An algebraic approach to Arabic sentence structure

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We employ the notion of a pregroup grammar to describe sentence structure in a fragment of Modern Standard Arabic. The emphasis is on syntax, but inflectional morphology also plays a rôle in how words are strung together.

1. The algebraic machinery.

Pregroup grammars have been used to study sentence structure in a number of European languages [3,5,8,9]. We here turn to Arabic [1,2,6] as our first example of a non-European (and non-Indo-European) language. As it turned out, for the fragment of Arabic we investigated, only a small part of the algebraic machinery of pregroups was needed, which we will briefly summarize.

The main idea is to attach to each word, sometimes also to morphemes, one or more *types*. To start with, one assumes as given a partially ordered set of *basic types*, for example, $\mathbf{s}_0$ and $\mathbf{s}_1$ for declarative sentences in the past and present tense, respectively, and $\mathbf{s}$ for such sentences when the tense is irrelevant. One postulates $\mathbf{s}_0 \to \mathbf{s}$ and $\mathbf{s}_1 \to \mathbf{s}$, where the arrow denotes the given partial order. From the basic types one forms *simple types*: thus from a one obtains a^ℓ and a^r, which we call the left and right *adjoint* of a respectively. For modern European languages also double adjoints $a^{\ell\ell}$ and a^{rr} were required, but iterated adjoints don't seem to play a rôle in the fragment of Arabic we have investigated so far.

The *types* to be attached to words are strings of basic types. For example, the word *lam* will have type $\mathbf{s}_0\mathbf{s}_3^\ell$, where $\mathbf{s}_3$ (another basic type) is the type of a clause in the jussive mood.

The only rules we require here are the *contractions*

$$a^\ell a \to 1, \quad aa^r \to 1,$$

where 1 is the empty string. For example, *lam yaktub* (= he did not write) has type

$$(\mathbf{s}_0\mathbf{s}_3^\ell)\mathbf{s}_3 = \mathbf{s}_0(\mathbf{s}_3{}^\ell\mathbf{s}_3) \to \mathbf{s}_0\, 1 = \mathbf{s}_0,$$

which implies that this expression is a declarative sentence in the past tense.[1)]

2. Conjugating the verb.

We have studied the finite verb forms elsewhere [4] and shown that they can all be calculated from a formal expression $C_{\ell kji}(\mathbf{V})$. Here:

(1) $\mathbf{V}$ is the verb stem, usually given by three consonants (radicals) and two characteristic vowels. (There are also verbs with four consonants, but these we shall ignore here.)

(2) $i = 1, 2m, 2f, 3m, 3f, 4, 5m, 5f, 6m, 6f$ stands for the three persons singular followed by the three persons plural; m means masculine and f means feminine. (There are also some dual forms, but these we shall ignore in this paper.)

(3) $j = 0, 1, 2, 3$ stands for the tense-mood, 0 for the past, 1 for the present indicative, 2 for the subjunctive, 3 for the jussive. Later, we shall also meet $j = 4$ for the future, which may be obtained with the help of a prefix *sa+* from the present tense.

(4) $k = 1, \cdots, 10$ stands for the pattern, usually called "form". These ten patterns are constructed from the basic pattern ($k = 1$) under which they are to be found in the standard dictionaries and to which they are loosely connected in meaning.

3. Typing the verb.

We distinguish between transitive verbs, which require an object, and intransitive verbs, which don't. As in English, many verbs can be either transitive or intransitive. A verb must be intransitive when $\ell = 2$ (passive) or when $k = 7$ or 9. First, look at intransitive verbs $\mathbf{V}$:

$C_{\ell kji}(\mathbf{V})$ has type $\mathbf{s}_j$ in verbal sentences.[2)]

In verbal sentences, the subject may be incorporated in the verb, as is assumed above, but it can also appear explicitly; but then the third person plural agrees with the third person singular of the verb, thus:

$$\begin{array}{rl} C_{\ell kji}(\mathbf{V}) \text{ has type} & \mathbf{s}_j\pi_i^\ell \text{ when } i \neq 6g \\ \text{but} & \mathbf{s}_j\pi_{3g}^\ell \text{ when } i = 6g \end{array}$$

Here π_i is the type of the i-th person subject. When $\mathbf{V}$ is transitive, replace $\mathbf{s}_j$ by $\mathbf{s}_j\mathbf{o}^\ell$ in the above, where $\mathbf{o}$ is the type of the object.

