

# Neuroimagerie des effets non formateurs d'images de la lumière sur le locus coeruleus

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Thèse de Master en sciences biomédicales

Promoteur: Gilles Vandewalle (PI)

Superviseur: Elise Beckers (PhD student)



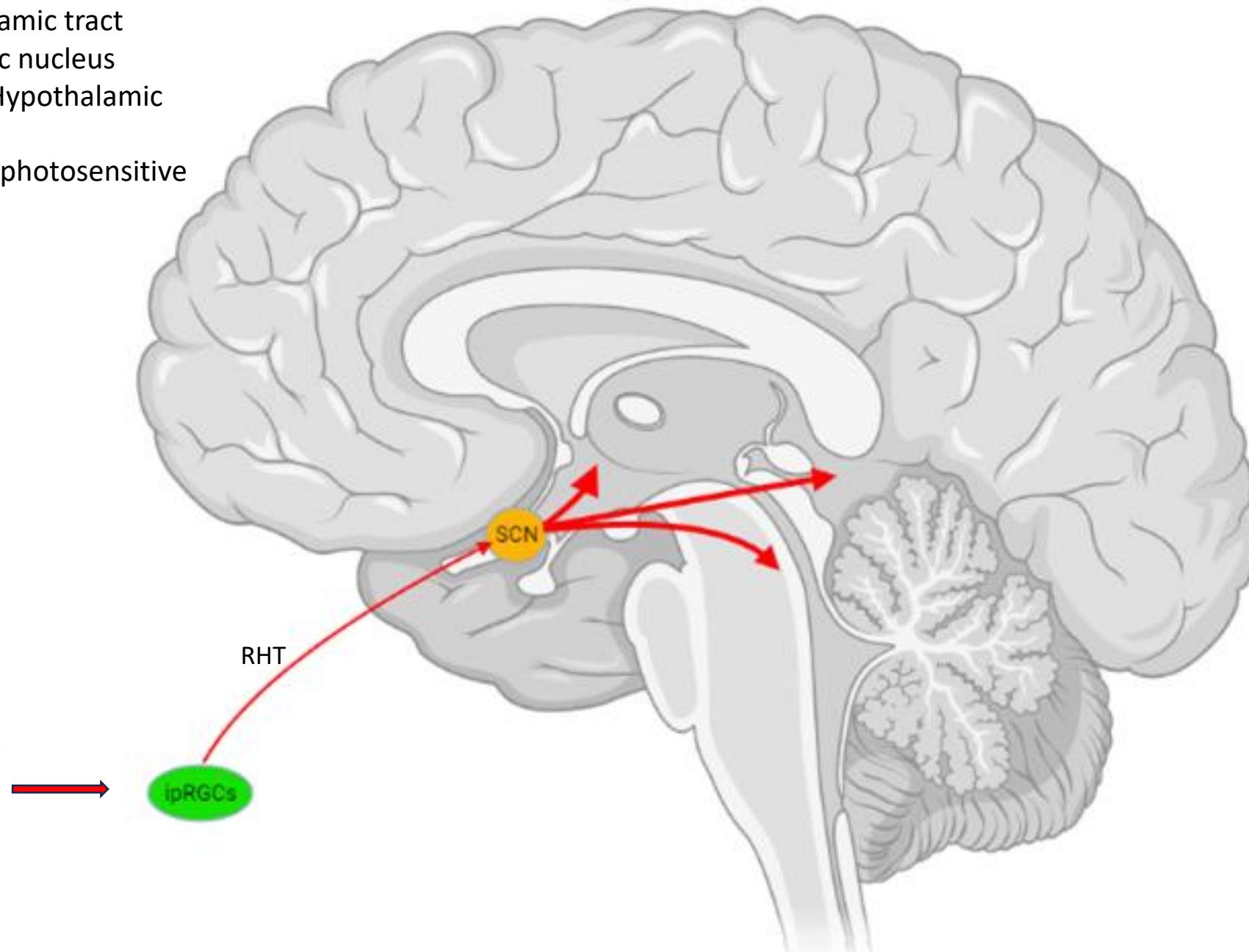
RHT: Retinohypothalamic tract

SCN: Suprachiasmatic nucleus

DMH: Dorsomedial Hypothalamic  
Nucleus

ipRGCs : Intrinsically photosensitive  
retinal ganglion cells

**LC: Locus coeruleus**

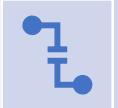


# Hypothèses et objectifs

Est-ce que la lumière bleue augmente l'activité du LC lors d'une tâche attentionnelle ?



**Hypothèse :** augmentation de l'activité du LC en condition de lumière bleue comparée à une condition contrôle (lumière orange)



**Variable évaluée :** changement du signal BOLD dans le LC et autres régions d'intérêt pendant la tâche



IRM 7T

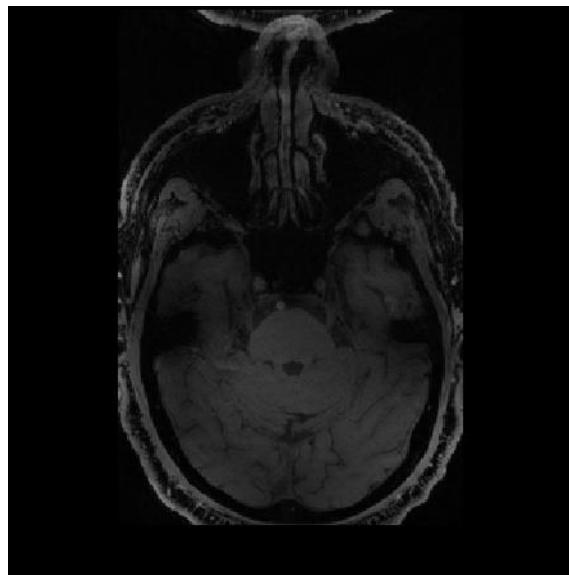


- Participants âgés en bonne santé
- 60 – 80 ans
- 11 M / 5 F

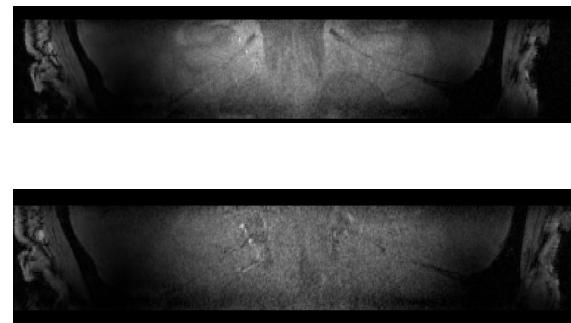


# Acquisition en IRM 7T

**MP2RAGE**



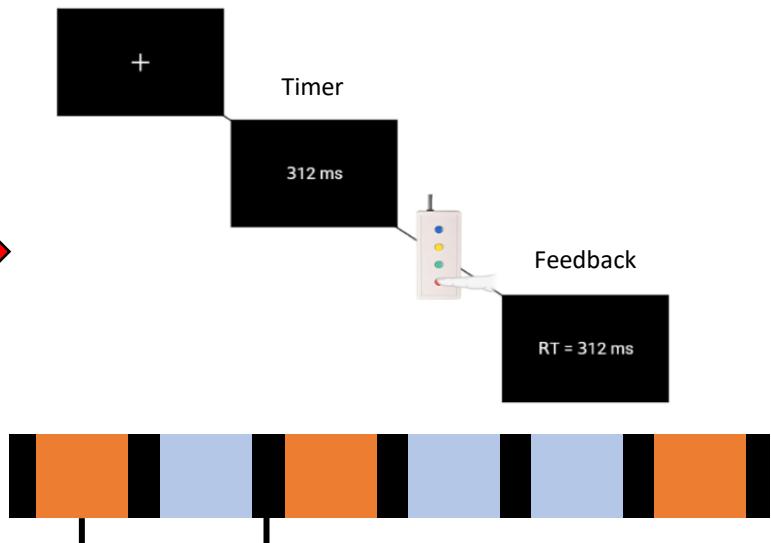
**MT-TFL**



~ 9 min

30s      10-15s

~ 12 min



# Résultats et conclusions

Aucun effet observé de la lumière enrichie en bleu sur le LC pendant la PVT

Activation plus importante dans les zones recevant ou envoyant des projections de/vers le LC

Activation plus importante dans les régions liées à l'attention soutenue

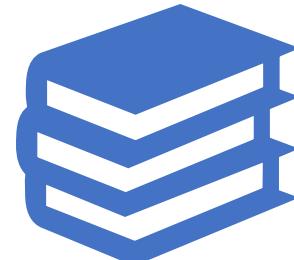
Faible nombre de participants ( $n = 16$ )

ACC, PFC, HIPP, THAL

ACC, PFC, IPS, STN



Besoin de plus de participants



Consistance avec la littérature

# Thank you



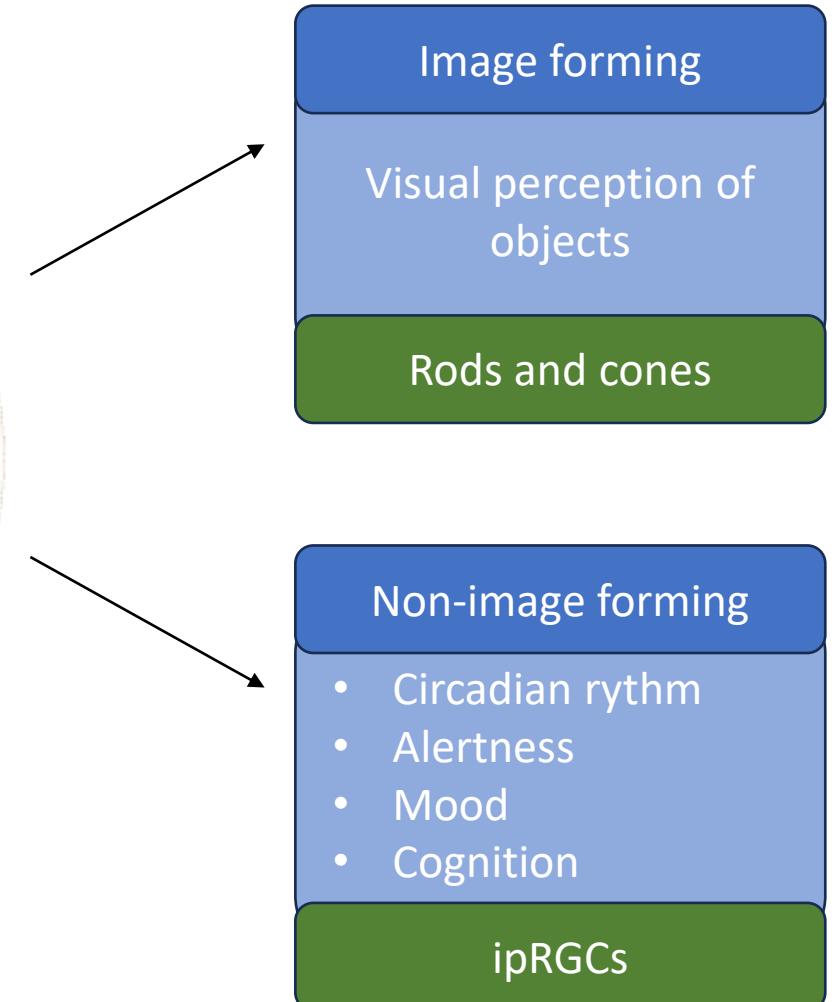
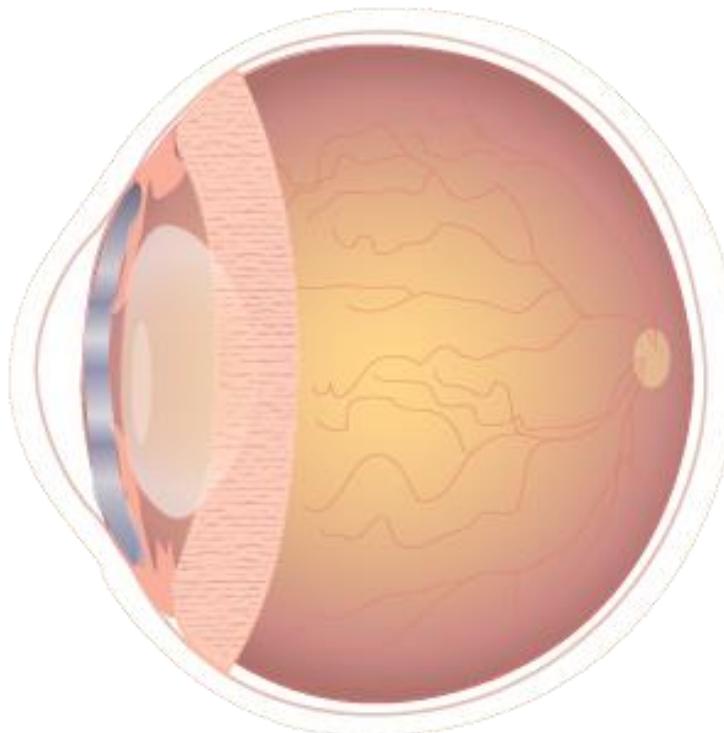
Elise Beckers

