

Immediate Processing of Sentences in Language Communication

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Abstract—Sentence processing is a fundamental and critical area of inquiry within the field of language processing, as it plays an essential role in facilitating effective communication. The present study focuses on the immediate processing of sentences in English language communication. The article begins by providing an overview of the basic principles underlying sentence processing. It then delves into the various parsing strategies, including the late closure strategy and the minimal attachment strategy. The modular and interactive models of sentence processing are also presented and discussed. Additionally, the relationship between sentence processing and meaning is explored, with an examination of the role of factors such as presupposition and plausibility in language communication process. Finally, the role of prosody in language processing is expounded upon. The paper draws several conclusions regarding the nature of immediate sentence processing in language communication.

Index Terms—sentence processing, parsing, modular model, interactive model, language communication

I. INTRODUCTION

In everyday communication, individuals encounter numerous sentences and are capable of comprehending them instantly and without hesitation. When processing a sentence, people rely on their extensive knowledge and information about various linguistic factors, such as syntax, lexicons, semantics, pragmatics, and other multimodal aspects (MacDonald et al., 1994). Parsing, which involves assigning the elements of a sentence's surface structure to linguistic categories, is often the first step in understanding a sentence during communication (Kimball, 1973). This allows individuals to determine who or what is doing what to whom or what. Such relationships can be represented using a tree structure or phrase marker. In the case of simple sentences like *Students read the book*, the constituent or phrase structure of the sentence can be readily identified. For instance, *Students* is a noun phrase (NP), *read* is a verb (V), and *the book* is another NP. However, more complex sentences like *Tom knows the fact that keeping clothes clean is necessary surprises Marry*, are more challenging to process due to the presence of embedding elements. In such cases, people may find themselves revising their initial analysis as different parsing strategies and ways of understanding language may be preferred in actual communication.

In addition to syntax, sentence processing requires consideration of other factors. At a semantic level, people need to recognize the semantic or thematic functions fulfilled by different words within the sentence (Stowe, 1989). For instance, in the sentence *Students read the book*, *students* are the agents, and *the book* is the recipient of the action. At the pragmatic level, individuals possess knowledge about the real world, which can help them understand the sentence's meaning. For instance, the sentence may describe a typical classroom scene where students are required to read their textbooks. Furthermore, multimodal factors can also influence the way individuals comprehend a sentence. Given the amount of knowledge and information individuals must consider when encountering a sentence immediately, a question arises regarding the patterns and types of information processing involved, specifically whether syntactic, semantic, and pragmatic knowledge are simultaneously employed in sentence comprehension. Alternatively, certain factors might take priority at various stages of comprehension. In this regard, two hypotheses of sentence processing patterns have been proposed: the modular model and the interactive model, which will be discussed in detail below. Moreover, the paper researches whether prosody can help language processing. This paper is organized as follows. In the first section, parsing is introduced, including how to identify the syntactic structure of a sentence, followed by a discussion of various parsing strategies. Next, the role of semantic and prosodic factors in language comprehension is explored, along with two models of sentence processing. The paper then elaborates on the role of multimodal factors affecting sentence processing and concludes by summarizing the nature and features of sentence processing.

II. PARSING

A. Surface and Deep Structure

In language communication, Chomsky (1957, 2014) proposed that sentences can be divided into two levels: deep structure and surface structure. Deep structure represents the abstract syntactic properties of a construction, while surface structure corresponds to the structural organization of a construction actually produced. Simple sentences can be easy to comprehend, while complex sentences with more intricate structures may require additional processing time. It was argued that sentences that had undergone derivational changes are more difficult to process, which is generally called Derivational Theory of Complexity by scholars, among which, one derivational process in this grammatical framework produced passive sentences, such as sentence (1) and (2) below. Sentence (2) is derived from an underlying or logic form that expressed the basic idea of the sentence (1). It suggests that passive sentences were further removed from this underlying form than active sentences. As a result, it is considered that passive sentences are more challenging to comprehend than active sentences, and the comprehension of sentence (2) requires greater cognitive resources than the comprehension of sentence (1).

(1) The teacher saved the file.

(2) The file was saved by the teacher.

Likewise, sentence (4) was anticipated to be more challenging than (3) due to the inclusion of a negative transformation.

(3) It is raining.

(4) It is not raining.

Research has demonstrated that relative clauses are more challenging to process than other derivational structures due to the presence of a relative pronoun as the object of the embedded verb, as exemplified in (6) below. In comparison, the relative pronoun as the subject in (5) is less challenging to comprehend. This is because the constituent order of the elements in the relative clause in (5) is identical to the logical form of the clause, whereas the surface order of the relative in (6) does not correspond with the logical structure but the deep structure. As a result, individuals need to exert more cognitive effort to process the relative clause in (6).

