

Developing a Deep Grammar of Indonesian within the ParGram Framework: Theoretical and Implementational Challenges

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Abstract

This paper discusses theoretical and implementational challenges in developing a deep grammar of Indonesian (IndoGram) within the lexical-functional grammar (LFG)-based Parallel Grammar (ParGram) framework, using the Xerox Linguistic Environment (XLE) parser. The ParGram project involves developing and processing computational grammars in parallel to test the LFG's theoretical claims of language universality, while at the same time testing its robustness to handle typologically quite different languages. Two relevant cases are discussed: voice-related morphosyntactic derivation and crossed-control dependency in Indonesian. It will be demonstrated that parallelism should be taken as a matter of degree, that it cannot always be maintained for good language-specific reasons and that the participation of IndoGram has also contributed to the rethinking and improvement of certain parallelism standards.

1 Introduction*

This paper discusses theoretical and implementational challenges to developing a deep grammar of Indonesian (IndoGram) within the Parallel Grammar (ParGram) framework. Using the Xerox Linguistic Environment (XLE) parser (Maxwell and Kaplan 1993; Crouch et al. 2007) with lexical-functional grammar (LFG) (Bresnan 1982, 2001; Dalrymple 2001) as the underlying linguistic theory, the IndoGram project joins the research and development program of broad-coverage grammars from a typologically wide range of languages. The approach (Butt et al 1999, 2002) involves developing and processing computational grammars in parallel to test the LFG's theoretical claims of language universality, while at the same time testing its robustness to handle typologically quite different languages.

While parallelism is preferred, it is demonstrated that this cannot always be strictly maintained for good language-specific reasons. It is also shown that the participation of IndoGram has contributed to the richness of linguistic phenomena to be handled within the ParGram project and to the rethinking and improvement of certain parallelism standards. Two relevant cases are discussed: voice-related morphosyntactic derivation and crossed control dependency.

The paper is structured as follows. An overview of the ParGram project is first presented in section 2. Linguistic analyses of voice alternations and crossed-control constructions and their XLE implementation are given in sections 3 and 4 respectively, followed by some discussion in section 5. Conclusions are given in section 6.

2 The (Indonesian) ParGram project: an overview

The Parallel Grammar (ParGram) project is an international collaborative research project for the development of large-scale computationally tractable grammars and lexicons of the world's (major) languages. Members include the corporate research laboratories of the Palo Alto Research

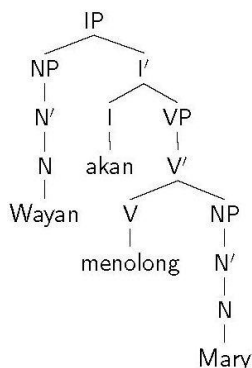
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Center (PARC) (USA) and Fuji Xerox (Japan), as well as Stanford University, Oxford University, Manchester University, the Universities of Stuttgart and Konstanz, (Germany), the University of Bergen (Norway), the University of Essex (UK) and Langue et dialogue (France).

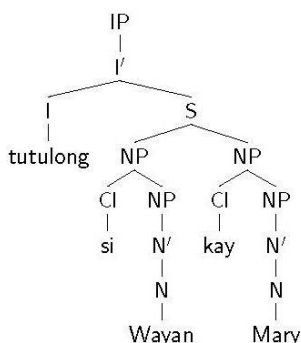
Current ParGram analyses (Butt et al 1999, 2002) are the result of over fifteen years of research and discussion based on data from a typologically wide range of languages (English, German, French, Japanese, Norwegian, Urdu, Welsh and Malagasy). The approach (Butt et al 1999, 2002) is to develop and process grammars in parallel. Similar analyses and technical solutions, wherever possible, are given for similar structures in each language. Parallelism has the computational advantage that the grammars can be used in similar applications and that machine translation (Frank 1999) can be simplified. However, ParGram also allows flexibility where parallelism is not maintained when different analyses are desirable and justified for good language-specific reasons. An encouraging result from ParGram work is the ability to bundle grammar-writing techniques into transferable knowledge and technology from one language to another, which means that new grammars can be bootstrapped in a relatively short amount of time (Kim et al 2003).

The underlying syntactic framework for ParGram is lexical-functional grammar (LFG), a stable and mathematically well-understood constraint-based theory of linguistic structure (Kaplan 1982; Dalrymple 2001; Bresnan 2001). Two important structures are assumed in LFG: constituent structure (*c-structure*; *c-str*) and functional structure (*f-structure*; *f-str*). The *c-structure* representation captures surface (overt) linguistic expressions that vary across languages. It is modelled in phrase structure trees that show structural dominance and precedence relations of units. *F-structure* captures abstract relations of predicate argument structures and related features such as tense. This is where cross-linguistic similarity or universality is represented. Thus, the equivalent sentences of English *Wayan will help Mary* in Indonesian and Tagalog are, respectively, *Wayan akan menolong Mary* and *Tatulong si Wayan kay Mary*. Indonesian is more like English in its *c-str*, whereas Tagalog is quite different, as seen in (1)a-b. However, they all share the same *f-str*, as shown in (1)b.¹

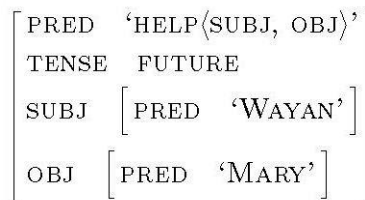
(1). a. *c-str*: Indonesian



b. *c-str*: Tagalog



c. *f-str* for both (a) and (b)

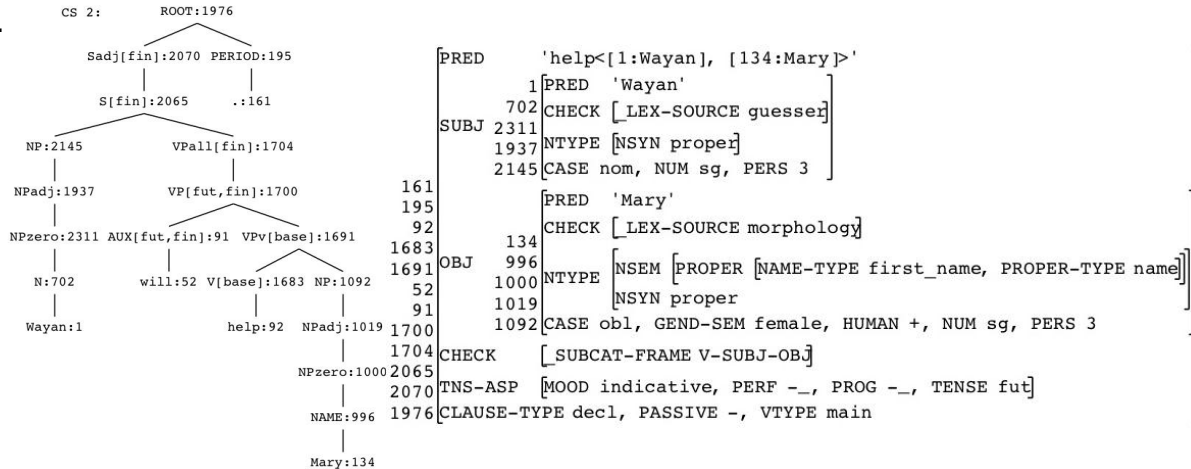


ParGram is built on the XLE platform (Maxwell and Kaplan 1993; Crouch et al. 2007), developed and maintained at PARC, which implements LFG theory. It outputs *c-structures* (trees) and *f-structures* as the syntactic analysis. The actual *c-str* and *f-str* output parse of a specific sentence from a given language contains richer information, however, as seen in (2) below.

Since *f-str* is the locus for cross-linguistic parallelism, it is of great significance in ParGram. It is the *f-str* that is used in a range of computational applications, e.g. in machine translation, sentence condensation and question answering. The ParGram project dictates the type of *f-str* analysis and the form of the features used in the grammars (Butt and King 2007).

