant ∧ an author $= i_o, iu_o$

b. ⟦{π, Participant}⟧
= the set contains a person ∧ a participant $= i_o, iu_o, u_o \equiv u_o$

c. ⟦{π}⟧
= the set contains a person $= i_o, iu_o, u_o, o_o \equiv o_o$

The geometry rules out the representations in (66), which break the implicational relationships of the geometry by lacking the subordinate [Participant] feature when the superordinate [Author] and/or [Addressee] features are present.

(66) *Impossible person representations under the original feature geometry*

a. {π, Author, Addressee}

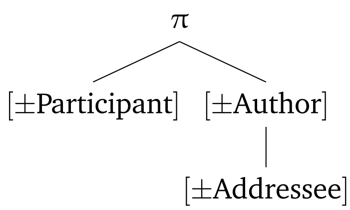
b. {π, Author}

c. {π, Addressee}

As Harbour (2016) points out, there are only four possible sets of features, while there are five possible person partitions to be captured. Therefore the original feature geometry cannot generate all of the possible core person partitions—the author bipartition, which would be represented by the collection of features in (66b), cannot be captured under the original proposal.

While the original feature geometry is not sufficient to account for the partition problem, Harbour shows that there are alternative geometries that can be put forward to get the right result (though, he argues against this hypothetical account too). The simplest solution, shown in (67), abandons the assumption that features are privative, adopting bivalent features instead. The positive versus negative variants can then respectively indicate that the set includes or does not include the property denoted by the predicate.

(67) *An alternative geometry entertained (and ultimately rejected) by Harbour (2016)*



With this revised representation, we can generate all and only the five partitions (with two ways of capturing the quadripartition, either with or without [Participant]), as summarized in (68).

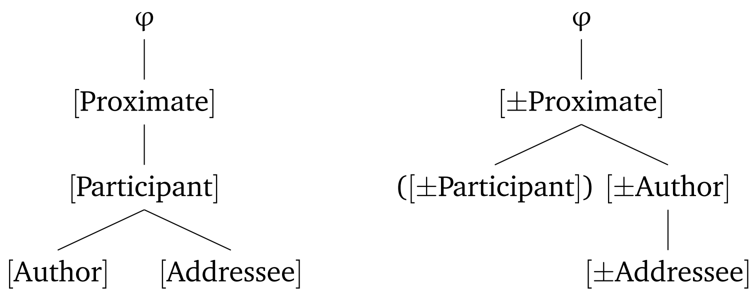
(68) *The alternative feature geometry solves the original partition problem*

a. *Monopartition:* {π}
b. *Participant bipartition:* {π, ±Participant}
c. *Author bipartition:* {π, ±Author}
d. *Tripartition:* {π, ±Participant, ±Author}
e. *Quadripartition:* {π, (±Participant), ±Author, ±Addressee}

While we have generated a pure feature geometric representation that solves the original partition problem, we have lost our basis for positing a universal geometry in the first place. The alternative geometry in (67) fails to reflect the semantic entailments between the features in two different ways. First, [Author] and [Addressee] each entail [Participant], but they no longer stand in an implicational relationship. Furthermore, [Addressee] *does not* entail [Author], but the presence of [Addressee] implies [Author]. To the extent that these entailments provided an *explanation* for why a particular geometry (and not some other geometry) should be the one to exist, the geometry that actually allows us to capture the full empirical landscape has lost that grounding.

While the above discussion could already be taken to close the book on the feature geometry, let us still turn to the main question at hand: whether a feature geometry can be proposed that captures Ojibwe, without losing the ability to capture languages that lack distinctions in obviation (I'll set animacy aside for now and return to it in §6). The standardly assumed geometry for Ojibwe is shown in the left in (69). However, given the arguments in the preceding paragraph, we may instead consider an extended version of the alternative geometry, shown on the right. The argument against the feature geometry will not rely on choosing between these two.

(69) *Standard (e.g. Oxford, 2019) and alternative extended geometries for person and obviation*



Let us run the arguments with the standard extension, since it is more likely to be familiar. This geometry suffices to capture the five-way contrast between INCLUSIVE, EXCLUSIVE, SECOND, PROXIMATE, and OBVIATIVE, as shown in (70).

