

The Role of Closure in Language Processing ¹

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1. INTRODUCTION

This paper contrasts two classes of language processing models in terms of the differential ease of processing of various structures. It is argued that a processing strategy of closure explains why certain types of structures are easier to process and more frequent than others. It is concluded that those processing models not incorporating a closure strategy should be rejected as inadequate to account for actual language processing.

The two models are characterized and contrasted in section 2, while in section 3 a wide range of evidence is adduced in support of the existence of closure strategy. Section 4 contains a summary and conclusions.

2. TWO MODELS OF LANGUAGE PROCESSING

No one would deny that grammatical knowledge must play an important role in actual language processing, but the precise nature of that role in comprehension, production, and acquisition is still uncertain. Although a host of alternative proposals has been offered over the past several years as to how language processing takes place, Foss and Hakes (1978) have distinguished two general classes of processing models, namely the 'direct incorporation' models and the 'strategy' models.

As the older and perhaps more familiar of the two approaches, the direct incorporation models assume that the speaker (or hearer) mentally executes those steps represented in the linguist's formal grammatical description as he produces (or comprehends) sentences. The most familiar version of this model is the so-called 'derivation theory of complexity', which was associated with much of the psycholinguistic research of the 1960's (cf. Miller and McKean 1964;

Fodor, Bever, and Garrett 1974). According to this theory, the speaker-hearer was hypothesized to utilize a transformational grammar in his production and comprehension activities such that as he processed a sentence psychologically, he mentally worked his way through its transformational derivation. Although the derivational theory of complexity has now been largely discredited (cf. Fodor, Bever, and Garrett 1974), other direct incorporation models are at least logically possible and indeed some have recently begun to appear (e.g. Ford, Bresnan, and Kaplan 1982). What is crucial in all direct incorporation models is not the kind of grammar involved, but rather the claim that the psychological processing steps carried out by the speaker-hearer are analogous to, or isomorphic with, the formal grammatical operations (rules) associated with the derivation of the sentence being processed. More important, perhaps, is the fact that the direct incorporation models attempt to account for all language processing phenomena in terms of grammatical factors. These models by and large deny the relevance of separate cognitive factors, such as processing heuristics, claiming instead that the grammar bears the full burden in processing.

In the second general class of processing models, the 'strategy' models, grammar also plays an important role, but unlike the direct incorporation models, the strategy approaches assume that the language user has access to grammatical (usually surface) structure, but not necessarily to the formal linguistic rules which the linguist constructs to account for the distributional properties of sentences. The crucial characteristic of the strategy models is that, in addition to accessing a knowledge of linguistic structures, the speaker-hearer also employs a battery of processing heuristics, often called 'perceptual', 'parsing', or 'cognitive' strategies, which he uses in comprehension, for example, to construct meaning representations directly from the surface structures he has mentally formed.

At the present state of research, serious problems can be discerned with both types of processing models, and it is useful to discuss these briefly. Within the direct incorporation models, both empirical and conceptual problems have

been uncovered. The derivational theory of complexity, for example, required that the more transformationally complex the formal derivation of a sentence, the more difficult psychologically the sentence should be to process. Accordingly, within the context of the transformational model most commonly associated with that theory (e.g. Chomsky 1965), a truncated passive should be more, not less, difficult to process than a full passive, and a prenominal adjective construction should be harder than one containing a relative clause. Both these predictions, and a host of others, have not been borne out empirically (cf. Fodor, Bever, and Garrett 1974: Ch. 5). Moreover, as revisions have taken place within linguistic theory, experimental results have had to be constantly reassessed against evolving theoretical perspectives. However, the conceptual issue still remains that it is a category mistake² to equate a formal linguistic rule with a psychological process, since the former deals with a description of linguistic objects (sentences, etc.), while the latter deals with mental processes taking place in the human mind in real time.

Similarly, there are difficulties with the strategy approach to language processing. The most obvious conceptual problem is the lack of a clear specification of what is meant by a strategy, coupled with a lack of understanding as to how strategies are interrelated. A secondary problem concerns how strategies interact with grammatical structure. Taking the first problem first, we can note that in Bever's (1970) early 'perceptual strategy' program, it was assumed that the hearer parses sentences to obtain surface structures, then uses various strategies, plus a wealth of lexical information, to construct semantic representations rather directly. For example, Bever (1970:290-293) suggests that the following four strategies are involved in comprehension:

STRATEGY A. Segment together any sequence X ... Y, in which the members could be related by primary internal structural relations "actor action object ... modifier".

