To the Best of My Recollection
The Cognitive Neuroscience of True and False Memory

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“Memory is not the re-excitation of innumerable fixed, lifeless ideas and fragmentary traces. It is an imaginative reconstruction, or construction, built out of the relation of our attitudes towards a whole active mass of organized past reactions or experiences, and to a little outstanding detail which commonly appears in image or language form.”

- Frederic Bartlett

Overview
- Amnesic syndrome & Multiple memory systems
- Recognition memory: Examples of very high capacity and forgetting
- Neural mechanisms of successful encoding
- Memory distortions and “sins”
- Source misattribution
- “Flashbulb” memories
- Misinformation and its neural basis
- Imperfect, distorted, and at times inaccurate memory is the status quo

Memory Stages & Processes

Getting it in
How are Memories created?
Encoding

Keeping it in
How are Memories Stored and Retained?
Storage

Using it
How are Memories Accessed and Used?
Retrieval

Pick a card, any card

Concentrate - remember your card ...

SHAZAM! Your card is gone...
Psychic Professor Stark?

Multiple Memory Systems

Amnesic Syndrome

Amnesic Syndrome
- Impaired ability to learn new facts and events (anterograde amnesia).
- Impaired memory for facts and events encoded recently before the onset of amnesia (retrograde).
- Intact:
  - Language
  - IQ
  - Working memory
  - Very remote memories
- Nondeclarative memory (priming, categorization, skill acquisition, classical conditioning, etc.)
Amnesic Syndrome

- Impaired ability to learn new facts and events
- Intact:
  - Language
  - IQ
  - Working memory
  - Remote memories (temporal gradient)
  - Nondeclarative memory (skills, habits, repetition priming, delay conditioning, etc.)
- Extensive MTL damage produces severe (complete) impairments.
- Damage limited to the hippocampus produces more mild impairments.

Summary

- “Memory” is not one thing.
- There are multiple processes and multiple memory systems.
- Memory can fail at any stage.
- Memory is stored across multiple systems and each can drive behavior.
- Each learns different aspects of a “memory”; has different capabilities, different time-courses, etc.
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### Memorize

### Recognition Performance

### Which did you see?
Visual memory can be very good but certainly shows signs of forgetting over time.

Why do we Forget?

- Encoding failure: Information was never encoded & never made it from working memory into long-term memory.
- Decay: Memories simply weaken with time, regardless of what other material is learned.
- Interference: Memories can interfere with each other to cause forgetting of existing information, or to hamper acquisition of new information.
- Loss of retrieval cues: We forget because we lose access to the information, but the information itself is not lost.

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Neuroimaging of Encoding

- Study novel items
- Delay
- Recognition test
- Examine activity at study for items remembered during the test (Hits) vs. those forgotten (Misses)

*The amount of activity (MTL and frontal) during encoding of novel pictures predicts your ability to remember it later.*

Incidental vs. Intentional

- Study novel items
- Delay
- Recognition test
- Delay
- Test for memory of novel foils in first test.
- Examine encoding during study and incidental encoding at test

Stark & Okado (2003)

Good, but not Perfect

Recall the Words

*Memory is far from perfect and false memories are to be expected (remember Bartlett). If you think it should have happened, you may think it did happen.*
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Memory Illusions
- Our declarative memory is lossy. In compressing information, data are lost.
- This lossy compression is adaptive but occasionally produces artifacts (false memories).
- These artifacts reveal aspects of normal memory processes. False memories are normal.
- Akin to visual illusions

Schacter's Seven Sins of Memory

<table>
<thead>
<tr>
<th>Distortions</th>
<th>Failures of Forgetting</th>
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<tbody>
<tr>
<td>1. Transience</td>
<td>Decreasing accessibility of information over time.</td>
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<tr>
<td>2. Absent-mindedness</td>
<td>Insufficient processing leading to weak encoding.</td>
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<td>4. Misattribution</td>
<td>Attributing a recollection to the wrong source.</td>
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<td>5. Suggestibility</td>
<td>Memories that are implanted as a result of leading questions or comments.</td>
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<td>6. Bias</td>
<td>Retrospective distortions and unconscious influences based on current knowledge and beliefs.</td>
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<td>7. Persistence</td>
<td>Pathological remembrances – information we cannot forget.</td>
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Imaging Source Misattribution

