ANAPHORA RESOLUTION IN HUNGARIAN

By

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How do listeners integrate divergent data sources when understanding sentences? Are all cues integrated on an equal footing or do certain types of cues have a temporal priority over others? Writers such as Smaby (1979) and Charniak (1975) argue that top-down processes have logical priority over bottom-up processes. On the other hand, Fodor (1982) and Forster (1981) believe that bottom-up processes have temporal priority over top-down processes. These modularists propose that the analysis of formal cues occur in an "encapsulated module" where all processing is obligatory, automatic, and self-contained. Yet another approach to information integration is found in interactive models such as the competition model of MacWhinney, Bates, and Kliegl (1984) or the on-line interactive approach of Marslen-Wilson and Tyler (1980) and Marslen-Wilson, Levy and Tyler (1982), and Tyler (1983). These interactive models attempt to explain how divergent cue types can be placed on an equal footing during sentence comprehension.

One critical proving-ground for these alternative approaches is the study of the disambiguation of the references of pronouns. In this paper we explore the integration of divergent cues to the resolution of pronominal anaphora in Hungarian. We will confine our attention to the resolution of anaphoric reference. MacWhinney (1984) points out that reference may be based on anaphora, cataphora (backwards anaphora), metaphora (reference to a whole speech act), or exophora (reference to the situation). However, we will not concern ourselves here with these last three types of reference, focusing only on the kinds of anaphora that arise when two simple clauses are joined together.

The literature on anaphora resolution in English has focused on the use of these five cues:

1. Referent-Pronoun Agreement: The third person pronouns *he*, *she*, *it*, and *they* must match their antecedents in gender, number, and animacy. This match is quite often a deciding factor in deciding between two competing alternative antecedents. Although there may be cases where these cues are ambiguous, it is never the case that these cues are misleading. If MacWhinney, Bates, and Kliegl (1985) are correct in claiming that cue

reliability is the primary determinant of cue strength, then these cues should be very high in reliability. Research by Springston (1975) and Chang (1980) indicates that this is in fact the case.

2. Cross-Over Constraint: Most formal analysts hold that the c-command relation or the cross-over constraint blocks coreference between *he* and *Bill* in a sequence such as *He wanted to buy the diamond, but Bill didn't get to the store in time*.

3. Parallel Function: When a lexical item is bound to a particular role in the first clause of a two-clause sequence, there is a tendency to continue this binding into the second clause. Perhaps the easiest way of thinking of this is to imagine that the connection between roles and lexical items is "sticky" and that the listener has to go to extra work to pry a lexical item loose from a role.

4. Verb-based Factive Role Frames: Interpersonal NP-complement verbs like *apologize*, *blame*, *praise*, or *criticize* seem to place presuppositional restrictions on the role relations in the complement clause. It is fine to say *Mary criticized Bill because he was late*, but it is strange to say *Mary criticized Bill because she was late*. The verbs involved here are factive in the sense that they presuppose that the complement clause is actually true.

5. Verb-based Action readiness: Verbs also differ in the extent to which they presuppose activity on the part of the different participants. Both *chase* and *hit* presuppose activity on the part of the subject. However, *chase* also presupposes activity on the part of the object. Thus, if there is a sequence such as *The dog chased the bear, and he ran into a cave* the pronoun *he* may refer to the *bear*, since the *bear* is already moving in the first clause. This effect is somewhat different from that of the role frame cue for verbs such as *criticize*, since the object of criticize is not engaging in any activity. Unfortunately, there has been little detailed study of the ways in which first-clause verbs affect action readiness. One of the goals of the present study is to clarify the status of this factor.

The psycholinguistic research literature on anaphor resolution is fairly rich. One set of 'studies has examined the competition between parallel function and factive role frames, as cues to pronominal anaphora resolution. Garvey and Caramazza (1974), Garvey, Caramazza, and Yates(1975) and Grober, Beardsley, and Caramazza (1978) and Caramazza and Gupta (1979) studies sentences such as (1) and (2) in which the gender and animacy cues are not

available since the possible antecedents of the pronoun both agree in gender and animacy.

(1) *John scolded Bill, because he was annoyed.*
(2) *John scolded Bill, because he was annoying.*

These studies found that the pronouns in these sentences are interpreted on the basis of parallel function. In sentence (1), the choice of *John* as the referent of *he* is supported by parallel function since *John* is the subject of the first clause. In (2), on the other hand, there is a competition between parallel function which supports *John* as the referent of *he* and the role frame strategy which supports *Bill* as the referent of *he*. In fact, subjects are more divided in their choice of a referent for the pronoun in (2) than they are in (1). Similar results with reaction times are reported by Corbett and Chang (1983).

