The nature of human language

What is human language?

- It may seem that this is a rather technical subject and just about language.
- But it is linked to amore general questions:
  - What is human nature (what are the capacities that define us as member of the human species)?
- These are fundamental topics for psychology and the neurosciences and how we answer this question inform our view of what happens in the case of language impairments like aphasia
- Today we discuss some evidence and arguments that address this questions
- First, however, one example to remind us of the phenomenon (language) we are dealing with…

A Reggie Watts tour of the language faculty…

In the speech you have just heard almost all of the processing levels involved in speech are preserved:

- **Phonology** (the language sounds appropriate for a given language);
- **Articulation** (phonemes are realized according to appropriate language-specific parameters);
- **The lexicon** (phonemes are combined appropriately into the words of a language);
- **The syntax** (words are combined in ways which are appropriate for their grammatical class and follow rules for constructing sentences);
- **The morphology** (words are appropriately inflected for tense, gender, number);
- **Prosody** (sentence are produced with an appropriate intonations with variations in pitch, loudness and duration to convey emphasis).

The only thing that is lacking is the meaning of the discourse (only individual words have meaning). This should make you aware language complexity and of different levels involved in producing human languages.

During the course we will see that all these different aspects of language can be differentially affected in aphasia throwing light on how language is represented in the brain.

We will ask:

- **Are some parts of language hard-wired in the brain?**
- **Is human language special?**
- **Are there brain-structures specifically devoted to language representation and computation (as an abstract faculty, independent of sensory modalities)?**

Are all aspect of language learnt or are some aspects hard-wired?

E.g.,

- Are there brain-structures devoted to represent language in a specific way or is language learned and used simply by relying on general cognitive capacities?
- How much of language is pre-wired versus it is learnt from input from parents/the community? In other words are we born with some pre-set language knowledge or, at least, with some constraints/structure which help us to learn what will be our language?

Which sentences are OK?

A. John saw himself in the mirror.
himself = John **YES**

B. John saw him in the mirror.
him = John **No**

C. John saw that he was about to fall.
he = John **YES**

D. John saw that himself was about to fall
himself = John **No**

E. John saw that $he_{1/2}$ was about to fall.
He_1 = John; he_2 = Bill **YES**

Some possibilities…

- Use "himself" to refer to John and "he" for a new person.
- Use "himself" only for John. Use "him" for John or a new person.

A few more…

- John suddenly saw he was going too fast. He realised he_2 was about to fall. [he_2 = John]
  - "Himself" is not the only way to refer to John
  - "he" is not always preceded by "that"
- From the other roof John saw Bob was going too fast. He realised he_2 was about to fall. [he_2 = Bob]
  - "he" can be John (previous sentence) or Bob (this sentence)
- *John suddenly saw he was going too fast. He realised himself was about to fall.
  - "himself" can't always be used to refer to John
  - Sometimes you have to use "he"

What is the rule really?

The understand this we need to introduce the concept of a *phrase*

- [John saw *pronoun*$_1$ in the mirror] [ ] = phrase marked by brackets

[John saw himself in the mirror]	himself=John	OK
[John saw him in the mirror]	him=Bill	OK
*[John saw him in the mirror]	him=John	not OK
*[John saw himself in the mirror]	himself=Bill	not OK

Rule: In the same phrase the pronoun must be "himself"
In the same phrase, "he" must be someone else

[John saw that [*pronoun* was about to fall]]

John saw that [he was about to fall]	he = John	OK
John saw that [he was about to fall]	he = Bob	OK

*John saw that [himself was about to fall] himself=not OK

If pronoun is in a different phrase must use "he" rather than "himself"

***That** is optional*
John saw (that) he was about to fall
[John saw that [he was about to fall]]
[John saw [he was about to fall]]

Rule: Different phrase – must use "he." Can refer to either Bob or John
What is the point?
Phrase boundaries are needed to express the rule, so you must know about these invisible things called phrase boundaries.

What is the point?

- We don't "know" the rules explicitly and we do not learn them through explicit teaching;
- To discover and use the rules we need an (implicit) understanding of **what a phrase is; BUT**
- **Phrases refer to an abstract concept**; [phrase boundaries] "aren't there" in any physical/visible way;
- The claim is that **we can easily learn about phrases because we are born with a predisposition to parse speech in this way** (provided by the mental grammar)
- Innate grammar claim: Phrase boundaries are part of innate grammar. Innate grammar is part of biology)
- These kinds of innate capacities are very common in the animal kingdom (e.g. a spider's ability to weave a web). We often call them "instincts"

Another example from another language domain

As they are rules to form phrases, there are rules to combine speech sounds (phonemes) with one another.

