Why do we sleep?

WEEK 8, LECTURE 3

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This lecture is going to cover a really important aspect of sleep that we haven't really discussed yet – what is the actual function of sleep?

Why Sleep? Why REM? Why Dreams?

We appear to have evolved mechanisms that force us to sleep

Involuntary inhibitory processes in our brains force us to become less aroused and less alert, and thus enable us to sleep

It appears that we’ve evolved mechanisms that force us to sleep. If you go without sleep for long enough, eventually your body will put you in a state of sleep itself, by inhibiting the brain functions that enable arousal and alertness. So there does appear to be an important, adaptive reason why we sleep.

There’s another question related to this, which is why we dream… but we’ll get to that later in this lecture.

Functions of Sleep

Some of the many functions of sleep include…

- Resting muscles
- Decreasing metabolism
- Performing cellular maintenance in neurons
- Reorganizing synapses
- Strengthening memories

Above are some proposed functions of sleep…

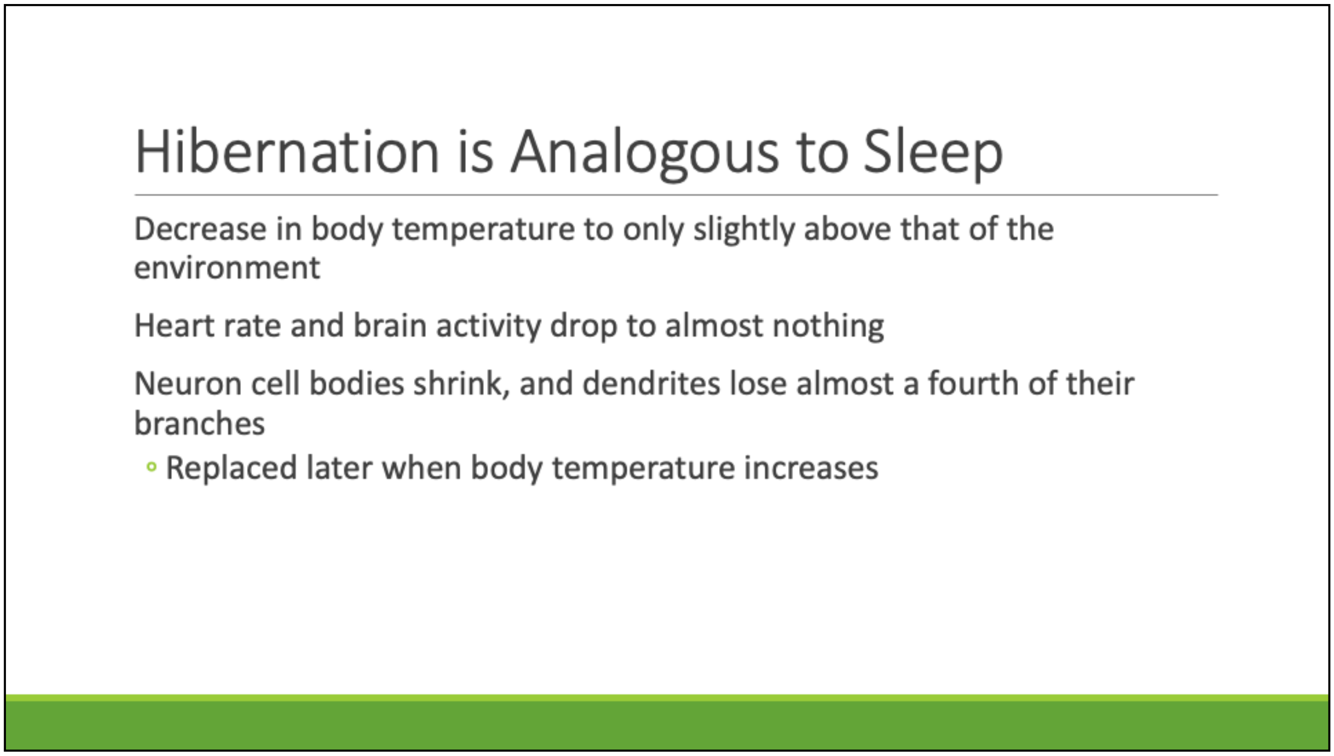
Sleep and Energy Conservation

The original function of sleep was probably to conserve energy

Conservation of energy is accomplished via…

- Decrease in body temperature of about 1–2 Celsius degrees in mammals
- Decrease in muscle activity

