

Sentence Processing  
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Glossary:

**articulatory planning:** the mental activity of ordering words and sounds into a sequence for the control of movements of the larynx, lips, and jaw.

**competition:** the form of mental processing that treats mental traces in terms of their relative strengths or activations and which selects out the strongest as the winners.

**cue reliability:** grammatical cues that are high in reliability are ones that point to the correct grammatical interpretation whenever one relies on them.

**garden-pathing:** the type of processing that occurs when one follows out a particular interpretation of a sentence that turns out in the end to be wrong and which then needs to be retraced to derive the correct interpretation.

**lexicon:** the mental representation of the words and grammatical markings in our language.

**modularity:** the theory of mental processing that attempts to minimize or restrict the competitive interaction between processes.

**proposition:** a relation between words in which one word functions as the predicate and the other words function as arguments, taking assigned roles determined by the logical form of the predicate.

SENTENCE PROCESSING is the mental activity in which we engage when we produce and comprehend sentences. This activity includes many component processes. When we listen to or read sentences, we must link words together into phrases; we must determine the parts of speech of ambiguous words; we must assign words and phrases to grammatical roles; and finally we must derive a deeper conceptual interpretation of the underlying meaning of the sentence. When we produce sentences, we must select a starting point that includes a sentence topic and a main verb; we must decide which material should be foregrounded into the main clause and which material backgrounded into subordinate clauses and adverbial phrases. We must then take our plans for the words to be included in an utterance and reduce them to a set of articulatory gestures. Both comprehension and production involve a finely-tuned interleaving of these various complex processes that typically occurs against a backdrop of noise, interruptions from other speakers, and competing cognitive tasks. Despite its great complexity, sentence processing is a skill that is smoothly executed for many hours every day of the year by billions of human beings in hundreds of languages all around the world.

#### I. Sentence comprehension

In order to understand sentences, we first need to pick out the words of which they are composed. The process of identifying the words in a sentence is known as “lexical access”. This type of access is a necessary preliminary to all other aspects of

sentence comprehension. In reality, lexical access involves very different operations depending on whether we are reading sentences or listening to them. When we are reading English text, words are neatly segmented by spaces. Using the rather inconsistent spelling rules of English, we can associate the written forms of words with their auditory forms. Together, the written and auditory forms are used to activate the underlying meanings of the word. In aural comprehension, the process is not guided by the clear markings of the written form. In fact, there are no strong and fully reliable cues to word segmentation in English. For example, it is easy to misperceive a word like “nitrate” as being “night rate”. Despite the absence of clear segmentation cues, we are able to use our rich lexical knowledge to directly pick out the auditory forms of words from the speech stream. Although frequent words are detected more quickly, even relatively rare words are recognized smoothly and without hesitation.

**Incremental processing.** There are at least four major levels of processing that occur during comprehension of a sentence. First, **auditory processing** takes uses input sound patterns to extract a set of phonological cues. Second, **lexical processing** uses phonological cues to activate particular lexical items or words. Third, **grammatical processing** matches up lexical items into relational structures. Fourth, **conceptual processing** extracts meaning from these relational structures. It is important to realize that sentence processing involves the simultaneous interaction of each of these four levels. We do not wait until we have completed all auditory processing before attempting lexical processing. Nor do we complete all grammatical processing before attempting any conceptual processing. Take as an example the sentence “The boy chased the baboon into the bedroom.” As soon as we hear the first two words “the” and “boy”, we immediately begin to relate them to each other and then to the following verb “chased.” Moments after hearing “chased”, we begin to construct an interpretation of the activity in which there is a boy doing some chasing. We do not need to wait until we have heard all the words in the sentence to begin to extract these meanings. In this sense, sentence

processing is both interactive and incremental -- we tend to make decisions about material as soon as it comes in, hoping that the decisions that we make will not be reversed.