Consider:

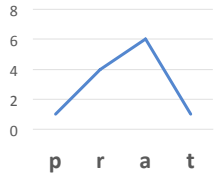
- Most of us would recognize the speech sounds of our language /a/, /b/,/tc/, /d/, /f/ etc. However these are **symbolic** units
- There are no clear discontinuities in a spectrogram of speech which would enable us to pick different phonemes.

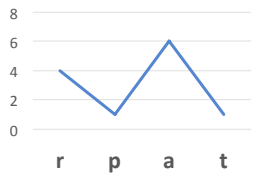
Phonemes are combined following rules. Some rules are universal others are language specific:

Consider which is better as a possible word: 'rtga' or 'trag'?

But 'stra' is a possible syllable in Italian and English but not in other languages

Sonority sequencing principle (Clements 1999): In a syllable, the sonority of segments needs to increase from the boundary of the syllable to the vowel and than decrease





Sonority hierarchy

1. **Plosive** /p t k b d g/
2. **Nasals** /m n/
3. **Fricatives** /s f ts tz/
4. **Liquids** /r l/
5. **Semivowels/glides** /j w/
6. **vowels**

Syllable template hierarchy

1. CV. (e.g., ta)
2. V, CCV, CVC (e.g., a, tra, tan)
3. VC, CCCV, CVCC (e.g., an, trua, tant)
4. VCC, CCCVC, CCVCC

Try some syllable: bwa, lwa, waban, rban, tra, trwa, wta, nta, kna, ban

Phoneme complexity hierarchy

1. Plosive unvoiced /p t k/
2. Nasals /m n/
3. Plosive voiced (but 1, 1b only for some languages like Italian / bdg/
4. /l/, /f/, /s/
5. /r/, /ts tz/, /N/ /l/

Same Hierarchies are seen in language acquisition, language loss and in the distribution of phonemes and syllable types in the languages of the world (see Jacobson, 1966; Romani et al, 2017; Romani et al, 2011; Galluzzi et al., 2015)

Parameters are genetically given;
the environment set the parameters to certain values

Discuss in groups of three:

What are the examples presented tell us about rules?

-- Are rules easy to learn? Did you have trouble learning the rules of your language?

-- Are they simple and easy to explain?

-- Are they physical? Can we see the rules in a stretch of speech?

What answering these questions tell us about rules?

-- Are they learned or innate?

-- Are they biologically based?

-- Are they universal?

Language from generative linguistics

The view that languages are based on rules was developed by generative linguists (a type of linguistics particularly associated with **Noam Chomsky,** see Sound Patterns of English 1968).

Main features still accepted today:

- **Grammar is abstract** – not driven by hearing (on the input side) or speech (on the output side)
- Some elements are **innate** [think about categories like *noun* or *verb* rather than specific words] and **therefore universal**
- It is **localized in the brain**
- It is a specifically ***human*** **biological trait**

These characteristics make a package in the current view, but they are not all logically connected (e.g. abstract ≠ *must* be localised)

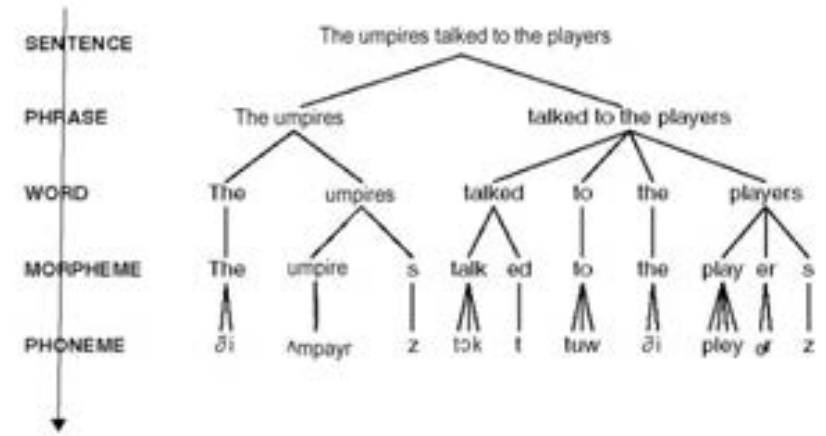
More about rules: They are symbolic and combinatorial