¹ Abbreviations: 1, 2, 3 (first, second, third person); APPL (applicative); ARG (argument), ART (article); AV (actor voice); FUT (future); ITR (intransitive); MIDD (middle voice); OBJ (object); OBL (oblique); PASS (passive); PRED (predicate, a semantic form in LFG); pl (plural); PROG (progressive); s (singular), REL (relativiser); SUBJ (grammatical subject), TR (transitive); U (undergoer); UV (undergoer voice).

(2).



3 Morphosyntactic alternations: voice and applicative/causative alternations

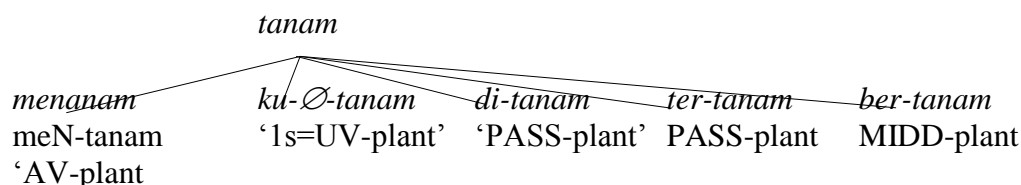
Current research in Austronesian (AN) linguistics has led to good understanding of voice systems in this language family, of which Indonesian is a member. Austronesian voice systems are generally richer than those encountered in Indo-European languages like English. English shows only a two-way system: active-passive alternations, e.g. *John kissed Mary* vs. *Mary was kissed by John*. Indonesian, like other AN languages of the Philippines/Taiwan, shows a multi-way system. There is more than one non-actor voice. In the AN languages of the Philippines and Taiwan, there is no clear structure that can be analysed as passive. In Indonesian, however, one of the non-actor voices, namely the structure with *di*-verb plus a PP agent as in (3)c, can indeed be analysed as a true passive equivalent to the English passive. The agent is grammatically oblique, expressed by a PP (like in English), optional (indicated by the brackets) and pragmatically not prominent.

- (3). a. *Aku akan menanam pohon itu* b. *Pohon itu akan ku=tanam*
 1s FUT AV.plant tree that tree that FUT 1s=UV.plant
 ‘I will plant the tree’.
 ‘The tree, I will plant’.
- c. *Pohon itu akan di-tanam (oleh mereka).*
 tree that FUT PASS- plant by them
 ‘The tree will be planted (by them)’.

Unlike Indo-European languages, the voice-system in Indonesian is symmetrical in a morphological and syntactic sense. Morphologically, they are symmetrical, as all voice types – AV (active/actor voice), UV (undergoer voice)² and PASS (passive voice) – are equally marked, e.g. from the root *tanam* ‘plant’, we can derive AV, UV, volitional/accidental PASS verbs and MIDD(1e) verbs, as shown in (4). Syntactically, they are symmetrical in the sense that, unlike the voice alternations in English, the system allows both the actor and undergoer of a transitive verb to be equally linked to SUBJ without demoting any of them. Consequently, the voice alternation does not affect the transitivity. Thus, (3)b is as transitive as (3)a, and is syntactically not passive.

² UV is a type of voice where the Undergoer argument is the grammatical subject (hence, like passive) but the Actor argument is still highly prominent, obligatorily present showing up as a core argument. Note that in passive the Actor argument is optional and not a core argument.

(4).



The unusual nature of the voice system in Indonesian and other AN languages poses descriptive, typological and theoretical challenges, and have led to controversy in linguistics. This also gives rise to an implementational problem in ParGram which is discussed further below. Descriptively, how to label different non-actor voices is not straightforward. Authors from different schools of linguistics analyse and label them differently. For certain linguists (Cole, Hermon, and Yanti 2008), structures like (3)b-c are analysed as passives, despite a clear difference in the syntactic status of the A argument. In my analysis (Arka and Manning 2008), sentences (3)b-c are syntactically distinct structures, with the first being active-like and translatable as active in languages like English (Purwo 1989). There are good linguistic reasons to label them differently. In this paper, I adopt my own analysis to capture the symmetry of the Indonesian voice system, while at the same time allowing passivisation of the English type to exist in the system.

From a typological-theoretical point of view, the voice type exhibited by Indonesian adds to the richness of voice, and any theory should be able to account for this. That is, our theory should be such that it is able not only to capture the English type of voice, but also to predict the Indonesian-type voice with its expected properties. I argue that an argument structure-based theory of voice within LFG can handle this in a precise way, as further discussed below. I also demonstrate that the analysis is computationally implementable. In addition, the causative-applicative derivation by *-i/-kan* further adds to the complexity of the voice system in Indonesian. That is, a verb can have voice morphology as well as *-i/-kan*, which constrains alternations. For example, the root *tanam* 'plant' without *-i* has its patient argument appearing as object in the actor voice, or as subject in the passive voice, as in (3)a and (3)c, respectively. With the applicative *-i*, it is the locative argument (*sawah*) that is the object in the AV sentence (5)a, and the subject in the passive sentence (5)b. The underlying theme *padi* becomes a second object or an oblique (possibly marked by *dengan*), as seen in (5).

- (5). a. *Mereka menanami sawah-nya (dengan) padi.*
3pl AV.plant-APPL rice.field-3POSS with rice
'They planted their rice field with rice'.
- b. *Sawahnya ditanami (dengan) padi oleh mereka.*
rice.field-3POSS PASS-plant-APPL with rice by 3pl
'Their rice field was planted with rice'.
- c. *?*Padi ditanami sawahnya oleh mereka.*
FOR: ?? 'The rice was planted (with) rice field'.

The challenge in the analysis and its implementation is to ensure the right output when both voice and applicative morphology are present. We want to have the applicative with *-i* applied first before the passive with *di-* as in (6)a. That is, the locative argument is first introduced into the second position by . This locative argument is then linked to SUBJ when the agent argument is removed or demoted by the passive from the first place in the argument structure list. (The linking mechanism picks up the most prominent argument from the *a-str* list as SUBJ.) That is, applicative and voice derivations must be applied in that order. Otherwise, we would get an unacceptable sentence where the theme (*padi* 'rice') becomes the passive SUBJ as in (5)c. The incorrect derivation can be schematised in (6)b.

- (6). a. *tanam* ‘plant<ag, th>’
 ↓
tanam-i ‘plant-APPL <ag, loc | th>’
 ↓
di-tanam-i ‘PASS-plant-APPL<loc| ag th>’
 SUBJ
- b. * *tanam* ‘plant<ag, th>’
 ↓
di-tanam ‘PASS-plant<th|agt>’
 ↓
di-tanam-i ‘PASS-plant-APPL<th, loc|agt>’
 SUBJ

We handle this by proposing an analysis where *-i* is a three-place predicate, as shown in (7). Affixation with *-i* involves complex predicate composition, with argument fusion of the matrix and embedded arguments. Importantly, *-i* comes with a thematically a locative (LOC)-related argument (i.e., possibly goal or source, in addition to locative) in the second argument (ARG2). ARG2 is either new, or fused with the LOC argument of the base wherever possible. ARG1 is thematically higher than ARG2, though not necessarily an agent. This representation allows us to capture both causative and applicative uses of *-i*, as well as other uses; see the different types of fusion exemplified in (10)–(14).

- (7). *A-str* of *-i* and its associated semantic roles
 ‘PRED₁ < ARG₁, ARG₂, PRED₂ < _, ...>’
 (A) (U:Loc) where argument(s) of PRED₁
 fuse(s) with arguments of PRED₂

Thus, the root *tanam* ‘plant’ affixed with *-i* gives rise to *tanami* with *a-str* showing the fusion, as seen in (8). This *a-str* becomes the input for voice linking. The AV links the most prominent ARG (namely ARG1) to SUBJ (9)a. In contrast, the PASS voice demotes ARG1 to oblique and makes the locative ARG SUBJ (9)b.

