Cognition

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Language
Language is a shared symbolic system for communication.

It consists of units that form words, where the units are either spoken sounds or written characters.

These units symbolize the referent of the word. (e.g., “car” refers to an object.)

The symbol system & the rules that form it are shared by the speakers of a language culture.
The speakers & the listeners of a language have all learnt the same set of arbitrary connections between symbols & meaning, and the same rules for combining those symbols into meaningful sentences.
Language consists of concepts & propositions.

Meaning are concepts and propositions.

Understanding & use of speech involves the whole of knowledge.

Concepts are linguistically relevant social categories.
Language Development in Babyhood (2 weeks – 2 years)

- Speech is a tool for communication.
- Speech has two distinct functions -
  * Ability to comprehend what others say
  * Ability to communicate

- Forms of language
  - Written
  - Spoken
  - Gesticulative
  - Musical
  - Artistic expressions
Language Development in Babyhood (2 weeks – 2 years)

- Baby understands what is being said to them from:
  - Facial expression
  - Tone of voice
  - Gesture

- **3 months:** Comprehension of Pleasure, Anger & Fear
- **18 months:** Words must be reinforced with gestures, such as pointing to an object.
- Average baby respond to 6 simple commands (e.g., put the spoon in the cup, give me kitty)
Language Development in Babyhood
(2 weeks – 2 years)

- Learning to speak

- During 1 & 2 years babies use prespeech forms to make known their needs & wants.

- Prespeech Forms:
  - Crying (Most frequently used form)
  - Babbling (Real speech develops from it)
  - Gesturing
  - Emotional expressions
Language Development in Babyhood (2 weeks – 2 years)

Babbling

- 2-3 months babbling begins.
- Peak – 18 months.
- Gradually real speech emerge (ma-ma, da-da)

Stages of babbling:

- 3-4 months - Coos & Gurgles
- 6 months - Repeat own accidental sounds
- 9-10 months - Repeat or imitate sounds
Language Development in Babyhood (2 weeks – 2 years)

- **Gesturing**: In adult stage it’s a supplement to speech. In babyhood it’s a substitute to speech (e.g., outstretching arm & smiling wants to be picked up)

- **Emotional Expressions**: Nothing is more expressive than facial expressions.
Language Development in Babyhood
(2 weeks – 2 years)

Tasks in speech development

Pronunciation
Vocabulary building
Sentences
Language Development in Babyhood
(2 weeks – 2 years)

Pronunciation

- Develops by trial & error method
- Develops also by imitation
- Consonant-consonant blend are difficult than vowel & diphthong.
Language Development in Babyhood (2 weeks – 2 years)

Vocabulary building

- Learning of names of people & object comes first. Then comes verbs.
- By the end of babyhood learns few adjectives.
- Preposition, conjunction & pronoun are not learnt.
- Vocabulary increases with age.
Language Development in Babyhood
(2 weeks – 2 years)

Sentences

- First sentence appear by 12-18 months.
- Generally one word is accompanied by gesture.
- Gradually more words creep but gestures predominate.
Language Development in Early Childhood (2 –6 Years)

- Prespeech forms are abandoned.
- Crying is curtailed.
- Gestures are used as supplement, not as substitute.
- Strong motivation to learn to speak (because it is essential tool of socialization, e.g., making friend, & it is a tool in achieving independence).
Language Development in Early Childhood (2 – 6 Years)

- Improvement in comprehension.
- Improvement in speech-skills -

Pronunciation of words:

Difficult constants Z, W, D, S, G
Difficult combinations ST, STR, DR, FL
Language Development in Early Childhood (2 – 6 Years)

- **Vocabulary building** -
  Development of number & name of colour
  Development of “good”, “bad”, “give”, “take”

- **Forming Sentences** -
  2-3 years: 2-4 words/ sentences
  Many of the sentences are incomplete.
  The sentence has many nouns. It lacks verb, preposition & conjunction.
  By 3 years- 6-8 words: All parts of speech are incorporated.
Language Development in Early Childhood (2 – 6 Years)

Content of speech

Egocentric speech
- Talk about themselves, their interest, family, possessions, etc.

