

NEUROLINGUISTICS

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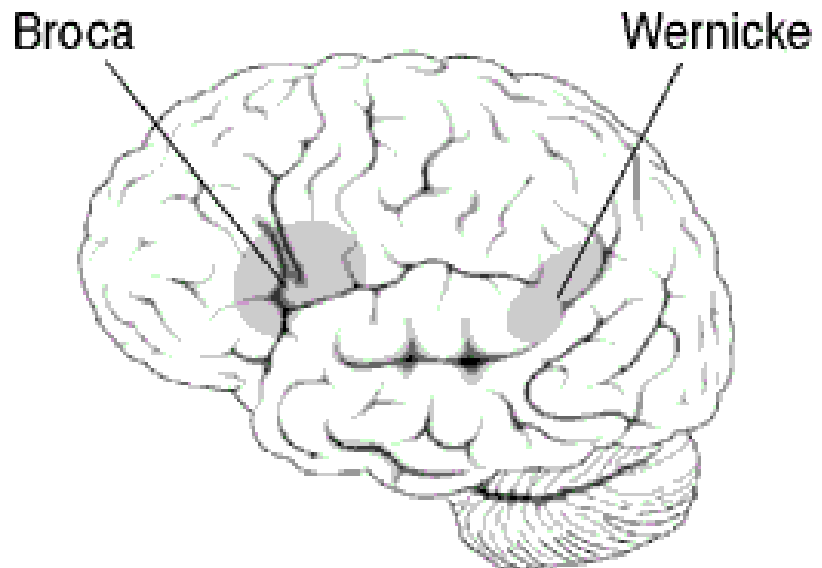
Introduction

- Neurolinguistics is the study of the neural mechanisms in the human brain that control the **comprehension, production, and acquisition** of language.
- Neurolinguists study the physiological mechanisms by which the brain processes information related to language.
- This is done using aphasiology [functional disorders in the brain], brain imaging, electro-physiology, and computer modeling

Brain and Language

Brain and language

- Language can be investigated in terms of the physiological properties of the brain.
- Brain mechanisms form the basis of Language Processing in humans.
- The two areas specialized for different linguistic tasks:
 - Broca's area
 - Wernicke's area



The Broca's area

- It is named after Dr Pierre Paul Broca, who discovered it.
- It is a region on the left frontal lobe of the hominid brain. [brain of humans and relatives of humans closer than chimpanzees]
- It has functions related to language and speech production.



The Broca's area

- Functions:
 - Syntax and Grammar of Language:

Broca's area is responsible for correct processing and production of syntactic i.e. grammatical information of sentences.
 - Speech Production:

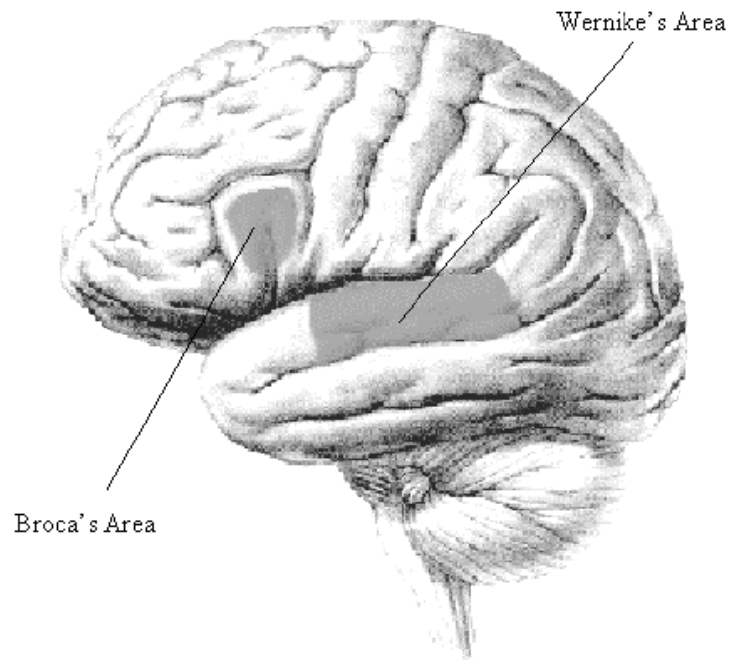
Broca's area is activated during phonetic and phonological tasks i.e. speech production.
 - Gestures and Body Language:

Broca's area is activated during communication using hand gestures and body language.
 - eg. Broca's Aphasia: The subject knows what to say but cant get it out grammatically correct.
- Ques: What brought you to hospital?

