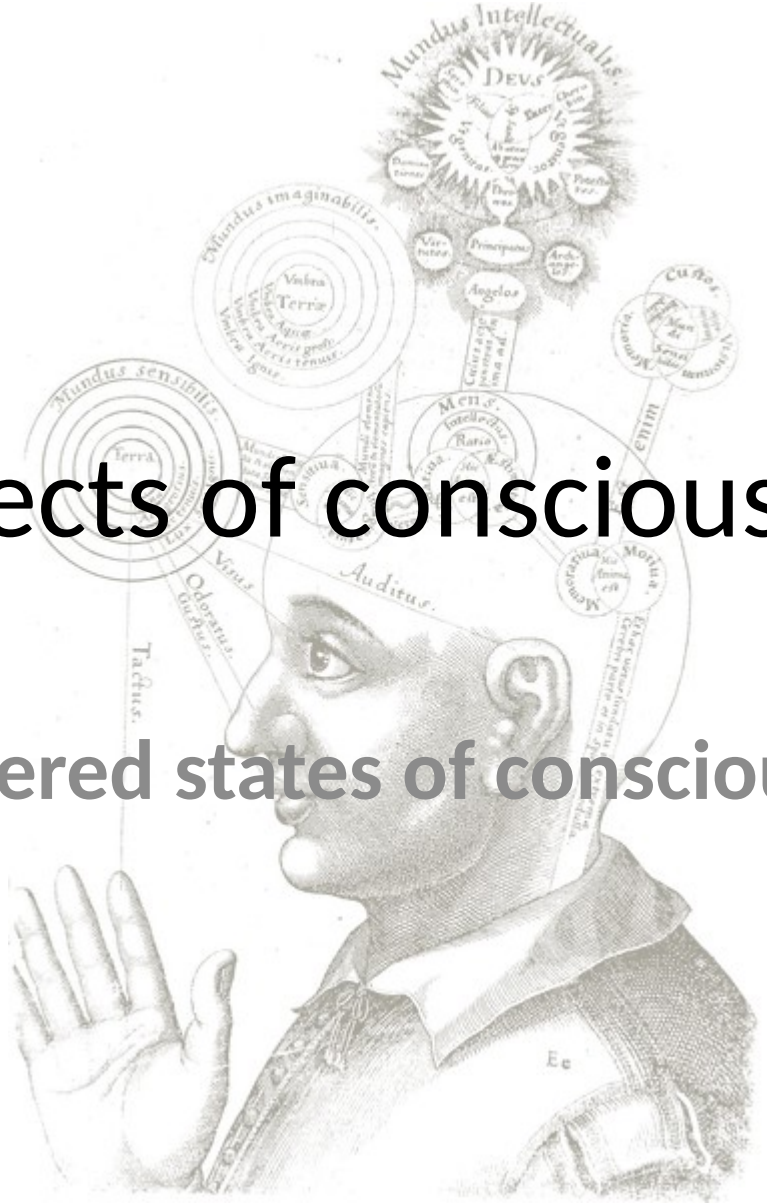
# Aspects of consciousness

## 3. Altered states of consciousness

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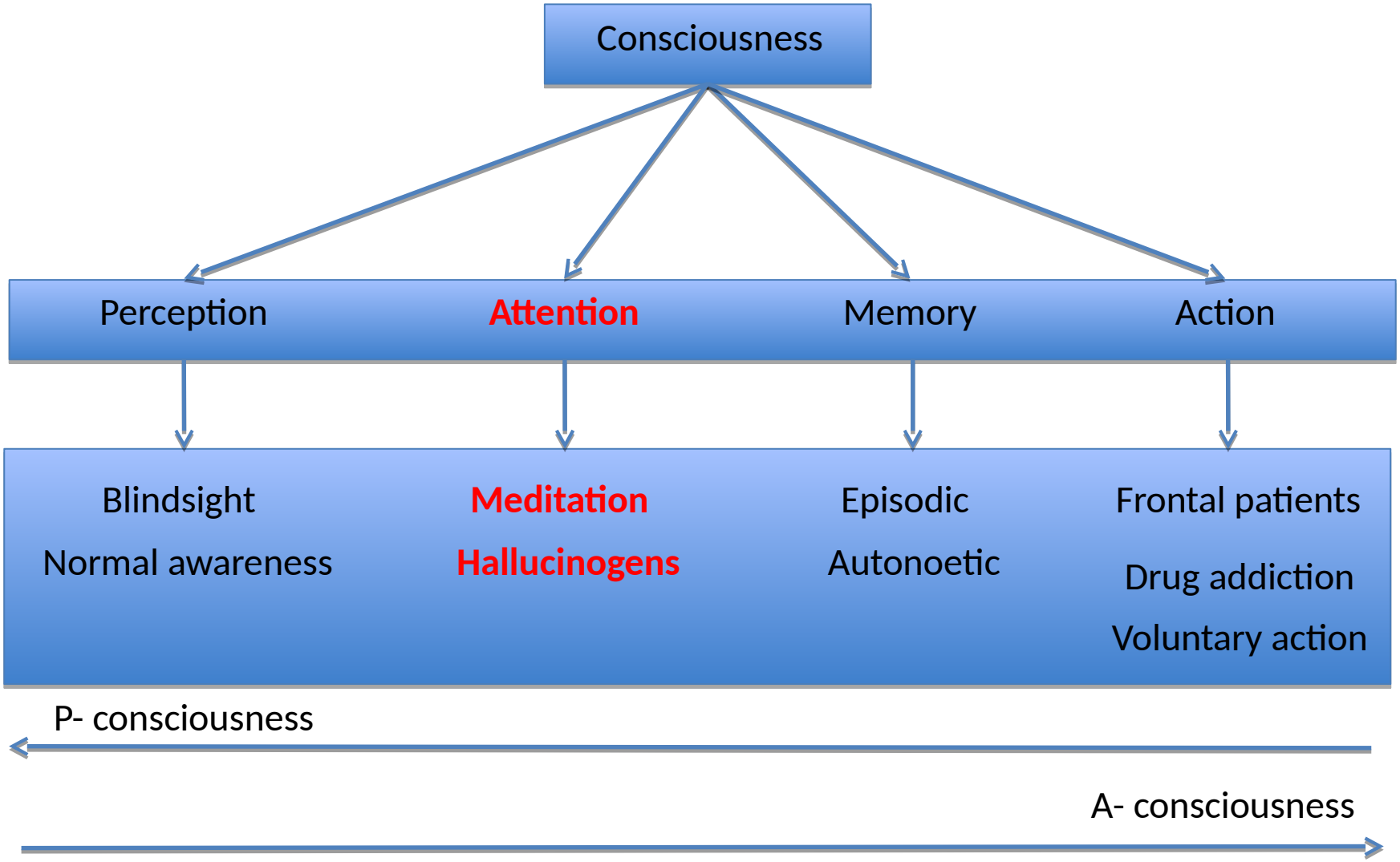
# Scientific study of consciousness



# Key concepts for today

Cognitive phenomena

- Binocular rivalry
- Stroop effect
- Attentional “blink”
- Erickson flanker task
- Spatial working memory
- Pavlovian conditioning

Research methods

- Control group
- Hawthorne effect

Neuroscience methods

- EEG; gamma waves.
- Salivary cortisol
- Agonist / antagonist

Neuroanatomy

