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Directionality and the Processing of Contracted Auxiliaries

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In a recent paper on the status of morphology in a generative theory of grammar, Zwicky (1982a) has argued 'that processes of cliticization and readjustment together constitute a component of grammatical description in any language, a component related to others by strict principles of precedence. . . that syntactic rules, as a set, can feed or bleed rules of cliticization/readjustment (but not vice versa)' (Zwicky 1982b:51). Here, I shall consider the question of whether such an assumption of strict directionality can be maintained in a theory of language processing, in which generative rules of syntax and cliticization are replaced with rules of parsing and word recognition. My hypothesis is that given certain natural assumptions about language processing, rules for analyzing complex phrases and rules for analyzing host-clitic groups must be able to feed information to each other, making directionality an untenable assumption. To develop this hypothesis in concrete terms, I shall consider certain problems which contracted auxiliaries pose for a theory of language processing; specifically, I shall show that these problems can be elegantly handled if parsing rules and word recognition rules are permitted to interact in a nondirectional manner.

In generative theories, Auxiliary Reduction is generally regarded as a cliticization rule which Chomsky-adjoins a finite auxiliary verb to the word which precedes it; auxiliaries which have undergone this process are subsequently assigned their reduced forms by an allomorphy rule, as in (1).[1] The application of Auxiliary Reduction is heavily conditioned by both the preceding and the following context. For example, the host expression of contracted <u>have</u> must be a pronominal NP which c-commands it (Kaisse 1983:114); thus, though sentence (2) is structurally ambiguous between the analyses represented in (3) and (4), (5) is unambiguous--in (5), the contracted <u>have</u> forces the analysis (4), in which <u>you</u> is the subject of the most deeply embedded

(1)	is, has	→	[z]	She'<u>s</u> going home. / He'<u>s</u> seen it.
	would, had	→	[d]	Who'<u>d</u> be invited? / He'<u>d</u> seen it.
	have	→	[v]	I'<u>ve</u> seen it.
	are	→	[r]	They'<u>re</u> going home.
	will	→	[l]	Who'<u>ll</u> be invited?
	am	→	[m]	I'<u>m</u> going home.

(2) John suspects the people who know you have arrived.

(3) John suspects $[_{NP}$the people who know you] have arrived.

(4) John suspects $[_{NP}$the people who know you have arrived].

(5) John suspects the people who know you've arrived.
(6) Bill is as tall as your [brʌðrz].
(7) Bill is as tall as your brothers.
(8) *Bill is as tall as your brother's (< brother is).

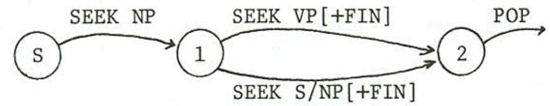
clause. Similarly, no auxiliary can be contracted if it immediately precedes a deletion or extraction site (cf. Zwicky 1970: 334f; Kaisse 1983:99ff); thus, sentence (6) has only one possible analysis, namely that represented in (7)--analysis (8) is ruled out by the gap in the comparative clause.

Contextual requirements like these will play a significant role in the processing of contracted auxiliaries. Suppose, for example, that in a theory of word recognition, the rule of Auxiliary Reduction has as its counterpart one or more rules which accept host-clitic groups such as you've and brother's. Clearly, such rules must fail to apply in certain contexts, as for example in (6); in other cases, such as (5), the application of these rules will have important consequences for the parsing of the surrounding context. In the following, I show how word recognition rules of this kind might be incorporated into an augmented transition network system for sentence analysis; the central feature of this account is the nondirectional interaction between word recognition and parsing.