Human language is based on combining a small set of symbols into larger units following rules

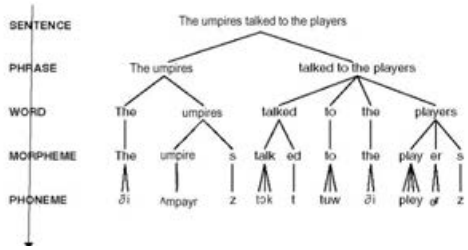
- In all languages, sentences are made up of phrases, phrases are made up of words (around 30/40,000 functionally used by educated speakers) and words are made up phonemes (15-40 depending on the language).
- In all language there are (grammatical) rules that govern the combination of smaller units into larger one.

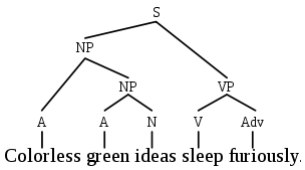
Human language is hierarchical and recursive:

Units are combined at different levels



some obvious linguistic levels of structure





Phonemes - The symbolic units sounds adopted by a language to represent words >**Phonology**

Phones - The acoustic/articulatory realization of speech sounds> **Phonetics**

Words - A unit of meaning which can stand alone

Morphemes - The smallest combination of phonemes which has meaning and can be combined with other morphemes to form words >**Semantics/ Morphology/Lexical processing**

Sentences - Combination of different phrases which convey meaning

Phrases - The smallest combination of words used in a sentence e.g. NP, VP >> **Syntax**

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In summary: Some language structures are hard-wired and, therefore, universal

- Some general principles are common to all languages of the world: all language have phrases which can be combined into sentences;
- In all languages, phrases are made up by words and words are made by re-combinations of a relatively small set of language sounds (phonemes).
- Combination of words into phrases and sentence is infinite; combination of phonemes into words is almost infinite;
- As there is a 'grammar'=set of rules to combine words so there are rules to combine language sounds into words;
- How these representations are realized in a particular language is learned and depends on the input from the community of speakers (e.g. specific words, inflections, phonemes, phrase and sentence structures)

(see Anderson & Lightfoot)

What is the alternative?

- Language is largely or entirely learned;
- Language is built on other more basic capacities;
- It is strongly shaped by sensory/motor systems;
- Localisation results from proximity to sensory systems (e.g. Wernicke's area to auditory cortex; Broca's area to motor cortex);
- Closely related forms exist in near animal neighbours (proto-language)
- This is a view that does exist, particularly among psychologists…

Is language special?

Or do close neighbours in the great apes also have language (or proto-language)?

(no human language is special)

First something about evolution: Why and how has human language evolved?

Why it has evolved?

- Need to communicate more complex information beyond the present context
- Need of ***social*** grooming in large groups where possibility of physical grooming are reduced.

FIGURE 8.2 Chimpanzee, adult human, and infant human vocal tracts compared

When ?

- We do not have a good idea;
- Modern primates do not have the right articulatory apparatus to produce the wide range of sounds associated with human language; First hominids 2 millions years ago.
- Archaeological evidence points to societies complex enough to require language at least 100,000 years ago.
- No evidence of language evolution since homo sapiens left Africa 50,000-80,000 years ago. No relevant differences between modern groups.

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How has human language evolved?

Prerequisites:

- Memory for acoustic sequences;
- Ability to use symbols (gestures/sounds) for the purpose of communication;
- Ability to imitate;
- Joint attention (follow gaze).

Evolved from vocalizations or gestures?

- Like humans, songbirds show: an incredible ability to imitate, critical periods to learn, a left hemispheric lateralization, the ability to recombine part of songs into new songs;
- Like humans, other primates are able to use gestures and call in a symbolic way (e.g., to indicate the presence of different types of predators).

Evolved very gradually or more suddenly?

- Some argue that it must be linked to a genetic mutation which has appeared quite suddenly, but others disagree.

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Instead, we know is that:

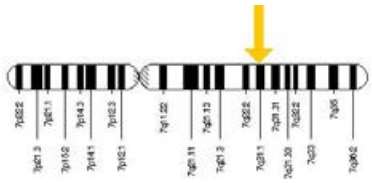
Language acquisition must have a strong genetic component

- The under-specification of input argument – As we have already seen, babies must be born with a predisposition to learn certain rules and extract certain information from the environment.

