This book provides an overview of the structures, topics and main theories of syntactic processing. It covers the last 40 years of sentence-level psycholinguistic research and debates and makes it accessible to both theoretical linguists and experimental psychologists.

Tying linguistically relevant issues to psycholinguistic theory, this book:

- Covers the processing of the grammatical phenomena adjunction, agreement and gap filling and discusses the relationship between grammars and parsers
- Discusses experimental work and theories, demonstrating how psychologists have made real strides in understanding language and how studying the processing of syntactic structure is the same as studying the nature of language
- Explores the key theories of psycholinguistics, including recent developments
- Explains the different methodologies of sentence processing, such as eye-tracking and electroencephalography

Bridging the gap between psycholinguistic research and the study of language, this book is essential reading for advanced students and scholars of linguistics and experimental psycholinguistics as well as cognitive science and psychology.

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SYNTACTIC PROCESSING

An Overview

Carlos Acuña-Fariña
Because every cloud has a silver lining, this book is very much a product of the pandemic, a time that I spent, adorably (I am embarrassed to add), at home with Mela, Aitana and Diego. I dedicate it to them for making me feel whole during that time, and for making me laugh every day.
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1

INTRODUCTION

1.1 Questions

In my experience as a linguist, most linguists do their demanding jobs and pursue their complex scientific agendas by studying the intricate system we call language from a large number of complementary angles without much regard for the actual psychological basis of whatever they describe and/or try to explain. When they mention ‘psycholinguistic evidence’, they do so mostly in passing, with the ‘evidence’ in question taking up an insignificant amount of their argumentations. Not many linguists actually know about late closure or minimal attachment, garden paths and Garden Path Theory, construal, cue-based processing, the Filled Gap Effect, attraction, grammatical illusions, marking and morphing, maximal input, the Direct Association Hypothesis, surprisal theory, inhibitory interference, lossy context or the Minimal Chain Principle. When they drop a reference to psycholinguistic experiments, they are, in general, not likely to know much about cumulative self-paced reading, first-pass and regression-path times, LANs and P600s.

This book is intended to show how cognitive scientists interested in language may benefit from a deeper knowledge of psycholinguistic research. It will try to exemplify how a linguist who doubles as a psycholinguist does his/her work in four specific areas of research: the first one is adjunction, the operation that places a constituent A next to another constituent B and produces a superordinate constituent A’. This will be done especially by focussing on research on the adjunction of relative clauses to complex noun phrases. The second area will be agreement, with its vast cross-linguistic variability. The third will be the processing of gaps or empty categories. The fourth will use the piecemeal evidence accrued from the first three areas to focus upon the relationship between a grammar and a parser, with (in order to make that discussion more tangible) grammatical illusions and so-called islands in mind. The first three areas have been...
chosen because they are central to actual language use and they cannot not relate to linguistic theory (that is, no theory of grammar can ignore them). Indeed, possessing a language means that one must have a way of merging/adjoining constituents together in the syntagmatic chain of speech. Additionally, given that over 80% of the world’s languages have some sort of agreement (Mallison & Blake 1981), and that languages vary massively on the size of the morphological components that make agreement possible, no linguistic theory can absent itself from an account of agreement co-indexations either. Likewise, no model of language can afford to remain silent on one of the most fundamental properties of the language faculty: the need to systematically drop given/recoverable information, as language systems cannot and need not spell out all of conceptual structure. Fortunately, psycholinguistic research on all these areas is abundant now. What seems to be missing is a bridge.

Assuming that you are a linguist with an interest in the idea of psychological adequacy, a psychologist who is not well versed in syntactic structure or a budding psycholinguist, you may have asked yourselves at times: how does the mind do these things? What things? Well, take agreement for instance. The string *the little, dark pens are all broken* presents seven words and two morphological marks on two of them (*pens* and *are*, both plural). The corresponding Spanish sentence (*‘los pequeños bolígrafos oscuros están todos rotos’*) has also seven words but now the morphological marks go up to thirteen. Assuming a speed of some fifteen–seventeen phonemes per second plus lexical recovery of every piece, phonological encoding, morphological encoding, phrasal packaging, clausal wrap-up and semantic decomposition, etc., all at the same time, it is easy to wonder why one should bother with the computation of so many cues all marking masculine + singular. After all, English proves that the alliterative excess is totally unnecessary (Taylor 2002: 332 ff.). And what is masculine about a pen anyway? Why replicate all those -os if they mean nothing? In sum, why make dear computational room for something apparently so useless so continuously? Some languages add case to that complexity. Others put gender on the verb. All linguists have always marvelled at these cross-linguistic mysteries. Some linguists cannot refrain from reflecting upon the kind of mind that does that online.