Socialized speech (2 years):
- Talk about others.
- Make unkind, derogatory comments.
- Engage in name-calling, boasting.
- As play group becomes larger, speech becomes more social & less egocentric.
- Amount of talking increases “Chatterbox age”.
Linguistic Universals – Hockett (1960, 1966)

- There are tremendous underlying similarities between languages in terms of abstract characteristics.

- The characteristics that are universally true of all human languages are *linguistic universals*. 
Hockett’s Linguistic Universals

Vocal-auditory channel:
Language is spoken & heard, i.e., is transmitted vocally & received auditorily.

Broadcast transmission & directional reception:
Language messages are “broadcast” in all directions from the source, & can be received by anyone within the range.
Hockett’s Linguistic Universals

Trasitoriness (Rapid fading):
The spoken message is transitory, lasting only as long as its transmission.

Interchangeability:
Messages & speakers are interchangeable; any speaker can in principle convey any message.
Hockett’s Linguistic Universals

Total feedback:
Speakers have total auditory feedback for their messages, simultaneous with listeners.

Specialization:
The sound of language are specialized to convey meaning.
Hockett’s Linguistic Universals

Semanticity:
Language symbols, and hence utterances, convey meaning (compared to sounds like coughing).

Arbitrariness:
The connection between a symbol & its referent is arbitrary. It is not built in (compared to iconic system).
Hockett’s Linguistic Universals

Discreteness:
Language uses only a small number of discrete ranges, say on vowel duration, to convey meaning, rather than changing meaning continuously across the dimension.

Displacement:
Language messages are not tied in time or space to the present.
Hockett’s Linguistic Universals

Productivity:

Language is novel & creative, produced by a set of rules, rather than repetitive.

Duality of patterning:

A small set of sounds is combined & recombined into an infinitely large set of sentences. By themselves, the sound have no meaning, but in combination they do.
Hockett’s Linguistic Universals

Cultural or traditional transmission:

Language is acquired by exposure to the culture, to the language of surrounding individuals.
Though the universals were essential to the evolution of language, several of them are not considered the essential characteristics of language now.

For example, the Vocal-Auditory Channel universal states true language is spoken & heard. But this excludes non-spoken forms of language, like writing and sign language.
There are universal grammatical rules used by all children everywhere & this universal grammar is stimulated by an inborn language-acquisition device.

• He rejected the behaviourist explanation of language.

• According to him language was based on mental rules, rather than habits learned through reinforcement.

Noam Chomsky (1957)
Theory of Universal Grammar

- Basic language structure resides internally and basic patterns are innate to human beings.
Theory of Universal Grammar

- We have a set of rules already built in us. These rules allow human beings the ability to learn any language.

- Children have the ability to produce an infinite number of sentences, as well as perceive and comprehend an infinite number of sentences.
A child will go into the learning of a language with the ability to formulate general parameters which, exist in a particular language, on the basis of a few instances of relative usage.

Children in the learning stage of language acquisition do not make errors that go against the principles of universal grammar.
How do children acquire phonotactically correct sounds and sounds combinations in which they create permissible words?

It is found that in phonetics and phonology as well as in grammar there are certain rules that govern sounds and sound types to formulate acceptable words.
Theory of Universal Grammar

- Chomsky's theory of universal grammar can be broken down into a large sum of rules.
- There is structure dependency, i.e., all operations on sentences are defined in terms of phrase structure.
Theory of Universal Grammar

- We have the head parameter, which states that in universal grammar the set of parameters describes the placement of the head in phrase structure.

- English is a head-initial language, meaning the head begins the phrase, whereas Japanese is a head-final language whereby the head follows the compliment.
Theory of Universal Grammar: Projection Principle

- The properties of lexical entries project onto the structure of the phrases of which they are the head.