**Garden-pathing.** However, sometimes these decisions must indeed be reversed. There times when the initial decisions that we have made take us down the “garden path.” A classic example of garden-path processing occurs with sentences such as “The communist farmers hated died.” It often takes the listener awhile to realize that it was the communist that died and it was the farmers who hated the communist. Inclusion of a relativizer to produce the form “The communist that farmers hated died” might have helped the listener sort this out. A somewhat different example is the sentence “The horse raced past the barn fell.” Here, we need to understand “raced past the barn” as a reduced relative clause with the meaning “The horse who was raced past the barn.” If we do this, the appearance of the final verb “fell” n longer comes as a surprise.

Garden paths arise when a word has two meanings, one of which is very common and one of which is comparatively rare. In a sentence like “The horse raced past the barn fell” the use of the verb “raced” as a standard transitive verb is much more common than its use as the past participle in a reduced passive. In such cases, the strong meaning quickly dominates over the weak meaning. By the time we realize our mistake, the weak meaning is fully suppressed by the strong meaning and we have to try to comprehend the sentence from scratch. A classic garden-path example from Karl Lashley is the sentence “Rapid righting with his uninjured left hand saved from destruction the contents of the capsized canoe.” If this sentence is read aloud, listeners find it extremely difficult to understand the second word as “righting” rather than “writing.”

**Ambiguity.** Standing in contrast to garden-path sentences, are sentences with ambiguous grammatical structures. For example, there are two readings of the sentence “Flying planes can be dangerous.” The planes can be either dangerous to their pilots and passengers or dangerous to onlookers down on the tarmac. Both interpretations of the

participle “flying” are fairly strong. Because the two readings are of similar strength, they can compete with each other and no garden-pathing arises. Another example of this type is “He bought her pancakes” in which “her” can be either the possessor of the pancakes or the recipient of the pancakes. Both meanings are strong and can compete with each other during sentence processing, yielding a clear ambiguity.

**Modularity.** The four types of processing mentioned earlier (auditory, lexical, grammatical, and conceptual) are fully intermixed in real time. We do not wait until the end of the sentence to complete a particular lower level before moving on to the next level. However, it is not yet clear whether the interaction between these levels is completely immediate. For example, it appears that during the first 300 milliseconds after hearing a word, we attend primarily to its auditory shape, rather than the degree to which it fits into some grammatical context. Take as an example the sentence “The sailors took the port at night.” Here the word “port” could refer to either the wine or the harbor. We can ask subjects to listen to sentences like this while watching a computer screen. Directly after subjects hear the word “port”, we can present one of these three words on the computer screen: “wine”, “harbor” and some control word such as “shirt”. If we do this, we will find that the recognition of both “wine” and “harbor” is facilitated in comparison to the control word “shirt”. If we change the sentence to something like “The sailors drank the port at night”, we would expect perhaps that the context would bias the subject to respond more quickly to “wine” than to harbor, because one is not likely to drink a harbor. However, in some studies there is evidence that both “wine” and “harbor” are facilitated in comparison to the control word “shirt”, even when the context tends to bias the “wine” reading of “port.” This facilitation is fairly short-lived and the preference for the contextually appropriate reading soon comes to dominate.

This type of result indicates that, in the first fraction of a second after hearing a word, we rely most strongly on auditory cues to guide our processing. This is not to say that context is not present or not being used as a cue. However, during the first fraction

of a second, we need to focus on the actual auditory form in order to avoid any “hallucinatory” effects of paying too much attention to context too soon in processing.

**Shadowing.** Children often try to tease one another by immediately repeating the other person’s words even as they are being produced. Some skilled shadowers can repeat words with only a 300 millisecond delay. However, most of us can shadow at around a 800 millisecond delay. If a distortion is added to the end of a word, shadowers will usually correct this distortion immediately. For example, if the word “cigarette” is distorted to “cigaresh”, the shadower will immediately and unconsciously correct it to “cigarette.” This indicates that the shadower takes in enough of the word to derive a unique lexical item and then simply predicts the shape of the rest of the word, essentially ignoring the additional auditory information. The speed with which this is done provides yet another indicator of the “on-line” and immediate nature of sentence processing.