Ans: Yes . . . ah . . . Monday . . . ah . . . Dad . . . Peter Hogan, and Dad . . . ah . . . hospital . . . and ah . . . Wednesday . . . Wednesday nine o'clock and ah Thursday . . . ten o'clock ah doctors . . . two . . . two . . . an doctors and . . . ah . . . teeth . . . yah . . . And a doctor an girl . . . and gums, an I.

The Wernicke's area

- It is named after neurologist and psychiatrist Carl Wernicke, who discovered it in 1874.
- Wernicke's area is located in the temporal lobe of the brain.
- It has functions related to language and speech comprehension.



Wernicke's Area

- Functions:

- Language Comprehension:

Wernicke's area is responsible for correct processing and understanding of the sentence meanings.

- It is activated for understanding of written and spoken language.

- It retrieves words and their meanings from the mental dictionary.

- eg. of Wernicke's Apathy: grammatically correct but senseless speech

- Ques: May I ask you some questions?

Ans: Oh sure, go ahead, any old thing you want. If I could I would. Oh, I'm taking the word the wrong way to say, all of the barbers here whenever they stop you it's going around and around, if you know what I mean....

Experimental techniques

How language is represented and processed in the brain?

Subtraction

Brain activations in a task which is thought to involve some aspect of language processing is compared against activation in a baseline task thought to involve similar non-linguistic processes.

Eg: Activations while participants read words may be compared to baseline activations while participants read strings of random letters.

Mismatch paradigm

- An electrophysiological response that occurs in the brain when a subject hears a "deviant" stimulus in a set of perceptually identical "standards" .

e.g the sequence s s s s s s s d d s s s s s s d s s s s s d

- Used to study syntactic processing and the recognition of word category

Violation-based

- Analyzing the brain responses elicited when a subject encounters violations of syntactic or semantic rules in experimental stimuli.

E.g: Sentences beginning with phrases such as

**the garden was on the worked*

violates an English phrase structure rule, often elicit a brain response called the **early left anterior negativity** (ELAN).

Violation-based

- Use of grammatical and spelling violations to investigate the location of syntactic processing in the brain
- Use of violation designs is to combine two kinds of violations in the same sentence and thus make predictions about how different language processes interact with one another

Used extensively to investigate how syntactic and semantic processes interact while people read or hear sentences.

Priming

A subject can recognize a word more quickly if he or she has recently been presented with a word that is similar in meaning or morphological makeup.

e.g: Subject is presented with a "target" word doctor and then a "prime" word nurse

Faster-than-usual response time to nurse shows word nurse in the brain had already been accessed when the word doctor was accessed

Used to investigate a wide variety of questions about how words are stored and retrieved in the brain and how structurally complex sentences are processed.

Subject tasks

- In many neurolinguistics experiments, subjects do not simply sit and listen to or watch stimuli, but also are instructed to perform some sort of task in response to the stimuli, usually in order to ensure that they are paying attention to the stimuli.

Lexical decision

- The lexical decision task involves subjects seeing or hearing an isolated word and answering whether or not it is a real word. It is frequently used in priming studies, since subjects are known to make a lexical decision more quickly if a word has been primed by a related word.
- For eg: "doctor" priming "nurse"

Grammaticality judgment, acceptability judgment

- Subjects make a decision about the acceptability (usually grammatical acceptability or semantic acceptability) of stimuli.
- This ensures that subjects read the sentences attentively and that they distinguish acceptable from unacceptable sentences in the way the experimenter expects them to do."
- One experiment showed that when subjects were instructed to judge the "acceptability" of sentences they did not show an N400 brain response (a response commonly associated with semantic processing), but that they did show that response when instructed to ignore grammatical acceptability and only judge whether or not the sentences "made sense.

Probe verification

- In this paradigm, each experimental sentence is followed by a "probe word", and subjects must answer whether or not the probe word had appeared in the sentence.
- This task, like the acceptability judgment task, ensures that subjects are reading or listening attentively, but may avoid some of the additional processing demands of acceptability judgments.

Truth-value judgment

- Subjects may be instructed not to judge whether or not the sentence is grammatically acceptable or logical, but whether the proposition expressed by the sentence is true or false.

