

## Amygdala lecture

John O'Keefe

Amygdala interface between the external world and the autonomic nervous system. Identifies stimuli which evoke emotions. May also be the primary area where activity is the neural correlate of emotional experience.

### Kluver-Bucy syndrome

disturbances in visual perception

disturbances in emotional/motivational behaviour

aggression

sexual behaviour

feeding behaviour

### Anatomy of the Amygdala

Basolateral Corticomедial Central nuclei

Afferents and Efferents

### Amygdala function in animals

Single unit studies

Fear conditioning

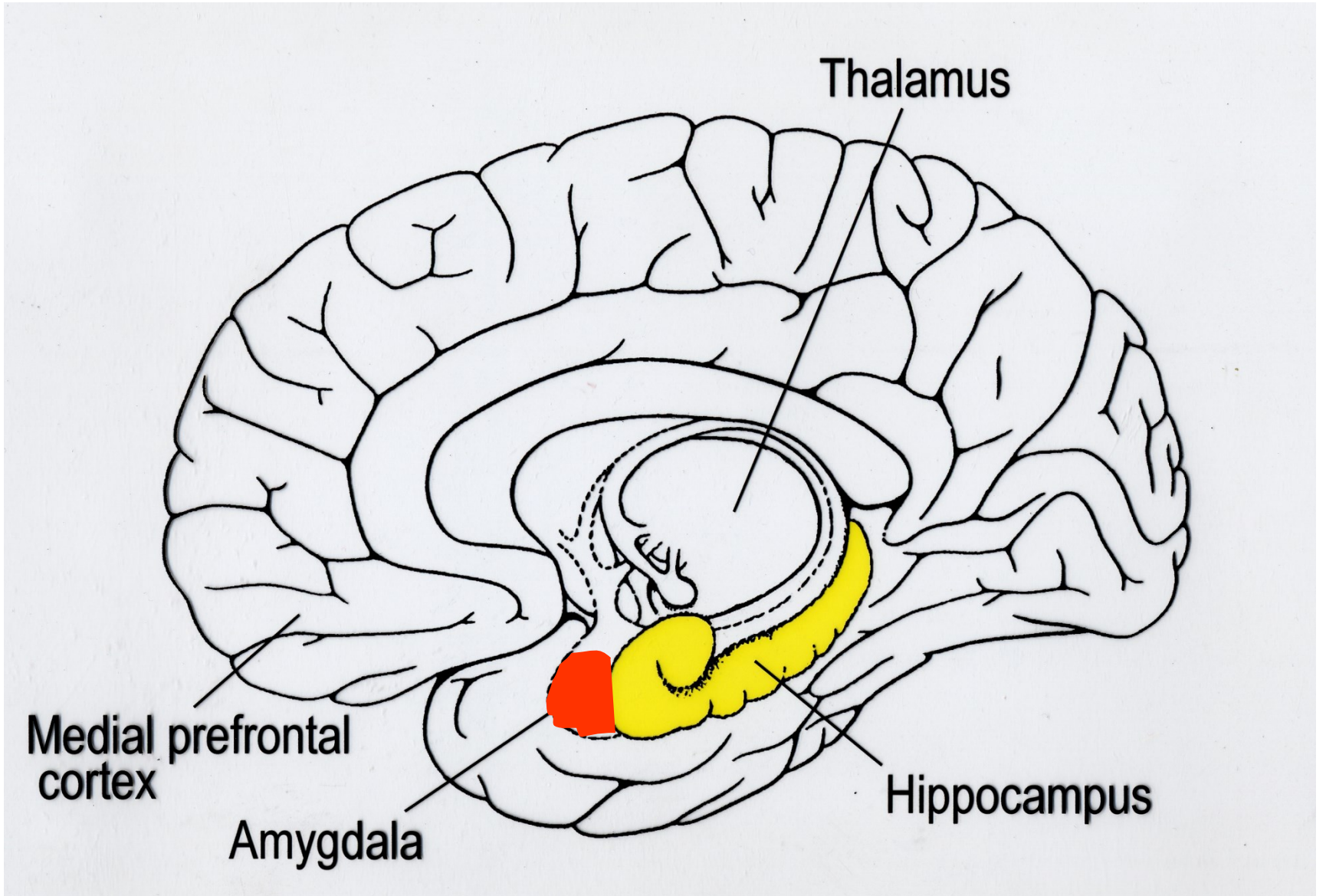
Social Interaction

### Human lesion studies

Case of SM - Loss of ability to recognise emotional expressions using visual or auditory cues

### Functional imaging studies

Involvement in fear and perhaps anger and disgust



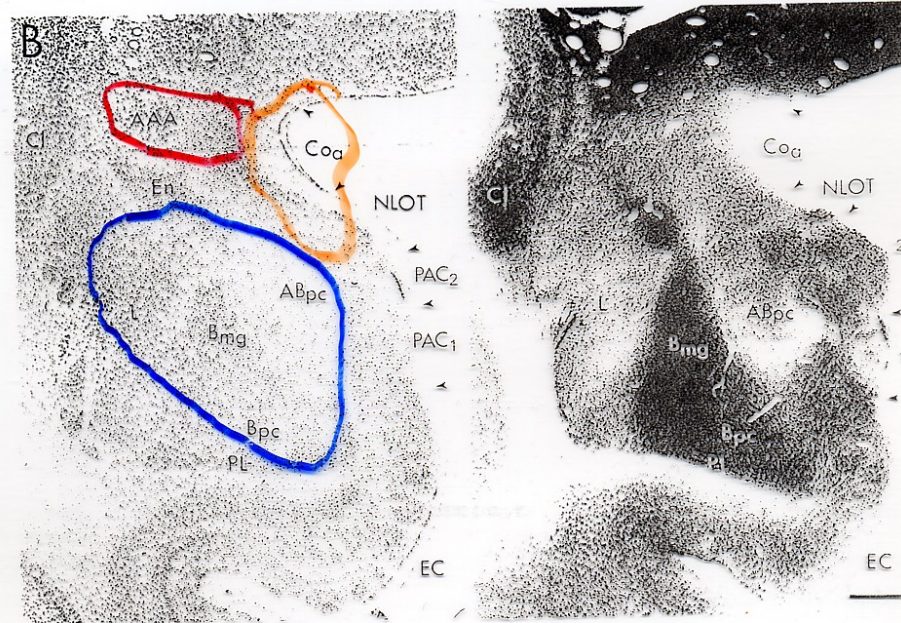
# Kluver-Bucy Syndrome

following bilateral temporal lobectomy in monkeys.

Main components are:

visual defects,  
oral tendencies, and  
changes in emotional behaviour  
(hypersexuality, hypo-emotionality)

