Formalizing a Unique Space-Time Grammatical Mapping in a North American Indigenous Language Family

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Abstract

The Na-Dene language family uses a system of verbal prefixes to indicate spatial orientation. This same system is generalized to express aspectual (temporal) meaning. I formalize the semantics of these prefixes as they relate to both time and space, arguing that this line of inquiry is a useful basis for interdiscplinary cognitive science focusing on the intersection of spatial and linguistic cognition.

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1 Introduction

A hallmark of many North American Indigenous language families, such as Na-Dene, is the possiblity of forming complex verbs expressing meaning equivalent to that of a full sentence in languages such as English [6, p. 1], [20, p. 475], [14, pp. 428-429]. Na-Dene appears unique in that spatial orientation is highly integrated into verbal grammatical structure, as will be the subject of this brief paper.

Levinson, a prominent scholar on the intersection of space and language, mentions an old trend of "localism" dating back to Aristotle claiming the cognitive underpinnings of language to be linked to spatial cognition. He draws on the idea that several nominal cases in Indo-European in e.g. Latin and Greek originally came largely from spatial words before undergoing development to acquire more abstract meetings; similarly, English has had the development of *of* ultimately from Latin *ab* (away, from) [16, pp. 3-4]. While the question of whether language evolved *from* spatial cognition is out of the scope of this paper, the intersection between these two cognitive domains has shown itself to be a promising locus of interdisciplinary inquiry. At the same time, the field of formalist linguistics has until recently seemed largely disconnected on this subject. As we shall see, it appears that space can be implicated in grammatical structure in largely the same structural, formal, and sharply categorical terms as tense is analyzed in formalist generative linguistics.

2 Brief Background on the Language Family

The Na-Dene language family is one of the largest on the North American continent, spanning much of its western half with particular concentrations in Alaska alongside Northern British Columbia and Yukon Territory, as well as smaller groups along the Pacific Coast and near

the border between the United States and Mexico (the latter two groups likely resulting from historical migrations). The first to diverge was Tlingit, followed by Eyak (now considered extinct); the remaining clade is known as the Dene (or exonymically, Athabaskan) subfamily [20, pp. 473-4], [14, p. 428], [13, p. 105].

3 "Conjugation" Prefixes and Spatial Orientation

Across centuries of scholarship in the linguistics of Na-Dene languages [12, pp. 9–67], several proposals have been put forth on the nature of a set of four prefixes (including one null element) within the verb word. These prefixes have been called a variety of names: *conjugation* markers (particularly in Tlingit scholarship), largely due to their at-a-glance arbitrary assignment to particular verbs; *perfective* prefixes due to the verbal aspects when they are widest-spread and seem the least easily explained; and *aspect/mode prefixes* owing to their use to express temporal information [19, pp. 251–283]. Until recently, none of the proposals have met widespread agreement or showcased a relatively clear link between the uses of these prefixes. Outside of these proposals, the general view has been that these prefixes may be semantically opaque if not meaningless [6, pp. 34, 484, 583].

On occasion, some authors have in passing mentioned some correlations between the spatial direction of an action expressed by a verb and the verb's conjugation prefix, but have viewed this secondary or vague so as to render further analysis either unwarranted or beyond reach (see chiefly [1, 19], among others). However, a recent and promising view focusing on Tlingit convincingly shows that for motion verbs, conjugation prefixes reflect a clear partition of space according to the direction of motion expressed – this is illustrated in (1). Similarly, verbs of extension feature a different conjugation prefix depending on whether they extend laterally, upward, or downward [6, pp. 142–144, 536–538, 620].