A study by Hirst and Brill (1980) examined the competition between parallel function, the cross-over constraint, and action readiness. They used sentences such as:

(3) *John stood watching while Henry fell down some stairs. He ran for a doctor.*
(4) *John stood watching while Henry fell down some stairs. He thought of the future.*
(5) *John stood watching. He ran for a doctor after Henry fell down some stairs.*
(6) *John stood watching, He thought of the future after Henry fell down some stairs.*

In (3) both perspective and plausibility are on the side of *John* as the referent of *he* and decisions are quick. In (4) there is a conflict and decisions are slower. More importantly, in (5) and (6) the syntactic cross-over constraint mitigates against identification of *he* with *Henry*. Nonetheless, (5) is faster than (6), indicating that, even with an relatively absolute syntactic constraint, listeners compute event plausibility.

Similar results are reported by Marslen-Wilson and Tyler (1981). In their experiment subjects listened to context sentences such as (7),

(7) *As Philip was walking back from the shop he saw an old woman trip and fall flat on her face. She seemed to be unable to get up again.*

This context was followed by three types of continuation fragments:

(8) *Philip ran towards...* (repeated name)
(9) *He ran towards...* (pronoun)
(10) *Running towards...* (zero anaphora)

At the end of the continuations, subjects received a further continuation word visually and were asked to name it. That further continuation was either *he* (appropriate) or *she* (inappropriate). For all three continuation types, subjects responded significantly faster for the appropriate continuation than for the inappropriate continuation. These results indicate that, even in the case of zero-anaphora, subjects are assuming that it is *Philip* who is doing the running. Presumably, the mental model they construct from the first clauses has in it the fact that only *Philip* is prepared to engage in further action.

Neither Hirst and Brill nor Marslen-Wilson and Tyler make specific use of the concept of action readiness to explain their results. However, this notion is very much in keeping with the emphasis that Marslen-Wilson and Tyler (1981) place on the extent to which the recognition system has adapted to the task of immediate interpretation. It may be the case that listeners continually compute the action readiness of each discourse entity. By doing this, they would be able to facilitate the on-line resolution of subsequent anaphors. Not all aspects of the discourse context have the same relevance to anaphora resolution as do action readiness. For example, spatial relations are generally less important to anaphora resolution. Consider a sequence such as *John watched Bill fall down the stairs. He looked up at the light.* Here, spatial considerations might favor *Bill* as the referent of *he*. However, action readiness favors *John*. In general, listeners do not need to compute a full mental model of a sentence (as in Anderson and Ortony, 1975) in order to extract action readiness relations. In the studies we report on here, we will examine some further approaches to the concept of action readiness.

All of the studies we have discussed were performed in English. However, there are ways in which the structure of English both facilitates and limits the ways in which we can understand the general process of pronoun disambiguation. English provides us with strong and reliable lexical constraints on the third person singular pronouns *he, she, it,* and *they*. These pronouns must agree with the gender of the antecedent. Chang (1980) and Springston (1975) have shown that this cue is so powerful that items that do not match by gender receive no detectable activation at all.

In Hungarian, on the other hand, there is no grammatical gender and no grammatical animacy contrast. Because third person pronoun disambiguation is not chained to strong lexical forces as in English, we would expect that

it would be able to show a somewhat greater sensitivity to inter-clausal cues for reference identification, such as parallel function, factive role frames, action readiness, topicality, and contrastivity. Although experiments in English have made good use of the absolute nature of the English gender cue for pronoun disambiguation, excessive reliance on these English data may provide us with a limited understanding of fundamental aspects of reference identification. In particular, the English data tell us fairly little about what happens when anaphora resolution is not driven by strong gender/ animacy agreement relations.

Hungarian is also interesting as a topic of study because it is a "pro-drop" language. In fact, Hungarian can drop both subject and object pronouns. Pro-dropping is simply the omission of pronouns under specified syntactic and discourse conditions. In Hungarian, it is fairly easy to omit subject pronouns because, as in the case of other pro-drop languages like Italian (Napoli 1984) and Chinese (Li and Thompson 1976), the agreement markers on the verb indicate in a quite reliable fashion (MacWhinney, Bates, and Kliegl, 1984) the person and number of the subject. In English the proroun can be dropped in (11) but not in (12). In Hungarian, the pronoun can be dropped in both (11) and (12). (To simplify the presentation only English translations of Hungarian sentences will be given in the text. The Hungarian sentences used in the experiments are given in the Appendix.)

(11)(a) ENGLISH: *The boy noticed the man and ∅ sat down.*
   (b) HUNGARIAN: *The boy noticed the man and ∅ sat down.*

(12)(a) ENGLISH: *The boy noticed the man. He sat down.*
   (b) HUNGARIAN: *The boy noticed the man. ∅ Sat down.*

The use of third person anaphoric forms, however, is regulated according to the grammatical roles of the noun phrases relative to each other in consecutive sentences. The basic rule stated by Pléh and Radics (1978) is rather simple. When subjects are repeated they can be dropped. But, if a noun is selected as subject that was in the previous clause, but was not the subject, then it must be pronominalized by the demonstrative pronoun *az* (that) as in (14). In the terms of Hale (1975), the pronoun *az* is used to mark "switch reference."

