

Iofu and Spreading Architecture in LFG*

Avery D Andrews

School of Language Studies, The Faculties, ANU

1 Introduction

Andrews and Manning (1999) proposed a revision of LFG architecture whereby the standard conception of f-structure is replaced by a more general feature structure, which includes c-structural and argument-structural information in addition to the standard content of f-structure. Results produced in standard LFG by the many-to-one correspondence between c-structure and f-structure are then accounted for by use of a ‘spreading architecture’, in which grammatical attributes are systematically shared across multiple levels of the c-structure. This revision of LFG architecture supports straightforward analyses of various kinds of complex predicate structures whose properties are quite problematic under the standard version of LFG, and indeed other explicit linguistic formalisms.

However the proposal has a compatibility problem with another recent development in LFG, the use of ‘inside-out functional uncertainty’ (iofu) to describe phenomena such as anaphoric dependence (Dalrymple 1993) and case-marking (Andrews 1996, Nordlinger 1998). In this paper I will present the problem and a proposed solution.

2 Spreading Architecture vs. Iofu

For a simple example of iofu, consider the application of the constraint (1a) to the f-structure (1b)

- (1) a. ((SUBJ \uparrow) OBJ)
c.f. (Nordlinger 1998)

$$\text{b. } \left[\begin{array}{ll} \text{SUBJ} & f: [\text{CASE} \text{ ERG}] \\ g: \text{TENSE} & \text{PAST} \\ \text{OBJ} & h: [\text{CASE} \text{ ABS}] \end{array} \right]$$

Suppose that in the process of instantiation, the \uparrow in (a) is instantiated to the f-structure f in (b). Now the position of the arrow at the end rather than the beginning of the expression (SUBJ \uparrow) indicates that it is an iofu designator; therefore it designates some f-structure which has f as its SUBJ-value; g in (b) satisfies this condition, and so is a possible value for this designator.¹ So now the whole expression (b) says that g

⁰I would like to thank Chris Manning, Jane Simpson and David Nash for comments and discussion.

¹Because f-structures allow a single f-structure to be the value of (possibly different) attributes in more than one f-structure, an ‘inside out’ designator has multiple possible values, that is, it is an instance of functional uncertainty.

has an OBJ-value, and therefore the structure (b) satisfies the constraint (a) (as long as \uparrow designates f , but would not if it were to designate h).

To see the incompatibility with spreading architecture, consider the treatment of simple NP-structure and case-marking under the two approaches. In standard LFG, an NP would have a c-structure with nodes such as NP, N, etc (the labels being specified by an independent function assigning c-structure categories to nodes), and an f-structure related to the c-structure by the many-to-one correspondence ϕ (from c-structure nodes to f-structures). This correspondence is determined by annotations on the c-structure nodes (or in more recent formulations by general principles regulating ϕ). Below is the structure for a simple NP in the Australian language Warlpiri (Simpson 1991), with the ϕ correspondence represented by the shared index f :

$$(2) \quad \begin{array}{c} \text{NP}_f \\ | \\ \text{N}_f \\ \uparrow = \downarrow \\ | \\ \text{kurdu-ngku} \end{array} \quad f: \begin{bmatrix} \text{CASE} & \text{ERG} \\ \text{PRED} & \text{'Child'} \end{bmatrix}$$

By contrast, with spreading architecture, the (equivalents of) the c-structure nodes are connected by a single function to feature-structures which specify all featural information relevant to the node. Since this information will typically be different for mother and daughter nodes, the NP will have a different feature-structure correspondent than the N, leading to an overall structure like this:

$$(3) \quad \begin{array}{c} \bullet_g \\ | \\ \bullet_f \\ = \{\alpha, \kappa, \rho, \mu\} \\ | \\ \text{kurdu-ngku} \end{array} \quad g: \begin{bmatrix} \text{CASE} & \text{ERG} \\ \text{CAT} & \text{N} \\ \text{PRED} & \text{'Child'} \\ \text{BAR} & 1 \end{bmatrix}$$

$$f: \begin{bmatrix} \text{CASE} & \text{ERG} \\ \text{CAT} & \text{N} \\ \text{PRED} & \text{'Child'} \\ \text{BAR} & 0 \end{bmatrix}$$