(1) a. * Kúx̲!
∅- kux̲
ZCNJ- go.boat.VAR
*: Ungrammatical. *Intended:* "Go by boat!"[1]

b. **N**ak̲oox̲!
n- kux̲
NCNJ- go.boat.VAR
"Go **along** by boat!"

c. **G**ak̲oox̲!
g̲- kux̲
G̲CNJ- go.boat.VAR
"Go **down** by boat!"

d. **G**ak̲oox̲!
g- kux̲
GCNJ- go.boat.VAR
"Go **up** by boat!" ([6, pp. 585-586][2])

[1] Linguistic glossing abbreviations: γCNJ = γ-conjugation, G̲CNJ = g̲-conjugation, 1 = first person, 3 = third person, ALL = allative, GCNJ = g-conjugation, INCP = inceptive, IRR = irrealis, MDIST = mesiodistal, MOD = mode, NCNJ = n-conjugation, OBJ = object, OC = open container, PFV = perfective, SBJ = subject, SCNJ = s-conjugation, SG = singular, VAR = stem variation, ZCNJ = zero-conjugation.

[2] The latter three differ from the cited source; the ones listed here are confirmed via personal correspondence with its author to be the correct ones.

Languages in the Dene family strikingly show the same spatial partition, as shown in (2) with data from Navajo. There are strict relationships between the conjugation prefixes and a wider set of directional prefixes [19, p. 322], the vast majority conforming to the proposed spatial partition scheme.

(2) a. niníyá
ni- **ni-** ∅- yá
across- NCNJ.PFV- 1SG- go.SG
"I went **across**." [22, p. 128]

b. nááyá
na- **yi-** ∅- yá
down- γCNJ.PFV- 1SG- go.SG
"I descended **down**." [22, p. 237]

c. haséyá
ha- **se-** ∅- yá
up- SCNJ.PFV- 1SG- go.SG
"I climbed **up**." [22, p. 231]

4 Axis Selection and Spatial Cognition

These data give rise to a complete partition of space relating to the set of four conjugation prefixes in each of Tlingit and the Dene subfamily. This is captured in Figure 1.

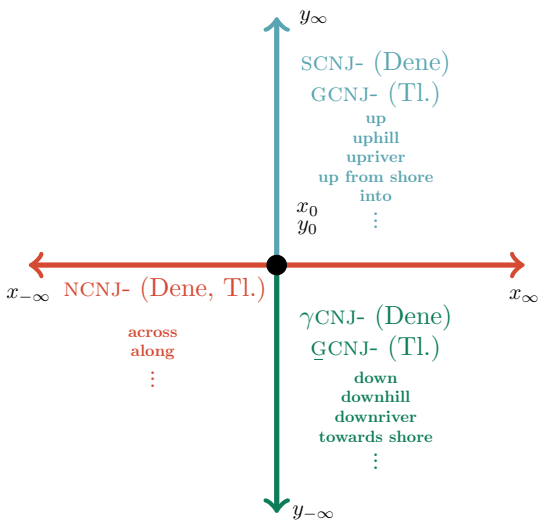

Figure 1 Representation of the spatial axes associated with each "conjugation" prefix for Tlingit (Tl.) and Dene.

Even before considering the labels, a striking fact about this figure is that it is clearly not a direct mapping from 3D space. The entire horizontal xz-plane is collapsed into a single axis, and the y-axis is broken up into two pieces with each beginning at the reference point (origo) and extending indefinitely.

The structuring of the spatial system in this manner appears to cohere with some previous research on spatial orientation from the perspective of cognitive science: Levinson points out that while gravity and its consequences for how we move around the Earth's surface mean we constantly have strong references for the vertical axis (i.e. what is up and what is down), this is markedly not the case for the horizontal plane. There are far fewer specific references for angles projecting laterally; they are thus underdetermined, to use Levinson's words, whereas vertical directions are overdetermined [15, pp. 75–76].

While Levinson repeatedly notes that different languages take different strategies with regard to the structure of space their directional terminology reflects, this general fact paired with the instance of very clear and rigid categorization at the basis of the Na-Dene system raises some intriguing questions about our spatial cognition. Namely: does this partition reflect something about how we perceive and model the world around us, a model which was simply co-opted by the linguistic system to express more information? If this seems at all likely, it would be an interesting line of inquiry to formally model that inner picture so as to better understand and test our spatial intuitions. What would such a mapping, between 3D-space on one hand and this asymmetrically compressed system on the other, have to look like?