STRATEGY B. The first N ... V ... (N) ... clause (isolated by Strategy A) is the main clause, unless the verb is marked as subordinate.

STRATEGY C. Constituents are functionally related according to semantic constraints.

STRATEGY D. Any Noun-Verb-Noun (NVN) sequence within a potential internal unit in the surface structure corresponds to "actor-action-object".

Strategy C is clearly semantically based and has no language-specific aspects, while Strategies A, B and D are directly dependent on English syntactic properties. Indeed, the confounding of language-specific with language independent factors on the one hand, and of semantic with syntactic factors on the other, plagued early versions of the strategy model. Later, however, attention came to be focused on those language independent factors which could be isolated and then viewed as interacting with the specifics of a given language structure.

A further problem concerns the distinction between a strategy on the one hand and a rule of grammar or a statement of grammatical structure on the other. When the strategy paradigm was first being developed, a strategy and a rule of grammar were often understood as being the same thing. As Slobin (1970:175) commented, 'We approach grammar as a set of linguistic strategies used to express various semantic relationships in spoken utterances'. Similarly, Lakoff and Thompson (1975: 295) argued that:

...GRAMMARS ARE JUST COLLECTIONS OF STRATEGIES FOR UNDERSTANDING AND PRODUCING SENTENCES. From this point of view, abstract grammars do not have any separate mental reality; they are just convenient fictions for representing certain processing strategies. (original emphasis)

Presumably, Lakoff and Thompson are inveighing against versions of generative transformational grammar when they speak of 'abstract grammars'. However, just because a grammar is not directly incorporated into a processing model

does not mean that grammar is another name for strategies. Indeed, as the strategy paradigm evolved, it became obvious that strategies should be understood as general, usually language independent, cognitive processes which are often manifested in other domains as well as being operative within language processing.

In summary, the strategy approach to language processing assumes the existence of a set of general strategies and it views production and comprehension as involving the interaction of language independent strategies with language-specific structural factors.

How then can these alternative approaches to language processing be assessed? Are there phenomena which will, in principle, distinguish between the two approaches? It will be argued below that there are several phenomena which allow the two types of processing models to be distinguished on empirical grounds. In particular, it will be suggested that a wealth of evidence exists in support of a strategy of closure, such that any processing model which incorporates this strategy will predict that certain structures are easier to process and more frequent than equally grammatical syntactic alternatives, while a model not incorporating the closure strategy will fail to make such a prediction, and thereby be inadequate as a processing model.

3. CLOSURE

The well-known psychological principle of closure can be characterized as the tendency for perceptual units to resist interruption and to be perceived as single entities rather than as two or more separate ones (cf. Fodor, Bever, and Garrett 1974: 330). While evidence for closure has been adduced from a variety of perceptual domains (e.g. visual perception, music), its earliest application to linguistic processing seems to be that found in the interpretation of Ladefoged and Broadbent's (1960) click migration study. In that work, it was suggested that the perception of click locations away from their actually occurring positions and toward constituent boundaries is a result of a principle of closure, coupled with subjects' knowledge of the (surface) structure of the stimuli they were hearing. Bever (1970) alludes to the closure strategy

several times. For example, Strategy A cited above claims that a set of constituents will be grouped together on the basis of membership in the same clause, which in turn requires that the speaker-hearer knows what constitutes the minimal components of a clause in English. At the same time, however, Strategy A requires language-specific knowledge of word order. Abstracting away from language-specific factors and toward the formulation of language independent 'operating principles' was proposed by Slobin (1973). One of his most important proposals was his 'Operating Principle D', which states that the language user will tend to avoid, or treat as relatively more difficult, structures which contain interruptions or which deviate from the 'normal' word order expected in a particular language. Here we find a language-independent formulation of closure, coupled with a second language-independent strategy of what might be called 'normal form' (Prideaux and Baker 1982). In general terms, closure can be formulated as follows:

CLOSURE: In processing a particular linguistic unit (clause, phrase, etc.), the speaker or hearer tends to complete that unit at the earliest possible point.