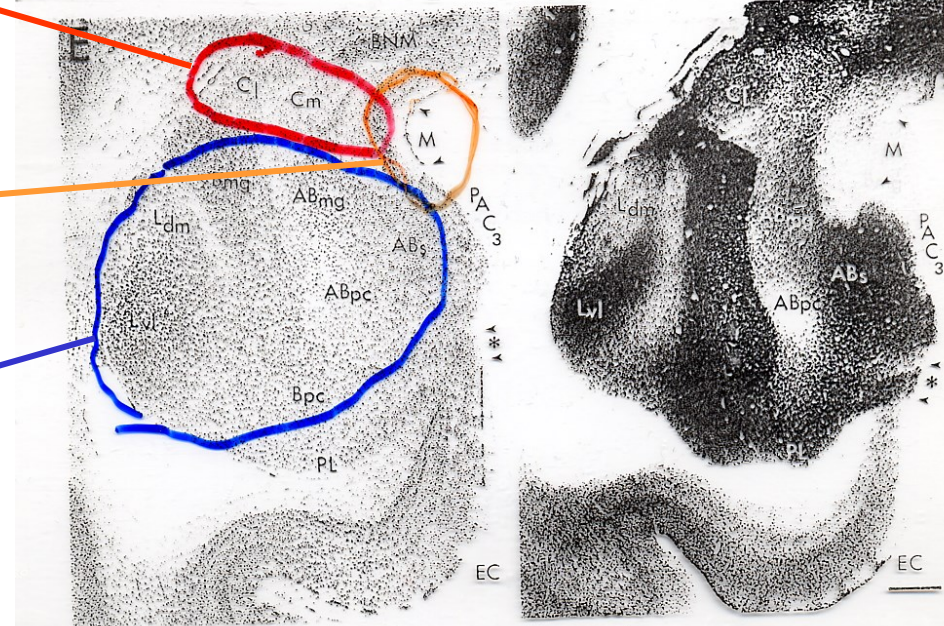
# Primate amygdala Transverse sections

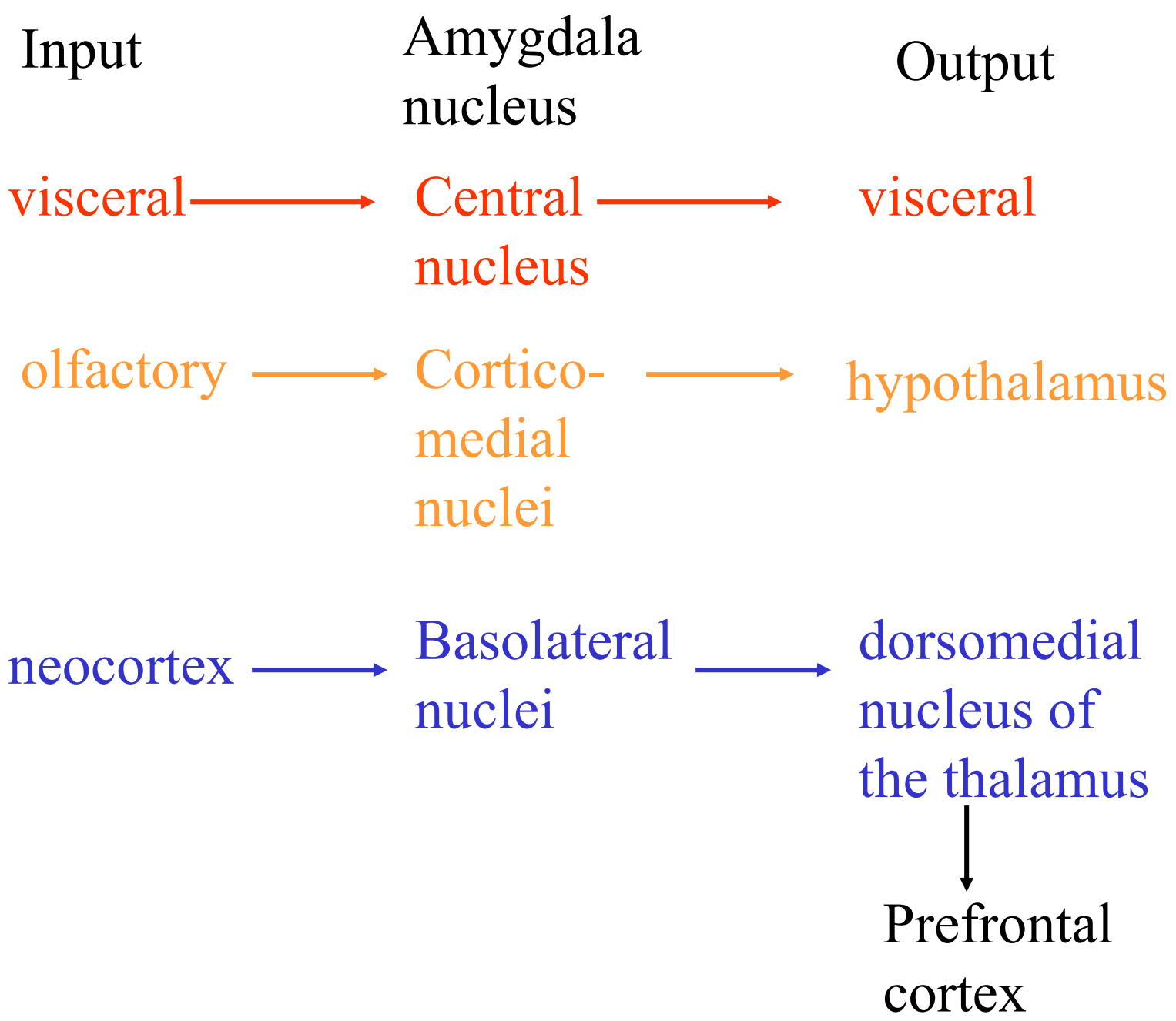


Central

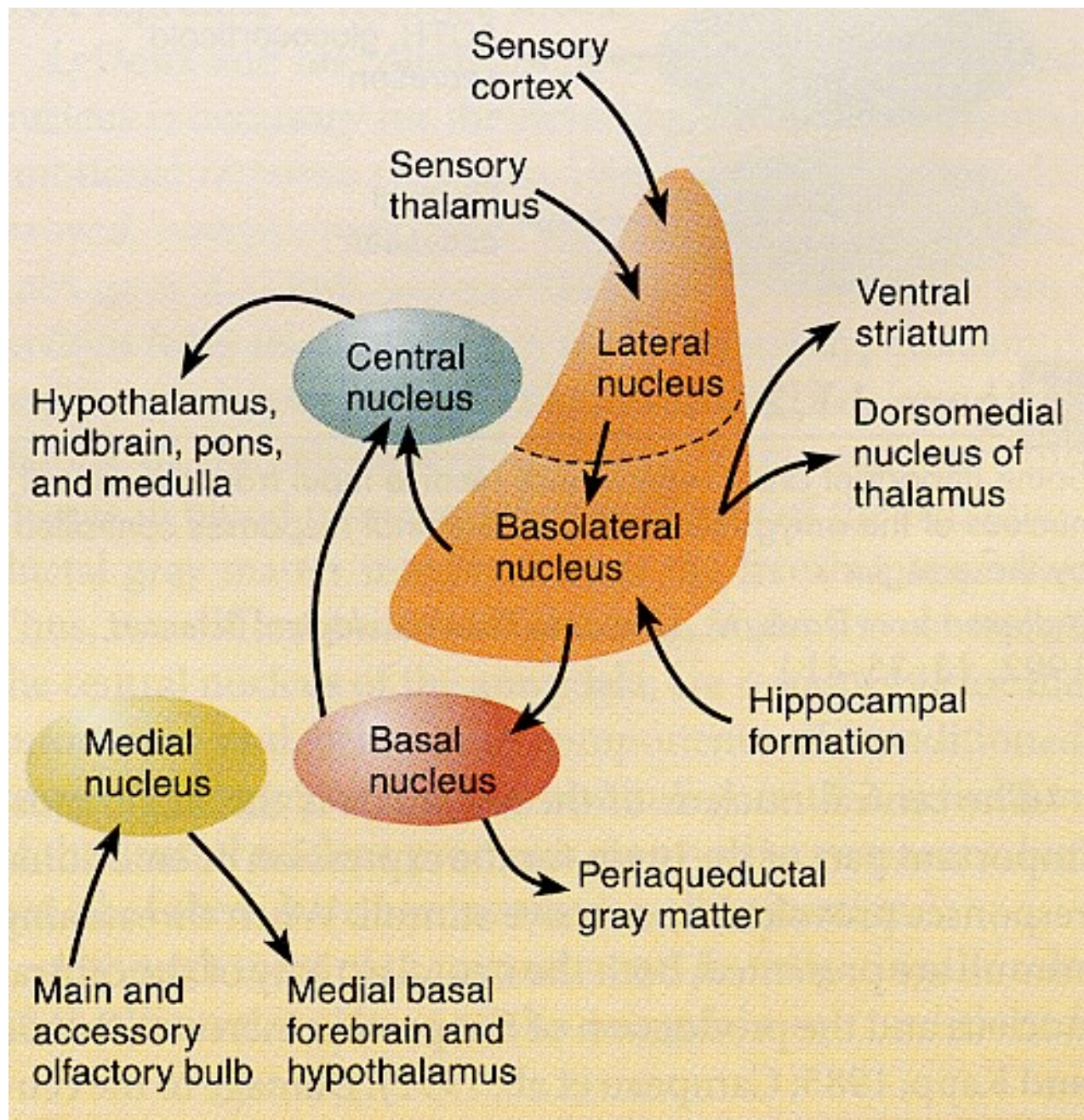
Corticomedial

Basolateral

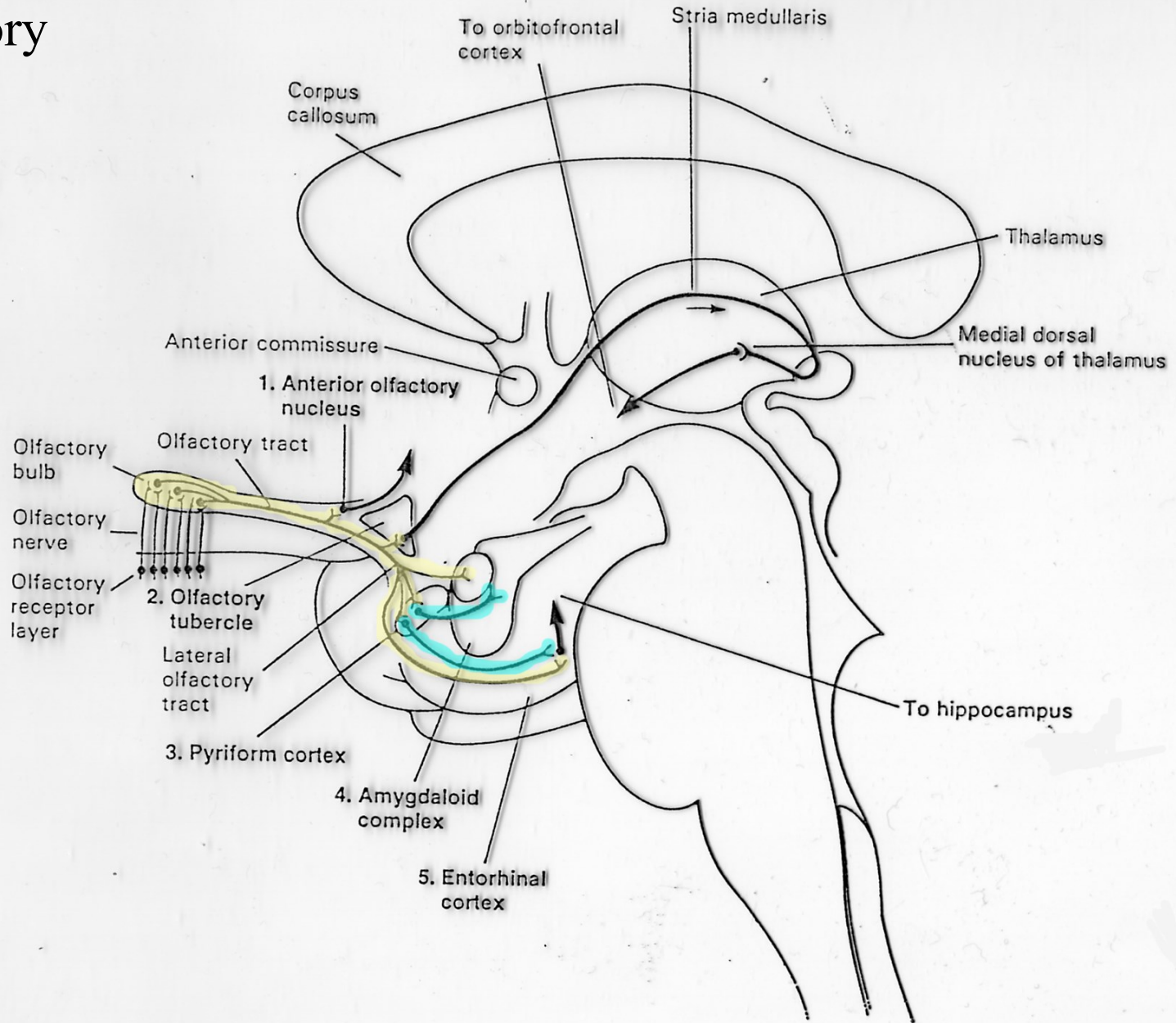


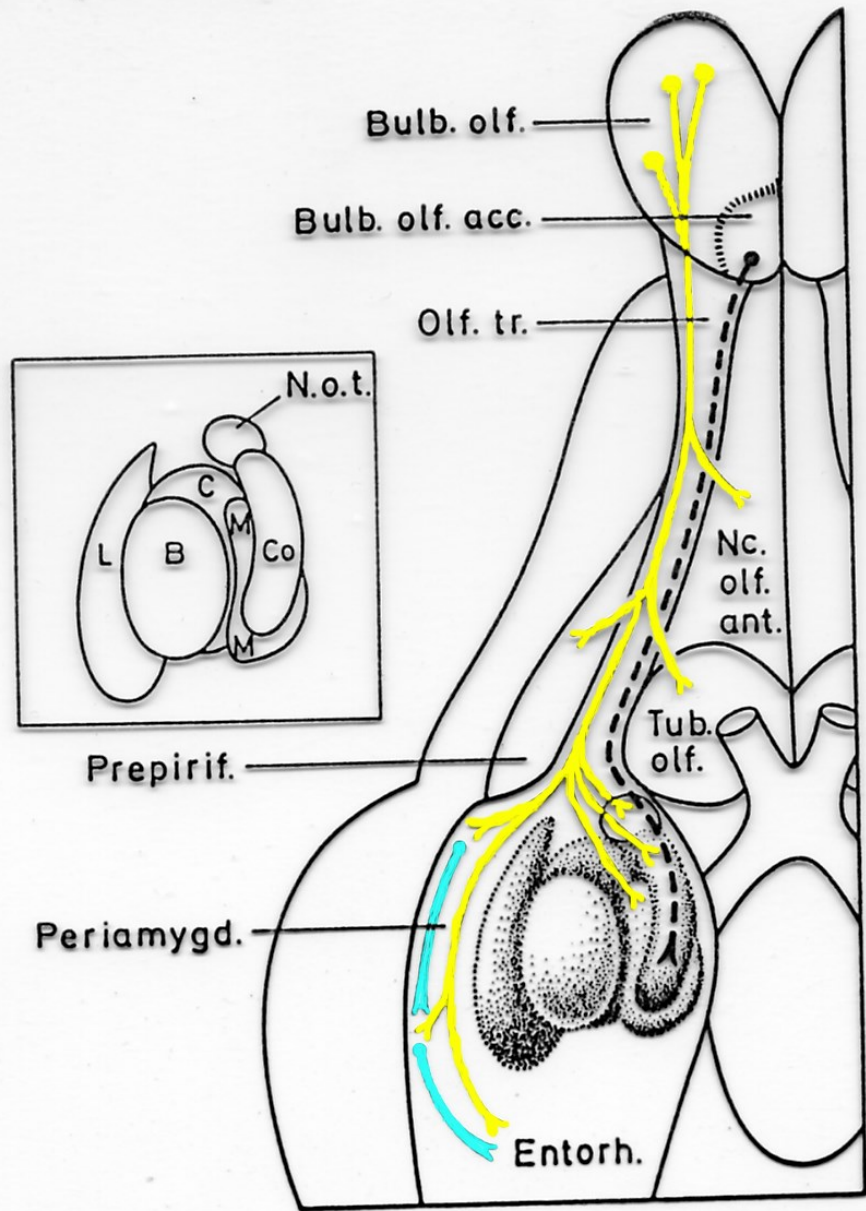


