THE INFLUENCE OF CANONICAL WORD ORDER ON STRUCTURAL PROCESSING

TRACY E. LOVE
DAVID A. SWINNEY

Department of Psychology
University of California, San Diego
La Jolla, California

1. INTRODUCTION

Language comprehension is something that humans perform rapidly, effortlessly, and typically without conscious thought. However, underlying this reflexive behavior there exists a multitude of processes at each of a number of different levels of analysis (spanning from basic phoneme discrimination to speech segmentation, to lexical access, to structural analysis, to discourse-level processing, etc.), processes that must be understood in detail if we are to have an accurate model of comprehension. The focus of this chapter is on one of the more subtle and complex areas in this array, structural processing. In particular, we will examine the role of underlying or canonical word order (or, more specifically, grammatical role order) on structural processing-something that is best done from a crosslinguistic perspective. Different languages have putatively different canonical word and grammatical role orders, allowing independent examination of the effects of such underlying facts about language on standard comprehension routines. In examining this issue, we will focus specifically on the structural processes involved in processing long-distance dependencies as found in filler-gap constructions, and we will examine the moment-by-moment processes involved in the comprehension of such structures via on-line methodologies. Finally, as theory of experimental methodology is intimately tied to theory of

Syntax and Semantics. Volume 31
Sentence Processing: A Cross!inguistic Perspective

0092-4563/98 $25.00

mental process, we also examine methodological issues relevant to the on-line examination of structural processing.

2. BASIC ISSUES

2.1. Canonical Order

A fundamental issue in the study of language is the distinction between the "underlying" word order (Subject-Verb-Object), hereafter referred to as canonical order, of a language and the many different surface forms of these elements that may appear in a language. Although there is often disagreement about the canonical order for any specific language, in general there is agreement that some languages have fundamentally different canonical orders (e.g., SVO vs. SOV): some of these languages are strongly ordered (again, underlyingly) and others are not as strongly ordered. "Strength" of the role of canonical order is commonly a function of issues such as degree of reliance of word order versus case marking for indication of the grammatical role of words in sentences-in short, the degree to which word "scrambling" is allowable and practiced in language use (see, e.g., Greenberg, 1963; Haegemen, 1991; Taraldsen, 1991; Travis, 1991). Due to this intralanguage difference in canonical order, crosslinguistic experimentation particularly lends itself to answering questions about the fundamental role, if any, of such canonical order on ongoing processing involved in comprehension.

2.2. Structural Processing and Discontinuous Dependencies

Discontinuous dependencies are a common structural property of language. They occur when two related elements are separated in the surface form of a sentence. In most languages, discontinuous dependencies exist in many types and forms. In English, one important type involves what are called antecedent-gap or filler-gap dependencies-conditions in which "gaps" in canonical word order are created in the surface form of a sentence by 'movement' of a word to a different position in the sentences (the moved element is termed the "filler" for the gap). In much of what follows we will examine processing of such antecedent-gap relationships as found in the object-relative constructions such as the following:

'The police stopped the boy that the couple accused ____ of the crime.'

English is deemed to be a canonical SVO language. In the object-relative construction in English, however, the object precedes (rather than follows) the verb, which is contrary to this canonical order (the underlying form of this sentence can actually be broken down into two SVO sentences: "The police stopped *the*

mind while the sentence is being processed. Thus, this task is one of the least intrusive behavioral techniques we have for the on-line examination of the normal comprehension process.

A planned relation exists between the tasks the subject performs in CMLP (auditory sentence comprehension and visual target classification). On experimental trials, the visual target is associatively/semantically related to a critical word in the sentence. Following the principle of automatic semantic priming, occurrence of an auditory word (the prime) just prior to processing of another item (the visual target word) that is associatively (and/or semantically) related to that prior item results in speeded processing and classification of the target-a result that is generally known as priming (see, e.g., Meyer, Schvaneveldt, et al., 1975; Neely, 1991). The CMLP task uses the fact that priming occurs between associatively related words to provide an indication of WHEN critical words in the sentence are active during processing. Consider an example in which subjects are presented auditorily with the following object-relative sentence:

The policeman saw *1 the boy *2 who the crowd *3 at the party *4 accused *5 of the crime

If a visual probe that was related to the noun `boy' (e.g., the letter string: GIRL) was presented at each of the asterisk-numbered (*) positions (in each instance, to different subjects in different experimental conditions), one might expect, *ceritus paribus,* the following effects on reaction time to make a lexical decision to that letter string: [2] First, no priming effects would be expected at test position * 1, as there have been no words related to `GIRL' heard by the subject up to that point. Second, at test position *2, one might (correctly) expect that reaction time to GIRL would be speeded (primed) due to the subject just having heard `boy'. Then, at position *3 (and certainly at position *4), one might predict that there would be no more priming effect of the word `boy' from the sentence on lexical decision times to the letter string `GIRL,' because sufficient time had passed so that `boy' would have been fully processed and stored, and no longer active in immediate sentence processing to be able to exert a priming effect . [3] On the other hand, if one believes a filler-driven account of linking antecedent fillers to gaps, then, *continued* activation of the filler ('boy') will occur at points *3 and *4 in the sentence (in that the filler is being kept active while the processor is looking for a gap site to fill). However, if one believes a verb-driven account of linking fillers and gaps (that is, the filler is searched for *only* once a gap-as marked by a verb requiring a direct object-is discovered), one would predict that reactivation of the filler will only take place at test point *5, when the verb requiring a direct object has been processed and a search of the appropriate antecedent filler is undertaken. In short, via the use of CMLP, we are exploiting the fact of priming to provide a basis for an existence proof about the time course of mental (re)activation of some `key' word in the sentence-in this case the antecedent filler for a structural gap.

2.3.2. EFFICACY OF THE CMLP PARADIGM IN THE EXAMINATION OF STRUCTURAL PROCESSING

Much debate, and rightfully so, centers around the efficacy and sensitivity of the experimental techniques employed to appropriately reflect sentence processing. Relevantly, the CMLP technique has recently been at the center of such a debate, and although it has passed muster on all counts, it is important that the issues raised in this debate be kept in the public eye, as they are relevant to the evaluation of all such on-line techniques. This particular debate has centered on the ability of the CMLP task to appropriately reflect the reactivation of antecedents in filler-gap constructions. This controversy focuses on claims by McKoon and Ratcliff (1994; hereafter M&R) of a potential confound in a filler-gap study by Ford, Frauenfelder, Bresnan and Swinney (see: Swinney, Nicol, Ford, Frauenfelder, Bresnan, 1987, see also Nicol and Swinney, 1989), which had demonstrated automatic reactivation of an antecedent filler at a gap site, only for the structurally correct antecedent. (More on this result will be presented, below, next section). McKoon and Ratcliff (1994) argued that the study was confounded in that the experimental (semantically related) visual target words used in the study constituted a "better fit" with the sentence than the unrelated, control words, and that this fit factor, and not the reactivation of antecedent fillers, constituted the source of priming found at the gap site. M&R then employed *a reading* task (a variant of Rapid Serial Visual Presentation-RSVP) to demonstrate this confound of fit could have an registerable effect. In their task, sentences containing no gaps were presented visually, one word at a time, and subjects read each word, making a lexical decision to a visual target (which was marked as being the target by being presented in a slightly different location on the screen from the sentential words that preceded it). Note that, except for location (five letter spaces to the right), the visual target was presented as a continuation of the rest of the word-by-word visually presented sentence. With this task they found priming for target words they judged to be a better fit with the sentence compared to those that were not. Thus, given that they found priming in their reading task with better-fit targets, they claim that this effect accounted for the original results of Swinney et al. (1987) with the CMLP task.

