Computational Thinkers

"a theoretical conception as deep as it is daring: namely, we are, at root, *computers ourselves*"
Haugeland, 1981

Mind as a computer

- As described by e.g.Craik (1943)
  - Thinking involves manipulation of internal models of external situations
  - Explains ability to act towards things, beyond the current stimulus and history of reinforcement (challenging behaviourism)
  - Computer is more than metaphor: it has the exactly the right kind of capabilities for flexible model representation and manipulation

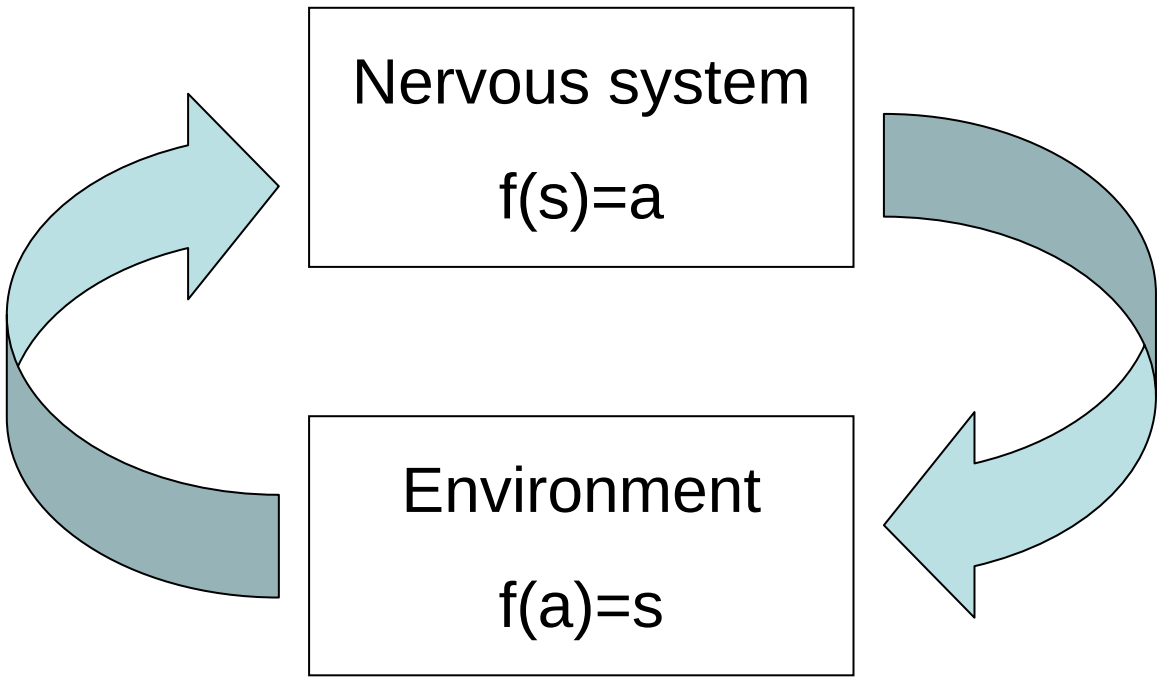
However…

- Should we consider all behaviour as falling under this description, i.e. all nervous systems are computers?
  - The internal model has to be produced/updated and read out from: at minimum need computer *plus* transduction processes.
  - And is it right to assume *all* behaviour is described by:

sense - construct model - manipulate model - act?

