Donna Rose Addis

School of Psychology & Centre for Brain Research
The University of Auckland

Brain Research New Zealand
Background

The mind (and brain) is always active

Adapted from: Raichle et al. (2001). Proc Natl Acad Sci USA 98, 676-682.
Background
The mind (and brain) is always active

past

future

problem solving

creativity

Photographs: DR Addis
Humans spend a great deal of time (~50%) engaged in mind-wandering about their past and their future (Killingsworth & Gilbert, 2010).

Distinct from mindfulness

In particular, future thinking is an adaptive function:
- Assists planning and decision making
- Increases coping
1. How does the brain imagine the future?

2. What goes on in the creative brain?

3. How can we use memory & imagination to enhance success?
Part 1:
How does the brain imagine the future?
1. How the Brain Imagines the Future

Future Thinking

**Forms of future thinking:**
- Vision of our future self
- Goals and planning steps to attainment
- Intentions to do things (to-do list)
- Mental simulations of future events

**Characteristics of Mental Simulations**
- Dynamic and video-like
- Information about people and settings
- Sequences of actions and consequences
- Flexible, with a capacity to try out multiple alternatives
Memory for past experiences is *constructive*:

- Although memories play like videos, they are stored as fragments across the brain
- Details are re-integrated into coherent memory

Image: DR Addis
1. How the Brain Imagines the Future

Memory & Imagination

Memory for past experiences is constructive:

• Constructive nature enables us to simulate future events
  – Details are easily extracted from memories
  – Can then be recombined to construct novel simulations

Memory provides the fodder for imagination
1. How the Brain Imagines the Future

Overlap of Past & Future

fMRI of Imagination

1. How the Brain Imagines the Future

Overlap of Past & Future

fMRI of Imagination

fMRI of Imagination

- Default mode network engaged when remembering past AND imagining future

Adapted from: Addis et al. (2007). Neuropsychologia, 45, 1363-1377.
1. How the Brain Imagines the Future

Overlap of Past & Future

**fMRI of Imagination**

- Some regions are *more* engaged by future simulation than by remembering
- **Hippocampus**

- Why?
- Recombining details into an imaginary event

1. How the Brain Imagines the Future

Overlap of Past & Future

fMRI of Imagination

- Hippocampus important for accessing & integrating details
- When damaged, memory \textit{and} imagination are impaired

1. How the Brain Imagines the Future

Overlap of Past & Future

**fMRI of Imagination**

- In depression:
  - memories and imagination become less specific and less vivid
  - the hippocampus is less active

1. How the Brain Imagines the Future

Overlap of Past & Future

**fMRI of Imagination**

- The hippocampus also *encodes* new memories
- For simulations to influence our future behaviour, they have to be encoded – which involves the **hippocampus**
- More *detailed simulations* are more likely to be encoded

Part 2:

What goes on in the Creative Brain
2. The Creative Brain

The Creative Process

• Creativity refers to the ability to generate novel and original ideas but these ideas should have meaning or be useful in some way

Step 1: Generating ideas
• Making new links between ideas stored in memory
• Known as “divergent thinking”
Step 2: Evaluating ideas

- We assess new ideas to determine if they are:
  - Original and novel
  - Meaningful
  - Useful

- Objective is to converge on one idea and discard the others
- Known as “convergent thinking”
2. The Creative Brain

Divergent Thinking

Testing creativity: Guilford’s Alternate Uses Task

- Test of divergent thinking
- List as many uses as possible for this item in 1 minute
  - PAPERCLIP
- Responses rated for different measures of creativity, including:
  - Fluency
  - Originality
  - Appropriateness
Do creative people generate more vivid simulations?

- YES

- Better divergent thinkers simulated more vivid future events

- Over and above age and memory ability

Addis, et al., (2016), Memory
Do creative people use their “right brain”? 

- Common idea that people use their left brain for analytic tasks and their right brain for creative pursuits 

- Evidence from fMRI speaks against this idea 
  - A variety of creativity tasks have been shown to activate regions in both the left and right hemisphere 

Image: DR Addis
2. The Creative Brain

Neuroimaging of Creativity

Divergent versus Convergent Thinking

- Brain activity in both hemispheres
- Generation = Hippocampus

Part 3:
How can we use memory & imagination to enhance success?
What are the benefits of imagination?

- Simulating the future events can enhance our success
  - Troubleshoot and problem solve in advance
  - Prepare ourselves and change behaviour to increase effectiveness
  - Remembering simulations important for implementing intentions

- But only specific types of simulations are useful
3. Enhancing Success

Process vs. Outcome Simulations

- **Process Simulation**
  - One sets a goal and mentally simulates the steps one needs to go through to reach it

Getting a PhD:
- Applying to grad school
- Conducting research
- Writing thesis chapters
- Taking required classes
- Attending conferences
- Thesis defense
Process vs. Outcome Simulations

• **Process Simulation**
  – One sets a goal and mentally simulates the steps one needs to go through to reach it

• **Outcome Simulation**
  – Actively visualizing the outcome to be achieved
  – Often used in self-help literature

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**Getting a PhD:**

- In your graduation gown
- Diploma in hand
- Feeling relieved it is all over
3. Enhancing Success

Process vs. Outcome Simulations

Effects of simulation on exam performance

• US undergraduates, 1 week prior to midterm exams
• Either: daily process or outcome simulations, or counted the number of study hours

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process Simulation</td>
</tr>
<tr>
<td>Number of hours of study</td>
<td>16.1</td>
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<tr>
<td>Exam Grades (%)</td>
<td>80.6</td>
</tr>
</tbody>
</table>

3. Enhancing Success

Process vs. Outcome Simulations

Effects of simulation on exam performance

• Reduced anxiety and increased planning and aspiration

Imagining the “If-Then” of goal attainment

IF
Situation
Obstacle

THEN
Goal-directed
response

GOAL

- Meta-analysis of 94 studies (8000 participants) showed consistent impact of implementation intentions on goal attainment

Can memory training enhance imagination & creativity?

- If memory supports imagination, creativity & problem-solving, then memory training should enhance these abilities

- Any sort of memory training?

- Our participants watched a brief video, then
  - One group questioned about the details
  - One group questioned about the themes

- Participants then completed a future imagination task, divergent thinking task or a problem-solving task
3. Enhancing Success

Taking in the Details

Training for remembering the details boosted creativity

- Memory training boosted creativity task (not control task)
- Also increased default network activity during creativity task

• **Past experiences** are the **building blocks of future simulations**
  • Default mode network, especially the hippocampus, are crucial
• **Past experiences** are the building blocks of future simulations

• **Encoding simulations** is necessary for putting them into action
  • You can remember the simulation when you need it
  • Detailed simulations are most memorable
• **Past experiences** are the building blocks of future simulations

• **Encoding simulations** is necessary for putting them into action

• **Process simulations** of the steps to a goal enhances success
  • Decreases anxiety about upcoming events
  • Increases planning, aspiration and timely completion
  • Enhances means-end problem solving
• Past experiences are the building blocks of future simulations
• Encoding simulations is necessary for putting them into action
• Process simulations of the steps to a goal enhances success
• Imagining the IF-THEN of goal attainment to keep on track
  • Imagining contingency plans increases goal attainment
• Past experiences are the building blocks of future simulations

• Encoding simulations is necessary for putting them into action

• Process simulations of the steps to a goal enhances success

• Imagining the IF-THEN of goal attainment to keep on track

• Focusing on the details increases success
  • Of imagination, creativity and problem-solving

Success depends on remembering a vision of the future
Thank you for not mind-wandering!