(70) *Capturing Ojibwe with the extended geometry*

a. ⟦{π, Proximate, Participant, Author, Addressee}⟧
= the set contains a pers. ∧ a prox. ∧ a part. ∧ an auth. ∧ an addr. $= iu_{po}$

b. ⟦{π, Proximate, Participant, Author}⟧
= the set contains a pers. ∧ a prox. ∧ a part. ∧ an auth. $= i_{po}, iu_{po} \equiv i_{po}$

c. ⟦{π, Proximate, Participant}⟧
= the set contains a pers. ∧ a prox. ∧ a part. $= i_{po}, iu_{po}, u_{po} \equiv u_{po}$

d. ⟦{π, Proximate}⟧
= the set contains a pers. ∧ a prox. $= i_{po}, iu_{po}, u_{po}, p_o \equiv p_o$

e. ⟦{π}⟧
= the set contains a pers. $= i_o, iu_o, u_o, p_o, o_o \equiv o_o$

The issue arises when we consider how we might capture the original five partitions with our new geometry. Both geometries considered above imply that all languages with a distinction between participants and non-participants, and by extension all languages with distinctions among the participants, will activate [Proximate] and make distinctions in obviation in the third persons. Clearly, this is a highly undesirable result. Unless we entertain a massive conspiracy of syncretisms, one need not look further than English to see that this prediction is incorrect. Very few languages distinguish obviation at all, and certainly there is not an implicational relationship of the sort predicted here. Furthermore, if we attempt to break the implicational relationship between [Proximate] and the features related to the participants, we run into trouble. Without such a relationship, we erroneously predict that both third persons and the various categories related to the participants should alternate in obviation: the same problem that plagued Harbour's original lattice-based account.

This all points to a bigger, and ultimately fatal, problem for geometries: positing direct implicational relationships between the features themselves is simply too strong. Without going into the fine details, Harbour provides an extended argument against these relations from a morphological point of view. He shows that requirement of the geometry that the deletion of subordinate features entails the deletion of all superordinate features misses the mark (Harbour, 2016, p. 195-6). Issues also arise for geometries in the syntactic domain, where they have been fruitfully applied to capture patterns of agreement (e.g. Béjar, 2003; Preminger, 2014; Coon and Keine, 2020). Hammerly (2020, 2021a) shows that, because of the implicational relations between features, the feature geometry under-generates the possible set of person probes, in particular lacking the means to capture so-called *me-first* (and *you-first*) type effects found with the Person-Case Constraint and other person-sensitive agreement phenomena. The conclusion to be drawn from all of this is that geometries, while useful descriptive tools for mapping the various relations that hold between features, should not be used to actually encode these relationships.

5.3 Interim discussion

The goal of this section was to show that the two primary alternatives, one based in Harbour's original theory of lattice interaction, and one based in the feature geometry, both fail (albeit in different ways) to capture the full empirical landscape covered by the proposed "set-based" account grounded in the theory of contrastive interpretations. In this section, I consider a number of additional points of difference between the accounts that deserve some rumination.

The first is that both the feature geometry and lattice operations must lean heavily on the principle of *Lexical Complementarity* to derive the proper partitions—the features themselves do not produce the right result. The current account leans on a somewhat similar set of principles through the theory of contrastive interpretations, but its point of influence is quite different. Lexical Complementarity operates on the *output* of feature composition, while contrastive interpretations is operative during the acquisition of features.

The second difference is that the current theory need not avail itself of additional extrinsic parameters on feature combination or composition. With the feature geometry, where, for example, the presence of [Author] necessarily entails the presence of [Participant], it is not possible to generate feature combinations that exclude a less specific feature such as [Participant] or [Proximate] when a more specific feature such as [Author] is present. This is not the case in the current set theory, where all feature combinations are possible (though, the ones that fail to result in a contrast are unattested). In the lattice operations account, all possible feature combinations are allowable, but the order of *composition* is not free of extrinsic restrictions. When two features are on a single head, as is the case for [Author] and [Participant], their order of composition must be externally specified (see the discussion of the parameters of π in §5.1.3). In the current theory, when two features are on a single head, their order of composition makes no difference to the final output — the conjunction-based semantics allows for the commutability of features. Therefore the set-based account is fully free of extrinsic restrictions both on the combination and composition of features, providing a more elegant solution that combines the best of both of these previous analyses.

While a conjunction-based account was shown to be sufficient here, Harbour (2016) argues rather forcefully *against* conjunction-based solutions to the partition problem. The main line of objection is the requirement that a "third feature" be introduced into the system — this additional feature is [Addressee]. With a conjunctive semantics and only [Participant] and [Author] features, it is not possible to generate an inclusive/exclusive distinction (see the derivation of the tripartition in (65)). The [Addressee] features makes the clusivity distinction possible.