Within the comprehension, closure can be interpreted as the hearer's attempt to complete a particular clause, etc., as soon as the minimal structural properties for that unit have been satisfied. At a certain point, the hearer is able to complete his construction of the semantic representation of that unit, and he can therefore dispense with the syntax, retaining only the meaning. Closure therefore obtains when the semantic representation for the unit is executed (Kimball 1973). The closure strategy predicts that, if a main clause is interrupted by a subordinate clause, the entire structure should be more difficult to process than a case in which the subordinate clause comes at the end of the main clause. In terms of production, closure suggests that the speaker tends to place subordinate constructions at the extremities of main clauses rather than within them. In other words, the closure strategy predicts that non-interrupted structures should be easier to comprehend and produce than those with interrupting clauses. If this is so, then there should be

a tendency for non-interrupted structures to be more frequent than interrupted ones.

Two important points must be kept in mind about the notion of a processing strategy. The first is that a strategy is just that -- a heuristic device, grounded in the human cognitive system, which is employed, albeit unconsciously, by the speaker or hearer as he processes language. It is not a steadfast rule, free from exceptions. Nevertheless, the usefulness of a strategy resides in the fact that it works so often; its high success rate supports its continued utilization, for if it failed to facilitate processing, it would surely be discarded as useless. The second point is that a strategy must by definition interact with language-specific grammatical knowledge. For example, if a given language permits both internal and sentence-initial or sentence-final subordinate clauses, the interaction of the closure strategy with these facts predicts that, all other things being equal, interrupted structures will be more difficult to process, less frequent, and even perhaps harder to acquire than non-interrupted ones. Such a prediction would not follow from the structural facts alone, but only when the structures are acted upon by the strategy.

Empirical evidence in support of closure is not hard to find, although the closure interpretation of certain empirical facts is sometimes disputed. In what follows, some anecdotal evidence in support of closure will first be presented, and then several experimental studies will be discussed.

English contains sentences such as:

- (1) a) That for Fred to win the race is easy is obvious.
- b) It is obvious that for Fred to win the race is easy.
- c) It is obvious that it is easy for Fred to win the race.

It has often been observed that these structures differ in perceived difficulty, with (1a) the hardest, (1b) next, and (1c) the easiest. Most English speakers

do not seem hesitant to accept (1c) readily, although many tend to reject (1a) as incomprehensible. While all three examples are 'grammatical' in some ideal sense, the reason for the relative differences in ease of processing can be found in the action of the closure strategy: sentence (1c) contains no interruptions, (1b) contains one interruption, and (1a) contains two. Closure therefore predicts precisely the relative order of difficulty which our intuitions reveal. Interestingly, such sentences also constitute counter-evidence for the derivational theory of complexity, since (1a) is closer in form to the presumed deep structure than is either of its two paraphrases, and yet is the hardest to process.

A second class of sentences has also been widely discussed as offering some evidence for the closure strategy, namely the so-called 'garden path' sentences such as Bever's (1970) famous example:

(2) a) The horse raced past the barn fell.

In this example, the hearer expects the main clause to be completed after the word barn since at that point all conditions for a simple sentence have been satisfied. What is not anticipated, of course, is that raced is both a past tense and a past participle, and accordingly when used as a past participle, as in (2a), it may be confused with the past tense form. If, however, the missing relative pronoun and a form of be are included, there is no chance of misinterpretation, as in (2b).

(2) b) The horse which was raced past the barn fell.

The reason for no misinterpretation of (2b) is clear: once the hearer encounters the relative pronoun, he knows that he is into a relative clause and thereby expects that the first verb he hears will be a part of that subordinate clause. Once again, knowledge of the structure of English interacts with closure, with the result that (2a) should be harder to process than (2b), again in accord with our intuitions.

While these two examples appear to constitute impressive evidence in support of closure, they might also be given other interpretations. For example, it might be argued that the order of difficulty of the example in (1) can also be explained by a variable weighting of the extraposition transformation such that the heavier a clause, the more likely (i.e. frequently) it is to be extraposed. Similarly, the difficulty of (2a) might be explained by calling upon a frequency-based argument along the lines that if a past tense and a past participle of a given verb share the same form, then whenever the hearer encounters the form in a potentially ambiguous construction, he always opts for the more frequent past tense form as his first interpretation. Both explanations might be plausible, even though the reason for a differential weighting for the extraposition rule remains unknown, as does the source for differential frequencies of verb forms.

