Language

• **Language** is:
  – a rule based system of **symbolic codes** used for communication.

Language is characterized by:

• **Semantics**
  – Rules used to communicate meaning.

• **Grammar (syntax)**
  – A limited set of rules describing how we can combine the symbols in certain orders.

• **Arbitrariness**
  – No inherent relationship between symbol & referent.

Language is characterized by:

• **Generative**
  – A limited number of symbols can be combined in (infinitely) novel ways.
  – Applies to syntax and semantics

• **Dynamic (Changes occur over time)**
  – New words are added to the lexicon (but not new sounds; Xhosa)
  – Rules of grammar change

• **Displacement**
  – Ability to refer to objects not physically present.
    • Vervet monkey (Cheney & Seyfarth, 1990).

Why is language a major area of research?

• Language requires many other capacities
  – Perception, categorization, memory, motor skill

• It can be explored from MANY different perspectives.

• It may be the one ability unique to humans.

• It may be the heart of *thought*.
The Relationship of Language & Thought

Sapir-Whorf (1956) Hypothesis

- Linguistic relativity (strong version)
  - Distinctions encoded in one language are not found in any other language.
  - Translation programs—sometimes fine distinctions are missed.

- Linguistic determinism (weak version)
  - The structure and complexity of a language determines how we perceive and think about the world.
  - Language may influence, but not determine, our perception of the world.
  -ambiguous figures

Now that we have an idea of what language is and isn’t, where does it come from?

- Did language evolve?
- (How do children learn language?)

Did language evolve?


[Section on Evolution from textbook]
Cangelosi & Parisi (1998)

• Given limited evidence (no fossils) it is difficult to prove language evolved, so simulations may provide useful evidence.
• What was done in the present simulation?

Cangelosi & Parisi (1998)

• 100 simple organisms (ANN) try to eat mushrooms
  – Feedforward net w/14 input, 5 outputs, 5 hidden units
• Edible & poisonous mushrooms look similar.
  – 2 one-word utterances are communicated among NN
  – Location of mushroom can be determined before edibility, so the words avoid & approach would be useful

Cangelosi & Parisi (1998)

• At the end of life (a certain number of time steps), the 20 individuals with the most energy (from eating mushrooms) produce 5 offspring each.
• Offspring have the same connection weights as parents (with 10% genetic mutations of weights).
• This is repeated for 1000 generations.
Cangelosi & Parisi (1998)

3 populations were examined:
1) No language
   • language inputs always = .5, everyone must learn about mushrooms on their own.
2) Language is externally provided
3) Language evolves
   – A creature sees a mushroom and labels it for another randomly selected creature nearby.

Cangelosi & Parisi (1998)

Results
• After 1000 generations the creatures were very good at discriminating mushrooms.
  – 28 mushrooms and 1 toadstool on average
• No-language group had 150 energy units whereas those with language had more than 250 units.
• No difference between outside- and evolved-language, but outside-language group reached plateau faster.

Cangelosi & Parisi (1998)

• Ability to categorize objects in the environment based on perceptual properties, repeated social interactions, and language may have co-evolved.
  – A consistent/distinct signal for mushroom/toadstool increases reproductive chances.
  – Analysis of the output units in the no-language group shows some support for this idea; increases in the quality of the signal coincide with an increase in fitness.
• The signal can act as a substitute for perceptual information when the object cannot be perceived
  – This is the power of language—an abstract symbol.
Cangelosi & Parisi (1998)

• Production and perception must have evolved in parallel.
  – One w/o the other is useless
  – All languages have both abilities
• How can language evolve if its informative function may be advantageous to the receiver but not the producer?
  – Why not lie to get all the food for yourself?
    • Vervet monkeys don’t lie, they signal lion when they see it, snake when they see it, etc.

The results are consistent with Burling (1993)

• Human language evolved from the cognitive (sensory-motor) capacities of pre-lingual ancestors rather than primate level communication.

Where did language come from?


Where did language come from?

Language evolved from animal cognition
NOT animal communication.
Where did language come from?

- Language grew out of cognitive systems already in existence and working.
- It formed a communicative bridge between animals that were already cognitive.

Where did language come from?

Consider the cognitive processes used for:

- Tool-using and making
- Cognitive maps
- Learning through imitation
- Social knowledge
- Deception
- Theory of mind

Similar processes are used with language.

Where did language come from?

- Language was used by early species to communicate thoughts.
- Sharing thoughts can be disadvantageous.
- So why bother?

Where did language come from?

- Greater cognitive intelligence outweighed that disadvantage.
- Social conditions such as reciprocal altruism (increased fitness by sharing and helping) lead to greater cognitive intelligence.
- Was the first language even *spoken*?
Is sign language a real language?

- YES! (LSA in 1970's)
- Same developmental trajectory as spoken language
  - Babble (9 m.o.)
  - 50 word stage (≈ 2 y.o.)
- It has syntax, semantics, morphology, phonology.
- Uses same parts of the brain as spoken language
- Signed languages emerge spontaneously

How do we learn/acquire language?

Language acquisition involves several stages:

- Babbling
  - 4-6 m. <all sounds>
  - 9 m <in/out & less/more common>
- First words: 1 year old
  - Overextension (milk, juice, glass, cup = “bati”)  
  - Underextension (Only “Spot” is “doggie”)
What can Physics tell us about language?


Important ideas to understand from Watts (2004)

• This article highlights the importance of interdisciplinary cross-talk
  – Each field “reinvented the wheel”
• A network is a useful tool to represent various systems
  – Biological, Social, Technological, etc. systems

Important ideas to understand from Watts (2004)

• Note that this type of network is more general or abstract than the “artificial neural networks” we discussed earlier.
  – These networks do NOT learn, do NOT have activation levels, etc.
    • Nodes = an entity
    • Links = a relationship between entities
  – In general these networks describe structures, not processes.
    • However, structure does have implications for processing

Important ideas to understand from Watts (2004)

• Many real-world networks are interesting mixtures of ordered and random networks.
• Two types of networks that have received much recent attention are small-world and scale-free networks.
  – Small-world
    • Although the network is very large, there are “random” shortcuts that allow one to traverse the network very quickly.
  – Scale-free
    • There are a few highly-interconnected nodes that contribute to the robustness (to damage) of the network.
    • Growth and preferential attachment are two mechanisms that lead to this type of structure.