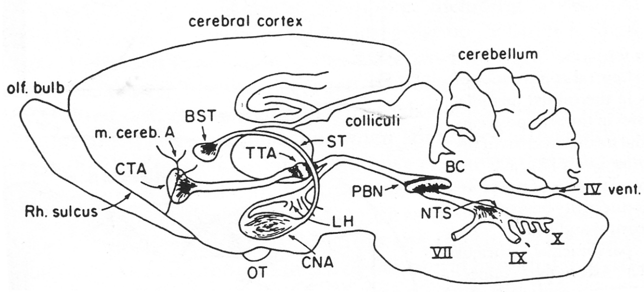
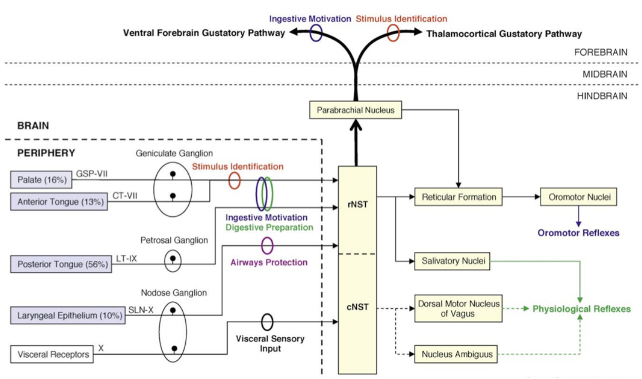
Central Taste Circuit 1



NTS: nucleus of the solitary tract
PBN: parabrachial nucleus
TTA: thalamic taste area
CTA: cortical taste area (insular/gustatory cortex)

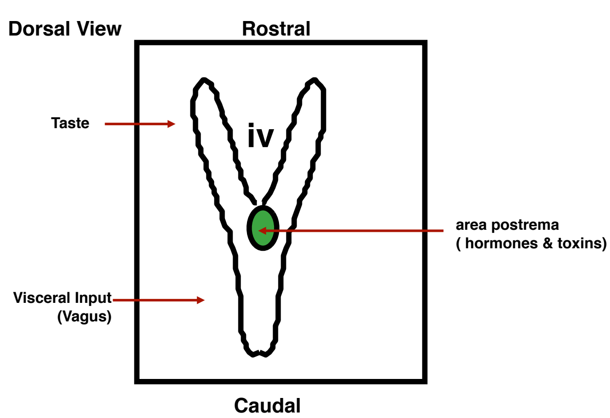
2



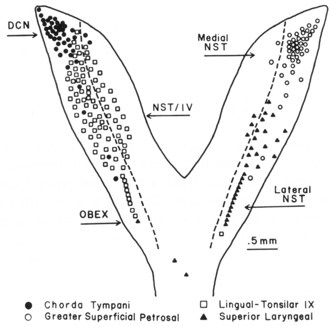
Spector and Glendinning, Current Opinion in Neurobiology 2009, 19:370-377

ID by who?

First central synapse: 3
Rostral Nucleus of the Solitary Tract (NTS)



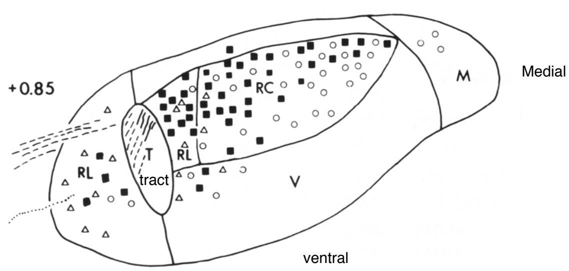
Rough Rostral To Caudal Topography of Taste Afferents into NTS



No discrete topography of taste quality in the NTS (nor in rest of central taste circuit)