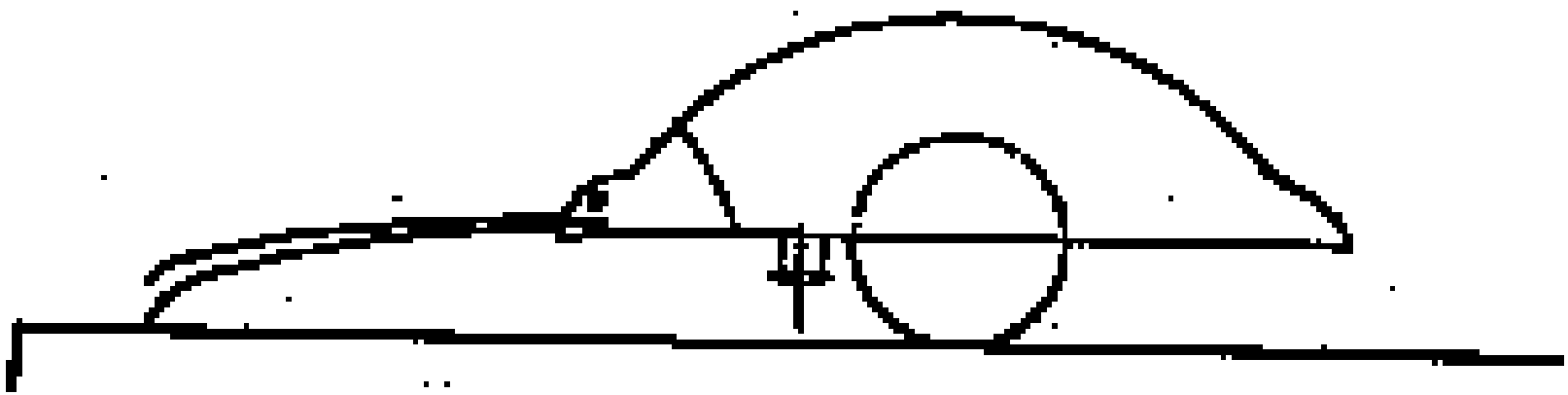
Bottom up view

- Nervous systems perform a transfer function from stimuli to actions



Mechanical example

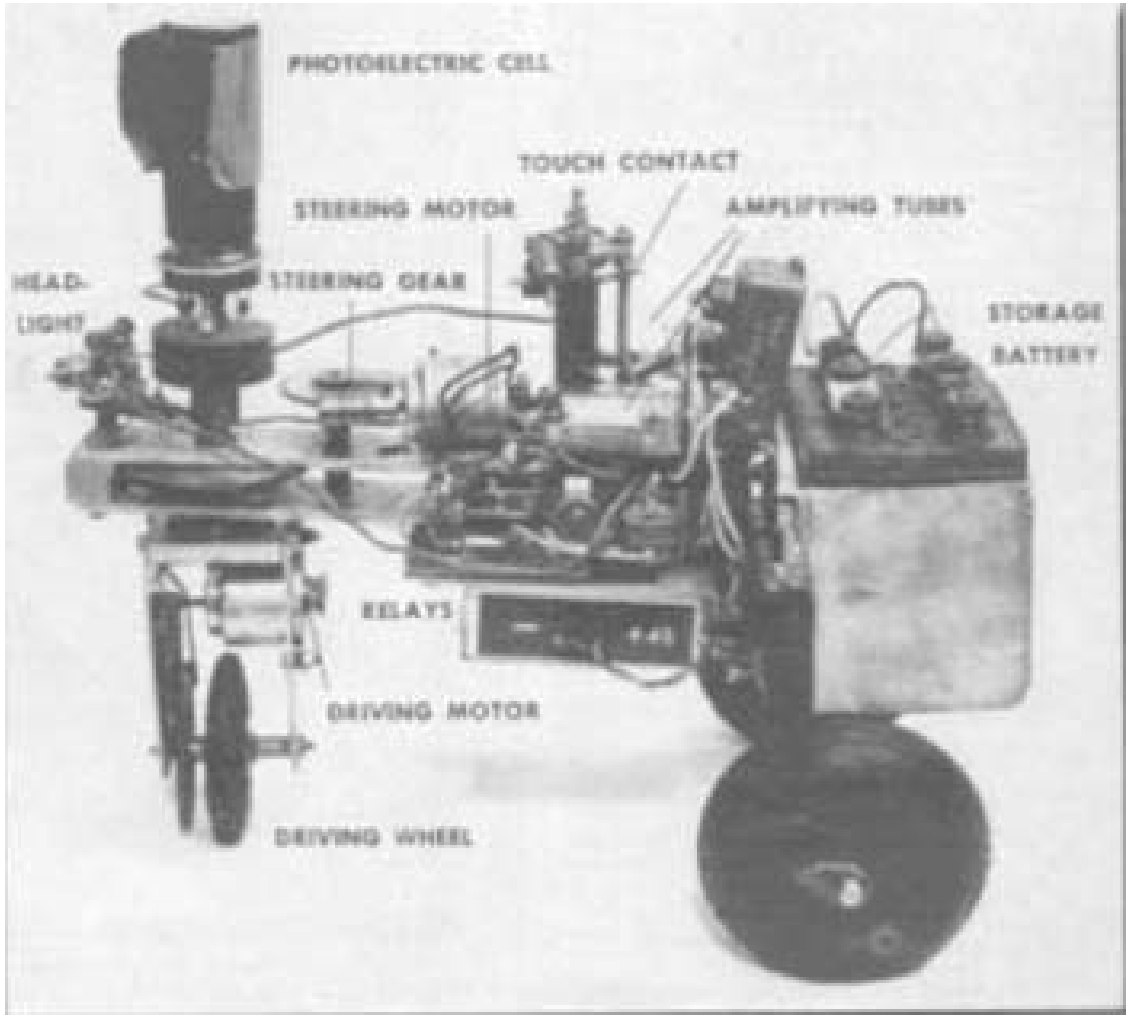
- Lotka (1925) described a simple toy insect that detected and avoided the edges of table tops:

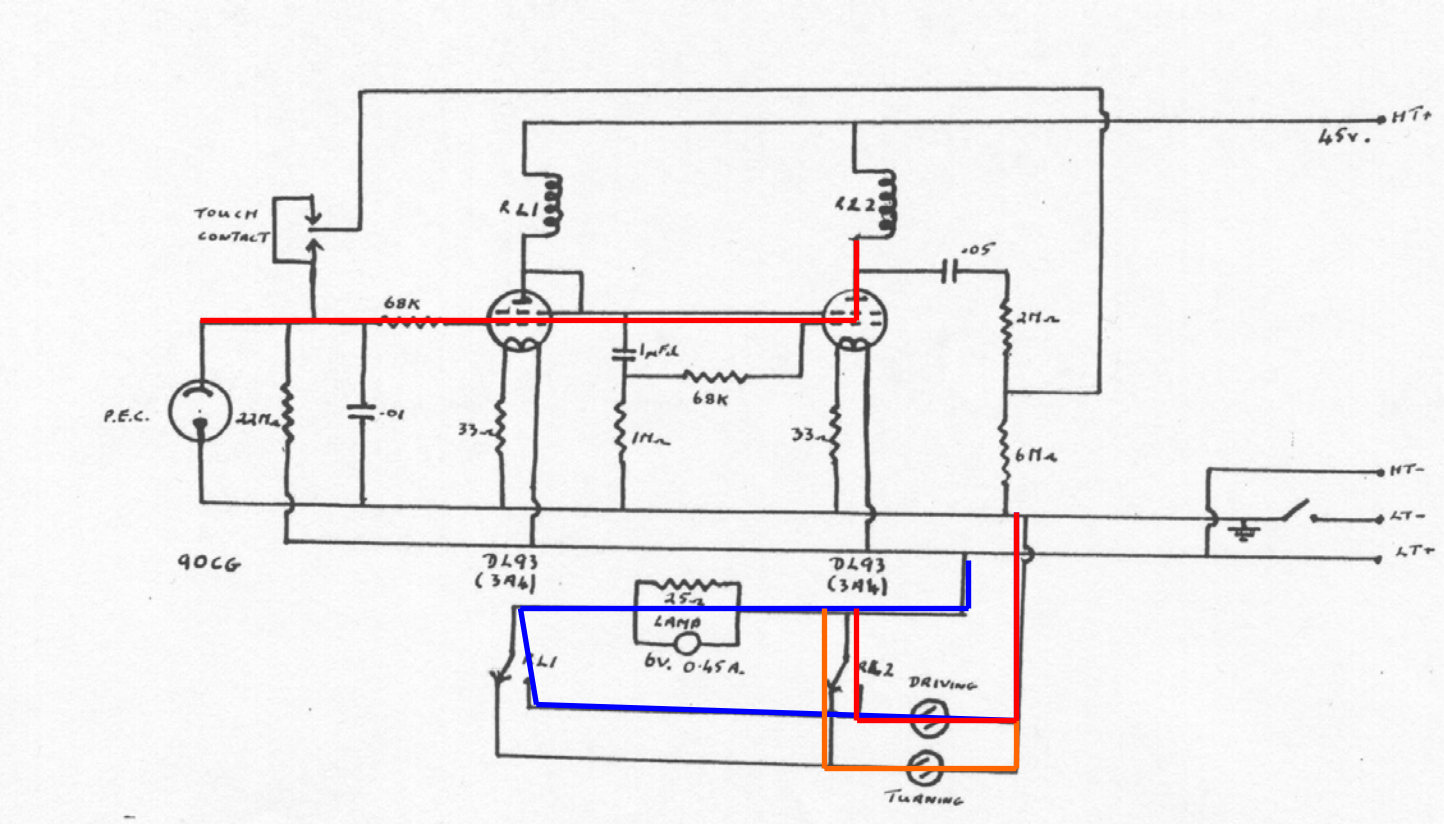


Electronic example

Can get surprising capability from a couple of vacuum tubes and relays…

Grey Walter's 'tortoise'1950

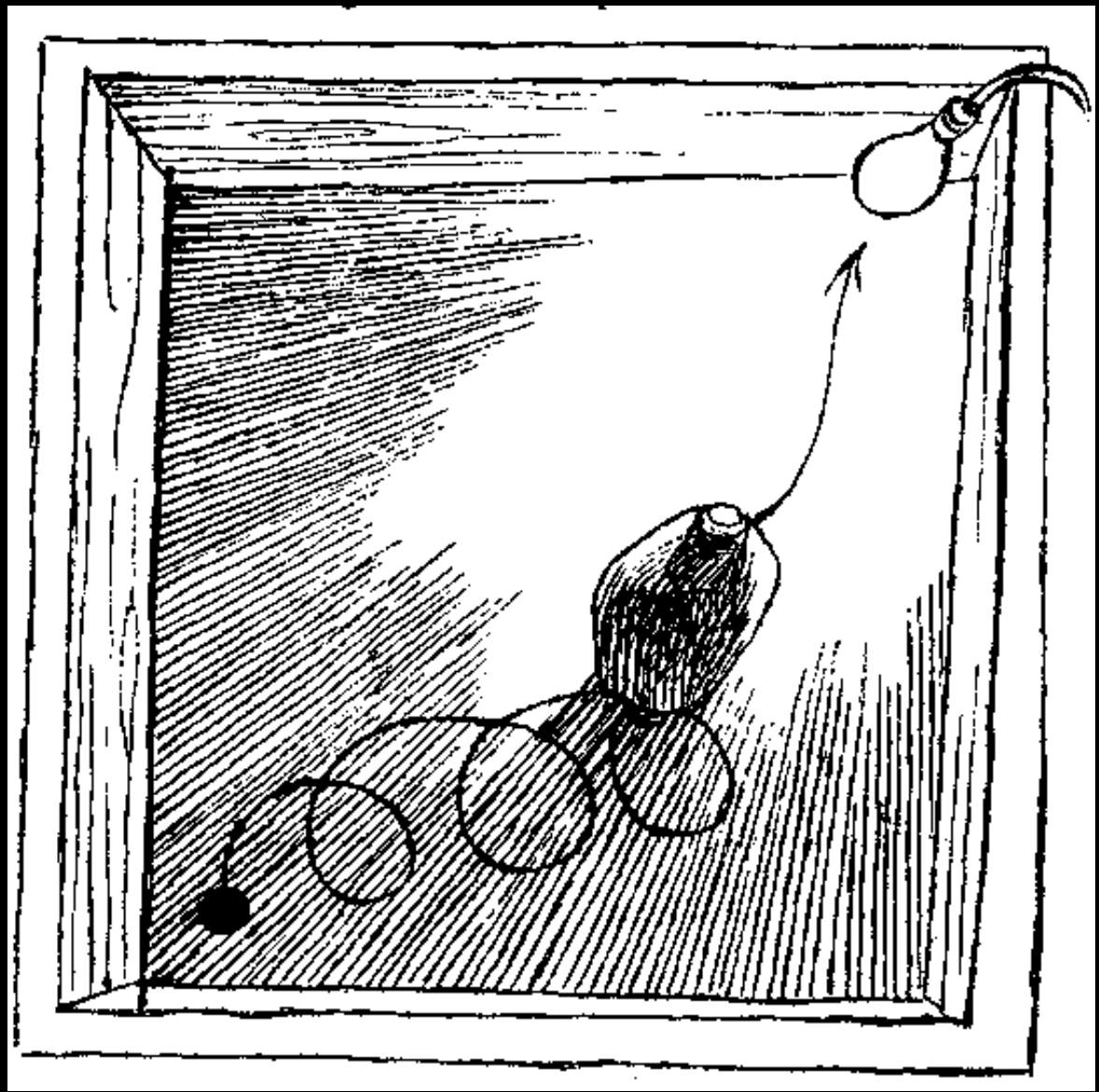


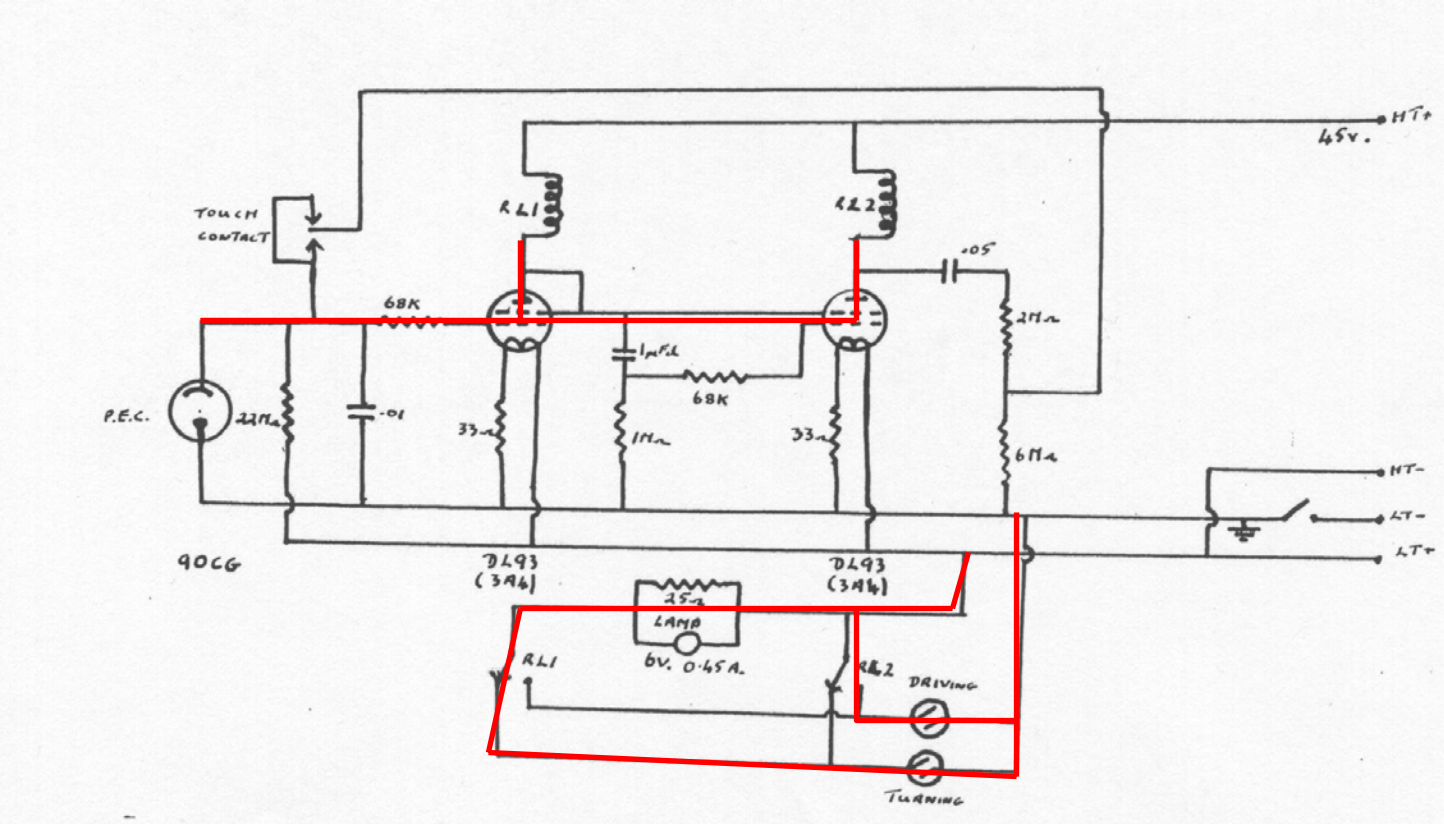


Starts with: drive motor in series with lamp and turning motor full on; get cycloid movement that scans for light.

Light input: passes through two amplifiers, switching relay 2, short circuit; so stops turning and drives double speed.