For instance, in the case of a verb phrase, it ensures that the head (the verb in this case) receives the correct number or tense.

Apparently the basis of this principle relies heavily on another grammar theory, government and binding.
Chomsky’s Transformational Grammar

Idea

Deep Structure

Transformational rules applied here

Surface Structure

Vocabulary words inserted here

Spoken Sentence

Phase structure rules applied here

Phonological component operates here
Chomsky’s Transformational Grammar: An Example

- Transformational rules for turning an active declarative sentence into a question, for negating the sentence, & for combining the question & negative transformation.

1. Mohan sells tickets at the theater.
2. Does Mohan sell tickets at the theater?
3. Mohan does not sell tickets at the theater.
4. Doesn’t Mohan sell tickets at the theater?
Chomsky has gone as far as to implement his innatist theory on other disciplines such as aesthetics, concept formulation, science, and morality.

His over emphasis on syntax tend to shortchange semantics.
Braine (1976)

Children may not really use the same underlying grammatical rules the world over. However, children seem to follow some remarkably similar steps as they begin to combine words in order to express ideas.
Language

- It is based on universal sound units called *Phonemes* (the basic sounds that make up any language).
- The sounds of *t, th, k* for instance are phonemes.
- There are 46 phonemes in English (Chomosky & Halle, 1968), 15 in Hawaiian (Palermo, 1978) & as many as 85 in some other language (Bourne et al., 1986).
Language

- Human language has around 200 phonems.
- By themselves phonemes are meaningless & hence to not play a role in thinking.
- E.g., ‘b’ has no meaning.
- But phonemes can be grouped together to form words, prefixes (un..., pre...), & suffixes (.ed, .ing).
These are called **Morphemes** (The smallest meaningful units of speech, such as simple words, prefixes & suffixes).

*Morphemes* can combine to form complex words representing complex ideas (e.g., pre-exist-ing, un-excell-ed).

In turn, words can be combined to form **phrases**, and **sentences**, which can represent even more complex thoughts.
There are rules for combining phonemes & morphemes, as well as sentences & their meaning.

These rules are grammar.

- Two major components of grammar-
  - Semantics (Criteria for meaning in a language) & Syntax (Rules for the structure of word forms & sentences).
Language

- Semantics describes how we assign meaning to a morpheme.

- Other semantic rules explain how different combinations of morphemes affect meaning (such as adding the suffix …ed to a verb).

- Syntax is the system of rules that govern how we combine words to form grammatically correct sentences.
Levels of Analysis

Linguistics traditionally approaches language as a system with three levels of complexity.

1. **Phonology**: The study of production & perception of language sounds.
2. **Syntax**: The study of structure of sentences, and the rules determining the order of words & phrases in those sentences.
3. **Semantics**: The study of meaning of words.
Spectrograph
Spectrograph of Spoken Words

Fig. 2
Auditory Word Processing: Temporal lobe (Wernicke’s Area)


Word Production: Primary Motor Cortex, Supplementary Motor Cortex.

Generating Verb: Frontal lobe (Broca’s Area).

Different parts of the brain are involved in lexical processing.
Routes to Word Recognition

Semantics

Phonology

Orthography
(Coding Visual Word Forms)

Processing of Visual Features
Subsystems Used in Reading

Print

Abstract Letter Identification

Word Recognition

Word Comprehension

Nonlexical Phonological Reading

Letter Naming

Word Pronunciation

Speech

Spoken Letters & Names
Models of Psycholinguistics

Autonomous Processing Model
- Serial or syntax-first model
- Syntax is processed autonomously before to semantic information.
- Simplest syntactic structure is constructed first on the basis of word-category information, independent of lexical-semantic information.
- Then information is processed for thematic role.

Interactive Processing Model
- Constraint-satisfaction Model
- All types of information interact at each stage of language comprehension.
Disadvantages of these models

- None of these models addresses explicitly the role of prosodic information whenever spoken sentences are processed.