Rather than having two c-structure nodes associated with a single f-structure, each c-structure node (represented by a dot with a subscript) is associated with a different feature-structure, but these feature-structures share large numbers of attributes, indeed in this example, all attributes except the bar feature. This sharing is controlled by annotations which refer to classes of attributes called ‘projections’. The annotation on the c-structure in (3) says that attributes belonging to the α (argument-structure and semantic), κ (lexical c-structure category), ρ (grammatical function) and μ (morphosyntactic feature) projections should be shared between the mother and the daughter.²

The issue with iofu is that it is not clear how a constraint such as (1a), which is supposed to be co-introduced with a morphological element such as a case-value, can

²This annotation is an abbreviation for statements that can be formulated using the set-theoretical concept of restriction, see (Andrews and Manning 1999) for details.

be satisfied in a structure like (3). Following the approach to case-marking proposed in (Nordlinger 1998), a constraint such as (1a) would be introduced together with the ergative marker on the node with feature-structure g in (3). But in order to be satisfied it needs to apply to feature-structure f , since this is what would be the value of SUBJ in a containing structure. But f and g never get equated, so the structures remain different, and the constraint cannot be satisfied. The same problem will apply to other iofu constraints associated with morphological material: without some way to get the iofu constraints to apply to a higher structure, these constraints can't be satisfied, and therefore cannot do useful work in a grammar.

3 A Proposal

The basic idea of my proposal is to have the iofu constraints ‘hitch a ride’ on shared attributes. Consider the question of what would be designated by an expression such as:

(4) (CASE (\uparrow CASE))

with \uparrow designating f in (3b). (\uparrow CASE) will designate the CASE-value of f (an ordinary ‘outside-in’ designator), which is ERG. So the whole expression will be a functionally uncertain inside-out designator referring to some feature-structure which has ERG as its CASE-value. There are two candidates, f and g , the latter being the one we want. Thus the sharing of the CASE-attribute between the upper and lower node provides a way to get iofu constraints to work. There is however a technical issue we need to deal with, and also a significantly different alternative formulation.

The technical issue is that in the standard formalization of LFG (Kaplan and Bresnan 1982), feature-values are thought of as set-theoretic objects for which there is no difference between types and tokens: all ergative case-values in a structure would be represented by the single set-theoretical object ERG. This interpretation is clearly not compatible with the present proposal: we need to think of grammatical feature values as tokens which may or may not be of the same type (ERG vs. ACC, etc.). The situation is similar to that for the PRED-feature, except that different PRED-tokens cannot merge regardless of whether or not they are of the same type, whereas for grammatical feature values we want tokens to be able to merge if and only if they are of the same type.³ On this account, the feature-structures designated by (4) would be for which there is an explicit identity between their CASE-value and that of f .

Another possible formulation that we need to consider depends on a possible alternative conception of the projections. In (Andrews and Manning 1999), projections are conceived of as mere sets of attributes, having no direct representation in sentence structures, which express only their effects, in the form of shared values of attributes between different parts of the structure. However there is another possible formulation (described in unpublished notes by John Maxwell), that projections might be distinct components of the f -structure. So the μ projection for example might be a distinct subregion of a feature-structure where the morphosyntactic features reside. This

³However see (Andrews 1990) for suggestions that things are not so clear-cut.

would make it possible to equate projections (parts of feature-structures) without saying anything about the specific attributes that reside on them. We won't pursue the consequences of this kind of choice here, but will remain with the first conception.

(3) is a rather cumbersome formulation, to simplify it I propose an abbreviatory notation whereby the attribute appearing on both sides of the \uparrow is subscripted to the arrow. The constraint (1a) can then be reformulated as either (a) or (b) below:

- (5) a. ((SUBJ \uparrow_{CASE}) OBJ)
 b. ((SUBJ \uparrow_{μ}) OBJ)

The interpretation of formulation (a) is straightforward under either conception of projections, whereas if we want interpret projections strictly as sets, the (b) formulation could be understood as functionally uncertain with respect to the 'outside in' portion of the designator as well as the inside out one: find some attribute on the μ projection (functionally uncertain because there may be more than one such attribute, and find a feature-structure with a shared value for that attribute).