# Amygdala inputs and outputs



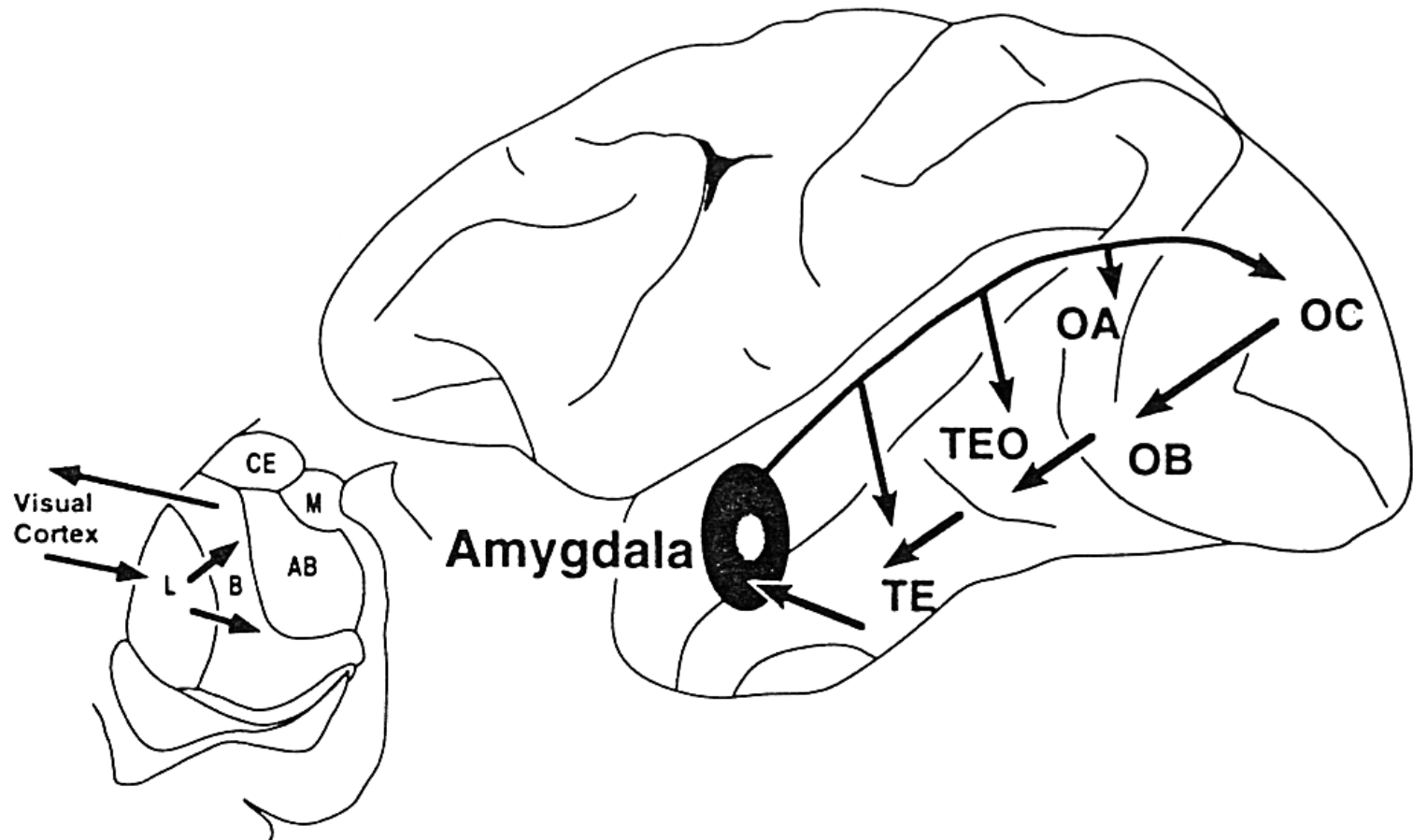
# olfactory input

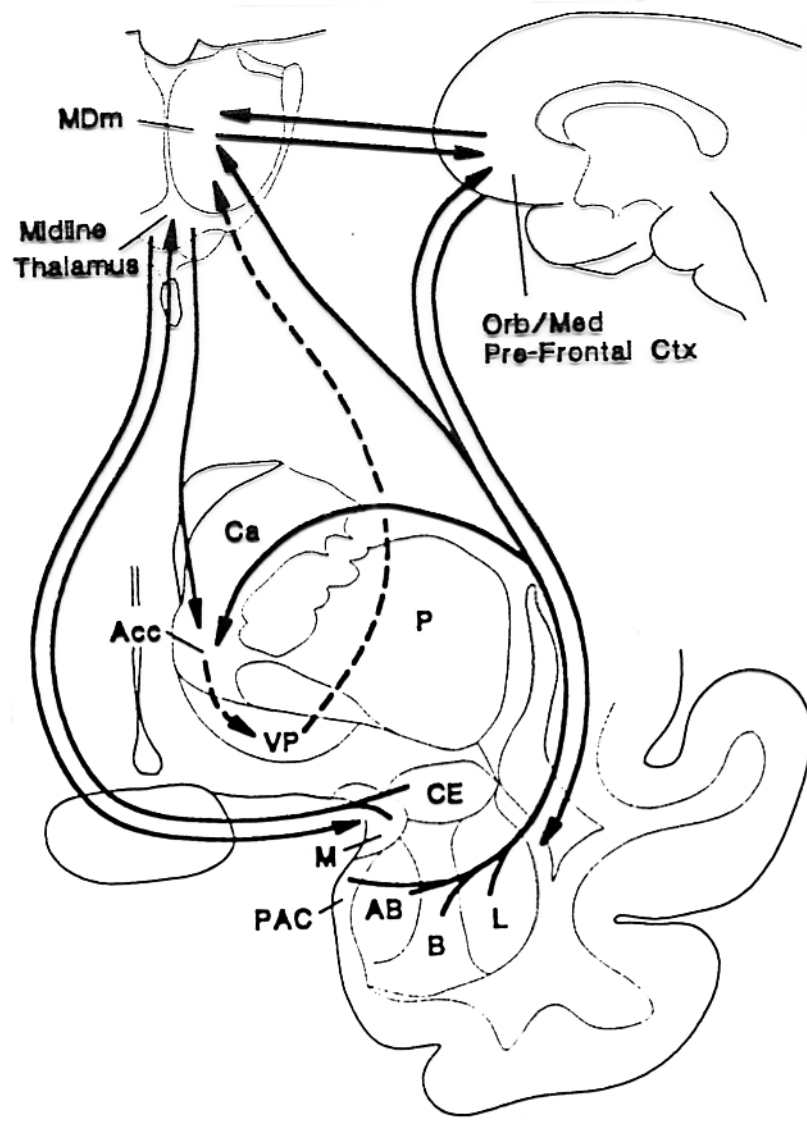




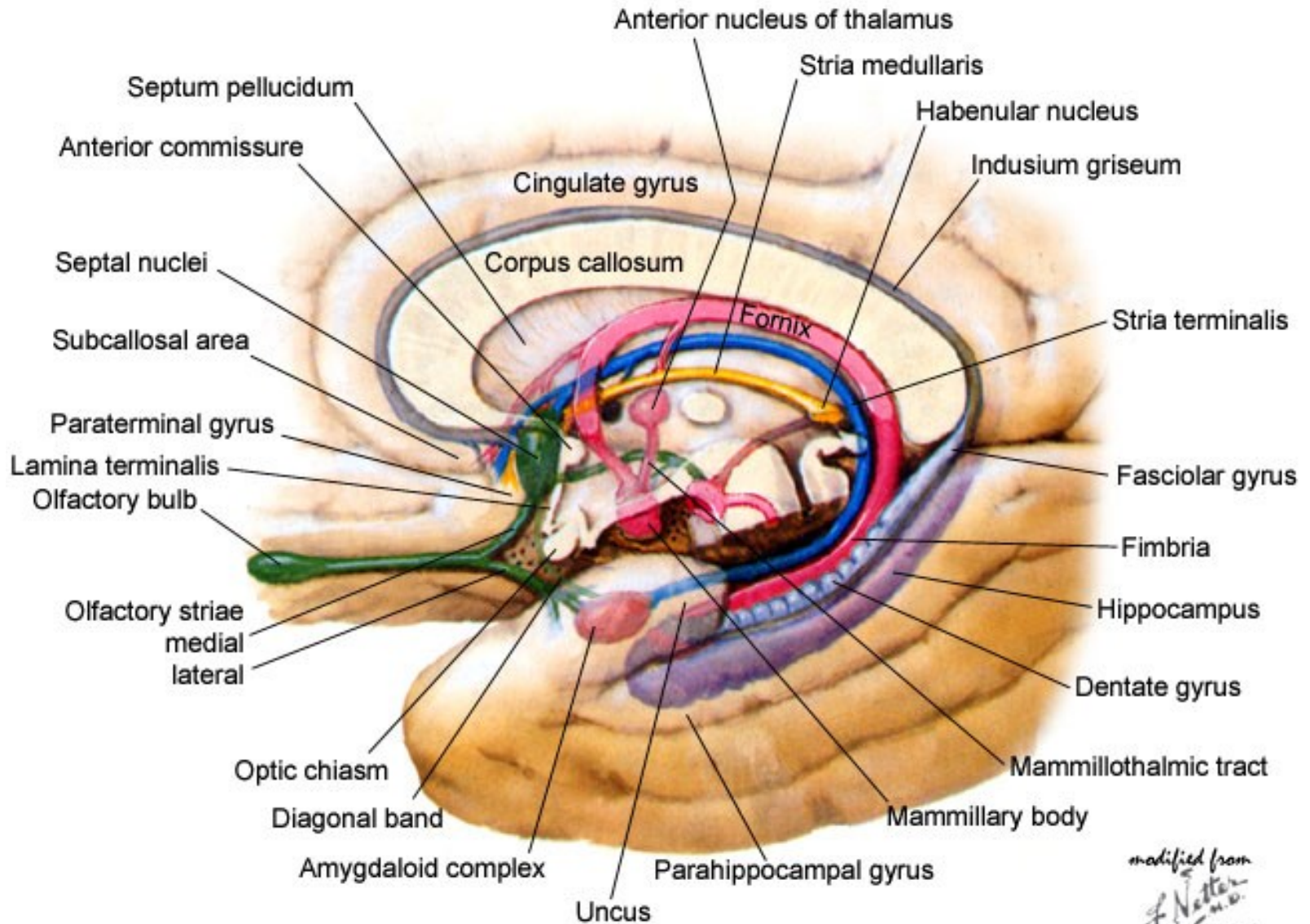


visual  
input

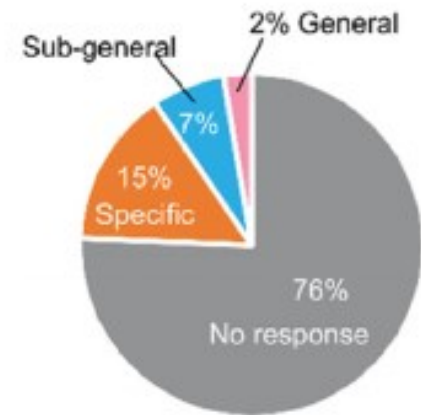
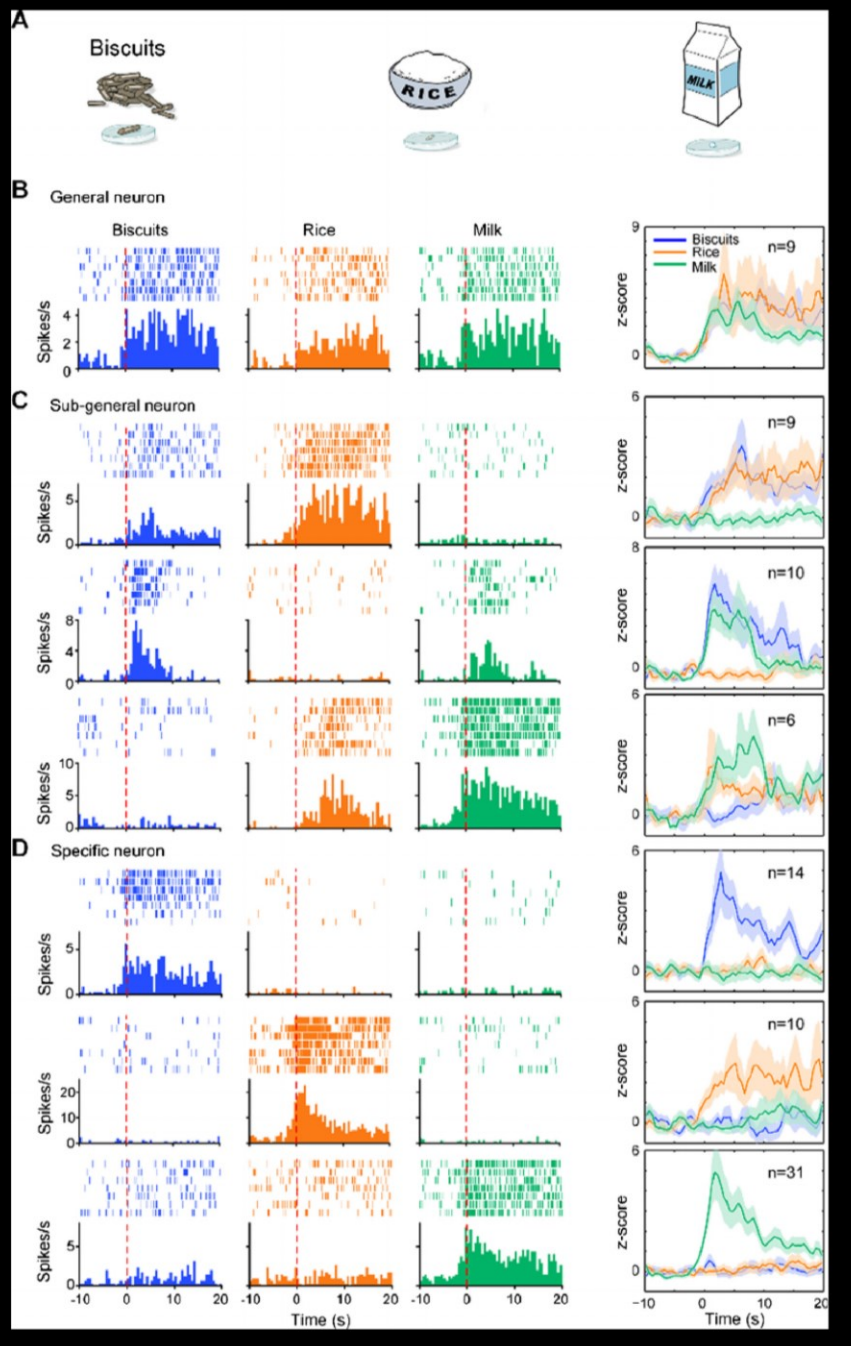