The third person personal pronoun is used when coreference violates some pragmatic presupposition. For example, in the sentence *John asked Paul to pick up the brick, but he picked up the boulder*, Hungarian uses the personal pronoun *ő* 'he' in the second clause rather than a zero-anaphora because the

action of picking up the boulder is unexpected in view of the fact that John asked Bill to pick up the brick. In such sentences, the third person pronoun must be used contrastively and must carry intonational and syntactic focus.

In general, instead of reflecting identification based on use of the lexical category of gender, Hungarian shows anaphoric resolution based on interclausal connections such as parallel function, verb-based expectations, and switch reference marking. To understand the nature of anaphoric resolution in Hungarian, the reader might think about what the situation would be like in English if there were only a single personal pronoun which was usually omitted. This fundamental difference between the languages is the subject of the experiments reported in this paper. Three types of cues to anaphoric resolution will be studied in these experiments:

1. switch reference: the use of the deictic pronoun as a marker of switch reference,

2. factive role frame: the allocation of roles in the second clause on the basis of presupposition contained in the verb of the first clause,

3. action readiness: the allocation of roles in the second clause on the basis of the nature of the activity of the participants in the first clause.

Experiment I: A developmental study of anaphora interpretation

In the first two experiments we focused on the competition between action readiness, parallel function, and the switch reference function of the deictic pronoun. Sentences were constructed with first clause verbs implying an activity on the part of the patient (e.g. *chase*) and verbs not implying such an activity (e.g. *kiss*). In the second clause, the shape of the verb was held constant but the reference used either the zero-anaphora or the switch reference deictic pronoun.

Karmiloff-Smith (1978) has shown that, during the period between ages five and seven, children begin to bring the use of pronominal anaphora under the control of discourse structure. For comprehension, Tyler (1883) shows that, before the age of seven, children do not always allow discourse structure to govern the processing anaphora. Along a similar vein, MacWhinney and Price (1980) and Bates, MacWhinney, Caselli, Devescovi, Natale, and Venza (1984) have reported that devices specifically designed to reverse normal syntactic expectations in English and Italian appear to be learned in the early school years, perhaps under the influence of training in literacy. Since the Hungarian switch reference deictic pronoun appears to be a device of this

type, we decided to investigate the comprehension of these sentences types in both adults and children, focusing on learning in the early school years.

Method

Subjects. Seven groups of subjects were used with 20 Ss in each group. The two youngest groups came from the nursery of the Hungarian Academy of Sciences. These children had an average age of 3;4 and 5;5. The four groups of school-aged children came from a public elementary school in Budapest; these groups had mean ages of 6;5, 7;5 8;5 and 9;5. Finally, a group of undergraduate psychology students from Lorand Eotvos University in Budapest supplemented the sample. Males and females were roughly equally represented in all groups.

Materials and design. We used a 7 (Age) × 2 (Anaphora Type) × 2 (Patient Activity) × 3 (Verb Replicate) design with the last three (stimulus) factors nested within the first (subject group) factor.

A list of 12 coordinate sentences was constructed based on the form given in 13 and 14.

(13) *The bear pets the lamb and then ∅ jumps into the box.*
(14) *The elephant sniffs the pig and then that jumps into the car.*

The predication in the second clause of the sentences was always *jumped into*. The actual identity of the object being jumped into was sometimes a box, sometimes a car, and sometimes a house. This random variation in destination locations was introduced to increase the interest in the task. The first factor that we varied systematically was the use of zero-anaphora or the deictic pronoun in the second predicate. The second factor was the type of the verb in the first clause: three tokens were used for first-clause verbs with an active patient (*chase, frighten, accompany*) and three for first-clause verbs with an inactive patient (*pet, sniff, kiss*). Verbs of the first type would prepare both the agent and the patient as further actors. Verbs of the second type were hypothetized to prepare only the agent. The 12 sentences obtained in this way were supplemented by 6 additional filler sentences containing the pronoun *ö*. These were used as fillers only, since there is no clear grammatical prediction for the coreferent of the personal pronoun, unless a fuller discourse context is established.

Procedure. Subjects were tested individually in their school environment. Children were asked to enact the sentences with toys. Sentences were spoken by the experimenter in a neutral intonation. Adults had to listen to the sentences

and tell immediately after each sentence who had jumped into the destination location.

We hypothetized that the use of the deictic pronoun to express switch reference may first arise under the impact of written language. Therefore, a few weeks after the initial oral testing, the school children and the adults worked with the same list in a written form. They had to read the sentences and answer a question (e. g. *Who jumped into the car?*) in writing after each sentence. For this subsample of five groups we have one additional repeated measures factor in the design–presentation mode.

Results

Answers were coded in terms of numbers of uses of the repeated subject strategy, and an analysis of variance was performed for the choice of subject. Table 1 presents the analysis of variance, and Table 2 the means for those effects that reached significance.

Table 1
Summary of the analysis of variance in Experiment I.

Factor	d.f.	F	p
Age	6,133	8.97	.00001
Anaphora	1,133	2.01	n.s
Activity	1,133	139.01	.00001
Verb token	4,532	12.52	.00001
Age×Ana	6,133	1.28	n.s
Age×Act	6,133	13.65	.00001
Ana×Act	1,133	< 1	n.s.
Age×V	24,532	6.70	.00001
Ana×V	4,532	11.24	.00001
Age×Ana×Act	6,133	1.38	n.s.
Age×Ana×V	24,532	1.09	n.s.