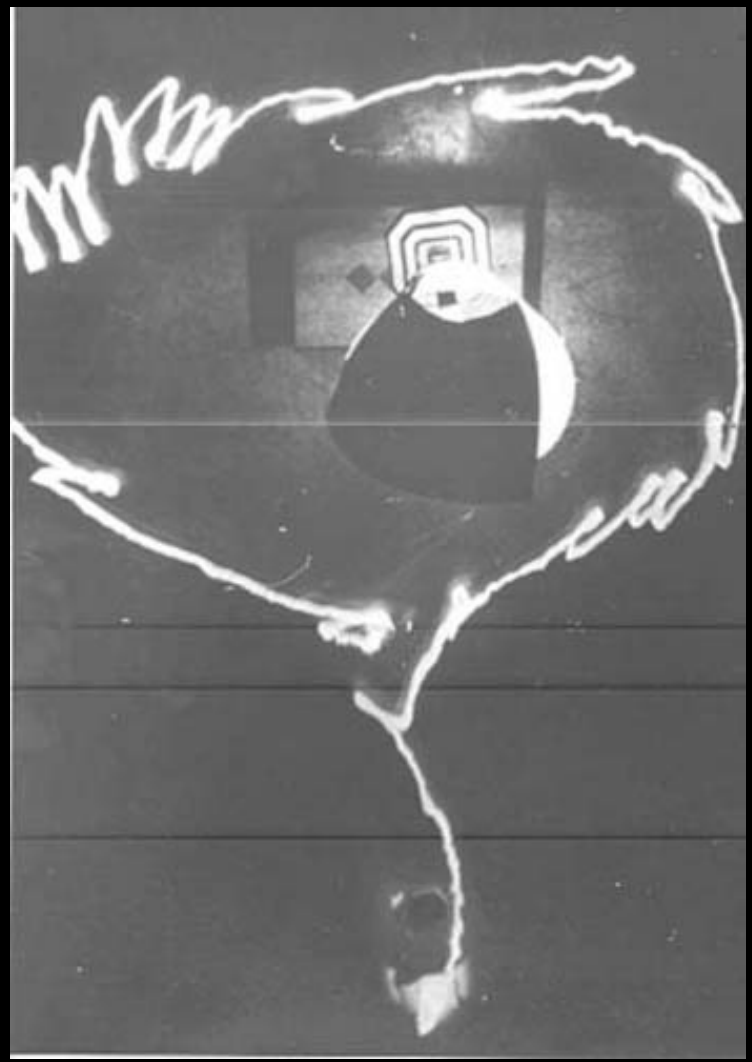
Steers at increasingly shallow angle towards light source



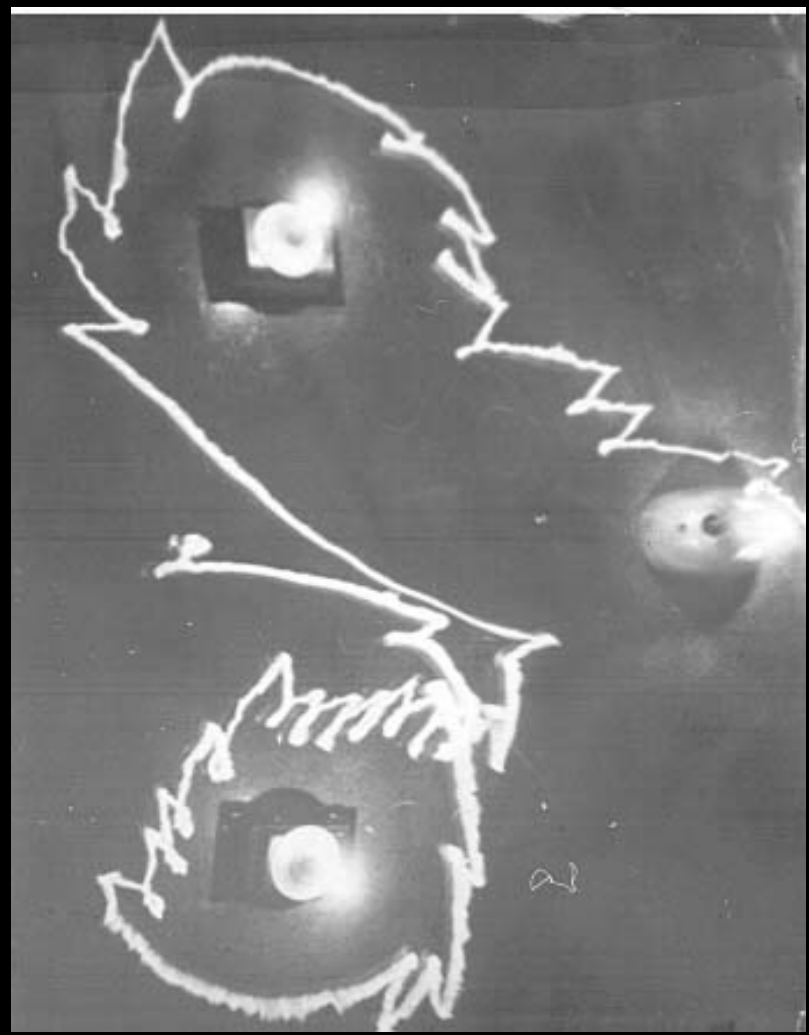


Strong light: switches relay 1, turning motor in series with lamp; turns smoothly away from light.

