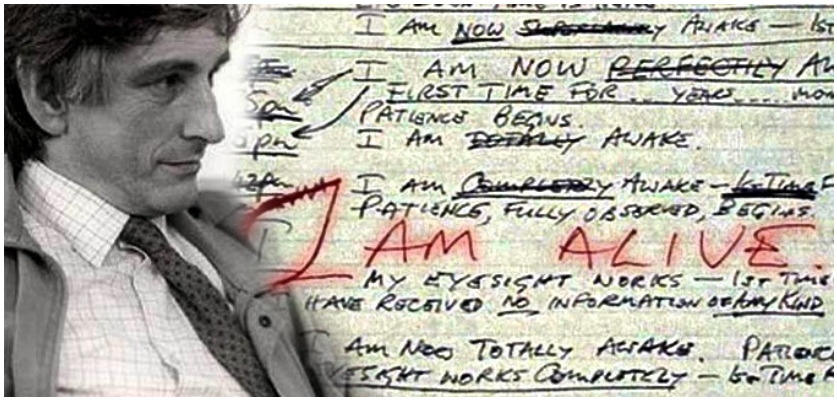
PSYC 365 Class 19:
Episodic memory

Can you get lost in time as well as lost in space?

We've been talking about the role of the hippocampus in navigating space. But what about time? HM was the famous lesion patient, and studying him gave us a lot of our knowledge of the role of the hippocampus in memory. Clive Wearing is a more recent, and more extreme, case of amnesia whose life since he lost his hippocampus has been well documented:

Losing memory

We will look at what it is like to live life with only 30 seconds of memory



So most of Class 19 will be a video on the story of Clive Wearing – because nothing makes you appreciate what memory does for us like seeing what it is like to totally lack it.

Learning objectives

- Give examples of both retrograde and anterograde amnesia
- Evaluate effects of extreme medial temporal lobe damage on episodic memory and the sense of having a self

Amnesia

- There are two broad categories of amnesia.
- Retrograde amnesia
  - People cannot recall events in their lives that occurred prior to some critical event that affected their brain (e.g., an accident or a stroke)
- Anterograde amnesia
  - A failure to form new memories after a critical event.

Please hold these categories in mind as you watch this video. I just went to Wikipedia to look up movies about characters with amnesia. There were 189 at Wikipedia's last count. So it's an idea that is very compelling in fiction. Mostly retrograde amnesia. Retrograde amnesia is the kind featured in the Bourne identity. Matthew Bourne can't remember who he is his past. Anterograde amnesia doesn't make for as good drama, but it's the inability to lay down new memories so events are just wiped away right after they happen.

Stages of memory

1. Encoding
   - Initial perception of event (attention, perception)
2. Consolidation
   - Strengthening and making more enduring over time
     - Synaptic level
     - Systems level
3. Retrieval
   - Calling it back up later

Encoding is laying down the memory in the first place. It's what you experience as it happens: what you are perceive, which in turn depends to a large degree on what you pay attention to.

Consolidation. As far back as 1904 it was recognized that consolidation has two components: one physiological, that involves neurochemical changes at the cellular level, and the other psychological, in which new experiences interact with existing cognitive structures– e.g., schemas -- to create long lasting memories. More recently researchers have distinguished between synaptic and systems consolidation. Synaptic consolidation, which is completed within minutes to hours, refers to a cascade of molecular and cellular mechanisms. The idea of consolidation at the physiological, synaptic level, which operates in all neurons that support memory across all species is well established. By contrast, systems consolidation is concerned with the reorganization of memory that takes place with time and experience across large brain networks. This involves interplay between psychological and physiological processes and may take decades. How that works has been more disputed and we'll get into some of weeds of that dispute in later lectures.

Retrieval. The act of calling up information from memory. Can involve re-activating sensory and other brain activity that happened during the original

event so that it is replayed. We'll get into some specific examples of that later as well.

Finally I also want to mention **reconsolidation** which we will not get into so much but you should know it exists. That's when a memory is changed at retrieval. The idea is that memories become labile, or changeable or unstable, when you call them up, and you integrate new information and change them before reconsolidating them. This allows us to update or memories but also to create false ones.