# Amygdala efferent-Stria Terminalis



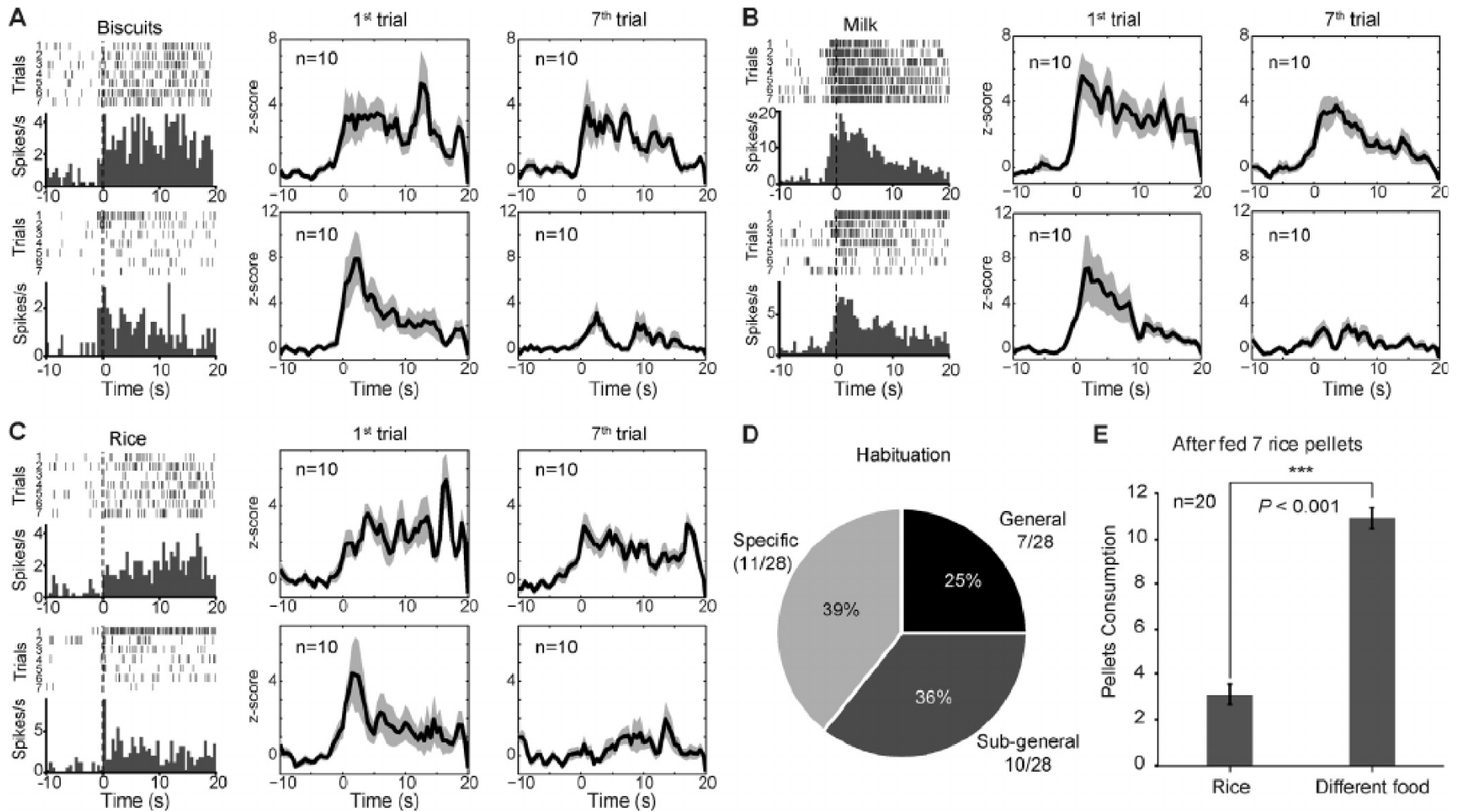
# Amygala Eating Cells



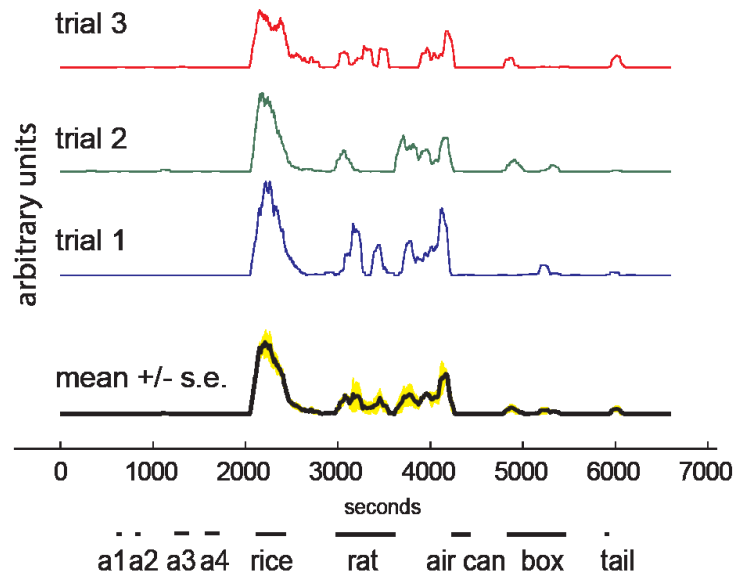
All putative pyramidal cells (n=371)

*Liu et al 2018*

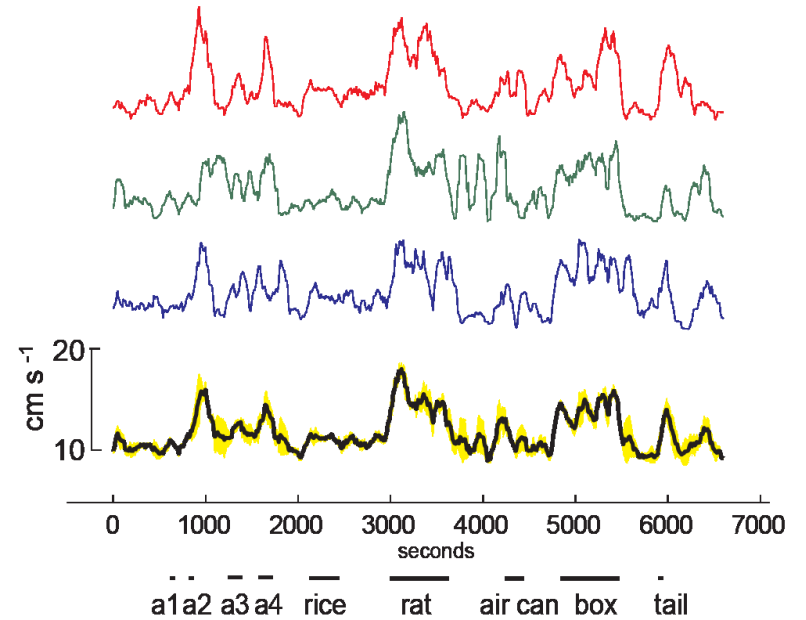
# Habituation in Eating Cells



### Chew/lick artifact



### Movement speed



Amygdala  
cells are  
Specific

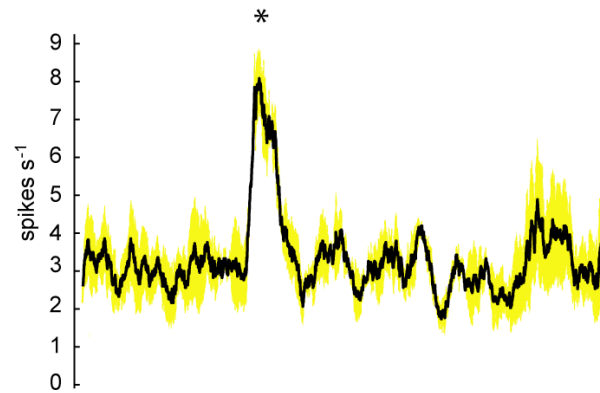
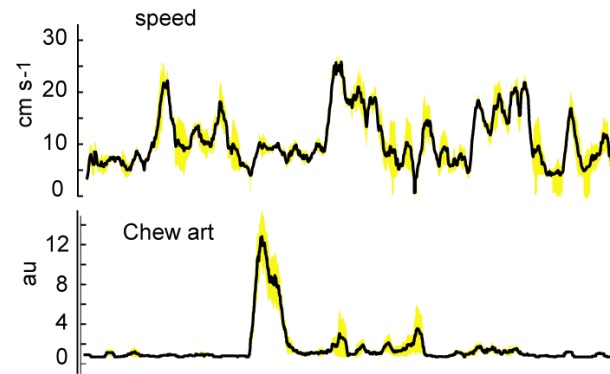
Responsive 55%

One Stimulus  
61%

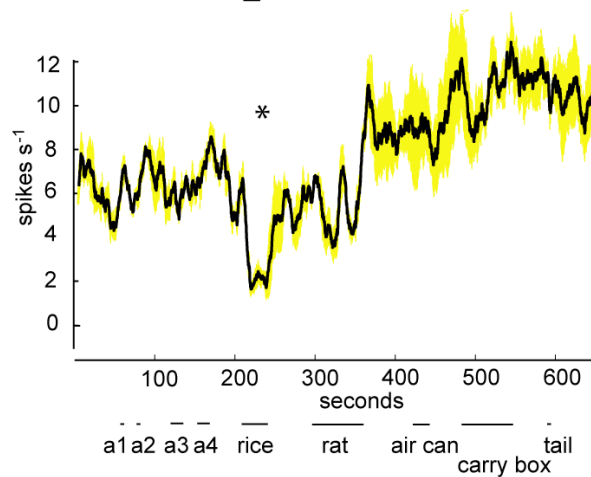
Rat 40%

Food  
35%

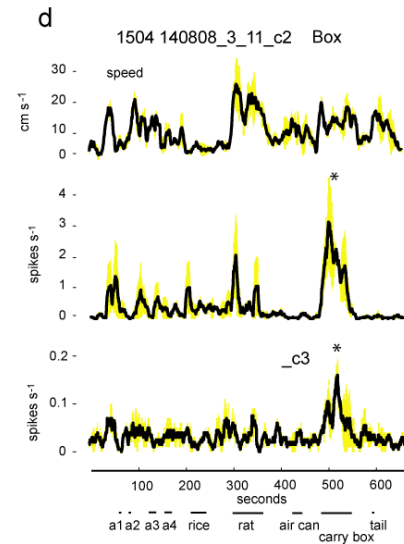
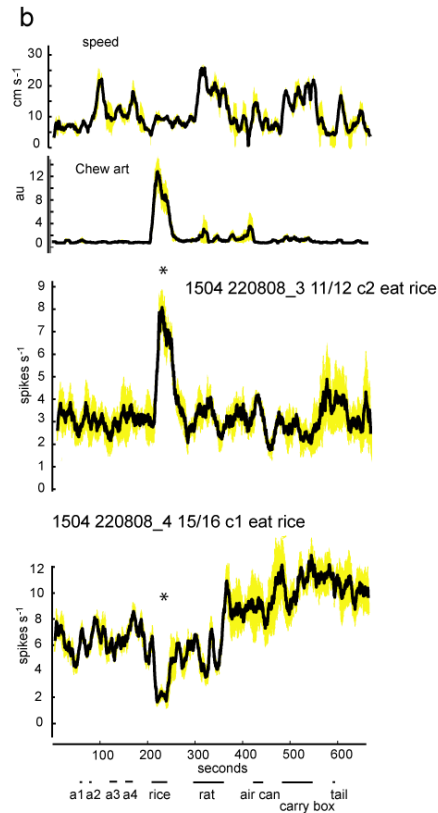
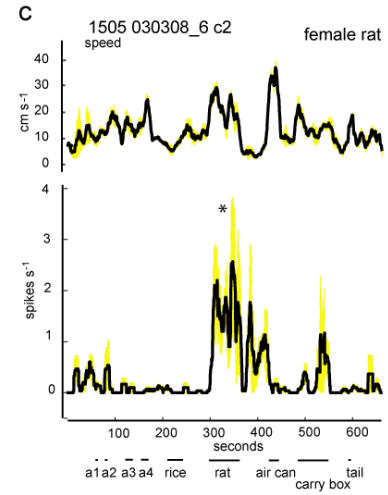
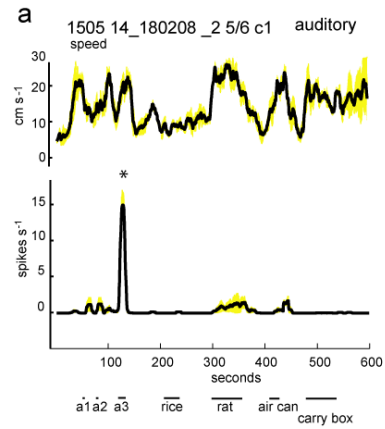
Transport Box  
18%



1504 220808\_4 15/16 c1 eat rice

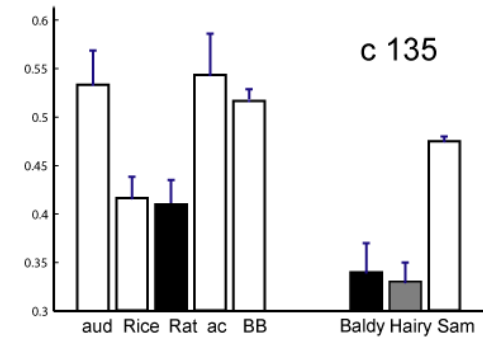
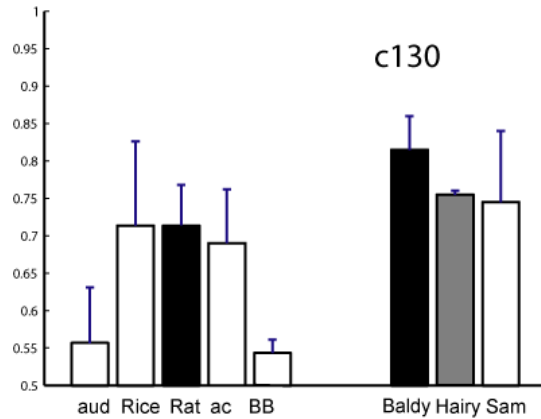
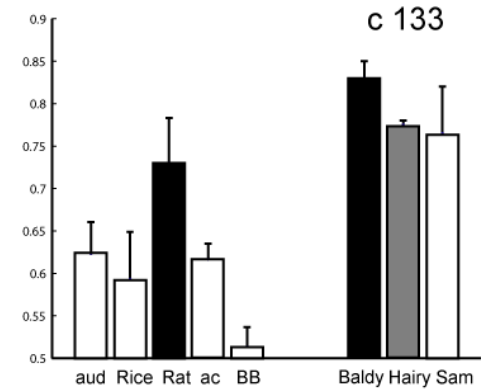
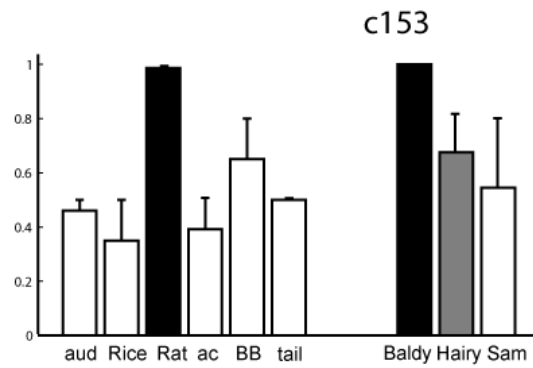


