Cogs 143

Lecture 6: Cetacean Foraging Skills

Focus on species that **hunt** (i.e. capture individual prey) vs. graze (e.g. baleen whales)
Fish are an unpredictably dispersed, difficult to monopolize resource, requiring active search & capture

Echolocation – Odontocetes' main strategy for finding, and helping capture, prey
- Echolocation clicks are produced by vibration of "**dorsal bursae**" ("Rabbit Ears") in dorsal nasal passages
  - Clicks exit forehead in **narrow beam**, ~10^o to either side of center, directly ahead of animal
  - Beam is focused & steered by fatty **Melon** (acoustic lens) in forehead, adjacent to bursae
- Clicks are sent out in a "**train**", with more closely-spaced click trains => higher detail resolution
  - Click intervals are adjusted per transit time to/from target, usually wait for echo before next click
  - **Lag time** (between returned echo & next click) typically .020 to .045 secs (can be .003 sec!)
    - NEW data suggests they do not always wait – for long-distance, send out "packets" of clustered clicks
- Each click is a **broadband** (multi-frequency, including super-sonic) high amplitude burst of sound

- **Hearing:** Echoes carried through fat in throat ("gular" channels) and lower jaw to inner ear for processing
  - Hearing range varies to over 150 kHz, and amplitude of vocalizations can exceed 200 dB
  - NOTE: Sound travels **4.5 times faster** in water than in air, so echolocation requires VERY high speed processing
- Variety of information can be gleaned from echoes
  - The predominant **frequencies** in echo will be those whose **wavelengths** (or λs) best match the **size** of the target
    - So, frequency spectra in echo can inform about overall size of target, as well as details of its shape/texture
      - (Note: The higher the frequency, the shorter the λ. So, higher freqs would return from finer details)
  - Also, frequencies that **resonate** with the target, per its **material**, are amplified in the echo
    - These resonant frequencies inform on content (e.g. bone vs. flesh vs. air sacs; metal vs. wood, etc.)
  - The **longer the latency** between click and echo, the **farther** away the target
    - Dolphins adapt to shortening latency as approach target by decreasing inter-click interval to accommodate
      - (TSP: To humans, as clicks more closely spaced, sound higher pitched as dolphin "zeros in" on prey)
  - **Amplitude** of echo also a function of both **distance** (via attenuation) & **absorption**
    - e.g. Air sacs reflect nearly all incoming sound, bones tend to absorb much

- Infant dolphins produce first click trains in first few weeks, but **learning** plays a major role!
  - i.e. Learn to refine outgoing beam, tune it to target & ambient noise factors, *interpret* echoes
    - Note that "baby position" at mother's side is ideal for listening-in to echos produced by mom's sonar
    - Also note they have been hearing & feeling sound since BEFORE they were born!
- Dolphins can "**listen in**" ("eavesdrop") and to some extend interpret echoes from other's output
  - (*Xitco & Roitblat 1996)*: 2 animals positioned side by side so narrow beam of output/echo returns to both
    - Listener on a "bite bar" at surface, so can hear (thru jaw) but not echolocate (thru melon)
    - Echolocator ensonifies a visually obscured target (behind thin black plastic sheet)
    - Listener must then pick matching stimulus from visible alternatives – *Succeeds!*
      - Apparently some info (e.g. resonance, some "shape" info) detectable w/o listener itself clicking!
  - Note: above suggests that "shared attention" important to these animals (More to come!)

- **Vision** can also be employed for hunting
  - e.g. **Spy Hop** – Locate prey, conspecifics, birds circling over/feeding on fish schools, etc.
    - Eyes specialized to see farther in air than in water
      - i.e. Weird pupils squeeze down to limit light (discrim WIDE range of intensities) & see farther in air
  - Especially sensitive to **contrast** & **motion**; Can see prey (and each other) well, especially close-in
    - e.g. Failed original visual MTS tasks using colored stimuli, or static, 2D detailed stimuli
    - Tasks modified to using high contrast, moving, 3D stimuli; Did fine (i.e. improved by **Ecological Validity**!)
      - e.g. In other work, reduced trainer gestures to moving point-light displays, animals performed fine

- **Ecological & Cultural Constraints** influence what/how hunting occurs (see Wursig & Pearson reading)
  - e.g. In Orca, **Resident** coastal pods, composed of extended family units, work together to take fish
      - Smaller pods of **Transient** Orca range widely, often eat other marine mammals
        - e.g. Stealthily capture seals onshore; unite to take whales, coordinate to wash seals off ice flow, etc
      - Plus, Residents noisy when hunt fish, Transients silent when hunt (acoustically sensitive) mammals
  - e.g. New Zealand **Dusky Dolphins**: Large FF groups rest in shallows in day, small groups feed at depth at night
    - In winter, some travel 170 miles, feed in small fixed groups in shallows in day, rest in large groups at night
      - But these day/night & FF/fixed reversals only seen in sub-population, a "cultural" practice
  - e.g. Coastal habitats: May provide more options: prey vary in sea grass, coral reefs, sandy bottom, estuaries etc.
    - Observe **great variation** in foraging techniques in coastal animals, even within same species
      - e.g. Bottlenose do kerplunking, sponging, beaching prey, crater fishing, etc etc.
        - Includes local traditions that vary across diff populations of same species (More later!)
    - May be another reason why coastal species like Bottlenose do well in captivity – VERY adaptable!