- (8). ‘3pl’ ‘garden’ ‘mango’
-i <ARG1, ARG2 ‘plant < _ , _ >’>
 (U:loc) (ag) (th)
- (9). a. AV:
 ‘3pl’ ‘garden’ ‘mango’
 SUBJ OBJ OBJ2/OBL
-i <ARG1, ARG2 ‘plant < _ , _ >’>
 (U:loc) (ag) (th)
- b. PASS:
 ‘garden’ ‘mango’ ‘3pl’
 SUBJ OBJ2/OBL OBL
-i < ARG2 ‘plant < _ , _ > < _ >’>
 (U:loc) (ag) (th)

Another property of the suffix *-i* that complicates the analysis is that *-i* is multifunctional. It shows applicative and causative polysemy. For example, *-i* in *panasi* is causative ‘hot-cause’, whereas *-i* in *tiduri* is applicative (i.e. ‘sleep on [loc]’). In addition, the stems are possibly intransitive or transitive, not necessarily verbal, as shown in Table 1.

The resulting subcategorisation frames of *-i* affixation are not uniform. There are at least four types. Each of them is briefly discussed and exemplified below; see Arka et al. 2009 for a detailed discussion.

Roots	Derived -i verbs	Roots	Derived -i verbs
<i>air</i> (N) 'water'	<i>air-i</i> 'water'	<i>lompat</i> 'jump' (V _{ITR})	<i>lompat-i</i> 'jump over'
<i>kulit</i> (N) 'skin'	<i>kulit-i</i> 'peel'	<i>tidur</i> 'sleep' (V _{ITR})	<i>tidur-i</i> 'sleep on'
<i>gula</i> (N) 'sugar'	<i>gula-i</i> 'put sugar in'	<i>diam</i> 'stay' (V _{ITR})	<i>diam-i</i> 'dwell in'
<i>ketua</i> '(N) chair (of an organisation)	<i>ketua-i</i> 'chair or lead in a meeting/organisation'	<i>tulis</i> 'write' (V _{TR})	<i>tulis-i</i> 'write on something'
<i>panas</i> (A) 'hot'	<i>panas-i</i> 'heat (water)'	<i> kirim</i> 'send' (V _{TR})	<i> kirim-i</i> 'send'
<i>basah</i> (A) 'wet'	<i>basah-i</i> 'dampen'	<i>siram</i> 'spray' (V _{TR})	<i>siram-i</i> 'spray with'
<i>lengkap</i> (A) 'complete'	<i>lengkap-i</i> 'complete'	<i>cium</i> 'kiss' (V _{TR})	<i>cium-i</i> 'kiss repeatedly'
<i>jauh</i> 'far' (A)	<i>jauh-i</i> 'make oneself far from'	<i>pegang</i> 'hold' (V _{TR})	<i>pegang-i</i> 'hold tightly'

Table 1: the suffix -i with its stems in different lexical categories

Type 1. Type 1 involves derived monotransitive -i verbs undergoing a valence-changing applicativisation effect. With a two-place intransitive base (with a goal/locative second argument) such as *jatuh* 'fell (on)to X', *datang* 'come to X' and *lewat* 'pass at X', the result is a strictly monotransitive -i verb³. This is exemplified by (10)a-b. The derived structure of *menjatuhi* (10)b can be represented as (10)c. The fusion of arguments is indicated by a line connecting the two arguments. This -i derivation involves a double fusion.

- (10). a. *Mangga yang besar jatuh ke rumah-nya*
 mango REL big fall to house-3s
 'A big mango fell onto his house'.
- b. *Mangga yang besar men-jatuh-i rumah-nya (*menjatuhkan)*
 mango REL big AV-fall-i house-3s
 'A big mango fell onto his house'.
- c.
- | | | | |
|----|---------|---------------|--------|
| | 'mango' | 'house' | |
| | SUBJ | OBJ | |
| -i | <ARG1, | ARG2 'jatuh < | (_)> |
| | | (U:loc) | |
-

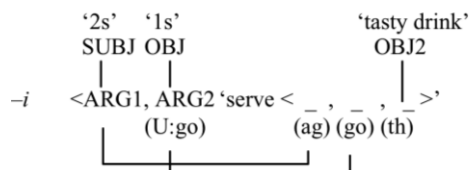
Type 2. This type is associated with three-place predicates with a displaced theme such as *kirim* 'send' and *suguh* 'serve'. The derived -i verb can either be ditransitive with the displaced theme being OBJ2, or three-place monotransitive with the displaced theme realised as OBL instrument. An example showing the derived ditransitive structure is shown in (11).

- (11). a. *Engkau menyuguh-i aku minuman lezat*
 2s AV.serve-i 1s drink tasty
 'You served me a very tasty drink'.

³ There is evidence that the goal/locative of *jatuh* 'fall' or *datang* 'come' is an oblique-like argument (i.e. associated with the conceptual unit of [PATH] of the verbs) although it is not required to be overtly present on the surface syntax. A (general) goal/locative adjunct cannot typically take -i in Indonesian:

- i) a. *Ia tinggal di Jakarta* b. * *Ia meninggal-i Jakarta*
 3s live LOC Jakarta 3s AV.live-i Jakarta
 'S/he lives in Jakarta; FOR 'S/he lives in Jakarta'.
- ii) a. *Ali menangis di kamar* b. * *Ali menangi-i kamar*
 Ali AV.cry LOC room Ali AV.cry-I room
 'Ali cried in the room.' FOR: 'Ali cried in the room.'

b.

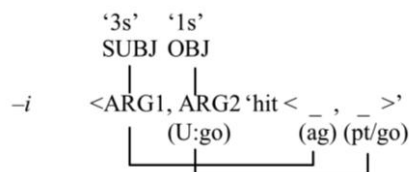


Type 3. There is no valence change in this type of *-i* derivation, e.g. *pukul* ‘hit’ (transitive) → *pukuli* (transitive) ‘hit repeatedly’, where *-i* signifies repetition or intensification.

(12). a. *Ia memukul-i saya*
 3s AV.hit-i 1s

‘S/he was hitting me, s/he hit me repeatedly’.

b.

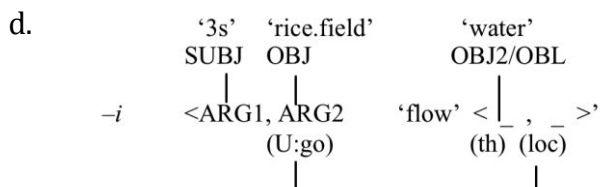


Type 4. This is the type of *-i* affixation resulting in causativisation. The *-i* verbs can be monotransitive (13b) (with the displaced theme showing up as an oblique instrument marked by *dengan*), or ditransitive (13c) (with the displaced theme being OBJ2). Type 4 *-i* structures involve single fusion, as depicted in (13d), the only difference being the realisations of the unfused embedded displaced theme⁴.

(13). a. *Air itu sedang meng-alir ke sawah.* SUBJ OBJ
 water that PROG AV-flow to rice.field ‘flow < _ , _ >’
 ‘The water is flowing to the rice field’. (th) (loc)

b. *Dia meng-alir-i sawah=nya dengan air itu.*
 3s AV-flow-i rice.field=3sg with water that
 ‘S/he flooded his/her rice field with the water’.

c. *Dia meng-alir-i sawah=nya air itu.*
 3s AV-flow-i rice.field=3sg water that
 ‘S/he flooded his/her rice field with the water’.

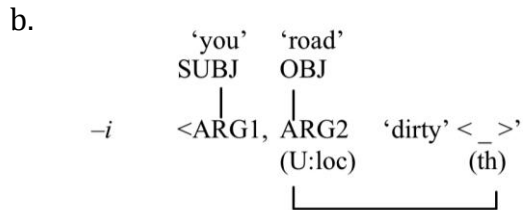


Type 4 *-i* includes those *-i* verbs with nonverbal roots, e.g. *sakit* ‘sick’, *panas* ‘hot’ and *kotor* ‘dirty’. This is exemplified in (14)a. The fusion of the theme-locative argument shown in (14)b captures the meaning that *jalan* ‘road’ is understood as the surface of the road.

⁴ In fact, the *a-str* of the type (13)d allows for double fusion if ARG1 is not filled in with an agent. Thus, the following is acceptable. The water flows because of its natural force.