Some further complications to this question come from the fact that while the axes corresponding to these prefixes at first glance seem to be anchored by default to the absolute directions as seen (typically egocentrically) from the reference point, the addition of other material such as any number "preverbal" outer prefixes can change how an axis is anchored. (3) shows an example of this from Ahtna, another Dene language.

(3) a. tayizkaan
ta- yi- **z-** kaan
water- 3SG.OBJ- SCNJ.PFV- handle.OC
"3SG carried it **up** *from shore*."

b. taghiyaa
ta- **gh**i- yaa
water- γCNJ.PFV- go.SG
"3SG walked **into** *the water*."

c. tatesni'aa
ta- tes- **n**i- 'aa
water- over- NCNJ- extend.
"It (bridge) **spans** *the water*." [9, pp. 323-325]

In fact, as shown earlier in Figure 1, these prefixes may often reflect directions related to other salient landmarks such as hills and especially rivers. It is very interesting to note that Dene culture has a strong and well-documented tendency to use riverine directionals in speech, narratives, and place naming [8, 17, 11, 10, p. 91]. This comes across strongly in the use of the spatial conjugation prefix system as well. It makes intuitive sense that highly salient and culturally landmarks would be highly integrated into the grammatical tools used to describe space; in fact, this is one important strategy Levinson notes languages use to deal with the underdetermination problem in the horizontal plane [15, pp. 76–91]. However, Na-Dene interestingly appears to have gone much farther by integrating these systems into *all* directions, rather than just the lateral ones.

Based on the foregoing, I propose that intuitions of metaphorical extensions of linguistic terms and cognitive perspectives from the language system can provide a basis for strongly formal and grounded work towards key questions for our understanding of cognitive phenomena such as those under study. I anticipate that the following section, which shows a

further metaphorical mapping extension of these prefixes' semantic domain from the spatial to the temporal: one which displays highly formal, structured and thereby readily analyzable properties and which has received much more of such attention from formalist approaches to linguistics in studies on grammatical tense and aspect.

5 Spatio-Temporal Cognition

In both Tlingit and the Dene subfamily, the conjugation prefixes can also be used to indicate aspectual (temporal) information. In Tlingit, the GCNJ ("upward") prefix is used in deriving the prospective ("future") form of a verb, while NCNJ ("lateral") is used to express the progressive form. These are shown in (4).

(4) a. Wé héende kx̲waagóot.
wé héen -dé w- g- g̲- x̲- gut -μH
MDIST river -ALL IRR- GCNJ- MOD- 1SG.SBJ- go.SG -VAR
"I will go to(ward) the river."

b. Wé héende yaa nx̲agút.
wé héen -dé ÿaa- n- x̲- gut -H
MDIST river -ALL along- NCNJ- 1SG.SBJ- go.SG -VAR
"I am going to(ward) the river." [6, 596]

There is a basic intuition here between upwardness and futurity, and between lateral motion "along" and progressive or continuing action, that points toward some sort of metaphorical mapping producing this shift from the semantic domain of space to that of time [6, pp. 582-585, 617]. We could consider this a second cognitive "co-optation" based on what was hypothesized in the previous section: one where an internal model of spatial cognition was co-opted by the linguistic system, and another internal to the linguistic system where spatial semantics are co-opted to express temporal semantics.

The Dene system is at once strikingly similar and yet poses many new questions. A typical view of motion verb aspectual derivations looks something like this in many Dene languages ([1, pp. 40–41, 135-138], [9, pp. 671–677], [19, pp. 250, 261, 304, 315–317], [7, pp. 394–395, 522, 527, 531–533, 556] and others):

Aspectual derivations using conjugation prefixes in Dene

1. Progressive verb forms are formed with γCNJ ("downward") along with specific stem variation.
2. Inceptives (*starting to/started to...*) are formed with a prefix *t/d-* plus SCNJ ("upward").
3. Combining the inceptive prefix *t/d-* with the progressive derivation yields the future form of a verb.