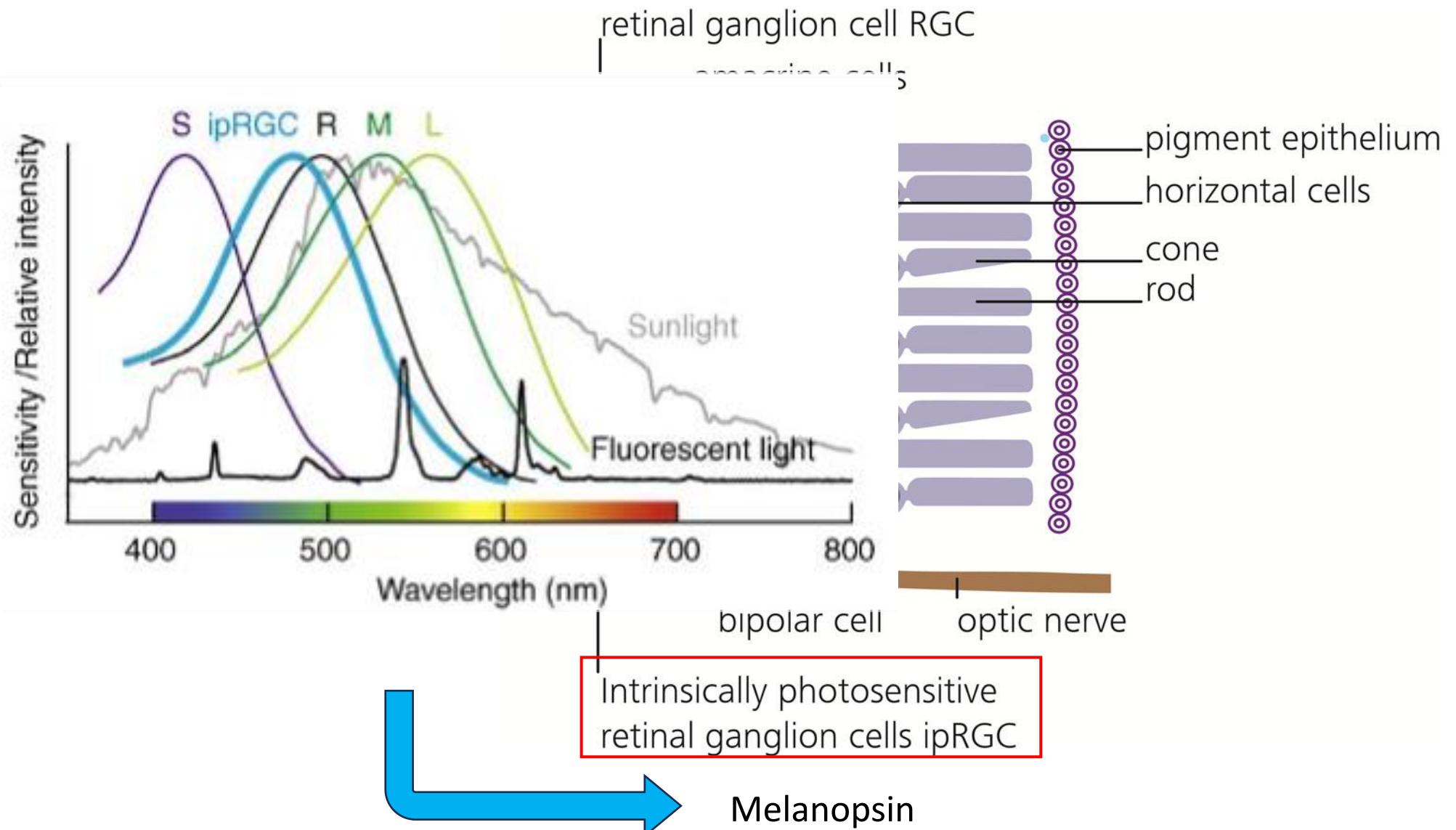


Gilles Vandewalle



# Effects of light

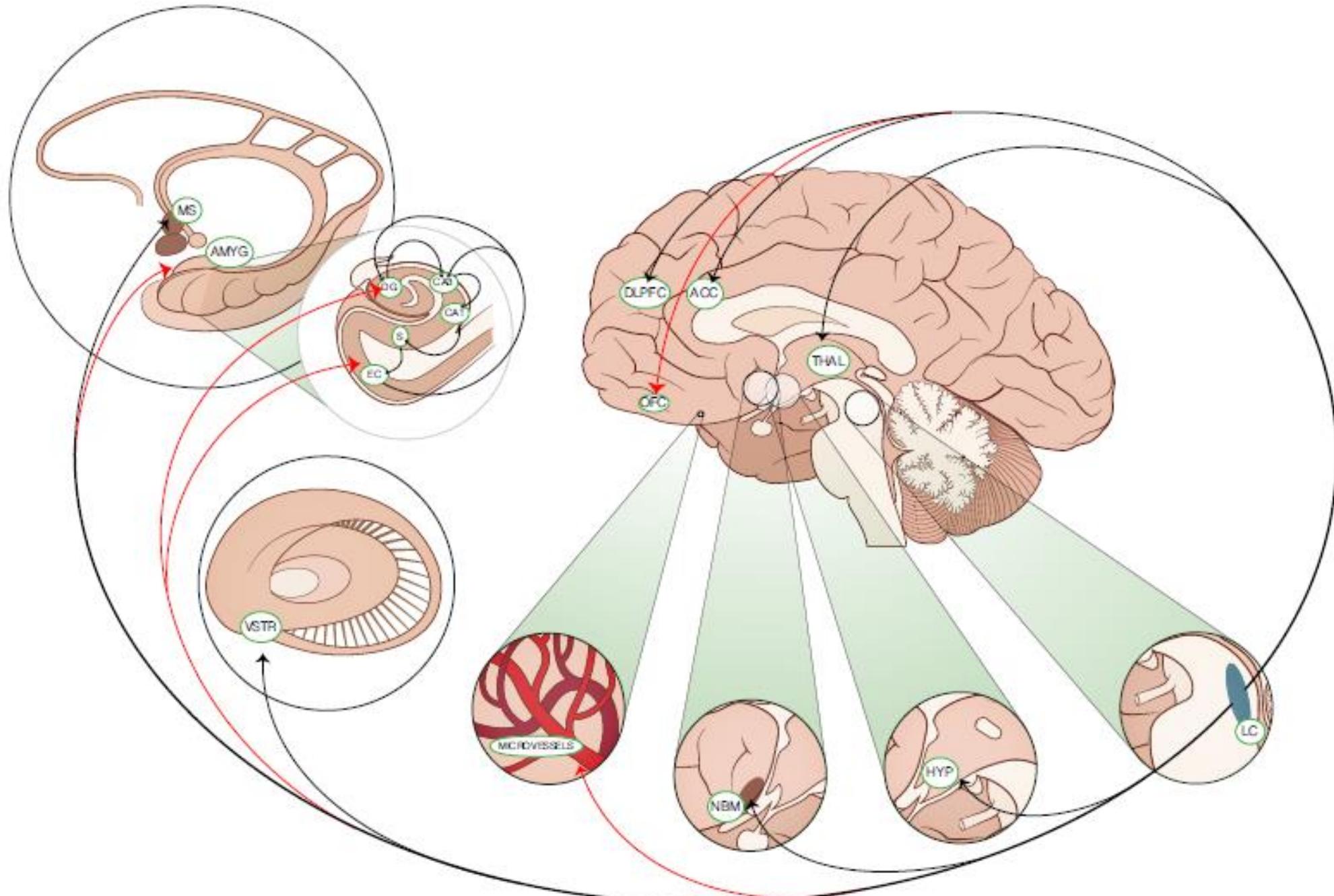




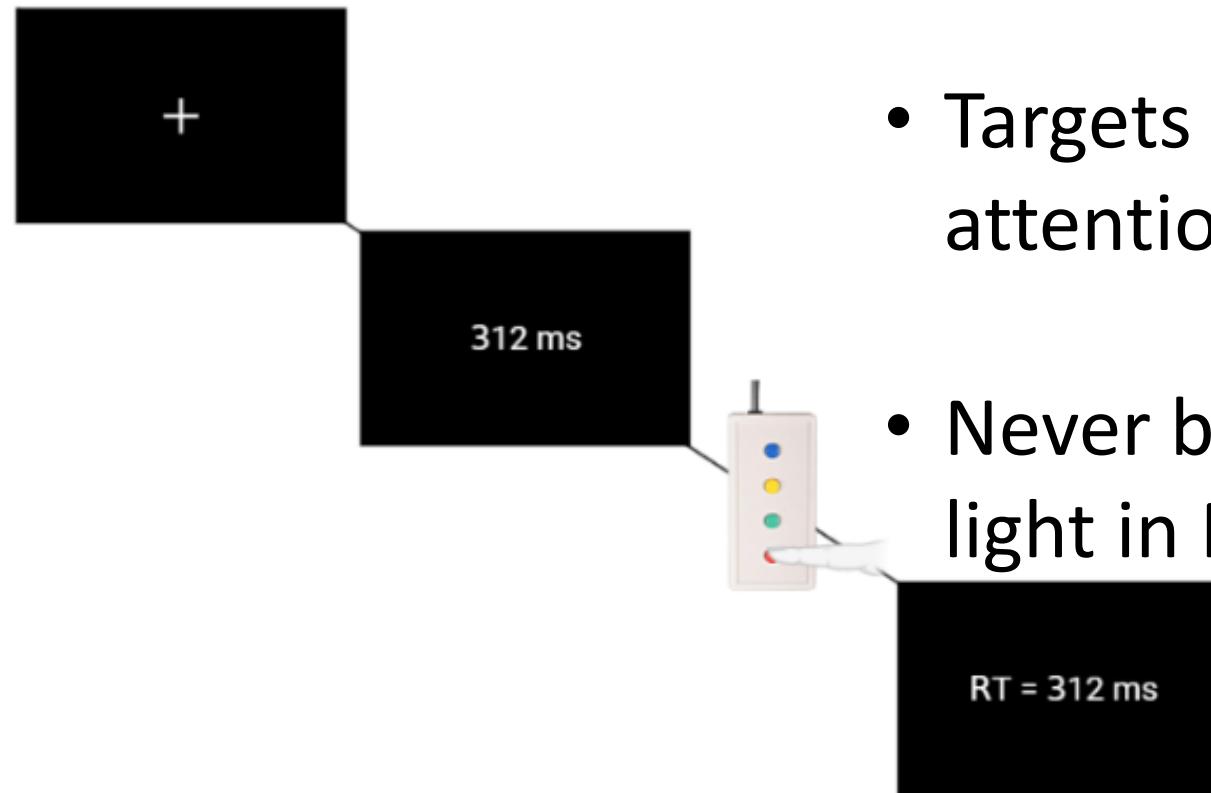
# The locus coeruleus



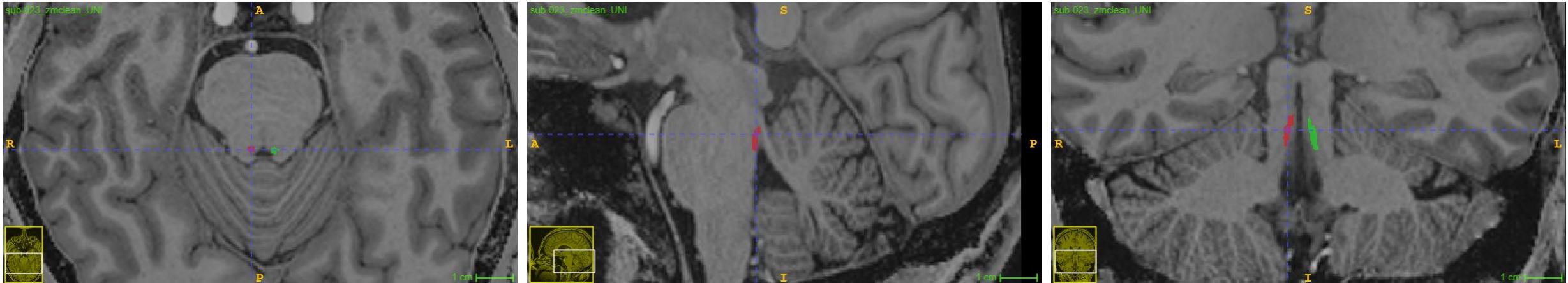
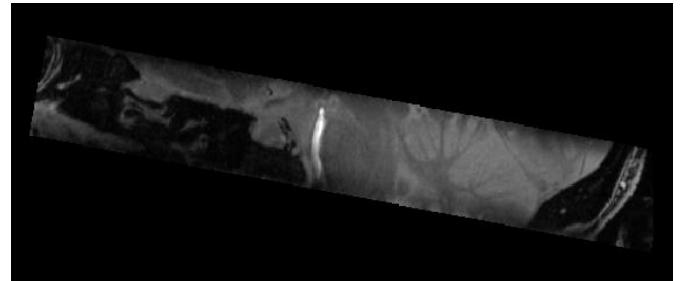
- Small brainstem nuclei of the dorsal pons (12–17 mm length)
- Main source of norepinephrine (NE) secretion in the brain
- Orchestrates cognition, notably attention
- One of the first sites of Alzheimer's disease onset