Interaction with other fields

Neurolinguistics and Psycholinguistics

- Theoretical linguists:
 - Propose models to explain the structure of language and how language information is organized.
- Psycholinguists:
 - Propose models and algorithms to explain how language information is processed in the mind.
- Neurolinguists:
 - Analyze brain activity to infer how biological structures carry out the psycholinguistic processing algorithms.

Subfields of linguistics

Neurolinguistics research is carried out in all the major areas of linguistics namely:

- Spoken Word Recognition
- Morphology and mental lexicon
- Syntax
- Semantics
- Discourse

Spoken Word Recognition

- The input signal
 - The acoustic structure of speech and how speech signals are processed by the human auditory system.
- The internal phonological representation
 - The way that words or phonological targets are stored in the speech recognition lexicon.
- The interface between above :
 - ‘lexical information retrieval’ i.e retrieving the phonological forms of words from the lexicon to be pattern matched with the auditory input.

Morphology and the Mental Lexicon

Three core issues of language processing at the lexical level:

1. The precise nature of the items which make up the mental lexicon, which we will refer to as 'words'.
2. How word meanings are represented in the mental lexicon?
3. How lexical meanings are assigned to words in the context of sentence processing?

Morphology and the Mental Lexicon

- Usually listeners 'strip' inflectional affixes off the word forms to access lexical meanings.
- Eg: cat and cats:
 - cats is a morphological construction, made up of the lexeme cat plus the plural inflectional suffix: i.e. cat + s.

Morphology and the Mental Lexicon

- There are three superficial sub-types of morphological relation found in English :
 - (1) regular forms (-s and -ed),
 - (2) partially regular forms, but members of which bear strong 'phonological family' resemblances
(eg. leave - left, dream - dreamt, sleep - slept)
 - (3) completely irregular forms (eg: go - went) .
- It is conceivable, that three distinct learning mechanisms: – rule-based learning, analogical learning and rote [memorization based] lexical learning – could underlie the acquisition of morphology.

Lexical Semantics

- A theory of lexical semantics should provide an explicit account of word meaning; of how similarities and differences in word meaning are established, how various word meaning relations, such as synonymy, antonymy, homonymy etc., are established.
- The problem to be accounted for in processing lexical semantics: 'polysemy' - how words change their meaning according to the immediate context in which they are 'embedded'
- Eg:
 - ...a show... → <a display>
 - ...show it is true... → <explain>
 - ...show your anger... → <indicate one's feelings>

Lexical Semantics

- Psycholinguistic and neurolinguistic research on lexical semantic processing has been dominated by the problem of finding ways to find how lexical entries are mapped to context-constrained word meanings.
- Many reaction-time based semantic Priming Paradigms have been tried but with limited success.
- In recent years, advances in the neuroimaging techniques are beginning to yield insights into the organization and retrieval of lexical semantic information.

Discourse Processing

- Discourse constitutes the highest and most complex level of linguistic representation.
- the core elements of discourse structure, such as “given” versus “new information” and “topic-comment” structure, can be illustrated as follows:
- eg.
 - Topic → Mr Paul. [old information]
 - Comment → He dead. [new information]
 - Topic-comment structure is one of the earliest identifiable structures and the most resistant to loss even in severe cases of agrammatism as seen above.
- As a discourse develops, new topics enter and old topics fade from the scene. A new topic is typically introduced as a comment to an existing topic.
- Discourse construction is an inference-driven process that makes use of information about the meaning and use of words stored in the mental lexicon and a vast store of encyclopedic pragmatic knowledge.

Summary

- Various researches mainly in the last two decades have led to the significant progress in this field.
- We discussed the Areas in brain specialized for the language tasks.
- Various experiments being performed to analyze the response of the brain to language scenarios.
- Researches and Inferences from the fields of linguistics.

Conclusion

There exists potential research areas in Neurolinguistics which aim to investigate

- Nature of language
- The acquisition process of language
- Biological mechanism that permit the elaboration & use of such knowledge
- Neural computation involved

Due to the continuous evolution of human brain and the language, the researches will always be an ongoing.

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- John C.L. Ingram, I. N. (2007). "Neurolinguistics an Introduction to Spoken Language Processing and Its Disorders". Cambridge: dulcinofraticelli.

Thank You