4. Tense modifiers.

Certain morphemes will change the tense-mood of a verb form. Thus,

saufa and the prefix *sa+* have type $\mathbf{s}_4\mathbf{s}_1^\ell$, transforming the present tense into the future. Moreover, the following morphemes all denote negatives:

lam of type $\mathbf{s}_0\mathbf{s}_3^\ell$, transforming the jussive into the negated past tense;

laa of type $\mathbf{s}_1\mathbf{s}_1^\ell$, transforming the present tense into the negated present;

lan of type $\mathbf{s}_4\mathbf{s}_2^\ell$, transforms the subjunctive into the negated future.

Here are some illustrations, using the transitive verb $\mathbf{V} = (k, t, b; u, a)$ with $\ell = 1$, $k = 1$ and $i = 3m$:

$$\begin{array}{lcccl} (1) & \textit{saufa} & \textit{yaktubu} & \textit{risalatan} & \\ & (\mathbf{s}_4\mathbf{s}_1^\ell) & (\mathbf{s}_1\mathbf{o}^\ell) & \mathbf{o} & \longrightarrow \mathbf{s}_4 \end{array}$$

$$\begin{array}{lcccl} (2) & \textit{sa} + \textit{yaktubu} & & \textit{risalatan} & \\ & (\mathbf{s}_4\mathbf{s}_1^\ell)(\mathbf{s}_1\mathbf{o}^\ell) & & \mathbf{o} & \longrightarrow \mathbf{s}_4 \end{array}$$

$$\begin{array}{lccc} (3) & lam & yaktub & risalatan & \\ & (\mathbf{s}_0\mathbf{s}_3^{\ell}) & (\mathbf{s}_3\mathbf{o}^{\ell}) & \mathbf{o} & \longrightarrow \mathbf{s}_0 \end{array}$$

$$\begin{array}{lccc} (4) & laa & yaktubu & risalatan & \\ & (\mathbf{s}_1\mathbf{s}_1^{\ell}) & (\mathbf{s}_1\mathbf{o}^{\ell}) & \mathbf{o} & \longrightarrow \mathbf{s}_1 \end{array}$$

$$\begin{array}{lccc} (5) & lan & yaktuba & risalatan & \\ & (\mathbf{s}_4\mathbf{s}_1^{\ell}) & (\mathbf{s}_1\mathbf{o}^{\ell}) & \mathbf{o} & \longrightarrow \mathbf{s}_4 \end{array}$$

$$\begin{array}{lcccc} (6) & saufa & laa & yaktubu & risalatan & \\ & (\mathbf{s}_4\mathbf{s}_1^{\ell}) & (\mathbf{s}_1\mathbf{s}_1^{\ell}) & (\mathbf{s}_1\mathbf{o}^{\ell}) & \mathbf{o} & \longrightarrow \mathbf{s}_4 \end{array}$$

In English translation:

(1;2) *he will write a letter*
(3) *he did not write a letter*
(4) *he does not write a letter*
(5;6) *he will not write a letter*

5. To be or not to be.

Arabic has two "auxiliary" verbs which translate the English copula *to be* and its negation in certain contexts. While the English copula requires a nominative complement, these Arabic verbs are transitive, requiring an object in the so-called accusative case. The two verbs are:

$$\mathbf{V}_1 = (k, (w), n; u, u)$$
$$\mathbf{V}_2 = (\ell, (y), s; -, a)$$

Both are so-called "hollow" verbs, the middle radical being a potential w or y, which may disappear in certain contexts.

$\mathbf{V}_1$ is only known to us in three tense-moods: the past ($j = 0$), the jussive ($j = 3$) and the future ($j = 4$). It is used to translate the English verb *to be*, except in the present tense.[3)]

According to the rules [4)] established in [4], the forms of $\mathbf{V}_1$ in the past tense should be as follows:

$$kuntu,\ kunta/kunti,\quad kaana/kaanat,$$
$$kunnaa,\ kuntum/kuntunna,\quad kaanuu/kunna,$$

the three persons singular followed by the three persons plural, with different masculine and feminine forms in the second and third person. The forms of the jussive are calculated as follows:

$$'akun,\ yakun/takun,\quad yakun/takun,$$
$$nakun,\ takunuu/takunna,\quad yakunuu/yakunna.$$

