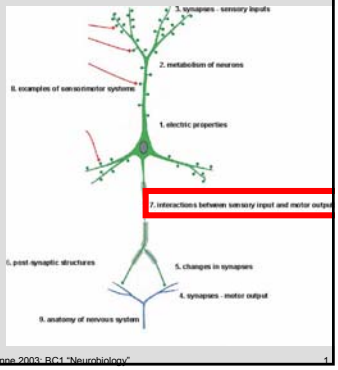
7. interactions between sensory input and motor output

script will be available by FTP from
IP address: 134.2.99.9
user: guenne03



eye movements:
example for sensorimotor integration

frame of references

Elevation, superior

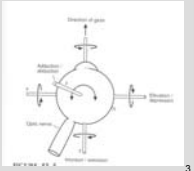
Intorsion

Extorsion

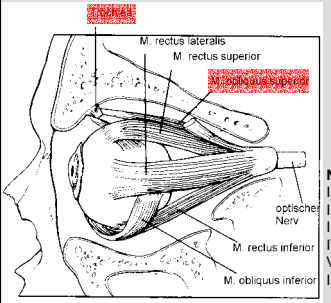
Adduktion, nasal

Abduktion, temporal

Depression, inferior



extraocular muscles



Nerve	Muscle	Action
III	rectus superior	Elevation
III	obliquus inferior	Elevation
III	rectus inferior	Depression
IV	obliquus superior	Depression
VI	rectus lateralis	Abduktion
III	rectus medialis	Adduktion

extraocular muscles have to compensate:

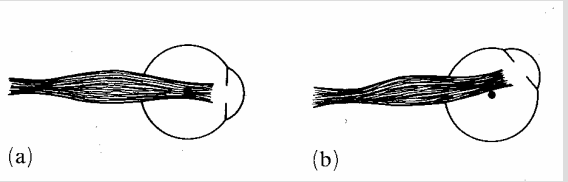
~~gravity (not relevant)~~

friction (constant)

viscosity (dx/dt)

inertia (d^2x/dt^2)

action of muscle depends on eye position

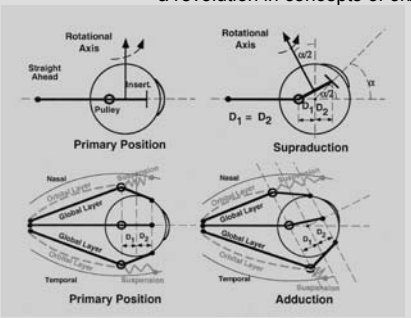


backup extra-ocular muscles

6 muscles, 3 orthogonal rotation axis

no monosynaptic reflex

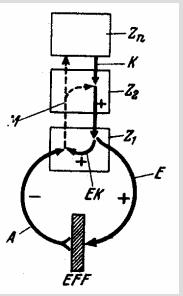
The orbital pulley system:
a revolution in concepts of orbital anatomy



tracking the eye position

methode	advantage	disadvantage
EOG (Elektro-Okulograph)	simple comfortable cheap	not precise, high drifts
IROG (infrarot-Okulograph)	non-invasive cheap	bad vertical signal narrow range
VOG (Video-Okulograph)	precise 3D	slow expensive
Coils (magnetic induction)	precise huge range 3D	invasive

example: visual motion perception



target movement in space

retinal image movement

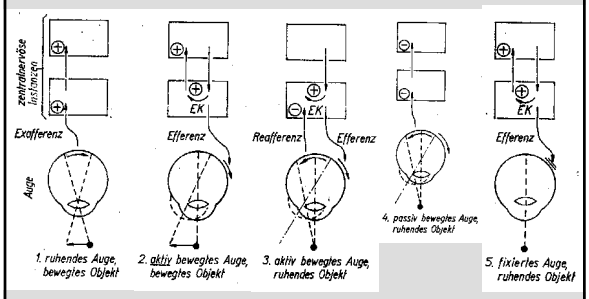
Perception?

centre Z_1 gives efferent (E) information to effector (EFF) and receives afferent information (A)

higher centres Z_2 to Z_n internal command (K) causes efferent impulses (E) and reafferent signals (A -)
simultaneously, efference copy (EK) is transmitted