Harbour argues that once a third feature is added, unless we add additional restrictions on feature combinations (e.g. as in the feature geometric account), we lose the possibility of explaining Zwicky's problem (and therefore the original partition problem). If [Addressee] were allowed to combine with [Participant] in the absence of [Author], as shown in (71), the unattested tripartition with a "generic second" category would be generated.

(71) *The unattested tripartition with the generic second person*

a. $[\![\{\pi$, Participant, Addressee$\}]\!]$
= the set contains a person $\wedge$ a participant $\wedge$ an addressee $= u_o, iu_o$

b. $[\![\{\pi$, Participant$\}]\!]$
= the set contains a person $\wedge$ a participant $= i_o, iu_o, u_o \equiv i_o$

c. $[\![\{\pi\}]\!]$
= the set contains a person $= i_o, iu_o, u_o, o_o \equiv o_o$

Following the insight of Cowper and Hall (2019), the adopted account gets around the third feature problem by instead *deriving* [Addressee] from [Participant] itself under constrained conditions grounded in a general theory of the acquisition of features. In the proposed system, there are only two features, but [Participant] lives a double life as either [Participant] or [Participant*], where [Participant*] is equivalent to an [Addressee] feature. The critical difference is that there is a tradeoff between these two variants: it is not possible for a language to have both [Participant] and [Participant*] active at the same time (the same way, for example, that it is not possible for *Spiderman* and *Peter Parker* to be seen in the same room together). As a result, it is impossible to generate the unattested pattern of conflation in (71).

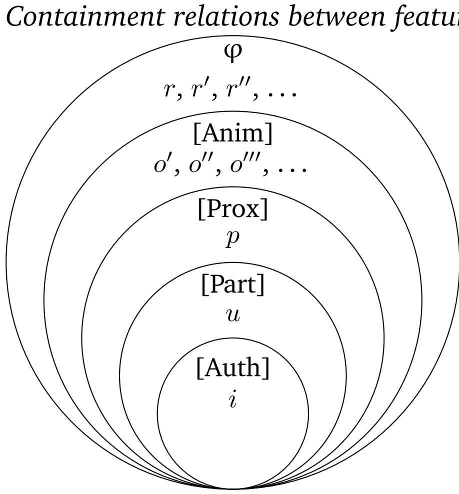
The final point, and the major contribution of this paper, is that the current account was the only one that adequately captured the partition made by [Proximate]. For the feature geometry, the options end up being (i) capture the original partition problem, but overextend obviation contrasts to the local persons; or (ii) capture the right partition for Ojibwe, but incorrectly predict that all languages with contrasts between participants versus non-participants should show an obviation distinction in the third persons. Neither of these pass empirical muster. For Harbour's theory, only with the addition of the theory of contrastive interpretations (or some other theory that prevents all logical feature-value combinations from arising) could obviation be restricted to apply only to the third persons. Given that a rather simple conjunctive semantics free of extrinsic restrictions on feature composition is also adequate when combined with the theory of contrastive interpretations, the present proposal has the edge.

6 Noun classification beyond animacy

Up to this point, only the animacy-based noun classification system of Ojibwe (which is more or less representative of the state-of-affairs in Algonquian languages) has been considered. In this section, I sketch how the account can be extended to capture other types of noun classification such as those found in Zapotec, Romance, and Bantu languages. I provide a formal typology of two different types of noun classification. The first, *containment-type* classification (e.g. Algonquian, Zapotec), leads to proper subset-superset relations between partitions related noun classification and person. The second, *crosscut-type* classification (e.g. Romance), results in partitions where such containment relations do not hold. Bantu languages show a combination of these two types.

I start with *containment-type* systems, which were the focus of the present paper. As schematized in (72), a critical property of the person, obviation, and animacy features in Ojibwe is that they stand in *containment relations*, with φ being the maximal set, and [Animate], [Proximate], [Participant], and [Author] forming smaller and smaller proper subsets of the overall ontology.