(5) The man who looked the waiter went home.

(6) The man who the waiter looked went home.

B. Parsing

After knowing the surface and deep structure of sentences, it is necessary to introduce Parsing in the process of language communication, which is the issue of complicity of the surface structure influencing sentence processing. Parsing can be regarded as the initial stage in comprehending a sentence, involving the allocation of elements from its surface structure to specific linguistic categories (Kimball, 1973). Then people have an internal representation of the linguistic relationships within a sentence through parsing, which is represented by a tree structure or phrase markers as figure 1 below. For example, the sentence *Some kids enter the room*. It is regarded that *some* as the determiner, which signals the beginning of the NP. Typically, an NP consists of a determiner, an adjective, and a noun. Upon encountering the determiner *some*, individuals search for the potential adjective or noun. Then, the subsequent word, *kids*, is identified as a noun and added to the NP. The following verb phrase (VP) comprises the verb *enter* and the object *the room*. And the latter is another NP composed of the determiner *the* and the noun *room*. The tree structure of the sentence is presented in Figure 1 below.

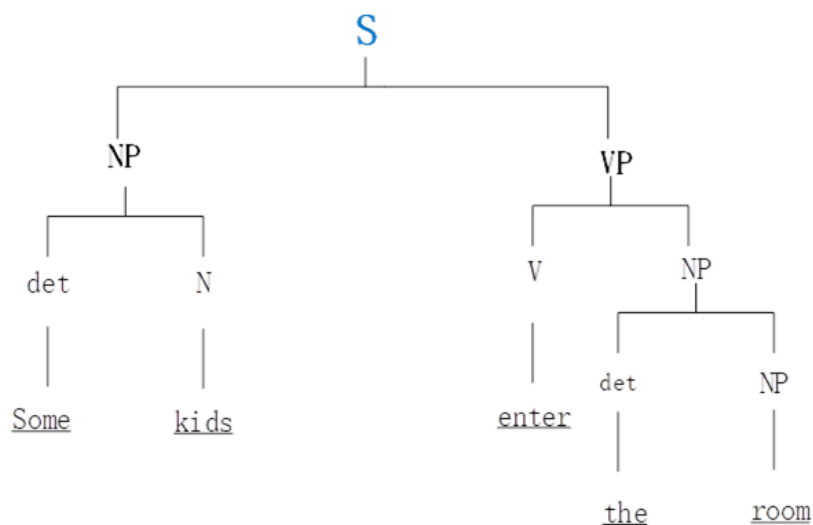


Figure 1. Sentence Tree Structure

C. Two Principles of Parsing

Upon understanding that individuals categorize sentence elements into linguistic categories during language communication, an inquiry must be answered: are these elements categorized immediately or later in the sentence processing? This question is explored through two distinct principles proposed by Carroll (2004): the Immediacy Principle and the Wait-and-See Principle. By examining these principles, the process by which individuals comprehend language in real-time can be better understood.

The Immediacy Principle, the first principle proposed by Carroll (2004), suggests that when encountering a word for the first time in a sentence, people retrieve its meaning from their long-term memory, recognize its probable reference, and integrate it into the syntactic structure of the sentence (Daneman & Carpenter, 1980). In contrast, the Wait-and-See Principle postpones interpreting a word phrase until it is clearer where a sentence is going (Carroll, 2004). While the Immediacy Principle is considered more reliable with greater empirical support, the Wait-and-See Principle is less supported as delaying decisions may increase working memory load and hinder later processing (Frazier, 1979; Gibson, 1991; MacDonald et al., 1992). On the contrary, immediate decision-making does not occupy many cognitive resources and ensures efficient processing, as demonstrated by the parsing of sentence (7) below.

(7) Tom and Mary argued for the ball.

Sentence (7) presents an example of an ambiguous sentence, which can be interpreted in various ways. The first interpretation suggests that Tom and Mary debated over a toy ball. The second interpretation implies that Tom and Mary argued with their father to purchase a ball for them. The third interpretation suggests that the term *ball* refers to a party, and Tom and Mary debated over who could attend the party or who could host the party. These diverse interpretations illustrate the complexity of natural language processing. Given the vast amounts of information in language communication, individuals must make rapid decisions, or else their working memory will become overwhelmed. If the Wait-and-See Principle is applied, individuals may struggle to keep up with the sentence's unfolding meaning and become lost in the processing. Therefore, rapid decision-making is crucial for efficient language comprehension.

In most cases, people apply immediacy principle in sentence processing of language communication, which may lead to misunderstandings. For example, consider the sentence (8) below:

(8) The man stood by the wall fall down.