Air itu mengalir-i sawahnya
 water that AV.flow-I rice.field
 ‘The water flooded his/her rice field’.

- (14). a. *Jangan kotor-i jalan itu*
 NEG dirty-i road that
 ‘Don’t (you) make (the surface of) the road dirty’.



As seen, the types involve different kinds of argument fusion, single or double. They are constrained by the semantics of the root. The general rule for *-i* composition appears to be that arguments of thematically similar types tend to fuse. Thus, the actor-like ARG1 of the matrix PRED tends to fuse with the actor-like ARG1 of the embedded PRED. Likewise, the undergoer-like ARG2 of the matrix PRED fuses with the undergoer-like ARG2 of the embedded PRED.

The properties of *-i* are now well understood. We are pleased to report that we have successfully implemented a novel unified argument structure–based analysis to capture those properties. The analysis and implementation make use of the idea of predicate composition (Alsina 1996; Butt 1995) and the restriction operator (Butt and King 2006 ; Butt, King, and Maxwell III 2003; Kaplan and Wedekind 1993). The main components of the implementation in XLE can be briefly described as follows.

The grammar consists of phrase structure and sublexical rules with certain relevant annotations, e.g. showing grammatical functions (SUBJ, OBJ and ADJUNCT) as in (15), or templates indicated by @ as in (16). The voice and applicative/causative templates are given in (17)a and (17)b, respectively. For the time being, as seen in (17)a, we still maintain the classic (simpler) analysis of voice alternations as lexical rules, rather than principled alternations based on a mapping theory (Arka 1993; Bresnan 2001). Note that the nesting of the templates with the @APPL template inside the @VOICE template in (16) is meant to capture the idea that applicativisation applies before voice alternation. This is to obtain the intended result as discussed earlier (cf. example (5), representation (6)).

- (15). a. $S \rightarrow NP \quad VP$ b. $VP \rightarrow V' \quad PP$ c. $V' \rightarrow (NP) \quad V \quad (NP)$
 $(\uparrow \text{SUB})=\downarrow$ $\downarrow \in (\uparrow \text{ADJUNCT})$ $(\uparrow \text{OBJ})=\downarrow \quad (\uparrow \text{OBJ})=\downarrow$

- (16). a. $V \rightarrow V_VOICE_BASE \quad V_STEM' \quad V_SFX_BASE$

- b. $V_STEM' \rightarrow \{ V_STEM\text{-APPL_I} \quad _ \quad V_I_BASE$
 $\quad @(\text{VOICE} \ @(\text{APPL_I} \quad VApp_I))$
 |
 $V_STEM\text{-CAUS_I} \quad _ \quad V_I_BASE$
 $\quad @(\text{VOICE} \ @(\text{CAUS_I} \quad VCaus_I)) \}$.

(17).

a. Voice template	b. Applicative/causative template
<pre> VOICE(_SCHEMATA) = { _SCHEMATA @ACTOR-VOICE _SCHEMATA @UNDERGOER-VOICE (↑ OBJ) → (↑ SUBJ) (↑ SUBJ) → (↑ OBJ) _SCHEMATA @PASSIVE-VOICE (↑ OBJ) → (↑ SUBJ) { SUBJ } → NULL (↑ SUBJ) → (↑ OBL) (↑ SUBJ) → (↑ OBJ) } }.</pre>	<pre> { (↑ PRED) = 'V_Appl_i <(↑ SUBJ) (↑ OBJ) %PRED3>' ↑\PRED\GF = ↓\PRED\GF { (↓ SUBJ) = (↑ SUBJ) (↓ OBL-LOC) = (↑ OBJ) (↓ SUBJ) = (↑ SUBJ) (↓ OBL-LOC) = (↑ OBJ) (↓ OBJ) = (↑ OBL-INST) (↑ OBL-INST CASE) = c obl-inst (↓ SUBJ) = (↑ SUBJ) (↓ OBJ) = (↑ OBJ) (↑ TNS-ASP PROG) = + ~(↑ OBL-INST) "just for the iterative meaning of -i" (↓ PRED) = (↑ PRED ARG3) (^ PRED) = 'V_Appl_i <(↑ SUBJ) (↑ OBJ) (↑ OBJ2) %PRED4>' ↑\PRED\GF = ↓\PRED\GF (↓ SUBJ) = (↑ OBJ) (↓ OBL-LOC) = (↑ OBJ) (↓ OBJ) = (↑ OBJ2) (↓ PRED) = (↑ PRED ARG4) } (↑ APPLICATIVE) = +.</pre> <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 5px;">Type 1: IntrRoot → Vtr</div> <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 5px;">Type 2: TrRoot → Vtr</div> <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 5px;">Type 3: TrRoot → Vtr</div> <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 5px;">Type 4: IntrRoot → Vtr</div>

The grammar also consists of a lexicon containing both free words and affixes. They are listed with their own entries. Sample entries are given in (18) below.

(18). Sample entries: free forms

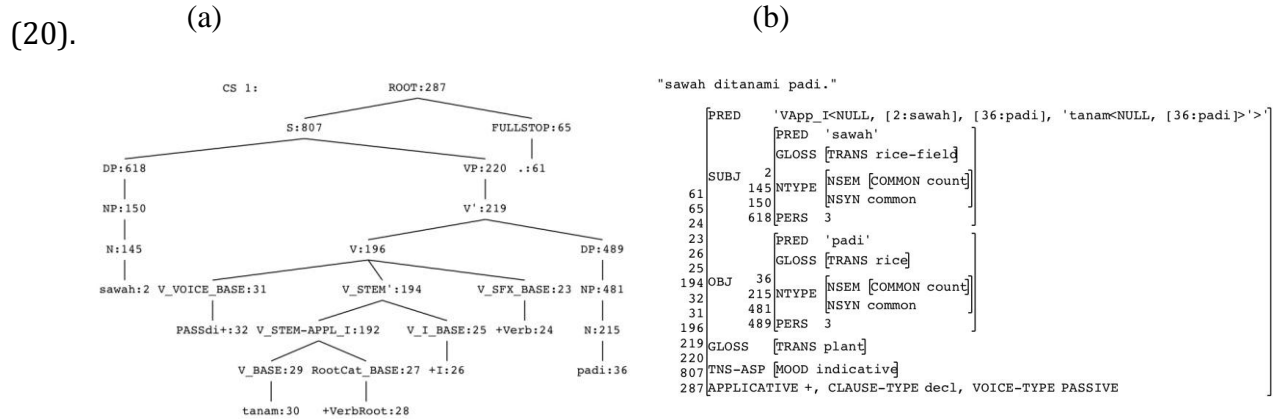
- | | | | | |
|----|---------------|------|-----|--------------------------|
| a. | <i>sawah</i> | N | XLE | @(CN rice field). |
| b. | <i>mereka</i> | PRON | XLE | @(PPRO 3 pl). |
| c. | <i>tanam</i> | V | XLE | @(VOICE @(TRANS plant)). |

Sample entries: bound forms

- | | | | | |
|----|---------|---------|-----|------------------------|
| e. | +I | V_I. | | |
| f. | AV+ | V_VOICE | | @(VOICE-TYPE AV). |
| g. | UV+ | V_VOICE | | @(VOICE-TYPE UV). |
| h. | PASSdi+ | V_VOICE | XLE | @(VOICE-TYPE PASSIVE). |

The Indonesian grammar is equipped with a tokeniser and morphological analyser (Mistica et al. 2009; Femphy et al. 2008). It was built using XFST (Xerox Finite State Transducer) (Beesley and Karttunen 2003). The grammar can therefore identify morphemes of words with a complex morphological make-up and collect their grammatically relevant information for the purpose of further processing. For example, the sentence *Sawah ditanami padi* 'A rice field planted with rice' consists of three words, with one word, namely *ditanami*, morphologically complex. The sentence can be correctly parsed. The input string (19)a is first broken into tokens by the tokeniser. The output is then fed into the morphological analyser so that the words *sawah*, *padi* and *ditanami* can be analysed and assigned morpheme and category tags, as in (19)b. Since the relevant tags and forms are listed in the lexical entries, e.g. PASSdi+ (for *di-*) and +I (for the suffix *-i*) (see (18)), the XLE grammar can pick up the tags, and use the information to assign the word a hierarchical structure based on the sublexical rules formulated in (16). In addition, given the functional constraints carried by the morphemes and the structures (cf. template calls signalled by @ in the entries and in the sublexical rules), the grammar can also build functional structures involving predicate composition for the *-i* verb. Other words of the sentence input are parsed in a similar way, and the grammar can unify all information and constraints for the whole sentence. The output *c-* and *f-structures* are displayed in (20). Note that the voice prefix *di-* is higher in the structure than the applicative *-i*. The AVM (attribute-value matrix) diagram shows that the applicative suffix *-i* is a matrix predicate, taking the *a-str* of the base *tanam* as an argument in its *a-str*. The subject is removed by the passivisation (indicated by 'NULL').