# Other selective amygdala cells

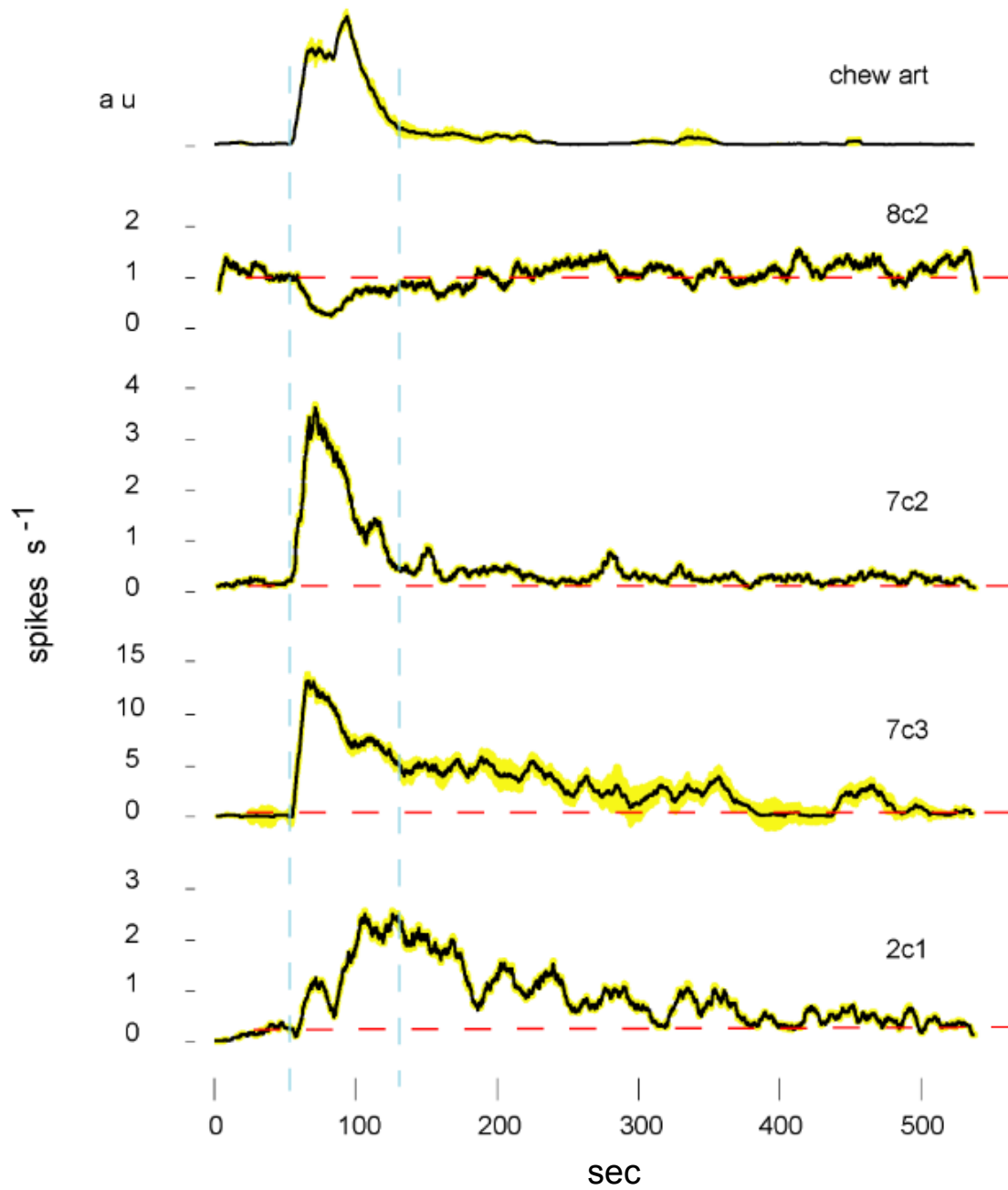




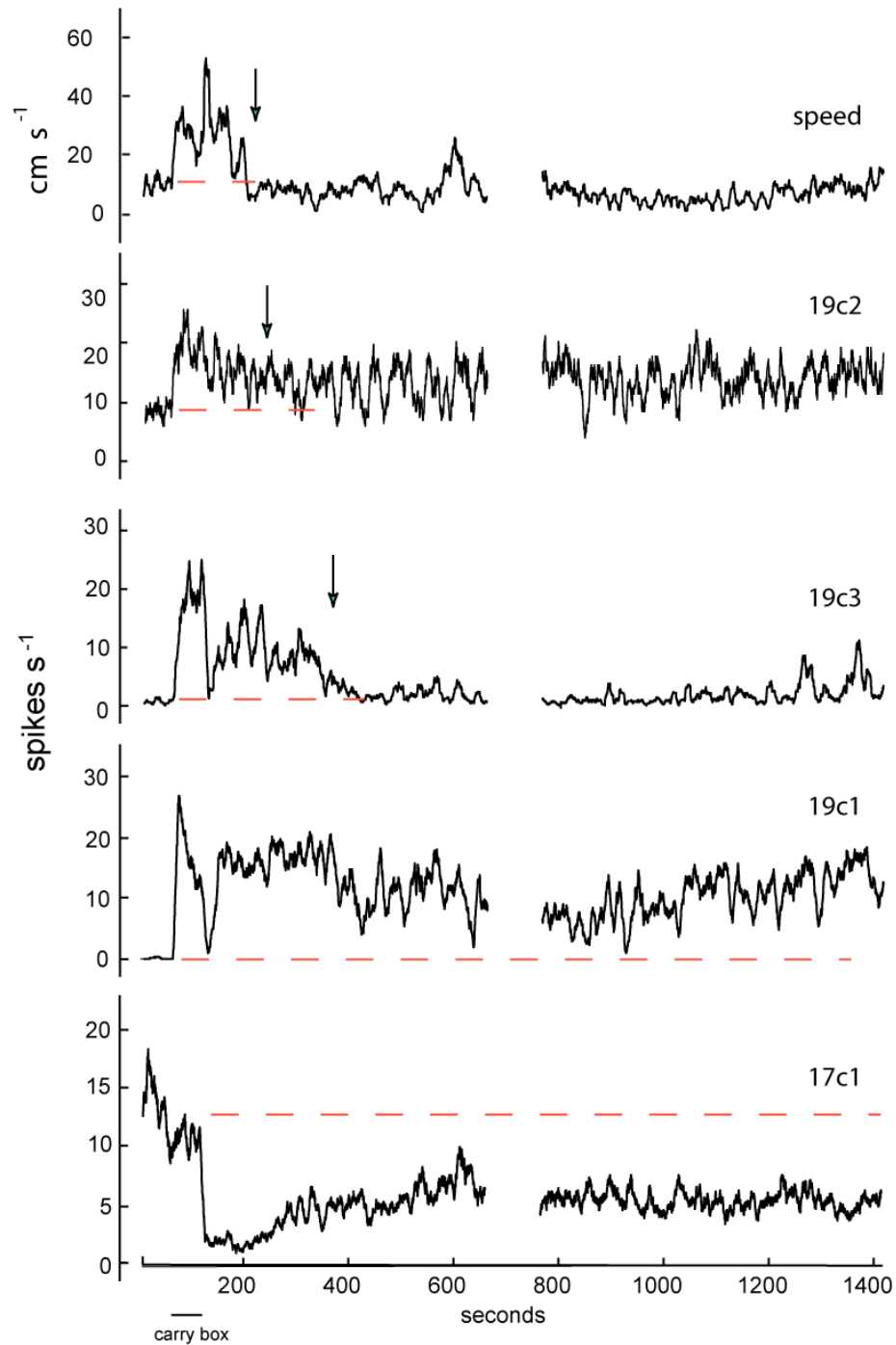
# selective rat cells



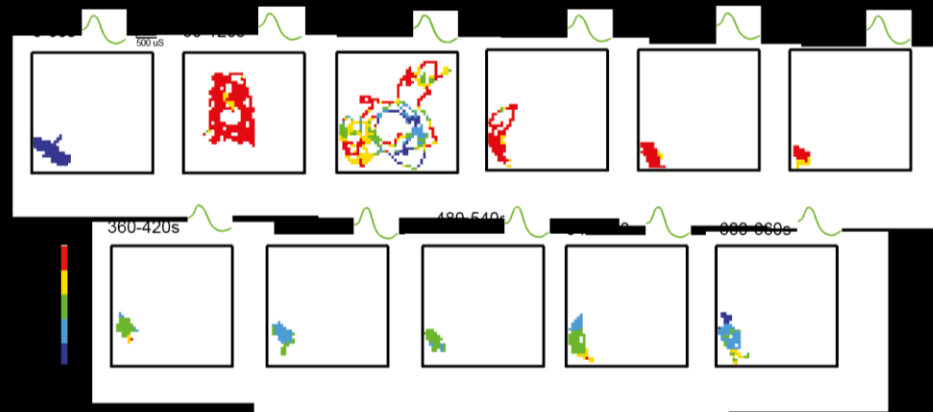
active  
memory  
traces  
for  
eating  
rice



active  
memory  
traces for  
experience  
of exploring  
transport  
box



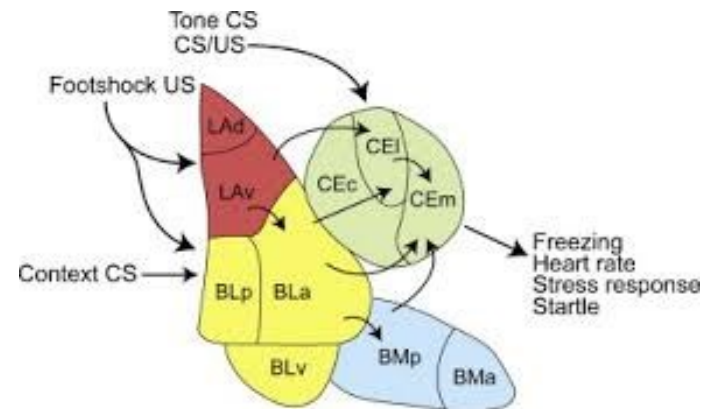
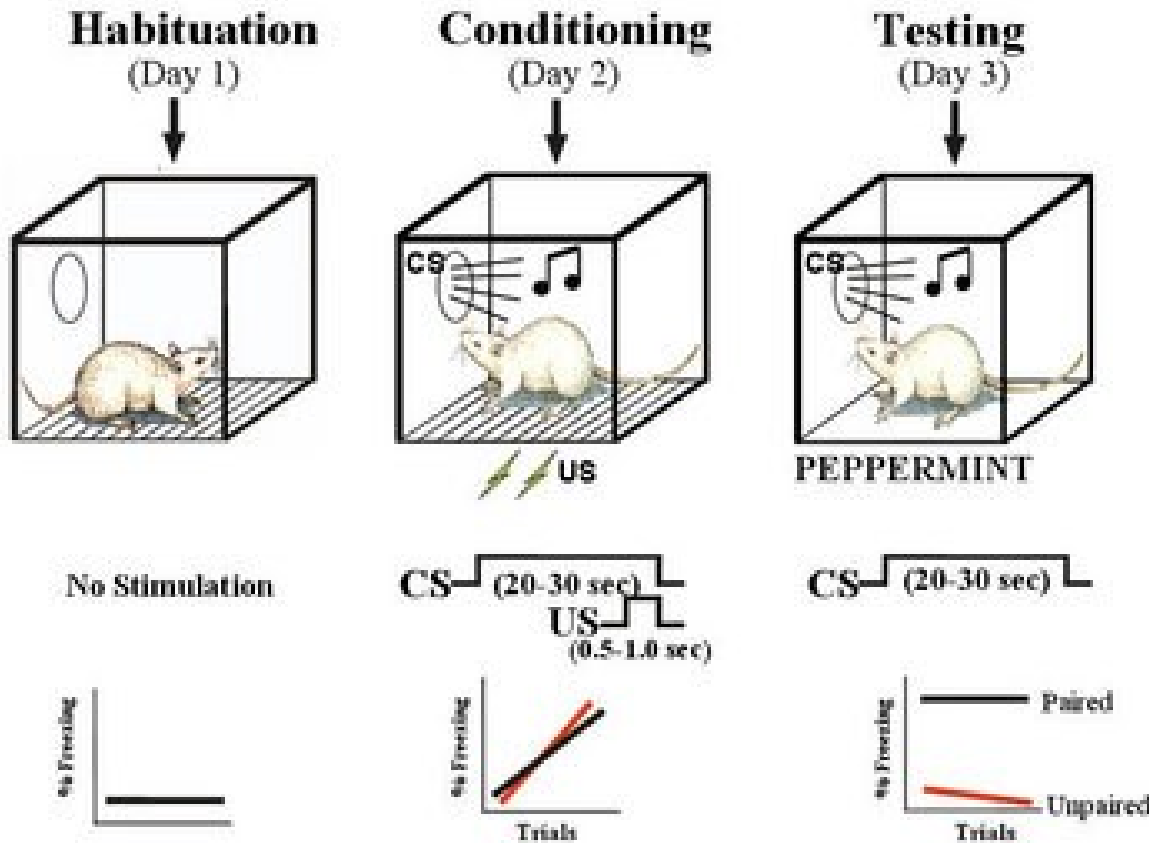
active m  
traces a  
independ  
behavior