When encountering a sentence in English language communication such as *The man stood by the wall fall down*, individuals may initially assume that *stood* is the main verb phrase, followed by *the wall fell down*. However, both interpretations are incorrect. In reality, the sentence is an embedded relative clause. The difficulty in comprehending this sentence lies in the fact that the reduced relative clause is not signaled by a relative pronoun, as in sentence (8). This lack of a relative pronoun makes it challenging for individuals to recognize the reduced relative clause. As individuals tend to apply the immediacy principle in language processing, they often misunderstand sentences and become surprised when they see the entire sentence. If individuals postpone interpretation until further context is available, they may more reasonably interpret the sentence as a noun phrase modified by a reduced relative clause.

III. PARSING STRATEGIES

During language communication, individuals encounter linguistic information word by word. Therefore, it is important to address parsing strategies, which involve categorizing linguistic elements and constructing sentences from the input words. Numerous studies have examined parsing strategies in sentence processing. In general, two types of strategies are typically discussed:

A. Late Closure Strategy

The first is called Late Closure Strategy, which means that people prefer to attach new items to the current constituent in the process of language communication, as it is a saving action for working memory (Frazier & Fodor, 1978; Frazier, 1987; Kimball, 1973). For example, in the sentence (9) below:

(9) Tom bought the book that I'd been trying to find for Jack.

When processing a sentence, it is common for individuals to interpret it as *I try to find a book for Jack*, rather than *Tom bought the book for Jack*, even though the latter interpretation is also possible. This preference for assigning close elements to the current constituent is known as the late closure strategy and occurs automatically in language processing. Although this strategy may result in ambiguous or problematic interpretations, individuals often fail to detect such ambiguity. Only upon revisiting the sentence may individuals realize the possible alternative interpretation.

In accordance with this preference, discontinuous constituents are difficult to process. Compare the sentence in (10)-(12) (Warren, 2013). The more elements that intervene between *range* and *up*, the more difficult it is to comprehend the sentence.

(10) Lily rang her friend up.

(11) Lily rang her friend in the Outer Hebrides up.

(12) Lily rang her friend in the Outer Hebrides that she hadn't seen since their trip together to Japan the summer before last up.

The aforementioned example sentences are hypothetical and serve as illustrations of a linguistic phenomenon. The difficulty with these sentences lies in the lack of semantic coherence between the word *up* and the preceding clause,

making it arduous for individuals to integrate them. The greater the syntactic distance between the constituents, the more substantial cognitive resources, such as working memory, are required for comprehension. It appears that constituents are bundled into cohesive units during the process of reading or listening, and *up* is no longer associated with a unified constituent. Therefore, such sentences are generally avoided in practical usage.

(13) He read the paper that he received yesterday.

In language communication, there are two ways of interpretation of the adverb *yesterday* in the sentence (13) (Altmann, 1998). The first one suggests that *yesterday* is attached to the subordinate clause, namely *he received the paper yesterday*. The other one is that *yesterday* is attached to the main clause, namely *he read the paper yesterday*. In accordance with the late closure strategy, individuals are more likely to favor the former interpretation, as this strategy dictates attaching new elements to the current constituent, conserving working memory capacity.

(14) She gave him a gift...

(15) She gave him a gift for Tom...

(16) She gave him a gift for Tom in London.

Sentences (14) - (16) provide examples of ambiguous sentences. The gift was initially thought to be given to the speaker, but later on, individuals discovered that the gift was meant for Tom. Adding to the confusion is the adverbial phrase *in London*, which could either modify the main clause *she gave me a gift* or the noun *Tom*. However, in line with the late closure strategy, individuals are more inclined to adopt the latter interpretation, thereby attaching the adverbial phrase to *Tom*. This sentence underscores the immediacy principle, which posits that individuals tend to construct mental representations of sentences incrementally, in real time.

Additional evidence can be gleaned from an experiment involving the fixation of the eyes on two comparable sentences. Eye fixation serves as a critical measure of eye movements, which is thought to mirror the extent of psychological or cognitive processing that a visual display demands (Rayner, 1975). Therefore, it can provide insights into the ease or difficulty of processing sentences. Measurements of eye movement are founded on fixations and saccades. Fixations denote the duration during which the eyes remain stationary, and prolonged fixations may suggest challenges in processing (Duffy et al., 1988). An increase in the number of fixations indicates a less efficient search strategy for processing. The two sentences, (17) and (18), appear comparable but differ in structure to test the proclivity for late closure strategy.

(17) Mary knows John well.

(18) Mary knows John left.

In sentence (17), John is interpreted as the object of the sentence; however, in sentence (18), John functions as the subject of the object clause, rather than as the object of the verb *knows*. Consequently, the initial parsing requires revision, which in turn induces the garden path effect, a phenomenon that can be investigated via eye-tracking experiments (Frazier & Rayner, 1982; Rayner & Frazier, 1987). Although the two sentences are of equal length and contain the same number of words, readers exhibit significantly longer fixation times on the word *left* compared to *well*. This finding aligns with the late closure strategy, which suggests that readers persist with the structure of sentence (17) as they parse sentence (18).