…although it seems like the "original" or primary function of sleep is to conserve energy. This is accomplished via a general decrease in temperature (and corresponding metabolic rate), as well as a decrease in muscle activity (remember that your brain has a pathway from the pons to the spinal cord that inhibits the firing of motor neurons).



Hibernation is a special cases – it's not quite the same as sleep, in that the body goes through more extreme changes, and of course the length of time is extended. You can read more about these physiological changes in the slide above.

Sleep and Memory

Sleep also plays an important role in enhancing learning and strengthening memory

- Performance on a newly learned task is often better the next day if adequate sleep is achieved during the night

Increased brain activity occurs in the area of the brain activated by a newly learned task while one is asleep

Patterns of activity in the hippocampus during learning were similar to those shown during sleep

- Suggests that the brain replays its daily experiences during sleep

The brain strengthens some synapses and weakens others during sleep

Sleep spindles increase in number after new learning → correlated with nonverbal IQ

In addition to conserving energy, more recent research has found that sleep actually plays a large role in memory consolidation. Evidence for this is discussed above.

Speaking to the second-to-last point, it seems like sleep is also good for updating and increasing the efficiency of neural connections; during this time, the brain prunes unused connections and strengthens those that have been use a lot. And this is likely related to the brain replaying its daily experiences during sleep – that helps it determine which information or skills are going to be useful in the future, and which aren't.

And with regards to this last point, recall that sleep spindles, which occur during stage 2 sleep, seem to be related to memory consolidation. It also seems like they're related to nonverbal IQ, in that individuals who produce more sleep spindles on average seem to have a higher IQ than those who produce fewer. So this may be a crucial aspect of encoding new skills and knowledge into memory.

