People have different kinds of memory:
- Sensory memory, short-term/working memory, long-term memory
- Each has different characteristics
  - Durations, capacities, contents
- Unifying model: *Stage theory*
  - Or “modal model”

#### Stage theory

<table>
<thead>
<tr>
<th>Sensory memory</th>
<th>Encoding</th>
<th>Short-term memory</th>
<th>Rehearsal</th>
<th>Retrieval</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Now often called: Working memory

<table>
<thead>
<tr>
<th>Long-term memory</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

• Also called *iconic memory*
  - Auditory sensory memory is called *echoic memory*
• Holds 1 item per spatial location
  - Evidence comes from *masking*: Presenting another item at a location *masks* (overwrites) the previous one

#### Masking

<table>
<thead>
<tr>
<th>80 msec</th>
<th>120 msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Contents and duration

• Contents are unidentified
  - You can know something was *there* without knowing what it was
  - You identify items one at a time
• Contents decay over time
  - Last about 1 sec
  - Contents of echoic memory last 2-3 sec
Decay

You can only identify so many elements before unidentified memory traces have decayed away

Subitizing

- We can encode the number of items in iconic memory, up to about 4 or 5, without counting
- For more items, we have to count
  - Or estimate, if items decay before we can count them all

Visual sensory memory

- Probably represented in the occipital lobe

Working memory (WM)

- The contents of our conscious awareness
- Has verbal and visual components
  - Often called “buffers”
  - More research has been done on verbal working memory

Verbal working memory

- Duration is a few seconds
  - Items decay, but can be maintained in an active state using rehearsal
  - Without rehearsal, an item lasts no longer than about 30 seconds
- Capacity is limited
  - Two different estimates:
    - 7 ± 2 chunks
    - As many items as you can rehearse in 2 seconds
Free recall procedure

- You’ll see 15 words, one at a time
  - Half a second apart
- Afterwards, write them down, in any order

Typical accuracy results

Primacy and recency effects

- Primacy: Early items get more rehearsal
  - Maintenance rehearsal: say the item repeatedly
  - Elaborative rehearsal: link the item to existing knowledge
- Recency: Late items are active because you just encoded them
  - Left alone, they decay
  - So the 30-second delay eliminated the effect

Verbal chunking

Visual chunking
Implications of chunking

- The more expertise you have, the more you can remember about what you're working on
  - Experts effectively have large working memories in their domains of expertise
  - In other domains, their working memory is no different anyone else's

The “working” in working memory

- You’ll see two numbers
- Multiply them in your head
- While thinking out loud

760 x 93

Altmann’s verbal protocol:

760 times 93, uh
3 times 760
so 3 times 0 is 0, 3 times 6 is 18, uh
so 3 times 760 is 22, 2 2 8 0, ok
that's the first line, the second line is
I was multiplying by 93 I think, times 760
so 9 times 0 is 0, 9 times 6 is 54
[?] the 4, carry the 5, uh
9 times 7 is, um ... 63
plus 4 is 67, so 6 7 4 0
plus ... 2 2 8 0
0 plus 0 is 0, 8, uh
now I've lost the second number