From the jussive one can calculate the present, which does not seem to exist independently, but which gives rise to the future with the help of the prefix $sa+$. Here are some examples:

$$\begin{array}{lcl} kuntu & \dot{t}aaliban & = \text{ I was a (male) student} \\ (\mathbf{s}_0\mathbf{o}^{\ell}) & \mathbf{o} & \rightarrow \mathbf{s}_0 \end{array}$$

$$\begin{array}{cccc} kaana & Saliman & ṭaaliban & = \text{ Salim was a student} \\ (\mathbf{s}_0\mathbf{o}^\ell\pi^\ell_{3m}) & \pi_{3m} & \mathbf{o} \to \mathbf{s}_0 & \end{array}$$

$$\begin{array}{ccc} sa'akuna & ṭaalibatan & = \text{ I will be a (female) student} \\ (\mathbf{s}_4\mathbf{o}^\ell) & \mathbf{o} \to \mathbf{s}_4 & \end{array}$$

$$\begin{array}{ccccc} lam & yakun & Saliman & ṭaaliban & = \text{ Salim was not a student} \\ (\mathbf{s}_0\mathbf{s}^\ell_3) & (\mathbf{s}_3\mathbf{o}^\ell\pi^\ell_{3m}) & \pi_{3m} & \mathbf{o} \to \mathbf{s}_0 & \end{array}$$

The forms of $\mathbf{V}_2$ are formally in the past tense, but semantically in the present, so we assign to them the types $\mathbf{s}_1\mathbf{o}^\ell$ and $\mathbf{s}_1\mathbf{o}^\ell\pi^\ell_i$. They are:

$$lastu,\ lasta/lasti,\ laiisa/laiisat,$$
$$lasnaa,\ lastum/lastunna,\ laiisuu/lasna.$$

Here are some examples:

$$\begin{array}{ccc} lastu & ṭaalibatan & = \text{ I am not a (female) student} \\ (\mathbf{s}_1\mathbf{o}^\ell) & \mathbf{o} \to \mathbf{s}_1 & \end{array}$$

$$\begin{array}{ccc} lasnaa & ṭulaaban & = \text{ we are not students} \\ (\mathbf{s}_1\mathbf{o}^\ell) & \mathbf{o} \to \mathbf{s}_1 & \end{array}$$

$$\begin{array}{cccc} laiisa & Salimun & ṭaliban & = \text{ Salim is not a student} \\ (\mathbf{s}_1\mathbf{o}^\ell\pi^\ell_{3m}) & \pi_{3m} & \mathbf{o} \to \mathbf{s}_1 & \end{array}$$

6. Noun declension.

Whereas the verb is marked for voice, pattern, tense and person, the noun and the adjective are marked for gender, number, case and definiteness. Many nouns have fixed gender, but adjectives and some nouns (such as ṭaalib) have variable gender. We will sketch a computational approach to the inflectional forms of the noun $\mathbf{N}$, to be generated by the expression $D_{gncd}(\mathbf{N})$, where $g = m$ or f is the gender (masculine or feminine), $n = 1, 2$ or 3 is the number (singular, dual or plural), $c = 1, 2, 3$ denotes the three cases nominative, accusative and a third case which resembles the Latin genitive or ablative, depending on the context, and $d = 1, 2$ denotes definite and indefinite respectively.[5)]

The following formulas should generate all the inflectional forms of the noun $\mathbf{N}$. (The arrow here should not be confused with the arrow for calculating types.)

First, ignoring the determiner, we write

$$\begin{array}{ll} D_{m1c}(\mathbf{N}) \to & \mathbf{N}V_c \\ D_{f1c}(\mathbf{N}) \to & \mathbf{N}\ at\ V'_c \\ D_{m3c}(\mathbf{N}) \to & \mathbf{N}^*V''_cV''_cna \\ D_{f3c}(\mathbf{N}) \to & \mathbf{N}aat\ V''_c \end{array}$$

Here $\mathbf{N}$ is the noun stem, exceptionally replaced by $\mathbf{N}^*$, where $\mathbf{N}^* = \mathbf{N}$ for most nouns, but $\mathbf{N}^* \neq \mathbf{N}$ for a few, but frequently occurring nouns. E.g.,

$$(mudarris)^* = mudarris, \text{ but } (ṭaalib)^* = ṭulaab.$$

The vowels $V_c,\ V_c',\ V_c''$ are calculated as follows:

$$V_c = u/a/i, \quad V_c' = u/a/a, \quad V_c'' = u/i/i$$

when $c = 1/2/3$ respectively.