Video

Clive Wearing: Living Without Memory

https://www.youtube.com/watch?v=ipD_G7U2FcM

https://www.youtube.com/watch?v=ipD_G7U2FcM

Affected Brain Regions

- Hippocampus
- Temporal lobes:
  - medial on right
  - medial and lateral on left
- Ventral Prefrontal Cortex (vPFC)
- Fornix (white matter)
  - Connectivity between regions key for memory

Let's review the brain regions that were damaged by Clive's illness. Medial is on both sides and includes regions like the entorhinal cortex, which sends information to the hippocampus and contains grid cells important for navigation. Left lateral temporal damage – language is completely spared also object processing. Temporal lobe regions are important for semantic memory. Some of of that is spared. He knows what things are -- he knows what a cup is. He has trouble with some other things, like his kids names VPFC is important for controlling emotion and behavior and you can see this in some of his strong emotional outbursts, especially in early days. Fornix – connects the hippocampus and hypothalamus. And we know about the importance of structural connectivity in linking large scale networks that allow for memory processes

Summary: Wearing's Amnesia

- *Retrograde*(recalling memories laid down before illness)
  - No *episodic* recall
  - Does have (at least some) *semantic* recall
  - Spared procedural memory (piano)
- *Anterograde* (laying down new memories)
  - No *encoding* of episodic memory
  - Some slight *encoding* of new *semantic* information
  - Appears to be able to acquire some *procedural* memory

Episodic. He knows he loves Deborah. That's implicit associative memory. Like conditioning. Like the coloured circles in Anderson but with super high intensity. He knows he's married, But he doesn't remember their wedding or even any time in the past that he has ever seen Deborah. Procedural memory -- skills developed over years are completely spared, completely separate or dissociable from episodic memory. Which is a vivid example of the evidence for multiple memory systems. New semantic info: Deborah lives far away, has to drive to see him.

Episodic Memory and The Self

- *Autonoetic Consciousness* (Tulving): The ability to time travel – to place our selves in the past or future (or hypothetical situations)
- Thought to be key for *explicit* self awareness
  - allows you to reflect on the contents of episodic memory

The other striking thing about Clive is that he has no sense of conscious self that extends in time. He eternally feels as though he has just woken up. Endel Tulving, the guy who introduced multiple memory systems, introduced the idea of autonoetic consciousness to describe our feelings of being a coherent self across time. *Auto* = self. *Noetic relating to mental activity or the intellect*. *Autonoetic:* relating to mental activity or the intellect. So really translates as self-knowledge.

Explicit self awareness. I believe I am a discrete and continuous individual living in the same body from moment to moment and having continuity in my personal traits over time. I'm a certain kind of person -- smart, outgoing, introverted, clumsy, funny, goofy, conscientious. That's the idea of personality, right? Our sense of self as a person with continuity affects our behavior, in the present, past and future. It relates to how we reflect on our own past behavior, what kind of person we are, who and what we identify with how we feel about it, and this in turn determines if we do it again. How we tell stories about ourselves.

Question

- How would you describe Clive Wearing's sense of self in relation to the idea of autonoeitic consciousness?

Take-Home 1

- Clive Wearing's example demonstrates dissociation between memory systems
- Conscious, "declarative" episodic memory, which relies on the hippocampus is gone
- Implicit procedural memory and strongest emotional associations, as well as semantic knowledge spared

Take-Home 2

- But there are some behaviours that don't quite fit a clean dissociation between memory systems as we currently describe them
- That existing semantic knowledge is mostly intact suggests that retrieval systems are at least partly separate from those required for episodic memory

Learning objectives

- Describe the role of rehearsal and replay and in the consolidation of episodic memory
- Outline a major theory of the relationship between episodic memory, consolidation and semantic memory
- Identify brain systems that play roles in autobiographical memory and reinstatement

Types of explicit memory: Review

- Semantic Memory
  - Facts
- Episodic Memory
  - Events – mental time travel
- Autobiographical Memory
  - Semantic + Episodic

Stages of memory: Review

1. Encoding
   - Initial perception of the event (includes attention & perception)
2. Consolidation: Laying down and strengthening over time
   - Synaptic consolidation
     - minutes to hours
   - Systems level consolidation
     - large-scale brain networks
   - Years
3. Retrieval
   - Calling it back up later

Synaptic consolidation, which is completed within minutes to hours, is a cascade of molecular and cellular mechanisms. By contrast, systems consolidation is concerned with the reorganization of memory that takes place with time and experience across large brain networks. It involves interplay between psychological and physiological processes and may take decades. As I mentioned, how that works has been more disputed. Let's look at some influential theories of how systems consolidation works.

