Human language and animal communication

Same or different?
Some characteristics of human linguistic communication

- Innate
- Arbitrary
- Structured
- Infinite
- Flexible

critical period
compositional
recursive
dischplaced reference
creative

• Systems with ALL these properties are termed language in the narrow sense (FLN, Hauser, Chomsky and Fitch 2002).
Question:

Do animal communication systems show these properties?

1. naturally intra-species in the wild?
2. when taught inter-species in the lab?
Where should we look?

• Social animals
• Large brains (relative to body size)
• Our close relations
• Visible or audible modalities
• Accessible environments
• Not too aggressive!
Species that qualify on one or more grounds:

- Honeybee
- Various birds
- Some monkeys
- Great apes
- Cetaceans
Some brain facts

- Birds: small cerebral cortex
- Chimps: enlarged plenum temporale in L hemisphere, sometimes assumed to be associated with language
- Whale: 11 lbs
- Human: 14oz at birth to 46oz max.
- BUT: Brain available after managing body: amount, relative to body size, increases in vertebrates and culminates in humans
The path to language?

- Fitch (various); Hauser, Chomsky & Fitch 2002
- Larynx in nasal cavity in most animals except during vocalizing, when it moves to oral cavity
- Same true for human infants, but around 3 months moves to throat
Macaque monkey: larynx at velum
Size enhancement hypothesis

- Formant structure of vocalizations correlates with vocal tract length and body size
- Signals body size; evolutionarily adaptive
- Lowering the larynx makes one sound larger. All mammals do this during calling
- Happens to facilitate speech production. Humans keep it permanently low
- In humans, larynx moves even lower when males reach puberty
Other prerequisites

• The ability to imitate: humans, parrots, songbirds, dolphins, but not much at all in non-human primates
• Conceptual-intentional system: rich in primates, parrots
• Theory of mind: controversial for apes
• Ability to compute transitional probabilities: cotton-top tamarins (Hauser, Newport and Aslin 2001)
But they seem to lack…

- Collaborative engagement (including non-verbal, such as pointing) (Tomasello)
- Can learn numbers (Matsuzawa 1985), but do not generalize to the next number. Each new number takes as long to learn as the first.
- Fail to learn long-distance dependencies (Fitch and Hauser 2004) such as AnBn. Finite-state ABn OK.
- Recursion is distinctively human, FLN (Hauser Chomsky and Fitch) But cf Gentner and Hulse 2005
Bee dance 1

Figure 2.3
Pattern of the tail-wagging dance. (Adapted from von Frisch 1967.)
Figure 2.4
Relation of solar-oriented flight to force of gravity. Box at center of landscape is the hive; three test feeding stations, A, B, and C, surround it. At bottom: dances corresponding to the paths to the three feeding stations. (Adapted from von Frisch 1967.)
Summary

- Orientation to vertical: direction w.r.t. sun
- Time spent on tail-wagging: distance
- Level of excitation: richness of source
- Compositional, but inflexible
- Von Frisch 1950
Clever Hans
Bird songs

Summary in Doupe and Kuhl
1999
Innate or not?

• European cuckoo: innate, and unaffected by environment
• Bullfinch: learned; can learn canary song if reared with canaries; can transmit it to offspring
Innateness + critical period:

- White-crowned sparrow: dialects. (Marler)
- Requires w-c sparrow input during critical period
- Day 7-60: perfect
- Day 60-100: basics only
- After day 100: never learns
Innateness continued:

• Botcher: zebra finches fail to learn song if the MAN area is lesioned.
• Gottlieb: Some birds learn from OWN vocalizations. If these are not heard, learn ANY ambient song. Innateness thus in question.
Adult learning

- Nottebohm: canary song areas die and re-grow annually, allowing for new tunes each year. Recent work suggests human brains may also regrow neurons. ?Plasticity?
- Whale songs change over time
- Starlings add new motifs throughout life. Also imitate other species.
- Rough analogues to humans ability to change accent, and acquire L2
Eastern white-crowned sparrow (Zonotrichia leucophrys)
Sparrow song dialects

FIG. 2.1. An illustration of song dialects in the white-crowned sparrow in the San Francisco Bay area. Songs of 18 males are illustrated, 6 from Marin County, 6 in the Berkeley area, and 6 from Sunset Beach, to the south. Each male has a single song type, for the most part. Local dialects are most evident in the second, trilled portion of the song (from Marler, 1970). These dialects have been studied in much greater detail by...
Structure in birdsong

- Like music, structure is present
- Like speech, formants can be detected
British starlings: two motifs

(Note clicks)
Zebra finch song bout, ~30 secs

(Doupe and Kuhl 1999)
motif=PrWd, notes=segments?