So we have a proposal that works, but to get a real result we need to find some advantage that the modified theory has over its predecessor. I claim that this can be found in the possibility of accounting for some of the different systems for distributing case-markers across the members of NPs in Australian languages.

4 Case Distribution

Dench and Evans (1988:3-6) observe the following major patterns of case-distribution in Australian Languages.⁴

- (6) a. mark on all members of the NP
 b. mark on the last member(s) of the NP
 c. mark on head of the NP
 d. mark on any member of the NP

(Dench and Evans 1988:3-6)

(a) and (c) are non-problematic for LFG (but see (Andrews 1996) for discussion of the role of the Morphological Blocking Condition for (a)). (d) is likewise probably not a problem, although available descriptions of the languages having it do not give an entirely consistent picture of how this distribution pattern actually works.⁵ In many languages, such as Turkish, (b) co-occurs with (c), since the head is final in the NP. But in certain Australian languages, the case-marker is final in the NP (at least normally), but the head isn't. Rather at least some modifiers are able to appear after the head (and normally do so), but before the case-marker. Examples from Central Australia are afforded by Arrernte, Pitjantjatjara and Warlpiri:

⁴Some of the Nyulnyulan languages, such as Bardi, appear to have a significant preference for a fifth pattern, case-marking (by means of a suffix) on the first member of the np (Gedda Aklif, Claire Bowern, p.c.)

⁵(Stokes 1982) for Nyigina, and (McGregor 1990) for Gooniyandi, both Nyulnyulan

- (7) Arrernte (Wilkins 1989):
- a. *Kngwelye-le ker arlkwe-ke*
dog-ERG meat eat-PAST
The dog ate (the) meat
 - b. *Kngwelye yanhe-le ker arlkwe-ke*
dog that-ERG meat eat-PAST
That dog ate the meat
- (8) Pitjantjatjara (Bowe 1990:29-31):
- a. *Minyma-ngku tjitji nya-ngu*
woman-ERG child saw-PAST
The woman saw the child
 - b. *Wati nyanga ninti pulka-ngku muttuka palya-nu*
man that clever very-ERG car fix-PAST
That very clever man fixed the car
 - c. *Tjitji pulka-ngku malanypa nya-ngu*
Child big-ERG younger sibling see-PAST
That big child saw his younger sibling
 - d. *Wati nyanga-ngku mutuka palya-lpai*
man this-ERG car fix-HABIT
This man fixes cars
- (9) Warlpiri (Nash 1986:170)
- a. *karnta(-ngku) kurdu-ngku wita-ngku*
female(-ERG) child-ERG small-ERG
 - b. *karnta(*-ngku) kurdu wita-ngku*
female(-ERG) child small-ERG
small female child (Nash 1986:170)

In Warlpiri, unlike the other two languages, case-markers are not restricted to occurring finally; the operative constraint appears to be that a final segment of the nominals in an NP must bear the case-marker.

Simpson (1991:131-133) proposed a c-structure category-based account of case distribution in Warlpiri, whereby nominal words could be introduced as instances of either N or N^{-1} , the latter being a nominal word incapable of bearing a case-marker. A simplified version of Simpson's proposal is:

$$(10) \bar{N} \rightarrow N^{-1*} N^* N$$

This could be modified to apply to Arrernte and Pitjantjatjara by removing the N* term. Simpson's proposal works for a wide range of NPs in Warlpiri, but there are expressions in all three languages for which it fails. The problem is it links the potential absence of case-marking to the distribution of a lexical category. It therefore cannot explain instances in which a phrasal category is non-final and consequently excluded from the domain of case-marking, whether optional or obligatory.