- (19). a. Input string: *Sawah ditanami padi.*
 b. Morphologically analysed string: *Sawah+Noun PASSdi+tanam+I+Verb padi+Noun*



4 Crossed-control structures in Indonesian

Our grammar can also intelligently handle the ambiguity and complexity of dependency relations, in particular the so-called crossed-control construction (CCC), exemplified by (21). The term ‘control’ here refers to a referential dependency between the unexpressed (controlee) argument and expressed (controller) argument. Sentence (21) is ambiguous between the ordinary-control reading in (21)a and the crossed-control reading in (21)b. In the first reading, represented in (22)a, the unexpressed argument of *dicium* (i.e. ‘kissed’, indicated by a dash) is SUBJ and understood as the matrix argument, *saya* (the ‘wanter’, controller). In the second reading, represented in (22)b, the wanter is the kissor, not expressed by the matrix SUBJ but by the embedded OBL argument. Of particular interest in this paper is the second, crossed control, reading.

- (21). *Saya mau/ingin [_ di-cium oleh Ibu]*
 1s want PASS-kiss by Mother
 a. ‘I wanted to be kissed by Mother’. (ORDINARY CONTROL READING)
 b. ‘Mother wanted to kiss me’. (CROSSED CONTROL READING)

<p>(22). a. Ordinary control reading: SUBJ = [_]SUBJ OBL [‘wanter’ [‘kissed’ [‘kisser’]] ‘I’ ‘mother’</p>	<p>b. Crossed control reading: SUBJ = [_]SUBJ OBL [‘wanter’ [‘kissed’ [‘kisser’]] ‘I’ ‘mother’</p>
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Note that reading (21)b is not possible in other languages like English. In English, the sentence *I wanted to be kissed by Mother* can never mean the ‘wanter’ is the ‘kisser’ (i.e. ‘Mother wanted to kiss me’).

CCCs are not restricted to intransitive verbs like *ingin/mau* ‘want’. Matrix transitive verbs such as *coba* ‘try’, *ancam* ‘threaten’ and *tolak* ‘refuse’ also show crossed-control reading. Consider (23), where the matrix verb and the embedded verbs are transitive, both allowing AV-PASS voice alternations. A crossed-control reading is observed in (23)b – the trier/actor is the killer (*temannya*), whereas the matrix subject *dia* is the patient of *kill*.

- (23). a. *Teman-nya men-coba [_ membunuh dia].*
 friend-3POSS AV-try AV.kill 3s
 'His friend(s) tried to kill him'.
- b. *Dia dicoba [_ di-bunuh (oleh) teman-nya.*
 3s PASS-try PASS-kill by friend-3POSS
 'His friend(s) tried to kill him'.

More examples from an online newspaper are given in (24). All the embedded verbs are in the passive, but the agents are understood as the matrix actor. For example, the syntactic subject of *berusaha* 'attempt' (24)a is inanimate (*politik lokal*). Its logical subject/actor, the attempter, is the embedded oblique argument (*pusat*).

- (24). a. *Politik lokal di Indonesia selalu berusaha dikendalikan oleh pusat.*⁵
 politics local in Indonesia always try PASS-control by central
 'The central government always tries to control the local politics'.
- b. *Ternyata skuter model Eropa nekat dijual disana oleh...Honda*⁶
 in fact scooter model Europe insist PASS-sell there by Honda
 'It turns out that Honda insisted on selling the European model of the scooter there'.
- c. *rancangan peraturan daerah ...akhirnya di-tolak*
 bill regulation local finally PASS-reject
*untuk di-sahkan oleh DPRD Gresik*⁷
 to PASS-pass by loca.legislative.assembly Gresik

'The DPRD of Gresik finally rejected to pass the local draft bill'.

The crossed-control reading is constrained by voice type, particularly when both matrix and embedded verbs are transitive. First of all, the crossed control reading is not possible when the matrix verb is in AV. Thus, sentence (25) is strange in its ordinary-control reading (i), and it can never mean (ii) (i.e. the crossed-control reading). Any theory or analysis of control constructions should be able to handle the blocking constraint of the crossed-control reading by the AV. This is further discussed in section 5.

- (25). *Dia mencoba di-cium oleh artis itu.*
 3s AV.try PASS-kiss by artist that
 i) 'He tried to be kissed by the artist'. (ordinary-control reading)
 ii) *'The artist tried to kiss him'. (crossed-control reading)

In addition, for the crossed-control reading to be possible, the verbs should have harmonious non-actor voice types. In (23)b, both have passive *di-*. In (26)a-b below, both have undergoer voice (UV). Note that the actor pronominal *kau* appears once, either on the matrix or on the embedded verb. Mixing the non-actor voices, PASS and UV, results in bad sentences (26)c-d.

- (26). a. *Dia kau=coba [_ _ bunuh]*
 3s 2SG=UV.try UV.kill
 'You tried to kill him/her'.

⁵ <http://politik.kompasiana.com/2012/04/12/politik-lokal-di-indonesia-dari-otokratik-ke-reformasi-politik/>.

⁶ <http://fanderlart.wordpress.com/2009/09/24/dual-keen-eyes-ga-laku-ya-di-vietnam/>.

⁷ <http://gresik-satu.blogspot.de/2012/04/2-ranperda-usulan-eksekutif-ditolak.html>.

- b. *Dia coba* [_ *kau=bunuh*]
 3s UV.try 2s=UV.kill
 'You tried to kill him/her'.
- c. * *Dia dicoba* [*kau=bunuh*]
- d. * *Dia kau=coba* [_ *dibunuh*]

The pattern seen in (26) serves as evidence for the analysis that CCCs involve syntactic argument sharing. That is, the two arguments ('controller' and 'controlee') must be of the same type syntactically. Mixing voice types results in the two having different argument types: OBL in passive and OBJ in UV; (26)c and d are bad due to the violation of this argument sharing constraint.

At first, it might look like a puzzle: How is it possible that the actor of the matrix verb (e.g. *ibu* 'mother') is not realised on the matrix structure, but rather controlled by the argument of the embedded verb? The reverse is cross-linguistically common. The challenge is to get a precise linguistic analysis of the CCC capturing the properties so far discussed and then to implement this. Any analysis of CCC should be consistent with, or built on, the existing theory of control so that the analysis should also naturally work for the ordinary-control structures. In this paper, the analysis and the implementation stem from a lexically based LFG theory of control, where the notion of syntactic *a-str* and argument sharing is important.

The proposal is that the CCC should be analysed as a serial verb construction (SVC), forming a complex predicate, which licenses 'raising' and argument sharing; this enables an argument to be realised only once in the surface syntax. Cross-linguistically, this is a well-known property of SVCs. One piece of evidence that the verb *ingin/coba* and the complement VP form a tight SVC unit and therefore allow crossed-control reading comes from the fact that the reading disappears when some material intervenes (observed by Purwo 1984) as in (27), or else the sentence is ungrammatical, as in (28).