- Neocortex
- Thalamus
- Amygdala

Neurotransmitters

- 5-HT (serotonin)
- Dopamine

# Meditation

Key reference:

Lutz, A., Slagter, H., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12* , 163-169.

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Brief introductory video – Andy Puddicombe's TED talk

https://www.youtube.com/watch?v=qzR62JJCMBQ

# Two categories of meditation

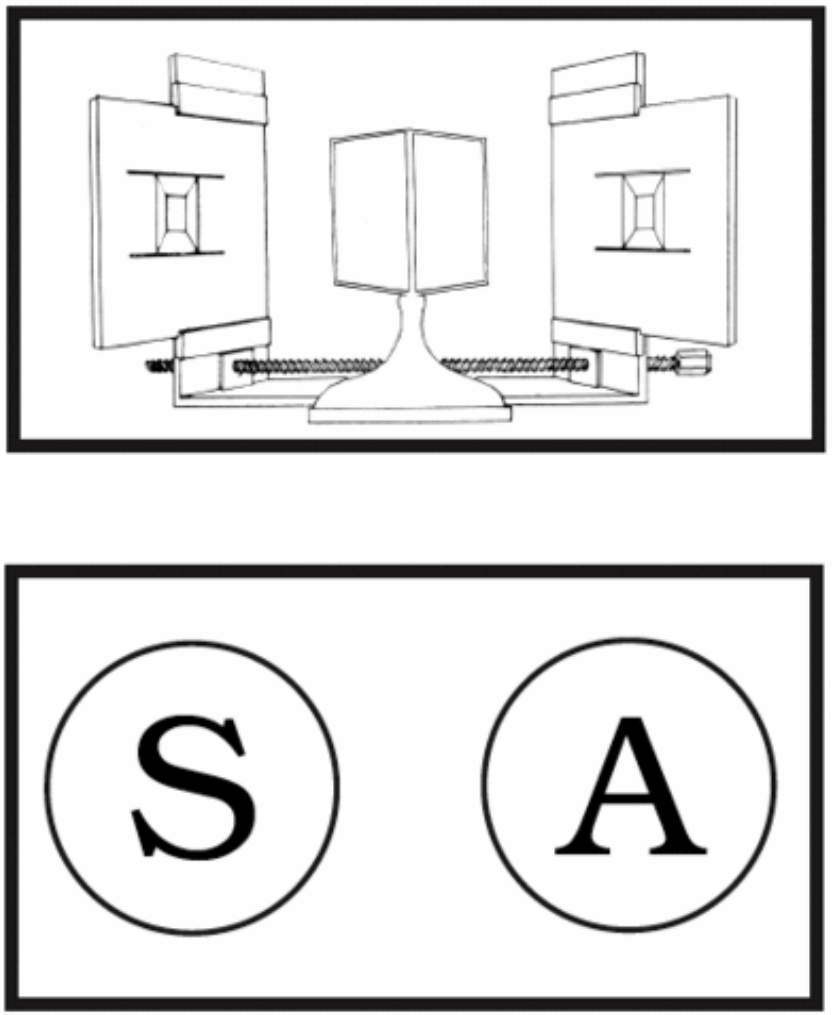
- Meditation by focussed attention (FA)
- There's also OM (open monitoring) meditation; I'm not going to focus on that today – see Lutz et al. (2008).