"**Tool Use**" –

- No (useable) fingers! But do occasionally manipulate non-food objects (& we humans tend to focus on this!)

- In captivity, sometimes imitate humans' use of objects (e.g. hold algae scraper in teeth, clean windows)
    - Invent novel uses, like grab stick to poke into reef hole to roust eels
    - In experiments, can be trained to manipulate apparatus, poke sticks into tubes, boxes, etc. for reward
    - The military trains dolphins to e.g. deploy uw cameras, attach locator beacons to sunken materials, etc
- In the field...
    - Sometimes see animals w/jewelry (e.g. kelp) hooked on fins, catch with tail etc. (Play)
    - In Australia, *Tursiops aduncus* seen "sponge carrying" (Not play)
        - Surface w/sponge draped across rostrum, few breaths, then tail-out (deep) dive for several min
        - ??? Protect face during bottom feed?? Attract prey?? Medicinal/psychotropic effects??
        - Small subset of animals practice, pass on this tradition, to esp their daughters (More later!)

- Above reflects less a (primate-like) obsession with "stuff" than a **general flexibility/adaptiveness**
    - **Curiosity**:
        - Wild cetaceans will come and investigate people, boats, stuff; Learn to cooperate with fisherman
        - Similarly, captive animals attend to activities outside their tanks; Require enrichment!
    - **Creativity:**
        - *Steno* (Rough-toothed dolphin) and later *Tursiops* taught command "do something new" (*Pryor et al 1969*)
        - Later, Herman did "Tandum Creative" w/*Tursiops* - where 2 animals had to create new, together, on the fly!
    - We'll see more of this flexibility when we assess social strategies as well…

But, while dolphins do NOT (compared to primates) do much object/tool manipulation, PREY are objects too!

- Need to be found, identified, processed, just as primates' foods do…
- How do dolphins discriminate, track "things" in the cluttered, dynamic ocean??

- Object Permanence

- Tests of "Visible Displacement" show dolphins can track objects when they move behind an occluder
    - e.g. Anticipate where object will reappear, based on trajectory when disappeared (Johnson et al 2013)
- Trained to **report absence** of cued and searched for object, using "NO" paddle
    - Trainer signals "Hoop Fetch" (no Hoop in pool), Dolphin searches, presses "NO" paddle
    - Trainer signals "Frisbee Hoop Fetch" (= "Take Hoop to Frisbee", no Frisbee); takes Hoop to NO
- After multiple presentations of similar sized targets, adjust echoloc bandwidth for next search
    - All of above suggests anticipating target shape, size, location, through a developed "**search image**"

- Invisible Displacement

- First tried with primate protocol: Put object into occluder, move occluder to 1 of 2 containers, leave object there
    - Dolphins required to choose which container to search for object – Unlike apes, **Failed**! *(Jaakkola et al, 2010)*
- Redone using object *moving* behind *moving* occluder that then *moves* behind 1 of 2 other occluders - **Succeeds**!
    - i.e. **Ecologically valid** redesign presents stimuli as dolphins may actually encounter them *(Johnson et al, 2015)*

- Match-to-Sample

- Like primates, show **first trial success** with novel stimuli on Identity MTS, acoustic or visual
    - Note: Some can learn based on very few trials! (e.g. young Hiapo got 19/first 24 trials correct!)
        - Suggests already a well-developed in skill in the animal's repertoire
- **Oddity**: Similar, first trial success w/novel stimuli, acoustic or visual (Not tested for transfer from IMTS/CMTS)
- **Same/Different**: More difficult task, since after assess if match, must then respond to sep SAME or DIFF paddles
    - Success provides additional support for hypothesis that dolphins' performance, like primates, is **Rule-Based**

- Cross Modal Mapping

- Can do visual<>auditory recognition of stimulus presented in other modality (no "haptic")
    - Can transfer rule (e.g. MTS) learned in 1 modality to other (vis<>aud)
        - In fact, can do more subtle visual discriminations when first taught acoustic MTS!
- No behavioral research on auditory<>tactile, but recall area in Temporal Cortex that responds to either acoustic or tapping/dripping input, esp to face/head area; Echoloc has tactile impact!