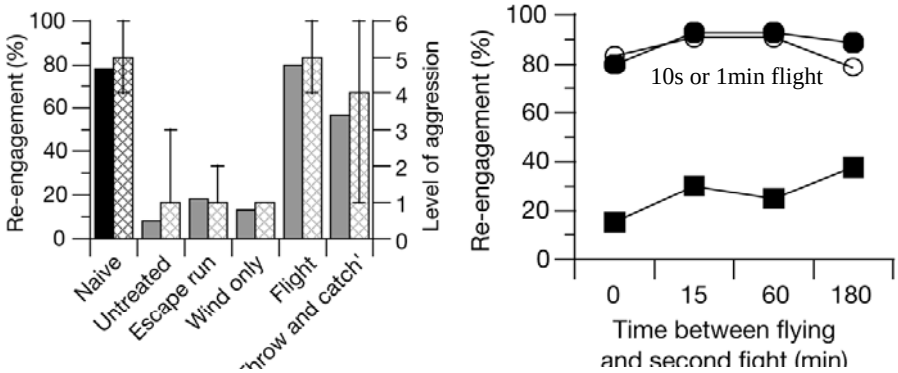
Lecture 12: Modulation of behavior

1. Immediate retreat
2. Fencing with antennae
3. Spread mandibles
4. Interlocking mandibles
5. wrestle

Gamblers inspecting fighting crickets

Flight restores fight in crickets

Hans A. Hofmann, Paul A. Stevenson Nature 403:613 (2000)



Requires intact connectives - therefore nervous command to reset aggressiveness rather than humoral … what about local release of octopamine? How do you score aggression of animals with cut connectives?

Types of modulation

- Modulation to “choose” particular variants of one behavior e.g. motor flexibility
- Orchestration of circuitry and periphery for different behaviors e.g. coordinating brain and body
- Modulation to bias the choice of different behaviors e.g. status, mood

Reconfiguration of circuits

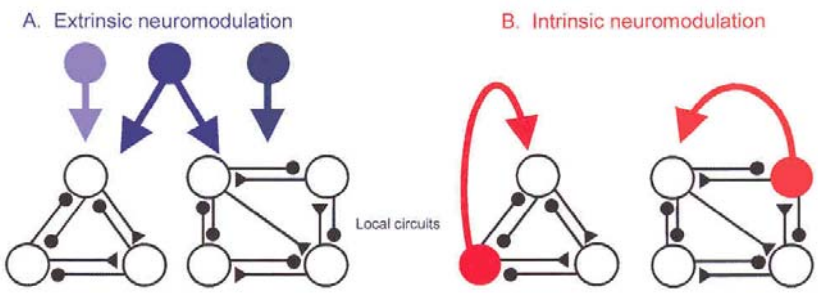
Short-term modulation - neurally mediated

- Sensory reconfiguration
- State-dependence of reflexes
- Presynaptic inhibition

Long-term modulation - humorally mediated

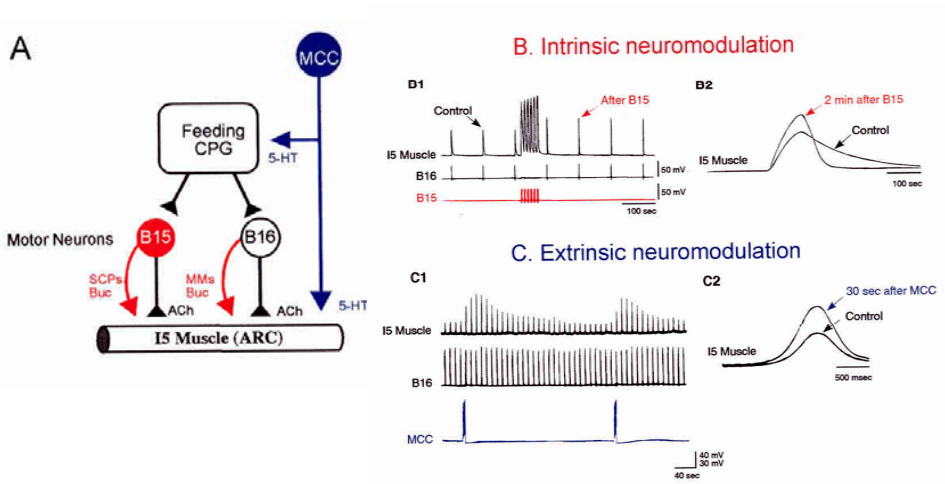
- Intrinsic neuromodulation
  local, dynamic, self-regulating
- Extrinsic neuromodulation
  global, state-dependent, motor pattern choice