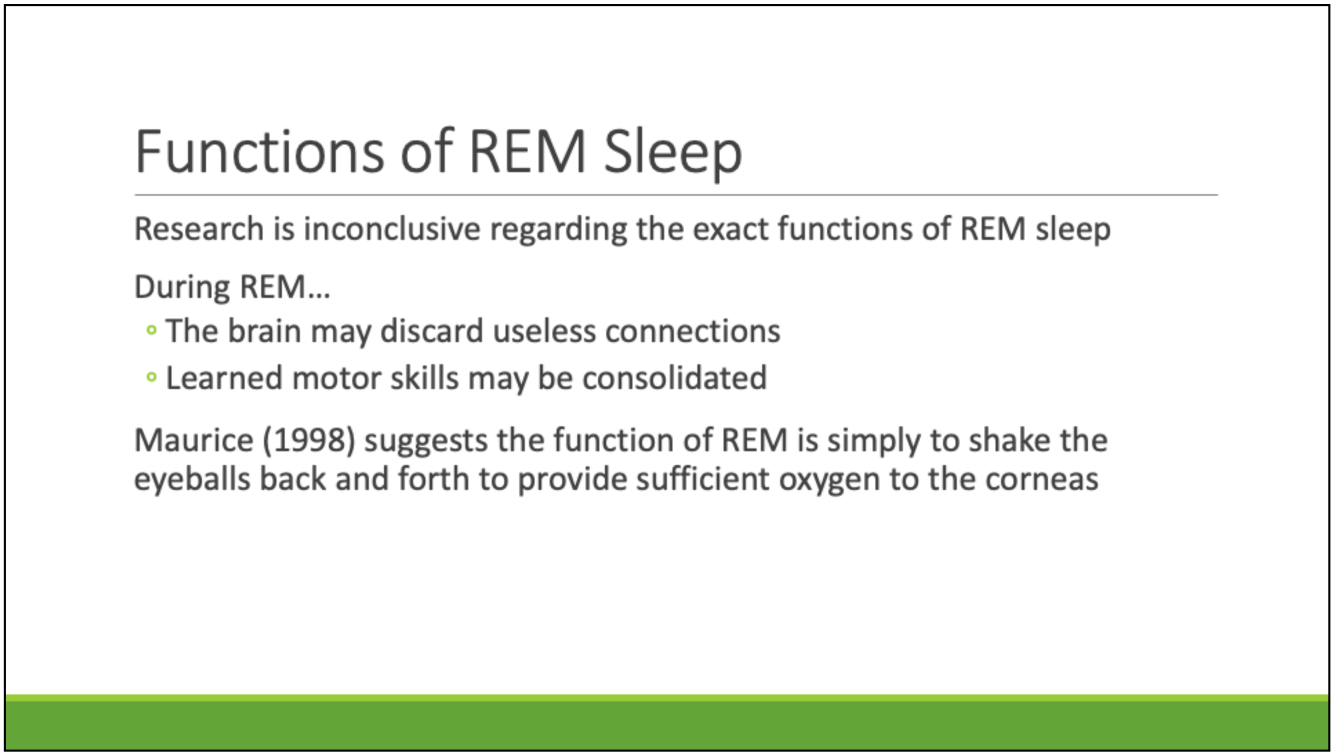
Amounts of REM Sleep

Humans spend one-third of their life asleep; about one-fifth is spent in REM

Species vary in amount of sleep time spent in REM

- Cats spend up to 16 hours a day sleeping with lots of that time in REM sleep
- Among humans, those who get the most sleep have the highest percentage of REM
- Percentage of REM sleep is positively correlated with the total amount of sleep in most animals

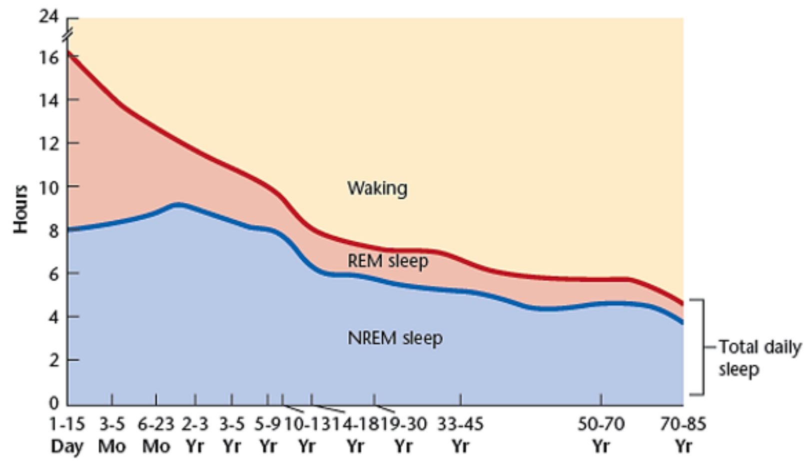
REM sleep seems to be one of the more important stages of sleep. Humans spend quite a large proportion of their time asleep in REM sleep - and the same goes for other species, as well. Generally speaking, animals (and individuals) that sleep more, tend to get more REM sleep in particular.