Approaches then circles light



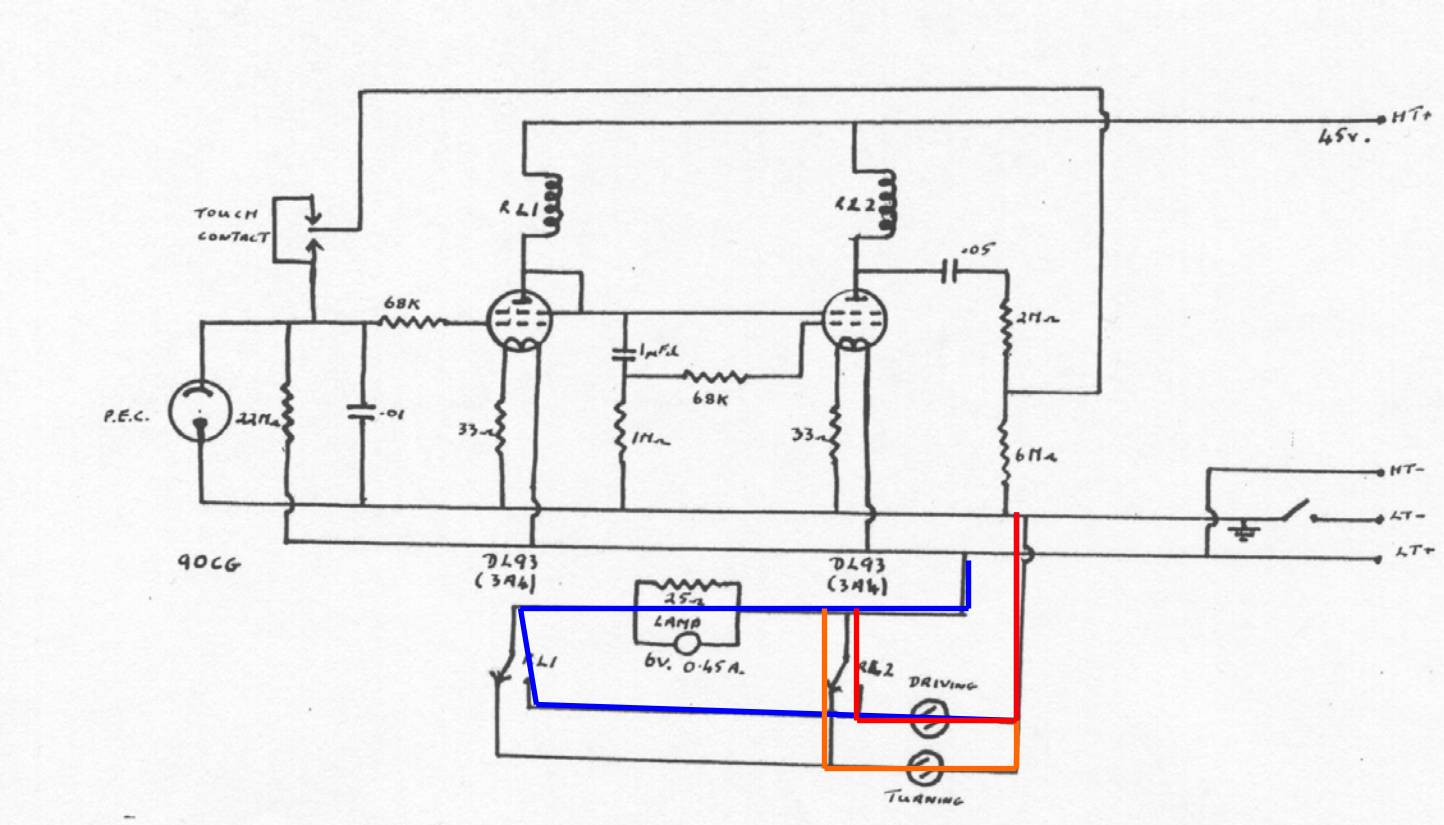
Inspects different light sources



If battery low: won’t reach threshold to turn away from light, so enters hutch to recharge.

Replica tortoise (original hutch)

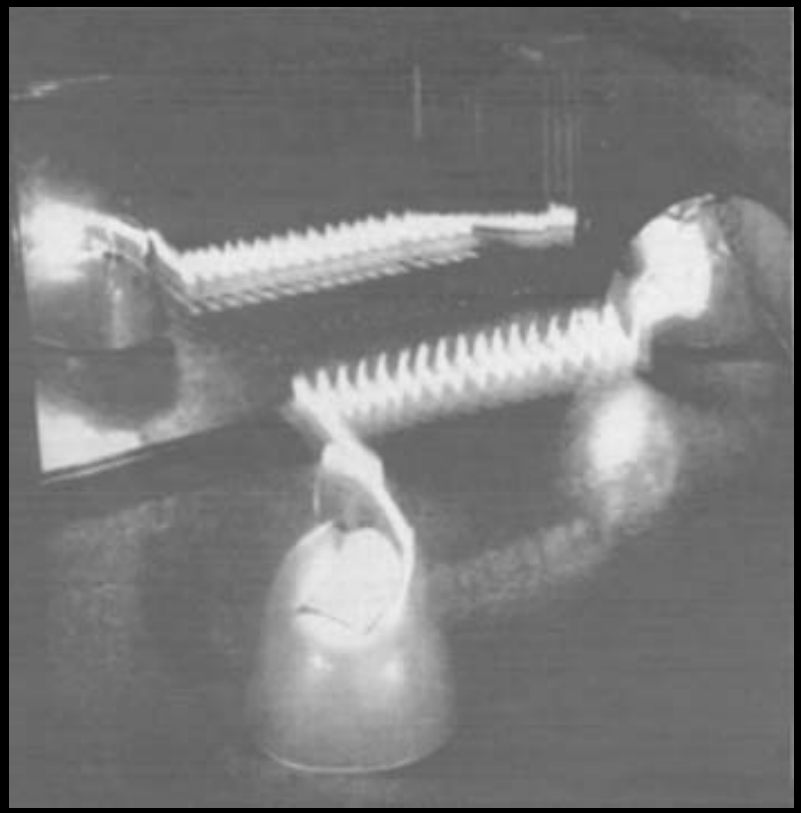
Holland, 1995



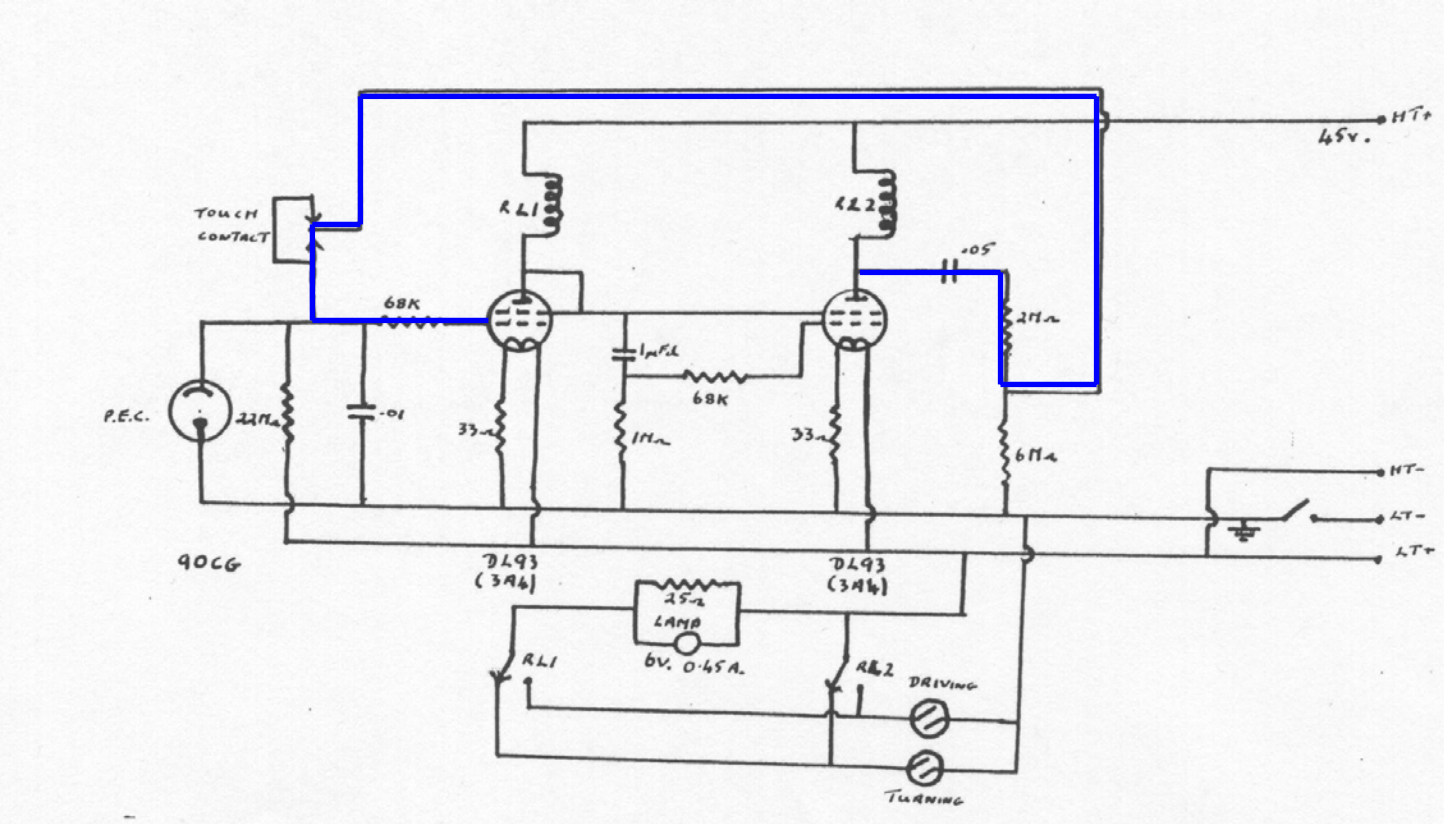
During scanning for light, own lamp is on.