Neuromodulation



Katz, P.S. and Frost, W.N. Intrinsic neuromodulation: altering neuronal circuits from within. TINS 19:54 (1996)

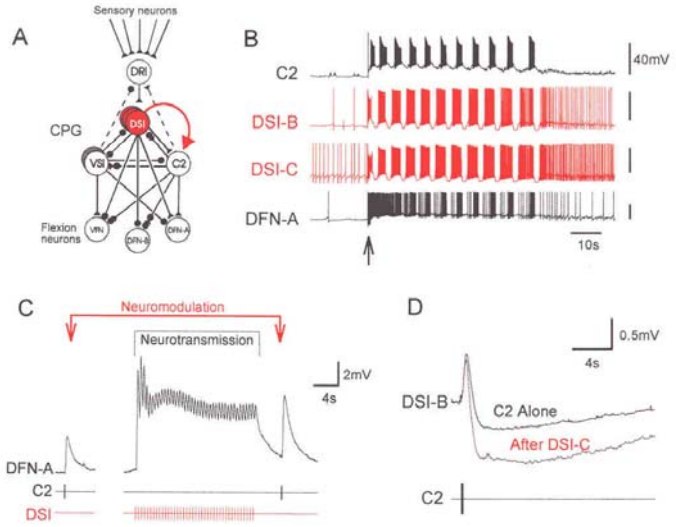
Intrinsic and Extrinsic Neuromodulation



Aplysia feeding

Katz & Frost (1996) Trends. Neurosci. 19: 54-61

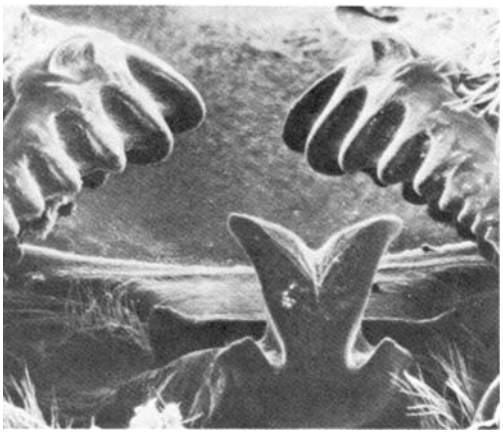
Intrinsic and Extrinsic Neuromodulation

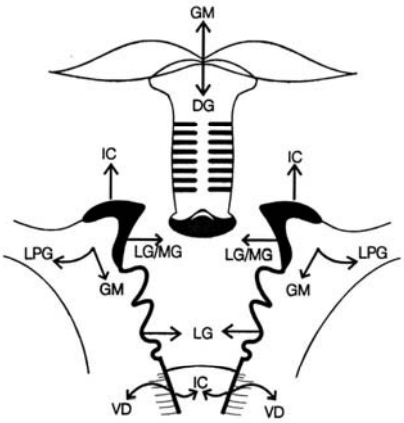


Tritonia escape swimming

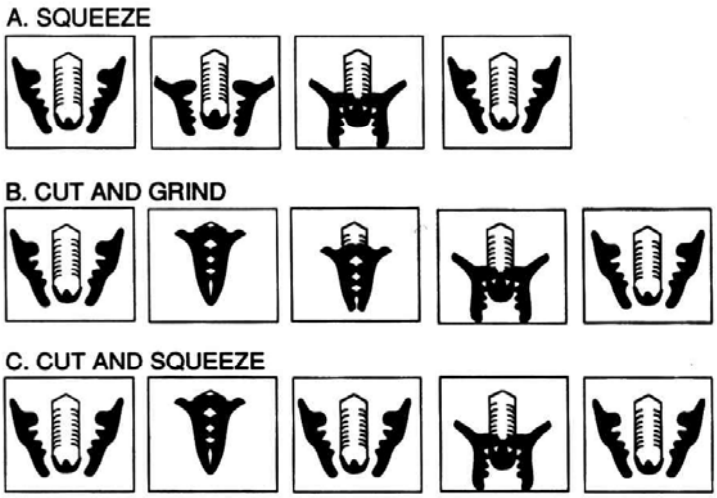
Katz & Frost (1996) Trends. Neurosci. 19: 54-61