- There are language universals common to all the languages of the world which dictate which structures are more or less difficult, the order in which they are acquired by children and the order in which they are lost in aphasia.

- Language is independent of modality. The same principles apply to spoken language, written language, sign language (we will see this in the last part of the lecture).

- The genes underpinning language abilities are just starting to be uncovered (see the *FOXP2* gene and the KE family).



Comparing language in humans and other primates: language is symbolic

apple
mela
pomme
Manzana
Apfel

jablko
Яблоко
苹果
mήλο
.....

Infants learn the association between objects and their labels very quickly (e.g., one per hour at the peak period of acquisition)

Labels for abstract concepts are also learned quickly (e.g., fair, allowed)

Animals and especially primates can also learn a lot of 'labels', although their learning does not seem to be equally well defined and context free (e.g., for a chimp apple = apple, eating an apples, the storage where apples are kept, what is used to peel an apple etc.).

There is a report in the literature of a dog who knows 1022 words (Pilley, J. W., & Reid, A. K. (2011). Border collie comprehends object names as verbal referents. *Behavioural Processes*, *86*(2), 184–195.)

There is no doubt that animals communicate efficiently, can reason and have problem solving and emotional abilities.

What if you really, really like oranges?

However:
Communication + thinking/reasoning is NOT language

The question is: Do our close primate relatives have a proto-language? E.g., Do they have the same form of communication of human language just in a simpler form?

Or does human language represent something qualitatively different (an evolutionary jump), even if some basis skills are in common?

To answer this question:

- Series of studies with chimpanzees, gorillas or orangutangs (Washoe, Sarah, Nim Chimpsky)
- Raised with humans
- Exposed to language – speech/sign language/word boards

BUT: Human language is also combinatorial

- Terrace et al (1979) was a systematic attempt to characterise signing of *Nim Chimpsky* and compare it to children's developing sign language. Comparisons were made in 3 areas (among others)

  1. Was order in two-sign combinations systematic?
     - Children use systematic orders, even in 2/3 word phrases

  2. Were regularities in order related to semantic regularities?
     - Children use systematic orders for semantic situations
       - E.g. beneficiary second (Kiss John – [Give a kiss to John])

  3. Did longer utterances develop and show increasing complexity?
     - Children's utterances rapidly get longer

Were two signed combination used with a systematic order? YES

- Verb and object phrases
  Conventional order: transitive verb + *me;* e.g., 'tickle me'; N=788
  Inverted order: *me* + transitive verb; e.g., 'me tickle'; N=158

- Phrases with qualifier "m*ore"*:
  Conventional order*: More food;*
  N=974
  Inverted order: *Food more;*
  N=124

- Nim is not just producing signs in random order
- This is like children

Are order preference linked to semantics? YES

- When the semantics indicates a beneficiary (tickle me), is the beneficiary systematically in second position?
  - Answer: Yes
- E.g. When semantics indicates recurrence (*more tickle*), is the recurrence word (i.e. *more*) systematically in first position?
  - Answer : Yes
- Problem – there are a limited number of recurrence and beneficiary words (more/give and Nim/me) so this could be the result of individual word patterns (e.g. always put *me* second – need to see other beneficiary phrases)
- Situations are often consistent with several ways of categorizing semantics
- This evidence is not conclusive

Do longer phrases develop? NO

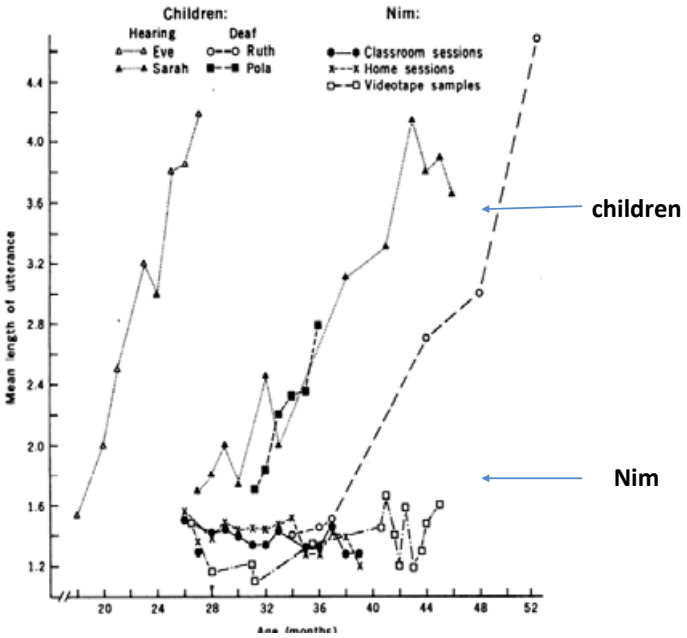
- Three word phrases are repetitive –
- Children don't do this

Not repetitive
Repetitive

Table 4. Twenty-five most frequent two- and three-sign combinations.