# The Psychomotor Vigilance Task (PVT)



# Manual LC segmentation



Betas extraction

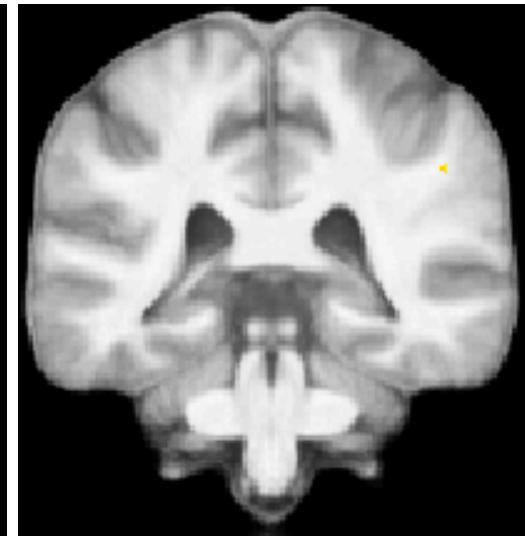
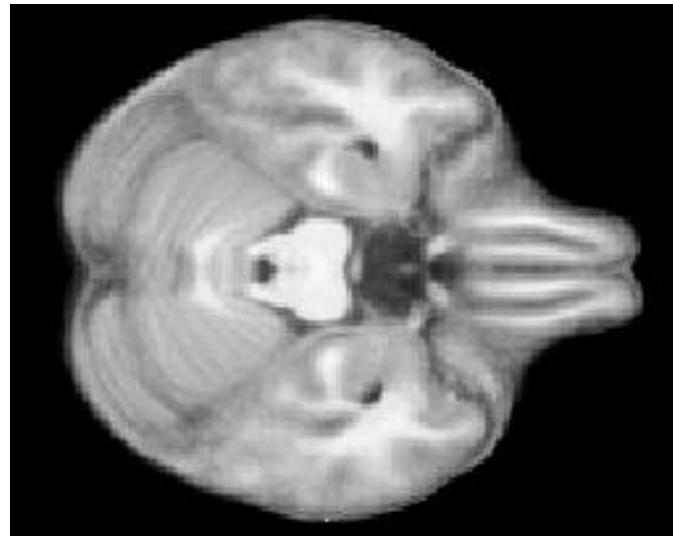
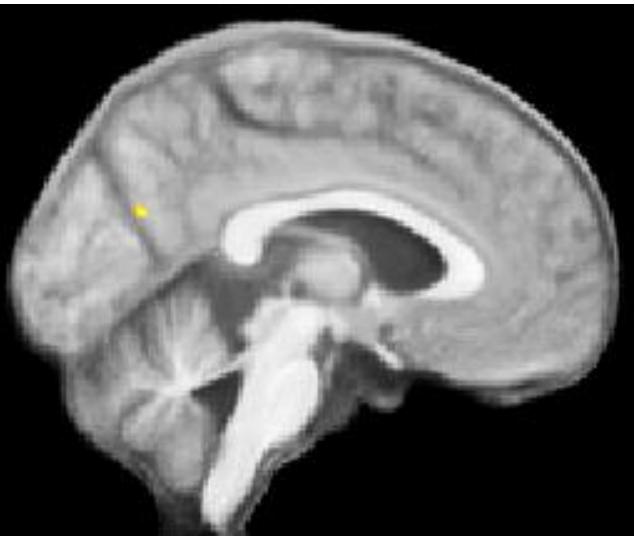


 SAS<sup>®</sup>

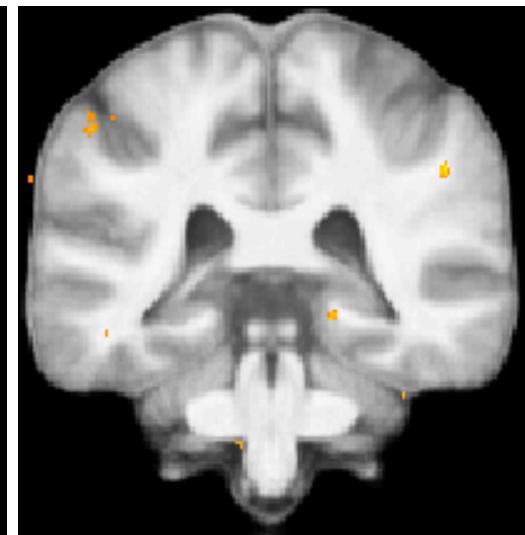
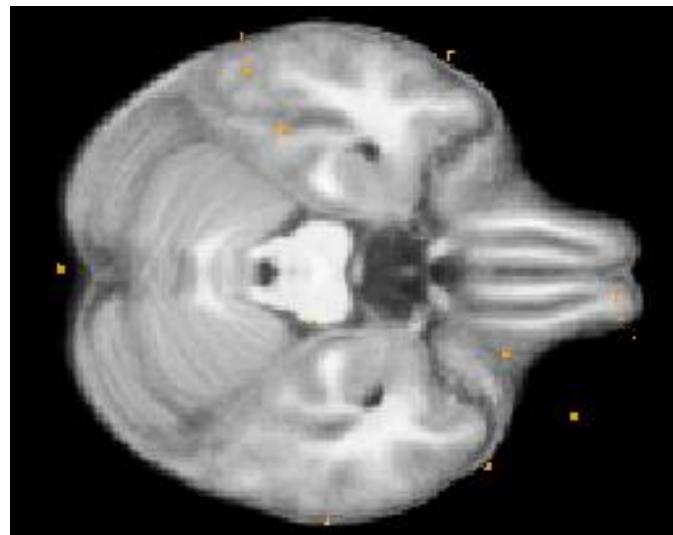
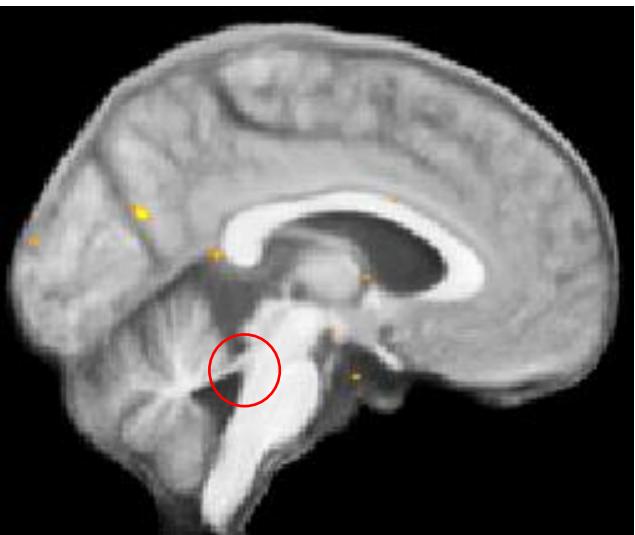
The SAS logo consists of a stylized blue 'S' followed by the word 'SAS' in a bold, black, sans-serif font, with a registered trademark symbol.