4

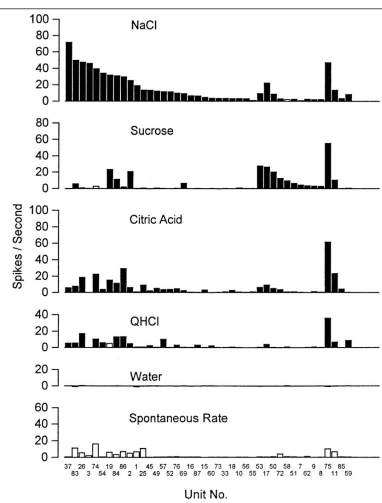
Trigeminal Projections overlap with Gustatory Projections



coronal section through NTS
responses to brush touch, cold, hot stimuli

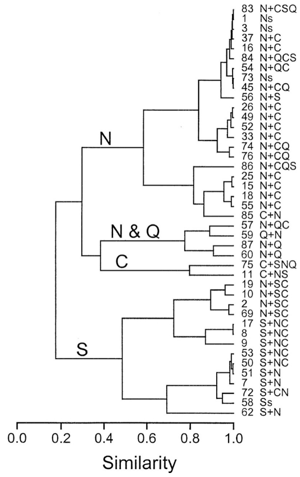
5

Can classify NTS neurons like gustatory fibers



6

Cluster Analysis to Group Similar NTS cells

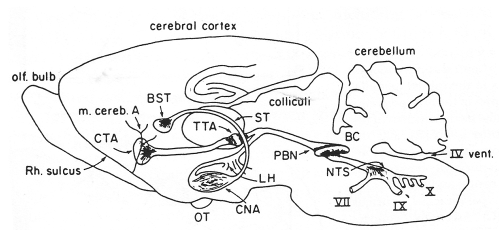


7

2nd Central Relays: Parabrachial Nucleus and Thalamus

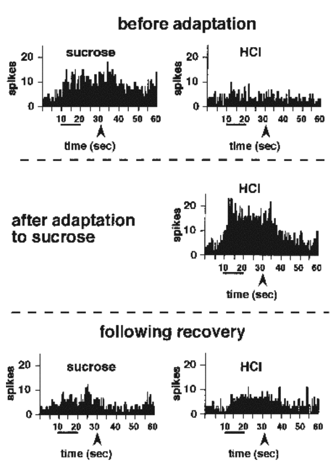
Medial Parabrachial Nucleus:
located in midbrain. Major relay to cortex for taste in rats.

Thalamus:
located in forebrain. Major relay to cortex for taste in primates. (also receives PBN input and some NTS input in rats)



8

Higher Level processing in the PBN



9

Brainstem as "spinal cord" for taste input

Brainstem mediates "reflex" like behavioral and physiological responses to tastants:

sweet, lo salt -> ingestive responses
licking, swallowing

bitter, sour, hi salt -> aversive responses
spitting, vomiting or gaping

sweet -> insulin release from pancreas
cephalic insulin response

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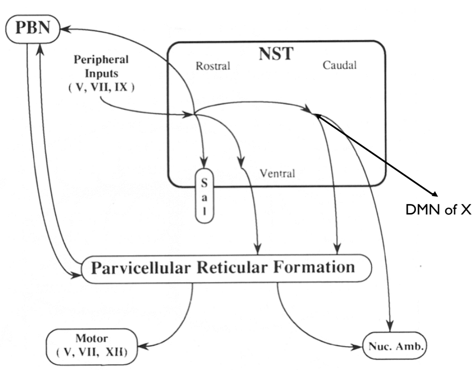
NTS sits on top of oral and visceral motor nuclei



11

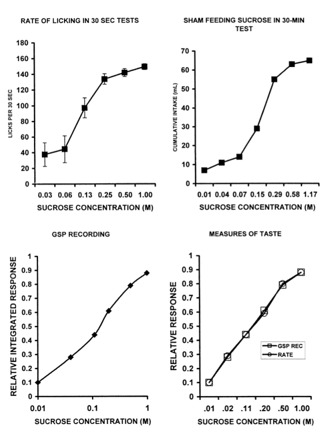
Lick Rate as measure of responses to taste stimuli

Fig. 8. The upper left panel illustrates the rate of licking in 30-s tests as a function of different sucrose concentrations.

In the upper right panel, the cumulative intake of sucrose is given for sham fed rats drinking different concentrations of sucrose.