Two-sign combinations		Fre-quency	Three-sign combinations			Fre-quency
play	me	375	play	me	Nim	81
me	Nim	328	eat	me	Nim	48
tickle	me	316	eat	Nim	eat	46
eat	Nim	302	tickle	me	Nim	44
more	eat	287	grape	eat	Nim	37
me	eat	237	banana	Nim	eat	33
Nim	eat	209	Nim	me	eat	27
finish	hug	187	banana	eat	Nim	26
drink	Nim	143	eat	me	eat	22
more	tickle	136	me	Nim	eat	21
sorry	hug	123	hug	me	Nim	20
tickle	Nim	107	yogurt	Nim	eat	20
hug	Nim	106	me	more	eat	19
more	drink	99	more	eat	Nim	19
eat	drink	98	finish	hug	Nim	18
banana	me	97	banana	me	eat	17
Nim	me	89	Nim	eat	Nim	17

Length remain very limited – in striking difference with children



Ok, primates do not have language; what about a *proto*-language?

- It depends on what this means
- Distinction between knowing some words… and starting to use them in systematic combinations th at requires a grammar to explain
- There was no evidence here beyond words and some simple preferences for combination

What makes human language special?

The properties which we have described mean that human language is characterized by being:

1. **Highly productive**: an infinite number of new words and messages can be created from a finite set of symbols and rules.
2. **Recursive**: (when one of the units of a procedure is the procedure itself);
e.g. sentences can be embedded into sentences

- Finite number of rules that can manipulate a finite number of words to produce an infinite number of sentences…
that can be infinitely long by using recursive devices

- The women looked in the mirror
- The women looked at [the women who looked in the mirror]
- The women looked at [the women who looked at [the women who looked in the mirror]]

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Discuss in groups of three:

What do you think about the language in primates?

-- Is it like human language?

-- What is the same? What is different?

-- What does this tell us about human language?

My answer:

It is its **combinatorial and hierarchical** characteristics which make human language special

Is language abstract and tied to a specific brain area?

Located systematically in LH because of *computational* and *representational* capacity of language areas in the left frontal and superior temporal lobes

VERSUS

Language as constructed/learned out of more fundamental capacities
Language areas are where they are to be near auditory cortex (temporal lobe) and motor cortex (frontal lobe)

Evidence from signed languages which uses vision and space instead of sounds and time

In the case of signed languages:

- Following brain damage, do aphasic speakers of a sign-language make linguistic errors analogous to the errors made by aphasic speakers of spoken languages?
- Is space used for linguistic/symbolic purposes special? Or it is the same of environmental space? If linguistic space is special, it would support an abstract representation tied to linguistic specific brain areas.
- Do brain areas involved in language shift so that they become closer to areas which process vision and and space or do they

Neuropsychology can help

- Examine two types of deficit resulting from brain damage.
- Neglect (an impairment in paying attention to one side of space
- Aphasia (a language impairment)

Aphasia – Problems with language production or comprehension

Some typical aphasic errors:

- Phoneme errors (sound level)
  - Strawberry -> "strewberry"; Fragment -> "fagmet"
- Semantic errors (word level)

-> "cow"

- Grammatical errors (phrase level)

BROCA'S APHASIC PATIENT B.L.

B.L.: Wife is dry dishes. Water down! Oh boy! okay. Awright. Okay . . . Cookie is down . . . fall, and girl, okay, girl . . . boy . . . um . . .