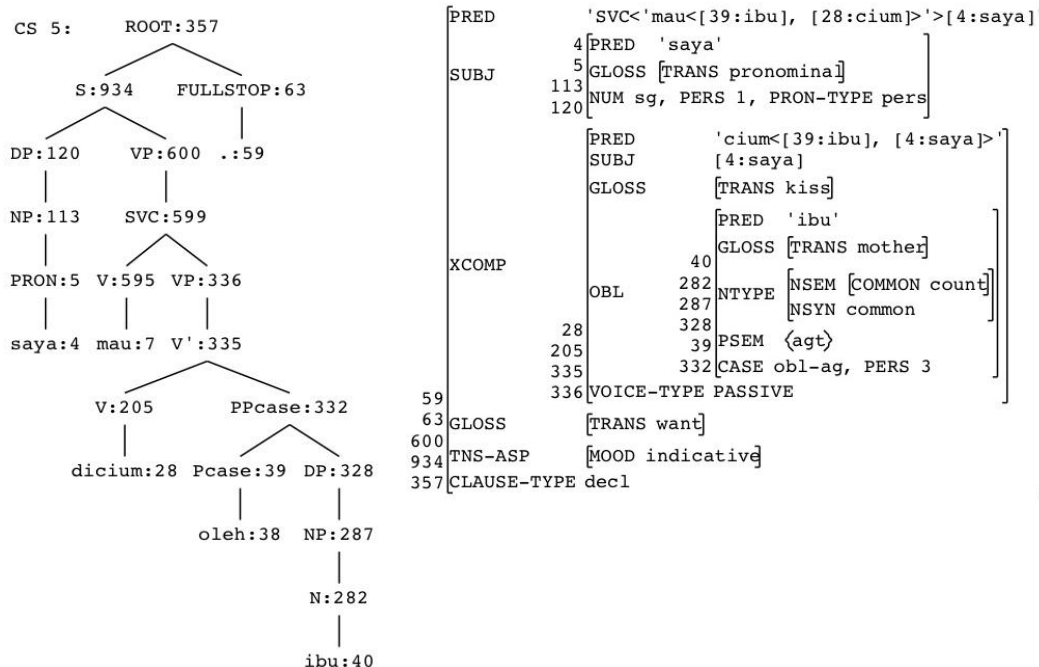
- (27). *Si Yem ingin supaya dicium si Dul.*
 ART Yem want in.order.to PASS-kiss ART Dul
 i. 'Yem wanted to be kissed by Dul'.
 ii. NOT FOR: 'Dul wanted to kiss Yem'. (Purwo XX)

- (28). * *Politik lokal di Indonesia selalu berusaha agar dikendalikan*
 politics local in Indonesia always try in.order.to PASS-control
oleh pusat.
 by central
 'The central government always tries to control the local politics in Indonesia'.
 (i.e. FOR the same meaning as in (24)a)

The SVC analysis of CCCs can be described as follows. First, verbs come with rich information in their lexical entries. Some of the information may be by default inherited from their class or type. Control verbs like *mau* 'want' and *coba* 'try' have their entries represented in (29). The SUBJ control equation of (\uparrow SUBJ)=(\uparrow XCOMP SUBJ) is the default ordinary control. The equation means that the matrix SUBJ is the same as the embedded clause's SUBJ. It is a semantically based control relation (Foley and Van Valin 1984; Sag and Pollard 1991). That is, with the orientation verb *mau* 'want' and commitment verb *coba* 'try', the controller/doer of the action wanted or tried is the wantor/trier. Other types of verbs, e.g. the influence type such as *suruh* 'ask', would have a different specification, namely OBJ control. That is, in the 'asking' event, it is the 'askee' (OBJ) that is the controller/doer of the action being asked.

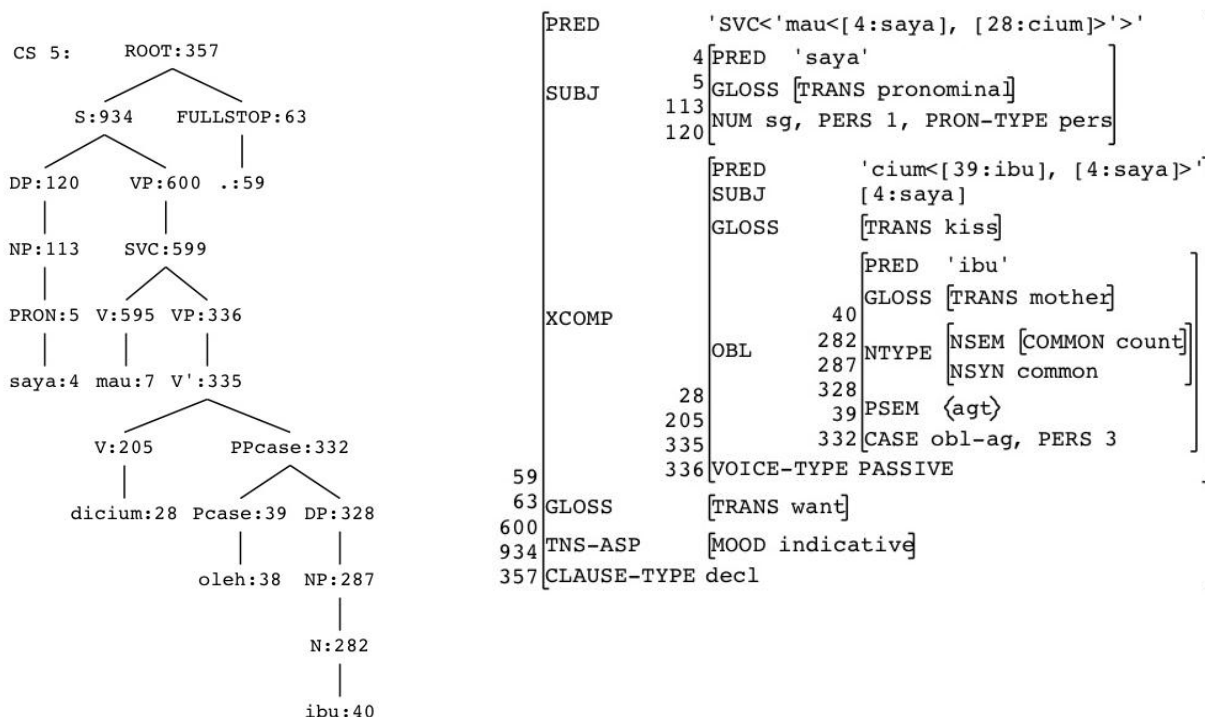
structure, even though *saya* is not an argument of the matrix verb *mau*. It also shows that *ibu* ‘mother’ (tag 39) is the underlying (thematic) subject of *mau* (i.e. the first argument of *mau*), not the syntactic (SUBJ) argument of the SVC: It shows up only as the OBL of the XCOMP.

(31). *c-str* *f-str*



The grammar can also capture the ordinary-control reading, e.g. (21)b. This is the reading equivalent to the English sentence *I want to be kissed by mother*, where the wanter is the controller and the kissee. The *c-str* and *f-str* parses are shown in (32).

(32). *c-str* *f-str*



An important point of analysis and implementation to note here is the status of the wantee argument. Unlike in the crossed-control reading in (31), the wantee *saya* (tag 4) is syntactically the matrix thematic SUBJ of *mau*, as well as SUBJ of the SVC controlling the embedded SUBJ, the kissee. That is, there is no raising of the XCOMP SUBJ to a nonthematic position in the ordinary-control reading. This is a critical point not made explicit in the earlier raising analysis of the Indonesian ‘want’ in Polinsky and Potsdam (2008). As intended, the argument *ibu* ‘mother’ (tag 40) is parsed by the grammar only as the (agent) argument of the embedded verb *cium* ‘kiss’, realised as an OBL.