In the lower left panel the magnitude of the integrated response to sucrose stimulation is reported when recording the electrophysiological response from the greater superficial petrosal nerve.

In the lower right panel, a comparison is made between the electrophysiological response from the greater superficial petrosal nerve (GSP REC) and the rate of licking on the sucrose tube in the 23-h preference test.



J.C. Smith / Neuroscience and Biobehavioral Reviews 24 (2000) 199–212

12

Taste Reactivity

measure orofacial responses to taste stimuli infused directly into mouth.

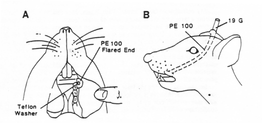
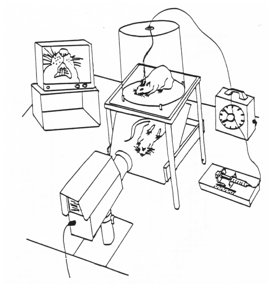


FIGURE 3. Diagram of the intraoral catheter. The intraoral end is placed just rostral to the first maxillary molar. The tubing is led out subcutaneously to the skull and secured to a short piece of 19-gauge (19 G) stainless steel tubing with dental acrylic. (A) Ventral view. (B) Lateral view.



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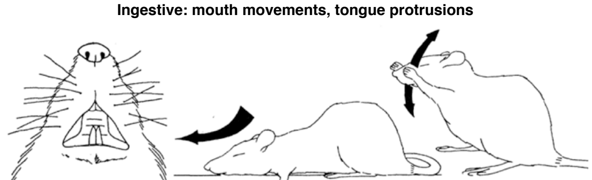
Taste Reactivity as “reflex” response

Stereotyped orofacial movements of the rat when mouth infused with tastants - scored with slow motion videotapes

Ingestive: mouth movements, tongue protrusions



Aversive:gapes,chin rubs, paw shakes

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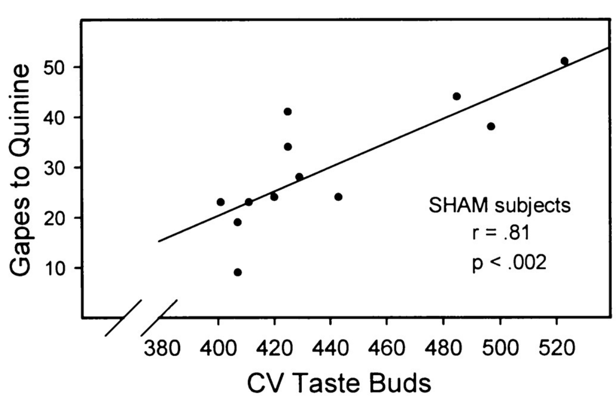
Behavioral Response to Bitter correlated with glossopharyngeal innervation in rats.

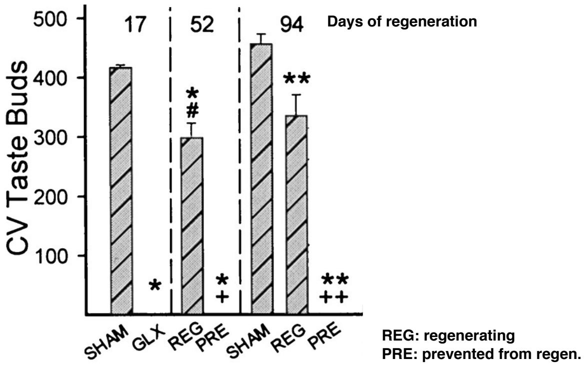


15

16

Dedicated neural input to motor reflex

Glossopharyngeal nerve cut eliminates circumvaliate taste buds, but they regenerate after 52 days (unless prevented)