Gonsalves & Paller (2000)
Okado & Stark (2002)
Flashbulb Memories

Defining characteristics (in theory)
- Rapid, one-shot learning
- Happen in highly emotional or aroused states
- Resulting memory is very complete and very accurate
- Immune to forgetting
- A “snapshot” of that event triggered by high-emotion

Tell me about
- The Challenger explosion
- The O.J. Simpson verdict
- The Columbia explosion
- September 11th

Automatic Distortions: OJ Study
- 222 College students interviewed 3 days after verdict.
- “Please describe how you first heard the news of the verdict in the O.J. Simpson double-murder trial.”
- What time was it when you first heard the news of the verdict? How did you first hear about it? Where were you? What were you doing? Who told you? Who else was there? …
- Half re-interviewed 15 months later
- Half re-interviewed 32 months later
- Compare delayed account to initial account

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
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<th>Delayed Account</th>
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<tr>
<td><strong>Major</strong></td>
<td>Leaving a 10-AM psych class, my roommate and I heard someone commenting on it, so we asked him the verdict. I first heard the verdict coming out of a lecture with my roommate. The verdict was to be read in the morning and we had psych during that time. As we left the lecture hall, I heard someone say, “The verdict is not guilty.” I was stunned and asked him to repeat himself and tell me about the verdict.</td>
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<td>I awoke to screaming outside my apartment window, so I looked at the clock (10:05) and realized the verdict had just been announced. I was in bed and reached for the stereo remote and turned the radio to 100.7 and listened to the verdict replayed. I knew what time the verdict would be read, so I got up and started running to the room. I was sitting in bed and listening to the radio and the screams from the other apartments and outside.</td>
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<td>I was watching TV at home in my living room. My sister and father were both there. Doing nothing in particular, we were watching how the news stations were covering different groups of viewers just waiting to hear the verdict. I think that the focus was mostly on law students and their reactions to the verdict.</td>
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<td><strong>Major</strong></td>
<td>I was in the Commuter Lounge at Revelle and saw it on TV at 10:45. More and more people began to come into the room. We kept having to turn up the volume, but it was kind of cool. Everyone was talking. I first heard it while I was watching TV at home in my living room. My sister and father were both there. Doing nothing in particular, we were watching how the news stations were covering different groups of viewers just waiting to hear the verdict. I think that the focus was mostly on law students and their reactions to the verdict.</td>
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Distortions increased with delay
Final accuracy poor
Convergence to “Heard on TV”
Confidence, if anything, inversely correlates with accuracy

**Misinformation**

*Misinformation after the fact can distort memories.*

*You’ll remember what you’re told to remember*

- Watch videotape of a white car driving along a road.
  - Asked either:
    - “How fast was the white car going when it passed the barn while on the country road?”
    - “How fast was the white car going while on the country road?”
  - There was no barn.
  - One week later, asked what they saw in the tape
    - Misinformed: 17% report a barn
    - Valid: 3% report a barn

- View a scene of a traffic accident. Asked either:
  - “How fast was the white car going when it smashed into the black car?”
  - “How fast was the white car going when it hit the black car?”
  - Question affected the response:
    - smashed: 40.8 MPH
    - hit: 34.0 MPH

*Eyewitness testimony altered by how the question is asked.*

**Misinformation Effect**

- Initial
  - *in the road and passed the yield sign.*
- Misinformation
  - *at the intersection and turned right at the yield sign.*
- Test
  - or
  - ?
“Lost in the mall” (Loftus 1993)

- Chris & his older brother
- “Remember when you got lost? ... We were in the mall ... Remember? ... That old man found you and brought you back.”
- Day 2: “That day, I was so scared that I would never see my family again. I knew I was in trouble”
- Day 3: “My mother told me to never do that again”
- Day 4: The elderly man has a flannel shirt
- Day 14: The man was balding and had glasses
- Debriefing: “Really? I thought I remembered being lost ... and looking around for you guys. I do remember that. And then crying, and Mom coming up and saying 'Where were you? Don’t you – don’t you ever do that again’.”