However, this interpretation is highly problematic. First, the task they use to demonstrate that better fit of targets can cause priming is exceedingly different from the CMLP task used by Swinney and colleagues. Most importantly in this regard, the visual sentence continuation task presents the target as a continuation of the sentence; due to this, it is naturally integrated into the sentence (something that does not happen with CMLP); hence it is no surprise that lexical decision times to the task are effected by fit with the sentence-that is, what an integration task measures. CMLP, when used standardly, does not allow such integration; a well-known property of the technique is that targets are essentially never reported as being perceived as `integrated' into the sentence by subjects, likely because of

the different modalities in which the sentence and targets occur. In addition, we note that the *reading* task used by M&R has very different properties from the auditory comprehension used in CMLP: Reading obviously has many properties that make for important theoretical and empirical differences than those studied in auditory comprehension.

As a means of providing a direct test of the claim that CMLP is susceptible to the "fit" or integration of the target into the sentence, as M&R claim, Nicol et al., 1997 (see also, Swinney et al., 1998) undertook a controlled study directly comparing CMLP and RSVP tasks in good fit and bad fit conditions. Essentially, it was a test of whether this potential confound of `fit' of the targets with the sentence could have caused priming effects in CMLP studies that supported claims of reactivation of antecedent fillers at a gap site. (This experiment also provided a test of whether it mattered whether the control condition constituted matched sentences or matched targets-an issue that McKoon, Ratcliff, and Ward, 1994, had raised as a potential problem in an earlier paper). In this study, subjects were presented with sentences such as,

The woman instilled fear in her daughter
Apple
Agony
The woman pushed fear ...
Apple
Agony

in *both* the RSVP and CMLP methodologies. In the examples, the word *agony* constitutes a better fit after the verb "instilled" but not after the verb `pushed,' whereas APPLE constitutes a better fit after `pushed' but not after `instilled.' The ratings of good or bad fit were gathered by pretesting all material (see Nicol et al., 1997, for specifics). The results of the studies were quite straightforward: The word-by-word visual task (that used by M&R) showed a significant priming effect for target words that constituted a better fit compared to those target words that were a worse fit. This, then directly replicated the findings of *M&R-with* their *reading task*. However, no effect at all (not even a trend) of better versus worse fit target words was found in the CMLP paradigm (again, using exactly the same materials and same number of subjects). There was no effect of fit at all intruding into CMLP results. Thus, the potential confound of better fit of experimental versus control target words with the sentence cannot account for priming found at gaps with the CMLP paradigm. CMLP does not lend itself to integrating the probe target into the ongoing sentence that is being studied. This is a critical lesson for on-line examination and on-line methodologies. It is paramount that tasks not be susceptible to integration effects (such as found in word-by-word reading combined with visual-target presentations) unless integration is the factor of interest. In studies of filler-gap processing (activation-reactivation studies) therefore,

CMLP is a behavioral task of choice (and sentence continuation tasks are not). Furthermore, this examination of M&R's claims found that there was also *no* difference between use of the matched sentence or matched probe designs-either type of control is equally efficacious. Finally, we note that in work by Love and Swinney (1996), the gap-filling effects that concerned M&R were *replicated* in *a CMLP task that was specifically matched for good or bad fit* of targets to the sentence, and thus much of this debate is academic: evidence for antecedent reactivation in gaps exists independent of the good or bad fit of targets with the sentence from CMLP experimentation. The CMLP task is a sensitive measure of specific details of sentence processing and, critically, it is not susceptible to integration of extraneous information into the ongoing sentence. It is, in fact, one of the more sensitive behavioral measures we have of ongoing sentence processing.

3. PROCESSING OF LONG-DISTANCE DEPENDENCIES IN ENGLISH

We now turn to an examination of filler-gap dependency processing in English, the language in which the majority of the work has been done so far. (Recall, again, that English is an SVO language.) A multitude of studies (see, e.g., Nagel, Shapiro, and Nawy, 1994; Nicol, 1988; Osterhout and Swinney, 1993; Swinney, Nicol, Ford, Fruenfelder, and Bresnan, 1987; Zurif, Swinney, Prather, and Love, 1994, among others) have demonstrated the following effect in English using the CMLP task (or variant thereof): (a) prior to the verb, there is no evidence of activation of a moved constituent and (b) reactivation is demonstrated at the immediate offset of the verb at the gap. These studies have also demonstrated that this process is unaffected by issues of plausibility and that the process is driven by structural knowledge (other candidate NP antecedents occurring in positions that are structurally precluded from being an antecedent filler for a moved direct object are NOT activated). These results taken together show that in a language that has a strict SVO underlying canonical word order, the processing system is actively attempting to recover the object of the verb on-line *at* the gap. (We note in passing that similar reactivation effects have been shown for pronouns, and reflexives).'