…motif

motif

motif

syllable

syllable

syllable

syllable

syllable
Monkeys and apes in the wild

- Fieldwork challenges
- Vervet monkeys (Marler et al):
- Apes: bonobo
  - mountain gorilla call
  - gorilla chest drumming
Vervet monkeys

- Seyfarth, Cheney and Marler 1980
- Different danger calls for leopard, baboon, eagle, python. Involuntary.
- Elicit different actions
- System of grunts: approaching a subordinate, vs a dominant animal vs a group. ?Referential?
- In both cases, tape recordings have same effect
- Non-compositional
Vervet alarm calls:

- Eagles
- Snakes
- Leopards

- Video: C:/animal communication/leopard.mov
Vervet leopard alarm video
Apes in the lab

- Taught, not just exposed
- Over-interpretation problem
- Incomplete documentation
- Limited results: small vocabulary
- Little evidence of grammar
- Little evidence of productive or innovative language
- Little evidence of displaced reference
Washoe 1
## Ape research

<table>
<thead>
<tr>
<th>Name</th>
<th>Species</th>
<th>Age at start</th>
<th>Trained?</th>
<th>Medium</th>
<th># of words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washoe</td>
<td>Chimp</td>
<td>~1 yr</td>
<td>Yes</td>
<td>ASL</td>
<td>132</td>
</tr>
<tr>
<td>Sarah</td>
<td>Chimp</td>
<td>5</td>
<td>Yes</td>
<td>Chips</td>
<td></td>
</tr>
<tr>
<td>Lana</td>
<td>Chimp</td>
<td>2</td>
<td>Yes</td>
<td>Lexigrams</td>
<td></td>
</tr>
<tr>
<td>Koko</td>
<td>Lowland Gorilla</td>
<td>1</td>
<td>Yes</td>
<td>Speech ASL</td>
<td>250</td>
</tr>
<tr>
<td>Nim</td>
<td>Chimp</td>
<td>2wks</td>
<td>Yes</td>
<td>ASL</td>
<td>125</td>
</tr>
<tr>
<td>Kanzi</td>
<td>Pygmy Gorilla</td>
<td>6mo</td>
<td>No</td>
<td>Speech Lexigrams</td>
<td>149</td>
</tr>
</tbody>
</table>
Washoe’s progress

- June 1965  Born
- June 1966  Begins training
- Dec 1966   4 signs
- July 1967  13 signs
- Apr 1968   34 signs
- June 1969  85 (Age 4; 3 yrs of training)
- June 1970  130 (Age 5; 4 yrs of training)
Compare to a typical child

- Age 3 1000 words
- Age 4 3000 words
- Age 6 10,000 words
Interpretive problems

• Incomplete reporting:
  Me banana you banana me you give
  reported as me banana you give

• Fixed sequence training:
  may not attach meanings to sub-parts
  Test by checking for FIRST trial in transfer tests:
  Teach ‘cherry’ see if they get ‘me cherry you give’ right FIRST time
More problems

- Cognitive skills clear, linguistic less so
- Sarah banana pail apple dish insert
  Sarah/insert constant, containers empty, so 50:50 chance of being right
- Experimenter often not native speaker of ASL, huge over-reporting of signs.
But they probably can:

• Use displaced reference
• Imitate (40% of Nim’s utterances; whistle-matching in dolphins in wild and lab)
• Sort objects into categories
Cetaceans
Killer whale (Orcinus Orca)
Dolphin whistles
Cetaceans in wild

• Humpbacks: only males, in mating season
  Same song all year, by whole ocean. Changes over time. Highly structured, possible rhyming.
• Fin whales: 20Hz pure tone blips, 2 sec apart. 155dB (louder than rock band). Travels 4000 miles! Function not known
• Dolphins: signature whistles (but see McCowan and Reis 2001), and echo location. Bursts of sound to stun prey (cephalopods)
• Extreme difficulty of study in wild
SONGS OF THE HUMPBACKED WHALE

FEATURING

- Why'd I Eat That Instamatic?
- Tired of Swimmin' Blues
- The Ballad of Jacques Cousteau
- Dolphins in My Face
- Gimme Some Plankton

and lots more!
Dolphins in the lab

• Entirely passive
• Word-order effects not much above chance
• Replicated with sea-lions
• Hoover bthe talking seal (Fitch)
A sound-based set of commands
The experiment (Herman)
## Dolphin object ‘words