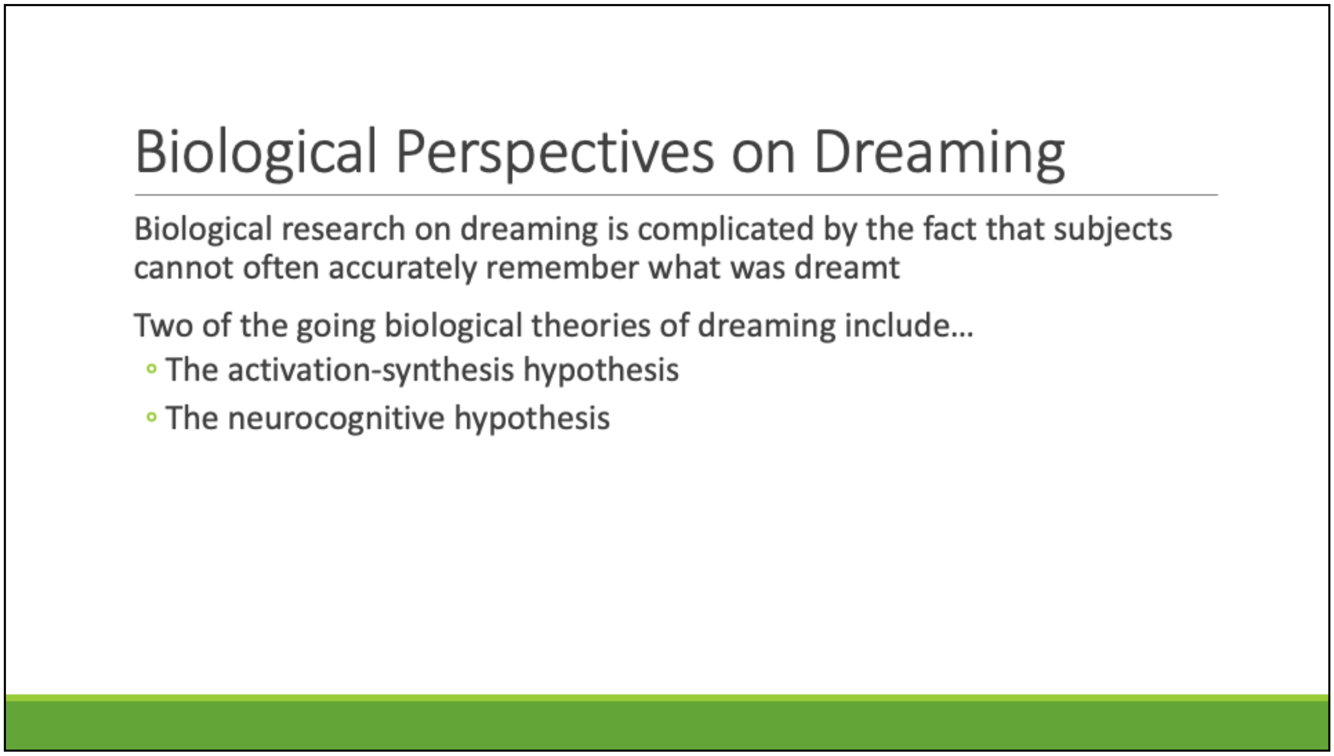
So that leads us to an important question: what is the purpose of REM sleep? If we spend so much of our sleeping time in this stage, it *must* be important.

The short answer to this question is: we still don’t know! Some interesting hypotheses have been proposed (and supported with evidence), which you can read about above (and in more detail in your textbook). The exists evidence to support each of these points, although nothing conclusive has been found as of yet. But at the very least, this does seem like another period in which the brain encodes new skills and knowledge in memory (and discards useless skills and knowledge).