Since alternative explanations are, at least in principle, available for the judgements discussed above, it is useful to turn to experimental data in which the closure strategy can be more directly assessed.

As discussed above, some of the earliest experimental evidence in support of closure was the Ladefoged and Broadbent (1960) click study. Later click studies provided continued support for the claim that subjects tend to perceive clicks at major constituent boundaries, thereby supporting the perceptual integrity of major constituents and hence closure. One of the most telling of the later studies was that of Ladefoged (1967), who told subjects that the sentences they were to hear contained 'subliminal' clicks, and that their task was to indicate the click locations. In fact, there were no clicks in the stimuli, but subjects contended that they heard clicks at major constituent boundaries.

Holmes and Forster (1970), using reaction time as a dependent variable, found that clicks located within major constituents were responded to more slowly than those at constituent boundaries. These and a host of other click studies suggest that hearers impose at least major constituent structure on sentences and tend to maintain the integrity of such constituents in such a way that closure forbids their easy interruption.

Relative clauses constitute one of the commonest types of subordination in many languages. Since in English a relative clause can be formed on an NP playing virtually any grammatical role, a set of sentences containing relative clauses in different positions provides a useful domain for investigating the role of closure. As a SVO language in which the relative clause follows the modified NP, English permits both interrupting and non-interrupting relative clauses. Closure predicts that sentences with interrupting relative clauses should be more difficult to process and less frequent than those in which the relative clause is final, even though both types are perfectly grammatical. Here grammaticality does not conflict with or become confounded with closure as was the case in the examples in (1). According to closure, then, a sentence like (3a) should be easier to process and more frequent than one like (3b).

- (3) a) The man saw the thief who stole the briefcase.
 b) The thief who stole the briefcase saw the man.

In a study dealing with English relative clause structures, Sheldon (1977) had subjects listen to sentence with both interrupting and non-interrupting relative clauses. Her stimuli consisted of the following four types, with examples of each:

- (4) SS: S(RPs V O) V O
 The dog that bit the man chased the cat.
 SO: S(RPo S V) V O
 The man that the dog bit chased the cat.
 OS: S V O(RPs V O)
 The dog chased the cat that bit the man.
 OO: S V O(RPo S V)
 The dog chased the man that the cat bit.

In the coding to the left of each structure, the first letter refers to the grammatical role of the NP to which the relative clause is attached (subject or object), while the second letter refers to the grammatical role (again,

subject or object) played by the relative pronoun. Sheldon had each subject listen to a sentence, immediately after which two wh-questions were asked, one based on the main clause and one on the relative clause. She tabulated the subject's errors and found that non-interrupted structures (OS and OO types) contained fewer errors than the other two types; the former are therefore easier to process, providing support for closure. When presented with non-interrupted structures, the hearer can complete his construction of the meaning of the main clause before he begins processing the subordinate clause, but with interrupted structures, he can construct only a part of the main clause's meaning, then must hold this information in storage while processing the subordinate clause, and finally complete the processing of the main clause.

Townsend, Ottaviano, and Bever (1979), using a probe-latency task, investigated a variety of complex sentences, including those with both interrupting and non-interrupting relative clauses. They found that subjects processed non-interrupted clauses faster than interrupted ones, and they also found that those clauses with the 'normal' SVO word order were processed faster than those with the non-standard OSV word order. These results constitute support for closure and for the normal form strategy mentioned above.

In a comprehension experiment designed to evaluate the closure strategy and its interaction with other strategies, Prideaux and Baker (1982) constructed four lists of 32 sentences each, based on the structures in (4). Each of the 61 subjects was seated before a computer-controlled CRT screen, and sentences were presented visually one word at a time. The rate of presentation was controlled by the subject, who pressed a button to make the next word come on. The latencies between words were measured. After the completion of each sentence, the subject had to recall the previous sentence, then go on to the next sentence. From the subject's point of view, the sentence unfolded word by word, with the speed determined by the subject himself. Closure predicts that the latency after the relative pronoun should be shorter for interrupted sentences than for non-interrupted sentences, since in the former case no closure could have taken place by the time the relative pronoun was reached, while in the latter,

non-interrupted, sentences, closure should take place after the final object NP had been processed. This is precisely the result which was obtained; latency was significantly shorter after the relative pronoun in types SS and SO (the interrupted structures) than in types OS and OO (the non-interrupted sentences).