# Whole brain results

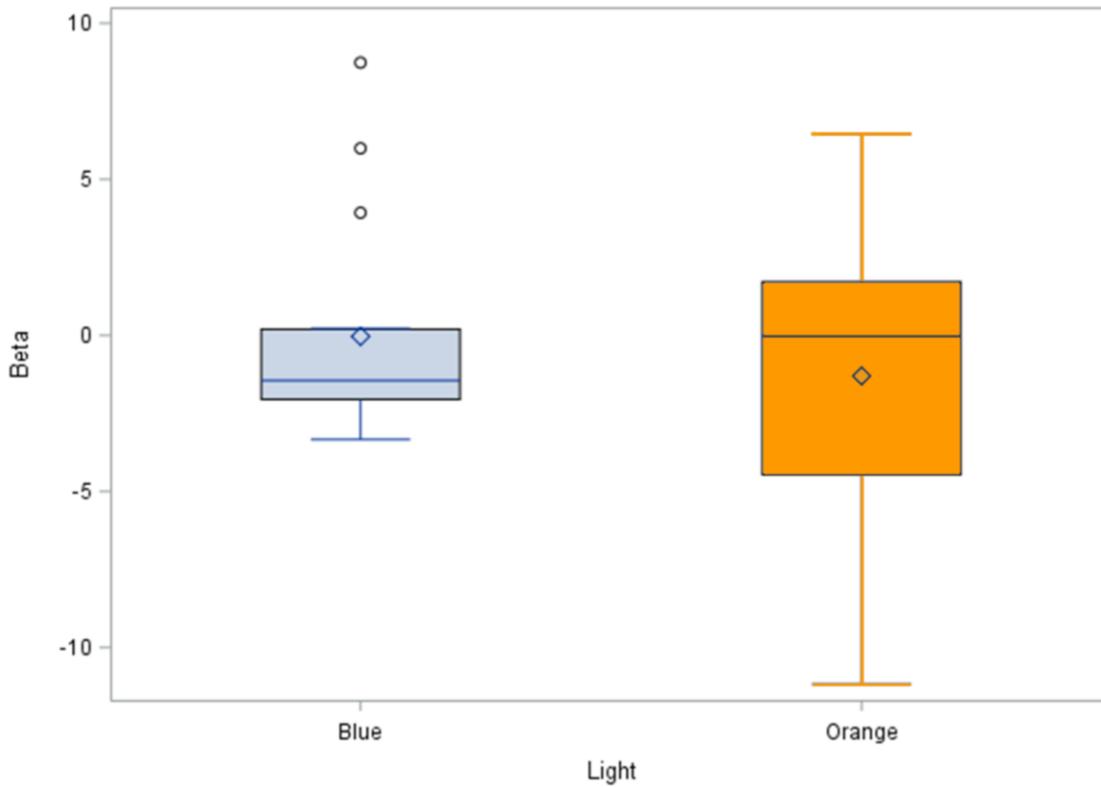
$p_{uncorrected} = 0.001$



$p_{uncorrected} = 0.005$



# No significant results in the LC

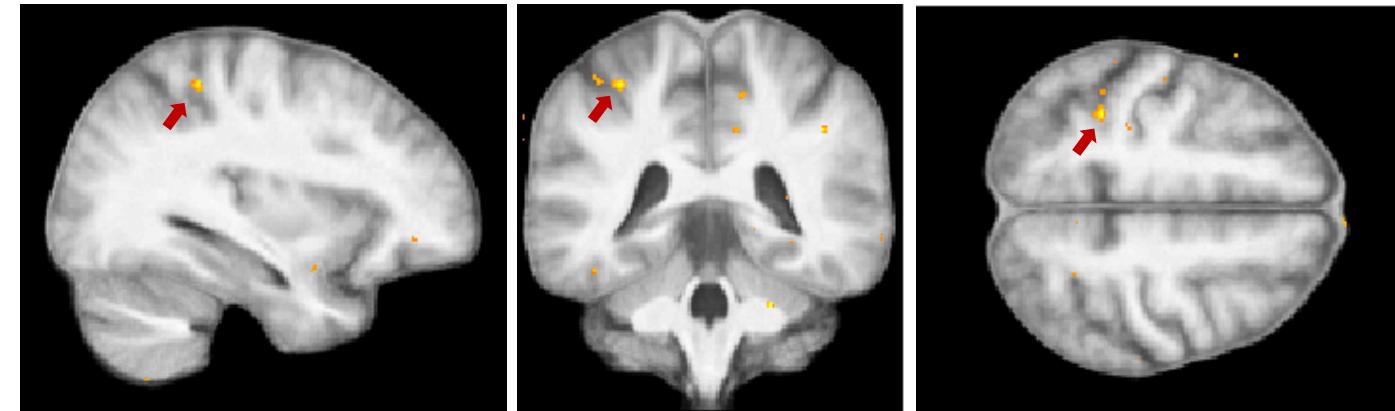
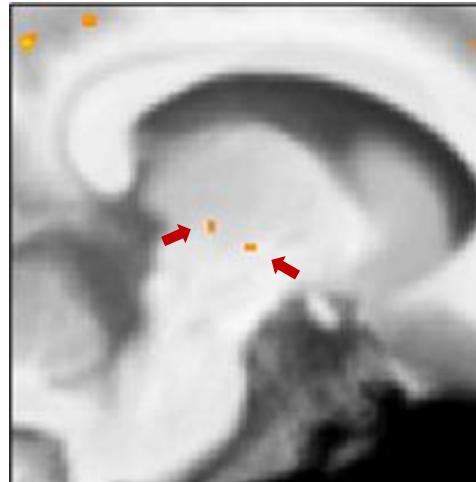


t-test				
Mean	SD	df	t	p
1.2667	3.9644	30	0.90	0.3734

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	28	0.80	0.3798
Gender	1	28	2.34	0.1375
Age	1	28	2.10	0.1579

# Higher activation under blue-enriched light condition

- Thalamus  
(intralaminar nucleus) (R)
- Subthalamic nucleus (R)
- Hippocampus (L/R)
- Intraparietal sulcus (L)
- Prefrontal cortex (R)
- Anterior cingulate cortex (R)



# Perspectives



**First indication of NIF impacts  
of blue-enriched light on  
cognition during a visual PVT  
in MRI**



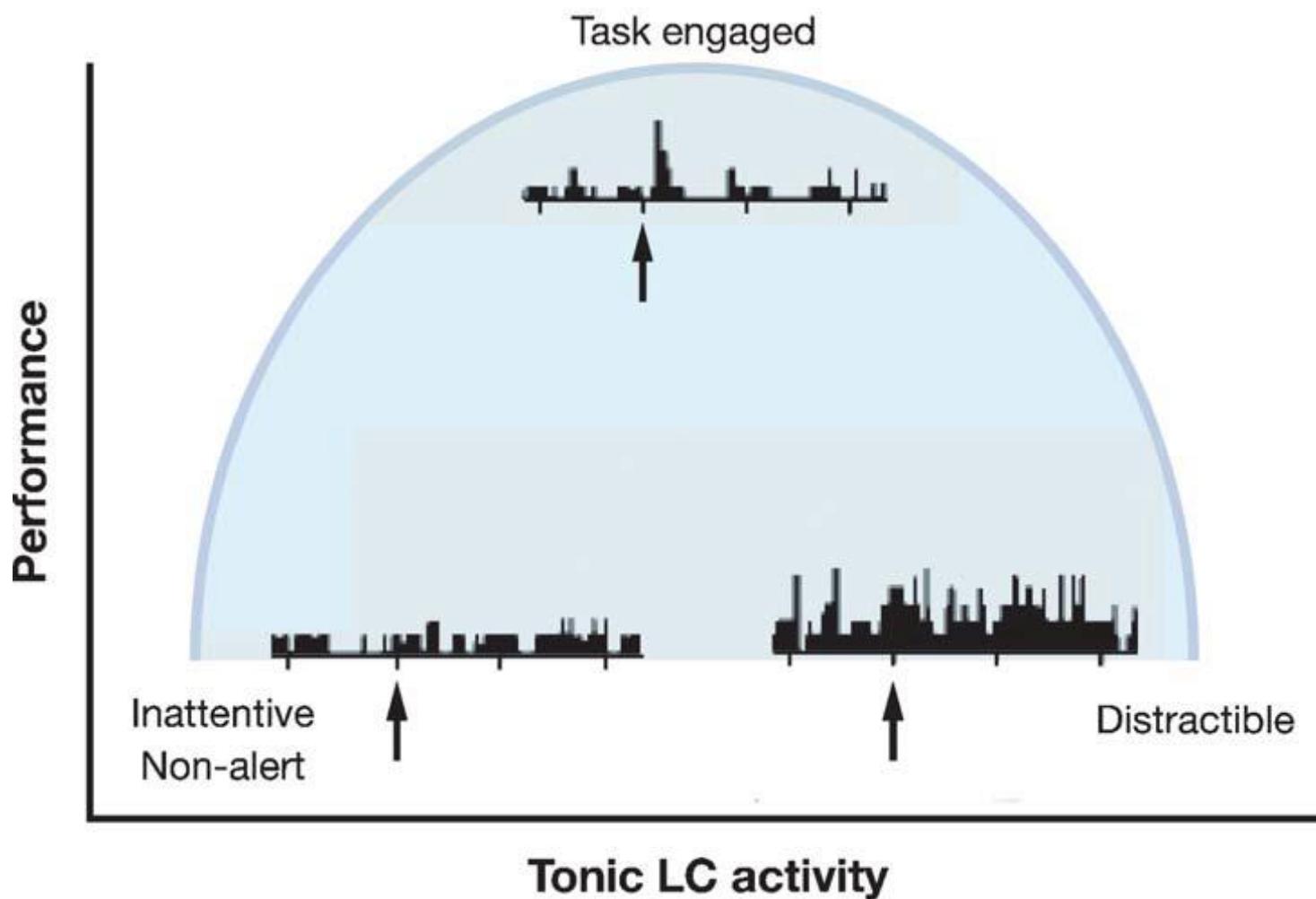
**Central role of the LC in  
Alzheimer's disease**



**tVNS**  
**New ways of impacting  
the LC**



## YERKES-DODSON RELATIONSHIP





- Habitual sleep schedule ( $\pm 1\text{h}$ )
- Sleep diary
- ActiGraph watch
- No naps