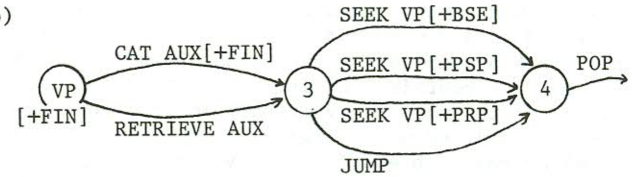
Augmented transition network (or ATN) systems have been widely and successfully applied to the problem of natural language parsing; an ATN system may be thought of as an algorithm which recognizes sentences by means of a word by word inspection from left to right. The rules in such a system consist of states linked to one another by labelled arcs, as in (9). One of these states, the one labelled 'S', is the start state of the system; certain others are final states, namely those marked with POP arcs. The arc connecting two states permits a transition from one state to the other under specific circumstances. An arc labelled 'CAT X' permits a transition just in case the word currently under inspection belongs to category X according to its lexical listing; if so, the word is admitted and the next word in the input sentence comes under inspection. An arc labelled 'JUMP' permits a transition without admitting a word or bringing a new word under inspection. An arc labelled 'SEEK X' permits an indirect sort of transition: the state at the end of the SEEK arc is placed into a pushdown store while control is transferred to the state labelled 'X'. Only when a final state in the system is reached can control be transferred to the state at the top of the pushdown store; thus, a POP arc can be thought of as permitting a transition from a final state to a stored state. A sentence is accepted by an ATN system provided that it allows a series of transitions from the start state of the system to a final state, and that the pushdown store is empty when this final state is reached.

There are two characteristics which distinguish an ATN system

(9) (a)



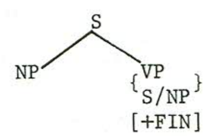
(b)



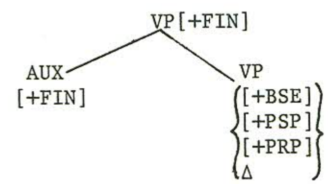
from an unaugmented transition network system. First, besides permitting transitions from one state to another, the arcs in an ATN network may perform structure-building actions such as placing elements of various sorts into memory registers, thereby allowing a phrase structure tree to be built up for an expression as it is being parsed; by means of actions of this sort, the phrase structure subtrees in (10a&b) may be assigned to any expression admitted by the networks in (9a&b), respectively. Second, special conditions may be imposed on the arc joining two states so that a transition is permitted only under special circumstances; for example, if the CAT AUX arc in (9b) places the expression which it admits into a register labelled 'AUX', then the three SEEK VP arcs in (9b) might have condition (11) imposed upon them.

The memory capabilities of an ATN system allow one additional sort of transition arc to be employed: an arc labelled 'RETRIEVE X' permits a transition just in case a previously encountered expression of category X has been placed into a special memory register labelled 'HOLD'; if so, this expression is taken out of HOLD (and may then be placed into some other register). RETRIEVE arcs are useful for matching up displaced constituents with their gaps.

(10) (a)



(b)



(11) A transition is allowed on the following arcs in (9b) only if the contents of the AUX register are as specified.

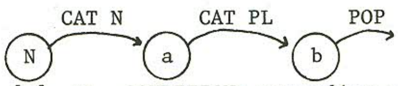
SEEK VP[+BSE] - AUX: will, would, ...
SEEK VP[+PSP] - AUX: have, has, had, ...
SEEK VP[+PRP] - AUX: am, are, is, ...

In most recent accounts of sentence parsing employing ATN systems, it has been assumed for the sake of simplicity that every word in any input sentence is available for lexical lookup. But the high regularity of many forms makes it reasonable to assume that they are not listed lexically, but rather that they are admitted by word recognition rules.[2] If such rules are themselves formulated as ATN networks, then they can be easily incorporated into an ATN system for syntactic analysis if the latter system is allowed to contain SEEK arcs for lexical categories; such arcs would cause the word recognition rules to function as subroutines in the analysis of morphologically complex (but syntactically simple) expressions encountered by the parsing rules.