**Reconstruction.** The type of reconstruction that occurs during shadowing can also occur directly during comprehension. For example, we may tend to think that we hear a final “s” on the word “cat” if it occurs in a sentence like “The cat sit under the table”. It is difficult for listeners to believe that the sentence was not actually “The cats sit under the table”. In general, we often use syntactic patterns to correct for problems in the sentences we hear, thereby patching up the various errors made by other speakers, even before they really come to our attention.

## II. Sentence production

There are many similarities between sentence comprehension and sentence production. In both activities, we rely heavily on the words in our lexicon to control syntactic structures. Both activities make use of the same patterns for determining grammatical structures. The most important difference between sentence comprehension and sentence production is based on the fact that, when producing utterances, we are in full control of the meanings we wish to express. In comprehension, on the other hand,

we are necessarily followers -- we need to piece together the meanings composed by others.

The processing of sentences in production also involves at least four structural levels. The first level governs the formulation of what we want to say or **message construction**. The second involves the reduction of our ideas to a set of words through **lexical access**. The third structure these words into utterances through **positional patterning**. The fourth activates a series of verbal gestures through **articulatory planning**. As in the case of comprehension, these four stages are conducted not in serial order, but in parallel. Even before we have finished the complete construction of the message underlying a sentence, we begin the process of articulating the utterance. Sometimes we find out in the middle of an utterance that we have either forgotten what we want to say or don't know how to say it. It is this interleaved quality of speech production that gives rise to the various speech errors, pauses, and disfluencies that we often detect in our own speech and that of others.

Speech errors come in many different forms. Some involve simple slurring of a sound or retracing of a group of words. Others provide more dramatic evidence of the nature of the language planning process. Some of the most entertaining types of speech errors are **spoonerisms**, who owe their name to an English clergyman by the name of William Spooner. Instead of "dear old queen", Spooner produced "queer old dean". Instead of "ye noble sons of toil", he produced "ye noble tons of soil". Instead of "I saw you light a fire in the back quad, in fact you wasted the whole term", he said "I saw you fight a liar in the back quad, in fact you tasted the whole worm." These errors typically involve the transpositions of letters between words. Crucially, the resulting sound forms are themselves real words, such as "liar", "queer", and "worm." The tendency of these errors to produce real words is known as the "lexical bias" in speech errors and indicates the extent to which the lexicon itself acts as a filter or checker on the articulatory process.

Another illuminating group of errors are named after a character named Mrs. Malaprop in the play “The Rivals” by Sheridan. Some examples of **malapropisms** include “Judas Asparagus” for “Judas Iscariot”, “epitaphs” for “epithets”, or even “croustons” for “coupons”. Some malapropisms can be attributed to pretentious use of vocabulary by uneducated speakers, but many of these errors are true slips of the tongue. In a malapropism, the two words have a similar sound, but a very different meaning. The fact that speakers end up producing words with quite the wrong meaning suggests that, at a certain point during speech planning, the processor handles words more in terms of their phonological form than the meaning they express. It is at this point that malapropisms can occur.

When two words end up directly competing for a single slot in the output articulatory plan, the result is a lexical **blend**. For example, a speaker may want to describe both the flavor and the taste of some food and end up talking about its “flaste”. Or we might want to talk about someone’s spatial performance and end up talking about their “perfacial performance”. These errors show the extent to which words are competing for placement into particular slots. When two words are targeting the same slot, one will usually win, but if there is no clear winner there can be a blend.

Another remarkable property of speech errors is the way in which grammatical markers seem to operate independently of the nouns and verbs to which they attach. Consider an “exchange” error such as “the floods were roaded” for “the roads were flooded.” In this error, the plural marker “s” and the past tense marker “ed” go to their correct positions in the output, but it is the noun and the verb that are transposed. This independent behavior of stems and their suffixes indicates that words are being composed from their grammatical pieces during sentence production and that grammatical markers contain clear specifications for their syntactic positions.

Some of the earliest thinking on the subject of speech errors was done by Sigmund Freud at the beginning of the century. He believed that slips of the tongue



could provide evidence for underlying anxieties, hostilities, and worries. From this theory, arose the notion of a “Freudian slip”. We now know that the majority of speech errors are not of this type, but it still appears that at least some could be viewed in this way. For example, if a speaker is discussing some activities surrounding a local barber, he might say “He made hairlines” instead of “He made headlines”. These errors indicate contextual influences from competing plans. However, even examples of this type of contextual influence do not necessarily reveal underlying hostilities or neuroses.