For common nouns, we distinguish three cases:

$$\begin{array}{rl} D_{gnc1}(\mathbf{N}) \to & \mathbf{al} + D_{gnc}(\mathbf{N}) \\ D_{g1c2}(\mathbf{N}) \to & D_{g1c}\mathbf{N} \ + n \\ D_{g2c2}(\mathbf{N}) \to & D_{g2c}\mathbf{N}. \end{array}$$

Note that, in spoken Arabic,

$$al \to aC \text{ before certain consonants } C.$$

Paradoxically, names are treated morphologically as indefinite nouns, though syntactically they are viewed as definite. Thus we should add:

$$D_{g1c1}(\mathbf{N}) \to D_{g1c}(\mathbf{N}) + n \quad \text{when } \mathbf{N} \text{ is a name.}$$

7. Typing nouns and subject pronouns.

We assign types to various declensional forms of the noun $\mathbf{N}$ as follows:

$$D_{gnc}(\mathbf{N}) : n_{gnc}, \quad D_{gncd}(\mathbf{N}) : n_{gncd}.$$

It follows that articles should be assigned types thus:

$$\begin{array}{rl} al: & \mathbf{n}_{gnc1}{\mathbf{n}_{gnc}}^{\ell}, \\ n: & {\mathbf{n}_{g1c}}^{r}\mathbf{n}_{g1c2}. \end{array}$$

Since no article is required for plurals, we should postulate

$$\mathbf{n}_{g3c} \to \mathbf{n}_{g3c2}.$$

To describe the rôle of nouns in a sentence so far, we postulate:

$$\begin{array}{rl} \mathbf{n}_{gn1d} \to & \begin{cases} \pi_{3g} & \text{if } n = 1, \\ \pi_{6d} & \text{if } n = 3, \end{cases} \\ \mathbf{n}_{gn2d} \to & \mathbf{o}. \end{array}$$

The case $c = 3$ will be considered later.

There are also personal pronouns P_{ic}, when $i = 1, 2g,\ 3g,\ 4,\ 5g,\ 6g$. Provisionally, we shall say P_{ic} has type $\hat{\pi}_{ic}$. So far, we have only mentioned subject pronouns, so we postulate

$$\hat{\pi}_{ic} \to \begin{cases} \mathbf{n}_{g1c1} & \text{if } i = 1, 2g, 3g, \\ \mathbf{n}_{g3c1} & \text{if } i = 4, 5g, 6g. \end{cases}$$

Note that all pronouns are considered to be definite, so $d = 1$. It follows that

$$\hat{\pi}_{i1} \to \begin{cases} \pi_{3g} & \text{if } i = 1, 2g, 3g, \\ \pi_{6g} & \text{if } i = 4, 5g, 6g. \end{cases}$$

Oblique cases of personal pronouns will be considered later.

8. Equational sentences.

A verbless equational sentence joins together two nominative noun phrases agreeing in gender and number, but only exceptionally both are definite. The easiest way to fit such sentences into our algebraic picture, is to assume an invisible copula $\emptyset$ of types

(1) $\mathbf{s}_1\mathbf{n}^{\ell}_{gn12}\mathbf{n}^{\ell}_{gn11}$

and

(2) $\mathbf{s}_1\mathbf{n}^{\ell}_{gn11}(\hat{\pi}_{i1}{}^{\ell})\mathbf{n}^{\ell}_{gn11}$

The first type ensures that an equational sentence usually consists of a definite noun phrase followed by an indefinite one, agreeing in gender and number. The second type ensures that exceptionally an equational sentence may consist of two definite noun phrases with an optional pronoun between them.

Equational sentences are verbless and always represent the affirmative present. To form the past or the negation of an equational sentence, one requires the auxiliary transitive verbs of Section 5.