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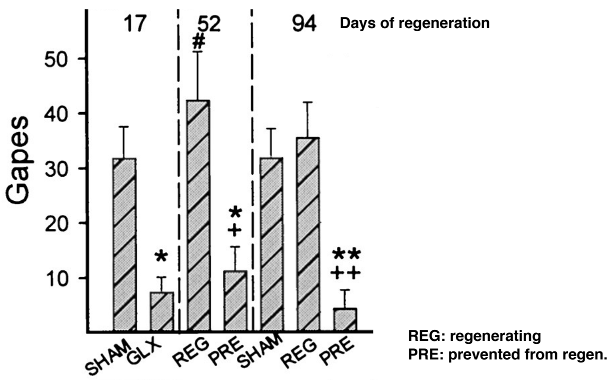
Dedicated neural input to motor reflex

Glossopharyngeal nerve cut reduces gaping unless regeneration occurs



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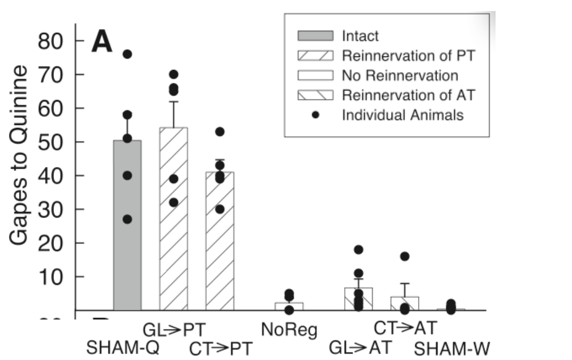
Cross-Regeneration: posterior tongue drives gapes, anterior tongue does not, regardless of cranial nerve

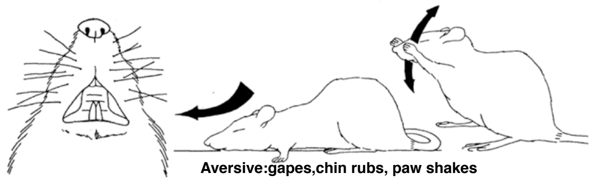


294:738-747, 2008.*Am J Physiol Regulatory Integrative Comp Physiol*
Camille T. King, Mircea Garcea, Danielle S. Stolzenberg and Alan C. Spector

Taste Reactivity as "reflex" response

Stereotyped orofacial movements of the rat when mouth infused with tastants - scored with slow motion videotapes

Ingestive: mouth movements, tongue protrusions



Aversive:gapes,chin rubs, paw shakes

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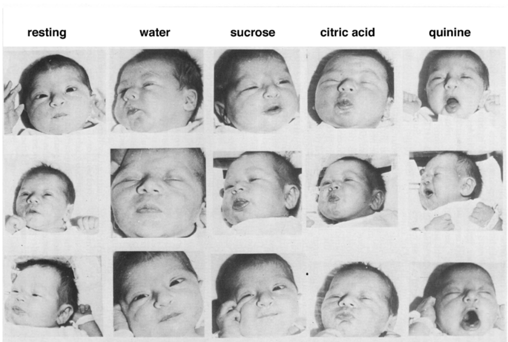
Behavioral Responses to Taste are innate:



20

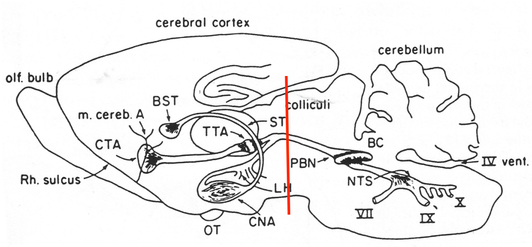
sucrose citric acid quinine

Newborns receiving tastants within minutes of birth:
sucrose elicits mouth smacking, swallowing, smiles
quinine elicits spitting, grimaces, crying

21

22

Hindbrain alone can generate behavioral responses

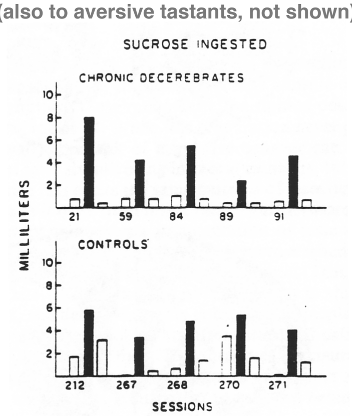


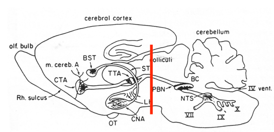
decerebrate rat with only hindbrain intact