# FA meditation

- Meditation by focussed attention
  - Focus your attention on the sensation in your nostrils as you breath in and out.
  - You may become distracted.
  - Recognize that distraction, and thereby be released from it. Return to your nostrils

# Effects of FA meditation

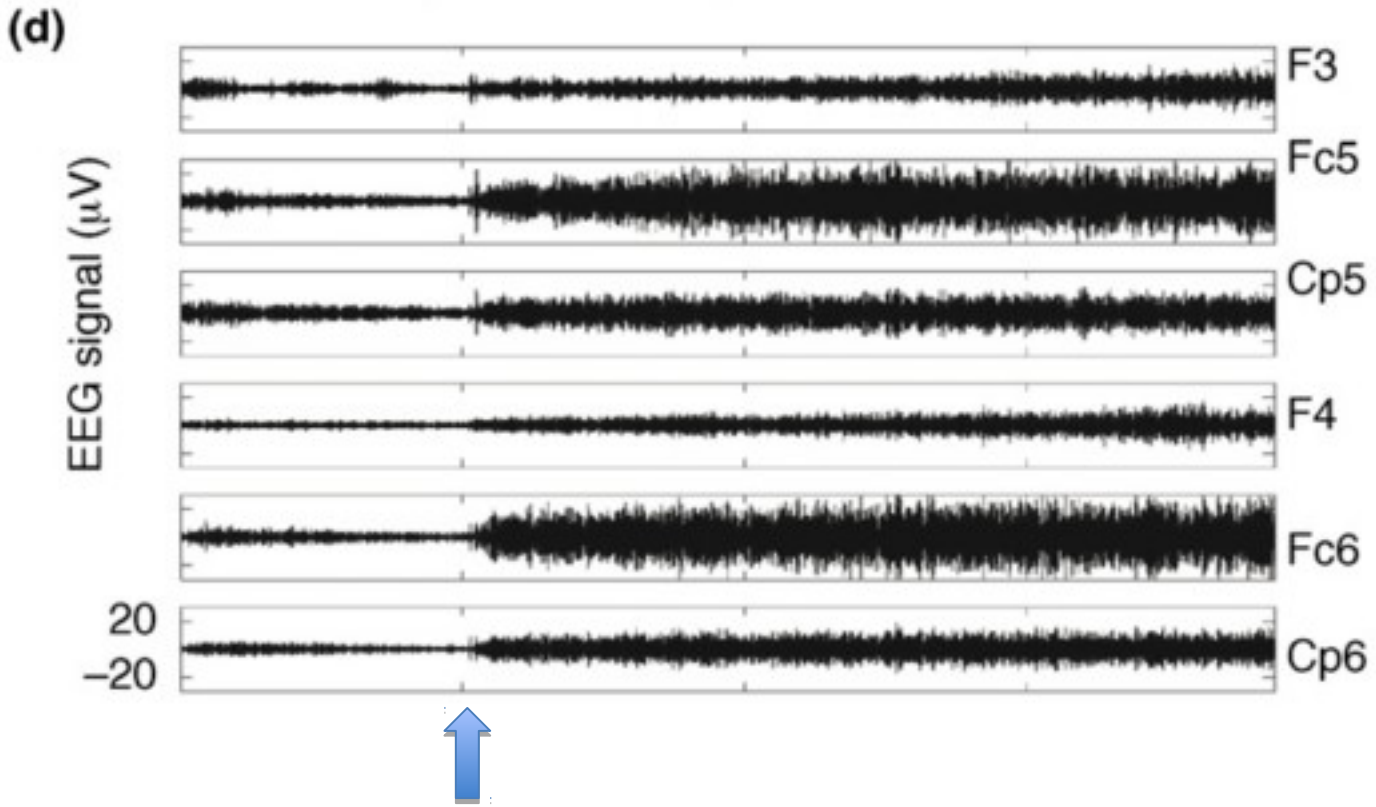
- Increased duration of superimposed image in Bhuddist monks before and after FA meditation (Carter et al. 2005, binocular rivalry procedure).



# Effects of FA meditation

- Reduction in Stroop interference after meditation (Wenk-Sormaz, 2005).

# Brain correlates of FA meditation




- Meditation in the highly practiced is easily detectable from EEG recordings (due to increased relative power of gamma (40Hz) activity).
- Lutz, A. et al. (2004) Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proc. Natl. Acad. Sci. U. S. A. 101*, 16369–16373. Image copyright (2004) National Academy of Sciences.