An example will help clarify the sort of rule interaction I have in mind. Suppose that regular plural nouns are analyzed by a network such as (12). (12) accepts an input expression as a plural noun if this expression can be segmented[3] into two substrings, the first of which matches a lexically listed noun and the second of which matches one of the listings in (13) and also satisfies its distributional requirement. Suppose in addition that noun phrases are parsed by a network such as (14). In the analysis of the noun phrase the brothers by network (14), the regular plural noun brothers comes under inspection at state 5; if this word is not listed lexically, then the SEEK N arc leaving state 5 allows control to be transferred to state N in network (12), which successfully admits brothers as a plural noun and then transfers control to state 6 in network (14).

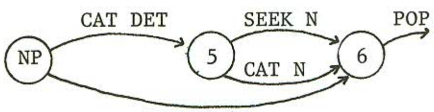
This sort of interaction between parsing rules and word recognition rules--in which the latter must be periodically consulted in the left-to-right parsing of an input sentence--is clearly nondirectional: taken as sets, neither the parsing rules nor the word recognition rules have logical priority in the analysis of an expression; rather, they apply alternately. Notice, however,

(12)



(13) [s], PL, CONDITION: preceding segment is [-voi,-sib]
[z], PL, CONDITION: preceding segment is [+voi,-sib]
[əz], PL, CONDITION: preceding segment is [+sib]

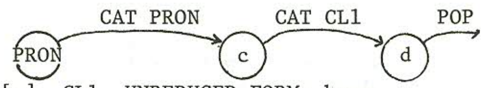
(14)



that in the example just discussed, the nondirectionality of the rule interaction is somewhat trivial, since it derives entirely from the procedure for performing a SEEK transition; the transitions specified in (12) are in no way conditioned by the syntactic environment of the expression under analysis, nor are those specified in (14) at all sensitive to the internal morphological structure of the words composing the input sentence. Contracted auxiliaries, on the other hand, provide a nontrivial example of nondirectional interaction between word recognition rules and parsing rules.

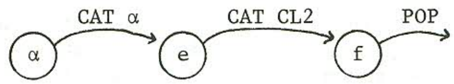
For many speakers (though by no means for all), contractible auxiliaries fall into two groups (cf. Zwicky 1970:331f): those which cliticize onto pronouns only[4] and those which cliticize freely onto any sort of expression which may end a noun phrase (as well as onto a small number of proforms not dominated by NP--cf. Kaisse 1983:103ff). Host-clitic groups containing contracted auxiliaries of the former type might be admitted by means of a network such as (15). (15) admits an input expression just in case it can be segmented into two substrings, the first of which matches a lexically listed pronoun and the second of which matches one of the listings in (16). Similarly, host-clitic groups containing contracted auxiliaries of the more freely distributed type might be admitted by the network schematized in (17). (17) admits an expression which can be segmented into two substrings, the first of which matches a lexical item of any category and the second of which matches one of the forms listed in (18), subject to the accompanying conditions.

(15)



(16) [v], CL1, UNREDUCED FORM: have
[r], CL1, UNREDUCED FORM: are
[l], CL1, UNREDUCED FORM: will
[m], CL1, UNREDUCED FORM: am

(17)



[where α is any lexical category]

(18) [s], CL2, CONDITION: preceding segment is [-voi,-sib]
[z], CL2, CONDITION: preceding segment is [+voi,-sib]
[əz], CL2, CONDITION: preceding segment is [+sib]
UNREDUCED FORM: has or is

[d], CL2, CONDITION: preceding segment is a vowel
UNREDUCED FORM: would or had

Like the generative rule of Auxiliary Reduction, the word recognition rules (15) and (17) must be sensitive to the syntactic context preceding an auxiliary. As was mentioned above, Auxiliary Reduction applies to the verbs in (16) only when[5] they follow a pronominal NP by which they are c-commanded; this means that rule (15) must be constrained so that it recognizes the auxiliaries in (16) only when the host expression has been parsed as a pronominal noun phrase immediately dominated by S. This requirement can be formalized as a condition which the CAT CL1 arc in (15) imposes on subsequent transitions; this is given in (19).