When moving to light, own lamp is off.

‘Recognises’ self in mirror and ‘dances’



Complex interactions of two robots

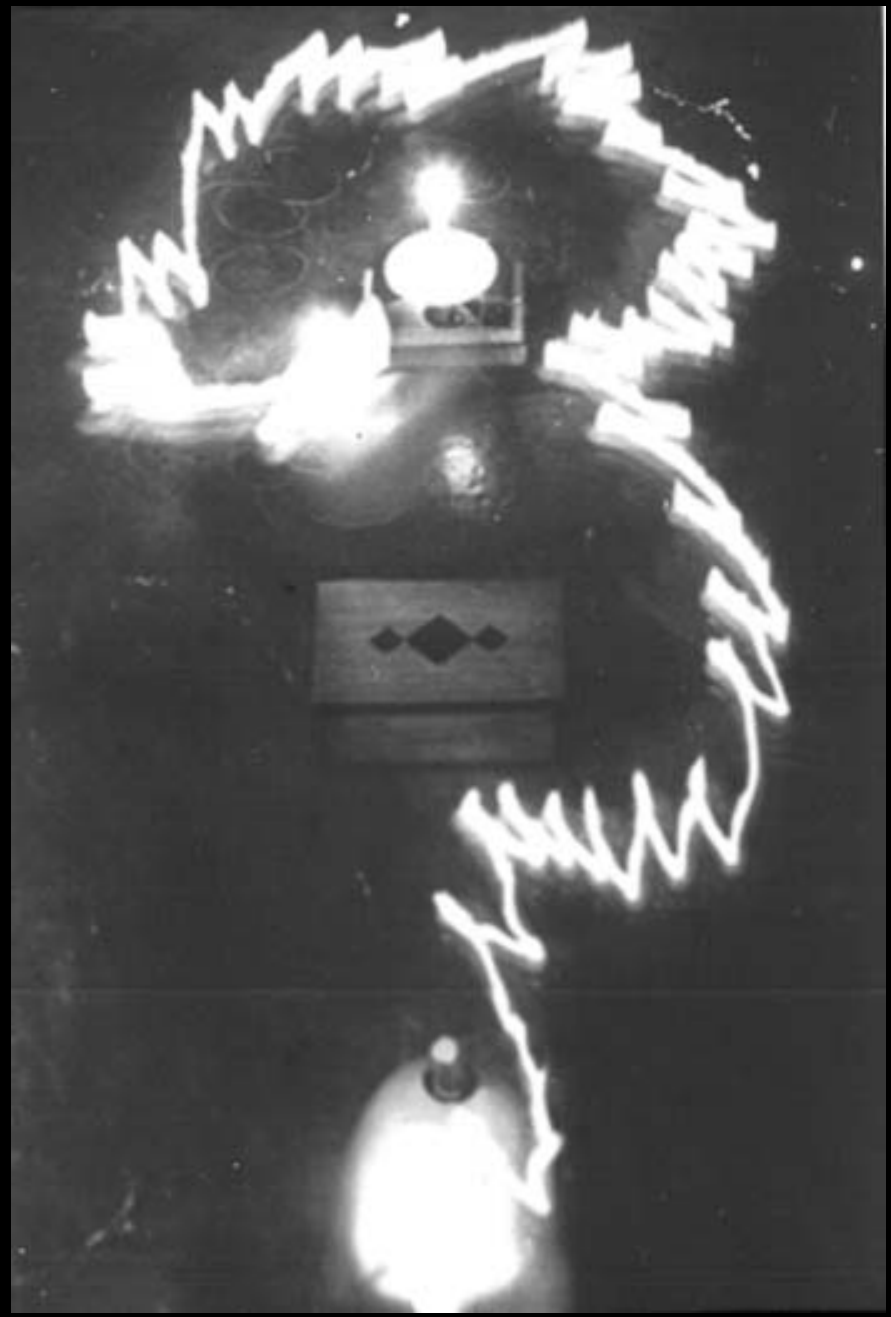


Shell collision: closes touch contact, output of amplifier 2 becomes input to amplifier 1; produces oscillator.

Rapidly alternates driving and turning speeds, overriding effects of light input, till clear of obstacle.

Can get round obstacles to find light.

Also tends to push small obstacles out of the way, gradually clearing the area.

