



Action and Problem Solving

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What Action? – Spontaneous Gestures

Representational gestures

No general symbolic meaning (unlike language, and gestures portrayed below)

Spontaneously produced with speech, often outside of awareness



defaultprme



dreamstime.com



What Action? – Guided Enactments

Enactments

- No general symbolic meaning

- Intentionally produced as a means of acting out an idea in space

Research on 'gesture' is sometimes actually examining enactments

Difficult to understand how these 'actions' relate to thought

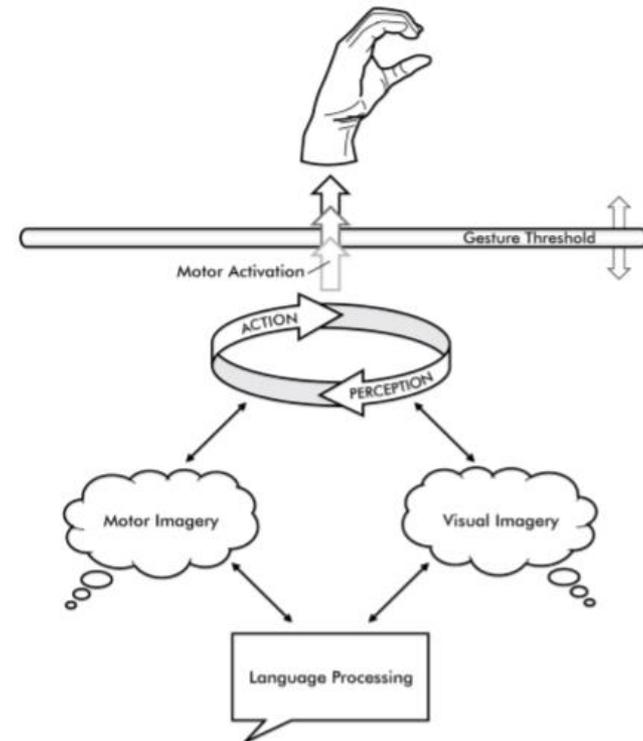
Gesture as Simulated Action

[GSA] framework

Hostetter and Alibali (2008)

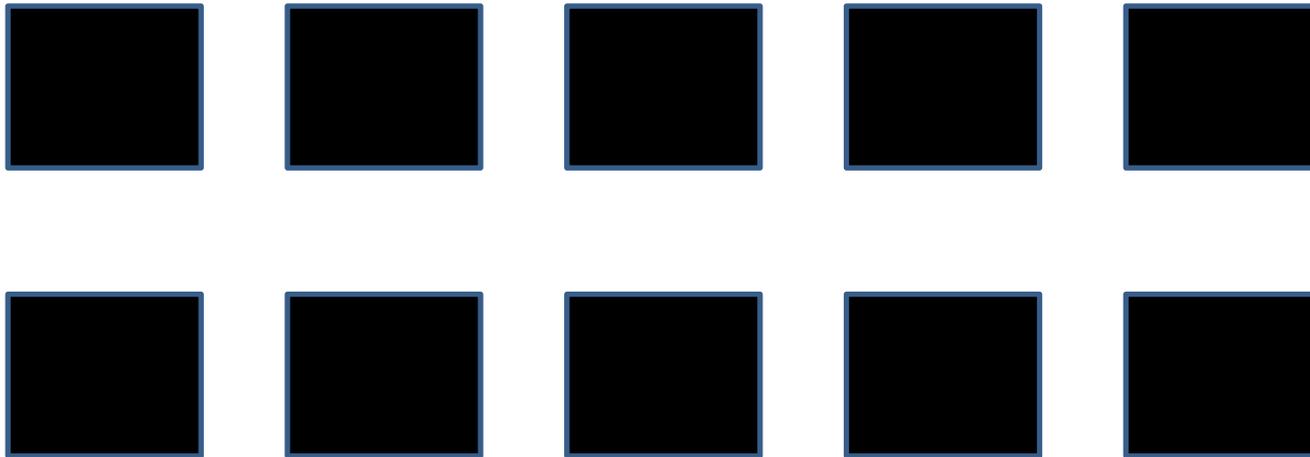
Mental simulations
critical in forming
language and thought

Gesture represents an
'acting out' of the
mental simulation
inherent in thought,
but not verbalized