The Gastric Mill

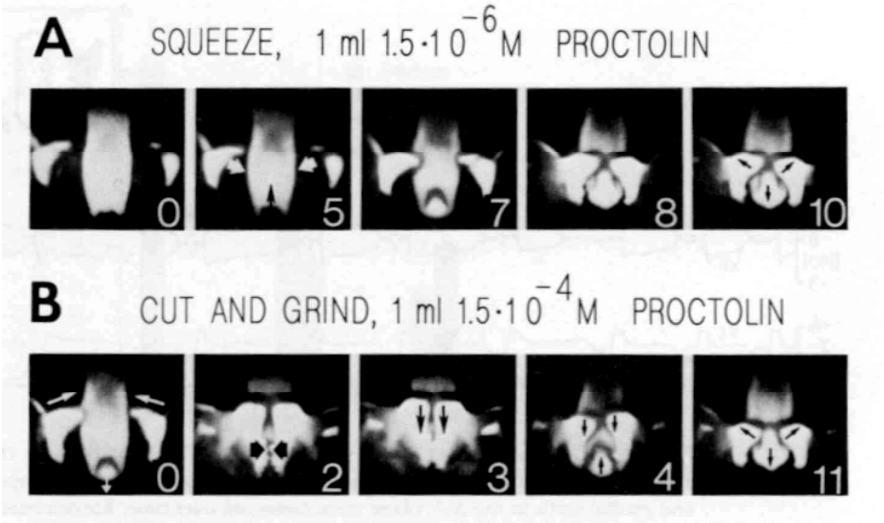




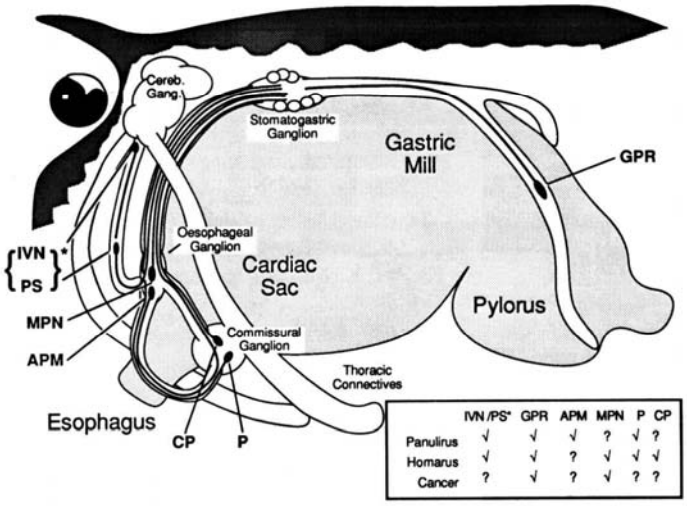
Chewing Modes



Induction of different chewing modes



Identified modulatory neurons

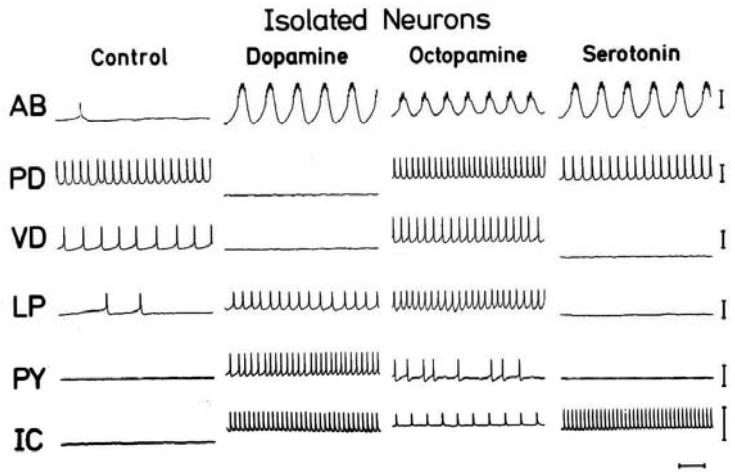


	IVN/PS*	GPR	APM	MPN	P	CP
Panulirus	√	√	√	?	√	?
Homarus	√	√	?	√	√	√
Cancer	?	√	?	√	?	?