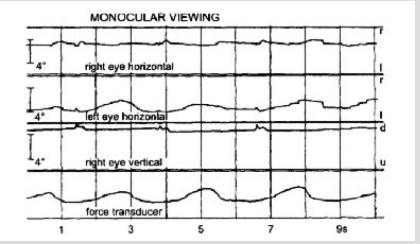
my own scientific interest

Reafferenz-Prinzip



Alles da

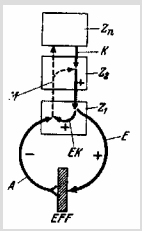
passive movement: different in monocular viewing conditions

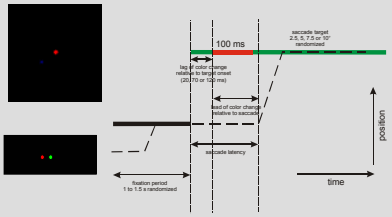


- pressed eye remains stationary (OKR)
- eye muscle compensates for finger force
- Hering's Law: conjugate eye movements
- occluded eye moves nasally

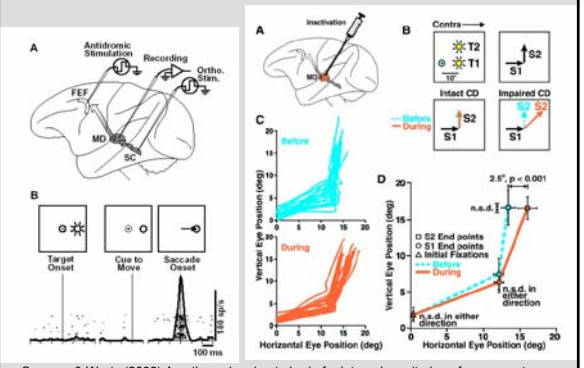
→perception of apparent motion is due to efference copy

Problem: time difference between efference copy and reafferent signal (=sum of motor and sensory delay)





efference copy (or corollary discharge) present in thalamus

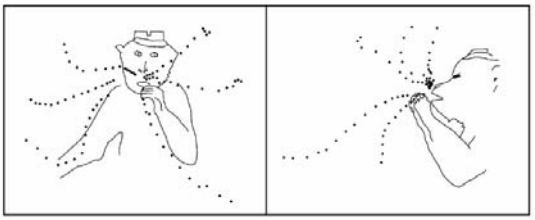


Sommer & Wurtz (2002) A pathway in primate brain for internal monitoring of movements

motor cortex (MI)

brief stimulation trains: twitches in muscles depending of homunculus

long stimulation trains: yields complex movement pattern



MI must know the present position of the hand!

Graziano et al (2002) Complex Movements Evoked by Microstimulation of Precentral Cortex

Summary:

ideal system for sensorimotor integration: eye movements

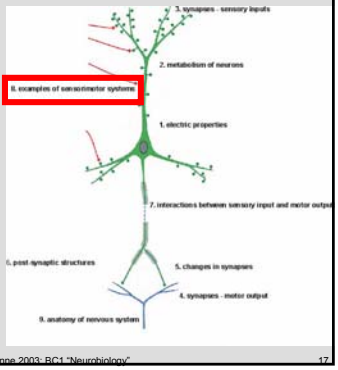
six extraocular muscles

reafference principle: sensory signals are combined with an internal copy of the motor command

Thalamus might transmit efference copy from SC to FEF

MI receives input related to the actual posture

8. examples of sensorimotor systems

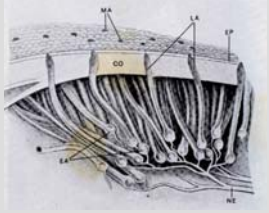


1. visual system of primates

2. whisker system in seals
   see Guido Dehnhardt, Ruhr-Uni Bochum, Zoo at Köln
   explain seal vs submarine

3. electric sense

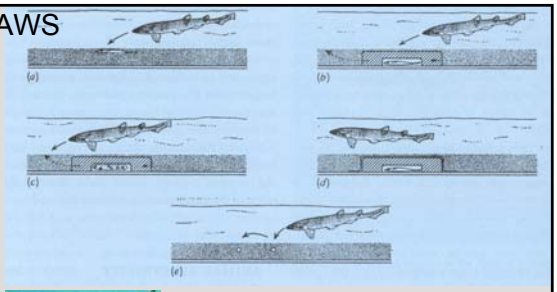
Lorenz' ampullae in sharks (rostrum)