# Cognitive Effects of FA meditation

- Reduced amygdala activation (emotional reactivity) to distracting sounds correlates with hours of FA meditation practice (Brefczynski-Lewis et al., 2007)

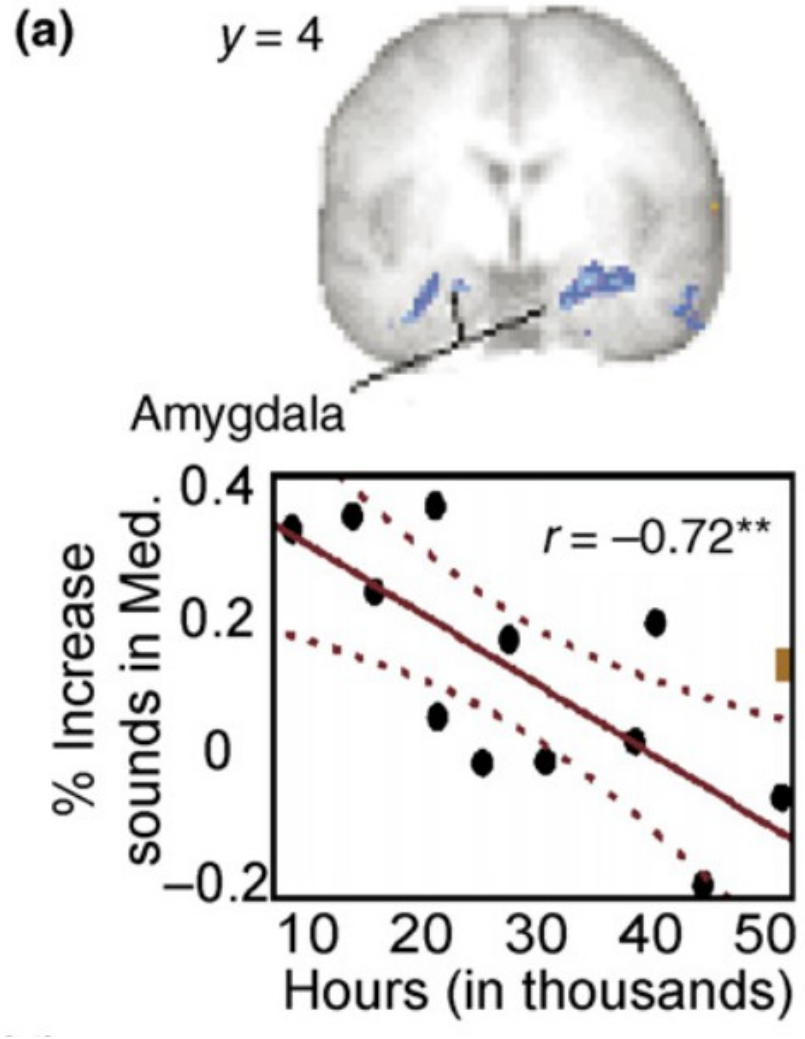
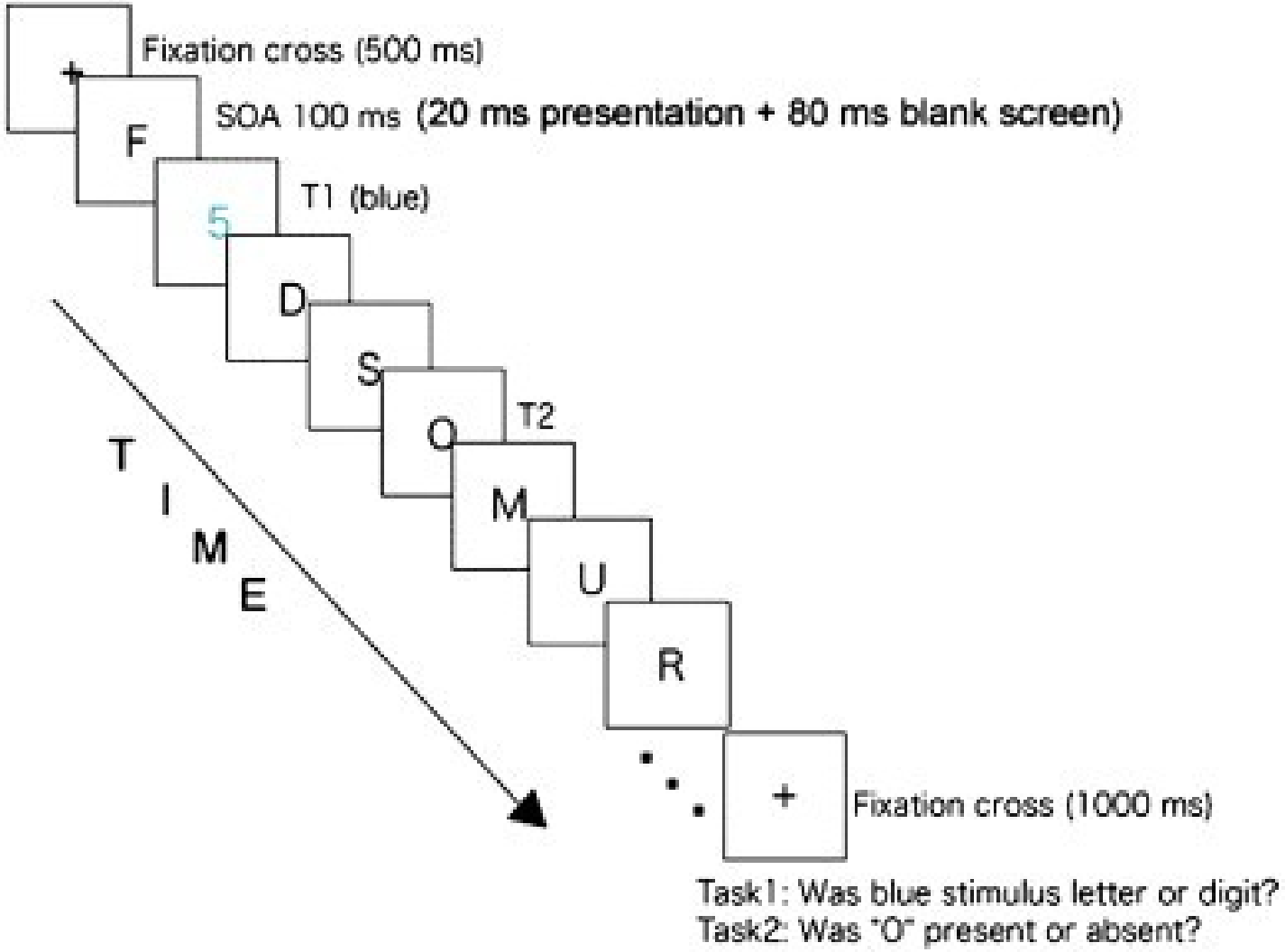
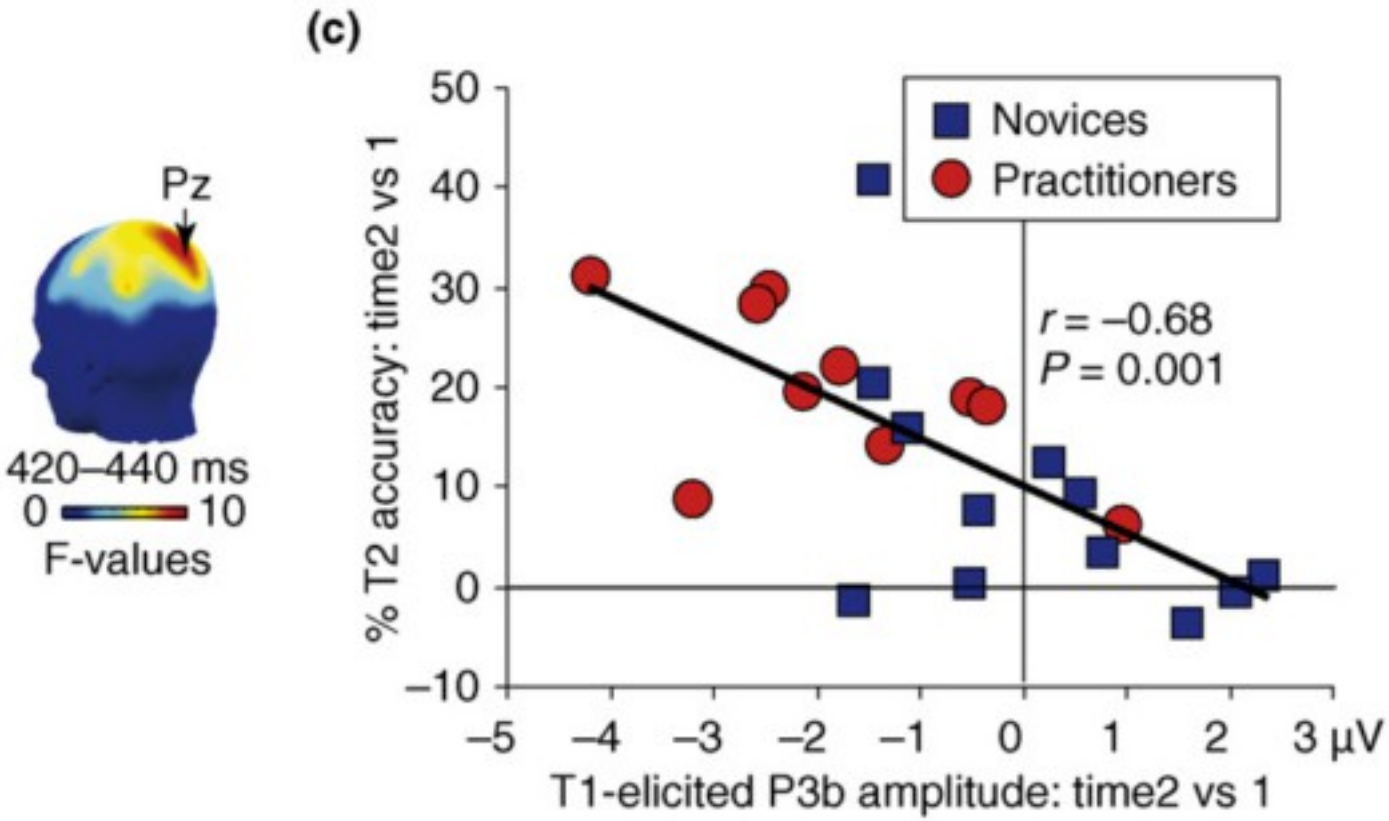