(72) *Containment relations between features in Ojibwe*



These containment relationships underlie the *Person-Animacy Hierarchy* (PAH; e.g. Silverstein, 1976; Aissen, 1999), which provides a description of a wide range of syntactic phenomena related to case, movement, and agreement. A general scale for Algonquian is given in (73).[7]

(73) FIRST > SECOND > PROXIMATE > OBVIATIVE > INANIMATE

To take a commonly discussed example, so-called *direct-inverse* Voice marking in Ojibwe can be described as “hierarchy sensitive”. Consider again the sentences in (74), repeated from (12).

[7]There is variation and debate with the ranking of the first and second persons in Algonquian. As Hammerly (2020) shows, Algonquian languages show two patterns: They either collapse the ranking between FIRST and SECOND, or show evidence of a ranking of FIRST over SECOND. The apparent 2 > 1 effects in the person prefix agreement marker (e.g. Lockwood and Macaulay, 2012) more likely reflect conditions on the spell-out of morphology rather than underlying agreement preferences. For the purposes of this discussion, which centers around animacy and obviation, the rankings of the participants is not particularly important.

(74) a. o-gii-waabam-**aa**-n ikwe-wan gwiiwizens
3-PAST-see-**DIR**-OBV woman-OBV boy
'The boy (PROX) saw the woman' (OBV)'

b. o-gii-waabam-**igoo**-n gwiiwizens-an ikwe
3-PAST-see-**INV**-OBV boy-OBV woman
'The boy (OBV) saw the woman' (PROX)' (Hammerly, 2021b)

When the higher ranked proximate argument is the external argument and the lower ranked obviative argument the internal argument, as in (74a), a DIRECT marker *-aa* is exponed as Voice. When the alignment between argument position and obviation status is reversed, an impoverished form of Voice, the INVERSE marker *-igo(o)*, appears instead.

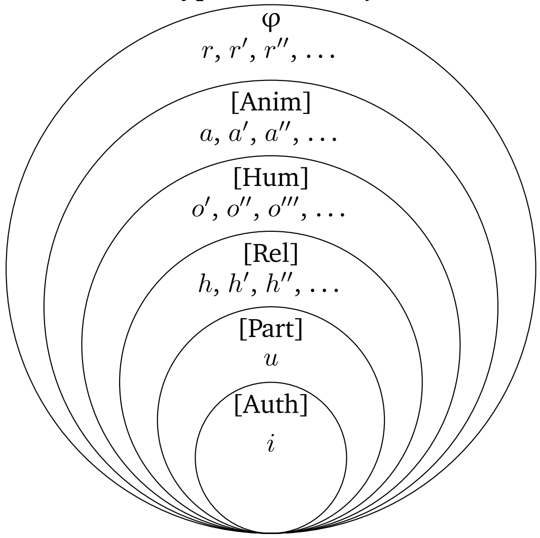
Going into the mechanics of how these types of agreement effects arise is beyond the scope of this paper (for recent analyses of hierarchy effects in Ojibwe and beyond, see Oxford, 2019; Hammerly, 2020, 2021a; Coon and Keine, 2020; Foley and Toosarvandani, 2019). What underlies each account, and what is relevant here, is an appeal to the containment relations between features, either directly through syntactic analogues of the sets that each feature ultimately denotes (Hammerly, 2020, 2021a), or indirectly by appealing to a feature geometric representation (Oxford, 2019; Coon and Keine, 2020; Foley and Toosarvandani, 2019).

Recent work by Foley and Toosarvandani (2019) on clitic restrictions in Zapotec languages is particularly relevant. Clitic combinations in some varieties of Zapotec show effects akin to the *Person-Case Constraint* (PCC)—a hierarchy-sensitive phenomenon commonly found in Romance languages—but with restrictions targeting categories related to noun classification in addition to person. Noun classification in Sierra Zapotec partitions third persons on four dimensions: ELDER human, non-elder HUMAN, ANIMAL, and INANIMATE. Like with direct-inverse marking in Ojibwe, the effects can be described by a scale that places both person and the categories related to noun classification on a single cline, as shown in (75).

(75) FIRST/SECOND > ELDER > HUMAN > ANIMAL > INANIMATE

Foley and Toosarvandani sketch a semantics for the features that encode these contrasts (I change their [Elder] feature to the more general [Rel(ational)] following Coon and Keine (2020)). Like the cline formed by person, obviation, and animacy, and as expected based on the hierarchical relations in (75), these features stand in proper containment relations, as schematized in (76).