(19) A transition made on the CAT CL1 arc in (15) must be immediately followed by transitions from state d to state 6 to state 1.

This condition guarantees that sentence (5), for example, will be assigned the analysis in (4), since the pushdown storage of states 1 and 6 is necessary for the recognition of a pronominal subject but does not occur in the recognition of a pronominal object.

In a generative theory, Auxiliary Reduction applies more freely to the verbs in (18): the preceding expression need not be pronominal, though with a small number of exceptions, it must still be a noun phrase c-commanding the auxiliary, as the contrast in acceptability between (20) and (21) suggests. Thus, rule (17) must be restricted so that it recognizes the auxiliaries in (18) just in case the host expression has been parsed as the last word in a noun phrase immediately dominated by S. This is accomplished by condition (22) which the CAT CL2 arc in (17) imposes on subsequent transitions.

(20) ??Near the bald guy's my brother.
(21) The bald guy's my brother.
(22) A transition on the CAT CL2 arc in (17) must be immediately followed by a series of transitions from state f to state 1, where all intervening states are final.

The fulfilment of conditions (19) and (22) requires that two or more states be in the pushdown store when (15) and (17) apply, and thus, in an indirect sense, makes the application of these rules contingent on the prior application of rules of parsing; however, the application of (15) and (17) will itself have important consequences for parsing the remainder of an input sentence.

The clitics recognized by networks (15) and (17) impose the same sorts of restrictions on subsequent processing as their unreduced variants, requiring, for example, that hit be recognized as a past participle in sentence (23) but as a bare infinitive in sentence (24). Dependencies of this kind can be accounted for by requiring that the CL arcs in (15) and (17) place the unreduced form[6] of the auxiliary which they recognize into the HOLD register, allowing a subsequent transition on the RETRIEVE AUX arc in (9b); this, in turn, can place the stored auxiliary into the AUX register, thereby causing it to condition the following

(23) They've hit it. (24) They'll hit it.

SEEK VP arcs as in (11).[7]

Because of the contextual restrictions on contracted auxiliaries, the clitics recognized by (15) and (17) impose an additional condition on subsequent processing which full auxiliaries do not. As was mentioned above, Auxiliary Reduction does not apply to verbs immediately followed by deletion sites or extraction sites. In an ATN system, both of these sorts of gaps can be recognized by means of a particular sort of transition arc: the transition permitted by a RETRIEVE X arc corresponds to the recognition of a gap into which a displaced constituent of category X can be 'fitted'; similarly, the transition permitted by a JUMP arc corresponds in some cases to the recognition of an ellipsis --the JUMP arc in (9b), for example, admits instances of VP-ellipsis. Thus, in order to guarantee that no sentence will be admitted in which a contracted auxiliary is immediately succeeded by a gap, it suffices to require that at least one CAT transition intervene between a transition on the RETRIEVE AUX arc in (9b) and any subsequent transition on a RETRIEVE or JUMP arc whose function is to recognize a gap; this requirement would, for example, rule out an analysis of sentence (6) as in (8), since this analysis would require a RETRIEVE AUX transition followed by a JUMP transition without an intervening CAT transition. This constraint on 'adjacent' transitions in an ATN analysis involves no direct interaction between word recognition rules and parsing rules; but since the RETRIEVE AUX transition in (9b) is only possible after rule (15) or (17) has placed an auxiliary in HOLD, there is an indirect sense in which this parsing constraint is contingent on the prior application of a word recognition rule.

In the foregoing discussion, I have assumed the range of grammaticality judgments typical of many speakers. Kaisse (1983), however, has recently observed that many speakers give evidence of a more restrictive condition on the syntactic context following a contracted auxiliary from what I have assumed above; among the examples which she cites as unacceptable for the more restrictive speakers are those in (25). Kaisse argues that for these speakers, the rule of Auxiliary Reduction is subject to the condition in (26).