Agreement involves a syntactic domain (the phrase, the clause, the discourse) and short-term memory (to keep the morphological features of a controlling head in mind in order to copy them or expect them later on a target, or several targets). It is surely useful to investigate whether these two aspects of it influence each other, or, alternatively, whether the grammar side is totally independent from the implementation side. Additionally, agreement features often originate in semantics (plurality, animacy, etc.), but once they become routinized in a myriad alliterative schemas of the Spanish -os, -os, -os type (above), does every occurrence of -o (meaning masculine) and -s (meaning plural) tap conceptual structure? If you believe in the Symbolic Thesis of Cognitive Grammar (Langacker 1991a, 1991b) then you may be inclined to answer in the affirmative, and that gives way to an easy hypothesis to entertain: we should be able to find
more semantic interference in agreement operations in Spanish than in English. Do we? Conversely, if you believe that agreement is an operation involving only feature co-variance running on formal rails and reined in by linguistic cycles (something like the *Phase Impenetrability Condition* of Generative Grammar; Chomsky 2001: 14; see Abels 2012), then another interesting prediction comes to mind: you should not see semantic interference inside a hypothesized formal phase. Reflexives provide an interesting test ground on a number of fronts. If you encounter the string *Mary couldn’t bring himself to believe in that*, you will no doubt experience a *garden path*, a sort of momentary breakdown after the onset of *himself* (whose masculine feature violates agreement with the head *Mary*). Reflexives are usually described as being very syntactically reined in, and c-command is usually mentioned as a configurational requirement in them. Is that syntactic configuration psychologically strong? Can it be fooled by semantics (Parker & Phillips 2017)? We can play with the configurations where the reflexives show up and see what happens, and we can compare agreement with reflexives with other kinds agreement, to see how encapsulated agreement co-indexations really are.

We can then relate our findings to the *Symbolic Thesis* or the *Phase Impenetrability Condition*. Past the bridge there are warehouses with people running experiments on all this all the time. In most of them the subject matter is language and the likes of c-command and agreement *ad sensum* are being tested. The continuous undercurrent is a latent evaluation of the competence vs performance fork. The bad thing is that running experiments is very time-consuming so the people who are actually doing that do not really have too much time to find out about c-command or, say, long-distance agreement by visiting the linguistics building. They could really use some help.

Take another example, the (psycholinguistically) famous *somebody shot the servant of the actress who was on the balcony*. It turns out that, statistically, British speakers are more likely to understand that the person on the balcony is the actress, not the servant. Spanish and French speakers are rather more inclined to *adjoin the relative clause to the first noun* (*servant*), instead (Cuetos & Mitchell 1988; Cuetos et al. 1996). Imagine that the context provides two servants and only one actress; that one of the nouns is animate and the other not (*the suitcase of the servant*); imagine one of the nouns is inflectionally plural, that one is modified, that one has no determiner, that the preposition joining the two nouns is ‘theta-marking’ (say, contentful like possessive *of*) … imagine that by changing any one of those ‘cues’ the pattern of adjunction of the relative clause to the previous complex NP changes. Why would it? And if so, what would that tell us about the human language faculty? Would we be entitled to talk about a grammar of constraints, instead of one with an ‘elegant’ design? It is hard to see why all that is less relevant to a linguist than, say, the fact that non–restrictive relatives disfavour *that* and prefer *which* or *who*, that the relativizer can be dropped in certain syntactic environments, or that we cannot extract and move certain constituents from certain domains. For one thing, adjunction is geometry, so no one would expect languages to differ
on that, and, especially, to keep differing given the slightest micro modification to the same macro template. If we were to find cross-linguistic differences plus the working of very many constraints, we would surely be challenged to come up with an explanation, as linguists. We would also need to consider a grain-size problem, namely whether the macro template (complex NP followed by RC) is more relevant than the micro parameters (lexical frequency, animacy, attachee size, etc.), or the other way around. All of that is ‘language faculty’ and it impacts the way we see the competence versus performance distinction.