Why do we Adopt Misinformation?

- Encoding
  - Variable encoding success leads to fragments of information that are later retrieved.
  - Source aspects may be poorly encoded
- Retrieval
  - Reconstruction of both true and false memories.
  - Little in the brain to let us know it’s not true.

The Misinformation Effect results from normal memory processing of a noisy / lossy / adaptive memory system.

fMRI Study of Misinformation

Does neural activity during the two encoding phases predict which version is later remembered?

- 8 Sequences
- 48 slides per sequence (12 critical)
Post-Scan
- 3 alternative forced-choice recognition. E.g.,
  - Where did the man hide the wallet?
  - Original – outside jacket pocket
  - Misinformation – pants pocket
  - Foil – inner jacket pocket
- Source Memory - “How do you remember?”
  - Saw in 1st
  - Saw in 2nd
  - Saw in both
  - Conflict
  - Guess

Defining True and False

<table>
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<th>False</th>
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<td>Participants chose the Original version</td>
<td>Participants chose the Misinformation version</td>
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<tr>
<td>Source listed as either “Saw in 1st” or “Conflict”</td>
<td>Source listed as either “Saw in 1st” or “Saw in both”</td>
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<tr>
<td>55% of Critical trials</td>
<td>34% of Critical trials</td>
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Predictive Encoding

Exploiting the Predictive Encoding (dM) effect

Activity in the hippocampus predicts which version will be remembered (i.e., which was encoded).

Do we Need Overt Misinformation?
- OJ Simpson study (and others) showed it can be automatic
- Memory is a reconstructive process. Distortions happen all the time without us knowing.
- Misinformation only helps this process by giving you new bits to incorporate.
- Misinformation is a powerful effect (“recovered memory syndrome”)
Y2K Study: Consistency Bias

Phase 1 1 week prior to Y2k, assess predictions and intentions about what will happen when the clocks turn over.

Phase 2 Weekend immediately after, assess what people did and what their intentions were.

Phase 3 10 weeks later (March 2000), assess outcomes, remembered intentions, and remembered predictions.

Pieters et al. (2006)

Prior Knowledge Intrusions

Gerald Martin strove to undermine the existing government to satisfy his political ambitions. Many people of his county supported his efforts. Current political problems made it relatively easy for Martin to take over. Certain groups remained loyal to the old government and caused Martin trouble. He confronted these groups directly and so silenced them. He became a ruthless, uncontrollable dictator. The ultimate effect of his rule was the downfall of his country.

Low “He was an intelligent man, but had no sense of human kindness.”

Medium “He was obsessed by the desire to conquer the world.”

High “He hated the Jews particularly and so persecuted them.”

Sulin & Dooling (1974)
You are going to make your decision of guilt or innocence based on the evidence presented in this trial. You should keep in mind that the evidence that you are required to consider consists of information presented in the answers of the witness and not information in the questions posed by the attorneys. Therefore it is important to separate out which information is actually presented by the witness and which information is implied by the attorneys. This is important because leading questions by attorneys have been found to have a distorting influence on memory. So listen carefully to what is actually stated by the witness in this trial.

- Neutral: Leading Question (DA asks leading questions with reference to unstated items), and Leading Question with Judges Instructions prior to hearing testimony.

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Neutral, Leading Question (DA asks leading questions with reference to unstated items), and Leading Question with Judges Instructions prior to hearing testimony.

Stated: Neutral
Unstated: Neutral
Unstated: LQ
Unstated: LQ + Instructions

% Recalled

1) People will "remember" unstated information based on their expectations.
2) Leading questions will inflate this ("How fast was the car going... barn!")
3) Instructions prior to testimony can help reduce the effect of leading questions.

Recap of Errors
- We often forget.
- We generalize and believe things happened that are similar to things that actually happened.
- Misleading information (misinformation) after the fact can distort the contents of memory.
- Memories of traumatic events, even novel traumatic events can be implanted and seem real.
- Distortions can and do happen automatically.
- Retrieving a memory leads to re-encoding this information, often along with distortions.
- None of this is "abnormal". It is all the result of normal operation of our memory system.

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