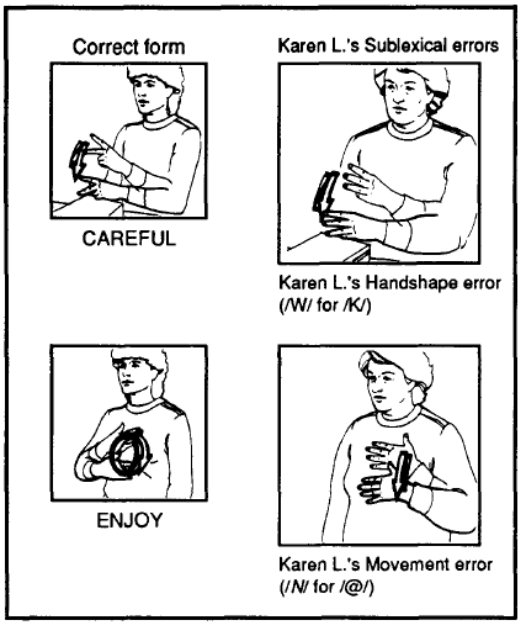
Examiner: What is the boy doing?
B.L.: Cookie is . . . um . . . catch
Examiner: Who is getting the cookies?
B.L.: Girl, girl!
Examiner: Who is about to fall down?
B.L.: Boy . . . fall down!

Aphasia in sign language looks like aphasia in speech

- Similar types of errors
- Errors at different levels in the language system (phoneme level vs. phrase level)

Aphasia in sign (Bellugi, Poizner & Klima, 1989)

"Phoneme" errors



In English grammatical roles are established

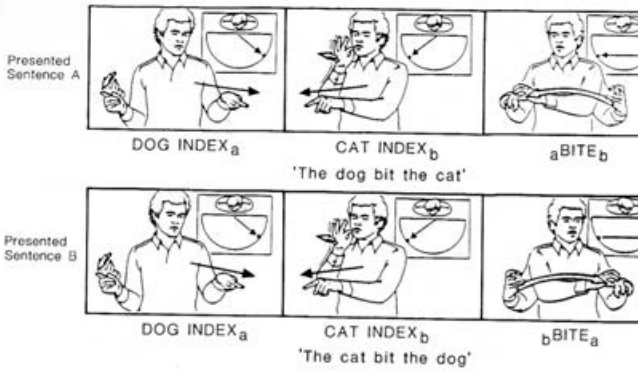
through word order
vs the cat bit the dog

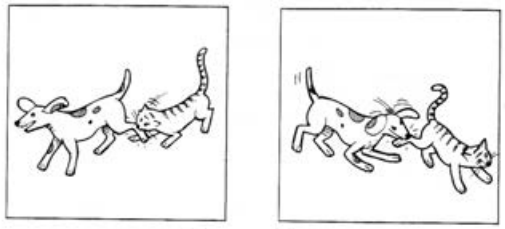
E.g., The dog bit the cat
Dog is subject
Cat is object
Dog is biting
Cat is being bitten

or function words
The dog is bitten by the cat

In ASL (American sign language)

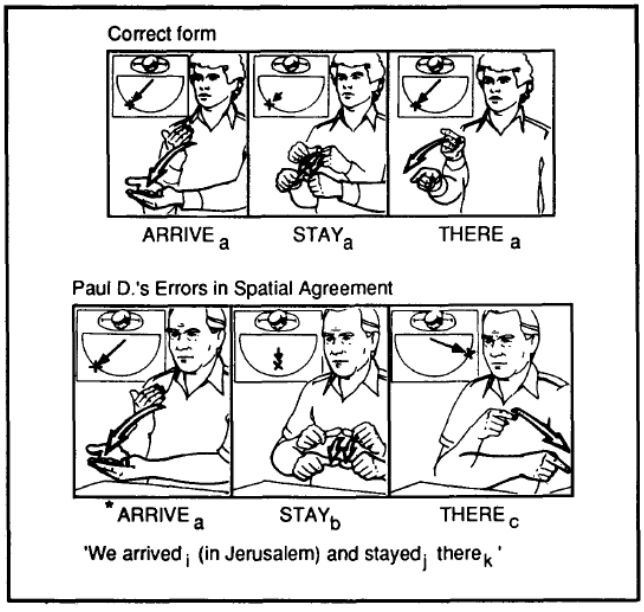
grammatical roles are established using space





Grammatical errors in sign-language

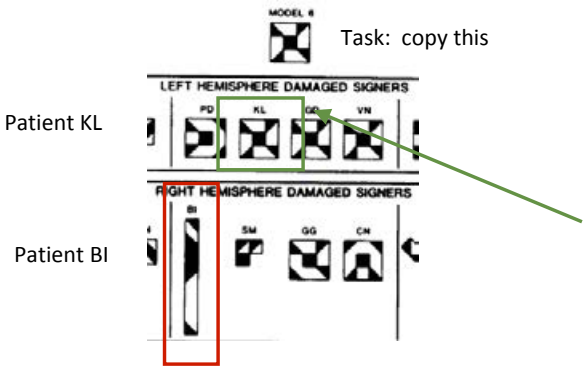
involve pointing to/ using the wrong position in space



Are there more general spatial problems?