A Warlpiri example is the following from (Simpson 1983:331):

- (11) a. *Maliki kurdu yali-kirlangu-rlu ka wajilipi-nyi mutukayi*
 dog child that.rem-POSS-ERG PRES chase-NPAST car(ABS)
- b. *Kurdu yali-kirlangu maliki-rli ka wajilipi-nyi mutukayi*
 child that.rem-POSS dog-ERG PRES chase-NPAST car(ABS)

The dog of that child is chasing the car

In these examples we have an NP containing another NP embedded as a possessive modifier. (a) is consistent with Simpson's approach, since the nonfinal element in each NP is a single word. But in (b), the first element of the NP is the possessor, expressed as a two-word phrase.⁶ The final word of the possessor phrase bears a possessive case-marker applying to the whole possessor phrase, but no instance of the ergative. Although this appears to be an instance of the pattern that (10) is trying to describe, (10) doesn't account for it, since (10) constrains the distribution of lexical rather than phrasal categories.

Similar examples are found in Arrernte and Pitjantjatjara:

- (12) Pitjantjatjara (Bowe 1990:40-41)
- a. *Wati wara-ku minyma ninit pulka-ngku numa palya-nu*
 man tall-GEN woman clever very-ERG bread make-PAST
 That tall man's very clever wife made the traditional bread
- b. *Wati panya minyma nyanga-ku-ngku malu waka-nu*
 man ANAPH woman this-GEN-ERG roo spear-PAST
 that husband of this woman speared the kangaroo
- (13) Mparntwe Arrernte (Wilkins 1989:156)
- a. *Kngwelye kweke artwe kngerre nturre-kenhe-le re-nhe utnhe-ke*
 dog small man big very-GEN-ERG he-ACC bite-PAST
 The small dog of the very big man bit him
- b. *Artwe kngerre nthurre-kenhe kngwelye kweke-le*
 man large very-GEN dog small-ERG
 the small dog of the very large man

⁶To make this point, it is essential to use a phrasal possessor. The reason is that possessive case-markers attached to single words can be construed as derivational affixes creating derived adjectives, which can fail to bear affixes as a regular consequence of the application of rule (10).

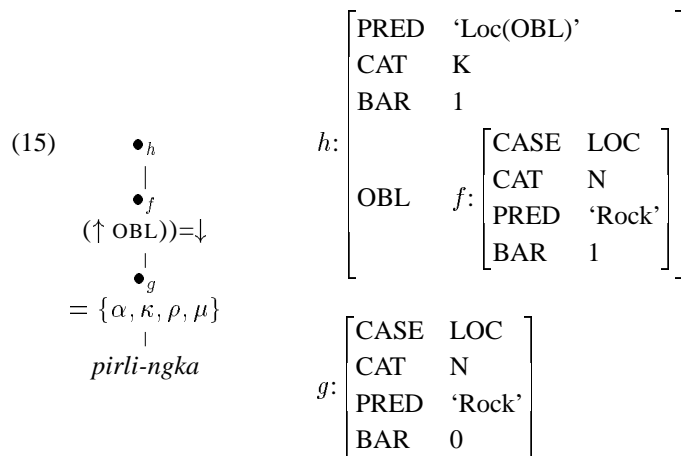
What we can do to accommodate these kinds of examples is to tweak Simpson's original rule so that it introduces phrasal as well as lexical categories, and uses spreading annotations rather than morphosyntactic categories. A first version might be the following, where the material in brackets is absent in Arrernte and Pitjantjatjara:

$$(14) \bar{N} \rightarrow N^* \langle N_{=\{\mu\}} \rangle N_{=\{\mu\}}$$

This formulation will confine the spreading of morphosyntactic features to the final nominal of the NP, or a final segment of the nominals of the NP. Nominals that don't get the $=\{\mu\}$ annotation will not be able to bear a case, because the IOFU constraints associated with the introduction of the case-marker won't be able to be satisfied, and when a nominal gets the annotation, the morphological blocking principle will require the appropriate case-marker, if any to appear.

The data involving phrasal modifiers of NPs is however still not accounted for, because (14) only introduces lexical categories, not phrasal ones. What we need is to allow the non-head constituents of an NP to be introduced either as N or as \bar{N} . It would be possible to invent notations to allow this to be done with a formulation along the general lines of (14), but it would be better to break the formulation down into general principles that have the capacity to apply across different kinds of phrase-structural configurations.