To give a detailed example of the methodology and interpretation underlying these findings, we turn to a presentation of a recent study in this area: Love and Swinney (1996) investigated whether or not the process of automatic reactivation of filler-antecedents found in gaps in these prior studies involved a search for an antecedent through a deep or superficial representation of the sentence. In order to examine this issue, lexical ambiguities were used as filler antecedents, in order to provide a method of disentangling the `level of representation' used in a search for an antecedent filler. The reason for use of ambiguities in this study is that all

meanings of lexical ambiguities are initially activated when the *(surface form* of the) word is heard (e.g., Swinney, 1979; Tanenhaus, Leiman, and Seidenberg, 1979). Thus, if *all* meanings of the antecedent filler are found to be reactivated at the gap site, then one could conclude that the search for an antecedent filler occurs over a surface form (acoustic memory) representation of the sentence; however, if only the contextually appropriate meaning of the antecedent-filler ambiguity is reactivated at a gap, then the search for the antecedent must be over a deeper representation of the sentence -one in which the appropriate interpretation of the ambiguity has been uniquely determined and stored in the structurally appropriate representation for the sentence up to that point. In addition, this study replicates many facets of the prior published results on gap filling just summarized above.

Briefly, subjects heard sentences that were strongly biased [5] towards one interpretation of a lexical ambiguity such as:

> *Jeff was concerned about Savings and Loan Institutions, so he went to the bank* ^{*1} *which his family* $*^{2}$ *always used -* $*^{3}$ *and asked about the safety it provided with respect to CD investments.*

Three separate probe points were tested (*1, *2, *3). The results were very clear: at the offset of the lexical ambiguity (* 1), there was evidence for exhaustive access (i.e., there was priming for both the `money' and the `river' meaning of bank). As stated earlier, this replicates the well-reported finding that lexical access occurs automatically and is not guided by the context of the sentence (among others, Swinney, 1979; Tanenhaus, Leiman, and Seidenberg, 1979). Next, at the baseline probe point (*2) there was *no* activation of either meaning evident. Finally, and most importantly, at the gap (*3), there was evidence for the reactivation of the antecedent-but *only* for the contextually relevant meaning ('money'). Moreover, a significant interaction in the level of activation between probe points 2 and 3 (for the contextually relevant meaning only) demonstrated there was reactivation of the antecedent at the gap (i.e., the system was actively recovering and reactivating the filler in the underlying canonical SVO order position). Furthermore, this reactivation involved a search through an underlying or deep memorial representation of the antecedent (since only the contextually relevant meaning was reactivated). As stated earlier, this finding of an automatic linking of a gap to its structurally defined antecedent has been shown in many other experiments using CMLP (Nagel, Shapiro, and Nawy, 1994; Nicol, 1988; Osterhout and Swinney, 1993; Zurif, Swinney, Prather, and Love, 1994, among others) and across other methodologies.'

Thus, there is considerable evidence that, at least in English, the comprehension device prefers to have the direct object activated immediately following the verb *during* ongoing processing. This fits with a view of comprehension as driven by the need to actively recover the canonical SVO order online during comprehension.

Of direct interest to both processing and Universal Grammar models is whether this pattern of structurally driven reactivation as a means of recovering the canonical word order is language specific and/or tied to canonical orders found in each language. We can explore these issues by studying whether or not these findings are evident and predictable in languages possessing different fundamental word orders than English. What follows is a brief review of the only currently existing on-line evidence from two such languages: Bulgarian and Spanish, each of which brings a different perspective on canonical order. Unlike English, which possesses a strict adherence to its underlying word order, Bulgarian allows for extensive scrambling (i.e., it has a more relaxed word-order system; Stamenov and Andonova, this volume). Spanish, on the other hand, finds itself somewhere in between English and Bulgarian in degree of allowable scrambling (strict canonical order), but there is considerable debate in the literature as to whether its underlyingly canonical word order is VOS or SVO (see, e.g., Basilico, Piiiar, and Anton-Mendez, 1995). These languages bring a unique perspective to this field of investigation and can allow us to explore these issues of underlying canonical word order driving structural reactivation.