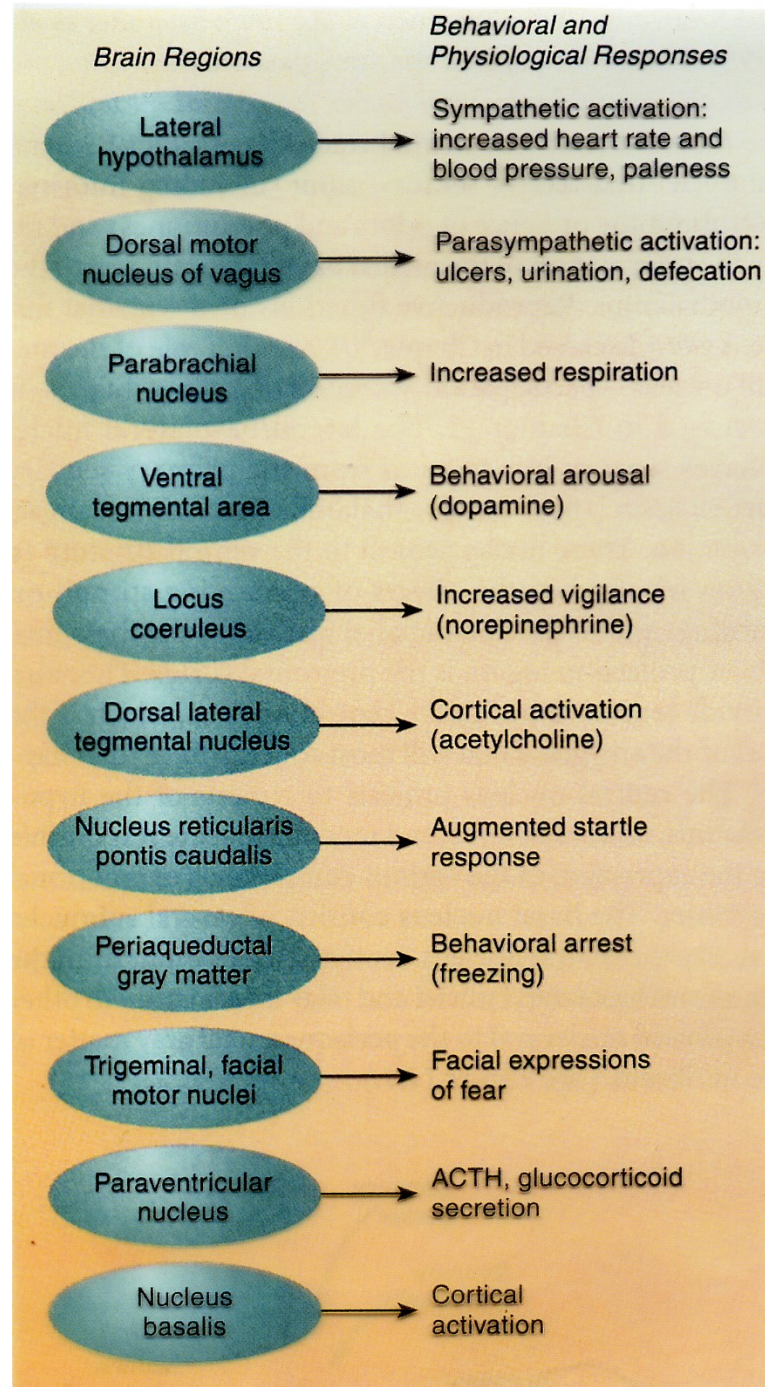
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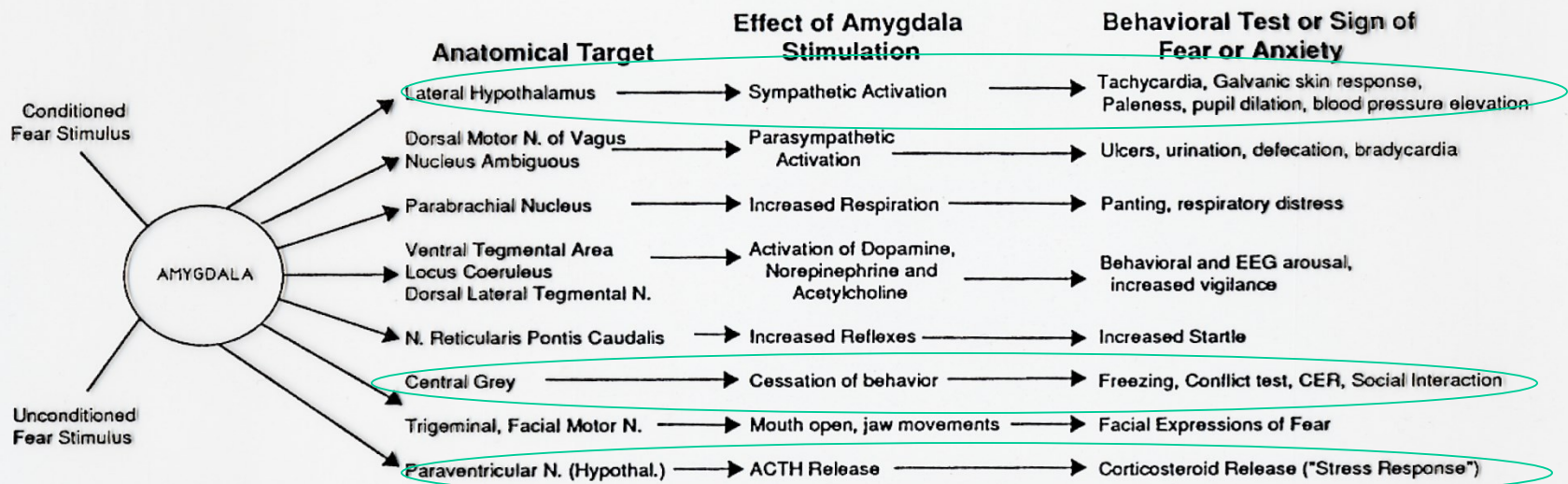
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# Pavlovian fear conditioning



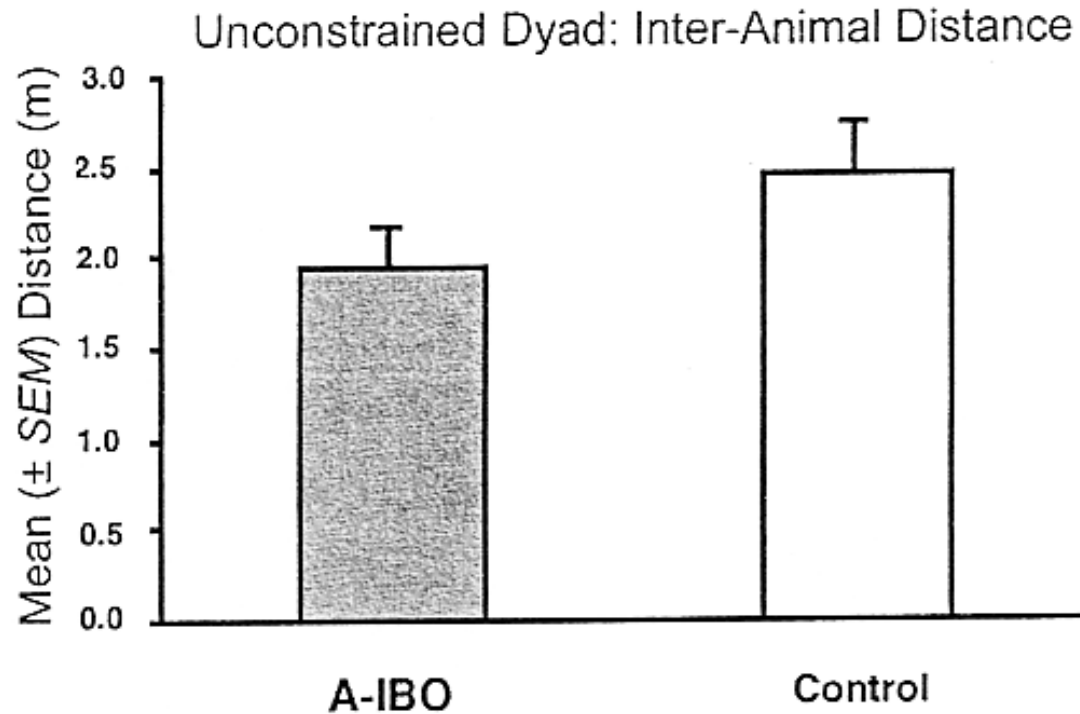
Nuclei involved in conditioned fear and their autonomic and behavioural actions





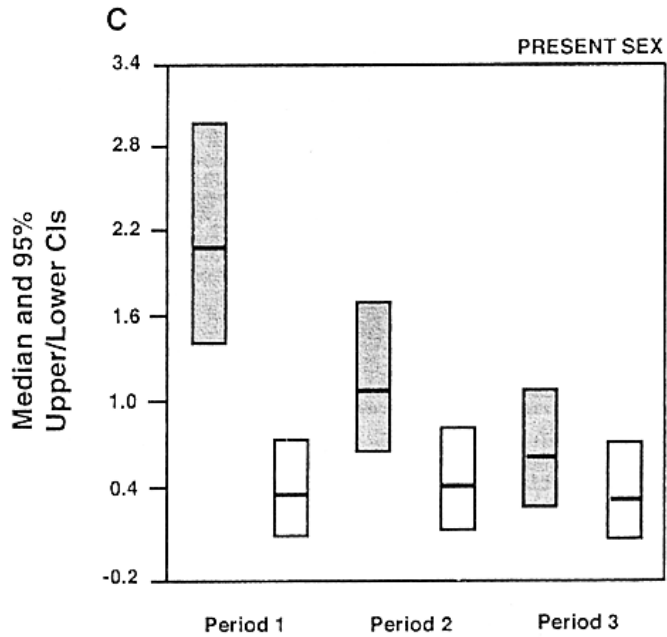
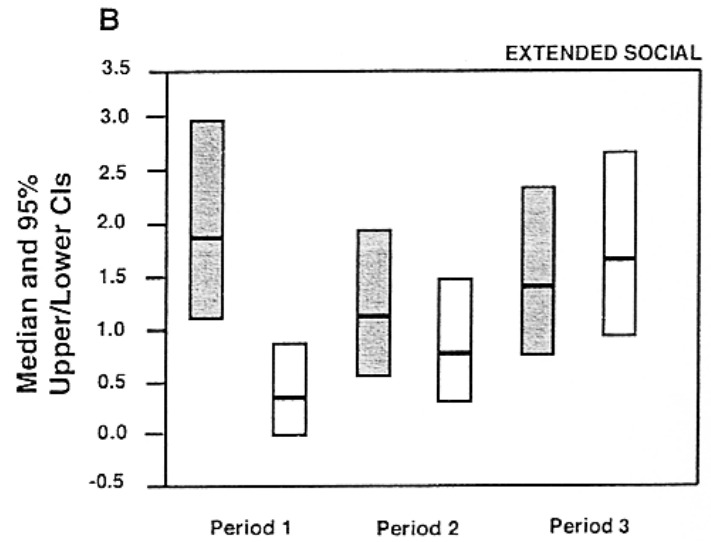
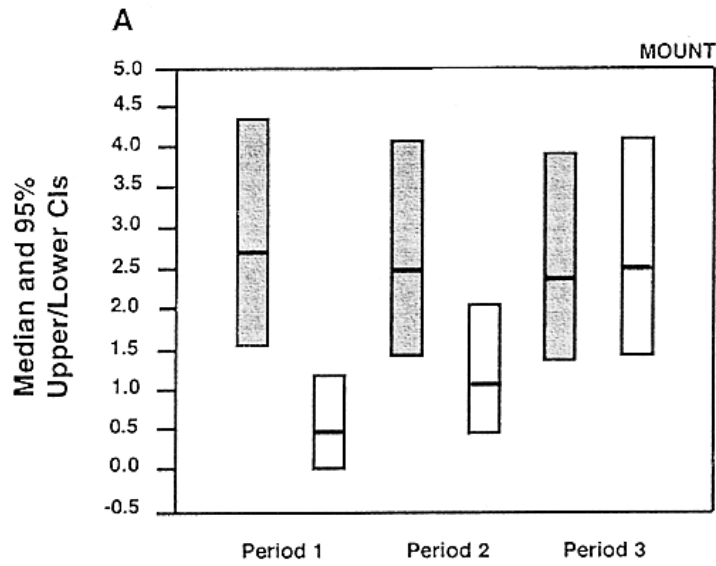
*Figure 2* Schematic diagram showing direct connections between the central nucleus of the amygdala and a variety of hypothalamic and brainstem target areas that may be involved in different animal tests of fear and anxiety.

# Effect of amygdala lesions on social behavior

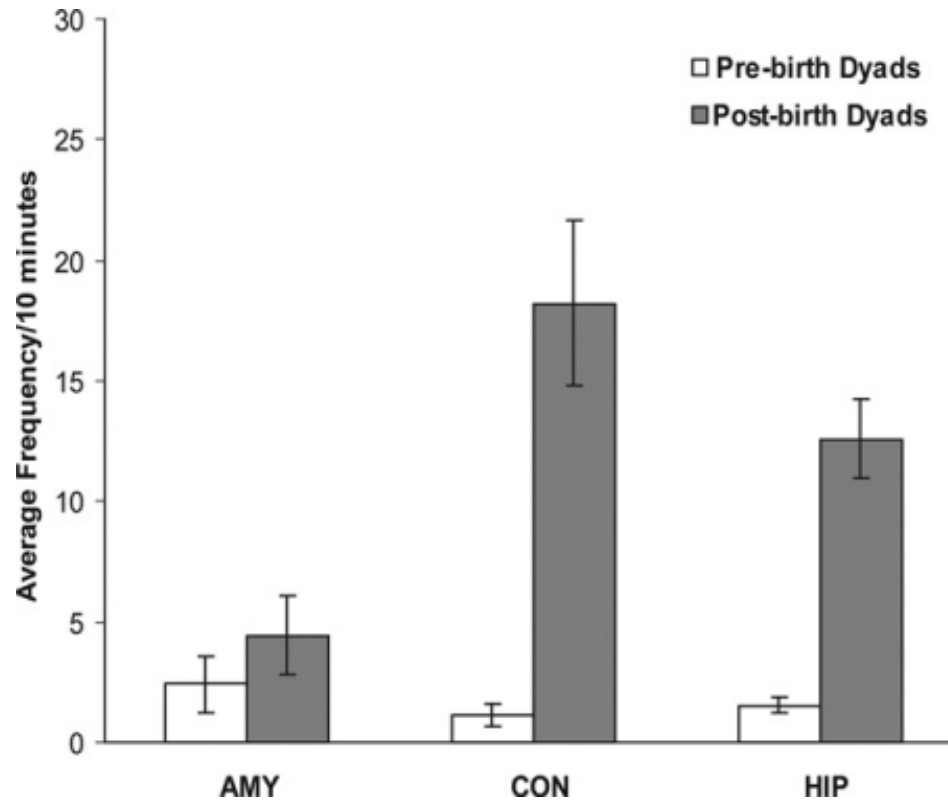


*Figure 8.* Spatial proximity. Mean ( $\pm$  SEM) distance between subject and stimulus monkeys during the 20-min test period for unconstrained dyad (both subjects and stimulus monkeys free in the test cage). Ibotenic acid lesioned (A-IBO),  $n = 6$ ; control,  $n = 6$ .