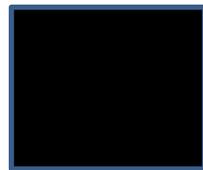
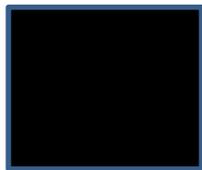
Gesture-Speech-Mismatches

Church & Goldin-Meadow (1986)



Gesture-Speech-Mismatches

Church & Goldin-Meadow (1986)



Gesture and Working Memory

Children: liquid conservation tasks

Adults: factoring (e.g. $x^2 - 5x + 6 = (\underline{\quad})(\underline{\quad})$)

Secondary task: Remember letters while explaining

Gesturing -> Remembering more letters

Goldin-Meadow et. al, (2001)



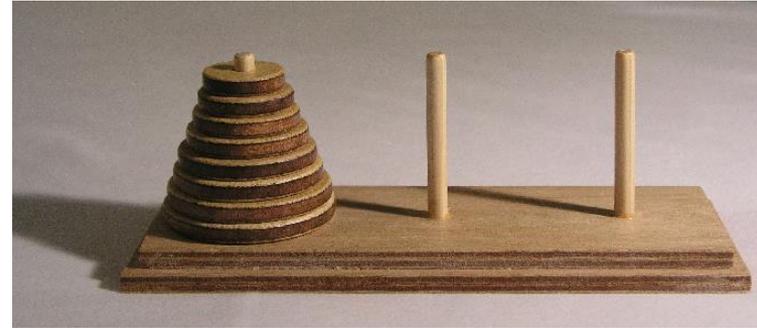
Gesture Shaping Thought

Tower of Hanoi problem

Solve problem once

Explain problem with gesture

Solve problem again



IF weight of the small disc was increased AND participants used one-handed gestures explaining, their performance suffered.

IF participants did not explain strategies, OR used two-handed gestures performance always increased

Beilock & Goldin-Meadow (2010)

Enactment Shaping Thought

Children are asked to solve simple algebra problems involving addition

$$8 + 2 + 3 = 8 + \underline{\quad}$$

Told to gesture in specific way while solving the problem, acting out the combining of (2) and (3), then sliding them to the (___)

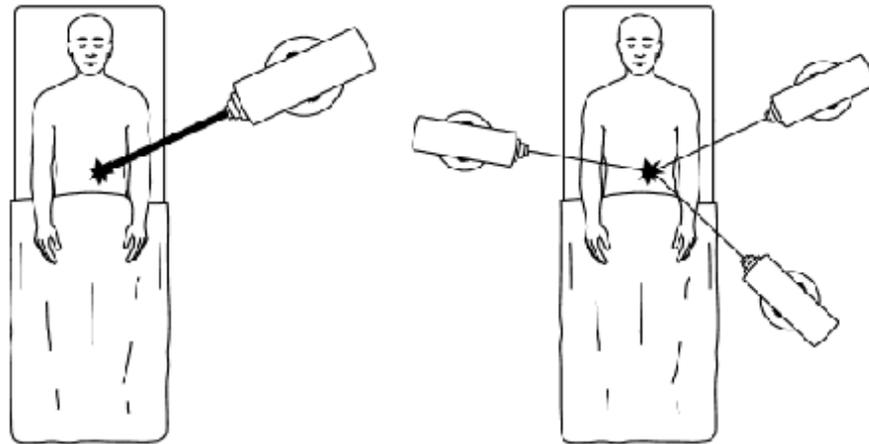
Children score higher on a test of similar problems after enacting the operation

(Broaders et al, 2007; Goldin-Meadow, Cook, & Mitchell, 2009)

Enactment Shaping Thought

Analogical transfer

People more likely to encode, then transfer a converging forces schema if the *enact* that schema, compared to drawing the schema or verbally recounting the schema Catrambone, Craig, & Nersessian, 2006



Gaps in the Literature

No studies have directly compared the effects of **gesture inhibition, allowing gestures, and encouraging enactments**

No studies investigating individual differences in **WMC** on effectiveness and production of gesture

Research Questions / Hypotheses

People **allowed to gesture about** and **encouraged to enact** information will be more likely to have encoded action information and be more likely to use that information than people **not allowed to gesture**

Individual differences in **working memory capacity** will predict successful problem solving

People **not allowed, allowed to gesture about** and **encouraged to enact** information will have different predictive value for successful problem solving, controlling for **WMC**