The Relationship Between Age and REM Sleep for Humans

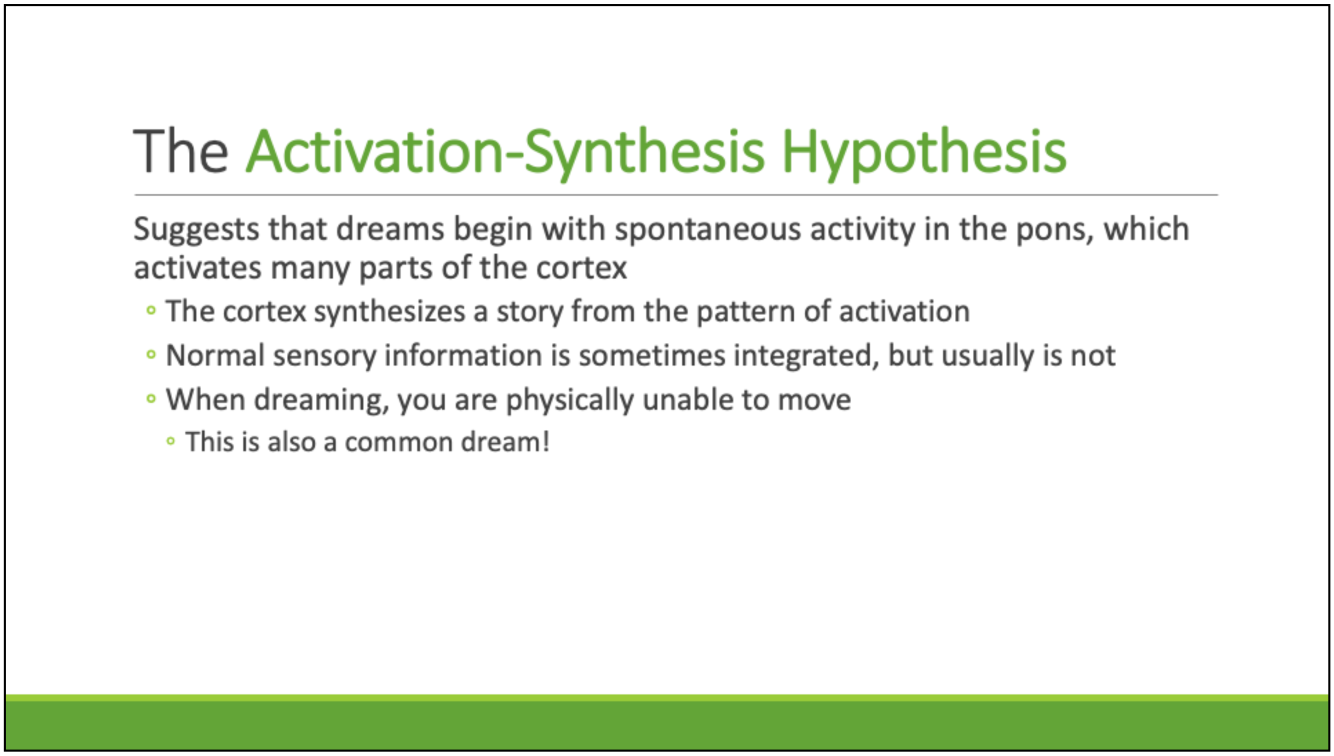


This graph shows how the amount of REM vs. NREM sleep changes over the lifespan. You can see, first and foremost, that the amount of time we spend asleep is highest in infancy, and gradually declines as we get older. NREM sleep actually stays fairly stable, but REM sleep seems to decrease: infants spend about 8 hours a day in REM (although sleep in general is different for infants, so this can be difficult to calculate), while older adults spend about 2 hours in REM. That's a pretty stark difference! But it makes sense if you think about the proposed function of REM sleep as a state of knowledge consolidation – this is more crucial to do at an earlier stage of life, and so infants and young children might need more time while asleep to do this.