Two theories of system consolidation

1. Standard Consolidation Theory (CST):

- Memories initially depend on hippocampus
- Later become consolidated across other brain regions

The first is standard consolidation theory or CST. [1] Hippocampal involvement is time-limited in the sense it is needed to form those associations that are necessary to create a coherent memory and to maintain it for a relatively short period but not forever. [2] With the passage of time, the memory reorganizes, or consolidates in non-hippocampal (neocortical) structures and can now be retrieved without the hippocampus. This was inspired by findings that HM had temporally graded amnesia. He could remember events from long ago but not recently. Because of that researchers concluded that recent memories required the hippocampus but older memories relied on other brain regions and did not. According to SCT, a recent memory is vulnerable because the consolidation process is not yet complete and a large lesion to the hippocampus would wipe it out. When enough time is allowed for consolidation to run its course and the memory is represented within a distributed network that includes the neocortex, it is highly resistant to disruption and damage to the hippocampus has no effect. Note that SCT does not distinguish between types of declarative memory—it lumps episodic memories that are detailed and context-dependent with semantic memories that are less tied to context and more generic, or schematic.

Two theories of system consolidation

2. Multiple Trace Theory (MTT)

- Episodic memories ALWAYS require the hippocampus
- System-wide consolidation is accompanied by changes in the nature of the memory -- *semanticization*
  - Memories become *semantic* memories once they are represented outside hippocampus
  - Episodic memories require hippocampus, semantic memories don't
  - Semantic doesn't have to replace episodic – can exist side by side

The second theory is multiple trace theory, or MTT. [1][2][3]. In support of multiple trace theory, not all hippo lesion patients have temporally graded amnesia as HM did. With respect to graded versus ungraded retrograde amnesia, the argument is that the pattern of amnesia exhibited by patients with extensive hippocampal lesions depends on the nature of the lesion and the type of memory that's tested. Tests of memory that involve semantic memory result in a temporal gradient that reflects the time required to complete the transformation process. In contrast tests of hippocampus-sensitive, episodic memory yield non-graded amnesia. regardless of the age of the memory. This claim by champions of MTT position is consistent with numerous demonstrations that patients with known, or presumed hippocampal damage have severely impaired episodic memory, but preserved semantic memory

MTT: Semanticization requires *rehearsal*

- Semantic memory is distilled from episodic memory
- When memories are called up many times, multiple traces are formed
- *Semanticization* is when general knowledge is pulled out from rehearsed events and stored separately
  - Requires hippocampus to create
  - Does not require it to retrieve

Morris Moscovitch

Nadel & Moscovitch, 1997
Winocur & Moscovitch, 2011

1. Every semantic memory starts out as one – or more likely multiple - episodic memories. Each time an old memory is retrieved, a new trace, which relies on the hippocampus, is created.
2. Whereas each episodic memory trace is unique, the creation of multiple, related traces allows the extraction of the information common among them. This information is then integrated with pre-existing knowledge to form semantic memories that can exist independently of the hippocampus. Thus, knowledge about the world, about people and events acquired in the context of a specific episode is separated from memory of the episode itself and ultimately stored independently of it.
3. This is the process process of increased *semanticization*. Without a well-functioning hippocampus, acquisition of semantic memory is slow and effortful, at least in adulthood. As we saw with clive wearing.

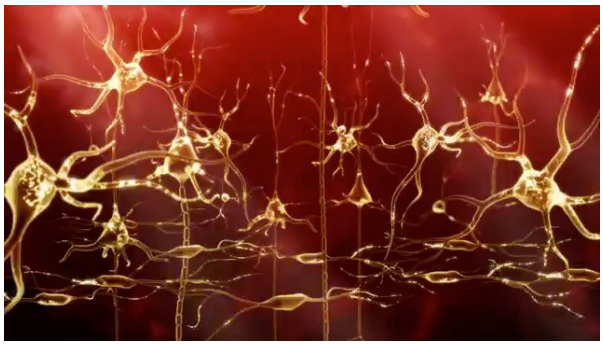
Introducing…two more concepts!

Reinstatement

Schema

Reinstatement

When the brain helps consolidate a memory by playing the pattern of brain activation (measured as neuronal or voxel activation) that represented the event during encoding offline later on.



Reinstatement is what happens in your brain when you rehearse a memory, which in turn helps you consolidate it more strongly. And it has been proposed that reinstatement is a mechanism that allows for semanticization – an idea that is central for the bird paper we're about to read. **You rehearse** a memory, **your brain reinstates** the same pattern of activation.

Reading question

- What is one way Bird et al. say that Memory for complex events differs from memory for simple stimuli?

To comprehend the sequence of unfolding actions, it is necessary to interpret them with reference to our prior knowledge of similar situations, sometimes referred to as memory “schemas” or “scripts” . Therefore, memory for a complex lifelike event is never a straight- forward representation of the incoming information, but is instead a combination of this and our stored semantic knowledge.