Finally, consider so-called empty categories briefly. The generative grammar of the 1980s provided a convenient way of conceptualising elided material. The notions of PRO, pro, NP-trace and Wh-trace originated in that time and will be used here for descriptive purposes only (Haegeman 1994). Examples (1)–(4) illustrate them:

(1) Petei tried PROi to be attentive all the time.
(2) Vine con Maríai, proi Es tan maja …
   I came with Mary, proi She (=pro) is so nice fem …
(3) Ronniei seemed tNPi to be too worried about our performance.
(4) Whati was Diego worried about tWHi?

Of the four categories, PRO and pro are ‘empty’ in the most literal sense in that there really is nothing at the position where they are posited to exist syntactically. Notice that, despite that, we easily understand that the subject of the infinitive to be in (1) is Pete and the subject of the tensed verb es in (2) is María. Wh-trace is also quite experientially salient in that, to take the example in (4), it involves leaving a preposition ‘stranded’ without its complement (what, presumably ‘moved’ to initial position). This is an area where psycholinguistic questions leap to the eye. The first one is: Are PRO and pro syntactic or semantic? We know that grammar theories have traditionally differed on that. Another question involves just pro. Consider (5) now, from de Vincenzi (1991):

(5) Ha chiamato Gianni
   a. pro has called Gianni
      ‘he/she/it has called Gianni’
   b. ti has called Gianni
      ‘Gianni has called’

In (5) there is ambiguity as to who did the calling: in interpretation (5a) that is a context-linked full pro like any other explicit pronoun (he, she, etc.; say, Maryi was really impatient; proi has finally called Gianni; so Mary did the calling). In interpretation (5b) a sort of trace takes the position of the subject Gianni, which presumably, being new information, is moved to a postverbal place in the overall structure (so Gianni himself made the call).2 Even if we disregard the particular
agenda of the Government & Binding grammar of the time, if we just assume that Italian is sufficiently SVO descriptively, we may ask ourselves: is movement costly? That is, is the interpretation in (5b) harder to process than that in (5a) just because in (5a) nothing is displaced whereas in (5b) Gianni has been moved to a post-verbal position from its ‘typical’ preverbal one leaving something like a trace behind? Long ago Chomsky (1995) voiced an opinion like that. So did de Vincenzi herself. If we were to find an effect of movement (meaning that movement is costly), we could further ask ourselves if that could be ameliorated in a language with case. German has case. Are NOM-marked + ACC-marked strings processed more easily than ACC-marked + NOM-marked ones in that language? Additionally, notice that in many languages syncretism often causes phrases to be morphologically ambiguous between the nominative and the accusative cases. This often results in syntactic ambiguity since sentences containing such segments can be interpreted in reference to either a canonical word order or a ‘scrambled’ one. It is surely interesting to see what the minds of the speakers of those languages do in those cases. Various current models of sentence processing appeal to preferred language-specific (and even construction-specific) word orders (Levy 2008a; Vasishth et al. 2010).

Consider, finally, raising versus control, as exemplified in (6) and (7) below:

(6) John seems PRO to be happy
(7) John wants PRO to be happy

In a raising structure of the kind in (6) the surface subject makes less sense beside the matrix verb because it is not really an argument of that verb but of the lower one. In (6) John ‘doesn’t do the seeming’; rather it seems that John is happy. In a control structure like (7) that is not the case, as John really wants something (so it is an argument of that verb, as well as of the lower one). That is why an expletive subject is impossible in that position: *it wants that John is happy. This is another way of saying that John in (6) might somehow originate in the lower clause before appearing as subject of the matrix one. Not so in (7), where John is in its lawful position as thematic subject of the matrix verb. Surely an interesting research agenda is to study whether the mind treats raising structures (involving something like real or ‘metaphorical’ movement) differently from control ones. Generative linguists differ on that, with some believing that raising and control are really the same thing and some others insisting that they are different because of their ‘derivational history’ (Jackendoff & Culicover 2003). Finding (or failing to find) some kind of psychological evidence of derivational history is surely worthwhile.