23

Decerebrate Rats respond normally to Palatable Tastants

(also to aversive tastants, not shown)





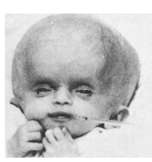
Fed

Food Deprived

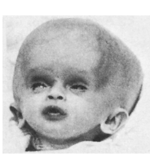
24

Human Hindbrain alone can generate behavioral responses

control



sucrose



citric acid

quinine

hydroanencephalic babies with essentially no forebrain but intact hindbrain have same responses

Cortical Taste Regions

25

Gustatory (insular) cortex
More segregation into taste specific regions

Orbitofrontal cortex
Multimodal integration
start to find “flavor-specific” cells
state-dependency
(i.e. motivational associations modulate firing)

Intimate Relation of Taste and Visceral Information

26

Taste	Visceral
gustatory nerves	vagus, area postrema
rostral NTS	caudal NTS
medial PBN	lateral PBN
ventral Insular Cortex	dorsal Insular Cortex

Plasticity of Taste Responses

27

Plasticity is a change in behavioral response to taste after some manipulation.

Conditioned Taste Aversion (CTA)
palatable -> aversive

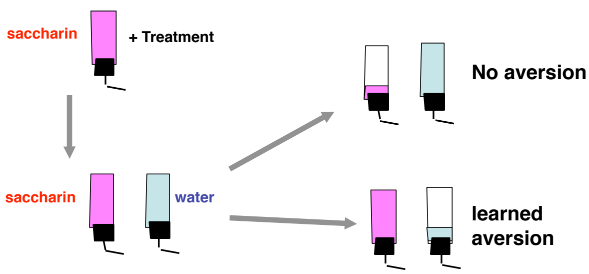
Sodium Appetite
aversive -> palatable

Other examples
eating disorders, learned preferences, estrogen effects, metabolic state, etc.

Often requires the forebrain.
i.e. decerebrate rat cannot learn CTA, or express Na appetite

Conditioned Taste Aversion

Form of Associative Learning in which an animal avoids and rejects a food after it is paired with a toxic effect.



Requires forebrain, because decerebate rat cannot learn or remember a CTA.

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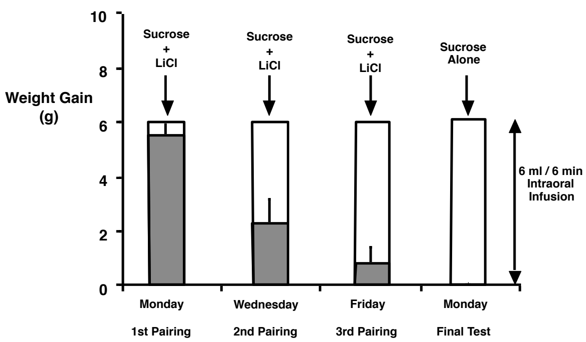
CTA After Contingent Intra-Oral Sucrose and LiCl



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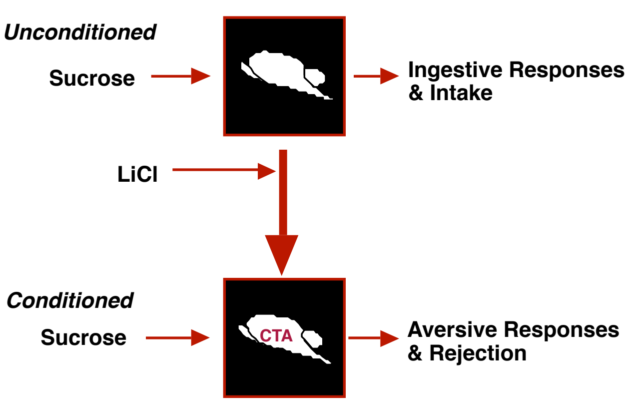
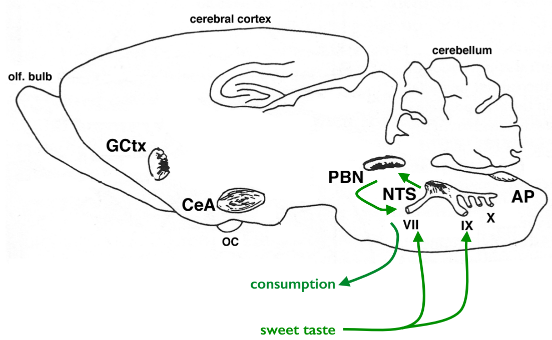
CTA Learning: A Change in Behavior