### III. Message construction

The basic goal of both sentence comprehension and sentence production is the linking of formal linguistic expression to underlying conceptual meanings. A common way of thinking about these underlying meanings is in terms of a **conceptual dependency** graph. As an example, take the set of propositions underlying the first sentence of Lincoln’s Gettysburg Address.

1. Forefathers set forth a nation.
2. Nation was new.
3. Nation was on this continent.
4. Setting forth occurred four score and seven years ago.
5. Nation was conceived in liberty.
6. Nation was dedicated to a proposition.
7. Proposition is: all men are created equal.

Lincoln brought together these varying underlying propositions into a single grammatical whole by foregrounding some material into the main clause (“forefathers set forth a nation”) and backgrounding other material into relative clauses and modifiers.

In the classical rhetorical theory of the Greeks and Romans, the art of combining ideas into sentences was called “arrangement”. In other everyday speech, we continually engage in simple forms of arrangement. For example, if we want to point out that there is

a dent in the side of the refrigerator, we can say “Someone knocked a dent in the refrigerator” or we can say “The refrigerator got a dent knocked into it.” In the first case we avoid the pseudo-passive construction, but are forced to point a finger at a specific perpetrator of the deed. In the second case, we background or deemphasize the doer of the activity, focusing instead on the result. These choices between what to foreground and what to background are being made in every sentence we produce.

Another choice we make is between alternative perspectives on a single action. For example, we could describe a picture by saying “The girl gave a flower to the boy.” If that is the form we select, we are taking the viewpoint or perspective of the girl and describing the activity of giving from her vantage point. Alternatively, we could say “The boy got a flower from the girl.” In this alternative form, we view the action from the perspective of the recipient. Depending on whether we choose to view the action from the viewpoint of the giver or the receiver, we will use either the verb “give” or the verb “get”. Language is full of choices of this type and sentence production can be viewed as involving a continual **competition** between choices for perspectives and foregrounding. The various points of view we could take and the various ideas that we want to express are continually in competition with one another for expression. At a given point in time, only one set of ideas can be expressed. In the end, we can never express all available information or all possible perspectives and we must make hard choices to pick some winners and leave some ideas unexpressed.

In comprehension, we also face a vigorous competition in our match of ideas to linguistic form. The first phrase in a sentence plays a crucial role as a starting point for the construction of the meaning underlying the sentence. In English, this first word is often the subject of the sentence, but it can also be some other adverbial phrase or a preposed topic, as in sentences such as “Ice cream and bananas, Bill really likes ‘em swimming in chocolate sauce.” Once we have established this initial starting point, the verb and additional nouns and phrases attached to the verb are all related propositionally

to the starting point. If we are lucky, the process of attaching material to this starting point goes smoothly, but if there are ambiguities or garden-pathings, we may be forced to undo some of our initial propositional connections.

The construction of relations between words depends strongly on a set of grammatical cues for **cohesion** relations. These cues include pronouns and articles that mark which of several preceding objects is being pointed to in a current sentence. For example, in a slight variation on the nursery rhyme, we can say, “Jack and Jill went up the hill to fetch a pail of water. He fell down and broke his crown and she came tumbling after.” In this sequence, we know that “he” refers to Jack and that “she” refers to “Jill”. This co-reference between the pronoun and its antecedent is part of a much more extensive system of cohesion markings that we use to construct stories and larger discourses. Underlying this system is the notion of givenness and newness. When something has already been mentioned, it is “old” material, and we can refer to it with an article like “the”. When it is “new” material, we can refer to it using an article like “a”. Across groups of sentences, the sentence processing mechanism depends heavily on these cues for the linking of propositions.