B. Minimal Attachment Strategy

In addition to the first strategy, the second strategy is known as the minimal attachment strategy. According to this strategy, we tend to attach new elements to the phrase marker being constructed by using the fewest syntactic nodes that comply with the language's rules (Frazier & Fodor, 1978). This strategy also conforms to the principle of working memory economy. An illustrative example is presented in (19) below (Baver, 1970):

(19) The horse raced past the barn fell.

When encountering the sentence *The horse raced past the barn fell*, individuals initially construe *the horse* as the subject and *raced* as the predicate verb, as the SVO structure is the most straightforward sentence structure in our minds. In accordance with the minimal attachment strategy, this interpretation requires the fewest constituent nodes. It is only upon encountering the word *fell* that individuals realize their initial parsing was incorrect and must revise their understanding. They reanalyze *raced* as the verb in the subordinate clause and *fell* as the main predicate verb, resulting in the sentence *The horse fell*. This sentence provides evidence for the minimal attachment strategy. Sentence (19) is one example of a garden path sentence, wherein individuals initially interpret a sentence in a specific manner only to realize near the end that they have made a misinterpretation (Pritchett, 1992). This experience of being led astray and having to backtrack provides further support for the immediacy principle; had individuals not committed to an immediate interpretation, they would not have found themselves in this predicament.

IV. MODULAR MODAL AND INTERACTIVE MODAL

A. Modular Modal

In language communication to comprehend sentences, there are other factors need to consider, including syntax, semantics, context and so on. Some scholars claim that syntax is the priority in sentence processing and it is independent of other factors (Breedin & Saffran, 1999), which has been demonstrated by Chomsky school. According to this view, one sentence processing modal called modular modal is proposed in which parsing is carried out by a

syntactic module that remains uninfluenced by higher-order contextual variables at the first time, such as the sentence's meaning or broader world knowledge (Frazier, 1990). In this modal, the syntactic factor plays a decisive role of parsing independent of other factors, while other factors influence the parsing (Frazier, 1987). The dependence can be illustrated by the following sentences (20) (Chomsky, 1957) and (21) below.

(20) Colorless green ideas sleep furiously.

(21) Love enlarges cloth in the language.

The two sentences above are very weird for they are syntactically well-formed but semantically anomalous. In essence, native speakers commonly acknowledge these as grammatically correct sentences, despite struggling with the interpretation of their meanings. Even though the meaning is strange, native speakers would try to use their imagination to attach meaning to them as if they are poetic sentences.

For the view that syntactic factors are independent and more important than other factors in sentence processing, supporters of modular model give more evidence (Caramazza & Berndt, 1978; Marin et al., 1976). This model does not negate the importance of other factors in sentence processing; rather, it emphasizes the separation of syntactic information from other information at the initial stage of sentence processing. One sentence is parsed into different syntactic elements which is the first step of sentence processing. Subsequently, a comparison with a semantic interpretation produced by an independent thematic processor becomes essential. Should the semantic interpretation conflict with the initial syntactic analysis, revisiting and amending the interpretation becomes imperative (Caramazza & Berndt, 1978).

According to the modular modal theory, the initial stage of syntactic analysis should be conducted independently of the meaning or plausibility of a sentence. So, in behavioral patterns in sentence comprehension, such as investigations of eye movements during reading, reading times during initial analysis should be primarily influenced by syntactic factors, as evidenced by the observed slowdown in reading when encountering a garden path sentence (Clifton et al., 2016). Non-syntactic factors, on the other hand, are expected to exert their influence during later stages of analysis, such as when readers engage in regression to revise their initial syntactic interpretation (Frazier & Rayner, 1982; Dempsey & Christianson, 2022). However, the latency of regressions is still determined by syntax, as it results from words that do not conform to the reader's initially preferred analysis.

A series of studies (Ferreira & Clifton, 1986) began by examining eye-movement patterns observed in individuals while they read sentences containing reduced relative clauses, such as the following sentences (22) and (23) below (Trueswell et al., 1994):

(22) The defendant examined by the lawyer turned out to be unreliable.

(23) The defendant that was examined by the lawyer turned out to be unreliable.

According to the minimal attachment strategy, individuals tend to interpret the word *examined* as the predicate verb rather than the past participle form of an embedded clause upon initial reading of the sentence. However, as they progress through the sentence and encounter the word *by*, it becomes clear that the sentence is a garden path sentence, where *examined* is a modifier element of *defendant*. Consequently, individuals realize that they are on the wrong path of processing and must backtrack to revise their parsing. Nonetheless, sentence (23) avoids this ambiguity by explicitly indicating the structural formation of the relative clause, specifically through the presence of the word *that*.