30

CTA Learning: A Distributed Neural Network



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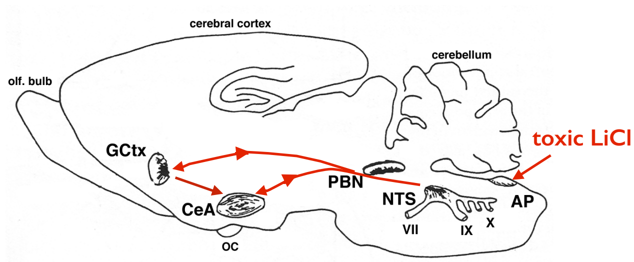
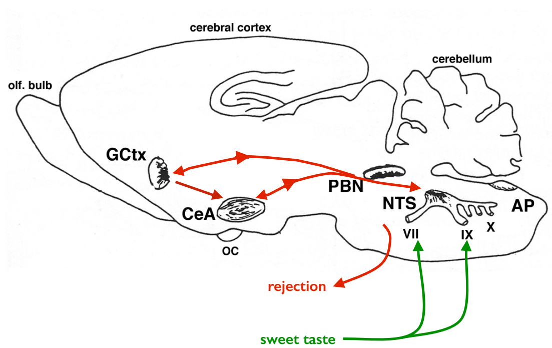
CTA Learning: A Distributed Neural Network



32

CTA Learning: A Distributed Neural Network



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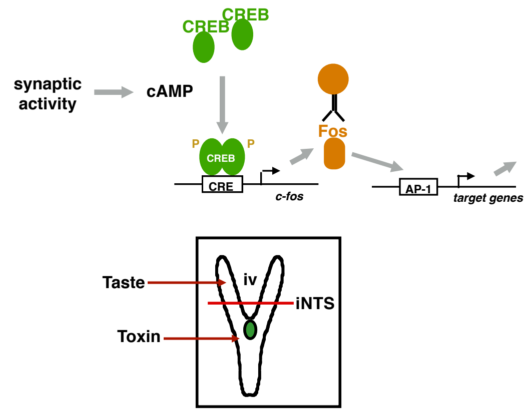
c-Fos as Marker of Neuronal Activity



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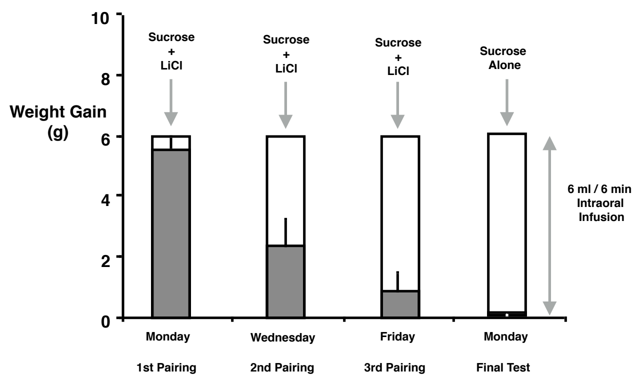
CTA After Contingent Sucrose and LiCl



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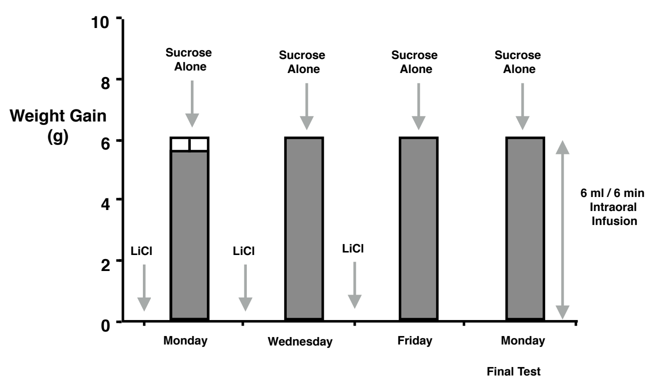
Control: Non-Contingent Sucrose and LiCl