### TABLE 10.1.
Comprehension Vocabulary of Phoenix (Pho) and Akeakamai (Ake);
If Only One Dolphin Understands a Listed Word it is Followed by the Name of that Dolphin.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Relocatable Objects^a</th>
<th>Transferable Objects^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Fixtures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GATE (divides portion of tank; can be opened or shut) (Pho)</td>
<td>SPEAKER (underwater)</td>
<td>BALL</td>
</tr>
<tr>
<td>WINDOW (any of four underwater windows)</td>
<td>WATER (jetted from hose)</td>
<td>HOOP</td>
</tr>
<tr>
<td>PANEL (metal panel attached underwater to side of tank) (Pho)</td>
<td>PHOENIX (dolphin as object) (Ake)</td>
<td>PIPE (length of rigid plastic pipe)</td>
</tr>
<tr>
<td>CHANNEL (channels connecting two tanks)</td>
<td>AKEAKAMAI (dolphin as object) (Pho)</td>
<td>FISH (used as object or as reward)</td>
</tr>
</tbody>
</table>

^a Relocatable objects are moved or manipulated by the dolphins.

^b Transferable objects are passed from one dolphin to another or retrieved by the trainer.
Dolphin action ‘words’

<table>
<thead>
<tr>
<th>Actions</th>
<th>Take Direct and Indirect Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take Direct Object Only</td>
<td>FETCH (take one named object to another named object)</td>
</tr>
<tr>
<td>TAIL-TOUCH (touch with flukes)</td>
<td>IN (place one named object in or on another named object)</td>
</tr>
<tr>
<td>PECTORAL-TOUCH (touch with pectoral fin)</td>
<td></td>
</tr>
<tr>
<td>MOUTH (grasp with mouth)</td>
<td></td>
</tr>
<tr>
<td>(G0) OVER</td>
<td></td>
</tr>
<tr>
<td>(GO) UNDER</td>
<td></td>
</tr>
<tr>
<td>(G0) THROUGH</td>
<td></td>
</tr>
<tr>
<td>TOSS (throw object using rostrum movement)</td>
<td></td>
</tr>
<tr>
<td>SPIT (squirt water from mouth at object)</td>
<td></td>
</tr>
</tbody>
</table>

| Agents                                        |                                                      |
| PHOENIX or AKEAKAMAI (prefix for each sentence; calls dolphin named to her station; indicates to dolphin which is to receive fish reward) |
Akeakamai

- DO + A  
  Basket Toss
- M + DO + A  
  Right Fish Pec-touch
- IO + DO + R  
  Pipe Hoop Fetch
- IO + M + DO + R  
  Ball Right Net In
- M + IO + DO + R  
  Right Basket Pipe Fetch
- M + IO + M + DO + R  
  Right Hoop Left Pipe Fetch
Typical signs
Typical instructions

• a. Akeakamai over
• c. person tail-touch
• e. water mouth

• b. pipe toss
• d. ball pec-touch
• f. surfboard spit
Results

• Semantically reversible sentences: 77% correct (Phoenix) 59% Akeakamai. Drops to 14% using new ‘words’
• Replicated with sealions (Schusterman and Gisiner 1988)
• No evidence for reference, despite Herman’s claims
• Response precedes full command
Alex, the African grey parrot
Cognitive experiments, not linguistic ones

- Other than apes, only two-way experimental work
- Only spoken work *(Russian)*
- Careful double-blind studies
- Tasks intermingled, making stimulus-response strategies unlikely
- Pepperberg 1999
Alex’s vocabulary

Shapes: 2-cornered, 3-cornered, ..6-corner
Materials: cork, wood, paper, chalk, wool, rock, (raw)hide
Colours: green, red, blue, yellow, gray, purple, orange
Labels: key, chain, grate, tray, toy car, clothes pin, block, cup, box
Comprehension task:

- Objects: purple key, yellow wood, green hide, blue paper, orange peg wood, gray box, red truck
- Question: What object is gray?
- Answer: box [ correct] (100% right)
## Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Correct</th>
<th>%</th>
<th>Error type</th>
</tr>
</thead>
<tbody>
<tr>
<td>What object is red?</td>
<td>10/12</td>
<td>83.3%</td>
<td>Wrong object</td>
</tr>
<tr>
<td>What color is wood?</td>
<td>8/12</td>
<td>66.7%</td>
<td>Wrong color</td>
</tr>
<tr>
<td>What object is 4-corner?</td>
<td>12/12</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>What shape is red?</td>
<td>9/12</td>
<td>75%</td>
<td>Wrong shape (2) wrong colour (1).</td>
</tr>
</tbody>
</table>
How do they do?

Innate: YES  critical period: YES
Arbitrary: YES  compositional: NO
Structured: YES  recursive: NO
Infinite: NO  displaced reference: ?
Flexible: ?  creative: NO

• In our present state of knowledge, no species other than our own has a system with all these properties.
The End
“He’s pretty good at rote categorization and single-object relational tasks, but he’s not so hot at differentiating between representational and associational signs, and he’s very weak on syntax.”