Over the past forty years or so, some linguists and many psychologists who take linguistic theory seriously have made real strides in understanding language processing. These results can be reflected back to inform us about the ways in which processing restricts our ability to understand the formal
envelope of the grammar due to restrictions from other cognitive systems in use (i.e., the different ways that other cognitive systems interfere with understanding the natural shape of the grammar as distorted by processing demands of memory, attention, etc.). A working linguist can take on board these lessons and come away with a sharper and more nuanced understanding of the grammar’s relationship with the wider cognitive system it finds itself in. This should in no way be taken to mean that the really ‘cool stuff’ lies in the experiments. Far from it, one of the major strengths of linguistics is that much of it relies on relatively cheap, clear-cut and robust evidence in the form of native speaker judgements of acceptability, which allows rapid cycles of hypothesis and test and provides the mental space to think theoretically. The psycholinguist with an interest in real-time processing does not have that luxury. Typically, the data of psycholinguistics are more expensive, time consuming and noisy – requiring statistical analysis to even discern when a data pattern is real, with many fewer opportunities to replicate. This leads psycholinguists to spend an enormous amount of their time thinking about experimental design and statistics and much less on theoretical issues. So linguists can and probably should learn from psycholinguistics, but that does not need to change the way that they do their job. Virtue is surely in knowing what the neighbour is doing and using that to improve oneself, not in launching or suffering a hostile takeover. Mutual enlightenment is the language spoken here.

A major aim of this book is to cover the main debates and achievements of sentence-level psycholinguistics in the past 40 years. It reviews a very large number of experiments on the processing of morphosyntactic structure (more than sixty in Chapter 2 alone) and in so doing it aims to reveal how this kind of work is done, how it relates to classic notions of linguistics, (importantly) what kinds of new questions it illuminates, and how it enriches us as scientists who love language and are continuously mystified by its ‘existence in the mind’. It is directed both to linguists with little knowledge of psycholinguistics and to experimental psychologists with a limited knowledge of grammar. Importantly, it is also directed to a growing body of young researchers who are now being trained in linguistics and the psychology of language from very early on in their academic careers (psycholinguists). Since psycho-grammar is discussed here, there may be times when particular topics may be of greater interest to one group of readers (the psychologists) or another (the grammarians) and when, accordingly, a particular group may struggle more or less given its previous academic background. Care has been taken to explain basic notions of grammar and of experimental research for the uninitiated in either of these two broad domains. Additionally, the beginning of each chapter will try to signpost what the main points will be for those groups so they know exactly what to expect. Whatever the case, though, this book is simply a psycholinguistic approach to the mystery of grammar and that is likely to interest a large portion of the population of cognitive scientists, regardless of their particular theoretical persuasions.
1.2 The functional architecture of the linguistic mind

The ultimate goal of a psycholinguistic agenda that looks into the processing of syntactic structure is to understand the cognitive processes that take place during language use and to shed light on the functional architecture of the linguistic mind. Most studies involve syntactic comprehension rather than production because experimental control is much easier in the former than in the latter — and it can be much more precise. This is because in production we are almost inevitably condemned to see the end result of message generation, missing the all-important stage (or stages) taking place in the ideational domain, before actual linguistic output. With the functional architecture of the linguistic mind in focus, we seek to comprehend how mental representations are formed, changed and stored. We also seek to establish what kinds of information are used and, specifically, whether listeners/readers compute syntactic structure during language comprehension. We may very well assume they do, but, on the one hand, there are theoreticians who believe that you do not really need a map to get from one place to another if you can count on good informative signposts along the way (meaning, if your lexicon is really informationally rich); on the other hand, even if we want to proceed from the assumption that there really is syntax in the mind, we surely want to know how we put it to use. Most importantly, we want to know when we may do so. One side of this syntax-in-the-mind agenda is the venerable question of syntactic autonomy: is syntax cognitively autonomous? Another side of the agenda is also the venerable question of syntactic supremacy or syntactocentrism: is syntax cognitively privileged? This involves pitting presumably syntactic operations against a-syntactic forces and seeing which one prevails. In psycholinguistics, prevailing means observing two things: a. either which one comes first in the time record; or b. which one interferes with what. If syntactic effects are registered first in the millisecond-by-millisecond time course of processing, then autonomy presents itself as a viable theoretical option. If, on the contrary, it does not or it is affected by a conceptual structure manipulation (say, animacy or context fit), a lexical dimension (say, lexical frequency) or a purely statistical bias, then it becomes much less viable.

