

ECPS5003: The Brain, Biology and Cognition

Lecture 2 – Language Development and Neurodevelopmental disorders

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1

What is language?

According to Harley (2008, p.5):

- “Language is a system of symbols and rules that enable us to communicate.
- Symbols are things that stand for other things: Words, either written or spoken, are symbols.
- The rules specify how words are ordered to form sentences.”



2

More than communication?

Remarkable human skill

- Used to think inside our head & record information
- Used to express, solve problems, & plan etc.
- Used creatively, to convey emotion, & form social relationships.

Evolved historically / culturally

- Information is passed down generations through language. Provides knowledge.



3

Cognitive Neuroscience of language


Includes three premises:

1. Use of language is mediated by activity in all areas of the brain that participate in the cognitive processes involved in the language related behaviour
 - The constituent cognitive processes involved in language are divided into:
 - Phonological analysis (sound)
 - Grammatical analysis (structure)
 - Semantic analysis (meaning)

4

Cognitive Neuroscience of language


2. Areas of the brain involved in language are not dedicated solely to that purpose
3. Areas of the brain involved in language are likely to be small, widely distributed, and specialised because they are also part of other functional systems (e.g., memory).
 - Brain imaging research has found far more widespread activity occurs in the left hemisphere during silent reading (Bavelier et al. 1997), and the areas of the left temporal lobe that activate during object naming depends on the object category (Damasio et al., 1996).

5

Levels of language creation


Language is a multi-layered structured system for combining abstract elements into meaningful productions

Levels of language

- Phonemes – speech sounds
 - E.g. **a** sound in *ba*by and *ta*ble (note: sound not letter)
- Phonemic rules
 - language specific, possible phoneme combinations (e.g. stop consonants *p,b,d*)
- Words – approx. 600,000 in English language
- Sentences
 - Word order governed by rules (grammar and syntax)

6

Five stages of Language production development



Stage 1 = Cooing 1-2 months

- Long drawn out vowels or combinations of consonant-vowels
- E.g. oooooooooh or gaaaaaaaaah

Stage 2 = Babbling 6-10 months

- More consonant-vowel combinations and repetitions
- E.g. dadadada
- Phonemes are beginning to be constrained by language exposure

Stage 3 = First words 10-15 months

- 50 words
- A single word has many purposes e.g. juice (request, comment, lament) – holophrases

Stage 4 = Two word utterances 18 months

- Telegraphic speech – omit grammatical words e.g. milk gone

7

Five stages of Language production development



Stage 5 = Vocabulary explosion 24 months+

- Straight from 2 words to sentences!
- Sentence structure and grammar develops
 - Is inconsistent at first
 - E.g. over generalise – more than one 'cat' are 'catses', playing with past tense makes 'go' becomes 'goed'
- Grammar develops in a particular sequence
 - Words ending in -ing (notes verb)
 - Prepositions in/on
 - Plural -s
- Consistent by age 4

8

Language production in infants



Average 6 year old

- 14,000-15,000 words (Clark, 1991)

Noam Chomsky (1957/1965)

Language is innate and species specific

- Explosion of language indicates innate nature of language
- Hard wired to pick up language, grammar and syntax and do so spontaneously with little formal training
 - E.g. parents correct for **meaning** but not **grammar**
- Sequence of language learning is universal
 - E.g. Sign/invented languages

9

Disorders of Neurodevelopment: Autism



- **Issues during the development of the nervous system can have detrimental effects.**
- **Three core symptoms of Autism:**
 - Reduced ability to interpret emotions
 - Reduced capacity for social interaction
 - Preoccupation with a single subject or activity
- Intensive behavioral therapy may improve function
- **It is a Heterogenous disorder** – level of brain damage and dysfunction varies
- Often considered a spectrum disorder



10

Disorders of Neurodevelopment: Autism



- Incidence: **6.6 per 1,000 births (or 1 in 166)**
- 80% males, 60% have mental disorders, 35% epileptic, 25% have little or no language ability
- Most have some abilities preserved – rote memory, jigsaw puzzles, musical ability, artistic ability
- **Autistic Savants** – poor intellectual abilities but display specific cognitive or artistic abilities.
 - ~1/10 autistic individuals display savant abilities
 - Perhaps a consequence of compensatory functional improvement in one area following damage to another

11

Neural Mechanisms of Autism



Understanding of brain structures involved in autism is still limited, so far implicated:

- Cerebellum
- Amygdala
- Frontal cortex

Two lines of research on cortical involvement in autism:

- Abnormal response to faces in autistic patients
 - Spend less time than non-autistic subjects looking at faces, especially eyes
 - Low fMRI activity in fusiform face area
- Possibly deficient in mirror neuron function



12

Disorders of Neurodevelopment: Williams Syndrome



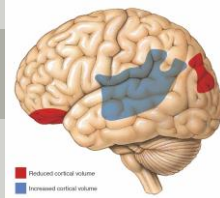
- Incidence: **1 in every 7,500 births**
- Mental disorders and an uneven pattern of abilities and disabilities
- Sociable, empathetic, and talkative– exhibit language skills, music skills, and an enhanced ability to recognize faces
- Profound impairments in spatial cognition
- Usually have heart disorders associated with a mutation in a gene on chromosome 7 – the gene (and others) is absent in 95% of those with Williams

13

Disorders of Neurodevelopment: Williams Syndrome



- General thinning of cortex at juncture of occipital and parietal lobes, and at the orbitofrontal cortex.
- A lack of development in these 2 areas may be related to the impairment of spatial cognition and hyper sociability
- Thickness of cortex in superior temporal gyrus is normal and has been linked to the high levels of language and music processing.
- “Elfin” appearance: short, small upturned noses, oval ears, broad mouths



Two areas of reduced cortical volume and one area of increased cortical volume observed in people with Williams syndrome.

14

Dyslexia



- Pathological difficulty in reading that does not result from visual, motor, or intellectual deficits.
- Developmental:
 - Can occur in different forms, making identification of the neural correlates involved difficult to ascertain.
 - Most now agree that it results from a disturbance in phonological processing (the representation and comprehension of speech sounds)
- Acquired:
 - Caused by brain damage, which can lead to:
 - Surface or deep dyslexia

15