To begin with we need to make some decisions about the representation of NPs with 'semantic' case-markers, not only adnominal ones such as proprietive and genitive, but also adverbial ones such as allative and locative (the latter can also function adnominally). Simpson (1991) provides an argument, recapitulated in (Andrews 1996:7), that semantic case-markers introduce an extra level of f-structure, needed to host the PRED-value of the semantic case, which is distinct from the PRED-value of the nominal to which the case-marker is attached. The argument can probably be circumvented in modern LFG by the use of glue-logic semantics, but we will accept the conclusion for the sake of putting forth some definite structural proposals. To make the outcome of the proposed principles easier to grasp, I will treat semantically case-marked NPs as instances of a category KP (for Case Phrase), which will in Warlpiri expand directly to an NP (ordinary NP), bearing the grammatical function OBL. In an NP such as *pirli-ngka* 'hill/rock-loc', the resulting structure will then look like this:



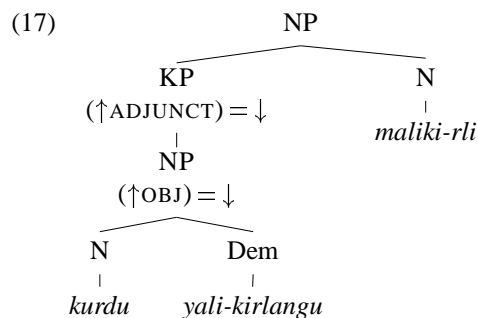
Note that the feature-structure of the lower N is not itself bear any function in the feature-structures of the nodes that dominate that N, but the values of many attributes are shared between them.

The PRED feature can be placed into its higher structural position by an annotation such as (16), introduced by the case-marker:

- (16) $((\text{OBL } \uparrow_\mu) \text{PRED}) = \text{'Poss(OBL)'}$
 (to implement case-stacking, Nordlinger's 'functional composition' applies)

Structures with significant resemblances to this proposal for semantically case-marked NPs include Enclitic Phrases in Navajo (Kaufman 1974), the structure proposed for 'Quirky' case-marked NPs in Icelandic by Andrews (1982), and Locative Phrases in Bantu languages such as Chichewa (Bresnan and Mchombo 1995).

On this account, an NP such as the ergative in (11b) would have a c-structure like this (c-structure categories written into the tree for convenience, and many attribute-sharing annotations omitted):



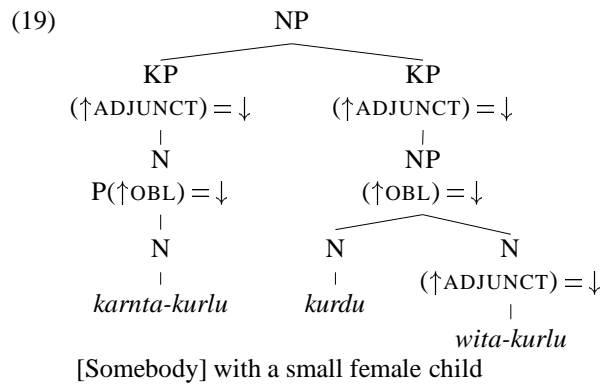
The following principles will produce the kinds of structures we want for NPs:

- (18) a. NP can dominate N or KP
 b. N under NP can be annotated $= \{\rho, \alpha\}$ or $(\uparrow \text{ADJUNCT}) = \downarrow$

- c. KP under NP must be annotated $(\uparrow\text{ADJUNCT}) = \downarrow$
- d. the final element (in Warlpiri, elements) must share its μ projection with the mother; the others may not.

Importantly, if the KP and N in (17) are reordered, the lexical entry for the semantic case-marker in (16) will interact with Nordlinger’s principle of functional composition so that the ergative marker will appear on the end of the possessor NP, after the genitive marker, as in (11a), and nonetheless apply to the topmost NP.

Another example of how these principles interact is provided by (19):



What is interesting here is the apparent exception to the generalization that it must be a final segment of the nominals of an NP that is case-marked. The rules allow this kind of example to work differently than (9) because this example involves an attributive KP, and Warlpiri allows discontinuity of NP and KP. The whole nominal has an unexpressed head and a discontinuous adjunct KP, with the case-marker appearing on the final member of each KP-piece.