Somno-Art device



Morning of  
the scan

1<sup>st</sup> scan

Light  
adaptation

-1 week

-3 days

-1 night

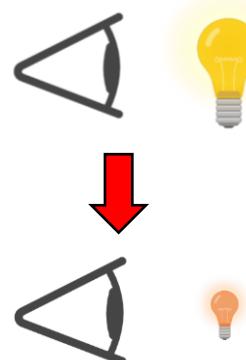
2<sup>nd</sup> scan



No stimulants drinks



- Arriving  $\sim 2\text{h}$  after waking time
- PVT before and after the scan

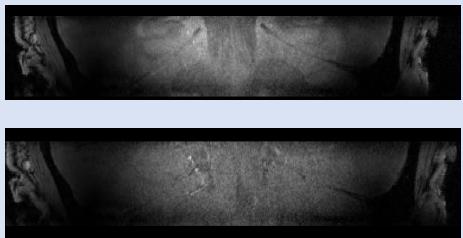


## Acquisition

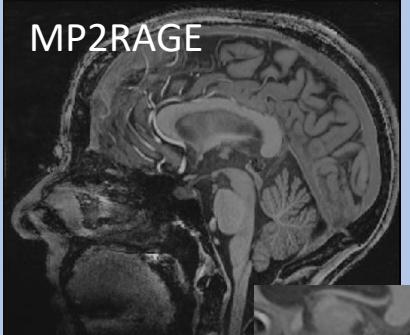
## Structural space

## MNI

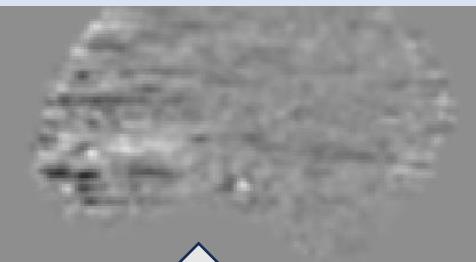
MT-TFL



Coregistration



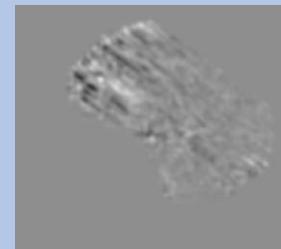
Mean



fMRI

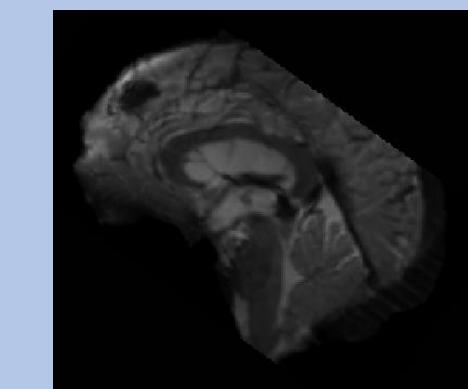
EPI

Yellow arrow

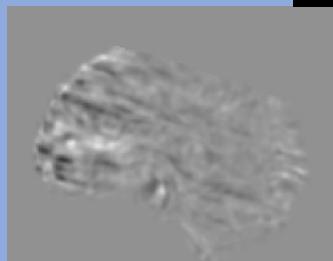


Segmentation

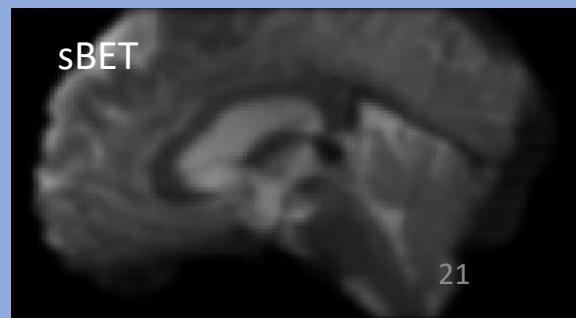
Beta extraction



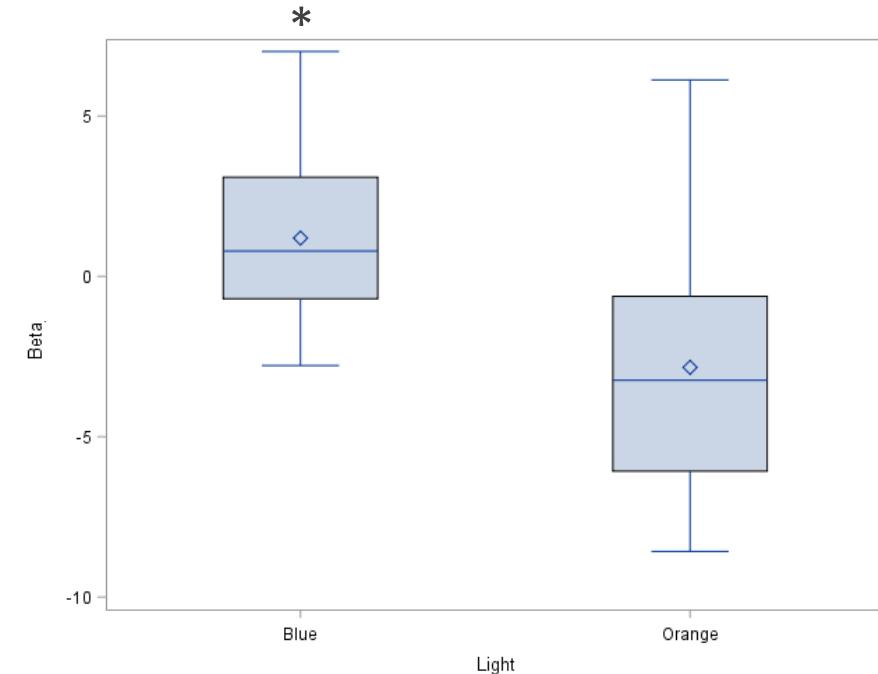
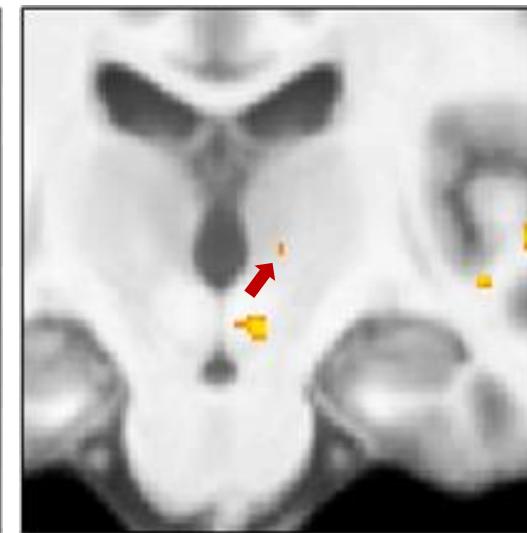
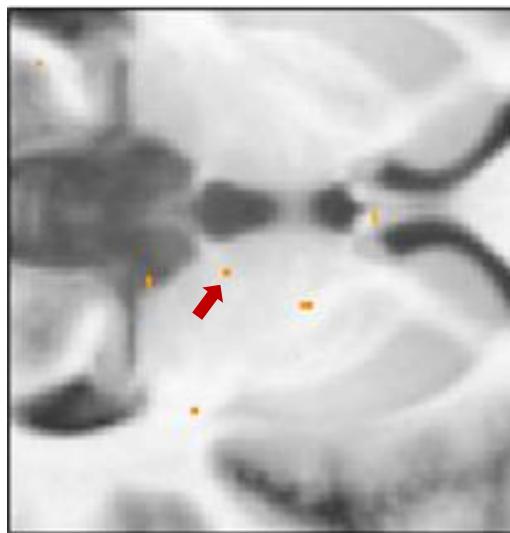
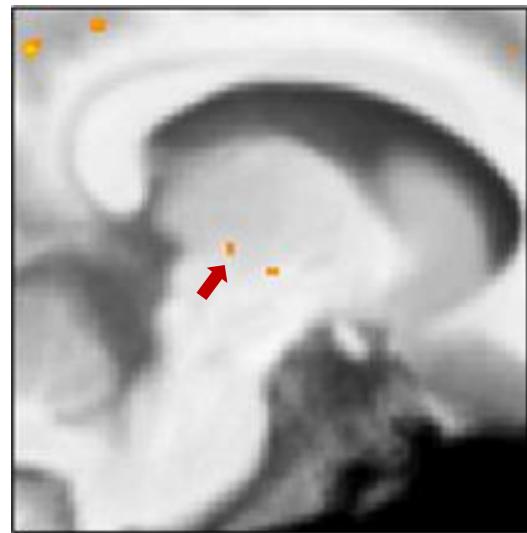
Yellow arrow



White arrow



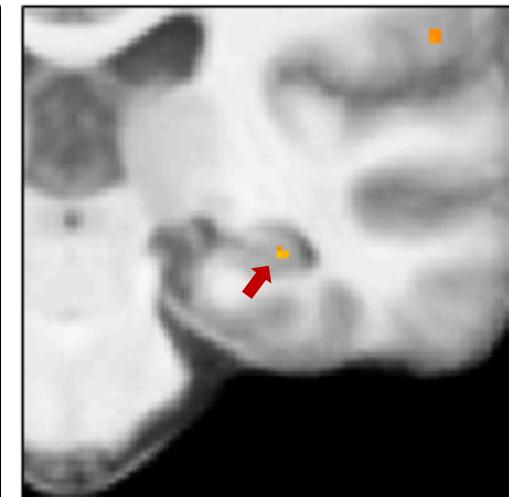
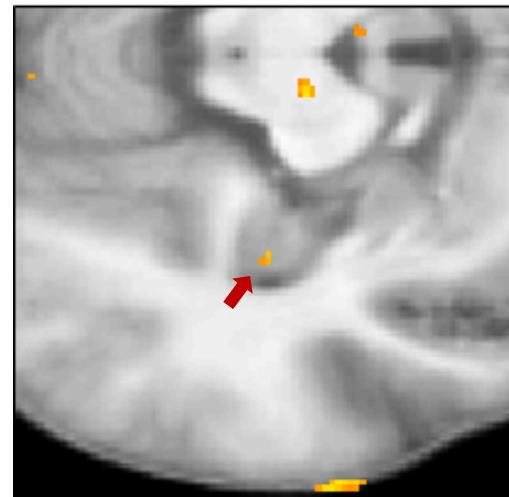
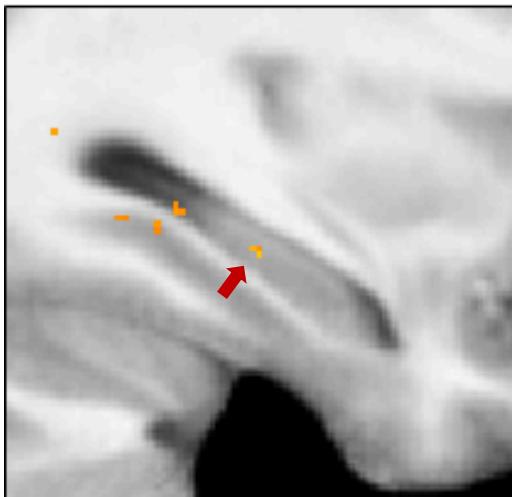
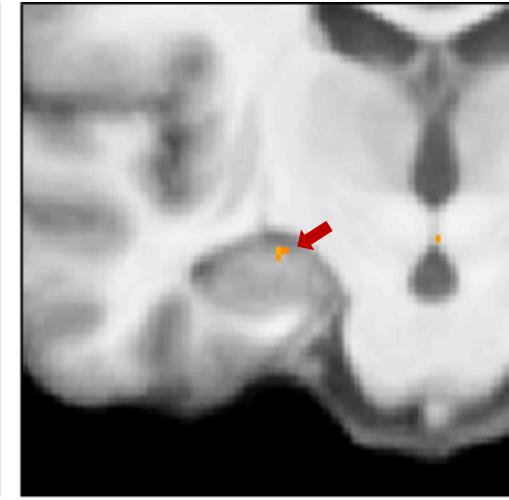
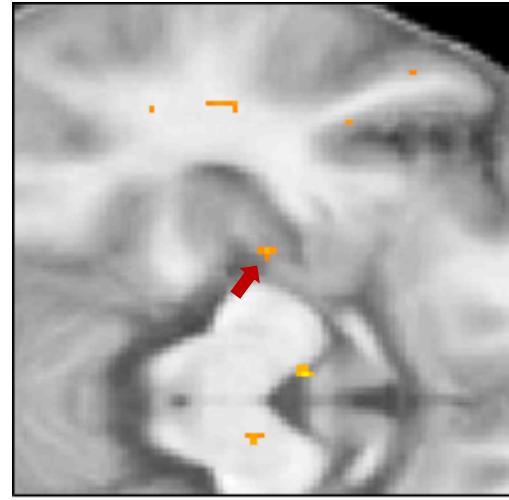
# Right thalamus (Intralaminar nucleus)



Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	28	8.78	0.0062
Gender	1	28	0.02	0.8982
Age	1	28	2.09	0.1594

t-test				
	Mean	SD	df	p
	4.0312	3.4905	30	3.27
				0.0027

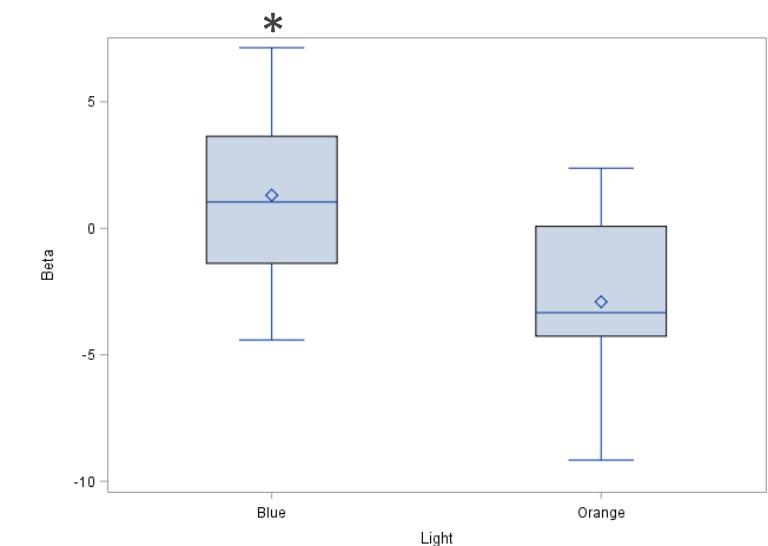
# Left and right hippocampus



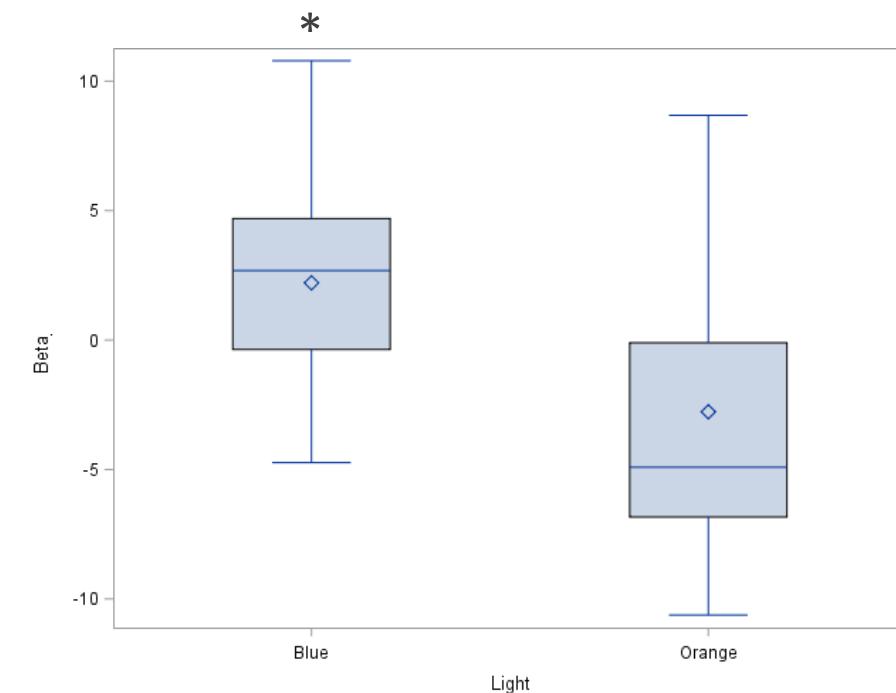
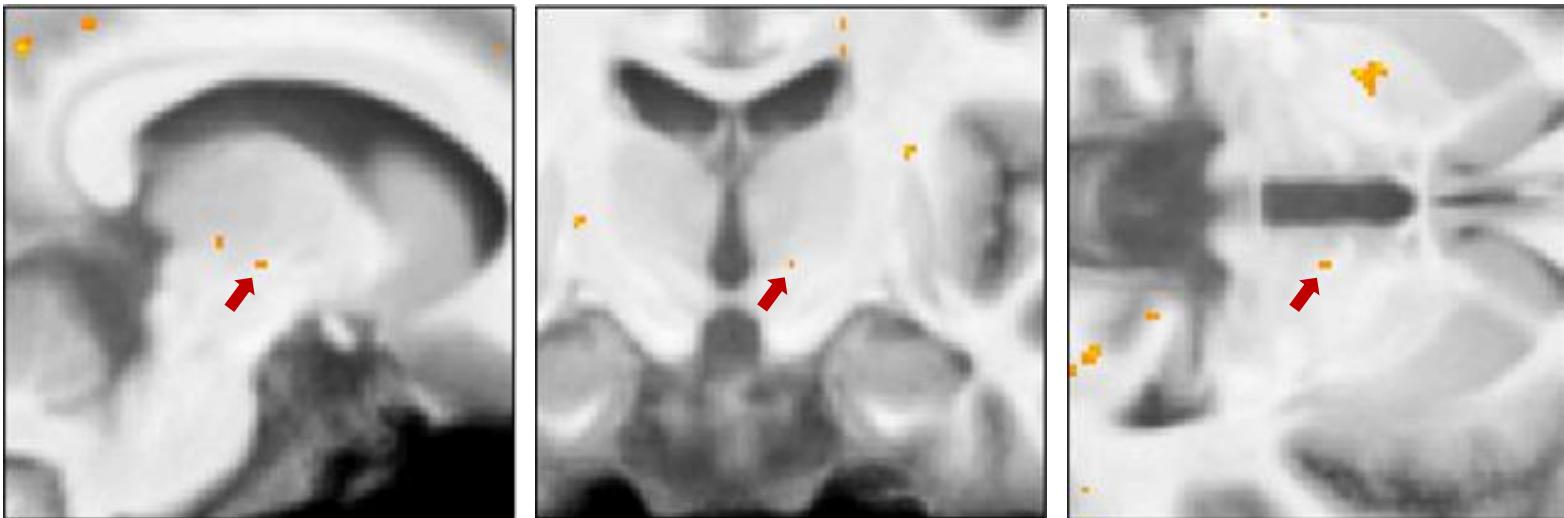
Side	t-test				
	Mean	SD	df	t	p
L	4.2162	3.4892	30	3.36	0.0022
R	4.1065	4.4517	30	2.61	0.0140