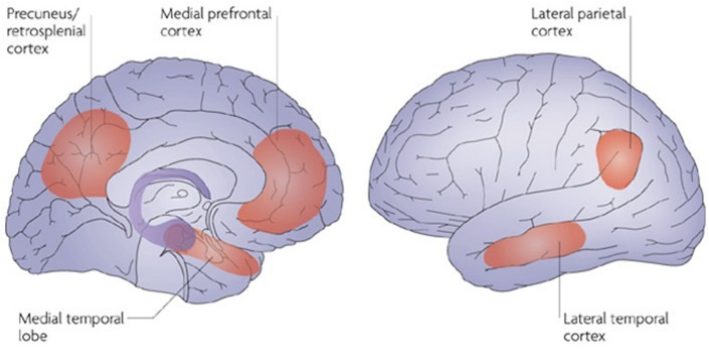
Now, back to the idea of a schema

- A schema is a mental concept that informs a person about what to expect from a variety of experiences and situations.
- Schemas are scripts based on information provided by life experiences and are maintained in memory.

[1] We talked about it briefly when we talked about cognitive maps.
2. It filters and organizes what we encode in the first place. So it filters like attention but it also allows us to organize events in time so that we are able to lay down more than just a static snapshot but sensory impressions that unfold like the frames of a film. If you think of it in terms of predictive coding theory, schemas are frameworks that determine our dynamically changing forward models of the contents of perception.

Schema example

Autobiographical variety network



1] In the intro to the paper, Bird et al. stress the role of the posterior cingulate, precuneus and retrosplenial cortex -- working as a unit in this example -- in ”spatially coherent visual imagery of environments” That is, in realistically imagining or remembering scenes – as well as in semantic memory, or memory for factual information.

Bird et al.: Memory reinstatement

Is the role of reinstatement in memory consolidation just passive?

Or does active rehearsal help?

They point to existing evidence for PASSIVE reinstatement processes. That's when patterns of brain activation spontaneously occur during sleep or on their own after encoding. They talk about how fMRI studies have shown that, for simple stimuli, reinstatement of patterns of BOLD activity occurs spontaneously between encoding and recall, and the more reinstatement there is the stronger the later memory.

But they go on to say that that typically many details of many memories of past events are lost within the first week. In this case they're often transformed into a much more general or gist like – memory. You just recall the outlines of it. Yet some memories are retained in a lot more detail and these are often memories that are actively retrieved many times – re-told often. So what they want to know is if active rehearsal helps retain detail in those cases. People who have a form of highly superior autobiographical memory are big memory rehearsers – they'd go over life events in their minds repeatedly -- sometimes obssessively

Memory consolidation: Passive vs. Active

- Big Picture Question: What roles do active rehearsal and prior knowledge (schemas) play in episodic memory consolidation?
- Research Questions
  - Does active rehearsal influence memory durability?
  - Do stronger patterns of neural similarity between encoding and rehearsal – reinstatement -- in episodic memory nodes lead to more detailed memory?

Again, this is a paper where they have research questions rather than directional hypotheses.
RQ1. Does actively recalling a memory over and over influence how long/well a memory lasts.
RQ2. If reinstatement, or the pattern of brain activity during rehearsal of memories is more like it was during encoding, will this lead to more detailed memory later on?

Two experiments

Goal of Experiment 1 (Behavioural)

- Investigate effect of active rehearsal on *durability* of memories

Goal of Experiment 2 (fMRI)

1. Identify whether they see reinstatement of BOLD activity when remembering unique videos.
2. Does the strength of this reinstatement when the memories are being actively rehearsed predict how well the video will be remembered later

1. **Durability**: How well they hold up over time. 2. **Trial unique** – it means they saw a different video in each trial of the task. Now we're going to try an exercise to illustrate how the authors addressed their research questions. So please roughly organize yourselves into pairs and have some way of jotting down information handy.

Where Am I?

Now watch this movie.

Stuck in Reverse

now this one

Describe what you saw

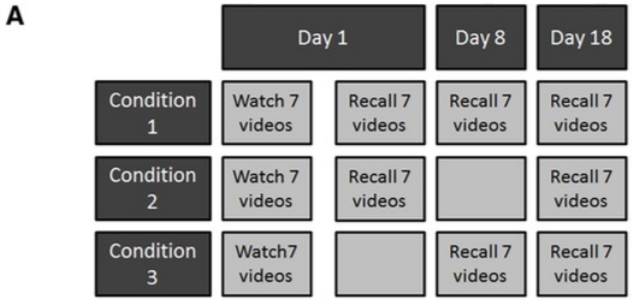
- Half of you describe *Where Am I?* to your neighbor in as much detail as possible
- Neighbor: Jot down details
- You can give hints to jog memory if you think something important is missing
- Now the other half of you describe *Stuck In Reverse* to your neighbor. Again in as much detail as possible
- Jot down details, hints etc.