The proposed reformulation of iofu-based rules thus provides some empirical coverage that has previously been missing from LFG theories of case.

5 Further Issues

There are a number of further issues to be dealt with. One is the possibility that the supposed case-markers might actually be postpositions, or phrasal clitics of some sort, rather than affixes. On such an analyses, we would treat them as occupying final (head) position in KP or an equivalent node, the syntax per se having no responsibility for their apparent relationship to the nominals they appear on. In Warlpiri, such an analysis is challenged by the possibility of case-distribution; it faces other problems in addition.

In Warlpiri, the ergative and locative case-markers begin with *-ngk* after disyllabic stems, *-rl* otherwise, a kind of allomorphy typically associated with affixes rather than clitics. Furthermore in Arrernte and Pitjantjara, different classes of nominals show different case-marking patterns. In Pitjantjara, common noun and proper names

inflect with an accusative-absolutive pattern while personal pronouns are nominative-accusative (using the otherwise ergative marker *lu* as a nominative marker). Furthermore proper names use *-nya* as an absolutive marker (which is typologically rather usual), while pronouns use it as an accusative marker:

(20) Pitjantjatjara CM Morphology:

	A	S	O
CN: man	wati-ngku	wati	wati
PN: Billy	Billy-lu	Billy-nya	Billy-nya
Pronoun: I	ngayu-lu	ngayu-lu	ngayu-nya

This kind of complexity is normal for affixes, but not for clitics.

Arrernte similarly has an ergative-absolutive system for non-pronominal N and also the first person singular pronoun, but nominative-accusative for the other pronouns. There is in addition an interesting phenomenon involving the third person pronoun *re*, which is also used as a definite article in NPs. While common nominals and the first person singular pronoun in Arrernte are inflected in accordance with an ergative-absolutive pattern, other pronouns, including *re* in its definitizing use, inflect in accordance with a nominative accusative pattern:

- (21) a. *kngwelye re(*-rle) ker arlkwe-ke*
 dog the(*-ERG) meat eat-PAST
 The dog ate the meat
- b. *artwe re*(-nhe) kngwelye-le uthwe-ke*
 man the-ACC dog-ERG bite-PAST
 the dog bit the man

NPs which end in *re* therefore partake in the nominative-accusative case-marking system rather than the ergative-absolutive that is normal for non-pronouns. This can be accounted for if case is being spelled out on the final word of the NP, as determined by its inflectional category, but is not consistent with the idea of case being a clitic. The case-marking cannot thus be seen as a particle which simply appears at the end of the NP, but rather has some kind of significant relationship with its final word.

A loose end in our treatment arises in Warliri. Simpson (1991:275) observes that an adnominal locative NP, unlike the genitive noted previously, must bear a case-marker appropriate for the whole NP:

- (22) *pirli-ngka*(-rlu) wati-ngki nganpa luwa-rnu*
 hill-LOC*(-ERG) man-ERG us shot-PAST
 The man on the hill shot us

Our analysis however predicts that the ergative marker should be optional in (c). A possible solution to this might be that locative is also, and perhaps preferentially, an adverbial case-marker, which will agree in case with an argument to which it ascribes a property (Simpson 1991:2-4-208). Omission of the ergative from *pirli* in (22) would be consistent with an interpretation in which the locative was describing the absolutive argument *nganpa* ‘us’ in O function, rather than the ergative. If this was the preferred

interpartition under a version of bi-directional optimality theory, the phenomenon of (22) would follow.

A final issue to consider is the fact that in several of the examples from Arrernte and Pitjantjatjara in (8) and (7), case-markers are appearing after intensifiers of words functioning adjectivally. This sits uncomfortably with the arguments already given that case-markers are inflections. A possible resolution of this discrepancy is that perhaps they can be both. Suppose that the head (K) position in KP was optional, sharing μ with KP. It might then be possible for optimality theoretic principles such as *STRUC, Parse Case etc. to allow case to be manifested as an inflection on the final member of NP under some circumstances, and as a clitic introduced under K in others. However information-sharing of the kind proposed here would be essential in getting such an analysis to work.

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