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	27	10.68	0.0030
Gender	1	27	1.30	0.2646
Age	1	27	0.22	0.6460

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	28	5.84	0.0224
Gender	1	13	7.49	0.0170
Age	1	13	0.31	0.5886



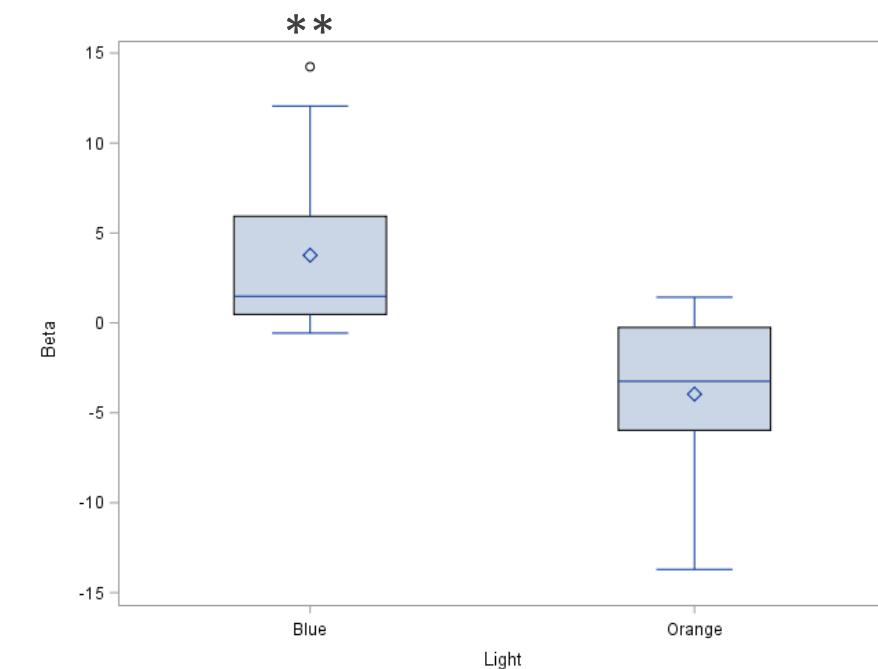
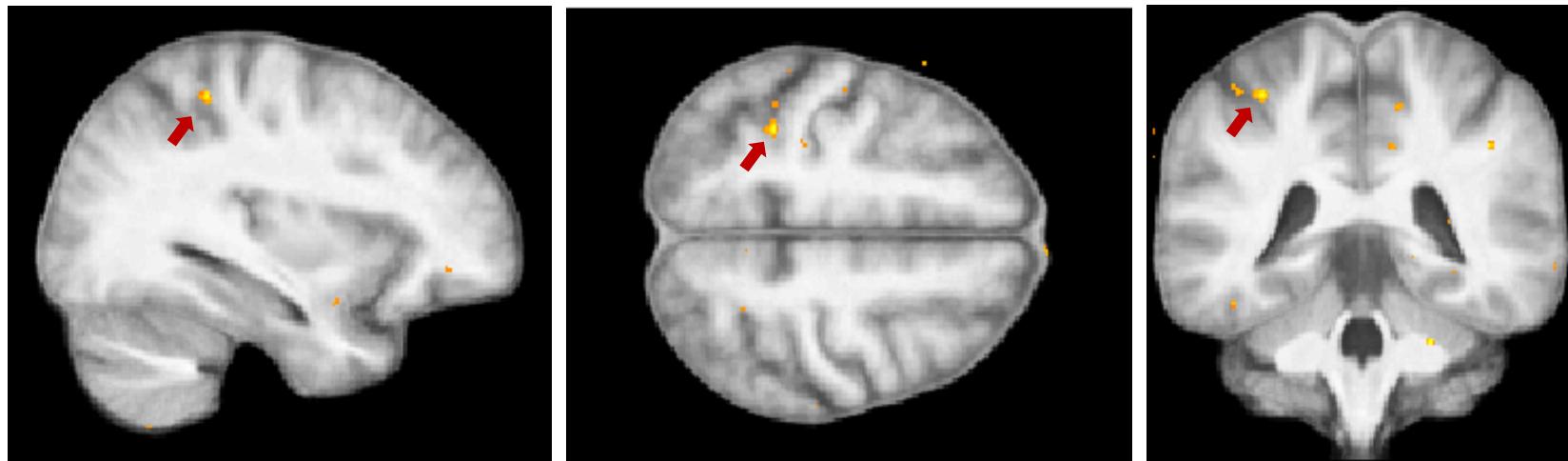
# Right subthalamic nucleus



Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	28	7.56	0.0103
Gender	1	28	2.21	0.1480
Age	1	28	1.89	0.1797

t-test				
Mean	SD	df	t	p
4.9785	5.0591	30	2.78	0.0092

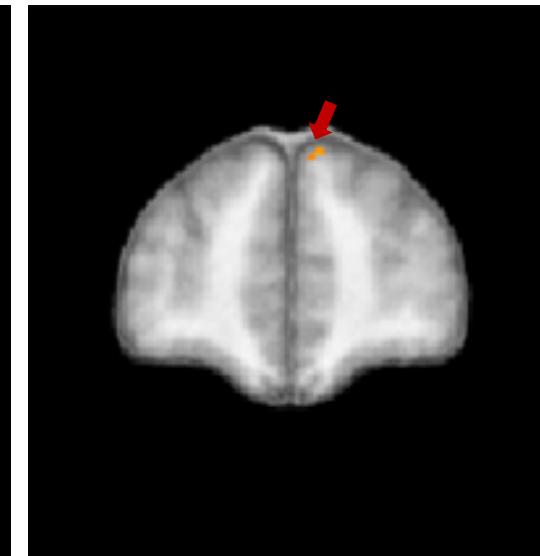
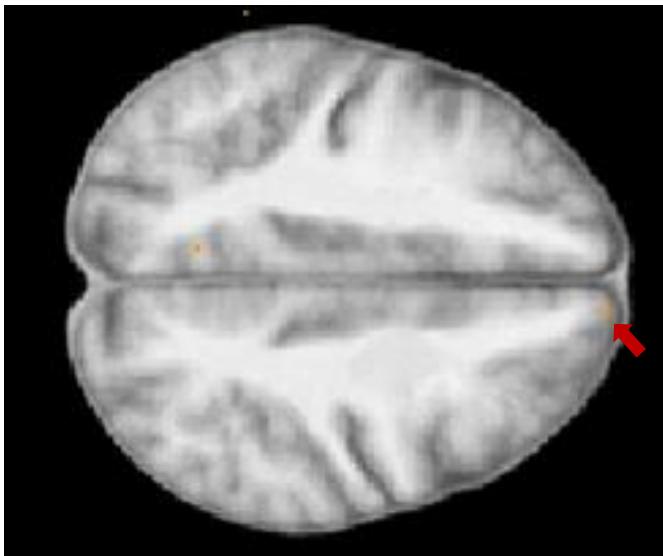
# Left intraparietal sulcus



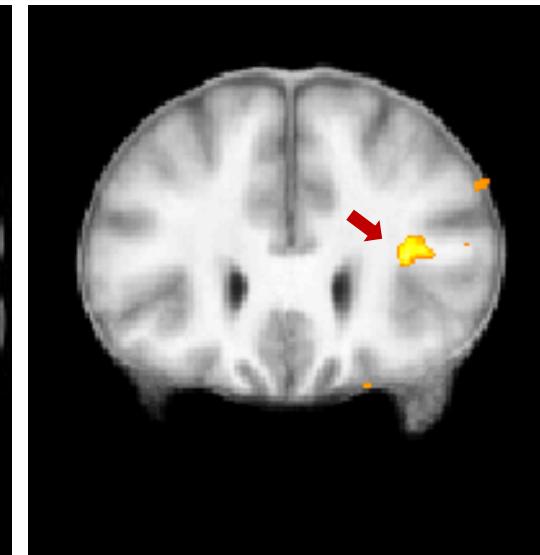
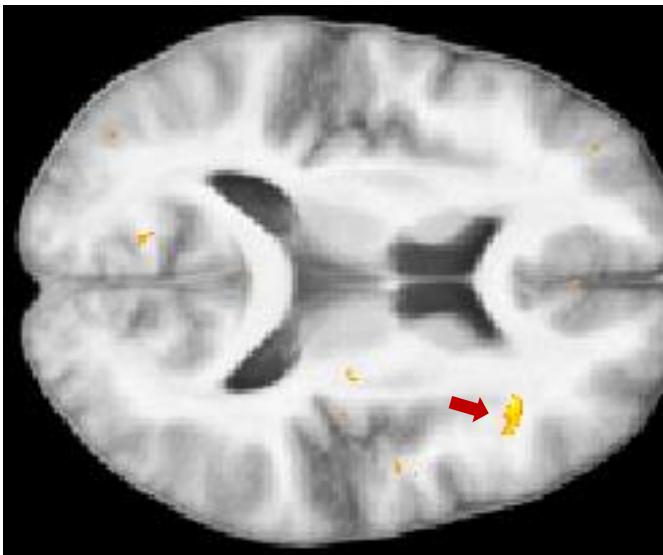
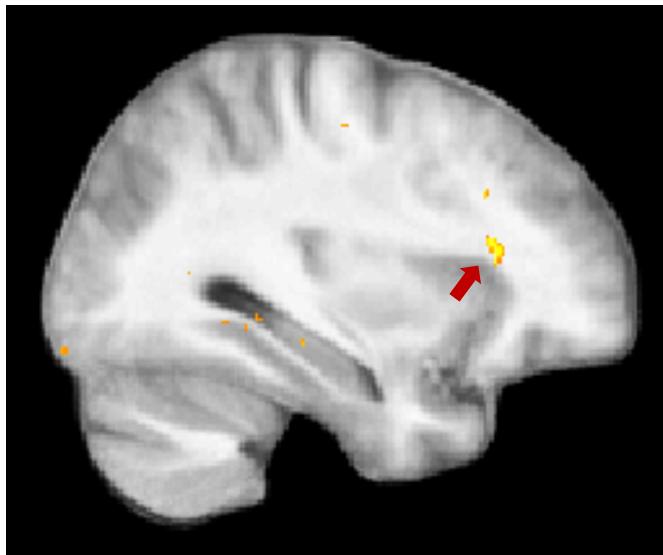
Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Light	1	26.97	24.88	<.0001
Gender	1	28	0.04	0.8428
Age	1	28	0.03	0.8635