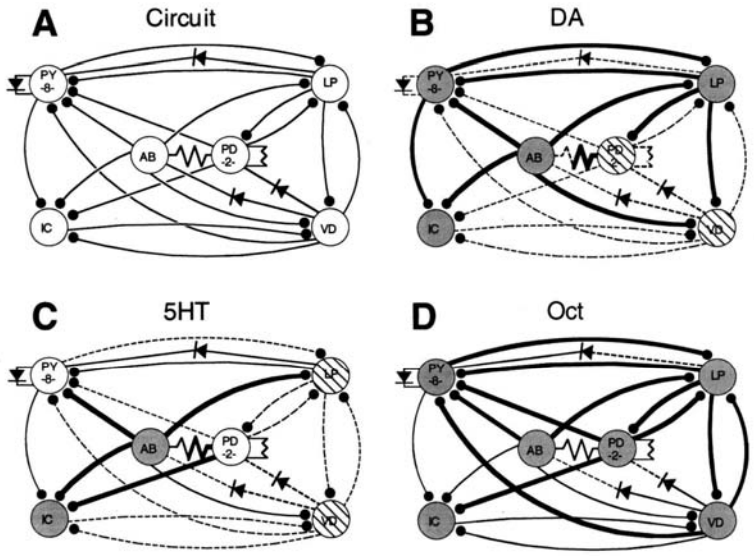
Modulatory inputs of identified neurons

APM - acetyl choline like
CG - FMRFamide like
GPR - serotonin, ACh, FMRFamide, CCK
IVN - histamine
MPN - proctolin
PS - FMRFamide like
CoG - proctolin

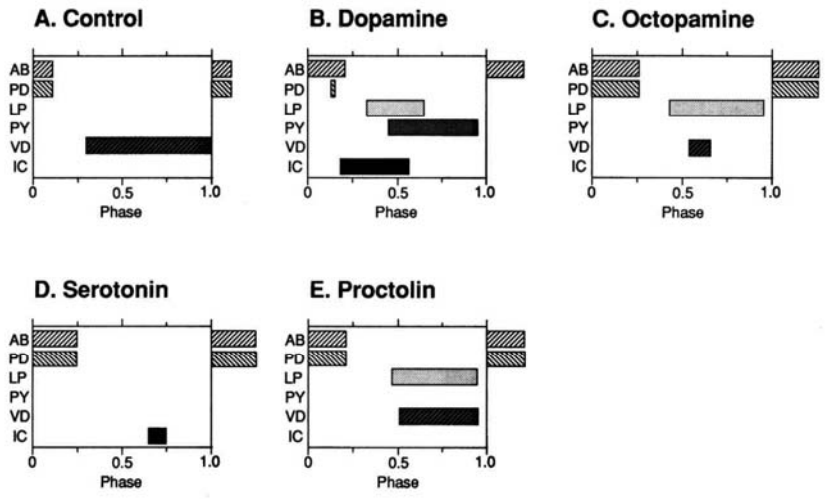
Changing cellular properties



Biasing synaptic strengths



Modifying motor patterns



Stomatogastric summary

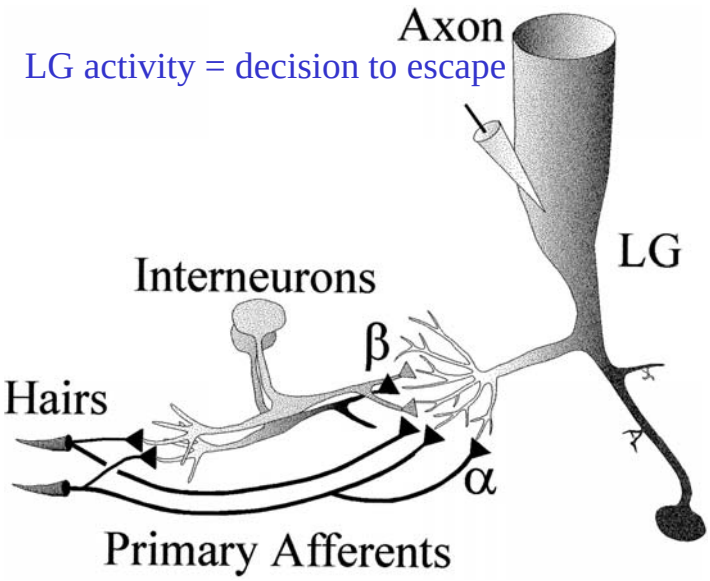
1. Complex modulatory input
2. Very flexible motor output
3. Different neuromodulators evoke distinct motor patterns
4. Neural networks can be reassembled
5. Mechanisms = change in firing and synaptic properties
6. One neuromodulator acts by a variety of mechanisms
7. State-dependent variation of responses
8. Evolutionary flexibility
9. Prolonged effects rather than cycle by cycle