Now grab a friend to help. **Which film do you think you'll remember better in a week?**

Bird experiment 1

You just saw an example of the kind of films they used in this experiment, and how memory was tested in the exercise I gave you. In the next slide you'll see the overall structure of Experiment 1.

Experiment 1



- Investigate effect of active rehearsal on memory "durability"

Now it gets a bit complicated. Study design for Experiment 1. Most of us need to look at it a couple of times. This is a within subject design, so every participant saw 7 videos in each of the 3 conditions on the first day and had to recall different combinations of videos on a second and third testing day. So every participant watched 21 short (~30-60s) soundless videos, kind of like the ones I just showed you, on day 1.. After a break of about 5 minutes, the videos from Conditions 1 and 2 were rehearsed/recalled (i.e., described aloud in response to the video title), with the experimenter present. Videos from Conditions 1 and 3 were rehearsed/recalled on day 8. All 21 videos were recalled on day 18.

Recall participants were prompted by title and asked to describe as much details as possible. A checklist of frequently recalled details was made for each memory to help in scoring and participant memories were scored for number of correct details. A point was awarded for every "idea" correctly recalled. Points were awarded for correctly recalling actions (e.g., "someone swiped their card to open the door") and specific descriptions (e.g., "a balding man" but not "a man").

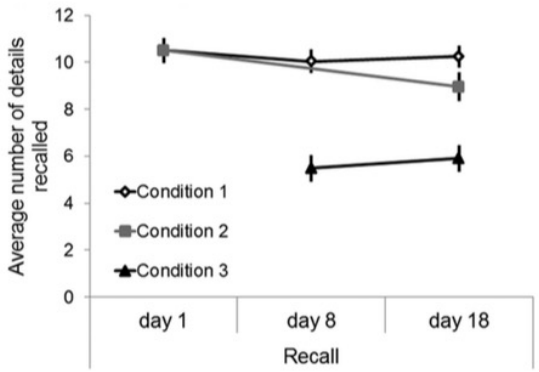
Methods for experiment 1

- Participants: 13 young adults
- Independent variables:

- Dependent variables:

Not a lot of participants right? But it is a within-subject design – they are comparing different conditions in the same people, not looking for differences between people. And they had to come back on multiple days. And they replicated the main pattern of findings in Experiment 2 Still. This is the last paper of the course so your job is to use what you've learned and determine the independent and dependent variables for yourselves!

Experiment 1 results



2x as many details remembered for details rehearsed on day 1 than not rehearsed!

Behavioral results from Experiment 1. Reminder Condition 1 was rehearsed on all 3 days, condition 2 was rehearsed on days 1 and 18 and condition 3 on days 2 and 18. Day 1 was only conditions 1 and 2. On day 1 memory was identical for conditions 1 and 2 and very good. On Day 8 memory in condition 1, where they had rehearsed right away was almost as good as on Day 1 whereas in condition 3, where they hadn't rehearsed right away, it was far worse. Finally on day 18, in conditions 1 and 2, where they had rehearsed right away memory was pretty good -- only a bit of memory loss when they hadn't rehearsed on Day 8. But in condition 3 is was much poorer. Take home – rehearse it right away or lose it. Good to know when thinking about studying! **Conclusion** – rehearsal shortly after encoding boosts details remembered.

They also looked at the degree to which the details recalled by each participant were similar across sessions relative to the details recalled between different participants. For each participant details across sessions were highly consistent ($r = .79$) whereas details between participants were much less so ($r = .27$).. This was not only the case for correctly recalled information but also for incorrect details. whether they were correct or incorrect they stayed the same. The authors wondered if that was an example of semanticization. For example, one participant falsely recalled a kiss between two characters when tested on day 1,

and then repeated this on day 8.