The previous comments boil down to whether the functional architecture of the linguistic mind is modular or interactive, serial versus parallel (or both), bottom-up or top-down (or both). One clearly identifiable research tradition defends the classic Fodorian view that linguistic computations are automatic, domain-specific, informationally encapsulated and cognitively impenetrable. As is well known, this view equates linguistic computation with syntactic computation. Everything else that many other cognitive scientists assume is also language (notably, lexical properties and semantics) need not really be an unimpregnable module. Another equally clearly identifiable research framework maintains that the language faculty is essentially interactive, a complex, goal-directed, predictive, dynamical system consisting of a fairly large number of interacting constraints and at least a few parallel generative engines. This framework rejects
the idea that the initial spark to get the whole system going must necessarily be syntax. These have been burning issues in psycholinguistics for at least forty years now, but with the development of sophisticated online experimental methods (such as eye-tracking and various brain scanning tools), and recent developments in probabilistic predictive models, the classic Fodorian view has become more of a challenge still (but see Ferreira & Nye 2018). The philosophies, the arguments and the debates in play are well known because they are the same in linguistics, and so are the players: syntactic structure (say, c-command, islands, binding requirements, bounding, etc.), lexical knowledge (say, a verb’s meaning, a verb’s preferred argument structure, a word’s frequency, etc.), conceptual structure (say, animacy, countability, plausibility, topicality, context fit, etc.), and statistical biases. An example from the early days of psycholinguistic research will suffice to illustrate how all these issues are addressed in the psycholinguistic literature (mostly by non-linguists).

1.3 Minimal attachment

Modern psycholinguistic research on language comprehension started after the foundational work by Chomsky and Miller in the 1960s and the famed Derivational Theory of Complexity ‘episode’ of the late 1960s and early 1970s, also right after the work of Tom Bever on parsing principles (Fodor et al. 1974: 320–328; Bever 1970; see Phillips 2013 for a modern reevaluation, and Chapter 5). It may very well be said to have started with a doctoral thesis, and work directly spawned by it afterwards, entitled On Comprehending Sentences: Syntactic Parsing Strategies, by Lyn Frazier, in 1978 (Frazier 1978; Frazier & Fodor 1978). Frazier proposed two overarching principles to account for language processing in all languages of the world: minimal attachment and late closure. These were principles of a formal nature, by which was meant that semantics and/or the lexicon were not supposed to play a part in the initial stages of syntactic computation (remember: the mind ‘sees’ syntax first, then all the rest, including ongoing context). Let us focus on the former principle briefly here now. Minimal attachment (henceforth MA) meant that the parser prefers to postulate (expect and/or generate) syntactic structures that contain fewer nodes in the tree over competing structures whose generation involves more nodes. In the classic example in (8) below:

(8) Amanda believed the senator …,

the unfolding structure is compatible with two kinds of continuations:

(9) Amanda believed the senator steadfastly
(10) Amanda believed the senator was guilty

but the continuation in (10) involves an extra node in the tree to make room for the complement clause the senator was guilty (the CC or Complement Clause node in Figure 1.1b). It is therefore hypothesized to be cognitively dispreferred.
At this stage we need to understand two things. First, how we come to know whether either interpretation is preferred or not. Second, why we need to care so much about ambiguous strings. Starting with the former point, it is time to introduce the technological tool of eye-tracking. An eye-tracker is a device that measures eye gaze relative to each and every character of a text millisecond by millisecond. Usually, only the recordings of the right eye are analyzed as that is the eye that connects to the left hemisphere of the brain, where most language comprehension is dealt with. An eye-tracker can give us amazing precision on the reading process, but the most important measures involve:

- **First-pass time or gaze duration**: the sum of all the fixations in an area before the eyes move to another area to the left or to the right.
- **Go-past time or regression path duration**: the time spent from the moment an area is first fixated until the eyes move to another area to its right. This also includes the time spent re-reading earlier areas of the sentence.
- **Total time**: the sum of all fixations in an area, including the fixations made on a given region during first-pass and go-past time and ulterior re-fixations.
- **First-pass regressions out**: this includes regressions (leftward movements) made out of an area into earlier regions before the eyes move to the right.
- **Regressions in**: this includes regressions into a particular area during the whole trial.

These measures somehow reflect the fact that when reading, the eyes do not uniformly travel along a straight line but make little jumps instead (called saccades). According to Carreiras and Clifton (2004: 4),
the eyes fixate on a word for something like a quarter of a second to identify it. About 90% of reading time is spent in fixations, including some regressions to an earlier misperceived word. The typical reader makes about three to four saccadic movements per second. Each movement lasts between 20 to 40 ms, and the eyes remain fixated for about 200 to 400 ms.

Following foundational work by Just and Carpenter (1980; see Pickering et al. 2004), it is assumed that if the eyes go quickly past a region of analysis, then that region presents no particular computational challenge by comparison with a similarly sized region that presents a longer time and, especially, more regressive saccades. Ease of reading is equated with preferred structure. If the eyes need not return to a previous region, then it is assumed that the first-pass journey was sufficient to understand the syntactic structure. If, by contrast, the eyes (stop and) need to go back to a previous segment (we care about which segment in particular, for it will surely be a disambiguating one), then again we assume the parser is now pursuing a repair strategy, instead of the initially preferred one. Let us go back to (9) and (10) and add an unambiguous control:

(9) Amanda believed the senator steadfastly (MA)
(10) Amanda believed the senator was guilty (non MA)
(11) Amanda believed that the senator was guilty (unambiguous control).

Frazier and Rayner (1982) recorded people’s eye movements when reading sentences like these and realized that the average reading time (henceforth RT) per character was longer for the likes of (10) than for the likes of (9). There were also more regressions in (10) and these were associated with the disambiguating region (underlined in 10) as compared with the same region in the unambiguous (11). The authors showed that the MA preference exerted itself surprisingly quickly, even in the first fixation duration of the disambiguating region. MA can be so powerful as a preferred heuristic that rather severe garden paths (i.e., moments of partial or total breakdown in the comprehension process) often result apparently as a result of its blind application, as in (13) versus (12) below, taken from Frazier and Clifton (1996: 11). That is presumably because, on the intended reading, in (13) an additional node is needed to accommodate the relative clause before the object complement node shows up. The effects were visible not only in RTs but also in offline grammaticality judgements:

(12) The teacher told the children the ghost story that she knew would frighten them.
(13) The teacher told the children the ghost story had frightened that it wasn’t true.

Now, if your research agenda is to prove a two-stage model of language comprehension, resting on the view that syntactic and semantic processing involves
different sets of processes (autonomy), and that the brain prioritizes a syntactic cycle of analysis (syntactocentrism), the previous results come in handy. However, to scientists with a different research bias, these results only spur them to come up with an alternative explanation. In order to visualize that explanation, consider (14) now first:

(14) The horse raced past the barn fell.

(14), due to Bever (1970: 316), is surely the most famous sentence in the history of psycholinguistics (on a par with colorless green ideas sleeping furiously in the world of linguistics). This is because it induces a major garden path in everyone who reads it. The sentence starts with an NP designating an animal capable of motion followed by a verb of motion and a PP complement with ideal motion-oriented possibilities. When a second verb comes (fell) we all experience the difficulty of having to find a place for it in a structure that we had felt to be already complete. It does not take much imagination to predict an eye-tracking crisis (with the eyes frantically going backwards in an attempt to salvage an interpretation) when reading such strings. What strings in particular? Well, this is the so-called main verb-reduced relative ambiguity. Indeed, (14) can mean ‘the horse that was raced past the barn fell’, and now, on the reduced relative interpretation, everything makes sense (compare the horse ridden past the barn fell, the horse that was raced past the barn fell or the horse racing past the barn fell, all suggested in Bever 2009). The main verb versus reduced relative ambiguity was soon summoned by MA proponents to promote the notion of MA. Indeed, the main verb interpretation (involving fewer nodes) is the one we unerringly prefer for (14), and it actually takes mental effort to undo it. Based on the previous considerations, we would surely agree that in (15):