(76) *Containment-type noun classification in Sierra Zapotec*



The presence of this type of system suggests further additions to the ontology, with the h's representing a honorific status related to being an elder, mayor, or the like, the o's representing other humans, the a's non-human living things, and finally the r's non-living things. As mentioned in §2.2, the expansion of these categories is likely due to the addition of ontological distinctions that have emerged diachronically. While it remains possible that all humans have an innate and universal set of ontological categories with features conspiring to either conflate or distinguish these various concepts, it is perhaps more likely that at least certain aspects of the ontology related to the various types of others are learned, and therefore not strictly fixed.

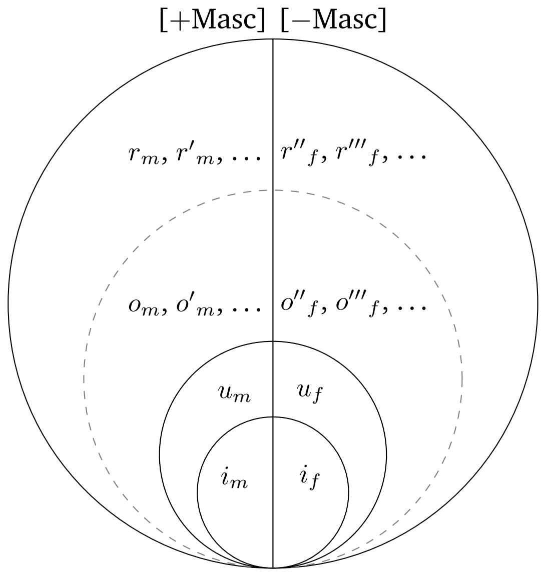
I turn now to considering what I have termed *crosscut-type* systems. For example Romance languages (and indeed, Indo-European languages more broadly) tend to have a binary (or ternary) noun classification system roughly based in gender or sex, with the MASCULINE category indicating that the referent is masculine or male, the FEMININE category indicating that the referent is feminine or female, and, if present, the NEUTER category leaving sex/gender unspecified.[8] That said, the "semantic core" of noun classification in these languages is often not observable, especially in the binary systems, where inanimate and abstract nouns are still classified as MASCULINE or FEMININE without any meaningful indication of "maleness/masculinity" or "femaleness/femininity".

To the extent that there is a semantic core to these systems, the cut being made does not result in the same sorts of containment relations as was seen with Algonquian and Zapotec. Continuing with the binary MASCULINE/FEMININE system, consider the figure in (77), which represents the state of affairs in French.[9]

[8]In some North Germanic languages, there is COMMON, which, historically, is the merger of MASCULINE and FEMININE.

[9]The line that divides ANIMATE/INANIMATE is greyed and dashed as to not take a strong stance on whether or not such a feature is present. The presence or absence of this distinction does not affect the main point being made here.

(77) *Crosscut-type noun classification in French*



The distinction between MASCULINE and FEMININE crosscuts all members of the ontology rather than creating a sub-division of the ontology. This is evidenced most clearly in the patterns of agreement, shown in (78), where the others (78a), the addressee (78b), and the author (78b) can all be associated with either MASCULINE or FEMININE agreement on predicative adjectives.

(78) a. Il/elle est heureu(-x/-se)
3.MASC/3.FEM be.3 happy(-MASC/-FEM)
'He/she is happy'

b. Tu es heureu(-x/-se)
2 be.2 happy(-MASC/-FEM)
'You are happy'

c. Je suis heureu(-x/-se)
1 be.1 happy(-MASC/-FEM)
'I am happy'

Roughly, the MASCULINE variant asserts or presupposes (the distinction is not particularly important here, but see Cooper, 1983; Heim and Kratzer, 1998; Sauerland, 2008) that the referent is masculine or male, while the FEMININE variant asserts or presupposes that the referent is feminine or female. This can conjunctively combine with the predicate that dictates the referent is the author, the addressee, or an other, as the case may be.

Much more needs to be said about the semantics of this type of system of noun classification, particularly given the fact that not all alternations between MASCULINE and FEMININE lead to straightforward meaning alternations based in sex or gender, and the fact that the masculine variant tends to be used as the "unmarked" or default form when gender or sex is unknown (for a recent account for French, see Hammerly, 2019). For now, I leave the reader with the fact that this general characterization of crosscut-type noun classifications systems captures the fact that, unlike containment-type noun classification, these systems do not give rise to Person-Animacy Hierarchy effects like the PCC (Stegovec, 2020). This is predicted by the fact that the denotations that underpin these features are not described by appealing to subset/superset relationships between MASCULINE versus FEMININE categories.