CO corium
EA end of ampulla
EP epidermis
LA lorenz' amplulla
MA opening of amplulla
NE nerve

black dots: openings of LA
open circles: sensors of lateral line organ
black line: lateral line organ

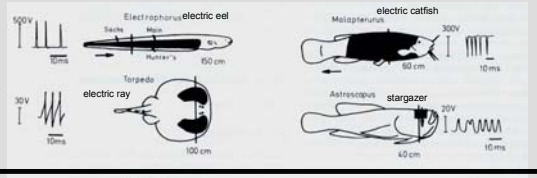
JAWS

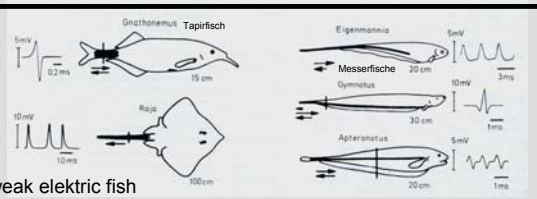


a) hungry shark and flounder (positive)
b) flounder below agar roof (positive)
c) pieces of fish below agar roof
(attack is directed towards the end of roof)
d) flounder below agar roof and isolator (negative)
e) artifical elektic field (positive)

positive = shark reacts

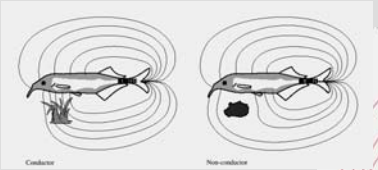
strong elektric fish



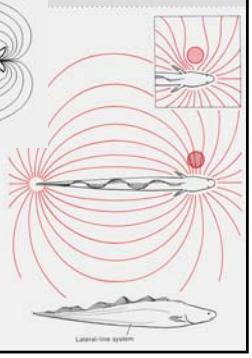


weak elektric fish

Elektric field around fish



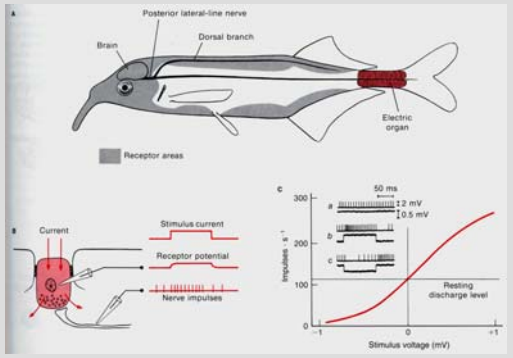
Gymnarchus



Gnathonemus petersii
Tapirfisch

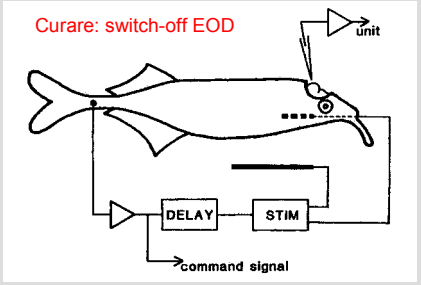
rigid swimming
undulating fins

size of object,
distance

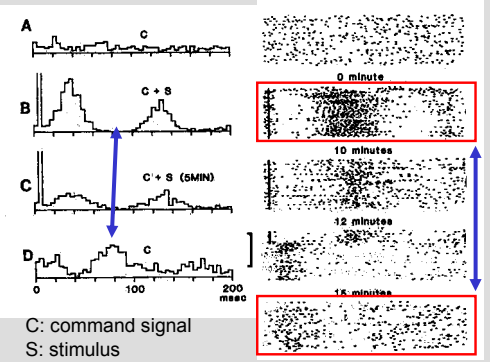


Experiment:

PLLL: posterior lateral line lobe



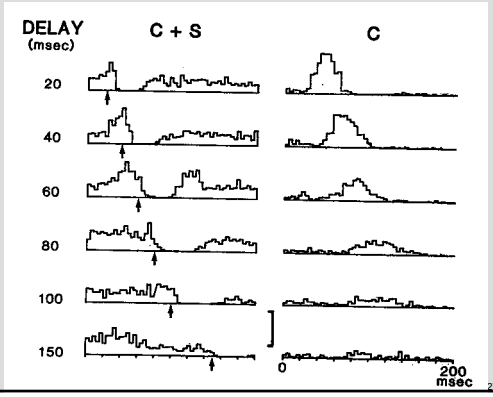
peri-stimulus time histograms PSTH Raster display