Social status and the crayfish tailflip

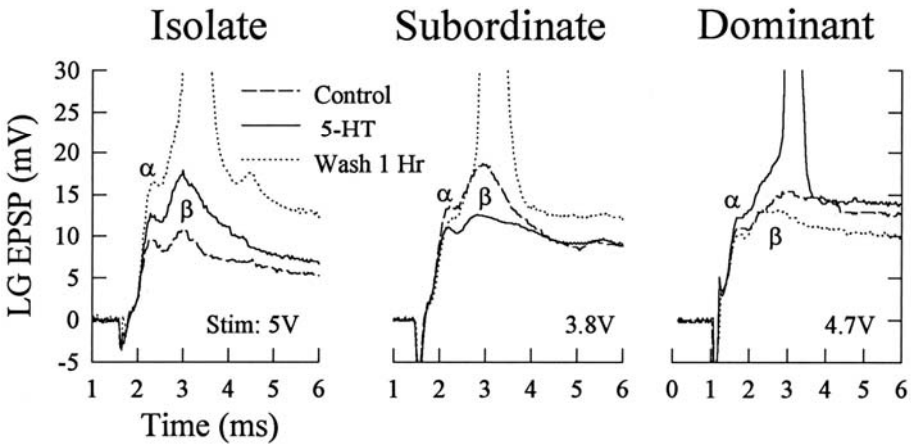
Neuronal adaptations to changes in the social dominance status of crayfish. S.-R. Yeh, B.E. Musolf and D.H. Edwards J. Neurosci. 17:697 (1997)
See also: Science 271:266 (1996)

Connections to LG

LG activity = decision to escape

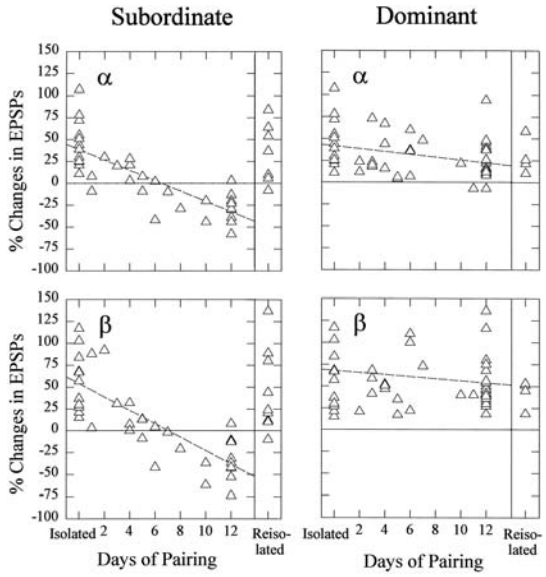


Status affects the effect of 5HT on sensory input



Mechanism = changes in population of 5HT receptors

Time dependence of modulation



History of status makes a difference also

Adaptive significance ?

Increased threshold in subordinates to prevent a flip upside-down and forward towards the aggressor
Decreased threshold in dominants to escape sudden attack of a third party
Slow onset so that modulation is only in response to persistent changes in status

General Conclusions

• Circuit modules that control behaviour are eminently flexible under the influence of neuromodulators either alone or presented as a cocktail.
• The modifications are adaptive and bias behavioural responses depending on external conditions (e.g. social status) or internal state (drives and moods).
• The final result is blended from complex and mutual interactions between circuits, effectors and the effected (e.g. effectiveness of a particular motor output is contingent upon environmental parameters)