Question

Based on those findings, I will do better on an exam if _____

a. I review my notes right after class
b. Wait a week to review my notes
c. Study right before the exam
d. a & c
e. b & c

d (a & c) -- but a is key! Now here is another film

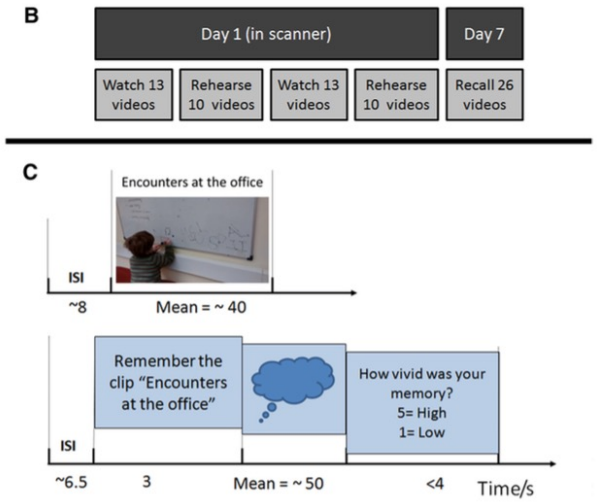
A Short Film

Rehearsal

- Silently describe the contents of that film in as much detail as possible in your own head.
- How vivid was your memory on a scale of 1-5?

fMRI experiment (Experiment 2)

Experiment 2



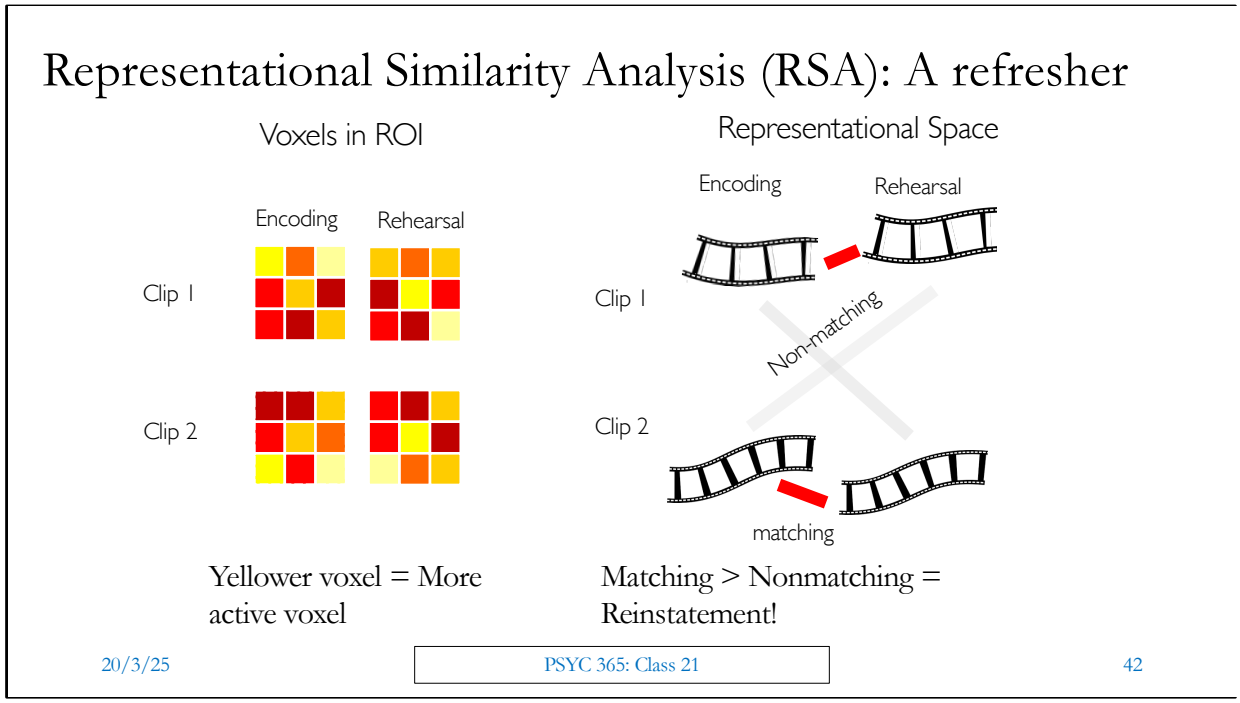
B, Study design for Experiment 2. On day 1, 26 videos were watched, and 20 of these were silently rehearsed in an MRI scanner. The watching and rehearsal periods were divided into two runs. **The rehearsal phase** used a cued recall paradigm, with the video title serving as the rehearsal cue. On each rehearsal trial, the title of the video appeared on screen and then faded but remained visible. Participants were instructed to spend approximately the same amount of time rehearsing the video as the video had originally lasted. After rehearsal, the participant pressed a button to indicate they had finished. They were then asked to rate how vividly they could remember the video on a visual analog scale from 1 to 5. A week later, all 26 videos were recalled in the presence of an experimenter. Note this did not take place in the MRI scanner. They were only scanned during encoding and the rehearsal right afterward. Then memory was scored for detail. Recall of the videos was scored so that a point was awarded for every "idea" correctly recalled. I'm only going to talk about the RSA results as they are the most important for the questions posed by this study and for the authors' interpretations. But they replicated the earlier result of > recall for rehearsed videos and also found that greater ratings of vividness of rehearsal in the scanner predicted better memory recall one week later.