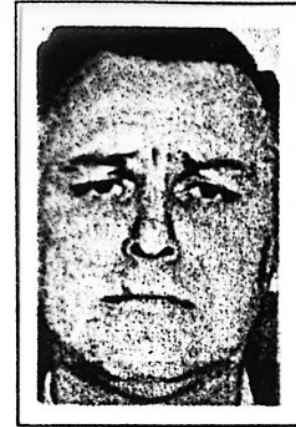




affiliative vocalizations towards mother/infant pairs  
are reduced by amygdala lesions



Ekman  
Emotional  
faces



Ekman  
Emotional  
faces



F55



H16



F50



C118

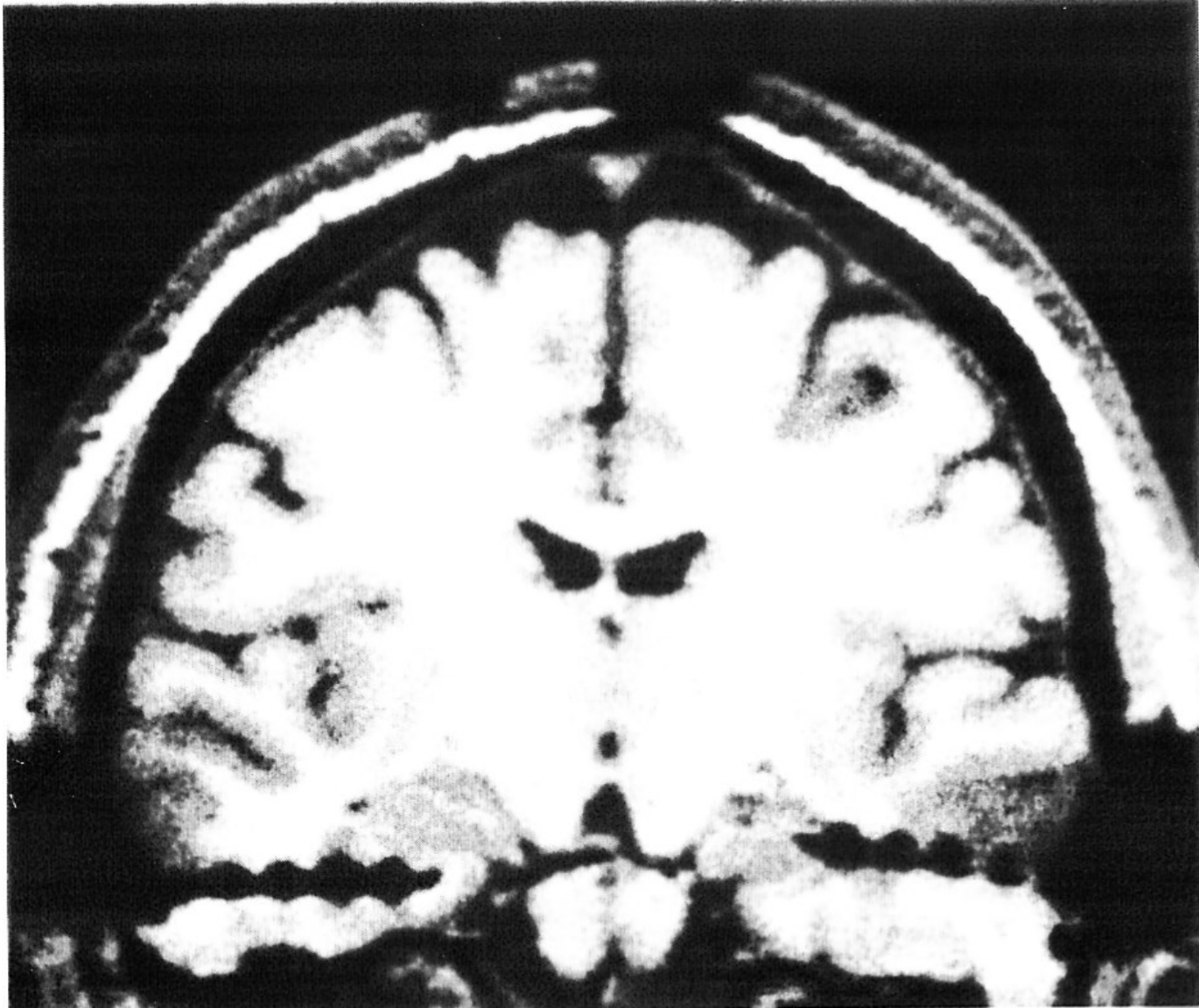


HE4

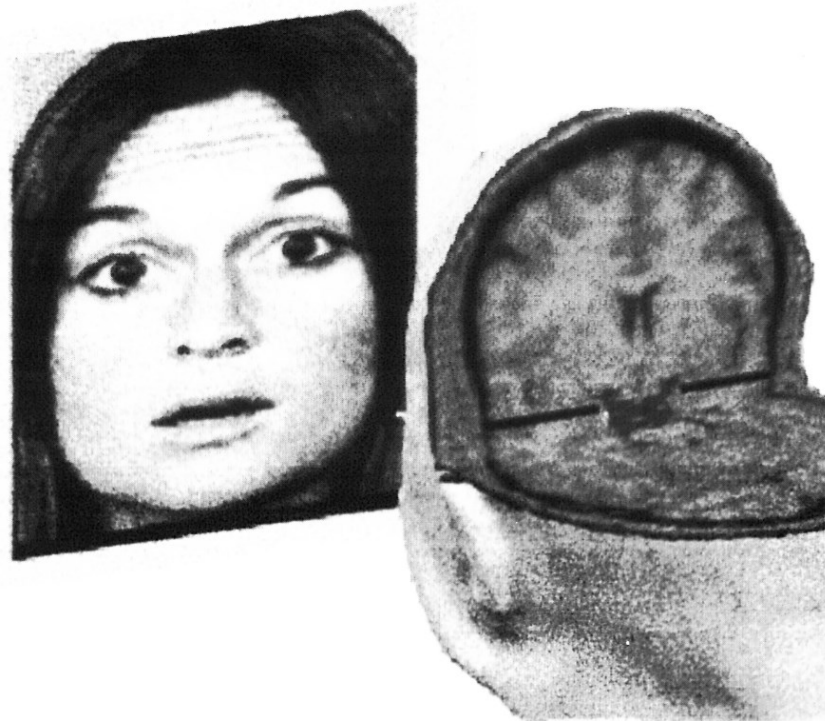


J38

electrode placements in temporal lobe



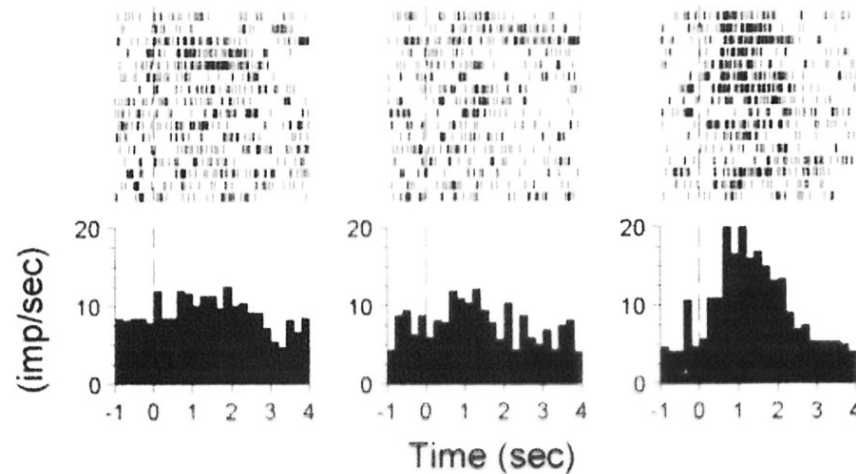
human  
amygdala  
cell  
responding  
to emotion  
of surprise  
on faces