Table 2.
Choice of the repeated subject alternative for different verb types in Experiment I (%)

	3	5	6	7	8	9	Adult	All
pet	50	80	95	78	90	85	75	79
sniff	68	95	100	98	98	90	83	90
kiss	95	83	98	92	83	90	98	85
chase	45	75	85	80	80	68	3	62
frighten	50	70	85	82	60	68	5	60
accompany	45	70	88	80	72	88	88	76
All inac.	58	86	98	90	90	88	85	85
All act.	47	72	86	81	71	74	32	66
Overall	52	79	92	85	80	81	58	75

The first and most surprising effect was a negative one: the anaphora type used had no effect at all on the interpretation selected for the agent of the second predication. At the same time, in the ANOVA, the type of the verb was by far the most significant determiner of sentence interpretation. As the lower part of Table 2 shows, there was a strong general preference (75%) for the repeated subject strategy. This preference does not show up as an effect im the ANOVA, since it appears merely as an overall shift in the dependent variable. If the patient was active in the first clause, the repeated subject option was selected only in 66% of the sentence, while if it was not active the anaphor was identified with the subject 88% of the time. This preference for a repeated subject is clearly present at age 5, but not at age 3 where the results are essentially random. We cannot determine from these results whether the strategy is missing at the younger age or whether the three-year-olds simply failed to understand the task.

Not only was there no main effect of anaphora type, there was also no interaction between anaphora type and the activity of the patient in the first clause. The strong interaction of age with activity of the patient was due to the fact that adults relied far more than children on the action readiness constraint.

There were large differences between the individual verb tokens originally allocated to the antecedent classes. These differences were especially clearcut in adults: following *chase* and *frighten* there was an almost exclusive use of the patient as subject of the second predication, while *accompany* (which was also grouped in this class) did not show these effect. These results indicate

clearly that we had made a mistake in grouping *accompany* together with the other two verbs. In fact, the verb *accompany* 'elkíséri' does not generate any strong action readiness for either the agent or the patient.

Finally, we should note that the results for the written and oral versions of the experiment were identical. Thus, there was no particular evidence that anaphoric relations are controlled earlier in written discourse.

Discussion

The results of this experiment went against the expectations we had derived both from research in English comprehension and from our own earlier studies of adult Hungarians. The fact that even adults did not apply the switch reference interpretation to the deictic pronoun indicates that the application of switch reference is far less automatic than we had thought. Most probably, the switch reference interpretation of the deictic requires the establishment of a convincing discourse frame within which there is an active competition between actors for roles.

What we have here is a formal morphological anaphoric marking that behaves very differently from the formal morphological anaphoric narking for gender found in English. In English, processing of the formal marking appears to pre-empt, precede, or dominate over processing of other sources of information (Chang 1980; Springston 1975). Simply put, pronoun gender is a highly reliable cue (MacWhinney et al. 1985) in English. In Hungarian, the formal cue is much lower in reliability and requires much more complex processing. From a functionalist perspective (Bates and MacWhinney 1982), the absence of gender and animacy marking means that this cue cannot depend on lexical cues, therefore it must be determined by cues that require inter-clausal processing. Because of this, in Hungarian, cues such as parallel function and action readiness preempt the formal morphological marking rather than the other way around. Given this, we will need to be quite careful in making generalizations about universal tendencies to give preference for formal cues over discourse cues, as suggested by the modularists. Smaby (1979) has proposed the opposite type of precedence–pragmatic constraints dominating over formal constraints. Although this principle might work for Hungarian, it is not clear how his principle could work for the English data. Together, the data from Hungarian and English seem to fit most adequately with models that allow for a general integration of various cue types as in the on-line account of Marslen-Wilson and Tyler (1981) and the competition model of MacWhinney, Bates, and Kliegl (1984).

Experiment II was designed to clarify these precedence relations between the formal and the pragnatic cues. We wanted to see whether anaphoras are obligatorily processed even if they are not required for the interpretation of the sentence. A reading time experiment was designed to obtain some rough measures of processing load with the same list used in Experiment I.

Experiment II: Anaphora resolution in reading

Methods

Subjects. Sixteen undergraduate psychology stuudents from Lorand Eotvos University in Budapest participated in the experiment on a volunteer basis. All had already some experience as subjects in reading time experiments using a video screen.

Design. The same list was used as in Experiment I in the same random order. However, half of the subjects were presented with an ascending and half of them with a descending version of the list. This was done to counterbalance possible ordering effects. Since an initial analysis of variance indicated that order of presentation had no effect here, data will be treated in a 2 × 2 × 3 within subject design with Anaphora Type, Verb activity and Verb token as factors, the same way as in Experiment I.