The recall data from the same experiment were evaluated, in part, in terms of the kinds of structural errors made. Subjects produced many sorts of errors, such as giving no answer at all, forming sentences which were only partially grammatical, or which contained prepositional phrases, conjunctions, or infinitives. Those errors containing relative clauses are the most instructive for our purposes here. When the stimulus type was of the interrupting sort (SS or SO), the most common error was to substitute a non-interrupting relative clause, and, in fact, most often in the form OS. When the stimulus types were themselves non-interrupting (i.e. OS or OO), errors tended to reestablish a normal SVO word order in the relative clause. These results suggest that closure is interacting with the normal form strategy. A similar tendency was found in the other errors as well, suggesting that subjects prefer the canonical word order SVO.

In an experiment dealing with production (Prideaux and Baker 1983), subjects were shown a short, silent TV clip consisting of several little episodes in a bar or lounge. The subjects' task was to write a short descriptive passage giving an account of what they had seen. The fact that the film was silent elicited considerable descriptive language, including many relative clauses. In data from 28 native speakers it was found that the vast majority of the relative clauses were attached to sentence-final NPs, and this result was highly significant statistically. Closure is again supported.

In a series of text counts (Prideaux in press), the location and structure of relative clauses were tabulated for both fiction (150 pages) and non-fiction (50 pages) texts. The tendency for non-interrupting relative clauses to dominate was again statistically highly significant, strongly supporting closure.

In all the studies discussed to this point, data have been cited from English, and it might therefore be suspected that the tendency for non-interrupting relative clauses to be more frequent and easier to process is a language-specific property of English, or it might even be suspected that there is a universal tendency for object NPs to be more available as relative clause hosts than subject NPs. In order to demonstrate that neither of these possibilities is correct, it is important to examine languages whose structures differ in important ways from that of English.

Japanese and Korean, both of which are SOV languages, constitute ideal contrasts to English, since both have relative clauses which precede the modified NP. Closure predicts that sentences with relative clauses attached to the subject NP, the non-interrupting structure, should be both easier to process and more frequent, than those with the relative clause modifying the object NP, thereby interrupting the main clause. Thus, structures such as (5a) should be easier to process than those like (5b), where RC represents a relative clause.

- (5) a) RC+S O V
 b) S RC+O V

To test this prediction, Prideaux (1982) carried out an experiment in which sentences with structures like those in (5) were presented to native speaker of Japanese, whose task it was to make acceptability and naturalness judgements of the stimuli. It was found that the non-interrupting structures like (5a) were judged significantly easier and more natural than the interrupting structures of (5b). Choi (1978) reported a similar finding for Korean. Even in the area of language acquisition, it has been reported that Japanese children have far more difficulty with interrupting structures than with non-interrupting ones (Harada et al. 1976; Kawashima 1980).

These studies considered together suggest that it is not the grammatical role of the modified NP which is crucial, since this changes across languages, but rather the location of the relative clause. In summary, there exists a wealth

of empirical evidence supporting the closure strategy.

4.CONCLUSION

The studies cited above, plus many others not discussed here, demonstrate the important role played by closure in actual language processing, including both production and comprehension. There is even evidence that closure is important as a guiding principle in language acquisition. Moreover, the closure strategy is not limited in application to one language only; rather it seems operative in languages as diverse as English and Japanese. A universal tendency is just what one would expect if the strategy has its source in the human cognitive constitution rather than in specific language properties.

An acceptable model of language processing -- one which purports to account for the actual skills, steps, and operations involved in real language production and comprehension -- must reasonably be held accountable to the evidence adduced above. The existence of so much evidence in support of the closure strategy therefore suggests that the strategy models of language processing represent real language processing more satisfactorily than the direct incorporation models, which do not in principle permit access to such strategies. At this point, then, it can be concluded that present evidence supports the strategy models and fails to support the direct incorporation models, in spite of the many unsolved problems associated with each.

FOOTNOTES

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² While the notion of a 'category mistake' is often attributed to Wittgenstein 1953, it appears that he himself never actually used this term. See Bartley 1973: 164.

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