Image credit: Brefczynski-Lewis et al. (2007). Proc. Natl. Acad. Sci., 104, 11483. Copyright (2007) National Academy of Sciences

# Cognitive Effects of FA meditation



# Cognitive Effects of FA meditation




- Reduced attentional blink (increased T2 accuracy), and reduced P3b component to T1 (T1 attracts fewer “resources”) in practitioners.
  - Slagter, H.A. et al. (2007) Mental training affects distribution of limited brain resources. *PLoS Biol. 5*, e138

# Meditation and consciousness

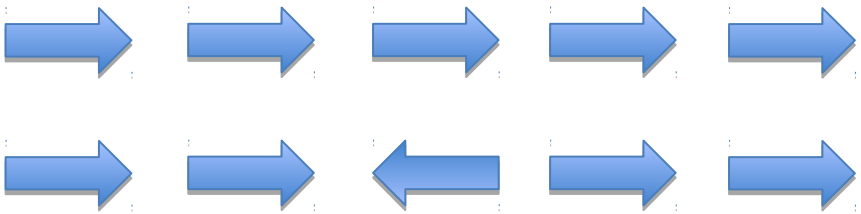
- Meditation changes EEG activity in the highly practiced, with widespread gamma activity.
  - Suggests that, at least for these people, it is an altered state of consciousness, distinct from sleeping or waking.
- People who meditate a lot seem less prone to interference; seem more able to distribute their attention flexibly in a task-relevant manner.
  - The question is… does meditation practice do this?
  - Or, is there something different about people who meditate a lot? A pre-existing difference in attentional allocation that leads them to be good at (and hence pursue) meditation?

# Better control

- Tang et al. (2007)
  - Random allocation to short meditation training vs. relaxation training.
  - No pre-existing differences on measures.
  - Studied: attention, mood, stress response.

# Tang - Attention

- RT(incongruent) – RT (congruent) = Conflict score.
- Lower score – better selective attention.
- Meditation practice lowers score.



Congruent

Incongruent

# Tang - Mood

- Various beneficial mood effects.

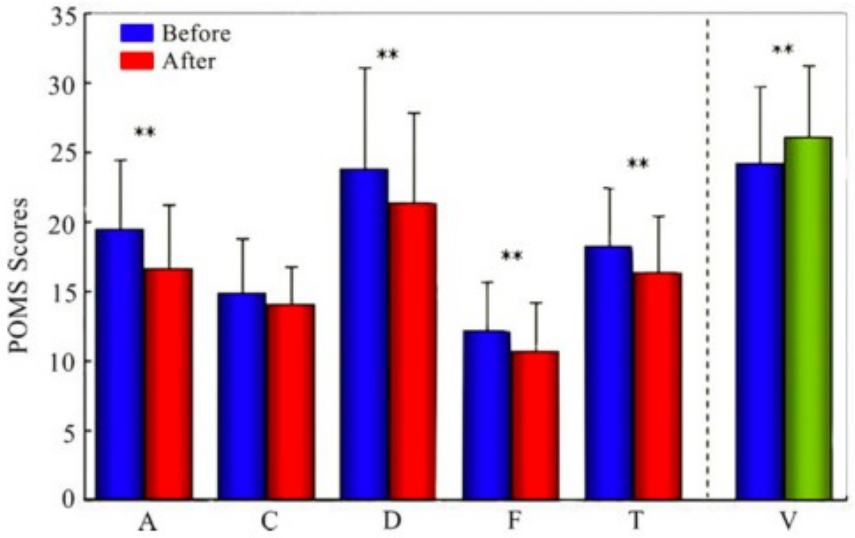
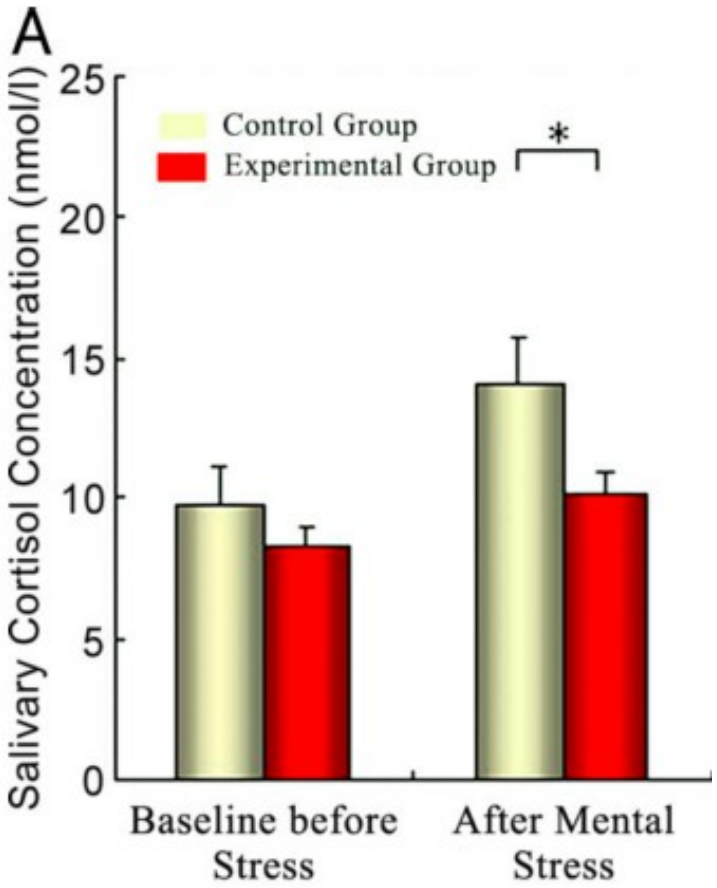