(Bellugi, Poizner & Kima, 1989)

Compare patient KL, aphasic (making grammatical errors) with patient BI with a spatial deficit



- Task is to copy model using blocks
- KL does not have more general spatial problems
- BI has spatial problems

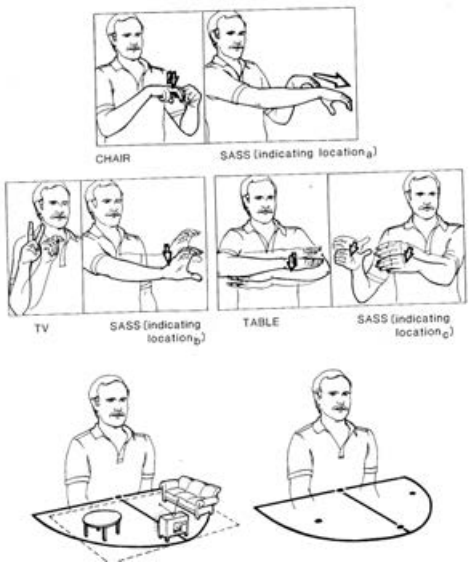
Given that BI has spatial problems, would this affect his ability to use space for linguistic purposes?

Would he make 'space' errors in producing sentences? In the same way as he distort object space?

One other fact to know:

How to describe a room in sign

- Sign each object – place it in the room in the ”proper place”
- “proper place” is an analogue of real space (not linguistic) even though it looks a lot like the space used for agreement.



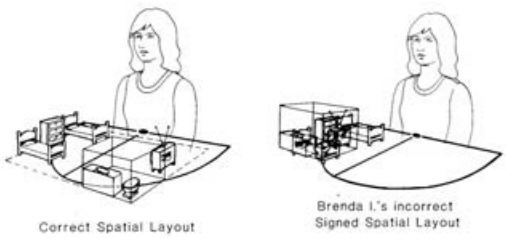
What kind of errors do you think BI made?

If the ‘*linguistic*’ space use for agreement is different from real/ analogue space

A. Errors in agreement ***and*** errors in room layout
B. Errors only in room layout
C. Errors only in agreement

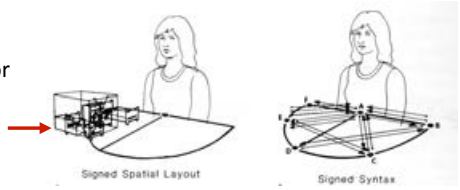
And the answer is:

In BI's room description, space is distorted (due to neglect)



But space for agreement is used correctly

Use of space for layout



Linguistic use of space

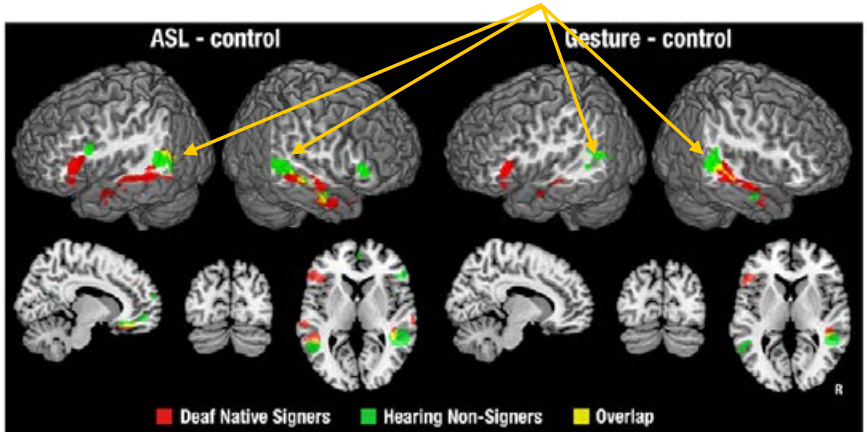
Linguistic space is not distorted – few/no agreement errors, L/R both used

We see a similar picture with brain imaging (Newman et al., 2015)