t-test				
Mean	SD	df	t	p
7.7249	4.2751	30	5.11	<.0001

# Prefrontal cortex

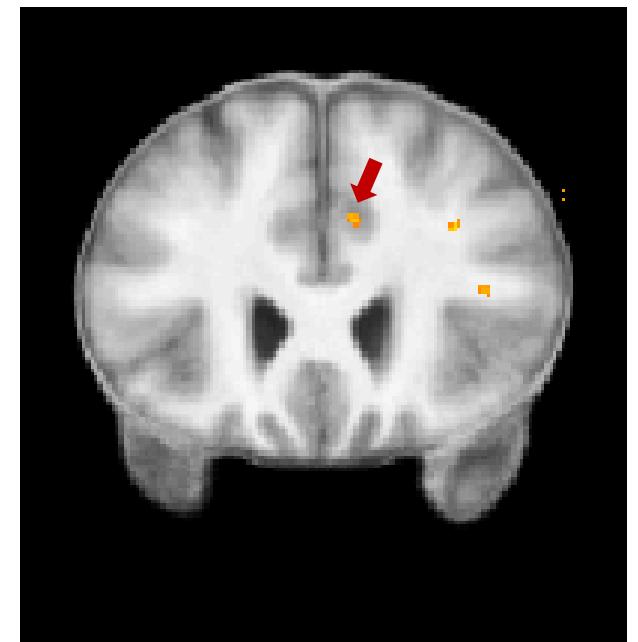
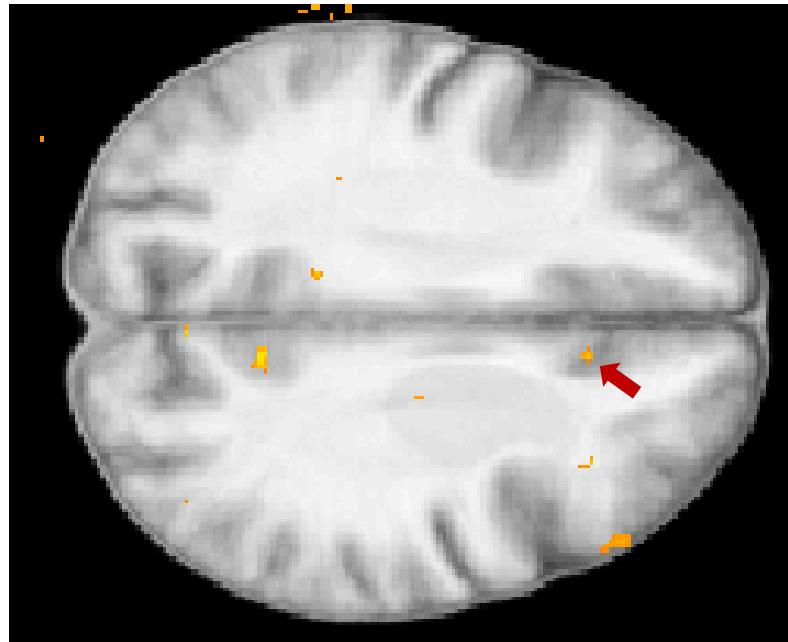
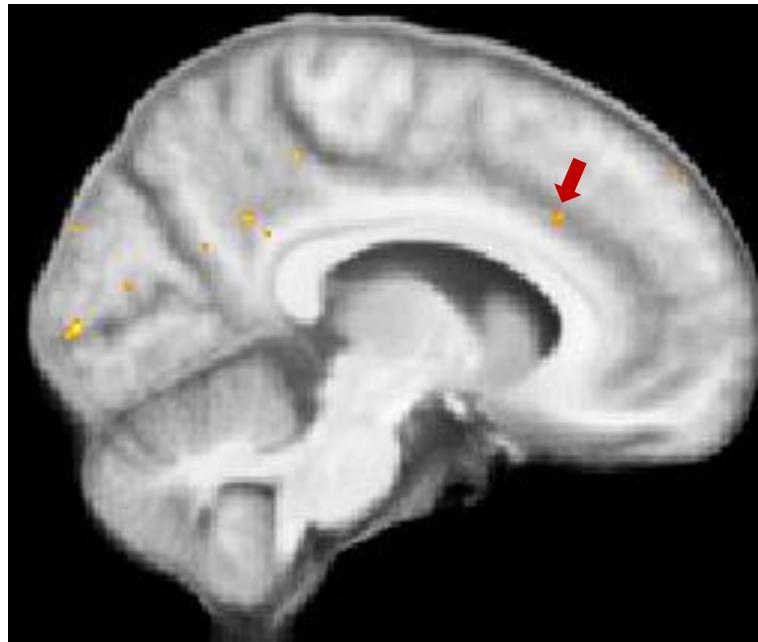


$T = 4.34$   
 $p_{uncorrected} = 0.002$



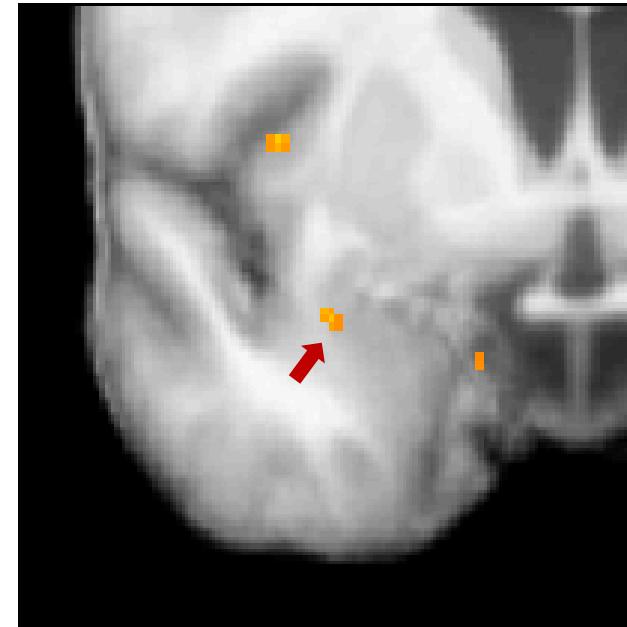
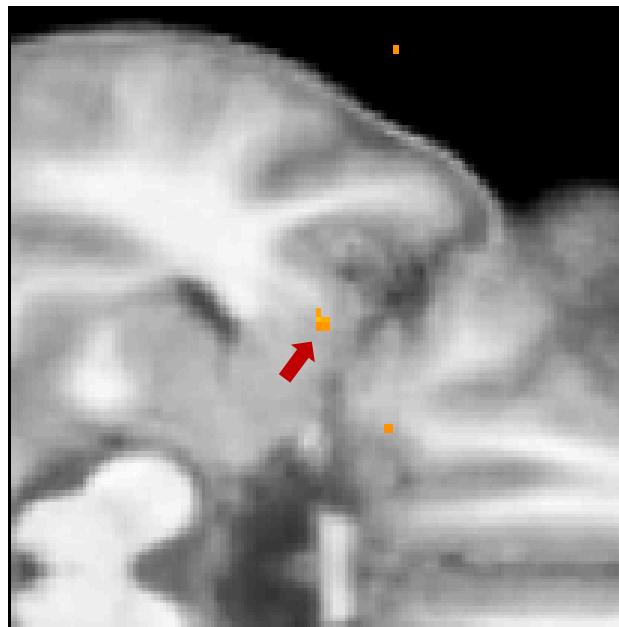
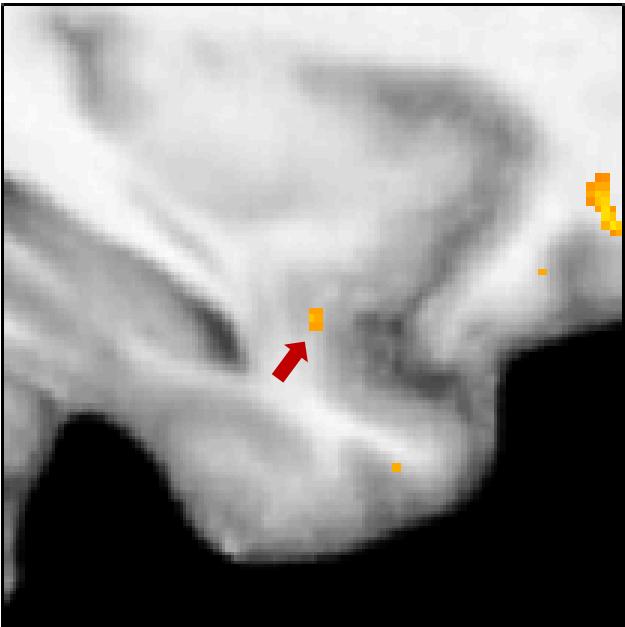
$T = 5.53$   
 $p_{uncorrected} = < 0.001$

# Right anterior cingulate cortex



$T = 3.81$   
 $p_{uncorrected} = 0.001$

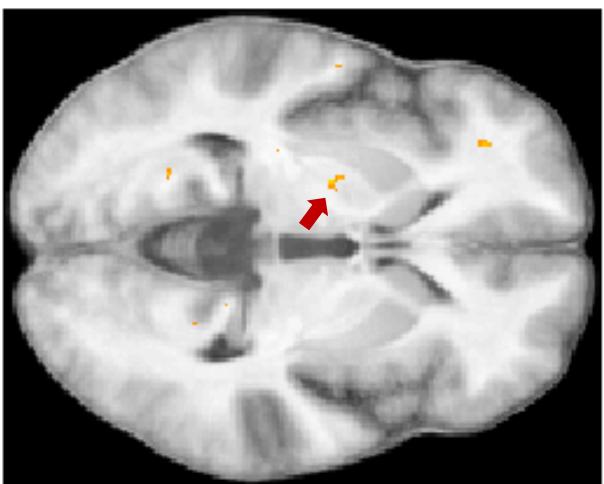
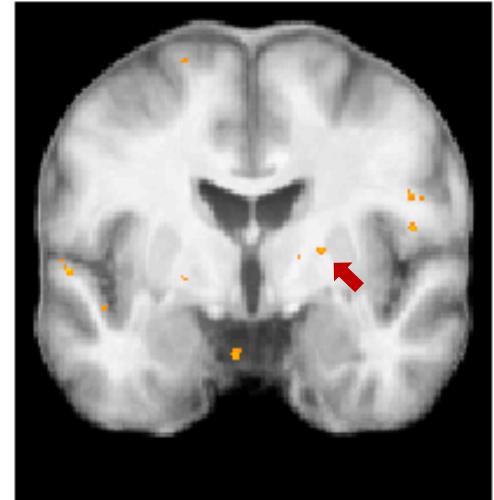
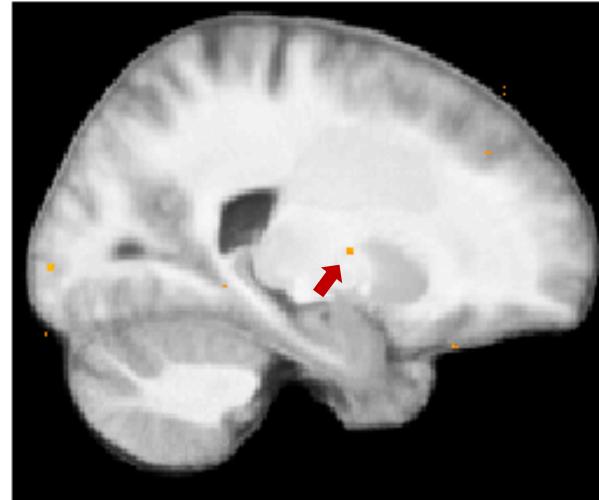
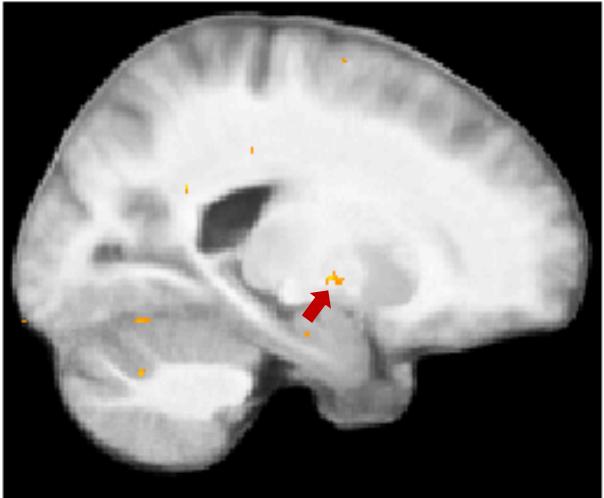
# Amygdala (?)