To determine whether plausibility or syntactic factors take precedence in the parsing process during language communication, researchers examined the subject of the sentence. To manipulate plausibility, they altered the noun preceding the verb in the subsequent sentences (24) and (25), as noted by Trueswell et al. (2021):

(24) The evidence examined by the lawyer turned out to be unreliable.

(25) The evidence that was examined by the lawyer turned out to be unreliable.

Both sentence (24) and the garden path sentence (22) share identical syntactic structures, and thus, the garden path effect would still be expected at the syntactic level. However, their interpretations are markedly different. In the sentence (22), it is entirely plausible that a defendant might examine something such as the object document, and so the past tense verb readers misunderstood seems both syntactically and semantically acceptable (Trueswell et al., 1994). On the other hand, since an inanimate object, such as evidence, cannot examine other objects, readers did not interpret the verb *examine* as the predicate verb of the sentence, rendering it implausible. Surprisingly, the reading experiment showed a similar pattern of eye movements for both (22) and (24), even though it was semantically implausible for evidence to examine anything else. Furthermore, the same difference in reading times observed between (22) and (23) was also found between (24) and (25). The results suggest that the syntactic preference for *examined* as a past tense verb still exists, regardless of the semantic implausibility of the inanimate object.

The preceding example exemplifies the modular modal, which highlights the autonomy and preeminence of syntactic analysis in sentence processing. Specifically, this implies that syntactic analysis can operate independently of other linguistic information, and that it constitutes the fundamental mechanism driving the comprehension of language during communication.

B. Interactive Modal

In contrast to the modular modal, the interactive modal postulates that during the initial parsing of a sentence, individuals make use of all available information, including syntactic, lexical, discourse, and non-linguistic contextual

information (Tanenhaus et al., 1995). A body of research has compared these two proposals by investigating structurally ambiguous sentences, such as those presented in Rayner et al. (1983):

- (26) The florist sent the flowers was very pleased.
- (27) The florist sent the flowers to the elderly widow.
- (28) The florist who was sent the flowers was very pleased.

Regarding the first sentence (26), individuals listening to it mentally parse the sentence into fragments, and then analyze each fragment individually. There exist two ways of parsing the sentence: the first involves interpreting *sent* as the verb, as exemplified in the second sentence (27). This interpretation may result in the occurrence of a garden path effect. Alternatively, the sentence may be interpreted as a reduced relative clause, as illustrated in the third sentence (28). Ambiguity arises due to the fact that English permits the omission or reduction of relative clauses, such as *who was*. The plausibility of the real world impacts the immediate processing of sentences, as people are inclined to construe *sent* as the verb, given their real-world knowledge that florists are typically the ones who send flowers rather than the recipients. Thus, it is the plausibility of the real world that influences sentence processing. Upon scrutinizing the eye fixations on the sentence (29), it has been discovered that the initial analyses of the sentence were not linked to the plausibility variable. Furthermore, clear evidence of a garden path effect was observed in both plausible and implausible sentences (Rayner et al., 1983).

- (29) The performer sent flowers was very pleased.

It seems that many researches have examined the two models and gained some results, yet there is not enough evidence to prove either of the hypothesis. More empirical studies need to be done in the future.

V. MEANING AND SENTENCE PROCESSING

Early psycholinguistic studies validated the intuitive belief that meaning indeed influences the comprehension of sentences during processing. Reversible sentences have been studied to research the role of meaning in language processing. Slobin (1966) compared reading times for reversible sentences (30) with those for non-reversible sentences (32). It can be seen in sentences (30) and (31), the exchange of subject and object is semantically acceptable, though the meaning of the two sentences is clearly different. However, in the sentence (32) and (33) if the subject and object exchange to each other's place, though the two sentences are syntactically right, but in semantics the later sentence is not acceptable.

- (30) The chicken saw the horse.
- (31) The horse saw the chicken.
- (32) The chicken pecked the horse.
- (33) The horse pecked the chicken.

The result of sentence-picture matching tasks indicated that passive versions of the reversible sentences, such as (34), are more difficult to process than passive versions of the non-reversible sentences (35).

- (34) The horse was seen by the chicken.
- (35) The horse was pecked by the chicken.

According to Berndt et al. (1996) and Schoenemann (2022), reversible sentences allow for the interchangeability of the subject and object, resulting in both active and passive forms being grammatically correct with the same underlying structure, but with contrast meanings. Typically, individuals tend to comprehend the subject as the agent and the object as the recipient of the action. Consequently, when processing passive reversible sentences, additional time is required to determine the correct interpretation between the two possible scenarios. Conversely, non-reversible sentences only require consideration of a single plausible condition as the corresponding active situation does not exist. This indicates that certain elements of grammar, like those indicating a sentence's passive structure, do not heavily limit the analysis during comprehension.