Methods for experiment 2

- Participants: 16 young adults
- Independent variables:

- Dependent variables:

Not a lot of participants right? But it is a within-subject design – they are comparing different conditions in the same people, not looking for differences between people. And they had to come back on multiple days. And they replicated the main pattern of findings in Experiment 2 Still. This is the last paper of the course so your job is to use what you've learned and determine the independent and dependent variables for yourselves!



We decode brain activity by looking at the pattern of activation across voxels in a region of interest to discover how similar or different the patterns are. Say the posterior cingulate cortex. We then look at the patterns of higher vs. lower activation across voxels for each movie clip at encoding and rehearsal. Then we correlate the voxel patterns to see whether the pattern is more similar or more different from the pattern of activity for mismatching pairs

2. This allows us to determine how close or far the pattern for each stimulus is from the others in representational space. We can read out the distance in representational space for each participant between one clip and another clip, or encoding or rehearsal for the same clip vs. other clips, or for encoding vs. rehearsal. SO THE MORE ALIKE THE PATTERNS OF VOXEL, THE CLOSER IN REPRESENTATIONAL SPACE. IF brain activity from encoding is reinstated during rehearsal then the pattern during rehearsal of that clip should look more similar to that clip at encoding than the pattern to another clip at encoding

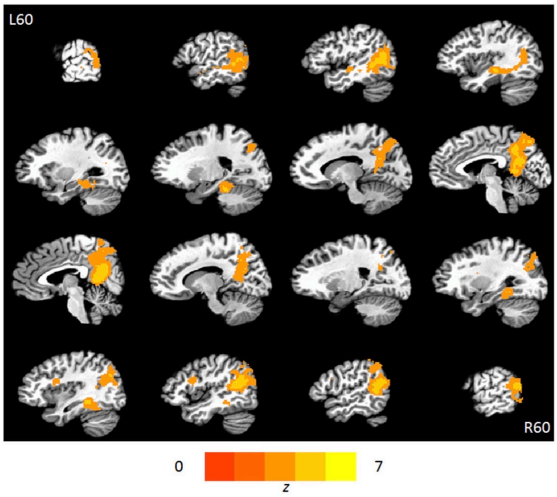
Encoding probe…

RSA was used to see if the pattern of activity…

a. In a single voxel was more similar for the same clip at encoding and rehearsal than for two different clips at encoding or rehearsal
b. Across voxels was more similar for the matching clips at encoding and rehearsal than for mismatching clips at encoding or rehearsal
c. In a single voxel discriminated activity from different clips

b. Cos always about the pattern of activation across voxels. Q: What fMRI analysis approach looks at single voxels?

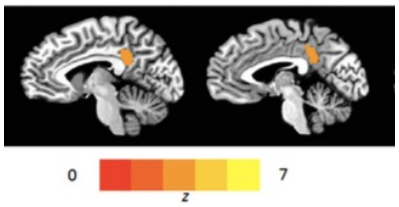
RSA1: Regions involved in memory reinstatement



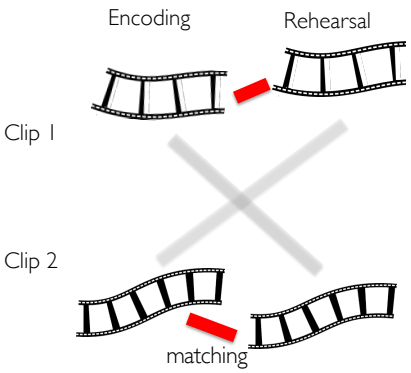
Heatmap shows regions where the pattern of BOLD signal when encoding the videos was more correlated with BOLD signal when rehearsing the corresponding videos (matching, compared with correlations of nonmatching videos). This network included the hippocampus and posterior midline regions (posterior cingulate, retrosplenial cortex, and pre- cuneus) all playing a key role in episodic memory processes.

To identify brain regions whose representations were more similar for matching than nonmatching pairs, we calculated for each participant the mean correlation for matching pairs minus the mean of the nonmatching pairs and assigned this value to each voxel.