This is illustrated in (5) for Ahtna.

(5) a. nikaen
ni- kaen
NCNJ.PFV- go.boat
"3SG arrived by boat."

b. akaeł
gh- kaeł
γCNJ- go.boat
"3SG is going by boat."

c. tezkaen
t- z- kaen
INCP- SCNJ- go.boat
"3SG started to go by boat."

d. takaeł
t- gh- kaeł
INCP- γCNJ- go.boat
"3SG will go by boat."
[9, p. 669]

The Dene system at first glance appears to run counter to our original intuitions. However, here I will make the case that while such intuition is a valuable tool to shed light on phenomena like those at the intersection of linguistic and spatial cognition and guide us toward hypothesis development, the actual analysis should proceed from formal grounds. While I leave out much of the detail here, I propose a formal and compositional semantics for the conjugation prefixes that extends much of the current work on grammatical tense and aspect to the spatial domain. Aspectual markers are often regarded as imposing some sort of restriction on the time of an event with regard to the time of speech and the time being referred to, all along the temporal axis [5, 18, 3, 4, 21, among many others]. By considering each spatial axis as structurally analogous to the temporal axis, we can generate semantic specifications for each prefix that capture both their spatial and aspectual uses.

For Tlingit GCNJ used for upward spatial meanings and verbs in the future, we can proceed relatively straightforwardly. We can use an equivalence between the temporal axis running between an origo t_0 (perhaps the speech time) and a point indefinitely far in the future, and the spatial y-axis running between an origo y_0 and a point located indefinitely in an upward direction.

Tlingit GCNJ semantics

$$\boxed{\text{GCNJ}_{asp} = t \subset (t_0, t_\infty)} \qquad \boxed{\text{GCNJ}_{loc} = y \subset (y_0, y_\infty)}$$

For NCNJ, I propose that while the semantics may be reinforced by a more informal metaphorical mapping (or a formal one we have not yet grasped), the progressive arises from the purely structural fact that each of these entries deal with intervals (thus necessarily having a *duration*) rather than single points. It may take this on because GCNJ is already occupied and GCNJ would restrict an event to only the past. There would likely be little pressure for GCNJ to develop as a dedicated past-marking strategy, given the robust perfective and past-tense grammatical elements in the language [3, 6]).

I show the anchoring of time with respect to space as reflected in Tlingit conjugation prefixes in Figure 2.

Tlingit NCNJ semantics

$$\boxed{\text{NCNJ}_{asp} = t \subset (t_{-\infty}, t_\infty)} \qquad \boxed{\text{NCNJ}_{loc} = x \subset (x_{-\infty}, x_\infty)}$$

In Dene, I propose that the anchoring of the vertical axis is flipped with respect to time. Both progressives and inceptives can take place in the present, but in my (NB: non-exhaustive!) research I have come across neither an SCNJ inceptive situated in the future nor a γCNJ progressive situated in the past. This neatly accounts for this data while predicting the use of γCNJ in expressing the future.

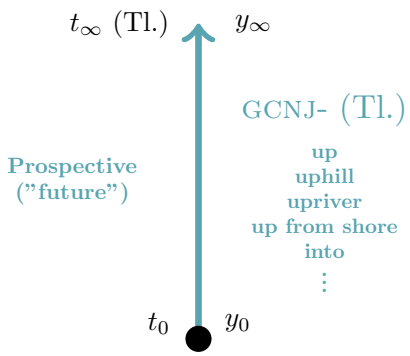

Figure 2 Anchoring of the temporal axis with respect to the vertical spatial axis in Tlingit.