Empirical investigations demonstrate that plausible sentences are processed more efficiently than implausible ones. Reading times were measured for a variety of sentences to evaluate their processing ease. Warren (2013) found that sentences like (36) were processed much faster than those like (37), despite identical syntactic analyses. This disparity arises because plausible sentences are easier to understand, while the processing of implausible sentences, although grammatically correct, poses a significant challenge.

- (36) They had a picnic under the tree.
- (37) They had a picnic under the teeth.

The experimental methods discussed demonstrate that the influence of meaning on sentence processing happens relatively late in the interpretation, captured through offline measures, contrasting with the more immediate and direct online measures obtained from eye-movement studies.

VI. PRESUPPOSITION, PLAUSIBILITY AND PARSING

Ambiguous sentences are studied to research language processing. The famous example is the garden path sentence (38) (Bever, 1970).

- (38) The horse raced past the barn fell.

Ambiguous sentences such as this have been attributed to a structural preference that results in readers mistakenly interpreting the verb *raced* as the main verb, rather than a past participle in a reduced relative construction. Consequently, readers are led astray by the garden path effect, and only upon encountering the word *fell* do they realize the error in sentence comprehension. Notably, such misinterpretation does not occur in sentence (39), as readers are proved to be right upon reaching the final word (Bever, 1970).

(39) The horse raced past the barn quickly.

Numerous instances of garden path sentences have been studied and are considered to be processed through syntax-driven mechanisms, with ambiguity arising from the interaction between past tense verbs and reduced relatives. However, critics of the syntax-first approach or modular model of sentence processing argue that there are additional complexities involved in the comprehension of many garden path sentences. For instance, according to Crain and Steedman (1985), reduced clause constructions in ambiguous sentences must incorporate certain assumptions or presuppositions that are absent in past tense verb interpretations. In light of these presuppositions, it becomes implausible to interpret the past verb as a reduced relative clause, unless there is further contextual information available to support such an interpretation. It is suggested that these presuppositions arise primarily because the relative clause in sentence (38) is restrictive, whereas in sentence (40) it is not.

(40) The horse, (which was) raced past the barn fall.

They proposed a Referential Hypothesis, which argued that in sentence structure (38), a set of potential horses is assumed, with the horse specified by the relative clause being the one in question. Conversely, sentences (39) and (40) presuppose a single, definite horse being described. It is suggested that this discrepancy between (38) and (39) and (40) gives rise to divergent interpretations. The resulting challenge in processing relative clauses is attributed to this disparity rather than to syntactic predilections. This distinction is believed to be the cause of challenges in relative clause processing rather than the syntactic preferences.

Scholars contend that the challenge in processing sentences such as (38) arises from a plausibility constraint, rather than a syntactic one. Upon encountering *The horse raced* in both (38) and (39), readers are presented with two possible directions: a past tense verb or a past participle. In view of the ambiguity, plausibility assessment mechanisms must be employed to predict the intended meaning. Specifically, we must rely on the mechanisms that evaluate the plausibility of a given sentence. In light of our real-world knowledge, the notion that a horse raced past the barn is eminently plausible and readily acceptable. By contrast, the restrictive relative reading carries a more complex presupposition than the former. Thus, the past tense is preferred for a plausibility constraint rather than the syntactic preference.

This account for the famous garden path sentence makes an earlier appeal to non-syntactic information. There is clear difference between the syntactic account and the non-syntactic information sources. At the parsing process, misanalysis is made by the syntactic approach which leads to the garden path effect. And we must resort to non-syntactic information that we can have the right interpretation.

This account can be applied to other garden path sentences too as (41)-(42) (Crain & Steedmen, 1985). In the sentence (41), there is a similar construction which is also a subordinate clause (that he was having trouble with). *Wife* is modified by the subordinate clause which is connected by *that*. This would be more obvious if *who* were used instead of *that*.

(41) The psychologist told the wife that he was having trouble with to leave her husband.

(42) The psychologist told that he was having trouble with her husband.

This indicates that comprehending sentence (42), where the sequence of words following *wife* forms a subordinate clause, specifically an object clause functioning as the direct object of *tell*, is easier compared to other structures. The sentence structure is that *the psychologist told the wife something*, and it could be asked what did the psychologist tell the wife. Notably, *that* in the sentence cannot be replaced by *who*.