Precedure. Subjects had to read the sentences on a video screen controlled by a special-purpose microcomputer. Each sentence was broken down to its two clauses. The first clause was presented for 5 seconds. Immediately after the first clause disappeared, the second clause appeared on the screen. The subject could read this as long as he wanted. When he was ready to answer the "who jumped" question he pushed the space bar and gave his answer orally. Following a 10 seconds inter-stimulus interval the next sentence appeared on the screen. In this way two dependent measures were obtained: 1) the time from the onset of the second clause until the subject indicated the beginning of his answer and 2) the choice of the repeated subject alternative in the answers themselves. These two measures will be referred to as "reading time" and "choice".

Results

For the choice measure, the only significant effect was that of the anaphora type used $F(1,15) = 9.56$, $p < .01$ (see Figure 1). In contrast, the time to read the second clause was only influenced by the nature of the verb of the first

clause. As the lower part of Figure 1 indicates, this means that sentences with
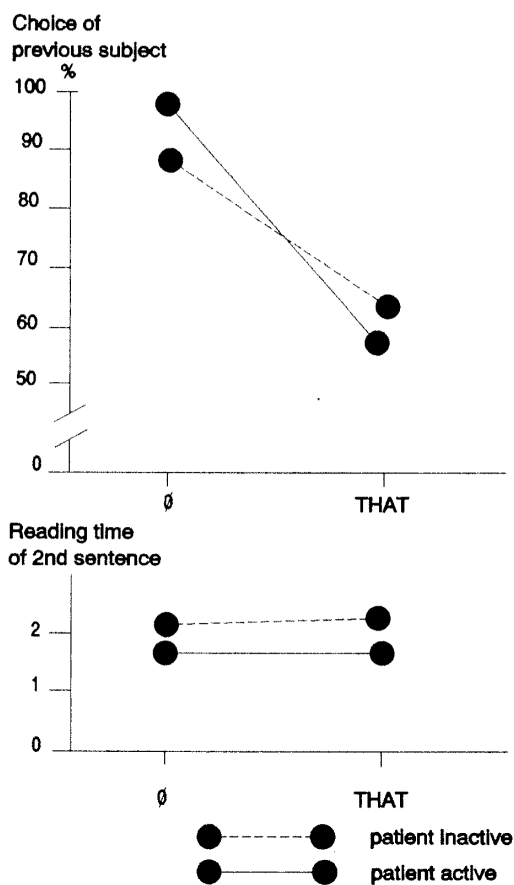a pragmatic bias towards a switch reference interpretation took longer to read.

**Choice of
previous subject**

Figure 1. Selection of the antecedent subject and reading times for the proform
sentence when a subject change is implied (broken lines)
and when it is not (solid lines)

Discussion

We can understand these superficially conflicting results by thinking about the differences between the tasks in Experiments I and II. In Experiment I the two clauses were processed as a single unit. In Experiment II, subjects were given a fairly long time (5 seconds) to read and encode the first clause. This allowed them to "set up" a parallel function strategy that would cut down their response times for the reading of the second clause. This strategy would allow them to provide the subject of the first clause as the subject of the second clause whenever there was no information in the second clause conflicting with this assignment. In such cases choice of the previous subject as the referent was close to 100%. Overall, choice of the previous subject as referent was higher than in the previous experiment, indicating that this parallel function strategy was indeed in effect. However, what is most interesting is that subjects were unable to simply override the information contained in the relation between the verb of the first clause and the verb of the second clause. When the patient was active in the first clause, this tended to facilitate a switch reference reading of the second clause which then was in competition with the parallel function strategy that the subjects were trying to enforce.

The results for the effects of the type of anaphoric marking have to be understood in a somewhat different fashion. The shape of the anaphor had no influence on reading times for the second clause, only on the choice itself. For sentences where parallel function and action readiness go against a switch reference reading, it appears that the presence of the deictic does not slow down reading. Thus, unlike the action readiness cue, the pronominal switch reference cue can easily be overruled. This conforms with our intuitions as Hungarian speakers regarding the lability of the switch reference assignment induced by the pronoun. If the stage for a switch of reference has already been set, the pronoun can tip the balances in favor of the switch reference reading. If the stage has not yet been set, the deictic pronoun can trigger a switch reference reading or it can be ignored and the parallel function reading maintained.

The results of this experiment set some limits on the possible relations between the formal and the pragmatic cues for anaphora resolution in Hungarian. The fact that the verb-based pragmatic bias actually slowed down processing rather than speeding it up clearly suggests that one cannot presuppose a strategy where implicit processes would always preceed the application of the formal means. But this is only to say that, even for Hungarian, we cannot follow Smaby (1979) in imagining that consideration of pragmatic factors

always takes precedence over consideration of formal cues. In Experiment III we try to shed some further light on these issues by examinig a construction in which a verb-based lexical cue for switch reference competes with the pronominal cur for switch reference.

Experiment III: Verb-based switch reference versus pronominal switch reference

Grober et al. (1978) made use of interpersonal communication verbs which promote a switch reference in order to study pronoun disambiguation. We can study a similar competition in Hungarian between verb-based switch reference and the switch reference interpretation of the deictic pronoun. Consider sentences such as (15) and (16). In (15) the formal constraint on anaphora interpretation provided in English by gender agreement is consonant with the semantics of *apologize*, while in (16) this semantics is contradicted by gender agreement.