RSA 2 and 3: Higher similarity between encoding and rehearsal associated with greater memory vividness & detail



Strength of the correlation between voxels between encoding and rehearsal for each video clip predicted memory detail 1 week later as well as in-scanner vividness



FOR each Video, the degree to which the pattern of PCC activity at encoding was correlated with the pattern at rehearsal (matching compared to non-matching), the more vivid and detailed the memories were. So the higher correlation between PCC activity at encoding and rehearsal was for a particular video the more vivid the rehearsal was rated and the better the memory was recalled one week later.

We directly contrasted the RSA above with an analysis in which the contribution of each matching encoding-retrieval pair was weighted by the number of details a given participant remembered for a given video compared with the participants as a group. For each subject, we calculated the difference between the weighted mean of the matching pairs and the unweighted mean of the matching pairs. If the degree of memory for a given video is unrelated to the similarity of the encoding-rehearsal pair, then the expected value of this contrast is zero. However, if the correlation between encoding-rehearsal pairs is in- creased when more details from that video are remembered, then the expected value of the contrast is greater than zero. This was

assessed by a one sample *t* test across subjects.

Summary so far…

- Successful consolidation of video content depended on rehearsal shortly after encoding
- Reinstatement of BOLD patterns **in episodic memory nodes** was associated with active rehearsal
- Rehearsal: Does it speed up s*emanticization* process as well as strengthen episodic memory*?*
- Findings consistent with integration of events into *schema,* which requires episodic + semantic info
- **Posterior Cingulate Cortex:** Crucial role in active memory consolidation
  - Integrates semantic and episodic information into a schema

2. Reinstatement. The authors say that we see reinstatement in regions key to episodic memory suggests that rehearsal strengthens episodic processes alongside semanticization.

3. Semanticization. Each participant's descriptions of each video very similar across recollections, suggesting some semanticization. "We note that our participants' descriptions remained highly detailed, which is contrary to the notion that **semanticized** memories are generic in nature, but is consistent with the observation that even very densely amnesic patients are often able to recall some stories from their pasts in considerable detail, although such anecdotes are typically repeated verbatim on each occasion." **5 Schemas:** Videos depict an unfolding sequence of actions that must be interpreted, with reference to prior knowledge or "schemas," to create a coherent representation of the whole event. Evidence: The descriptions of the videos frequently referred to external information (for example, one video was described as being "like the film 'Twilight,'" and in another, a character acted "like James Bond").

From Bird et al.

- In addition to known role in recollection and visual imagery, the PCC plays a crucial role in integrating incoming episodic experience with existing knowledge to create a coherent representation of the event (schema).
- Reinstatement of this representation helps consolidation by strengthening episodic details as well as more general schematic information, resulting in a memory that is resistant to forgetting, but rather inflexible and semanticized.

The posterior cingulate cortex has been identified as a candidate region for linking episodic and semantic information. And nearby retrosplenial cortex translates between egocentric (body centred self to object) and allocentric (objective object to object) views of the environment. **Q: So is this consistent with multiple trace theory?**

Take-homes

- Memory reinstatement – passive and active – is a key component of memory **consolidation**.
- Memory rehearsal allows reinstatement of representations to contribute to memory detail in wakefulness as well as sleep
- This involves reactivating patterns of activity in brain regions, including hippocampus/MTL/PCC, that were active during encoding
- The PCC plays a key role in reinstatement of memory vividness & detail

Question

- Do you buy their story of rehearsal speeding semanticization?

What alternative explanations did the authors give to explain the results? 1. Rehearsal actually inhibits consolidation of unrehearsed videos. Although this explanation does not explain why active rehearsal is such a good method for retention of detail over long periods it may explain why recall for nonrehearsed videos was so poor. **A second mechanism that** might serve to stabilize the memories is the strengthening of a hippocampal-dependent "episodic" representation of the events. This is supported by the fMRI RSA findings. Key episodic memory regions reinstated during active rehearsal AND RSA similarity in PCC correlated with memory detail

Discussion time

Given that dopamine reinforces attention to past rewards, how might companies (e.g., social media platforms, advertisers) leverage this to maintain user engagement? Should we be concerned about the ethical implications of designing systems that hijack this cognitive process?

Discussion time

We know that DA circuitry is important for the incentive salience that leads to attentional biases for reward, which serves as a marker for both depression and addictive behavior. We also know the brain is most malleable in our formative years. So, could early-life experiences shape dopamine-related attentional biases and potentially predispose individuals to addiction or depression later in life?

Discussion time

Being aware of attentional bias, what can we do to direct our attention towards relevant class material when studying? Will using colour or other ways of differentiating information (varying font sizes, patterns, symbols, etc.) direct our attentional bias towards relevant information and help our memory when studying?

The end!