Finally, Bantu languages appear to combine containment-type and crosscut-type classification in what we can term a *hybrid-type* system. I take Swahili as an immediate example (Pesetsky, 2019), though many other Bantu languages show the same type of contrast (see, e.g. Carstens, 1991, 2008, 2010). The containment-type portion of the system is found with class 1/2, which only picks out animate-denoting nouns (though, *not all* animate-denoting nouns fall into this class). The examples in (79) give a sample reported in Pesetsky (2019).

(79) *m-toto* 'child', *m-walimu* 'teacher', *m-dudu* 'insect', *m-nyama* 'animal', . . .

While short threads of semantic coherence can be found in the other noun classes, for example, 3/4 includes nouns referring to most trees, no class is uniform in the same way as 1/2—3/4 also includes many other types of nouns. Across a number of Bantu languages, class 1/2 often shows exceptional morphosyntactic behavior that can be readily described as a hierarchy effect—for example, by aligning with the first and second person to the exclusion of all other noun classes in patterns of anti-agreement (e.g. Diercks, 2010; Baier, 2018). Like Romance, many additional complexities have been glossed over in this short discussion, but the main point stands: Noun classification in Bantu languages generally shows a mixture of containment-type behavior (with class 1/2) and crosscut-type behavior (with all other classes). The consequences of the proposed typology of different noun class systems should be rich ground for future work.

7 Conclusion

The goal of this paper was to provide a feature representation and a theory of feature composition to capture distinctions in animacy and obviation in Ojibwe. I showed that the addition of two binary features [±Animate] and [±Proximate] is able to capture the six-way partition that distinguishes EXCLUSIVE, INCLUSIVE, SECOND, PROXIMATE, OBVIATIVE, and INANIMATE in addition to distinctions in number. I provided set-based denotations for features related to person, animacy, obviation, and number with composition based in predicate modification (i.e. conjunction) and governed by binary values. I joined Cowper and Hall (2019) in arguing that the theory of contrastive interpretations provides the proper means to derive patterns feature interpretation, providing a novel formalization of the system and a new extension to Ojibwe. A major boon of the proposed system is freedom from extrinsic restrictions on feature combination (i.e. there are no universal implicational relations between features) and composition order (i.e. composition between features is fully commutable).

The extension to Ojibwe gave way to a critical discussion of alternative accounts including the feature geometry (Harley and Ritter, 2002) and lattice action (Harbour, 2016), which have previously been argued to capture the partition problem in the core persons. I showed that accounts based in the feature geometry are not able to capture the partition of Ojibwe without over-predicting the typological distribution of the distinction. The lattice action account could not capture the partition of Ojibwe on its own, requiring the theory of contrastive interpretations (or some similar account) to restrict possible feature combinations and prevent obviation distinctions from arising in the local persons.

The paper sheds light on the similarities and differences between person, obviation, and noun classification. All three of these types of features are connected by serving to carve up the ontological space of possible "persons". However, the way in which this carving occurs, the particular ontology implied by the presence of each feature, and the functional heads with which they are associated are distinct. While the animacy-based noun classification system of Ojibwe was the primary focus, the account showed promise in being applied to other noun class systems exemplified by languages in the Zapotec, Romance, and Bantu families. Further explication of the account to these systems and beyond is sure to bear more fruit.

Acknowledgments TBA.