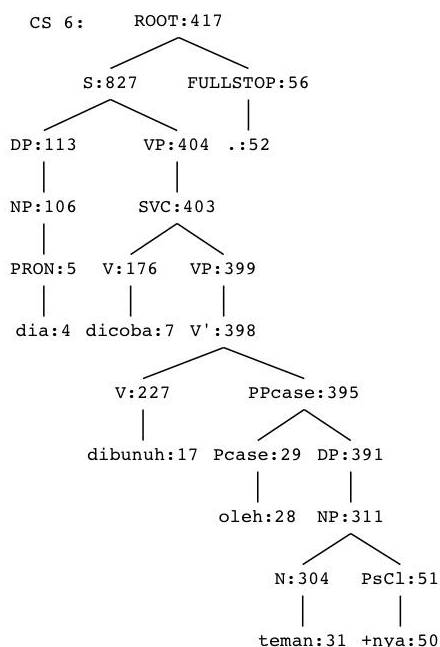
4.2 Transitive *coba* ‘try’

Unlike *mau/ingin* ‘want’, which is strictly intransitive, the verb *coba* is transitive, allowing the possibility of different voice marking: *men-coba* ‘AV-try’ vs. *di-coba* ‘PASS-try’ exemplified in (23). It is only when used passively do we find the crossed-control reading, as seen in (23)b. As noted earlier, the AV matrix verb does not allow a crossed-control reading, as shown in example (25).

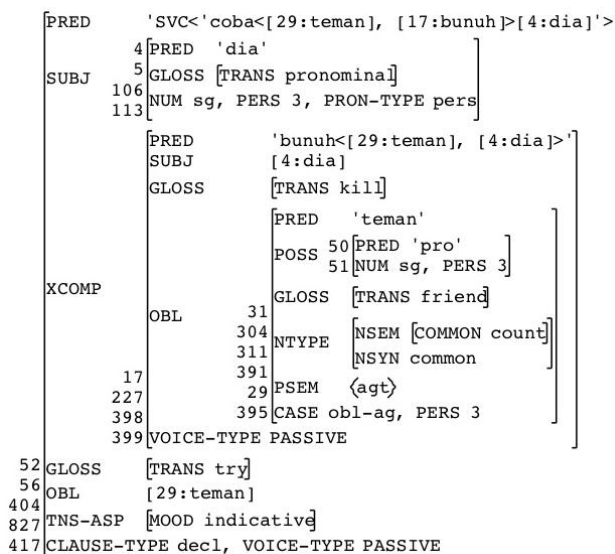
The *c-str* and *f-str* parses of the crossed reading (23)b are given in (33). As shown, the grammar correctly analyses the subject of the matrix verb *dia* (tag 4) as a non-thematic SUBJ of the verb *coba*, placed outside the angle brackets in the *f-str*. That is, *dia* is not the trier; rather, it is the SUBJ/patient of the embedded verb *bunuh*, raised to the matrix SVC’s SUBJ. The logical subject (actor) of the verb *coba* ‘try’, namely *teman*, is correctly analysed as OBL, as realised in the embedded verb (tag 29).

For the ordinary-control reading of *coba*, exemplified by (23)a, the trier is the controller, realised as matrix SUBJ. The analysis is that the SVC just takes the whole SUBCAT frame of *mencoba* where the actor/trier is already linked to SUBJ, and there is no need for an embedded argument to raise to a nonthematic argument. In short, a nonthematic argument is not needed. The grammar can capture this analysis as intended, as seen in the *f-str* parse output in (34). That is, the matrix SUBJ *teman* (tag 6) is the trier/actor, controlling the SUBJ of the embedded verb *membunuh* ‘kill’. All arguments are thematic: No SUBJ argument is represented outside the angle brackets.

(33). *c-str*

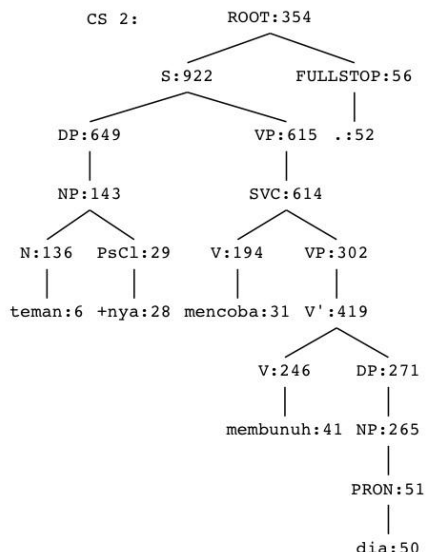


f-str

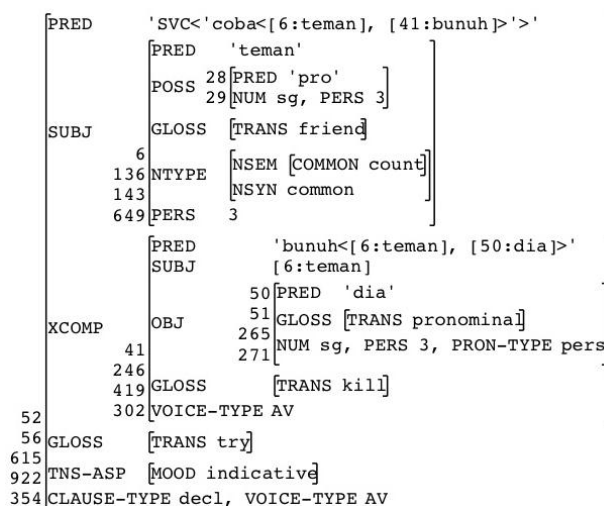


(34).

c-str



f-str



To sum up, our Indonesian grammar has the ability to handle not only the standard or ordinary-control construction of the type found in English, but also the complex crossed-control constructions involving voice alternations.

5 Discussion

The goal of the ParGram project was to have a common grammar development platform and a unified methodology of grammar writing to develop large-scale (parallel) grammars for typologically different languages (Butt and King 2007). Such an endeavour is, in fact, at the heart of the lively debate in linguistics with respect to the two opposing ideals given in (35), and is therefore a constant challenge both from a theoretical perspective in linguistics and from a practical standpoint in its implementation in ParGram.

- (35). a. The generativist-universalist ideal: Having explicit formal representations of universal linguistic properties/features within some kind of generative system;
- b. The descriptivist-typologist ideal: Capturing language-specific, possibly distinctive genius and/or typologically different patterns.

In this section, I briefly discuss further theoretical points and challenges on the basis of voice alternations and CCCs in Indonesian presented in this paper.

On voice, grammatical function (GF) and features

The *f-str* representation is supposed to capture a universal level of language analysis, showing parallelism or universalism. Indonesian grammar has brought in the richness of voice systems of AN languages, and raised theoretical and implementational challenges in incorporating it into the ParGram framework.

Linguistically, as discussed in section 3, a symmetrical voice system as exemplified by Indonesian is typologically distinct from the nonsymmetrical type shown by English. Any theory of syntax should be able to capture both this distinct property and other shared properties with English. In LFG, the theory of voice adopted in this paper makes use of the notion of a syntactic argument structure distinct from surface grammatical functions (GFs) such as SUBJ and OBJ, and voice alternations are handled by a linking theory (Manning 1996; Arka and Manning 2008; Arka 2003).

Before IndoGram joined the group, there was a simple feature of voice, namely [PASSIVE +/-] to capture voice in English-like languages. Surely this feature cannot satisfy the descriptive-typological ideal because Indonesian has a multi-way voice system. A new voice feature should be introduced, namely [VOICE-TYPE], whose value can be one of these in Indonesian: *actor-voice*, *undergoer-voice*, *passive-voice* and *middle-voice*. Thus, the parallelism is captured by having the same feature attribute VOICE-TYPE, whereas typological variation is captured by allowing different languages having to have different voice values.

A serious theoretical issue is the nature of parallelism in relation to GFs. The relevant question to raise here is how tenable it is to adopt GFs such as SUBJ and OBJ as universal functions residing in the *f-str*. Given the descriptive-typological ideal, how should these GFs labels be interpreted? They are assumed to be ‘universal’ in LFG. Should we qualify the notion of universalism, particularly given the nature of voice types and related GFs in Austronesian languages like Indonesian? I argue that we should. One reason for this is the fact that the notion of OBJ, for example, is broader in Indonesian (and other AN languages like Tagalog and Balinese) than in English. OBJ in these languages can be linked not only to the undergoer as in AV, but also to actor as in UV. An OBJ-actor is not possible in Indo-European languages like English. In other words, while we use the same GF labels such as OBJ, their exact grammatical space across languages is not the same. In addition, the status of a GF in the grammar is not exactly the same across languages. While both Indonesian and English have SUBJ, SUBJ in English is obligatory, as seen in the existence of dummy/expletive ‘it’ as in *it rained*, *it’s hot*, etc.; in contrast, SUBJ is not obligatory in Indonesian. Therefore, the grammatical space of GFs and the related voice types in Indonesian are not the same as in English. The UV structures, for instance, have no exact parallel in English.