The distinction between the two sentences lies in the type of subordinate clause employed. Specifically, the first sentence features a restrictive relative clause, while the second sentence utilizes an object clause. According to the minimal attachment strategy, readers tend to interpret the phrase *that he was having trouble with* as part of an object clause. Consequently, readers expected an object clause in the first sentence, which led to greater processing difficulty compared to the second sentence. However, the restrictive relative clause in the first sentence, like the one in the preceding example, presupposes that there are multiple wives involved. This presupposition competes with readers' tendency to assume that there is only one wife in the sentence, rendering interpretation more complex. In other words, the interpretation of the restrictive relative clause is complicated by its presupposition, making it less plausible for readers. From this example, we can conclude that misunderstandings in sentence interpretation arise more from non-syntactic information than parsing strategy.

Further evidence has been made by Crain and Steedmen (1985) for this alternative explanation. They altered the presuppositions associated with a sentence by preceding it with different kinds of context. These could guide the readers to the bias of a relative clause interpretation of *that he was having trouble with* or the bias of an object clause interpretation.

(43) A psychologist was counselling two married couples. One of the couples was fighting with him, but the other one was nice to him.

(Relative clause bias)

(44) A psychologist was counselling a married couple. One member of the pair as fight with him, but the other one was nice to him.

(Object clause bias)

In the experiment, participants were presented with distinct conditions for each sentence in (41) and (42) and were asked to determine their grammaticality. The results indicate that the frequency of ungrammatical responses to relative clause structures (41) did not exceed that of object clause structures (42). Nevertheless, it is crucial to note that the primary cause of ungrammatical responses for both types of structures resulted from a contextual mismatch between the test sentence and the preceding context. For instance, a common scenario involved (41) followed by (43) or (42) followed by (44).

These researches provide us with some evidence indicating that our processing of sentences involves not only syntactic information but also non-syntactic factors such as presupposition and plausibility. This finding is in contrast to earlier research that suggested that semantic factors do not have a direct impact on syntactic analysis. It is important to note that grammatical judgments are typically made after the initial processing of the sentence, and therefore can be influenced by a range of additional factors that may affect interpretation. The current results suggest that initial syntactic analysis is followed by a subsequent check by a thematic or meaning-based processor, which underscores the importance of considering both syntactic and non-syntactic factors in understanding the mechanisms underlying sentence processing.

VII. PROSODY AND PARSING

Previously, the prioritization of syntax in the parsing process was discussed based on studies that primarily focused on reading tasks and written sentence processing. However, the role of syntax differs in listening tasks, as speech conveys cues not only to syntactic structure but also to other aspects of sentence and utterance organization, such as explicit syntactic markers in written language. Specifically, speech provides prosodic cues, including intonation patterns, stress, and rhythm patterns of words, phrases, and sentences. In this section, we will examine the role of prosodic information in immediate sentence processing. Given that prosodic structure can aid word recognition, as demonstrated in slips-of-the-ear, we will investigate how prosody facilitates immediate sentence processing in communication.

(45) When Mary was writing the letter, it fell off the desk.

(46) When Mary was writing, the letter fell off the desk.

The two sentences presented above represent two possible interpretations of an ambiguous sentence, which can be disambiguated with the inclusion of a comma. Without a comma, the Late Closure principle suggests that the noun phrase *letter* is likely to be attached to the verb *writing* as its object. However, the addition of a comma after the verb signals an Early Closure interpretation, with the subsequent noun phrase belonging to a new clause, as in the second sentence. In spoken language, prosody serves a similar function to punctuation by indicating the syntactic structure of the sentence.

(47) Mary saw the skirt and gave her opinion.

(48) Mary saw the skirt was nice.

Regarding the two sentences presented in (47) and (48), the inclusion of a comma is unlikely to disambiguate the pairs of syntactic structures. However, prosody can be utilized to differentiate between the two interpretations through the use of pausing, rhythm, amplitude, and pitch. The key question is whether listeners can effectively use such information during sentence processing, and to what extent. In a study conducted by Schafer, Speer, Warren, and White (2000), participants engaged in a simple continuation experiment in which they listened to spoken sentence fragments and selected their completions. Results indicated that prosodic information was used by participants to comprehend the sentences. Nevertheless, the study was unable to determine whether prosodic information influences the initial analysis of a sentence, or whether prosodic analysis takes priority in parsing or exists solely in post-perceptual analysis. To address these questions, a variety of online tasks must be employed.

In a cross-modal naming experiment conducted by Marslen-Wilson et al. (1992), a set of minimal attachment sentences were used which had been previously extensively studied in reading experiments. Participants were required to read aloud the visual probe, when they were listening to a spoken utterance fragment followed by a visual probe. The experiment aimed to determine if participants could initiate their naming response more quickly when the probe word was related to the preceding utterance fragment, resembling a smooth continuation. It investigated whether prosodic cues, similar to how the complementiser *that* clarified sentence (49), could resolve ambiguity in spoken versions of minimal attachment sentences like (50).

(49) The workers considered that the last offer from the management / was a real insult.