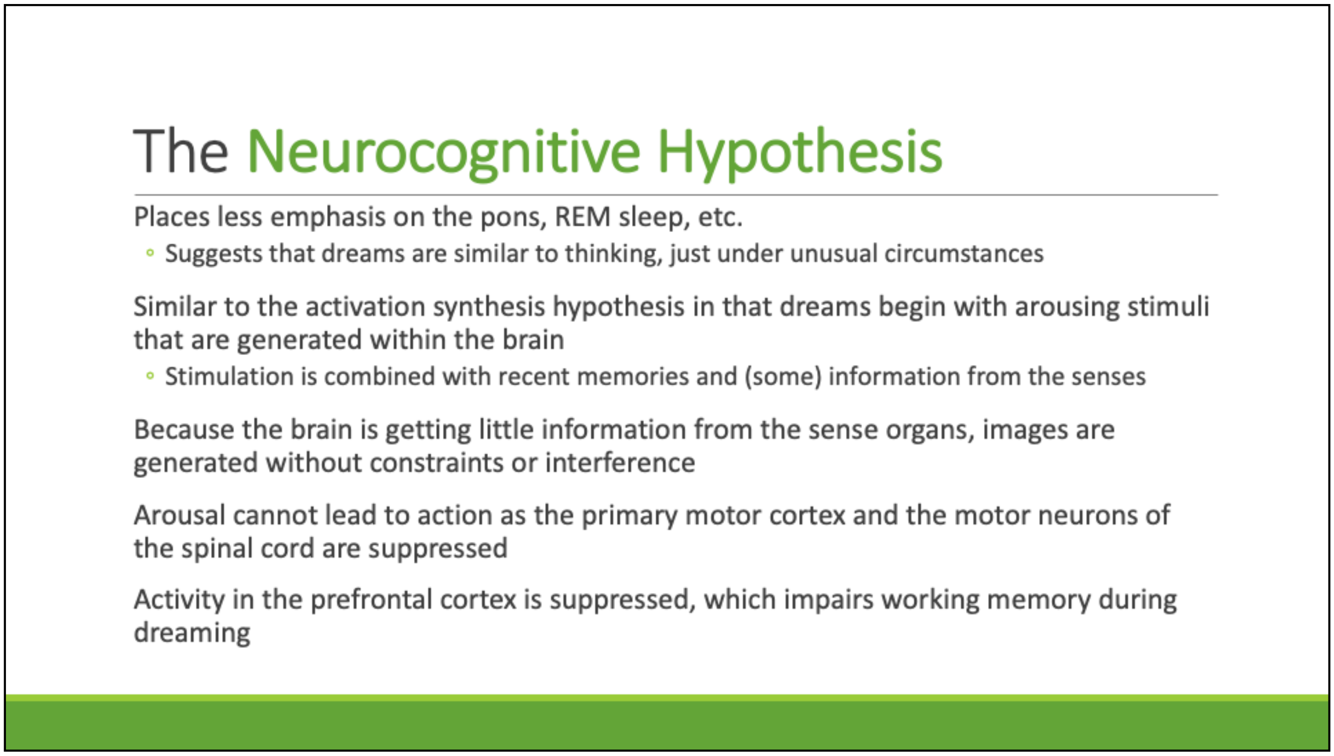
Now we come to (at least in my opinion) one of the most interesting questions about sleep: dreaming. Specifically, why do we dream?

As of now, there are two prominent hypotheses that attempt to answer this question: the activation-synthesis hypothesis, and the neurocognitive hypothesis. We'll review these over the next few slides.