The construction of propositional meanings is strongly guided by our default assumptions about language and the world. For example, if we hear a sentence describing “Indians and cowboys”, we may tend to recall it as having been about “cowboys and Indians.” In general, the exact surface form of sentences often fades within seconds after we hear them. This is particularly true of the commonplace, predictable material that is used in textbooks or in experiments on sentence processing. However, if one examines memory for more lively, charged, interpersonal communications, a very different picture emerges. For this type of discourse, memory for the specific wording of jokes, compliments, insults, and threats can be extremely accurate, extending even over several days. Often we are careful to note the exact phrasing of language spoken by our close associates, since we assume that this phrasing

contains important clues regarding aspects of our interpersonal relations. For material that contains no such interpersonal content, we focus only on underlying meaning, quickly discarding surface phrasings.

#### IV. The role of syntactic theory

Sentence comprehension necessarily depends on at least some use of grammatical knowledge. We have to use the order in which words occur to distinguish the meaning of “The dog is chasing the bear” from that of “The bear is chasing the dog.” We cannot derive the correct interpretation of even the simplest of sentences without paying attention to word order and other grammatical markings. But how and when do we impose our ideas about grammatical structures on the incoming stream of words? Some researchers believe that the impact of grammar is full and immediate particularly during the first 500 milliseconds after hearing a word. Consider these example sentences:

The spy shot the cop with a revolver.

The spy saw the cop with a revolver.

In the first sentence, we can say that the prepositional phrase “with binoculars” modifies or attaches to the noun “cop”. In the second sentence, the prepositional phrase “with a revolver” modifies or attaches to the verb “shot”. These assignments seem immediate and direct, occurring during the processing of the prepositional phrase itself. Some studies have suggested that a universal property of the basic human sentence processing mechanism known as “minimal attachment” biases the listener toward the correct interpretation in the first sentence and forces a mild garden-path in the second. However, other studies have questioned these claims, demonstrating that these biases can easily be shifted around with other materials. Evidence for the direct action of complex syntactic structures on sentence processing is currently minimal.

On the other hand, there is a great deal of evidence for effects that depend directly on the association between individual words. In the examples given above, a direct

lexical effect from the verb “shot” tends to bias the listener to thinking of the revolver as an instrument more than in the case of the verb “saw.” Sometimes lexically-based expectations can be fairly complex. Consider these sentences:

John criticized Mary, because she hadn’t delivered the paper on time.

John apologized to Mary, because he hadn’t delivered the paper on time.

?John criticized Mary, because he hadn’t delivered the paper on time.

?John apologized to Mary, because she hadn’t delivered the paper on time.

Processing of the first two sentences is quick and easy, because the gender of the pronoun matches that of the expected agent. However, the processing of the second pair is more problematic because the gender of the pronoun forces the selection of an unexpected causer of the criticism or the apology.

Another lexical effect centered around the verb involves the degree to which a verb anticipates a direct object or complement. For some listeners, this sentence leads to a garden-path: “Since Jay always jogs a mile seems like a short distance to him.” The natural tendency here is to assume that “a mile” is the complement of the verb “jog”. It appears that even verbs that are sometimes intransitive and do not require direct objects tend to be processed as taking objects or complements, if there is a noun immediately following the verb. It is expectations of this type, centered in individual words and operating through our general understanding of relations in the world, that most strongly determine the time course local syntactic effects in sentence processing.

## V. Cross-linguistic comparisons

What stands out most clearly when one compares sentence processing across languages is the fairly tight relation between the time course and ultimate results of sentence processing and the **reliability** of specific grammatical cues in the language.

Consider a comparison of these sentences from English and Spanish:

The lion kisses the cow.

El león besa la vaca. (The lion kisses the cow).

A major difference between the two language revolves around the use of variable word orders. In Spanish, it is possible to invert the word order and produce “la vaca besa el león” while still meaning that the lion is kissing the cow. This inversion is even clearer if the particle “a” is added to marker the direct object as in these variant orderings in which the two nouns are moved into different places around the verb “besa”.

El león besa a la vaca.

A la vaca la besa el león.

Besa el león a la vaca.

Besa a la vaca el león.