**Fig. 2.** Comparison of six scales of the POMS before and after training for the experimental group. Blue bar, five negative moods and one positive mood pretraining; red bar, five negative moods posttraining; green bar, one positive mood posttraining. Significance was found in POMS scales of anger–hostility (A), depression–dejection (D), fatigue–inertia (F), tension–anxiety (T), and vigor–activity (V) posttraining in the experimental group. No significant difference was found in POMS scale C (confusion–bewilderment) posttraining. **, $P_{average} < 0.01$. Error bars indicate 1 SD.

Image credit: Tang et al. (2007). Proc. Natl. Acad. Sci., 104, 17152. Copyright (2007) National Academy of Sciences

# Tang - Stress management

- Mental arithmetic as a stressful event.
- Salivary cortisol higher in control group than experimental group (cortisol is a stress hormone).

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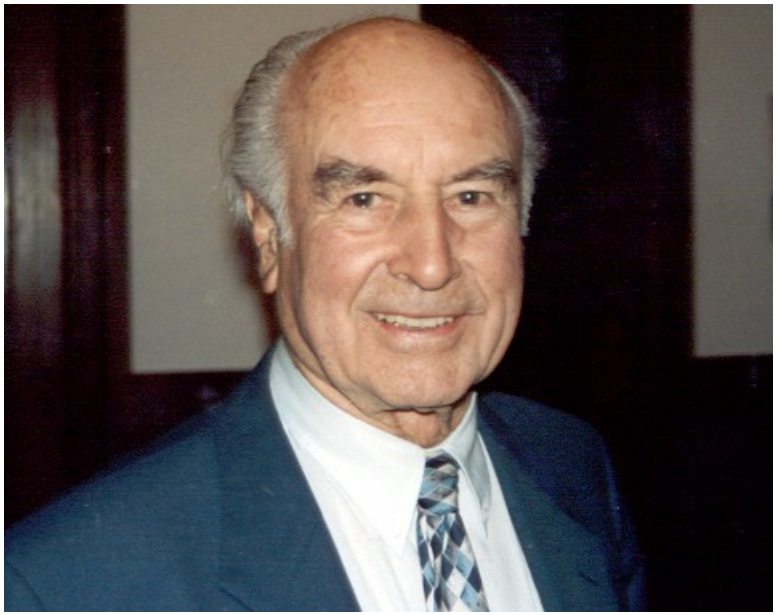
# Tang – Other possible issues

- Hawthorne effect
  - Experimental group taught by enthusiastic world experts with many years experience; not clear the relaxation training was as engaged or enthusiastic.
  - Is meditation helpful? Or relaxation therapy actively unhelpful? Time 1 data might help here, but it's not presented.

# Hallucinogens

**HEALTH AND LEGAL WARNING:**
Hallucinogen possession is illegal (Class A). Those under the effects of hallucinogens are at significantly higher risk of death by misadventure. Use of hallucinogens can lead to permanent and serious medical consequences.

- "Hallucinogenic" – although hallucinations, in the sense of believing something to be there which is not, are rare.
- Users sometimes report altered states of consciousness including:
  - Closed eye visions
  - Contemplative mood
- What might altered states of consciousness tell us about consciousness?