Participants

- 108 participants will be recruited from research pool, as well as from undergraduate courses for extra credit
- Power analysis using G*Power for chi-square test of independence with $\alpha = .05$, power = .8, 2 Df, and medium effect size $w = .3$
- Effect size computed using a previous study using a similar task ($\phi = .28$, a medium effect size)

Materials – AOSPAN

Automated Operation Span – Well validated measure used to assess working memory capacity in participants Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005)

Materials – General Story

Appendix A

Give participants opportunity to form mental schema of converging forces

[A rebel leader must split his army to avoid setting off land mines, and have them *reconverge forces* at a dictator's compound]

Abbreviated, adapted from Gick & Holyoak, 1980; Catrambone, Craig, & Nersessian, 2006

Materials – Radiation Problem

Appendix B

Give participants opportunity to transfer converging forces schema

Solve radiation-tumor problem

[You are treating a tumor with radiation, but radiation will kill healthy tissue while targeting tumor]

*converging forces scheme optimal solution

Abbreviated, from Duncker, 1945

Design - IV

Participants told to study the general story, then explain what happened, focusing on what the rebel leader planned to do, and did in the story

1. Not allowed to gesture
 - Participants are told that they are not allowed to gesture while explaining the general story, to ensure the quality of the video recording they keep their hands flat on the table
2. Allowed to spontaneously gesture/enact
 - Participants are not given instructions on whether or not to gesture
3. Encouraged to produce enactments
 - Participants are instructed to explain the general story and act out the story using their hands