These differences between English and Spanish can be traced to the relative cue validities of word order and object marking in the two languages. In English, it is virtually always the case that the noun that appears before the verb is the subject of the sentence. If the verb is an active verb, the preverbal noun is almost always the actor. This means that the cue of preverbal positioning is an extremely reliable guide in English to assignment of the actor role. In Spanish, no such simple rule attains. Instead, the best cue to assignment of the actor role is the presence of the object marker particle “a”. If one of the nouns in a two-noun sentence is marked by “a”, then we know that the other noun is the agent or subject.

Other languages have still other configurations of the basic cues to sentence interpretation. For example, Hungarian makes reliable use of a single case marking suffix on the direct object. German uses the definite article to mark case and number. The Australian language Warlpiri marks the subject with a variety of complex case markings. Navajo places nouns in front of the verb in terms of their relative animacy in the Navajo “Great Chain of Being” and then uses verbal prefixes to pick out the subject. These languages and others also often rely on number agreement between the verb and

the noun as a cue to the subject. English also requires subject-verb agreement, but this cue is often missing or neutralized. In languages like Italian or Arabic, subject-verb agreement marking is extremely clear and reliable.

When one looks at the ways in which languages deal with complex structures such as relative clauses, a parallel picture of processing based on relative cue reliability also emerges. For example, in Japanese the basic order of sentences is noun-noun-verb, rather than the noun-verb-noun order found in English. In addition, Japanese places relative clauses before the head noun, rather than after the head noun. Japanese marks subject and object with case particles or postpositions. All of these differences lead to great contrasts between the processing of conceptually similar relative clause structures in English and Japanese. However, what appears to be constant in all languages is the fact that relative clause structures that involve any extreme “stacking up” of nouns or verbs are comparatively difficult to process. In English, this occurs in center-embedded clauses such as “The dog the rat the cat chased bit barked.” In Japanese, this concept would be rendered as “cat-by chased rat-by bit dog barked.” The Japanese form of the utterance is relatively easy to process, but a pattern such as “dog cat-by chased rat-by bit barked” is difficult in Japanese, since it involves a greater stacking up of nouns and verbs, although not quite as extreme as in the English version.

These crosslinguistic comparisons point out the extent to which all processing requires the linking of nouns to verbs in a smooth and conceptually-driven fashion. Any stacking up of unattached, unrelated nouns puts a burden on short term memory that then impedes further processing. Effects such as this can be treated in terms of the general concept of **cue cost**.

When a monolingual speaker comes to learning a second language, they need to fundamentally retune their sentence processing mechanism. First, they will need to acquire a new set of grammatical devices and markings. Second, they will need to associate these new devices with the correct cue validities. Third, they will need to

reorganize their expectations for particular sequences of cues and forms. Initially, the learner simply transfers the cues, cue validities, and habits from the first language to processing of the second language. Over time, the cue validities change smoothly, until they eventually match that of the native monolingual.

#### V. The development of processing

When children come to the task of language learning, they have no idea which language they are being asked to learn, so they must be equally well prepared to pick up virtually any possible human language. What they learn first in a given language is primarily influenced by the clarity of its marking or its **detectability**, as well as its cue reliability. English-speaking children quickly learn to rely on the preverbal positioning cue, whereas Spanish-speaking children quickly learn to rely on the use of the particle “a” to mark the direct object. Although cue reliability is the primary determinant of the order of acquisition of grammatical markings, there are some deviations from this general rule. In particular, children are slow to pick up difficult patterns such as subject-verb agreement marking. It appears that what makes this type of marking particularly difficult for the child is the fact that markings on one grammatical phrase must be carried over to and matched by properties on another grammatical phrase. This type of processing across a distance is a cue cost factor that limits full acquisition of this type of structure until age 5 or 6.

In general terms, young children have not yet organized their processing systems in a way that provides maximally quick and efficient processing. In reaction time experiments measuring sentence comprehension, children are markedly slower than adults. In tasks requiring picture descriptions, young children often fail to organize a variety of concepts into a single well-structured sentential package. Increases in expressive skills continue well into the adolescent years. Although all of the basic syntactic structures of the language are usually mastered by age 3, it takes many more



years to coordinate the use of these various devices in actual sentences, particularly in sentence production.

