Spatial working memory is necessary for embodied guidance of insight

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Background

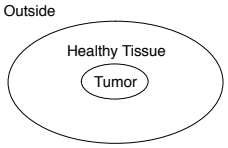
Directed actions can play a causal role in cognition[1-4]

Embodied guidance of insight:

Directed eye movements can prime performance on Duncker's radiation problem[5-7]

The Radiation Problem

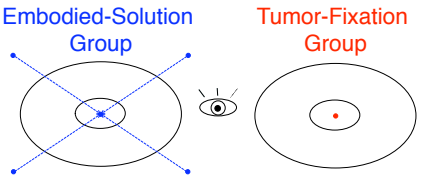
Using only lasers that destroy organic tissue when set at sufficient intensity, destroy the inoperable stomach tumor without harming the surrounding healthy tissue

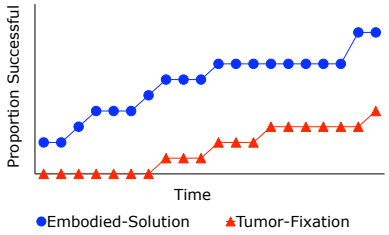


Solution: Fire multiple lasers converging on the tumor from the outside

Previous Findings

Participants try to solve the radiation problem while occasionally performing a visual tracking task:





Directed eye movements that embody the problem's solution guide insight[6]

How do actions guide thoughts?

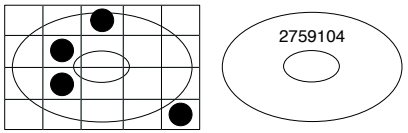
Hypothesis: Compatibilities between action and thought reflect interactions within spatial working memory

Method

Participants try to solve the radiation problem while occasionally performing a visual tracking task (embodied-solution or tumor-fixation) and concurrent working memory task (spatial or verbal):

1. Problem diagram (1 s)
2. Working memory stimulus (1.5 s)

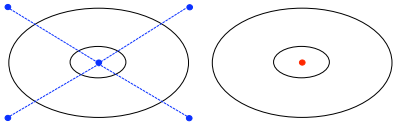
Spatial or Verbal



Time

3. Visual tracking task (9.5 s, 1 s/item)

Embodied-Solution or Tumor-Fixation



4. Working memory probe (until response)
5. Problem diagram (30 s)

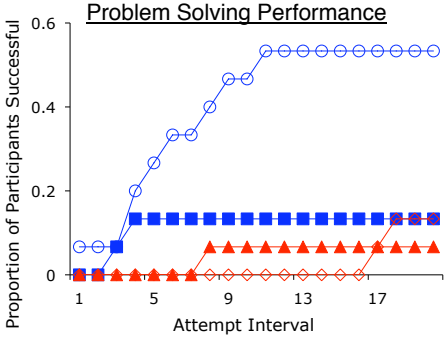
Participants repeat steps 1-5 until they solve the problem or have made 20 attempts

Participants assigned to one of four groups:

- Embodied-solution-spatial
- Embodied-solution-verbal
- Tumor-fixation-spatial
- Tumor-fixation-verbal

Results

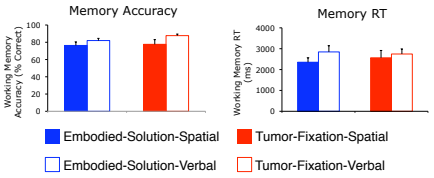
Problem Solving Performance



Embodied-solution-verbal participants solved the problem at a higher rate than other groups ($\chi^2(3, N = 60) = 14.21, p < 0.01$)

- Embodied guidance of insight was eliminated when priming eye movements were paired with a spatial working memory task

Working Memory Performance



- No effect of group on working memory accuracy ($F(3,58) = 1.90, p > 0.1$) or response time ($F(3,58) = 0.61, p > 0.1$)

Visual Tracking Performance

Average accuracy on the visual tracking task was 95%

- Participants moved their eyes to the directed locations during the visual tracking task

Conclusions

- Directed eye movements that embody the radiation problem's solution guided insight when paired with a verbal, but not spatial, working memory task
- Verbal and spatial working memory task performance was roughly equivalent across groups
  - Spatial working memory task was not more difficult/distracting than verbal working memory task
  - Difference in problem solving success stems from the distinction between engaging spatial versus verbal memory resources during priming movements
- Performing a specific action biases the conceptualization of space in working memory

Cross talk between action and thought requires spatial working memory resources

References

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