Examples where the invisible copula, here indicated by $\emptyset$, has type (1):

$$\begin{array}{cccc} \emptyset & ana & ṭaaliban & = \text{ I am a (male) student} \\ & P_{11} & D_{m112}(ṭalib) & \end{array}$$

$$(\mathbf{s}_1\mathbf{n}^{\ell}_{m112}\mathbf{n}^{\ell}_{m111})\hat{\pi}_{1m1} \quad \mathbf{n}_{m112} \quad \to \mathbf{s}_1 \quad (\text{using } \hat{\pi}_{1m1} \to \mathbf{n}_{m111})$$

$$\begin{array}{cccc} \emptyset & anta & arabiyan & = \text{ you (male) are an Arab} \\ \emptyset & Faridun & ṭaaliban & = \text{ Farid is a (male) student} \end{array}$$

The last two examples are similar to the first. However:

$$\begin{array}{cccc} \emptyset & ana & ṭaalibatun & = \text{ I am a (female) student} \\ \emptyset & hia & ṭaalibatun & = \text{ she is a student} \\ (\mathbf{s}_1\mathbf{n}^{\ell}_{f112}\mathbf{n}^{\ell}_{f111}) & \hat{\pi}_{3f1} & \mathbf{n}_{f112} \to \mathbf{s}_1 & (\text{using } \hat{\pi}_{3f1} \to \mathbf{n}_{f111}) \end{array}$$

Examples when the copula has type (2):

$$\begin{array}{cccc} \emptyset & hua & alaawalu & = \text{ it is the first} \\ (\mathbf{s}_1\mathbf{n}^{\ell}_{m111}\mathbf{n}^{\ell}_{m111}) & \hat{\pi}_{3m1} & \mathbf{n}_{m111} \to \mathbf{s}_1 & \end{array}$$

$$\begin{array}{ccccc} \emptyset & almudiiru & hua & \underbrace{ra`issu\ alaajnati} & \\ \cdots & \mathbf{n}_{m111} & \hat{\pi}_{3m1} & \mathbf{n}_{m111} & \end{array}$$

$=$ he is the committee chairman

9. Oblique personal pronouns.

The personal pronoun P_{ic} may occur in the nominative when denoting the subject (although this is usually absorbed in the verb) and in the oblique forms: accusative and genitive. The latter are identical, except in the first person singular, and are attached to the verb and noun respectively. The genitive pronoun may also be attached to a preposition, often producing a verbless sentence.

i	P_{i1}	P_{i2}/P_{i3}
1	*ana*	$+(u)nii/(ii)$
$2m$	*anta*	$+ka$
$2f$	*anti*	$+ki$
$3m$	*hua*	$+(hu)$
$3f$	*hia*	$+haa$
4	*naḥnu*	$+naa$
$5m$	*antum*	$+kum$
$5f$	*antunna*	$+kunna$
$6m$	*hum*	$+hum$
$6f$	*hunna*	$+hunna$

$$(u) \to \begin{cases} u & \text{after } m \\ \emptyset & \text{otherwise} \end{cases} \qquad (ii) \to \begin{cases} a & \text{after } i \\ ii & \text{otherwise} \end{cases}$$

$$(hu) \to \begin{cases} hi & \text{after } i \\ hu & \text{otherwise} \end{cases}$$

The accusative pronoun will be given type

$$\hat{\pi}_{i2} \to \mathbf{o},$$

thus transforming an incomplete sentence of type $\mathbf{s}_j\mathbf{o}^\ell$ into a complete one:

$$(\mathbf{s}_j\mathbf{o}^\ell)\hat{\pi}_{12} \to \mathbf{s}_j\mathbf{o}^\ell\mathbf{o} \to \mathbf{s}_j.$$

Here are some examples:

$$\begin{array}{rl}
\textit{taraktu} + \textit{ki} & \to \textit{taraktuki} = \text{I left you (female)} \\
(\mathbf{s}_0\mathbf{o}^\ell)\ \ \hat{\pi}_{12} & \to \mathbf{s}_0 \\
\textit{tarakti} + (u)nii & \to \textit{taraktinii} = \text{you (female) left me} \\
(\mathbf{s}_0\mathbf{o}^\ell)\ \ \hat{\pi}_{2f2} & \to \mathbf{s}_0 \\
\textit{taraktum} + (u)nii & \to \textit{taraktumunii} = \text{you (male plural) left me} \\
(\mathbf{s}_0\mathbf{o}^\ell)\ \ \hat{\pi}_{5m2} & \to \mathbf{s}_0 \\
\textit{lam yatruk} + (u)nii & \to \textit{lam yatruknii} = \text{he did not leave me} \\
(\mathbf{s}_0\mathbf{s}_3{}^\ell)\ \ (\mathbf{s}_3\mathbf{o}^\ell)\ \ \hat{\pi}_{12} & \to \mathbf{s}_1
\end{array}$$

The case $c = 3$ of a personal pronoun differs from the accusative case $c = 2$ only in the first person. If the pronoun P_{i3} is attached to a noun, we think of it as being in the genitive case. But if it is attached to a preposition, a comparison with Latin would suggest that it is in the ablative case. Morphologically, the genitive and ablative cases coincide, but, syntactically, they behave differently.