- As these models are based on data from reading, they comprise semantic & syntactic processes but ignore prosodic processes.
Neurocognitive Model of Auditory Sentence Processing
(Left hemisphere)

- **Phase 1** (100-300 ms):
  - The initial syntactic structure is formed on the basis of information about the word category.

- **Phase 2** (300-500 ms):
  - Lexical-semantic & morphosyntactic processing for assigning theme.

- **Phase 3** (500-1000 ms):
  - Different types of information are integrated.

- **Left temporal area**: Identifies phonetic, lexical & structural elements.

- **Right temporal area**: Identification of prosodic parameters.

- **Left frontal cortex**: Sequencing & formation of structural, semantic & thematic relations.

- **Right frontal cortex**: Processing of sentence melody.
Semantic Processing

- Studies on functional neuroanatomy of semantic processing of sentences are rare.
- Most studies have been conducted for words.
- **Left middle temporal gyrus, angular gyrus** & **left inferior frontal gyrus** support semantic processing.
- **Frontal cortex** is responsible for strategic & executive aspects of semantic processing.
- Semantic processing are mainly subserved by **left temporal region** & **frontal cortex** is involved when strategic and/or memory aspects come into play.
Inferior frontal cortex & anterior portion of temporal cortex are involved in syntactic processing.

Complex sentences are accompanied by increased activation of left inferior frontal cortex (BA 44/45).

Recent study demonstrates that BA 44 is activated due to aspects of working memory rather syntactic complexity.

Anterior & posterior temporal areas are activated during sentence processing.
**Syntactic Processing**

- This is accompanied by either substantial activation of *inferior frontal gyrus* or minimal or no activation in Broca’s area. (Sometimes activation in left frontal operculum is observed)

- There is a partial difference in sentence comprehension between auditory & reading tests.

- Sentence reading involves phonological recoding. Inferior frontal gyrus is involved during this process.
Syntax & Semantics

- The brain reacts in accordance with the grammar.

- **Left temporal and frontal cortices**: Semantic & syntactic processing.

  - *Temporal cortex*: Identification of word category & its meaning (encoded in mental lexicon).

  - *Frontal cortex*: Construction of syntactic relations (structure building) & semantic relations (categorization & selection restriction).
Phases of sentence comprehension

Three functionally distinct phases-

- **Phase 1**: Initial parsing phase.
- **Phase 2**: Processes of theme assignment based on Semantic & morphosyntactic information.
- **Phase 3**: Revision. Interaction between semantic & syntactic information might take place.
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<tr>
<th>Stage</th>
<th>Process</th>
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<tr>
<td>1.</td>
<td>Identification of meaning; Generation of to be expressed meaning.</td>
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<td>2.</td>
<td>Selection of syntactic structure; construct a syntactic outline of the sentence, specifying word slots.</td>
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<td>3.</td>
<td>Generation of intonation contour; assign stress values to different word slots.</td>
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<td>4.</td>
<td>Insert content words; retrieve appropriate nouns, verbs, adjectives, and so on from the lexicon &amp; insert into word slots.</td>
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<td>5.</td>
<td>Add function words &amp; affixes; fill out the syntax with function words (articles, prepositions, etc.), prefixes &amp; suffixes.</td>
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<td>6.</td>
<td>Specify phonetic segments; express the sentence in terms of phonetic segments according to phonological rules.</td>
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Prosody Processing

- Recently prosodic processing has been studied using PET & fMRI.
- **Right prefrontal cortex**: Increased activation during pitch discrimination in speech syllables.
- **Left frontal operculum** (adjacent to Broca’s area): Modulation of activation during violation of pitch for lexical elements in a tonal language (e.g. Thai).
- **Right superior temporal region & frontal-opercular cortex**: Processing of suprasegmental information.
- **Temporo-frontal Network** (within right hemisphere): Supports prosodic processes.
Electrophysiological evidences suggest that prosodic information interacts with syntactic information at some point.

