Language

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

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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.

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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).

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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*.

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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

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The Relationship of Language & Thought

Sapir-Whorf (1956) Hypothesis

- 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

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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?)

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Did language evolve?

Cangelosi & Parisi (1998). The emergence of a "language" in an evolving population of neural networks. Connection Science, 10, 83-97.

[Section on Evolution from textbook]

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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?

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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

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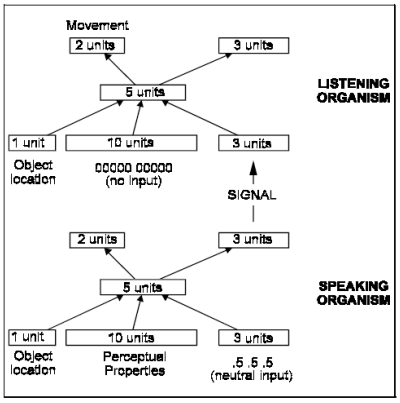

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Cangelosi & Parisi (1998)

- 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.

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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.

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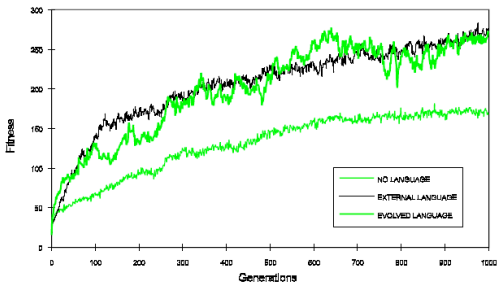

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Cangelosi & Parisi (1998)

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.

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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.

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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.

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Cangelosi & Parisi (1998)

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.

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Where did language come from?

- Ulbaek (1998). The origin of language and cognition. In Hurford, Studdert-Kennedy & Knight (eds). *Approaches to the evolution of language*.

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Where did language come from?

Language evolved from

<u>animal cognition</u>

NOT

animal communication.

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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.

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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.

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Where did language come from?

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

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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*?

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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

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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")

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How do we learn/acquire language?

Displacement & Over-regularization are also exhibited about this time (18 m.)

- A rule is applied to a word that is an exception to the rule.
  - In applying the rule "X + s = plural" a child might say "mouses" instead of "mice."

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How do we learn/acquire language?

- Holophrastic Speech
  - One word means many things
- Telegraphic Speech: 18-24 months old
- Children have a "vocabulary explosion" after about 50 words (expressive); 18 months.

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What can Physics tell us about language?

Watts (2004). The "new" science of networks. Annual Review of Sociology, 30, 243-270.

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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

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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

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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.

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