(50) The workers considered the last offer from the management / was a real insult.

(51) The workers considered the last offer from the management / of the factory.

In the experiment, participants can only listen to the sentence fragment before the point marked by / and then they saw the probe word. For these examples this was the word *was*. And the sentences fragment before the / in sentence (50) and (51) are identical in word strings. However, their spoken forms in the experiment are different. This is because the first sentence is a non-minimal attachment version of the sentence, but the second sentence is a minimal attachment version.

Result shows that even though the fragments contained identical word strings, the naming times after the non-minimal attachment fragment in sentence (51) were slower than after the non-minimal attachment fragment in sentence (50). In the experiment, the two sentences are spoken in different prosody which is the only difference between the two sentences. And this result implies that participants used prosodic information online to resolve potential temporary ambiguities. What's more, results show that there is no significant difference between the response times of the two non-minimal attachment versions (49) and (50). This demonstrates that prosodic information is just as effective in online parsing as explicit syntactic marking.

A further experiment conducted by Warren et al. (1995) explored the concept of Late Closure sentences and arrived at a similar conclusion. In this study, participants were presented with sentence fragments, such as sentence (52), and subsequently exposed to a continuation word for naming purposes that was only consistent with an early closure interpretation of the fragment, for instance, closure after the term *Hong Kong* instead of *problem*. Notably, when the spoken version of the utterance was derived from a late closure reading, naming times were considerably slower.

(52) Whenever parliament discusses Hong Kong problems...

Results show that stress shift influences the presence or absence of phonological process. Stress shift is a phenomenon in English and in some other languages it prevents two stressed syllables from being too close together. In the example sentence, the stress of *Hong Kong problems* should be shifted, for the second syllable in *Hong Kong* is stressed and the first syllable in *problem* is stressed. So, the second syllable in *Hong Kong* should be shifted to the first syllable. In the late closure reading, *problem* should be in the same constituent as *Hong Kong*.

(53) The spies informed the guards of the conspiracy.

(54) The spies informed the guards of the palace.

Another research by Pynte (1996) used sentences like (53) and (54) in a word monitoring task. The two sentences have the same syntactic structure but the PP constituents *of the conspiracy* and *of the palace* possess structural ambiguity in their relationship to the preceding material, as they could potentially modify either the verb or the object noun, leading to different interpretations. The point lies in the last word of the two sentences and participant did not know that the target word was going to be the last one in the utterance. In the word monitoring experiment, it is found that a prosodic break after the verb made the attachment of the PP to the noun easier to process. The research shows that the placement of prosodic breaks can have a profound influence on the preferred analysis.

The preferred argument structure of verbs can also influence the effect of prosody. Different verbs have different argument structure preference. For example, the verb *inform* prefers a prepositional phrase as in the sentence (53) and (54). The structure is *inform somebody of something*. While the verb *choose* does not have the preference. So influenced by the different argument structure preference, a prosodic break will make different contributions to the interpretation of syntactically ambiguous sentences. Therefore, a prosodic break after *chose* in sentence (56) plays a less significant role to the interpretation of syntactically ambiguous sentences, as the preference was already to interpret the PP as a modifier of the verb.

(55) The student chose the apartment with a balcony.

(56) The student chose the apartment with care.

Other research shows that sentence structure parsing can be influenced by the focus of the sentence, where the focus can be marked by prosody and intonation of speaking (Schafer, 1996). The sentence structure of (55) and (56) is NP1-V-NP2-PP, where the PP can modify either NP1 or NP2. The research of reading time shows the preference for PP as modification of the second noun phrase. And the preference changes as the stress changes. That is to say, if the NP is marked by sentence stress, the NP is most likely to be modified by the relative clause.

These studies provide evidence that prosodic features play a crucial role in the rapid processing of sentences. It is apparent that these features interact with lexical and structural preferences in intricate ways, highlighting their importance in the comprehension of spoken language. In further studies, it is found that such prosodic structures may also have a significant impact on language comprehension during silent reading. This is because, during reading, an individual's internal monologue can be leveraged to facilitate sentence parsing (Fodor, 2002).

VIII. CONCLUSIONS

The purpose of this paper is to provide a clearer understanding of the immediate processing of sentences in language communication. Recent evidence suggests that sentence processing is influenced not only by syntactic information, but also by various non-syntactic factors such as meaning, background knowledge, plausibility, and prosody. These findings challenge earlier research, which claimed that semantic factors do not directly affect syntactic analysis.

Modals of sentence processing have been articulated with ample examples. It can be argued that sentence processing in language communication involves a comprehensive range of factors. The complexity of this process necessitates further investigation, as current findings indicate that an initial syntactic analysis is subsequently validated by a thematic or meaning-based processor during sentence processing in language communication.

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