Dene SCNJ, γCNJ semantics

$$\boxed{\text{SCNJ}_{asp} = t \subset (t_0, t_{-\infty})} \quad \boxed{\text{SCNJ}_{loc} = y \subset (y_0, x_\infty)}$$

$$\boxed{\gamma\text{CNJ}_{asp} = t \subset (t_0, t_\infty)} \quad \boxed{\gamma\text{CNJ}_{loc} = y \subset (y_0, y_{-\infty})}$$

I illustrate how time is anchored with respect to space ("in reverse") in Dene in Figure 3. Finally, Figure 4 summarizes of the overall proposal for this paper.

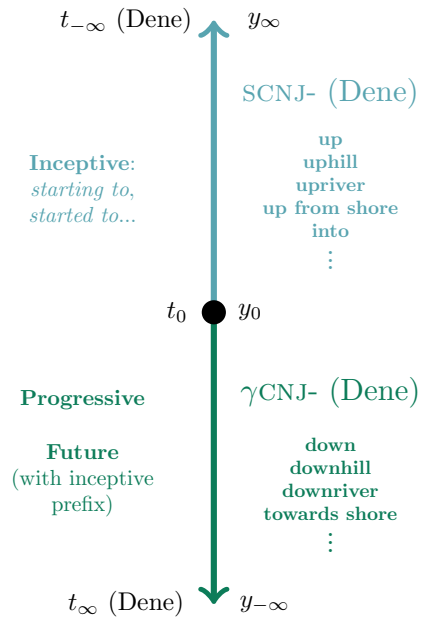

Figure 3 Anchoring of the temporal axis with respect to the vertical spatial axis in Dene.

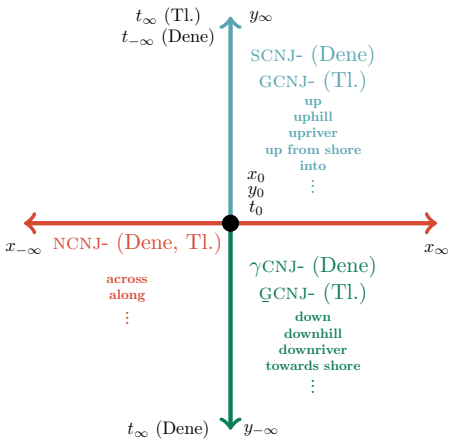

Figure 4 Near-complete range of meanings for conjugation prefixes in Tlingit and Dene across space and time.

6 Conclusion

We have seen how investigating a single under-analyzed prefix system in an Indigenous language family has raised a host of questions relating to spatial cognition and its intersection with language. Such inquiry has a significant potential to shed light on ways to formalize and model our internal representations of time and space, both inside and outside the context of natural language. The neural and environmental constraints there are on which spatial models we develop – and which we must instead rule out as impossible or implausible – as well as the constraints on the mappings we make between domains like space, time, and linguistic structure, are key questions which relate strongly to this interdisciplinary mode of inquiry. Inquiry in linguistics in tandem with other fields can help to show which features are salient in a representation, and pairing this intuition with formal explanatory models is a promising program for future research.

While this is a preliminary and theoretical work, there are some applications that can extend the scope and wider usefulness of this sort of research. At this stage, this is perhaps most helpful as an exercise rather than to generate concrete proposals. We can imagine the future prospect of creating useful technologies as a method to further guide research focuses. While much more theoretical linguistic and general cognitive inquiry will need to be done in order to get to such a point, we can for example imagine needing to make a machine translation or geospatial navigation system for a language like Tlingit in light of the spatial system at play in the language. The clearly formalizable nature of spatial systems such as the one laid out here could also have significant utility in practical projects for Indigenous communities to practice resurgence by (perhaps literally) realizing certain aspects of their worldviews. For example, a map or geospatial model coloured by a Dene language view of space may be a good fit for alternative, Indigenous mapping projects such as those of the sort proposed in *Decolonizing the Map: Indigenous Maps and GIS* [2].

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