Prosodic information can influence syntactic processes.
Prosodic Processing (fMRI)

Left perisylvian areas: Processing grammatical information.
Right perisylvian areas: Processing of slow prosodic modulations in spoken sentences.

Fig. 4
Language Processing: fMRI

Semantic comparison > Letter matching

Letter matching > Semantic comparison

Fig. 5
Visual Area Involved in Language Comprehension

**Fig. 6**

- **Nonword vs. Single False Font**
  - Activation in ventral occipital cortex
  - Represents “global” paradigm
  - Comparing a non-word & a single false font with no lexical meaning.

- **False Font String vs. Single False Font**
  - Activations representing horizontal length encoding (seeing)
  - Comparing a string of false fonts vs a single false font

- **Nonword vs. False Font String**
  - Activation in left hemisphere
  - Representing processing of lexical input (reading)
  - Comparing a non-word vs a length-matched string of false fonts
Language Areas in the Brain

- Throat
- Tongue
- Jaw
- Lips

Motor projection areas related to speech

- Broca's area
- Wernicke's area
- Auditory projection area

Arcuate Fasciculus

Angular Gyrus
Language Localization: Lichtheim-Geschwind Model

Wernicke’s Area: Representation of sound

Broca’s Area: Planning & organization of speech

Parietal lobe (Angular Gyrus): Representation of concepts
Conclusions

- A bilateral temporo-frontal network subserve auditory sentence processing.

- Although syntactic & semantic information are processed predominantly by the left hemisphere, processing of prosodic information occurs predominantly in the right hemisphere.
Conclusions

- Temporal regions support identification processes, with
  Syntactic processes involving left anterior STG
  Semantic processes involving left MTG
  Prosodic processes involving right posterior STG

- Frontal regions support the formation of syntactic relationships (BA 44 & frontal opercular cortex) & semantic relationships (BA 45/47).
Culture, Thought & Language

- Culture can be defined in terms of socially acquired knowledge.

- Culture gets imprinted in the memory facelessly, i.e., without involving others.

- Cultural knowledge help people interpret each other’s behaviour and conclude similar propositions.
Culture, Thought & Language

Knowledge

Cultural Knowledge
(Learnt from others)

Shared non-cultural knowledge
(Shared by people within the same community or world over, but not learnt from each other)

Non-shared non-cultural knowledge
(Unique to the individual)
Culture, Thought & Language

- Majority of a language is cultural knowledge; however a part of it is shared non-cultural knowledge.

- ‘A concept has a feature-based definition, but the definition applies to the prototype’.
  
  - Hudson (1999)*

- A concept is dependent on the proximity with a particular prototype and/or difference with other comparable prototypes.

E.g., A prototype for bird has features such as laying eggs, flying, wings, legs, building nest, and so on.

- A crow happens to be a ‘good’ bird as it has the features associated with the prototype ‘bird’.

- However, an ostrich is a ‘bad’ example as it is exceptional on many a features.

- But as it is nearer to the prototype ‘bird’ as compared to other prototypes such as fish, insect, etc., it is recognised as a bird.
A prototype is applicable to a general concept and their subconcepts.

E.g., we encounter situations/ objects that are hard to classify, such as rain or drizzle, booklet or leaflet.

Concepts have a complex ‘radial’ structure where subconcepts group around a central core.

- Lakoff (1987)
“....a prototype-based concept can be learned on the basis of a very small number of instances- perhaps a single one- and without any kind of formal definition, whereas a feature-based definition would be very much harder to learn since a much larger number cases, plus a number of non-cases, would be needed before the learner could work out which features were necessary and which were not.”

- Hudson (1999)*

“....the choice of a language in a bilingual community varies from domain to domain, and that domains are congruent combinations of a particular kind of speaker and addressee, in a particular kind of place, talking about a particular kind of topic.”

- Hudson (1999)*

We use language based on domain.

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