(25) %Which dog's he buying?
%Which man's she the fondest of?
%Whose food's the dog eating?
%What dog's that? (1983:102)
(26) AR may not apply if the element following the AUX is not the same as the element that follows it at NP-structure. (1983:99)

In the theoretical framework assumed by Kaisse, NP-structure is a level of syntactic derivation distinguished from 'surface structure' in that it precedes certain deletion and movement rules, including Subject-Aux Inversion; since Auxiliary Reduction only applies after these rules, (26) is a global constraint. Whether (26) is the right way to account for the more restrictive dialect is a controversial issue which I shall not address here (but see Bissantz 1983 for a different approach to the facts which Kaisse discusses). I do, however, wish to point out that Kaisse's generalization is not inconsistent with the approach to processing discussed here: because the structure-building capabilities of transition arcs allow 'deeper' levels of syntactic derivation to be built up directly as an expression is parsed (cf. Woods 1970), it would in principle be possible to formalize an ATN system which would automatically reconstruct the NP-structure of an input expression; in such a framework, (26) could be reformulated as a constraint on the structure-building actions performed by a parsing network; this constraint would, of course, have to be sensitive to the morphological analyses assigned by rules like (15) and (17). Thus, condition (26) could be thought to reflect an additional way in which word recognition rules condition parsing rules.

What I hope to have suggested here is that, despite the plausibility of the assumption that all rules of readjustment/cliticization follow all rules of syntax in a generative theory of grammar, it may nevertheless be undesirable to make an analogous assumption in a formal theory of language processing; specifically, I have shown that the constraints and actions proposed for the word recognition rules (15) and (17) entail an interaction with rules of parsing that is significantly nondirectional. On the one hand, transitions on the CAT CL arcs in (15) and (17) are conditioned by the syntactic analysis of the earlier words in the input string; on the other hand, the same arcs 'absolutely feed' the RETRIEVE AUX arc in (9b) and thus indirectly restrict the later transitions which are dependent on it. Thus, unlike the nondirectional interaction observed in connection with networks (12) and (14), which derives entirely from the nature of SEEK transitions, the absence of any strict logical priority of parsing rules over word recognition rules (or vice versa) is fundamentally necessary for the approach to the processing of contracted auxiliaries which I have outlined here. This conclusion suggests that there may be considerable differences in format between adequate theories of language structure and language processing, but does not rule out the possibility of important similarities. For example, just as syntactic rules and cliticization rules can be plausibly claimed to constitute distinct components of organization in a generative theory of grammar, rules of parsing and word recognition might likewise be argued to function as distinct 'modules' in a theory of processing: notwithstanding the possibility of nondirectional interaction, they do seem to differ in fundamental ways--in their sensitivity to the phonological content of their input, in the extent to which they exploit the recursive capabilities of ATN systems, and so on. A precise delineation of such convergences in organization must, however, await further study.

Footnotes

1. The reduced form [z] of is and has is itself subject to the morphophonemic alternation [s ∿ z ∿ əz], which likewise affects the plural suffix, the third person singular present tense suffix, and the possessive enclitic.
2. Very little work has been done on formal theories of word recognition (but see Chapin & Norton 1968, Kay 1977, Karttunen et al. (ms.)); my remarks on the formal characteristics of word recognition rules must therefore be regarded as tentative.
3. The use of an ATN network like (12) to analyze a word's structure requires a trial segmentation of the word's parts, e.g. brothers → brother-s. The principles for segmentation are nontrivial, but cannot be considered in detail here.
4. Of these, am is subject to the further restriction that it may only cliticize onto I; cf. Zwicky 1970:332f.
5. There are a limited number of exceptions to this requirement --cf. Zwicky 1970:333; Kaisse 1983: fn. 11.
6. This action is nondeterministic, since [z] has both is and has as unreduced forms, and [d] both had and would.
7. Since contracted auxiliaries are 'displaced' hierarchically but not linearly, it must be required as a general condition on CAT arcs that they permit no transitions when an auxiliary verb is in HOLD.

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