10. Personal pronouns attached to prepositions.

After the personal pronoun P_{i3} is attached to a preposition, the subscript i becomes irrelevant, hence we introduce the basic type γ for such a pronoun and postulate

$$\hat{\pi}_{i3} \to \gamma.$$

To keep this article within reasonable bounds, we will consider only three types of prepositional phrases:

possessive of type π,
dative of type δ,
locative of type λ.

We can now assign types to prepositions as follows:

preposition	type	translation
la	$\pi\gamma^\ell$	of
ila	$\delta\gamma^\ell$	to
fi, rala, ran	$\lambda\gamma^\ell$	in, on, about

Here is a typical example:

$$\begin{array}{cccccc} katabtu & risalatan & ila & + & ka & \\ (\mathbf{s}_0\delta^\ell\mathbf{o}^\ell) & \mathbf{n}_{f122} & (\delta\gamma^\ell) & \hat{\pi}_{2m3} & & \to \mathbf{s}_0 \end{array}$$

$=$ I wrote a letter to you (male).

Note that *katabtu* here has type $\mathbf{s}_0\delta^\ell\mathbf{o}^\ell$, although it can have type $\mathbf{s}_0$ when used intransitively, $\mathbf{s}_0\mathbf{o}^\ell$ when used transitively, or even $\mathbf{s}_0\delta^\ell$, as in "I wrote to you". All this, if the subject is not mentioned. Presumably, the dictionary would list the type of *katab* as $\mathbf{s}_0(\delta^\ell)(\mathbf{o}^\ell)(\pi^\ell_{3m})$.

The form *risalatan* is the accusative singular of a feminine noun with indefinite article. We recall that $\mathbf{n}_{gn2d} \to \mathbf{o}$.

The preposition *ila* is the preposition translating English "to" (in the dative, not locative sense) and the morpheme *ka* is the masculine second person pronoun. We recall that $\hat{\pi}_{i3} \to \gamma$.

The preposition *la* (= of) can also occur in verbless sentences, which we may parse with the help of an invisible copula. For example:

$$\begin{array}{lll} & \emptyset \quad lii \quad ibnun & \\ (\mathbf{s}_1\pi^{\ell}_{3g}\pi^{\ell}) & \pi \quad \mathbf{n}_{n112} & \rightarrow \mathbf{s}_1 \end{array}$$

$=$ I have a son (= mine [is] a son).

Note that *lii* arises as follows:

$$\begin{array}{rl} la \ + \ (ii) \rightarrow & lii \\ (\pi\gamma^{\ell}) \ \hat{\pi}_{i3} \rightarrow & \pi \end{array}$$

if we recall that $\hat{\pi}_{i3} \rightarrow \gamma$.

The invisible copula has type $\mathbf{s}_1\pi^{\ell}_i\pi^{\ell}$ when $i = 3g$ or $6g$, and we recall that $\mathbf{n}_{g11d} \rightarrow \pi_{3g}$.

The form *ibnun* is the nominative singular of the masculine word *ibn* with indefinite article.

11. Personal pronouns attached to nouns.

The oblique personal pronoun P_{i3} may be suffixed to a noun without article rendering it definite. Thus it may be compared to a definite article, although this is attached as a prefix. We could explain this by assigning to P_{i3} the type $\mathbf{n}^r_{gnc}\mathbf{n}_{gnc1}$:

$$\begin{array}{l} D_{gnc}(\mathbf{N})P_{i3} \\ \mathbf{n}_{gnc}(\mathbf{n}^r_{gnc}\mathbf{n}_{gnc1}) \rightarrow \mathbf{n}_{gnc1} \end{array}$$

The reader might wish to explain this by a rule

$$\hat{\pi}_{i3} \rightarrow \mathbf{n}^r_{gnc}\mathbf{n}_{gnc1}$$

or, equivalently,

$$\mathbf{n}_{gnc}\hat{\pi}_{i3} \rightarrow \mathbf{n}_{gnc1}.$$

Unfortunately, such rules are not admitted in the kind of grammar we are advocating, which permits rules $x \rightarrow y$ only when x and y are basic types.