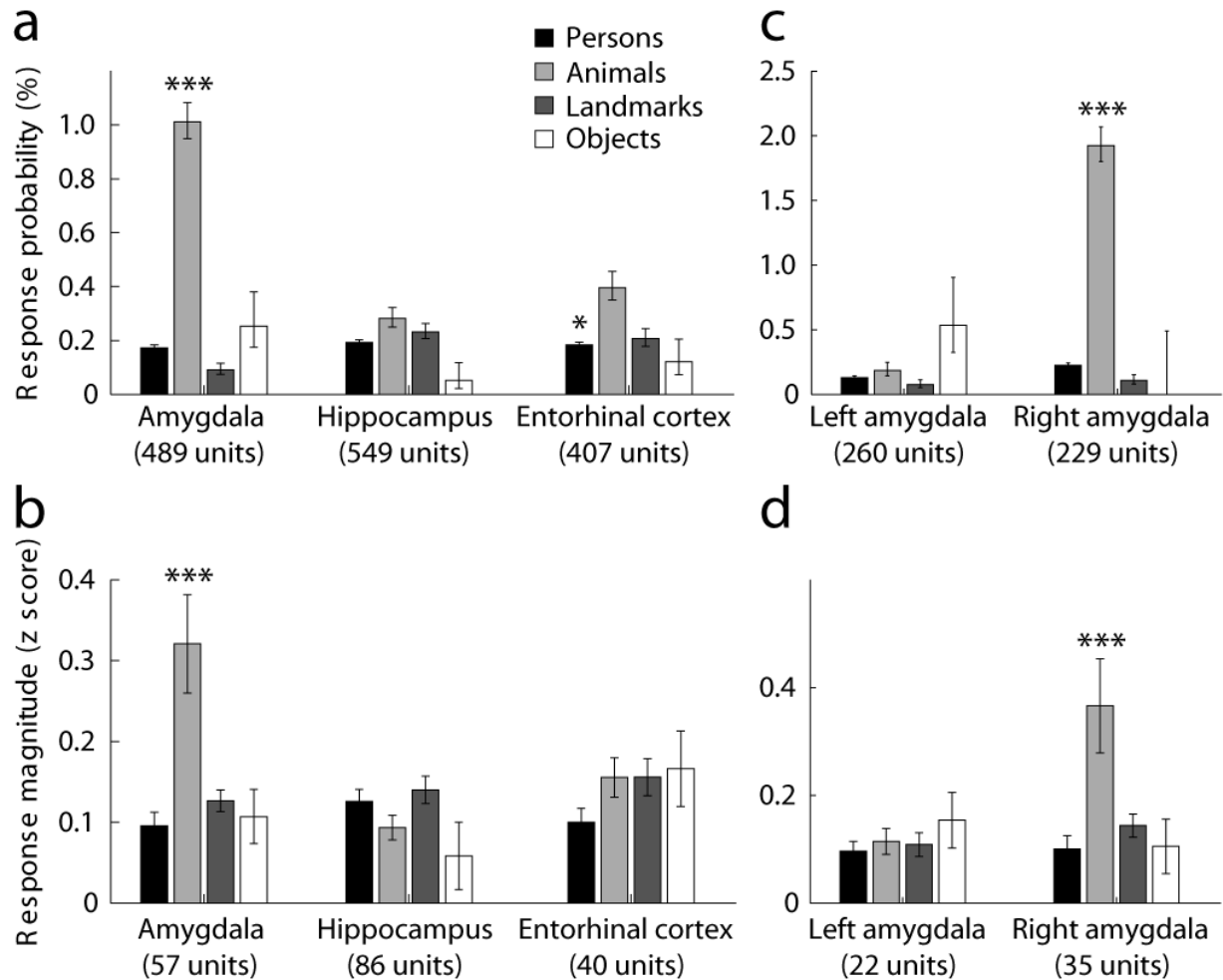
Anger

Sad

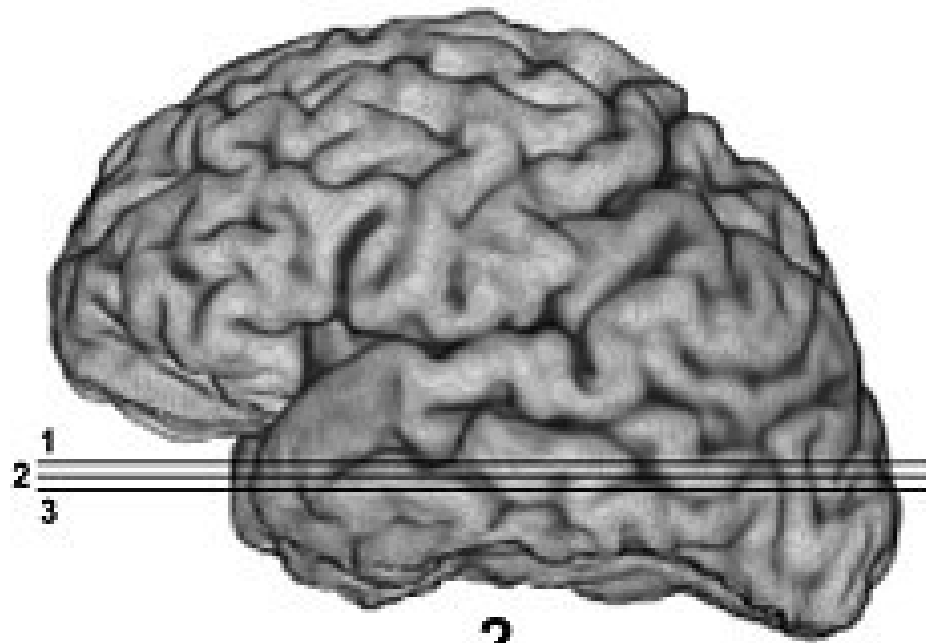
Surprise



right  
human  
amygdala  
cells  
responding  
to pictures  
of animals



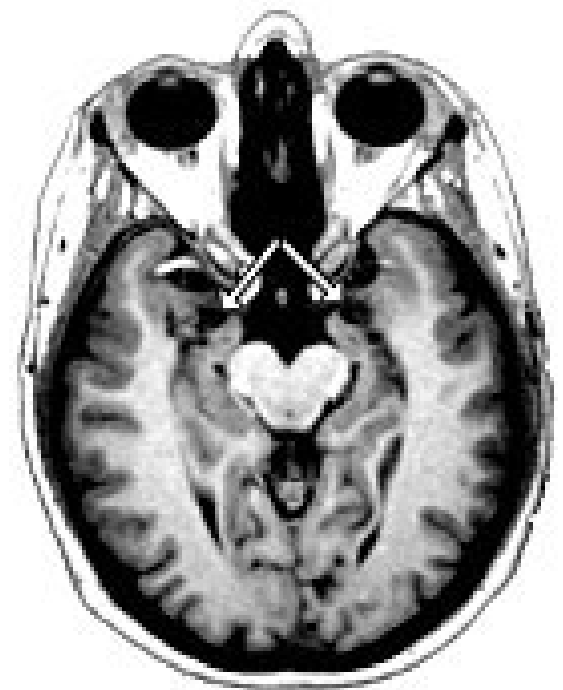
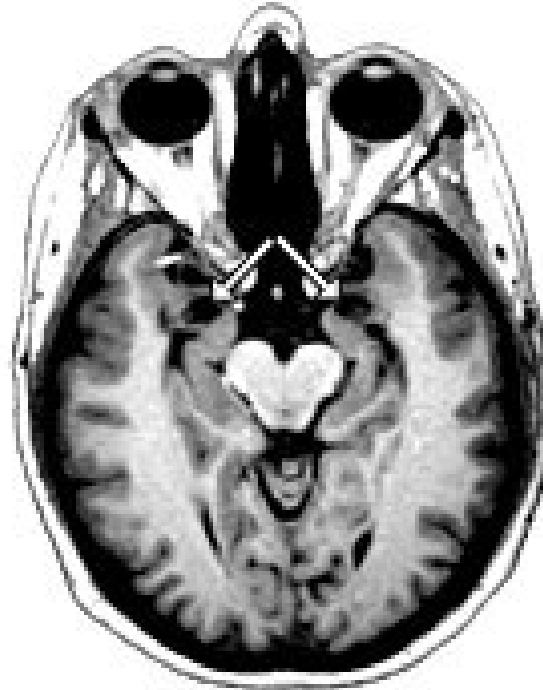
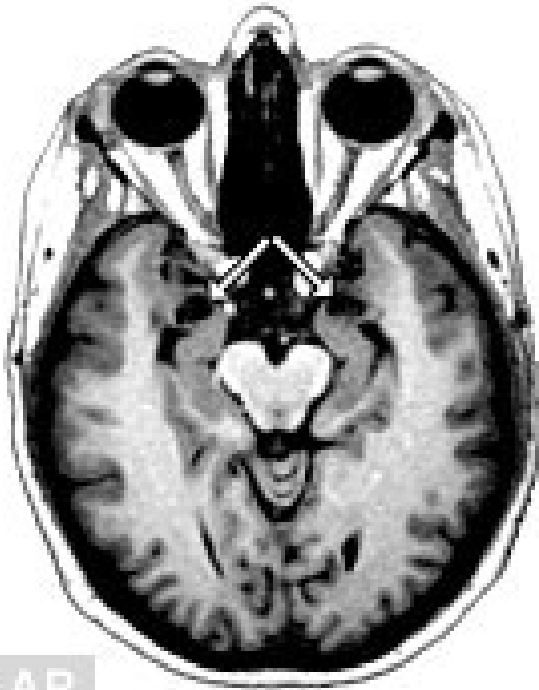
SM's  
Missing  
amygdala



**1**

**2**

**3**





S.M's  
drawings  
of  
emotions



**HAPPY**



**SAD**



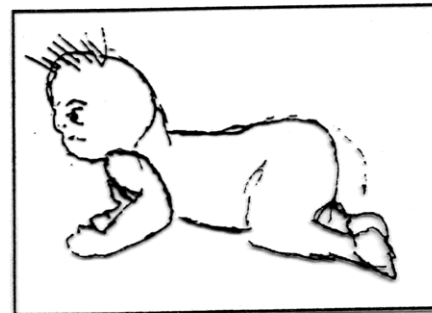
**SURPRISED**



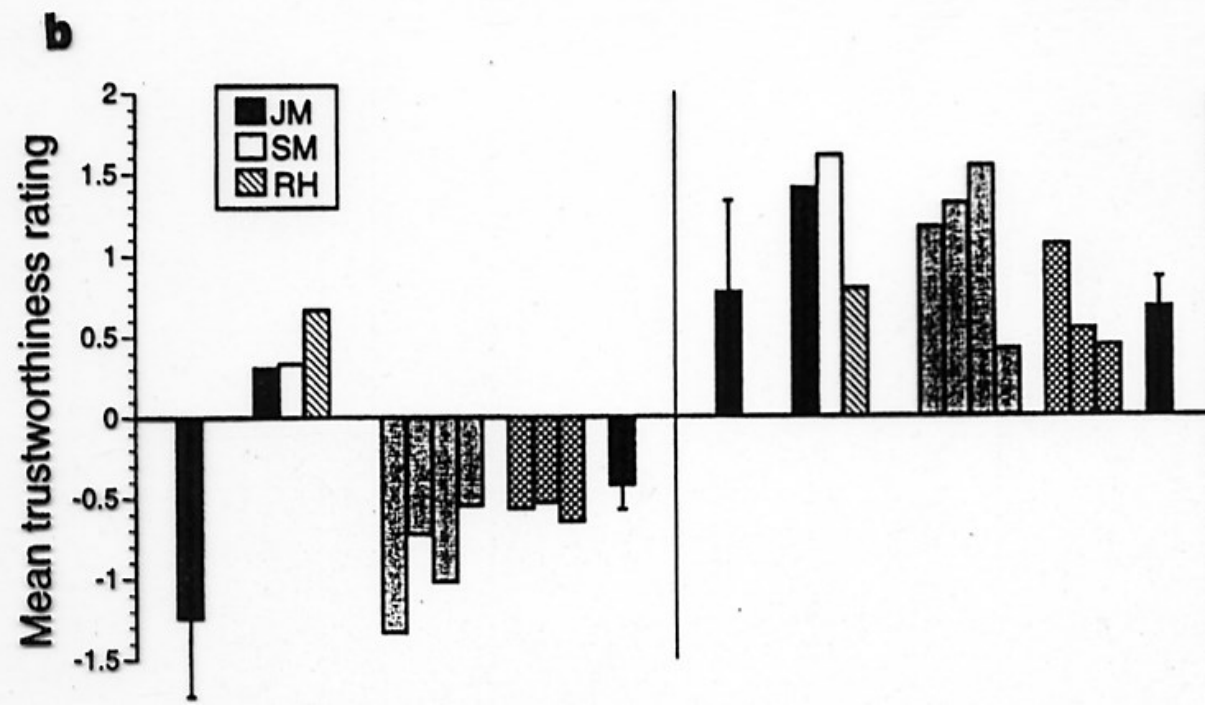
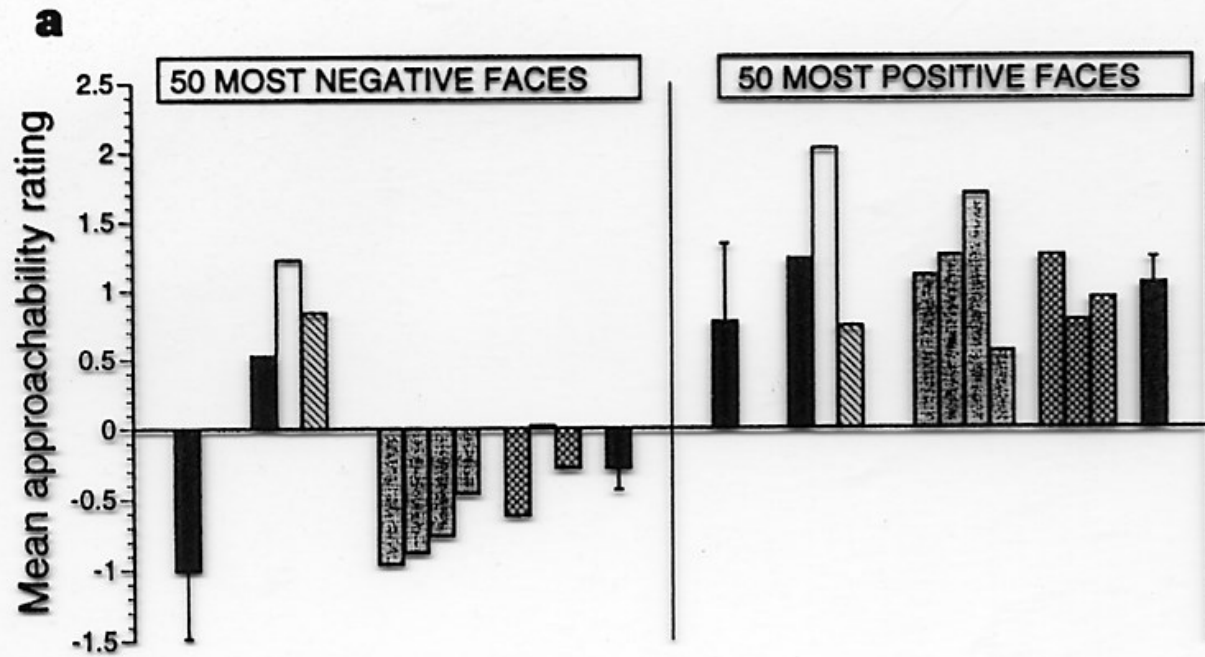
**DISGUSTED**

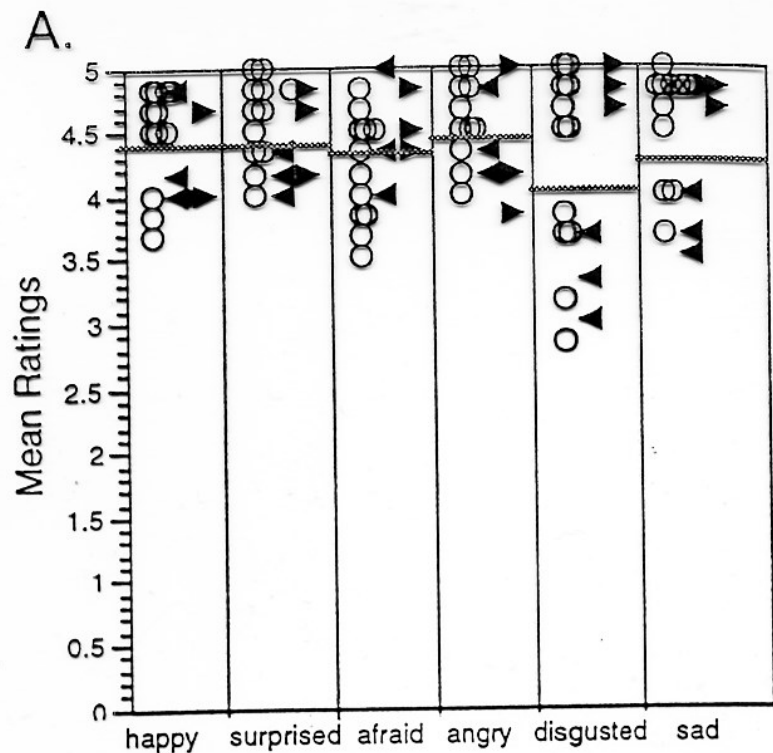


**ANGRY**

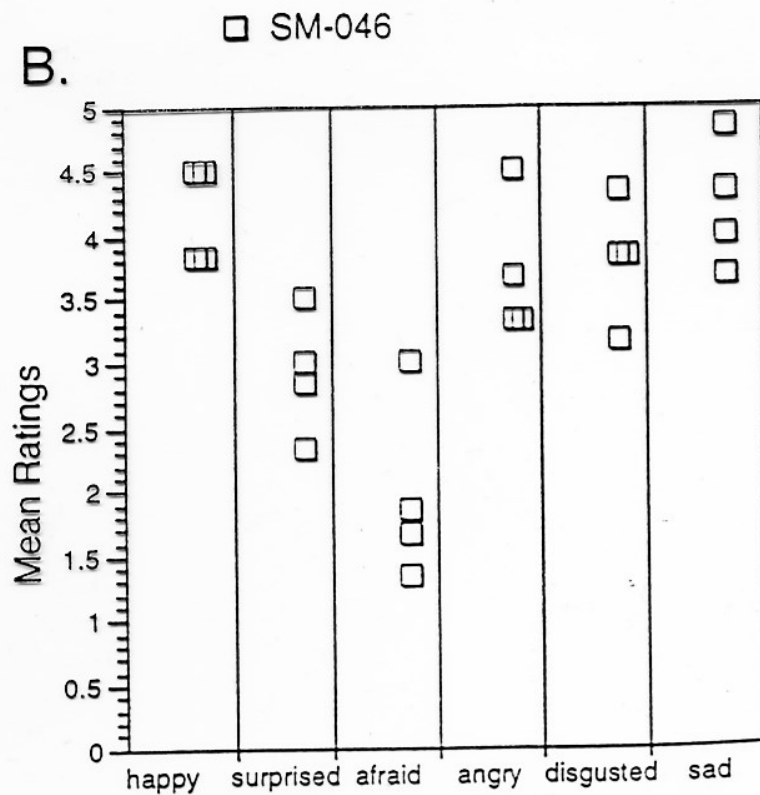


**AFRAID**





- Brain-damaged controls
- Normal controls
- ◄ Left Amygdala damage
- Right Amygdala damage



*Figure 3.* Ratings of the intensity of an emotion in facial expressions. Rating scores (from 0–5) on the emotional word for which the face was a typical example are shown as the mean of all faces within an emotion category. *A.* Data from 12 brain-damaged controls (○), 3 subjects with left (◄), and 3 with right (►) amygdala damage. *B.* Mean data from four experiments with SM-046 (□).

Bilateral  
amygdala  
activation from  
threatening  
words