4. A CROSSLINGUISTIC PERSPECTIVE

Stamenov and Andonova (this volume) investigated the time course of antecedent reactivation via a CMLP task in Bulgarian, which, as mentioned earlier, has a much more relaxed word order than English. They studied object-relative constructions such as:

Za obyad v restoranta predlagaha teleshki drob, koyto Stefan mnogo obichashe of maluk.

`For lunch, in the restaurant (they) offered **veal,** which Stefan loved very much since his childhood.'

They tested at multiple sites in the sentence (at the offset of the lexical ambiguity, a baseline probe point and at the gap) and found-quite unlike the findings for English-no evidence of reactivation of the antecedent *drob* at the gap. The authors entertain the idea that they can attribute this finding, in part, to the fact that Bulgarian allows for a more lax word-order representation in object-relative constructions (i.e., Bulgarian is considered to have a relatively free word-order system). Given that this language has a lax canonical word order, there may be no expectation built up in the system to find specific grammatical role objects in structurally defined positions (on-line), and hence no reactivation of such items in any particular position takes place in a first-pass analysis of the sentence.'

However, in a similar priming study in Spanish, Basilico, Pinar, and Anton-Mendez (1995) examined for reactivation priming for a verb in V-S-O and V-O-S Spanish constructions, at a point between the subject and object in those sentences

(recall that Spanish is argued to be either an SVO or a VOS language, underlyingly). They reasoned that if the underlying canonical order is really SVO, then one should find reactivation of the verb between the subject and object in the VSO constructions only (as compared to the VOS construction, where it might be expected after the subject). And this is precisely what they report finding, lending credence to the belief that the underlying word order in Spanish might be S-V-O, and that the underlying word order is strict enough for th6 comprehension device to expect and require grammatical objects in their canonical position.

5. CONCLUSIONS AND DISCUSSION

Although there are as yet few pieces of evidence from crosslinguistic work to contrast with the extensive English findings, we can see that work from two languages with far less stringent word orders than English presents us with mixed results. In one, Spanish, evidence suggests that even though one is allowed a freer surface word order, it appears that the comprehension device is attempting to actively recover conceptual information in an underlying SVO order *during* ongoing comprehension (as is found in English; we note that similar evidence has been hinted at in early work in German; Clahsen, personal communication, March 1997). However, in Bulgarian, no such evidence of the processor expecting or utilizing canonical word order is found. This fits with some general beliefs that strictness of word orders may be a continuum. Some languages are truly freer-even at an underlying level. And, this may well percolate to the workings of the comprehension device, as seen in these data.

Clearly, in order to examine this hypothesis further we need many more studies that investigate languages with a variety of canonical word orders that fit all along this continuum of a lax to strict adherence to word order. Now, however, we have techniques sensitive enough to allow researchers to temporally map out such delicate sentence processes as they are occurring, and we can use crosslinguistic phenomena such as canonical word order to assist the understanding of processes by which long-distance dependencies are linked. Furthermore, we can investigate whether or not this linkage is language specific or in fact performed in a universal fashion, across similar language structures in all languages, thereby adding to our evidence concerning questions of universality of structural processing. As already seen, the influence of canonical word order on structural processing may vary (e.g., the Bulgarian evidence). However, even this evidence is only preliminary. A major goal of this work is to determine if there are natural categories or groupings into which languages may fall with regard to structural *processing* issues (which may, in turn, effect linguistic theory at some level), thus, only further crosslinguistic examination of such processes, with sensitive on-line techniques, will bring us closer to answers on these issues.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of a grant from the National Institutes of Health (D000094) for the writing of this chapter and for much of the research reported herein.