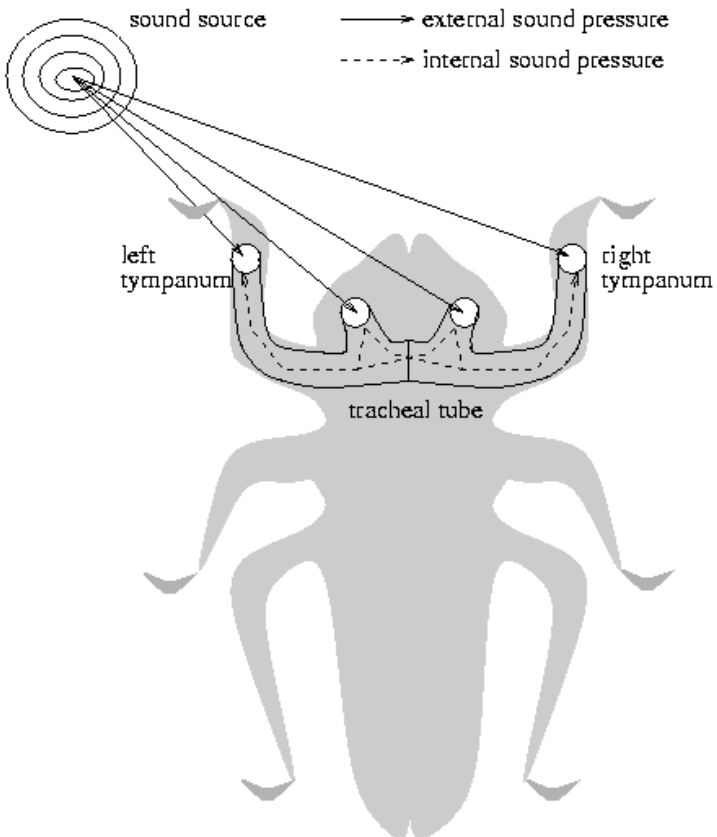


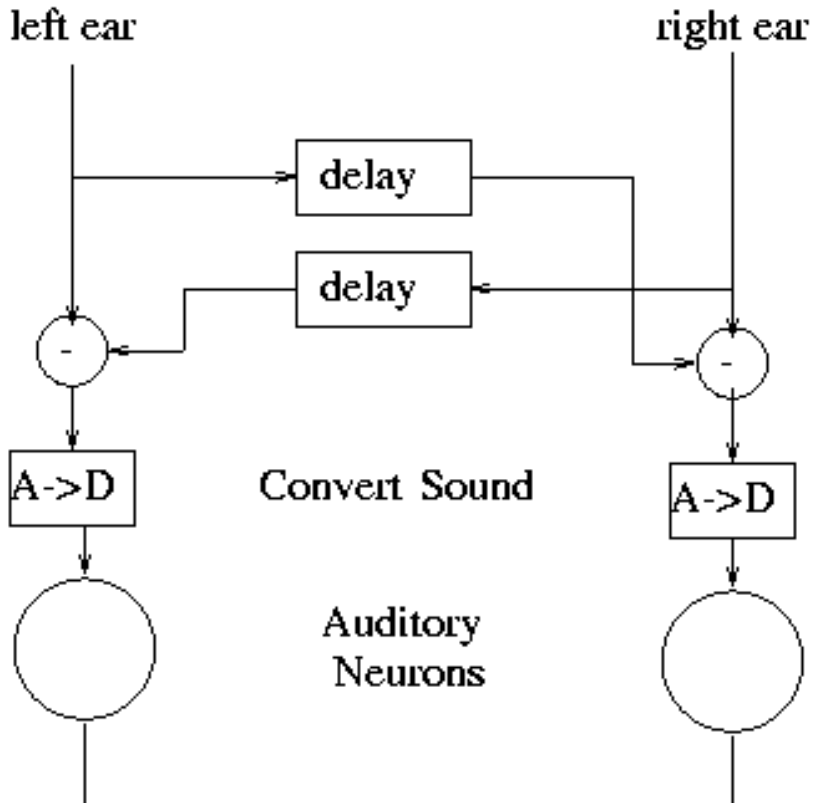
Biological example

- Female crickets recognise male calling song and move towards it

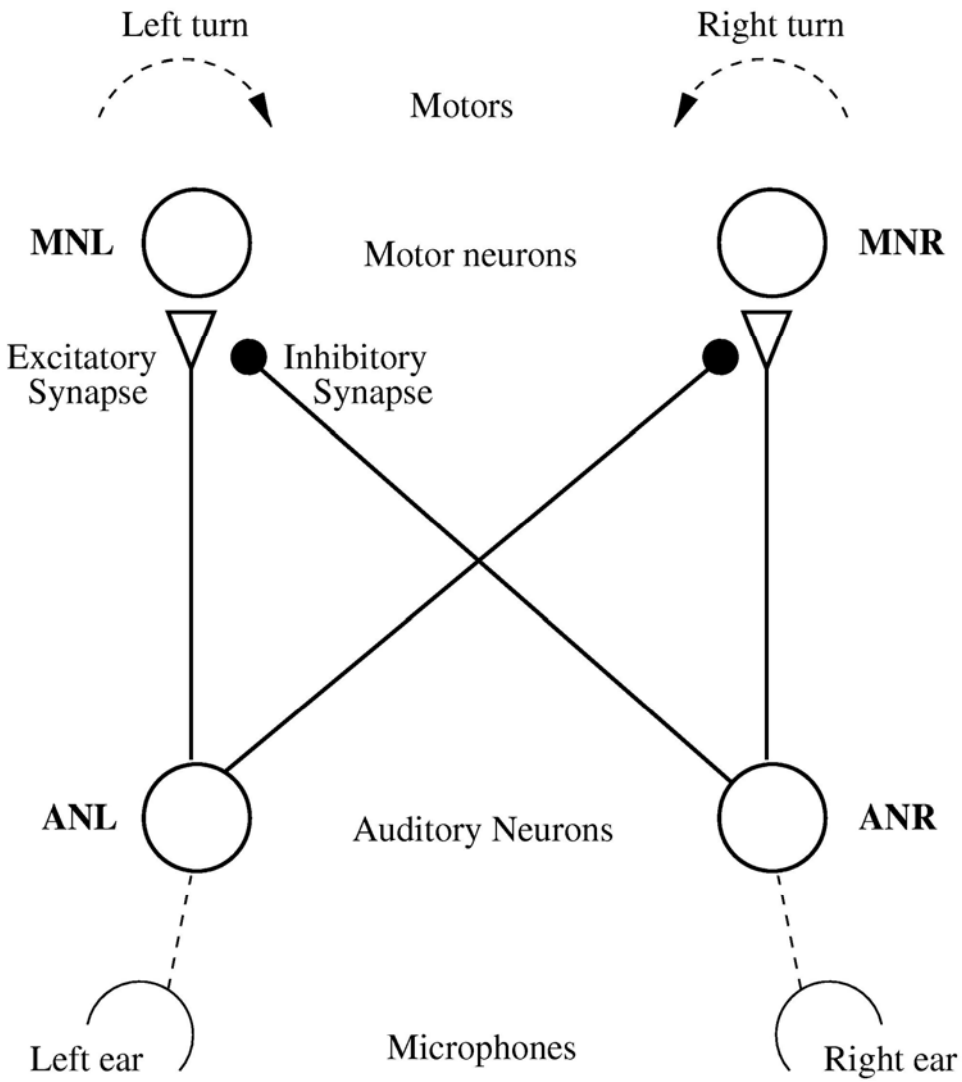
Reactive response to sound tested in treadmill experiments