(15) *John apologized to Mary because he forgot to mail the letter.*
(16) *John apologized to Mary because she forgot to mail the letter.*

In Experiment III we crossed this feature of verb semantics with the zero anaphora – deictic pronoun anaphora contrast in Hungarian. Interpersonal verbs were selected which either presupposed that the agent of the main verb did something which was the reason for her/him of doing the activity denoted by the main verb, or on the contrary presupposed the patient of doing something which served as the cause of the main action. By crossing this with the zero–that contrast sentences like (17) and (18) were used. In 17 the (a) version while in (18) the (b) version is the one where there was no contradiction between the two sources of information concerning co-reference relations, since the zero anaphora assigns the subject role in the second clause to the previous subject, while that suggests a switch subject according to the formal model. At the same time there was a contradiction between the formal anaphora model and verbal semantics in 17b and 18a.

(17)(a) *John apologized to Bill because ∅ forgot to mail the letter.*
   (b) *John apologized to Bill because that forgot to mail the letter.*

(18)(a) *John blamed Bill because ∅ forgot to mail the letter.*
   (b) *John blamed Bill because that forgot to mail the letter.*

A reading time experiment was performed with sentences of this, kind to see whether the conflicts introduced by contradictions influence ease of processing.

Methods

Subjects. Twenty undergraduate psychology students of Lorand Eotvos University in Budapest participated voluntarily in the experiment. They all had some previous experience participating in computer controlled reading time experiments.

Materials and design. An experimental list of 28 sentences was constructed in the following way. Seven pairs of interpersonal verbs were selected. In each pair there was a contrast between presuppositions favoring agent or the patient as the cause of the main action. The following pairs were selected:

Agent Presupposed	Patient Presupposed
apologized	*condemned*
begged	*congratulated*
confessed	*blamed*
asked for directions	*gave directions*
begged pardon	*reprimanded*
confessed	*pardoned*
acknowledged	*criticize*

Compound sentences with the selected verb as the main verb and a *because*-clause were constructed in the following way: with each verb pair the causal clause was always the same except that there was one version with zero and one with that *az* the subject in the second clause with each verb. This insured control for word length, frequency and other factors affecting reading speed.

The design was as follows: 2 (Anaphora Type) × 2 (verb-based switch reference) × T (verb tokens). The list of 28 sentences was administered in the context of a much longer list of 168 sentences containing relative clauses. This was done to minimize the use of task-specific strategies. The entire list was divided into five blocks with each subject receiving a different ordering of the blocks.

Procedure. Subjects read the sentences on a televison screen directed by a special purpose microcomputer. They had to push the space bar when they

had finished understanding the sentence. After that, a question concerning the agent of the second sentence appeared on the screen (e.g. for (17) and (18) this would be *Who has forgotten to mail the letter?*). They had to push the bar again when they were ready to respond ang give their response orally. Three dependent measures were obtained in this way: reading time, decision time and selection of the repeated subject option.

Results and discussion

Table 3 presents the most important effects of the analysis of variance and Figure 2 shows the means.

Table 3.
Analysis of variance tables for the three dependent measures in Experiment III.

	d.f.	Reading		Decision		Choice	
		F	P	F	P	F	P
Anaphora	1,19	6.38	.002	< 1	n.s.	58.68	.00001
Pragmat.	1,19	11.09	.005	3.76	n.s.	227.07	.00001
ProxPrag.	1,19	21.11	.0002	4.70	.05	87.61	.00001

The effects of the verb tokens themselves were minimal, so we will focus on a discussion of the verb-based and pronoun-based cues. For choice, the verb-based cue had an overwhelming effect. As the upper part of Figure 2 shows, the average selection of the repeated subject option in the agent biased sentences was 62% while in the patient biased sentences it was only 3%. This asymmetry indicates that the bias is in fact a stronger bias for verbs such as *criticize* than it is for verbs such as *apologize*. The main effect of the anaphora type and the strong interaction between the anaphora type and the pragmatic bias is due to the agent biased sentences. For these sentences, the use of switch reference anaphora (that) produced a 71% interpretation against the pragmatic bias. In patient presupposed sentences (see the flat broken line) the anaphora type did not matter in choice: it was exclusively based on verbal pragmatics. The absence of an effect of switch reference in patient-presupposed sentences is probably best understood as due to a floor effect for these sentences.