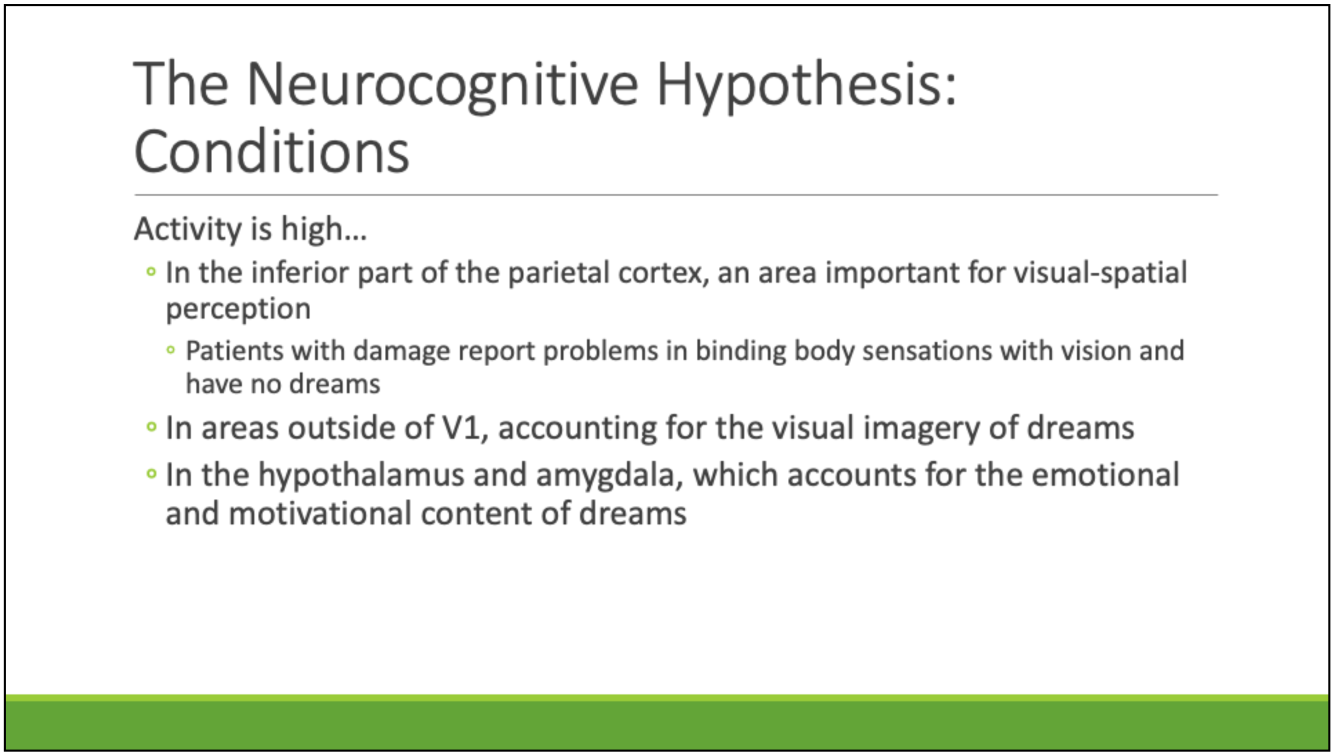
Let's start with the activation synthesis hypothesis. You should read through the slide first.

So, the idea here is that the pons is active in REM sleep, and this activation leads to activation in other areas of the brain. In order to make sense of this *activation*, the cortex *synthesizes* it into a coherent narrative – a dream. Under this hypothesis, dreaming is the result of spontaneous activation, and while the source of that activation is unclear (it might have a function, but this isn't specified), the purpose of dreaming is to make sense of that activation. Also note that under this hypothesis, there is very little input from sensory information.



There’s also the neurocognitive hypothesis, which you should read about first above.

This hypothesis places little emphasis on the pons or even REM sleep. It states that, during sleep, parts of our brain are still active – specifically the “thinking” parts. However, because activity in some areas of the brain is suppressed (specifically incoming sensory information), this can lead to unusual or strange perceptions while dreaming. Essentially, you’re still processing information while you’re asleep and dreaming, but your brain is simulating sensory input rather than taking it in directly from the outside world.



And you can see further evidence for this hypothesis if you look at the areas of the brain that are active while dreaming (you can read about this above).

The Neurocognitive Hypothesis: Summary

Either internal or external stimulation activates parts of the parietal, occipital, and temporal cortex

Lack of sensory input from V1 and no criticism from the prefrontal cortex creates the hallucinatory perceptions

This is kind of a difficult hypothesis to wrap your head around, so I provided an incredibly quick and over-simplified summary here, just to tie it all together. If you still have questions after this, feel free to ask me or Sierra!

Questions for your discussion groups…

1. What is one possible function of sleep? Provide evidence for this function.
2. With regards to dreaming, which hypothesis do you endorse more, the activation-synthesis hypothesis or the neurocognitive hypothesis? Why do you support that particular hypothesis?

Okay, that does it for this lecture! The fourth and last lecture will cover sleep disorders. See you there!