Pressure difference receiver

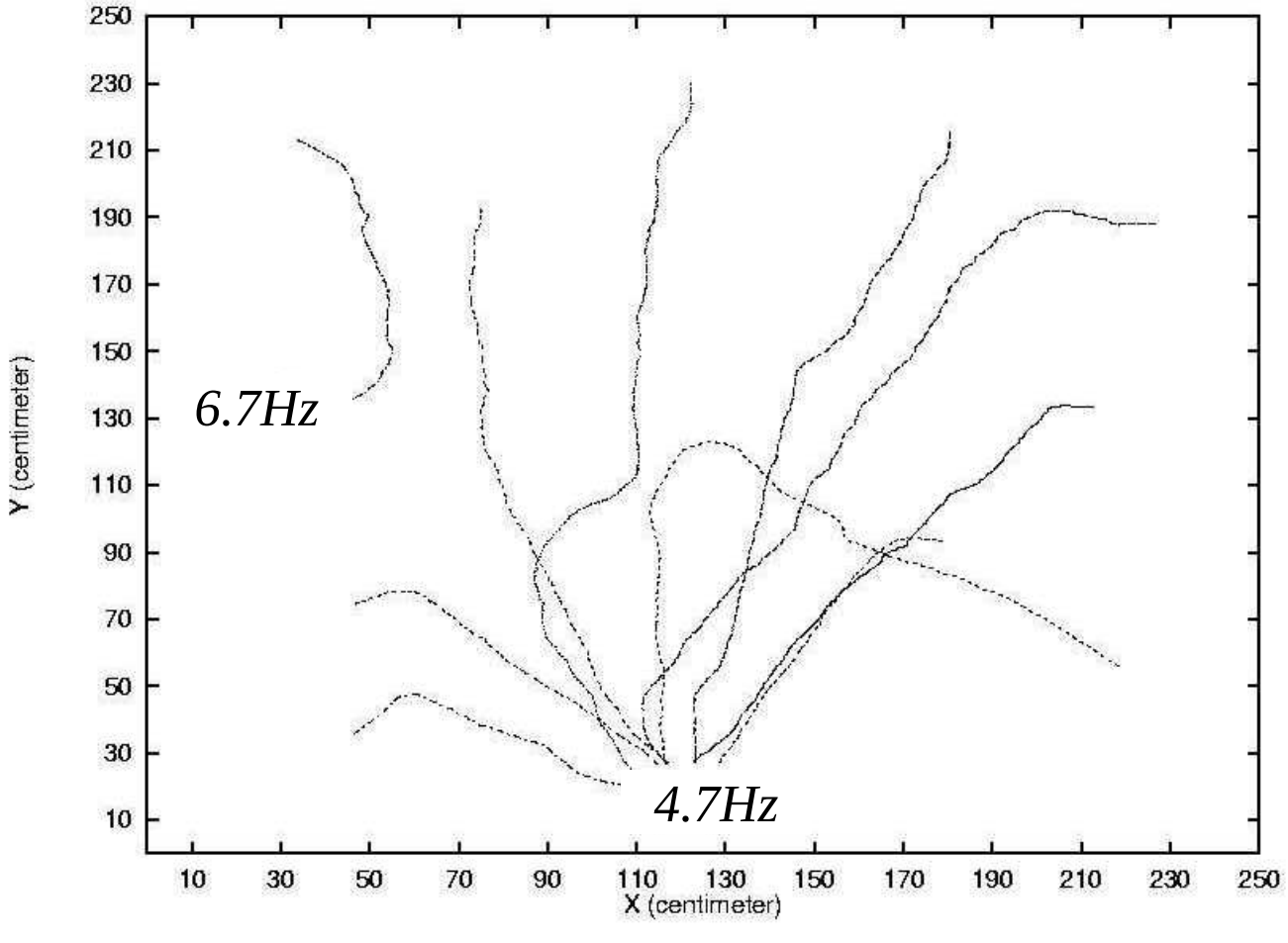




Suggested neural circuit

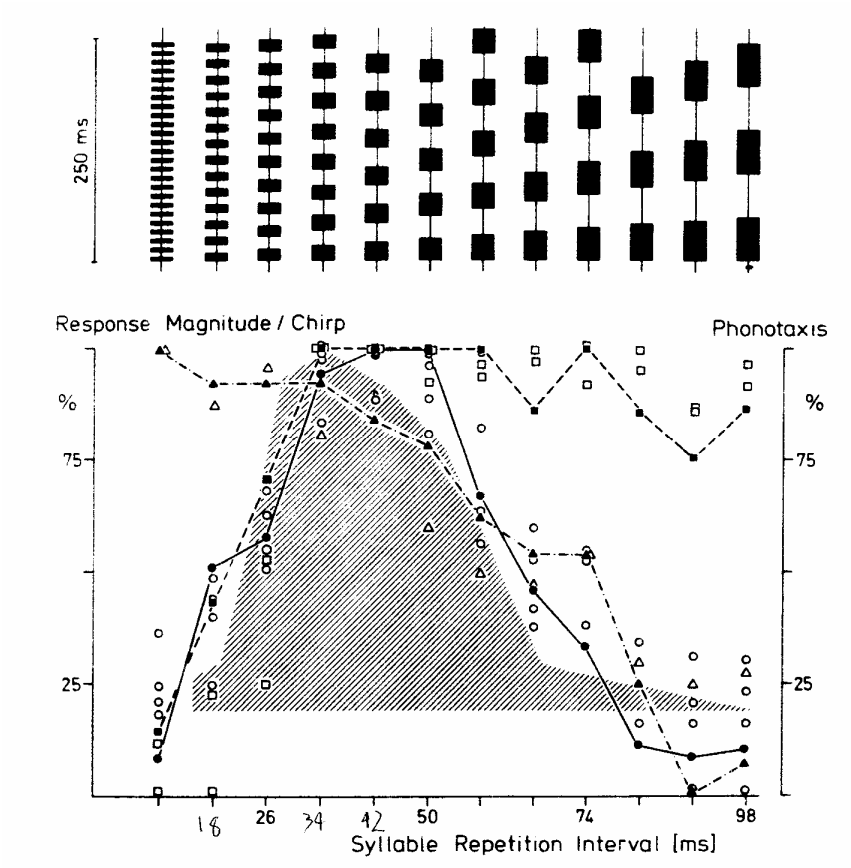


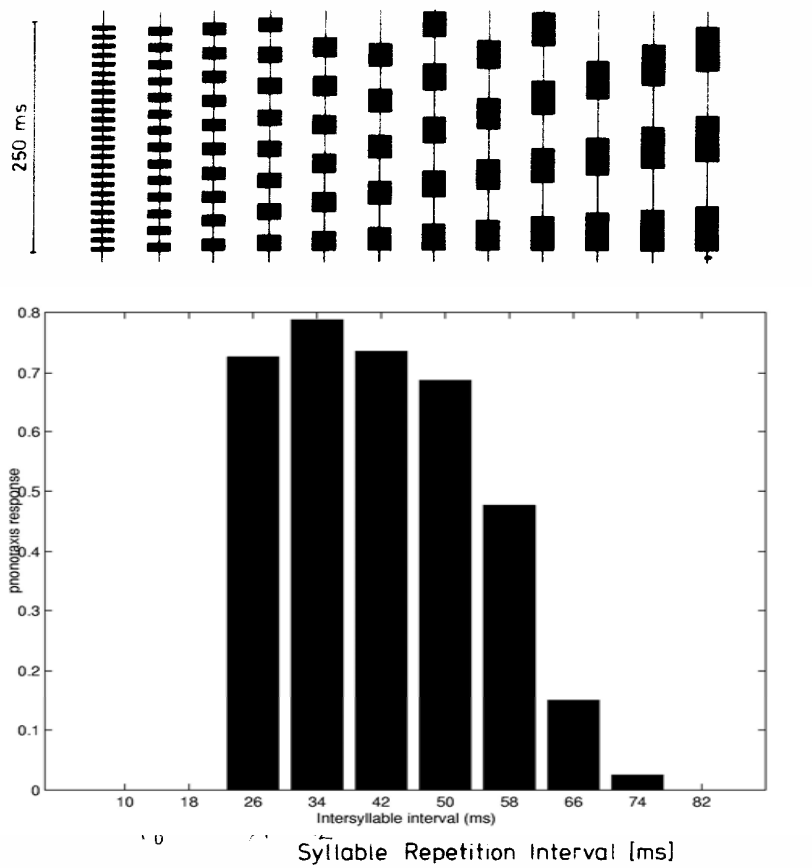
When tested on the robot, can choose between sȯunds. - preferring correct carrier frequency



When tested on the robot, can choose between sounds,

- preferring correct temporal pattern





Should this be called computation?

- Can choose to view any of these examples as ‘encoding’ and ‘processing’ of information (about table edge, light direction, sound location…)
- But if this is ‘computation’, then so is every kind of causal process, or transformation.
- So we haven’t said anything “deep and daring” about minds and brains by identifying them as computers.

A reasonable objection

- The simple behaviours I have described are not the kind of behaviours Craik was talking about.
- Perhaps insects are not real ‘thinkers’. That simple nervous systems are not computing (in any interesting sense) does not necessarily mean that *no* part of *our* nervous system is computing (in some interesting sense).
- But then we need to identify the tasks and nervous system structures that *do* require a computational interpretation…