(15) The witness examined by the lawyer was useless.

we should experience a (minor) garden path following our bias to understand the unfolding structure up to the by phrase as a ‘minimal’ active structure (as in, say, the witness examined the photographs of the scene). Ferreira and Clifton (1986) reasoned that contextual or plausibility manipulations should have no effect on a first pass of processing when dealing with these structures. This means that in (16), which is biased towards a passive reading, we should also experience the same kind of minor garden path, despite the bias:

(16) The evidence examined by the lawyer was useless.

That is precisely what they found: the same reading difficulty for both sentences, a fact that they used to argue for the view that plausibility/contextual information could be used only during reanalysis, after the workings of MA.

After a series of experiments confirming this, Trueswell et al. (1994) came up with counterevidence. This took the form of what would later become an
habitual pattern: Trueswell et al. reexamined the Ferreira and Clifton structures closely and found out that they contained confounds that contaminated the experimental comparisons at issue. For instance, many of the examples that had been used in the ‘helpful context condition’ (e.g., 16) admitted other interpretations, thus invalidating the presumed contextual benefit. When they improved materials and data analyses they could show that a plausible context/world knowledge did annihilate most of the difficulty associated with the passive, reduced relative interpretation. MacDonald et al. (1994) reexamined previous results further and managed to show that context plausibility was not the only a-syntactic factor intervening in syntactic ambiguity resolution. They studied the lexical frequency of the verbs actually used in past experiments and found an interesting correlation: those verbs that tended to appear in the sentences which were preferentially interpreted as matrix sentences appeared more times in corpora as main verbs in simple transitive structures, whereas those other verbs that appeared in the sentences which were preferentially construed as reduced passive relatives appeared in corpora more often in the passive form (for instance, a sentence that starts with the sofa scratched ... is likely to induce a minor garden path because the verb scratch is rarely used in the passive and sofas do not usually scratch anything but are scratched themselves; Trueswell 1996). This underscored the role of probabilistic information in parsing (Hale 2001; Levy 2008a; Gennari & MacDonald 2009). In this connection, MacDonald et al. made a point too that the preferred argument structure of a verb should be taken into account. And they finally were bold enough to include a little section by the end of their paper which they entitled ‘Parsing without a Parser’, a clear pointer to the idea that most (probably not all, they conceded) apparent syntactic ambiguity resolution is, in fact, the consequence of lexical ambiguity. So, in the lexicalist model they proposed, far from syntax being privileged, it would rather be a secondary player at most, in humble combination with many other constraints.

So, an initial hypothesis of a purely elegant, formal nature that looked all too promising and perhaps all too good (MA) soon had to face the test of semantic/pragmatic/lexical interfacing. During the unfolding of the battle of views, a richer knowledge of the psychological reality of language was nicely revealed.

1.4 Ambiguity resolution and beyond: the oracle component of parsing

As can be seen, the dynamics of investigating processing bias rests principally on a timing issue and on an interference agenda. If you postulate that something takes precedence (syntax), then finding that a conceptual structure manipulation is effective at a really initial round of processing is a problem. If you postulate informational encapsulation, then a conceptual or a lexical cue interfering with a presumably syntactic choice is a problem too. It is surely useful to compare this research agenda with a doctor administering a dose of a medicine to a body and seeing how the body reacts. Say you have an ambiguous structure relatable to a
phrase structure tree defined in reference to MA and you inject a dose of plausibility in it (thus forcing a reading of the string contrary to the MA tree). If there is a reaction in the body then MA is not all there is to its ordinary functioning. You then need to keep injecting in the body all kinds of other doses (of either a formal or a functional/semanticist nature) to see what makes it react (admittedly, this is a rather strange metaphor).