The reading and decision times show the interactions between the two cues even more clearly. In reading times there was a main effect of pronominal switch reference (sentences with the switch reference anaphora taking longer to read) and pragmatic bias (patient bias being faster). However, the interaction between these two factors was much stronger as the middle part of Figure 2
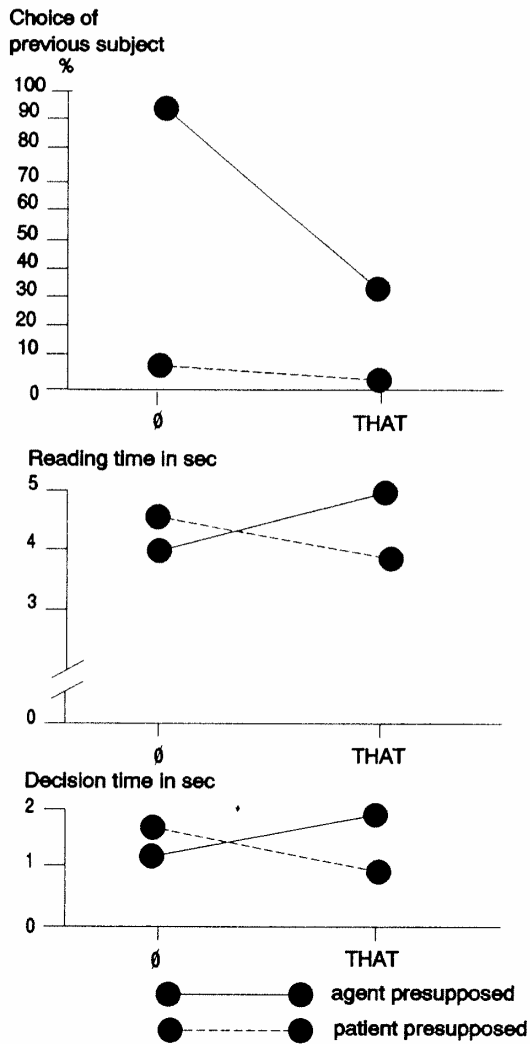
Figure 2. Choice of main clause subject as coreferent (above) reading times (middle),
and decision times (lower chart)
in pragmatically different "because" sentences

shows. The use of the switch anaphora slowed down reading in the agent biased sentences, while it slightly speeded up reading when the two cues pointed towards the same coreferent. In decision times only this latter interaction reached significance (see the bottom of Figure 2).

General discussion

The most important results of these studies relate to the ways in which the cue to switch reference is integrated with the other cues to anaphora resolution. Experiments 1 and 2 showed that, at all ages, switch reference marking is a much weaker than either verb-based expectations or the parallel function strategy as a cue to sentence interpretation. Although switch reference had a significant effect in Experiment 2, this effect was conditioned on the presence of a verb-based expectation for role switching. Experiment 2 indicated that processing of the switch reference pronoun does not slow up reading in the same way that action readiness of the patient slows down application of the parallel function strategy. We can think of this as a contrast in the relative reliability of the two cues. The switch reference cue is an important one, but it is conditioned by many other cues and easily overriden. Action readiness, on the other hand, is a highly reliable cue — at least for the verbs *chase* and *frighten*.

However, it is also probably the case that the effect of switch reference in Experiment II is muted by the presence of the 5 second gap between first and second clauses. In Experiment III there was no interclausal gap and there we found the same pattern of statistical interactions indicating cue summation that we have found in many other studies testing aspects of the cue integration in the competition model (MacWhinney et al 1984, MacWhinney et al. 1985). Thus, although the switch reference marker was relatively weak in all three studies, it was strongest when the discourse context was presented in a smooth and natural way. This again indicates that processing of the switch referent marker is dependent upon a wide variety of cues occurring in integrated natural discourse.

How can Hungarians achieve on-line integration of parallel function, action readiness, factive switch reference, and pronominal switch reference? Does processing of these four types of cues require access to all of the listener's knowledge or can we define a constrained set of processes required for this integration?

The competition model can be extended to provide a reasonable account of this integration. Let us consider how the model will need to account for the four basic cue types:

1. Parallel function: We must assume that, during the processing of a clause, listeners bind NP referents to a handful of roles. For our current purposes, these roles are: perspective (MacWhinney, 1977), topic, given, agent, and patient. Referents associated with these roles carry over their association into subsequent clauses (Bock, 1982)

2. Action readiness: In addition to these basic roles, listeners use verbs to determine additional activity properties for these roles such as action readiness. More work will be needed to determine the status of additional properties of this type. Like the roles discussed above, these roles will carry over into subsequent clauses. However, these roles will not simply continue in the next clause unchanged. Instead they will potentiate the treatment of their referents as actors in the next clause.

3. Implicit causality: In the case of verbs such as *criticize* the listener will associate with the arguments of the verb in the first clause an implicit "factive cause" role. In the case of *criticize* the factive cause role is associated with the patient. In the case of *apologize* the factive cause role is associated with the agent. These roles are then expanded in the subsequent clause.

For the last two factors, the generation of roles in the first clause is governed by specific verbs. But note that the roles established in the first clause in this way need not be continued or expanded. A switch reference marker can defeat parallel function binding. In the case of action readiness and the factive cause role, the discourse may simply continue without saying what the rabbit did after it was frightened or why Bill apologized to Fred. The point is not that these roles must be filled, but that they are generated in the first clause so that when the listener reaches the second clause he can choose between a small set of well-delimited roles that will allow him to disambiguate pronominal coreference.