## VI. Disorders in sentence processing

Although all of us learn the basic structure of our language, we vary greatly in our abilities to control language smoothly and to use language to delight and persuade others. Even in the first years of life, there are often vast differences between the ways in which children come to grips with language learning. Some children are able to produce their first two-word sentences even by the time of their first birthday, whereas other children remain speechless as late as three or even four years of age. Classic examples of children with language delay include Albert Einstein and Lord Macauley. In some cases, these children speak secretly with their peers or siblings long before engaging in conversations with adults. A short period of language delay is also found in children suffering from chronic ear infections or disorders of the trachea. When these disorders are corrected, these children quickly pick up the missed stages of development and soon come to talk like their age-matched peers.

There are other children who have various forms of organic disorders or brain injuries that lead to long-term and sometimes permanent disabilities in language processing. The general term for children with normal cognitive abilities, but with specific disorders in language processing is Specific Language Impairment or SLI. Children with SLI fall into two further groups -- those with impairments specific to language production and those with impairments to both production and comprehension. The root cause of disorders in production often involves problems with the timing of articulation or sentence formulation. The root causes of a general language impairment can include problems with auditory processing, central timing problems, or problems in lexical access.

Adults who have suffered from strokes or other injuries to the brain can develop somewhat different language problems. Patients whose only problem lies in the smooth and rhythmic articulation of words are said to suffer from **dysarthria**. Patients whose only problem is the finding of the correct word for objects and activities are said to suffer from **anomia**. Patients with more central language disorders are said to suffer from **aphasia**. If the patient tends to speak in a telegraphic fashion, omitting grammatical markings and other small words, the standard classification is for **expressive aphasia**, which is also known as agrammatism, non-fluent aphasia, or Broca's aphasia. If the disorder leads to too great a use of verbal material, the classification is for **fluent aphasia**, which is also called Wernicke's aphasia. When the ability to imitate is specifically impaired, the diagnosis of **conduction aphasia** is often used. The localization of these various forms of aphasia in particular areas of the brain is difficult to achieve, although both anterior and posterior areas around the Sylvian fissure are typically involved in all of the aphasias.

Aphasia has a standard pattern of effects on language loss in different languages. This pattern is determined by the relative cue reliability of grammatical markers in each language. As we noted earlier, the strongest cue for sentence processing in English is the preverbal positioning of the subject. This particular cue remains well-preserved in English-speaking aphasics, whereas the weaker cue of subject-verb agreement is virtually totally destroyed. On the other hand, Italian-speaking aphasics show the opposite pattern, with a strong preservation of subject-verb agreement and a fairly minimal use of word order cues. In terms of sentence production, aphasics also show a strong sensitivity to the relative importance of grammatical markings in their language. English-speaking aphasics retain the subject-verb-object word order of the English and Turkish-speaking aphasics retain the subject-object-verb order of their language. German-speaking aphasics retain the definite article, since it is a crucial marker of case and number,

whereas Hungarian-speaking aphasics drop the article, since it is not a crucial marker in their language.

The various characteristics found in aphasics comprehension of language can be mimicked in normal subjects by exposing them to a high level of noise or additional concurrent tasks while listening to complex sentences. Noise and cognitive load can also have strong effects on sentence processing in the weaker language of bilinguals. For example, a German-English bilingual with relatively weaker English abilities will start to resemble an English aphasic when subjected to a slight amount of noise. These results suggest that the language processing system relies on a core set of computational resources for many different purposes. Various forms of damage or temporary impairment to this core set of resources tends to affect those aspects of language processing that require particular care or attention.

## VIII. Overview

Together these many facts gathered from different languages and different types of speakers point toward a view of sentence processing as highly interactive and competitive. During comprehension, there is a struggle between words for recognition in the input speech stream. Grammatical roles activated by verbs compete for nominal arguments and nominals compete for roles. Phrases compete for alternative attachments and pronouns compete for alternative referents. In production, ideas compete for expression, words compete for slots, and everything competes for final articulation. Given this massive struggle between forms and functions, it is remarkable how effortless language processing seems and how easy it is for us to pour our ideas into words.

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