A Derivation of the full ontology

(80)
$$
\begin{aligned}
[\![\varphi]\!] &= \mathcal{P}(\{i,u,p,o,o',\ldots,r,r',\ldots\})\\
&= \{\{i\},\{i,o\},\{i,o'\},\ldots,\{i,o,o'\},\ldots,\\
&\qquad \{i,r\},\{i,r'\},\ldots,\{i,r,r'\},\ldots,\\
&\qquad \{i,r,o\},\{i,r',o\},\{i,r,o'\},\{i,r',o'\},\ldots,\\
&\qquad \{i,r,r',o\},\{i,r,r'o'\},\{i,r,o,o'\},\{i,r',o,o'\},\ldots,\{i,r,r',o,o'\},\ldots,\\
&\quad \{i,p\},\{i,p,o\},\{i,p,o'\},\ldots,\{i,p,o,o'\},\ldots,\\
&\qquad \{i,p,r\},\{i,p,r'\},\ldots,\{i,p,r,r'\},\ldots,\\
&\qquad \{i,p,r,o\},\{i,p,r',o\},\{i,p,r,o'\},\{i,p,r',o'\},\ldots,\\
&\qquad \{i,p,r,r',o\},\{i,p,r,r'o'\},\{i,p,r,o,o'\},\{i,p,r',o,o'\},\ldots,\{i,p,r,r',o,o'\},\ldots,\\
&\quad \{u\},\{u,o\},\{u,o'\},\{u,o,o'\},\ldots,\\
&\qquad \{u,r\},\{u,r'\},\ldots,\{u,r,r'\},\ldots,\\
&\qquad \{u,r,o\},\{u,r',o\},\{u,r,o'\},\{u,r',o'\},\ldots,\\
&\qquad \{u,r,r',o\},\{u,r,r'o'\},\{u,r,o,o'\},\{u,r',o,o'\},\ldots,\{u,r,r',o,o'\},\ldots,\\
&\quad \{u,p\},\{u,p,o\},\{u,p,o'\},\ldots,\{u,p,o,o'\},\ldots,\\
&\qquad \{u,p,r\},\{u,p,r'\},\ldots,\{u,p,r,r'\},\ldots,\\
&\qquad \{u,p,r,o\},\{u,p,r',o\},\{u,p,r,o'\},\{u,p,r',o'\},\ldots,\\
&\qquad \{u,p,r,r',o\},\{u,p,r,r'o'\},\{u,p,r,o,o'\},\{u,p,r',o,o'\},\ldots,\{u,p,r,r',o,o'\},\ldots,\\
&\quad \{i,u\},\{i,u,o\},\{i,u,o'\},\ldots,\\
&\qquad \{i,u,r\},\{i,u,r'\},\ldots,\{i,u,r,r'\},\ldots,\\
&\qquad \{i,u,r,o\},\{i,u,r',o\},\{i,u,r,o'\},\{i,u,r',o'\},\ldots,\\
&\qquad \{i,u,r,r',o\},\{i,u,r,r'o'\},\{i,u,r,o,o'\},\{i,u,r',o,o'\},\ldots,\{i,u,r,r',o,o'\},\ldots,
\end{aligned}
$$

$$\{i,u,p\},\{i,u,p,o\},\{i,u,p,o'\},\dots,\{i,u,p,o,o'\},\dots,$$
$$\{i,u,p,r\},\{i,u,p,r'\},\dots,\{i,u,p,r,r'\},\dots,$$
$$\{i,u,p,r,o\},\{i,u,p,r',o\},\{i,u,p,r,o'\},\{i,u,p,r',o'\},\dots,$$
$$\{i,u,p,r,r',o\},\{i,u,p,r,r'o'\},\{i,u,p,r,o,o'\},\{i,u,p,r',o,o'\},\dots,\{i,u,p,r,r',o,o'\},\dots,$$
$$\{p\},\{p,o\},\{p,o'\},\dots,$$
$$\{p,r\},\{p,r'\},\dots,\{p,r,r'\},\dots,$$
$$\{p,r,o\},\{p,r',o\},\{p,r,o'\},\{p,r',o'\},\dots,$$
$$\{p,r,r',o\},\{p,r,r'o'\},\{p,r,o,o'\},\{p,r',o,o'\},\dots,\{p,r,r',o,o'\},\dots,$$
$$\{o\},\{o'\},\dots,\{o,o'\},\dots,$$
$$\{o,r\},\{o,r'\},\{o',r\},\{o',r'\},\dots,\{o,o',r\},\{o,o',r'\},\dots,\{o,o',r,r'\}$$
$$\{r\},\{r'\},\dots,\{r,r'\},\dots,\{\}\}$$
$$= \{i_o, i_r, i_{or},$$
$$ip_o, ip_r, ip_{or},$$
$$u_o, u_r, u_{or},$$
$$up_o, up_r, up_{or},$$
$$iu_o, iu_r, iu_{or},$$
$$iup_o, iup_r, iup_{or},$$
$$p_o, p_r, p_{or},$$
$$o_o, or,$$
$$r_r\}$$
$$= \{i_{po}, i_{pr}, i_{or},$$
$$u_{po}, u_{pr}, u_{por},$$
$$iu_{po}, iu_{pr}, iu_{por},$$
$$p_o, p_r, p_{or},$$
$$o_o, or,$$
$$r_r\}$$
$$= \mathscr{L}_\varphi$$

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