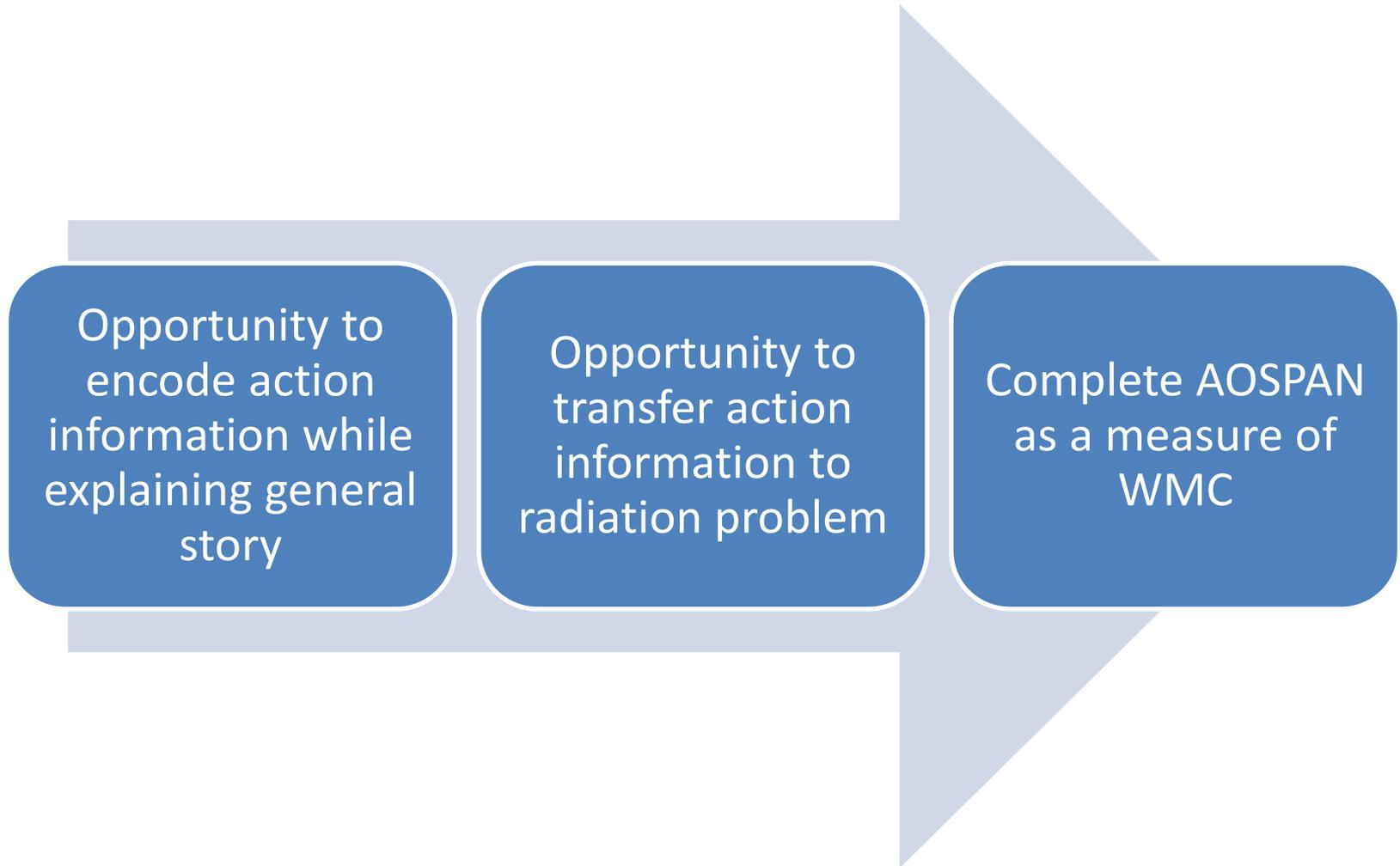
Design – DV

Does radiation solution indicate:

1. Use of multiple beams of radiation
2. Use of weak radiation
3. Use of strong radiation
4. Use of mixed weak and strong radiation
5. Use of multiple doses of radiation over time
6. Use of radiation from different sides, or angles

Success: Solution contains (2), either (1) or (6), and not (3), (4), or (5)

Procedure



Plan of Analysis

Compare outcome frequencies using a chi-square test of independence for all three groups, then with pair-wise comparisons

Compare individual conditions to other conditions using dummy coding and multiple logistic regression controlling for WMC as another predictor

Expected Findings

Participants **allowed to gesture about** and **encouraged to enact** solve the radiation problem at higher rates than participants **not allowed to gesture**

WMC will significantly predict radiation problem solution

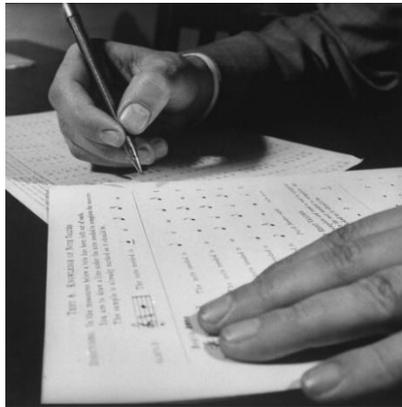
Controlling for WMC will effect the predictive value of **allowing gesture** and **encouraging enactments** on solving the radiation problem to different extents

Possible Implications

Psychological ability measures and hand occupation

Interface design and reduction of cognitive load

Training interface design and the encoding of action information



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General Story

In the woods in the middle of a small country is a dictator's compound. Although the dictator and his men are usually quiet, they pose a potential danger to the people in the surrounding area and therefore must be constantly monitored.

General Story

At any time they could become agitated and start causing trouble. One day, John, a rebel leader, decides to do something about the dictator and approaches the compound with a big army of men.

General Story

He knows that the dictator lives in a bunker in the center of the compound, and he is pretty sure that if he has his entire army attack that spot he can take out the dictator and force the rest of the dictator's men to disband. He also knows, though, that the compound is filled with mines and that the mines will probably explode in a blizzard of shrapnel if he sends his army through the compound all at once, simply because of the size of his army and the sensitivity of the mines.

General Story

After thinking about his dilemma, John decides to split his big army into two smaller groups. He positions the two smaller groups at two different points around the compound and has them march in toward the center from different directions, using a two-way radio to communicate with both of them at once.

General Story

Because the two groups are relatively small, they pass safely through the compound without detonating the mines, but as they meet in the center their combined force is enough to take out the dictator. Once the dictator is dead, the rest of the dictator's men leave without a fight.

Radiation Problem

Suppose you are a doctor faced with a patient who has a life-threatening stomach tumor. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die.

Radiation Problem

A new form of radiation may be used to destroy the tumor, but there is a complication: A beam of radiation strong enough to destroy the tumor will invariably destroy any healthy tissue it passes through as well, thus killing the patient in the process.

Radiation Problem

A weaker beam of radiation, on the other hand, won't harm the healthy tissue it passes through, but it won't destroy the tumor either, no matter how long it is used. What type of procedure might be used to destroy the tumor using the new form of radiation, without destroying any healthy tissue and without cutting the patient open to expose the tumor?