This proposal resembles in various ways the proposal for the processing of givenness and coreference offered by Sanford and Garrod (1980). In its emphasis on the dynamics of binding to roles, the proposal offered above is very much like the principle of maximum efficiency proposed by Tyler and Marslen-Wilson. By making role assignments available from clause to clause, the processing of each subsequent clause is made faster and backtracking is

minimized. At the same time, there is a certain way in which the delimiting of a small set of discourse and syntactic roles that can be carried over between clauses tends to insulate the processing system from the whole of cognition. Because inter-clausal processing is governed by a small set of assigned roles, the competition between alternative referents for an anaphor can occur in a semi-insulated space. This space allows for all lexical influences and for the influences of a small set of discourse entities. What is most important about this proposal is that it opens the door for an integration between the analysis of clausally-based syntax and discourse-based syntax, as occurs in the processing of switch reference in Hungarian.

Appendix I. List of sentences used in experiments I and II

In this appendix, sentences with zero anaphora are always given first, followed then by sentences with the deictic anaphoric pronoun *az*.

INACTIVE PATIENT

A medve símogatja a bárányt és aztán beugrik a kocsiba.
'The bear pets the lamb and then jumps into the car.'

A szarvas símogatja a medvét és aztán az beugrik a kocsiba.
'The deer hugs the bear and then that jumps into the car.

A bárány megszagolja az elefántot és aztán beugrik a kocsiba.
'The lamb sniffs the elephant and then jumps into the car.'

Az elefánt megszagolja a malacot és aztán az beugrik a kocsiba.
'The elephant sniffs the pig and then that jumps into the car.'

A bárány megpuszilja a szarvast és aztán beugrik a kocsiba.
'The lamb kisses the dear and then jumps into the car.'

A malac megpuszilja az oroszlánt és aztán az beugrik a kocsiba.
'The pig kisses the lion and then that jumps into the car.'

ACTIVE PATIENT

Az elefánt kergeti a bárányt és aztán beugrik a dobozba.
'The elephant chases the lamb and then jumps into the car.'

A kecske kergeti a vízilovat és aztán az beugrik a dobozba.
'The goat chases the hippopotamus and then that jumps into the box.'

A ló megijeszti a medvét és aztán beugrik a szobába.
'The horse frigtens the bear and then jumps into the room.'

A medve megijeszti a lovat és aztán az beugrik a szobába.
'The bear frightens the horse and then that jumps into the room.'

Az oroszlán elkíséri a malacot és aztán beugrik a kocsiba.
'The lion accompanies the pig and then jumps into the car.'

A gorilla elkíséri az oroszlánt és aztán az beugrik a dobozba.
'The gorilla accompanies the lion and then that jumps into the box.

Appendix II. List of sentences used in experiment III.

Within all units of four sentences everything was the same except that in the first two sentences the verb implying the cause on the part of the agent and in the second two that on the part of the patient was used and (a) and (c) sentences used a zero (b) and (d) a that-anaphora. Therefore we only give the first four sentences in detail, with the others only the a sentence and the two verbs used.

APOLOGIZED – CRITICIZE / ENÉZÉST KÉRT – MEGBÍRÁLT

(a) *Pali elnézést kért Ágitól, mert nem ment haza.*
'Paul apologized to Mary because did not go home.'

(b) *Pali elnézést kért Ágitól, mert az nem ment haza.*
'Paul apologized to Mary because that did not go home.'

(c) *Pali megbírálta Ágit, mert nem ment haza.*
'Paul criticized Agnes because did not go home.'

(d) *Pali megbírálta Ágit, mert az nem ment haza.*
'Paul criticized Agnes because that did not go home.'

BEGGED – CONGRATULATED / SZABADKOZOTT – GRATULÁLT

(a) *Józsi szabadkozott Verának, mert beengedte a vendégeket.*
'Joseph begged Vera because let in the guests.'

CONFESSED – BLAMED / VALLOMÁST TETT – BEOLVASOTT

(a) *Imre vallomást tett Győzőnek, mert elvesztette a kéziratot.*
'Imre made a confession to Victor because last the manuscript.'

ASKED FOR DIRECTIONS – GAVE DIRECTION / ÚTMUTATÁST
KÉRT – ÚTMUTATÁST ADOTT

(a) *Tibor útmutatást kért Iréntől, mert elfelejtette a receptet.*
'Tibor asked directions from Iren because forgot the recipe.'

BEGGED PARDON – REPRIMANDED / BOCSÁNATOT KÉRT – RÁRIPAKODOTT

(a) *Ádám bocsánatot kért Gézától mert nem hozta el a füzetet.*
'Adam begged pardon from Geza because did not bring the copy book.'

CONFESSED – PARDONED / BEVALLOTTA – MEBOCSÁTOTTA

(a) *Gyuri bevallotta Dezsőnek, hogy nem olvasta el a könyvet.*
'George confessed to Dezso that did not read the book.'

AGKNOWLEDGED – CRITICIZED / BEISMERTE – FELHÁNYTORGATTA

(a) *Gizi beismerte Tóninak, hogy megette a főzeléket.*
'Gizi acknowledged to Tony, that ate the cooked vegetables.'