Albert Hoffman

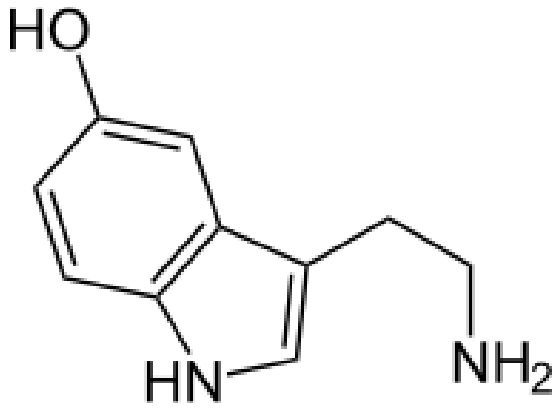
# Basic information

- Hallucinogens = Mescaline, psilocybin, LSD.
  - Other substances e.g. Ectasy, have different mechanisms of action. Thus, although sometimes classed as hallucinogens, they are not the topic today.
- Hallucinogens are physiologically safe molecules (no recorded deaths as a direct result of ingestion).
- Are not considered reinforcing (O'Brien, 2001)
  - Most dependence-liability substances are dopaminergic – opiates, nicotine, cannabis, PCP, cocaine, amphetamine, alcohol, benzodiazepines, barbituates, caffeine (see session 5).
  - Most hallucinogens are not dopaminergic (LSD is an exception).

- Hallucinogen persisting perception disorder ("flashbacks")
  - Low incidence.
  - No treatment.
- Contributory factor in fatal and serious accidents
  - Flying delusions
  - Starting into the sun
- Largest risk is induced psychosis
  - About 1:250 to 1:1000
  - Pre-disposed individuals.

# Mechanism of action

- Hallucinogens are 5-HT agonists.
  - Drug discrimination tests in rats using 5-HT antagonists (Glennon et al., 1983)
  - Tolerance to LSD correlates with down-regulation of 5-HT in rats (Buckholtz et al., 1990)
  - 5-HT antagonists in humans block reported effects of psilocybin (Vollenweider et al. 1998)
  - Other possible effects too, including some DA in LSD, see review.

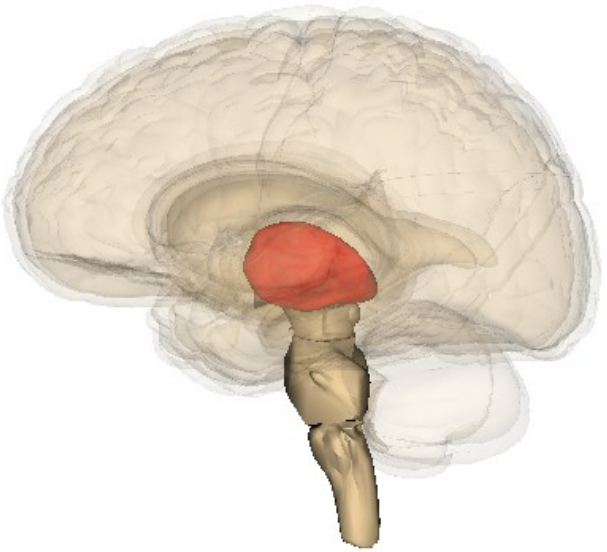



*Note:* This is not a pharmacology course – you do not need to follow the neurochemistry of this; we are concerned with the cognitive / cognitive neuroscience consequences.

# 5-HT affinity

- 5-HT receptors concentrated in the neocortex (Pazoz et al., 1987)
- 5-HT agonists also affect thalamic activity
- Theory
  - Hallucinogens greatly increase cortical neuron sensitivity
  - At the same time they lead to thalamic afferent activation that would normally signal incoming sensory input to be processed.
  - Thus… amplified/distorted sensory input
  - Plus impaired sensory gating/filtering
  - …leading to problems with selective attention

(Vollenweider & Geyer, 2001)



# Relation to schizophrenia

- This is also the symptomology of acute schizophrenia
- Antipsychotic drugs seem to work by 5-HT antagonism (see review)
- Quite a close correspondance between hallucinogen ingestion and acute schizophrenia – at least in terms of some symptomology and likely mechanisms of action.

# Other effects

- Increased indirect semantic priming (Spitzer et al., 1996)
  - Basically, the increased availability of remote associations
- Binocular rivalry – change in distribution of switch times (Carter & Pettigrew, 2003)
- Spatial working memory deficits (Vollenweider et al., 1998)
- Enhanced Pavlovian conditioning in rabbits (Romano & Harvey, 1994)

# Summary

- One (medical) way of conceiving consciousness is as a progression in arousal (Awake -> Asleep -> Coma -> Death)
- Studies of FA meditation, and of hallucinogen ingestion, suggests the presence of multiple, distinct, forms of *waking consciousness* – sometimes called altered states of consciousness (ASC).
- One common thread to these two different ASCs are the processes of selective attention
  - FA meditation seems to promote the more flexible (task-relevant) and adaptive use of selective attention.
  - Hallucinogens seem to massively disrupt sensory gating mechanisms, leading to sensory overload; a failure of task-relevant selective attention.
- Thus, one defining feature of the phenomenology of both our typical waking state, and ASCs, may be the function selective attention plays in preventing us from becoming overwhelmed by the “buzzing, blooming confusion” of an information-rich world.