C: command signal
S: stimulus

interpretation: adaptive efference copy

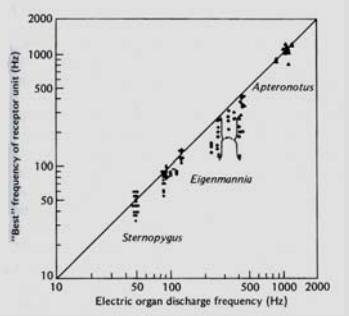
specific for delay



more examples for

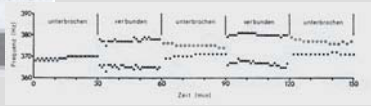
S E N S O R I M O T O R I N T E G R A T I O N

best frequencies
of
EOD electric organ discharge
and
receptors



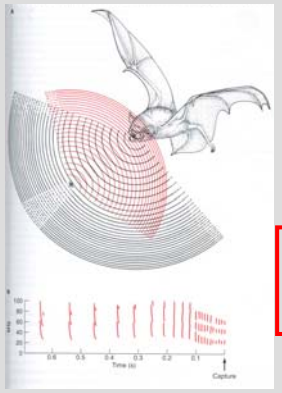
2. Jamming Avoidance Response JAR

cable connecting two basins
with 2 Eigenmannias



Eigenmannia vs sinus-generator

echo-localization in bats

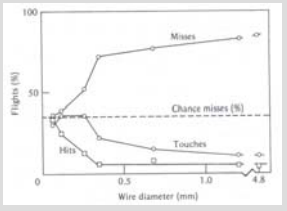


Myotis lucifugus
FM bat

performance of bat:

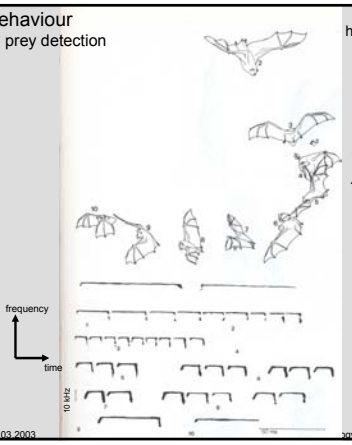
a) detection of (reflected) echo
b) determine the distance
c) determine the direction
d) determine properties of object

behaviour
1. detection of obstacles



Myotis lucifugus
vertical wires 30 cm spacing

behaviour
2. prey detection

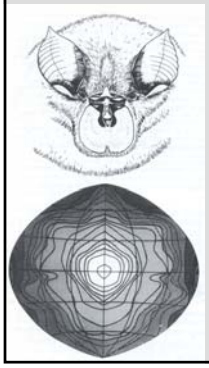


hunting Rhinolophus

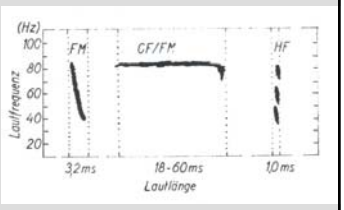
1: CF 82 kHz, FM sweep at on- and offset

4: butterfly caught,
no vocalisation

horseshoe bat:
tuning of vocalization



different localisation calls

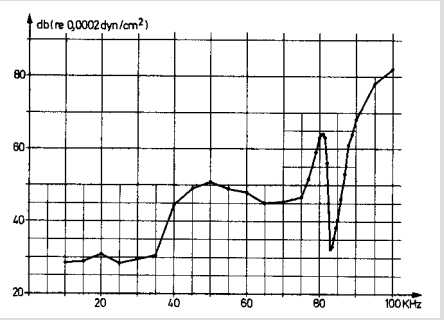


FM
Myotis myotis

harmonic frequencies
Megaderma

CF/FM
Rhinolophus

auditory fovea in CF bats
audiogram (IC recordings)