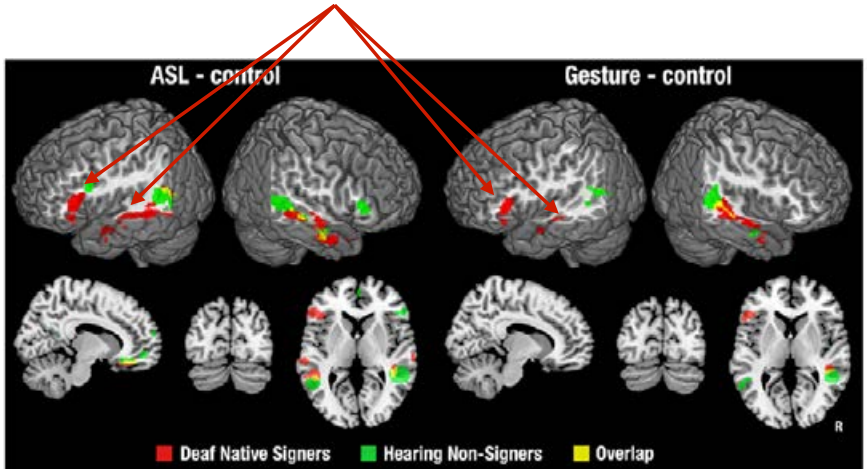
- Signers vs. non-signers looking at ASL and non-language gestures
- Both should activate non-language visual areas for non-signers (and perhaps some frontal motor areas – based on imitation)
- What should happen for signers?

Task – look at gestures that are not signs and signs

- Green – non-signers
- Red – Native ALS signers
- Green is in temporal/occipital junction (arriving from visual occipital processing) – same in both tasks – non-signers don't treat ASL as language
- Non-signers did not activate language areas in task as signers did

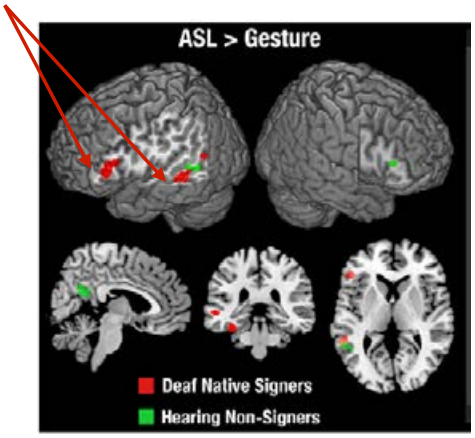


- Red – signers – show activation in language areas, for both ASL and gesture (signers initially treat gesture as if it might be meaningful signs)
- Both frontal and temporal areas – stronger on the left
- Signers treat both ASL and gesture as potentially linguistic



Activation in language areas is stronger for ASL than gesture (but only for signers

- Stronger activation in left inferior frontal and left superior temporal lobes for deaf signers only
- Sign activates the same areas (when treated as a language) as sound-based language
- Sign does not activate these areas in non-signers (who don't know it as language)



Discuss in groups of three:

What do you think sign-language tell us about spoken language ?

-- How closely is language related to speech?

-- Does language have some brain resources which are special and independent of modality?

General Summary

- Language has complex abstract structure that is not explicitly taught and yet it is learned, without explicit instruction, by children
- In the absence of deficits, all children complete this amazing task
- Apes and near relatives do not show anything similar, despite the ability to associate signs and things
- Language is acquired and breaks down in similar ways not matter whether it is signed or spoken
- The anatomical areas serving language are not changed by visual vs. auditory modes of communication

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Test your acquired knowledge!!

1 **Differently from animals, the properties of human language allow us:**

a To produce long utterances;
b To produce lots of new utterances;
c To express many emotions;
d Both a and b

2 **What is the main characteristic that distinguishes human language from the communication of other animals**

a It is symbolic;
b It is acquired during a critical period;
c It combines symbols into hierarchies;
d All of the above

3 **The rules of human languages are:**
a Acquired easily by young children;
b Difficult to express formally;
c Difficult to express without recourse to abstract concepts;
d All of the above

4 **The characteristics of linguistic rules suggest that:**
a Some aspects are innate;
b A lot of resources are needed to acquire them;
c Learning is only based on experience

5 **The characteristics of signed-language show:**
a Language processing has specific brain resources dedicated to it;
b Language characteristic are partially independent of modality;
c Both a and b