To capture both universalist-typologist ideals (35), the notion of parallelism should not be taken in its strict sense. The same GF with its related structure and features might be assigned a slightly different interpretation in different languages.

On the implementation of linking and different layers of syntactic representation

The existing ParGram platform makes use of the earlier conception of LFG, where surface constituency (*c-str*) and rich the syntactic functional (*f-*)structure are distinguished. The latter contains syntactic and semantic information. In this earlier conception of LFG, GFs such as SUBJ and OBJ are primitive/basic notions listed in the entries. LFG theory has developed, particularly with the emergence of mapping theories. It is theoretically necessary, as evidenced from languages that exhibit voice alternations such as Indonesian, to recognise the surface SUBCAT frame containing SUBJ/OBJ as distinct from the argument structure level containing syntactic-thematic information such as core/non-core, actor/non-actor in order to capture the principled syntax-semantics interface in relation to the universalist and typologist’s ideal. We now have a good analysis of how linking works across languages, including AN languages like Indonesian.

The challenge is how to implement recent analyses within ParGram’s XLE framework, cast in an earlier version of LFG. One particular question is how to capture the notion of deep(er) *a-str*, where actor (ACT) and undergoer (UND) are relevant. Note that in the earlier LFG version implemented in XLE, the deep *a-str* (<ACT, UND>) and surface syntactic *a-str* are conflated in the SUBCAT frame, e.g. the verb *bawa* ‘bring’ would have the SUBCAT frame of ‘*bawa*<SUBJ OBJ>’, with SUBJ and OBJ interpreted as both as SUBJ/actor and OBJ/undergoer by default.

The tricky part is capturing principled argument alternations (i.e. alternative linking) as in voice and applicativisation/causativisation. As discussed in sections 3–4, we have made use of the restriction operator in the implementation, manipulating the SUBCAT list in the *f-str*, e.g. in applicativisation and CCC analysis. In this way, we can talk about the underlying arguments

SUBJ/actor/experiencer that become (surface) OBL in crossed reading constructions⁸. However, if we look further afield at other Austronesian languages of eastern Indonesia (and the Papuan languages of Indonesia), there seems to be good reason to keep the idea of deep SUBJ/OBJ (i.e. ACT/UND) without distinguishing between surface and underlying relations. These languages show no voice alternations. If we maintain the idea of linking in these languages, then the linking is fixed (i.e. actor is always SUBJ and undergoer is always OBJ). Again, the interpretation of SUBJ in these languages is slightly different from that in Indonesian and English, where SUBJ can carry any semantic role. In short, the parallelism/universality of very basic notions of GFs remains an issue theoretically if more AN languages are taken into account in the ParGram project.

Handling constraints interaction and ambiguity

As the grammar becomes larger, the rules and related constraints become more complex. Handling constraint interactions between parts of the grammar poses a challenge in the analysis and implementation. The grammar often produces multiple parses. The IndoGram experience suggests that most of these are not wanted, but certain others are. However, as we know, natural language is full of ambiguity. Certain ambiguity that is attested should be recognised by our grammar. This is the case with the ambiguity of the ordinary and crossed-control reading in (36), when the subject is animate, *dia* ‘3SG’.

- (36). *Dia/pintu itu mau di-tendang oleh John.*
 3s/door that want PASS-kick by John
- i) a. He wanted or was willing to be kicked by John. (ordinary control)
 - b. #The door wanted to be kicked by John. (ordinary control)
 - ii) John wanted to kicked him/the door. (cross-reading)

A deep intelligent grammar should be able not only to recognise the ambiguity but also to select one reading (i.e. disambiguate) (36) when the subject is inanimate, *pintu itu* ‘the door’. The inanimate subject renders only the crossed-control reading (36)ii. This does not appear to be a big challenge, but nouns should be semantically tagged with ‘animacy’. At the moment, our Indonesian grammar has no ability to sort out this kind of animacy-based disambiguation.

Indeed, the interaction between lexical class properties and syntactic behaviour is important in the grammar of Indonesian. One task not yet fully implemented in the IndoGram project at the moment (despite a good linguistic analysis) is the semantically driven causative-applicative polysemy. For example, the same suffix *-i* can appear as a causative (as in *sakit-i* ‘make hurt’) or an applicative (as in *datang-i* ‘come to X’) depending on the semantic type of the root, whether it is agentive/motion or patientive. In principle, the analysis is implementable: Roots need to be tagged appropriately with their semantic classes, and then the morphosyntactic components of the grammar recognise the tags and respond accordingly in the parsing process. This is one of the items in progress at the moment that needs further work.

Grammatical constraints also interact with the pragmatic information structure. For example, focussing the control verb by fronting it also results in disambiguation, as illustrated by (37)a-b. The declarative sentence (37)a is ambiguous between the two readings of control. However, fronting/focussing the verb with the focus marker *kah*, as in (37)b, gives rise to only one reading, namely the ordinary-control reading. In addition, there is also a slight nuance of temporal difference, with the fronted *maukah* focussing on present/future event in (37)b.

⁸ One problem with this is that, with the current setup of XLE, the implementation can typically only parse, but not generate.

- (37). a. *Kau mau dicium oleh orang itu?* (ambiguous:
 2s want PASS-kiss by person that both ordinary and crossed reading)
 i) 'Did/do you want to be kissed by the person?'
 ii) 'Did the person want to kiss you?'
- b. *Mau=kah kau di-cium oleh orang itu?* (unambiguous)
 want=KAH 2Ss PASS-kiss by person that (ordinary reading only)
 'Do you want to be kissed by the person?'

We have a good explanation based on the theory of control developed in this paper as to why the crossed-control reading disappears in (37)b: Fronting the matrix verb in effect breaks up the SVC structure. The argument fusion of (\downarrow SUBJ)=(\downarrow XCOMP OBL) is licensed only by an SVC structure, and is therefore inapplicable here. The verb *mau* is the main matrix verb imposing the lexical semantic control specified in its entry, that is, the experiencer is SUBJ, i.e. (\uparrow SUBJ)=(\uparrow XCOMP SUBJ). Our grammar has not yet able to capture this pragmatic-syntactic constraint interaction, however; while we have a good analysis of the disappearance of the crossed-control effect, some more work needs to be done to implement the analysis, and this is not always easy.

6 Concluding remarks

Developing a large-scale, deep, intelligent grammar is expensive in terms of both time and resources, mainly due to the complexity of natural languages. This complexity has been illustrated by discussing how to handle two types of structures – voice alternations and crossed-control constructions – in our computational development of IndoGram within the ParGram project. We are primarily concerned with theoretically well-grounded analyses of the structures which meet the universalist and descriptivist-typologist ideals in linguistics.

We are also concerned with implementational issues such as efficient and intelligent parsing. We want the grammar to be able to give us the most wanted parse(s), reducing unintended ones. However, at the same time, we want the grammar to be able to recognise and maintain natural ambiguity, as demonstrated in cases of multiple readings associated with control structures. For this, and for other cases such as the causative-applicative polysemy of *-i*, the grammar needs to be able to check the semantics of lexical items.

There is also a challenge to the complexity of the grammar due to its interaction with pragmatics. We have demonstrated that focussing by fronting the control verb renders an unambiguous control reading.

While there has been progress in our understanding of how lexical classes play a role in the grammar, and how the grammar interacts with pragmatics, much of the precise interplay among them is still unknown. This is indeed a real challenge, particularly in a project that aims to produce a deep intelligent large-coverage grammar.

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