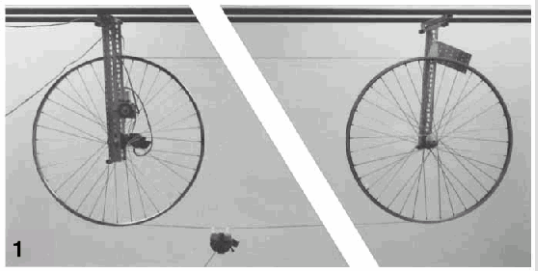
dopplershift
1. physics

doppler-shift
moving sound sources

$f = f_0 / (1 + v/c)$

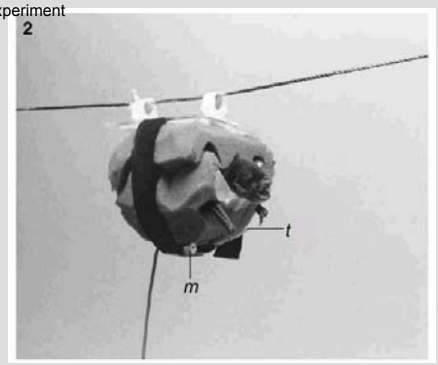
c: 330 m/s in air

Dopplershift
2. Experiment



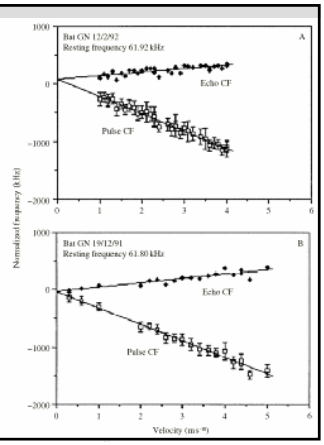
Dopplershift
3. Experiment

Bat holder

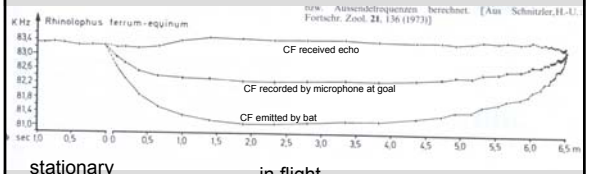


Dopplershift
4. data

yes, bats do
doppler shift compensation



Dopplershift
5. more data



stationary

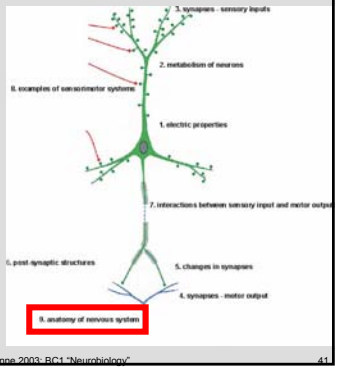
in flight

distance

Summary:

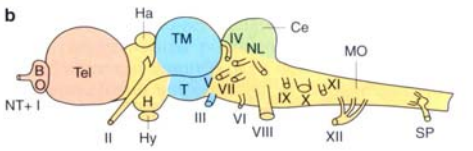
more examples for sensorimotor integration:
- whisker system in seals
- electric fish (adjustable efference copy)
- bats, compensation for doppler shift

9. anatomy of nerveous system



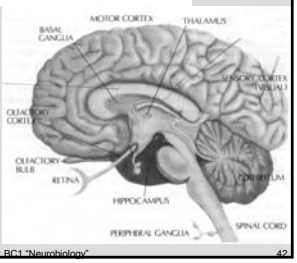
standard brain

telencephalon diencephalon mesencephalon metencephalon myelencephalon



cranial nerves:
I. N. olfactorius
II. N. opticus
III. N. oculomotorius
IV. N. tochlearis
V. N. trigeminus
VI. N. adducens
VII. N. fascialis
VIII. N. statoacusticus
IX. N. glossopharyngeus
X. N. vagus
XI. N. accessorius
XII. N. hypoglossus

other nerves
N. terminalis
laterale nerves
spinal nerves



Summary:

standard vertebrate brain: five sections,
12 cranial nerves

what is the take home message of all four lectures:

neurobiology is sometimes simply,
unfortunately often complicated,
but definitively thrilling!

For further discussion do not hesitate to contact:
uwe.ilg@uni.tuebingen.de

script will be available by FTP from
IP address: 134.2.99.9
user: guenne03