REFERENCES

Basilico, D., Pinar, P., and Anton-Menedez, I. (1995, March). Canonical word order and the processing of verbal traces in Spanish. *The Proceedings of the Eighth Annual CUNY Conference on Human Sentence Processing,* Tucson, Arizona.

Chomsky, N. (1981). *Lectures on government and.binding.* Dordrecht: Foris.

Garnsey, S., Tanenhaus, M., and Chapman, R. (1989). Evoked potentials and the study of sentence comprehension. *Journal of Psycholinguistic Research, 18 (nl),* 51-60.

Greenberg, J. (1963). Some universals of grammar with particular reference to the order of meaningful elements. In J. Greenberg (Ed.), *Universals of language (pp.* 73-113). Cambridge, MA: MIT Press.

Haegemen, L. (1991). *Introduction to government and binding theory*. Cambridge, UK: Blackwell.

Love, T., Nicol, J., Swinney, D., and Nafie, K. (1997). *The processing of explicit anaphors in Broca's and Wernicke'c aphasics.* Center for Human Information Processing Technical Report, #97-2.

Love, T., and Swinney, D. (1996). Co-reference processing and levels of analysis in object-relative constructions: Demonstration of antecedent reactivation with the cross modal priming paradigm. *Journal of Psycholinguistic Research,* 25 (1), 5-24.

McKoon, G., and Ratcliff, R. (1994). Sentential context and on-line lexical decision tasks. *Journal of Experimental Psychology: Language, Memory and Cognition, 20(5),* 1239-1243.

McKoon, G., Ratcliff, R., and Ward, G. (1994). Testing theories of language processing: an empirical investigation of the on-line lexical decision task. *Journal of Experimental Psychology: Language, Memory and Cognition, 20(5),* 1219-1228.

Meyer, D. E., Schvaneveldt, R. W et al. (1975). Loci of contextual effects on visual word recognition. In. V. P. M. A. Rabbit and S. Dornic (Eds.), *Attention and performance* New York: Academic Press.

Nagel, H. N., Shapiro, L. P., and Nawy, R. (1994). Prosody and the processing of filler-gap sentences. *Journal of Psycholinguistic Research, 23 (6),* 473-486.

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In G. W H. D. Bresner (Ed.), *Basic processes in reading: Visual Word Recognition.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Nicol, J. (1988). *Co-reference processing during sentence comprehension.* Unpublished doctoral dissertation, M.I.T., Cambridge, MA.

Nicol, J., and Swinney, D. (1989). The role of structure & coreference assignment during sentence comprehension. *Journal of Psycholinguistic Research, 18 (n1),* 5-19.

Nicol, J., D. Swinney, Love, T., and Hald, L. (1997). Examination of sentence processing with continuous vs. interrupted presentation paradigms. *Center for Human Information Processing, Technical report* #97-3, La Jolla, U.C.S.D.

Osterhout, L., and Swinney, D. (1993). On the temporal course of gap-filling during comprehension of verbal passives. *Journal of Psycholinguistic Research, 22,(2),* 273-286.

Shapiro, L., and Swinney, D. (1998). On-line examination of ,language performance in normal and neurologically-impaired adults. *American Journal of Speech-Language Pathology, 7,49-60.*

Stamenov, M., and Andonova, A. (1997). Lexical access and co-reference processing in Bulgarian. In D. Hillert (Ed.), *Cross linguistic studies of language processing.* San Diego: Academic Press.

Swinney, D., Nicol, J., Ford, M., Fruenfelder, U., and Bresnan, J. (1987, November). *The time course of co-indexation during sentence comprehension.* Paper presented at the Psychonomic Society Meeting, Seattle, WA.

Swinney, D. (1979). "Lexical access during sentence comprehension: (Re) consideration of context effects." *Journal of Verbal Learning and Verbal Behavior* 18, 645-659.

Swinney, D., J. Nicol, Love, T., and Hald, L. (1998). Methodological issues in the on-line study of language processing. In Schwartz (Ed.) *Childhood language disorders.* Hillsdale, NJ: Erlbaum.