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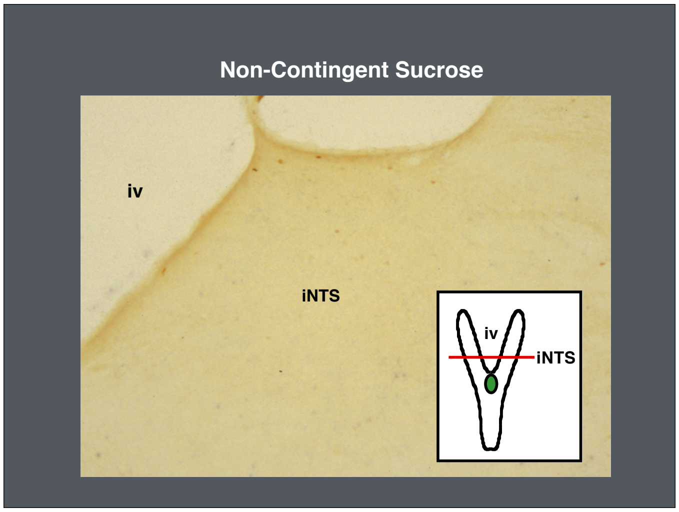
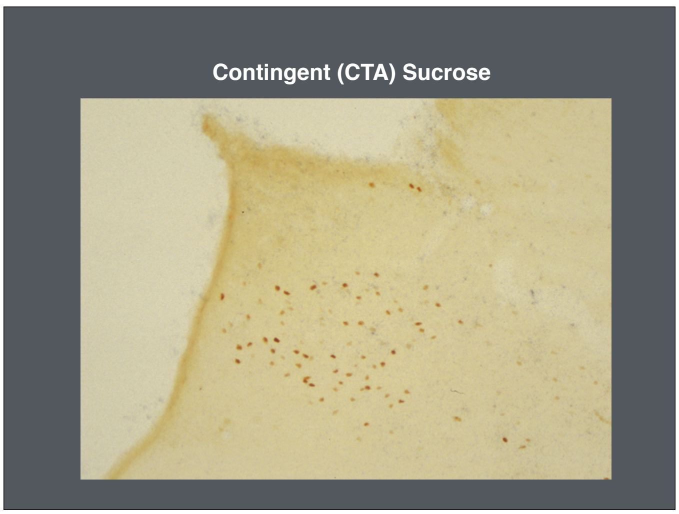
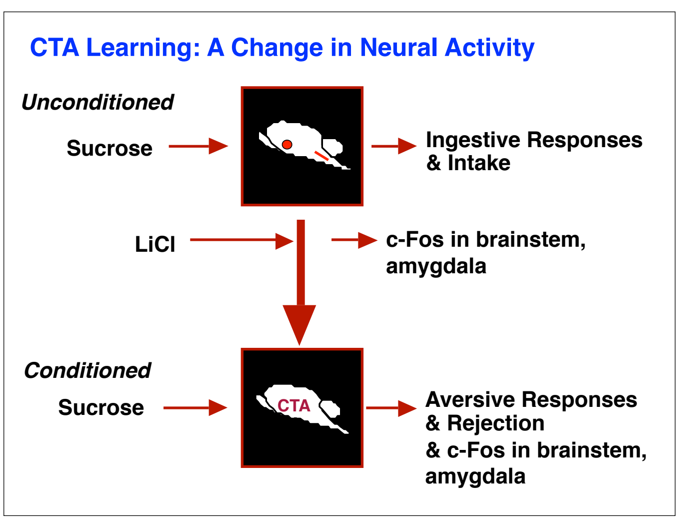