To get around this, we propose a "metarule", which affects the dictionary only, asserting that any noun $D_{gnc}(\mathbf{N})$ without article has not only type $\mathbf{n}_{gnc}$, but also type $\mathbf{n}_{gnc1}\gamma^{\ell}$. One might say that the noun then no longer denotes a thing but a relation. Here are some examples:

$$\begin{array}{rll} maktabu \ + \ ka & & = \text{ your office} \\ (\mathbf{n}_{m111}\gamma^{\ell}) \ \gamma & \rightarrow \mathbf{n}_{m111} & \end{array}$$

$$\begin{array}{rll} fi \ maktabi \ + \ ka & & = \text{ in your office} \\ (\lambda\gamma^{\ell})(\mathbf{n}_{m131} \ \gamma^{\ell}) \ \gamma & \rightarrow \lambda & \end{array}$$

This requires the postulate

$$\mathbf{n}_{gn31} \rightarrow \gamma,$$

from which the earlier rule $\hat{\pi}_{i3} \to \gamma$ follows.

$$\begin{array}{c} sa \ + \ yakun\ al \ + \ ustaazu\ fi\ maktabi \ + \ hi \\ (\mathbf{s}_4\mathbf{s}_1^\ell)\ (\mathbf{s}_1\lambda^\ell\pi_{3m}^\ell)(\mathbf{n}\quad \mathbf{n}_{gnc}^\ell)\mathbf{n}\quad (\lambda\gamma^\ell)(\mathbf{n}\quad \gamma^\ell)\hat{\pi} \\ \qquad\qquad\quad gnc1 \quad\ m11 \qquad\quad m131 \quad 3m3 \end{array}$$

$$= \text{ the professor will be in his office}$$

The analysis requires that *yakun*, the present third person masculine of the verb "to be somebody", has not only type $\mathbf{s}_1\mathbf{o}^\ell\pi_{3m}^\ell$, but also type $\mathbf{s}_1\lambda^\ell\pi_{3m}^\ell$ in the sense of "to be somewhere". We also recall that the assimilation

$$\begin{array}{l} (hu) \to \ hi \quad \text{after } i \\ \hat{\pi}_{3m3} \to \gamma. \end{array}$$

12. Concluding remarks.

We will stop our investigation at this point, even though we had planned to discuss other grammatical phenomena, such as duals, doubly transitive verbs and relative clauses. In our investigation so far, we had no need for double adjoints, such as arise from Chomskian traces in English or from clitic pronouns in Romance languages, although they may still come up if the investigation is carried further. In the absence of double adjoints, our rudimentary pregroup grammar could have been replaced by the better established Ajdukiewicz grammar, as modified by Bar-Hillel and supplemented by an ordered set of basic types, richer than the usual set $\{S, N\}$.

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FOOTNOTES

[1)] For readers interested in the theoretical background, the notion of a pregroup also requires expansions $1 \to aa^{\ell}$ and $1 \to a^{r}a$. But, as was shown in [8], these can be dispensed with, as long as we are only concerned with sentence verification.

[2)] It may also have type $\pi_i^r \mathbf{s}_j$ in so-called "nominal" sentences, where π_i is the type of the i-th person subject. However, we will ignore nominal sentences in this paper.

[3)] The Arab philosopher al-Kindi [7] proposed the verb $\mathbf{V}_3 = (', (y), s, -, a)$ as a back formation from $\mathbf{V}_2$ to render the verb "to be" in the present tense.

[4)] Our rule $(W1)$ in [4] needs two corrections:
(1) When $Y = w$ or y and $V' \neq a$, we wrongly asserted that

$$V(Y)V' \to V' \text{ before } CV''V''.$$

This should be corrected to say that

$$V(Y)V' \to VV \text{ before } CV''V''.$$

(2) We also implied that

$$a(Y)a \to aa \text{ before } CV''.$$

The auxiliary verb *laiisa* contradicts this and suggests instead

$$a(Y)a \to aYY \text{ before } CV''.$$

[5)] In this paper we shall ignore the dual $(n = 2)$.