Swinney, D., Onifer, W, et al. (1979). Semantic facilitation across sensory modalities in the processing of individual words and sentences. *Memory and Cognition 7(3),* 159-165.

Tabossi, P. (1988). Accessing lexical ambiguity in different types of sentential contexts. *Journal of Memory and Language,* 27, 324-340.

Tanenhaus, M. K., Leiman, J. M., and Seidenberg, M. S. (1979). Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning and Verbal Behavior,* 18, 427- 440.

Taraldsen, K. (1991). A directionality parameter for subject-object linking. In Freiden (Ed.), *Principles and parameters in comparative grammar (pp.* 219-268). Cambridge, MA: MIT Press.

Travis, L. (1991). Parameters of phrase structure and verb second phenomena. In Freiden (Ed.), *Principles and parameters in comparative grammar (pp.* 339-364). Cambridge, MA: MIT Press.

Zurif, E. Swinney, D. Prather, P., and Love, T. (1994). Functional localization in the brain with respect to syntactic processing. *Journal of Psycholinguistic Research,* 23, (6), 487-498.

NOTES

[1] While this chapter is concerned only with providing a processing account of aspects of language (and, hence, we do not intend or attempt to support one linguistic account of these constructions over another), we have adopted much of the terminology of the government

and binding theoretic herein because it descriptively captures the phenomena we examine, and empirical data we provide, more coherently than most other accounts. We note, however, that that this does not at all mean it will ultimately represent a better universal grammar account of these language phenomena.

[2] Note that all effects are evaluated in comparison to lexical decision reaction time to a control letter string presented at each of these test points; a control letter string is a word that is associatively/semantically unrelated to the key wdrd in the sentence, but which is matched to the `experimental' (related) letter string on the basis of *a priori* reaction time (lexical decisions taken on the words presented in isolation).

[3] The priming that is standardly found to classification of a visual target immediately following occurrence of a semantically or associatively related word in an auditory sentence typically lasts between 100-700 msec, *ceterus paribus.*

'In a study by Nicol (1988), subjects were presented with sentences containing three unrelated noun phrases (NPs) such as:

NP I NP2 NP3

The boxer said that *the skier* thought that *the doctor* from the team had blamed HIM/HIMSELF for the recent injury.

At the offset of the pronoun or reflexive, a word either related to the 1st NP (fighter), 2"a NP (snow), or 3rd NP (nurse), or matched control words were presented. In the case above, the structurally correct antecedent for the reflexive HIMSELF is *the doctor,* whereas the structurally correct antecedent for the pronoun HIM cannot be doctor. The results showed that the structurally defined antecedent was in fact activated after the overt anaphors (skier for HIM and doctor for HIMSELF). These findings have recently been replicated (Love, Nicol, Swinney, and Nafie, 1997) and support the view that antecedent re-activation is automatic and structurally driven.

[I] Of the many pretests run on these materials, three separate pretests were run to ensure (a) Tabossi (1988) criteria were met; (b) a strong biasing context; and (c) there were no goodness-of-fit confounds. (Please see Swinney et al., 1998, for details.)

[6] One such example is by Garnsey, Tanenhaus, and Chapman (1989) where subjects were presented with the following sentences:

a. *The businessman knew which customer the secretary called at home.*
b. *The businessman knew which article the secretary called at home.*

They obtained electrophysiological measures (evoked response potentials) during comprehension of these sentences and found a larger N400 at the verb ('called') for (b) than for (a). N400 potentials are believed to be, among other things, a response to semantic incongruity. If a large N400 was found in (b) at the verb, it likely is because the incongruent filler (the word *article)* was reactivated at the gap following the verb. Thus, it seems likely, based on these data that the object filler was activated at the site of the gap during processing (and, such activation was independent of plausibility constraints).

[I] An interesting aside is that although they did not find reactivation at the gap, they did replicate the finding of contextually independent exhaustive access of lexical ambiguities when testing at the offset of the lexical ambiguity.