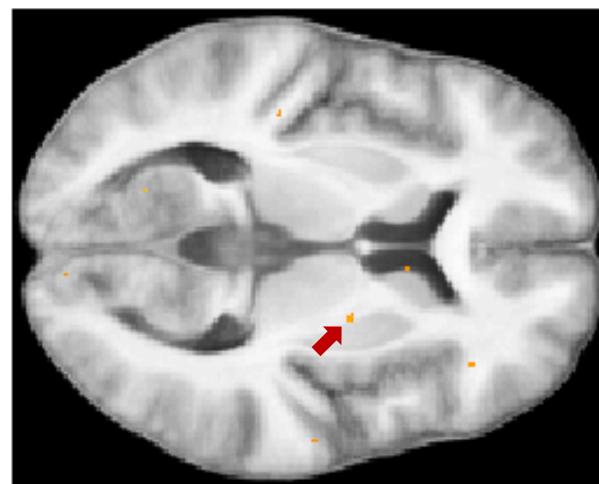
$$T = 3.74$$

$$p_{uncorrected} = 0.001$$

# Globus pallidus

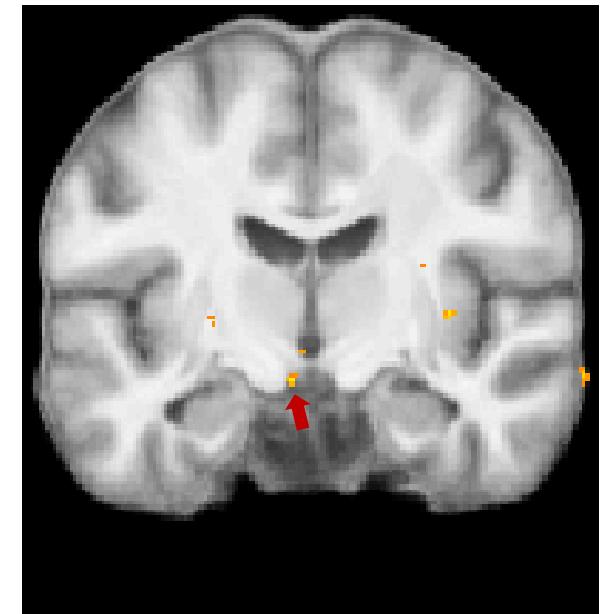
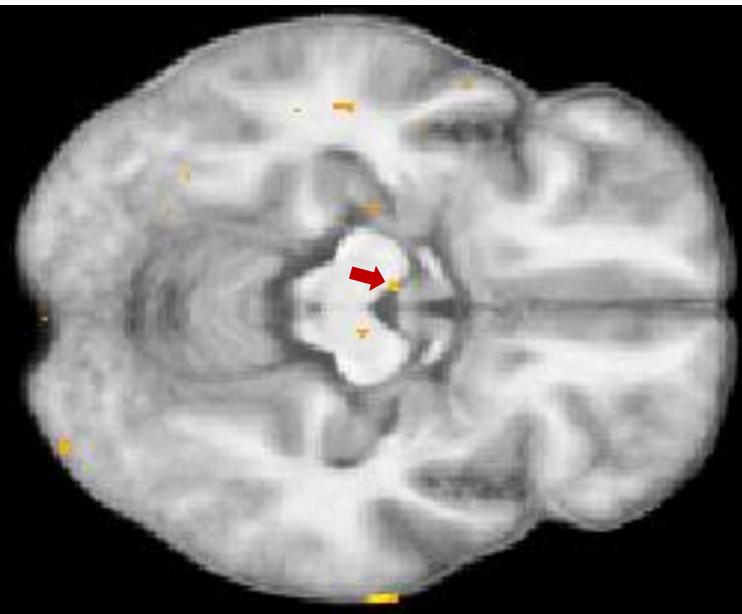
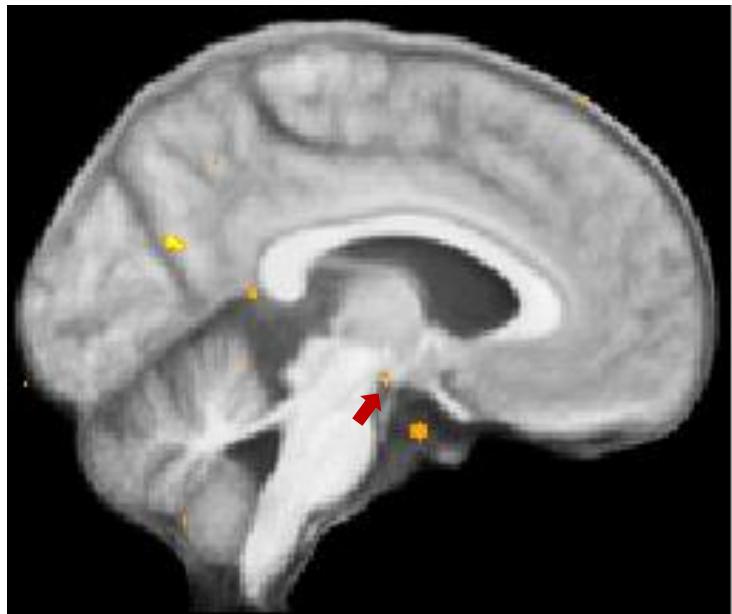


$T = 2.87$   
 $p_{uncorrected} = 0.002$



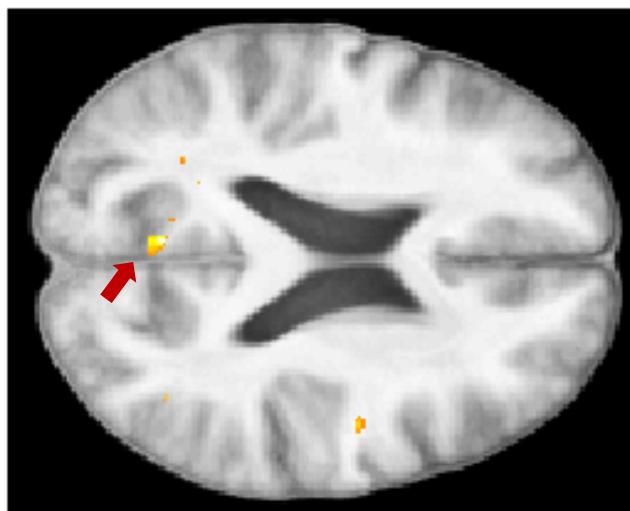
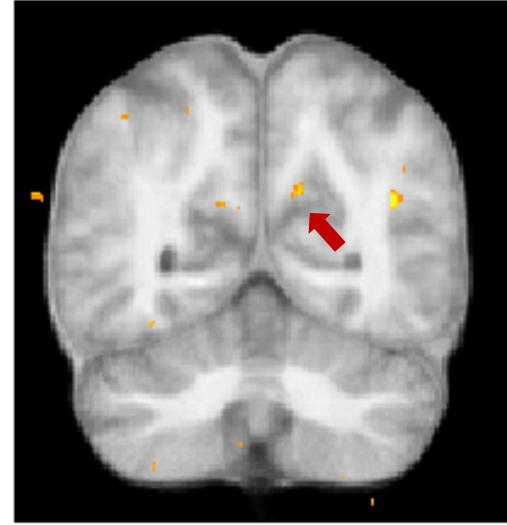
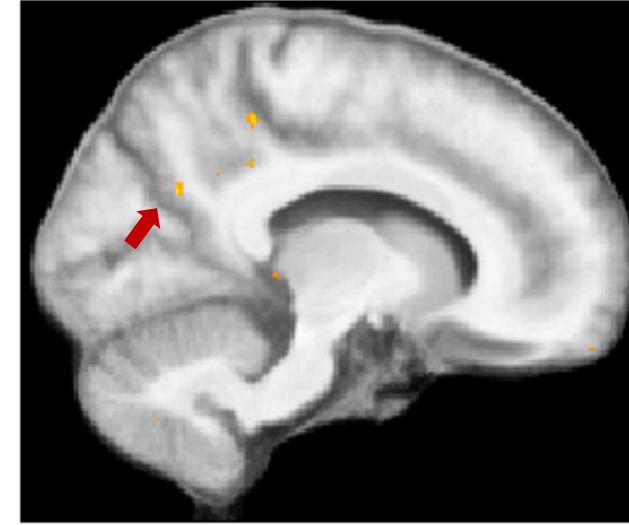
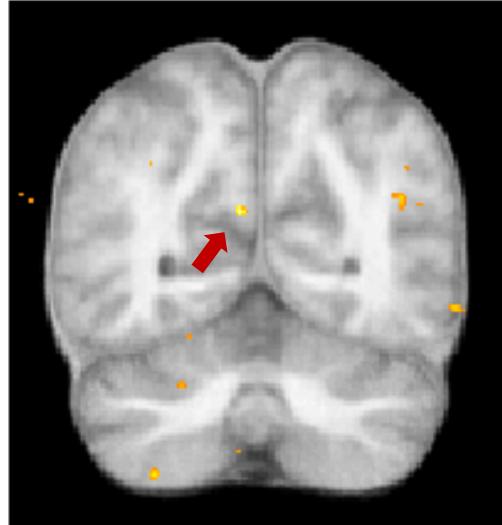
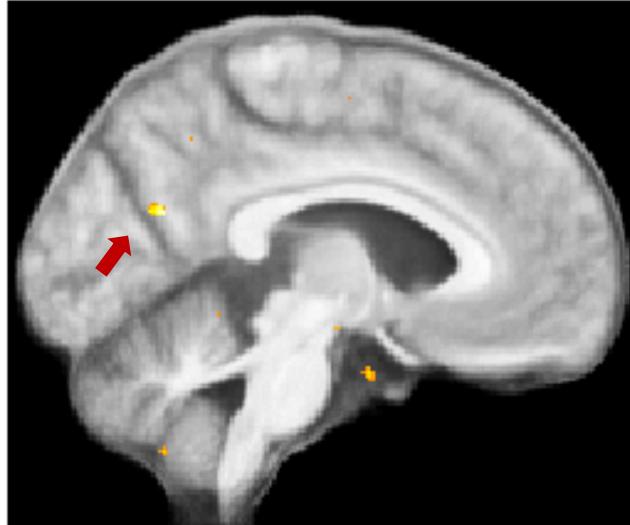
$T = 3.15$   
 $p_{uncorrected} = 0.004$

# Left mamillary body

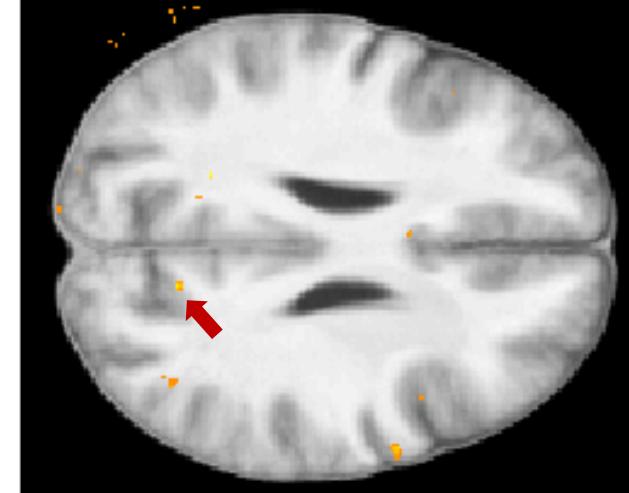


$T = 3.27$   
 $p_{uncorrected} = 0.001$

# Precuneus



$T = 4.22$   
 $p_{uncorrected} = < 0.001$



$T = 4.18$   
 $p_{uncorrected} = 0.001$