Non-Contingent Sucrose
iv
iNTS
iv
iNTS

37


Contingent (CTA) Sucrose

38


CTA Learning: A Change in Neural Activity
Unconditioned
Sucrose
Ingestive Responses
& Intake
LiCl
c-Fos in brainstem,
amygdala
Conditioned
Sucrose
CTA
Aversive Responses
& Rejection
& c-Fos in brainstem,
amygdala

39

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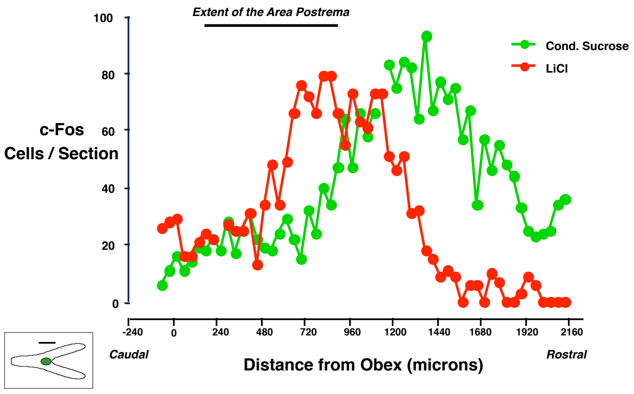
Overlapping Distribution of c-Fos induced by LiCl or Cond. Sucrose



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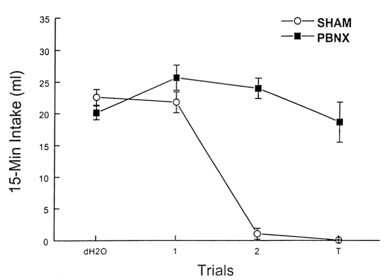
Learning a new CTA requires the PBN



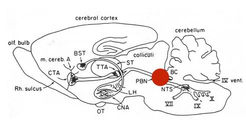


Figure 2. Mean (±*SE*) 15-min fluid intake for control (sham) rats and for rats with parabrachial nucleus lesions (PBNX) during baseline (dH_2O), acquisition (1 and 2), and test (T) trials. The conditioned stimulus was 0.3 M alanine, and the unconditioned stimulus was LiCl (0.3 M, 1.33 ml/100 g body weight).

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PBNX does not block Cond. "Somatosensory" Aversion

(Capsaicin paired with LiCl)

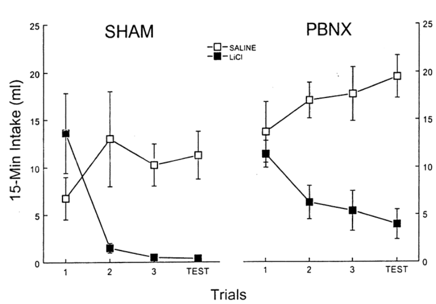


Figure 5. Mean (±*SE*) 15-min intake of the conditioned stimulus 0.01 mM capsaicin) for control (sham) rats and for rats with lesions of the parabrachial nucleus (PBNX) during acquisition (1, 2, and 3) and test trials. During acquisition trials, all rats were injected with either saline or 0.15 M LiCl (1.33 ml/100 g body weight).

Salt Appetite

43

Induced by loss of sodium
by sodium-free diet, diuretic (e.g. lasix), or hemorrhage

Elevation of angiotensin and aldosterone
-> hypothalamus, amygdala -> taste centers

Requires forebrain, because decerebate rat cannot learn or remember a sodium appetite.

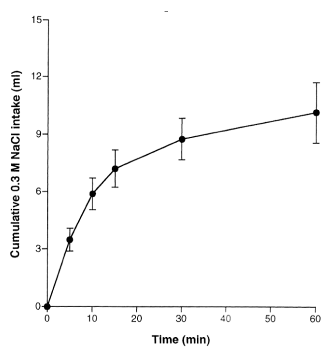
PBN lesion also blocks sodium appetite.

Evidence in humans is slim.

Sodium appetite in furosemide-treated rat

44

furosemide -> Na excretion, but allowed to drink H_20 overnight



given access to 0.3M NaCl the next day

30% PEG hypovolemia: water and salt intake

45