As can also be seen, a lot (though by no means all) of this research agenda rests also upon the existence of structural ambiguities that experimental researchers can manipulate and measure. The manipulation is typically a disambiguating one. The basic dynamics is to compare the RT patterns of disambiguated versions of an ambiguous string. The disambiguation that takes less time (= less cognitive load) is assumed to reflect the mind’s processing bias. Thus, in the *ha chiamato Gianni* structure of (5) above, for instance, we need to disambiguate towards a reading where Gianni is the caller (the displaced subject version), and another in which Gianni is the callee (the in-situ version, with Gianni as object). If, for instance, the second one takes less time, then we reach the conclusion that movement of the subject across the verb is indeed dispreferred: that movement is costly.

An important prerequisite to this agenda is the existence of ambiguities that we can disambiguate. So how ambiguous is language? It turns out a lot. In fact, this aspect is quite often exploited in humorous environments, as when Groucho Marx used a well-known modifier attachment ambiguity: “I shot an elephant in my pajamas. How he got into my pajamas I don’t know” (from the movie *Animal Crackers* [1930]). Careless headlines often also contain ambiguities that later become a kind of joke: *Prostitutes appeal to pope; Soviet virgin short of goal again*. In 2006 a CNN headline went “Leahy Wants FBI to Help Corrupt Iraqi Police Force”.

The following is a long list of ambiguous structures of various kinds that populate the Internet, many of which became popular since they first appeared in Stephen Pinker’s famous book *The Language Instinct*. I predict you are going to experience numerous garden paths right now, some of them of colossal proportions, but bear in mind that all these strings are perfectly grammatical once you manage to pull up the right syntactic tree in your mind:

(17a) The wolf was shot by the angry farmer with a scar.
(17b) The wolf was shot by the angry farmer with a rifle.
(18a) They told us they were going to do it tomorrow!
(18b) They told us they were going to do it yesterday!
(19) The old man the boat.
(20) The lady who sews dresses beautifully.
(21) I convinced them pets are dirty.
(22) Fat people eat accumulates.
(23) The prime number few.
(24) While mom was dressing the baby wouldn’t stop crying!
A friend that I had really loved musicals.

Until the police arrest the drug dealers control the street.

They painted the house with cracks.

Tonight we will discuss sex with Dick Cavett.

The cotton clothing is usually made of grows in Mississippi.

My mum gave the lady a dog bit an antiseptic.

If you always jog two miles and a half is easy.

Vegetarians don't know how good meat tastes.

I'll tell you when they arrive.

She wants to marry a Norwegian who is rich.

Many of these structures are permanently ambiguous, like other famous instances such as cleaning ladies can be delightful and visiting relatives can be boring (eating pizza with a friend versus eating pizza with a fork, etc. See Altmann 1998). Others, however, are only temporarily so, such as the one we have already discussed in examples (15)–(16) above: the witness examined ... Take another one first discussed by Bever (1970) and then in The Language Instinct, nicely explained by Pinker himself (1994: 208):

The plastic pencil marks …

(...), the parser has to keep several options open: it can be a four-word noun phrase, as in The plastic pencil marks were ugly or a three-word noun phrase plus a verb, as in The plastic pencil marks easily. In fact, even the first two words, The plastic, are temporarily ambiguous: compare The plastic rose fell with The plastic rose and fell.

Note that even the ambiguities that have a lexical origin (e.g. the prime number few, where number is used as a verb) often have cascading structural consequences, since they enforce a different syntactic structure.

Structural ambiguities are not just convenient for us to manipulate as tools; they embody a fundamental lesson in our quest to reveal the true nature of the human language faculty. This is because they differ from lexical ambiguity per se in a very important way. In 1979, David Swinney made a great discovery when he managed to show that ambiguous lexical items activate all of their disparate meanings in parallel, however counterintuitive that may sound. Swinney (1979) had participants in an experiment listen to sentences like (33), containing the ambiguous word bug (equibias, out of context, towards the meaning of either insects, on the one hand, or surveillance device, on the other):

Rumor had it that, for years, the government building had been plagued with problems. The man was not surprised when he found several spiders, roaches and other bugs in the corner of his room.