**THE ROLE OF INTERNAL AND EXTERNAL REPRESENTATIONS IN STRATEGY ACQUISITION**

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**INTRODUCTION**

- A distributed conceptions task is defined as a task involving both internal (e.g., a memorized rule) and external representations (e.g., a visual aid).
- Technology is becoming increasingly integrated in the completion of everyday tasks and classroom instruction. This shift promotes the introduction of external representations to problem spaces and changes how problem information is processed.
- Prior work with the Tower of Pisa (ToP) suggests that participants spend more time between moves and use fewer moves when solving a problem high in internal representation (compared to solving a problem high in external representation, where a trial-and-error strategy may be implemented). The current study examines if participants learn task-relevant information when solving problems (ToP) that vary in the amount of internal or external information available, and whether this knowledge may be applied to a new problem.
- Hypothesis: Internal representations promote strategy acquisition as reflected by task performance and performance on a task measuring transfer.

**METHOD**

**Participants:**
- Data were collected from 279 Purdue University undergraduates. Data were excluded from 2 participants for issues such as computer malfunction, misunderstanding of problem instructions, and completing the problem in the same amount of time as the median.
- Procedure:
  - Participants were shown the ToP problem and rules. Participants were asked to solve the problems mentally and drag and drop the ToP program regardless of condition.
  - Participants completed 2 ToP problems and a strategy survey. They were given 15 minutes to solve each problem.
- Design:
  - Participants were separated into 6 groups with approximately 30 participants per condition:
    - MC = Problem 1 mentally, problem 2 on the computer
    - CL = Problem 1 on the computer, problem 2 mentally
    - CM = Solved both problems mentally
    - MC = Solved both problems on the computer
- Mental Procedure:
  - Participants were instructed to solve the problem mentally via mental imagery to provide the experimenter with instructions to solve the problem. The experimenter solved the problem on the computer with the provided instructions. Participants were given a visual aid (Figure 1) to assist with creating mental representations.
- Computer Procedure:
  - Participants were given a virtual version of the ToP problem. Participants moved blocks by pressing keys corresponding to labeled keys and arrows.

**Experiment 1**
- Participants completed a 4-ring problem followed by a 5-ring problem.
- Experiment 2:
  - Participants completed a 5-ring problem followed by a 4-ring problem.

**RESULTS**

**Mental vs. Computer Performance:** A 2x2 ANOVA was conducted with normalized score on the 5-ring problem as the DV. Mental performance was higher than computer performance, with the computer problem included in the analysis. A significant main effect of mode of presentation (p < 0.01) suggests that solving a high problem mentally leads to more optimal performance than solving a high problem with a computer. A significant interaction (p < 0.05) was noted and decomposing the interaction revealed that the difference in performance by condition was significant for Experiment 2, but not Experiment 1. The same procedure was completed for the 4-ring problem and no significant main effects or interactions were noted.

**Impression of Blockers:**
- In Experiment 1, Chi-Square tests revealed significant differences between conditions in the proportion of participants able to complete the 5-ring problem within the 15-minute time frame (see Figure 3). In Experiment 2, a significant difference between conditions in the proportion of participants able to complete the 5-ring problem (see Figure 4) was also noted. There were no significant differences for the 4-ring problem.

**CONCLUSIONS**

- Participants who successfully completed the 5-ring problem were more optimal mentally when compared to those who completed the task on the computer. This suggests that participants who use the computer to solve the problem are more likely to make mistakes and require more time to solve the problem. This finding is consistent with prior research on mental imagery and its role in problem-solving. The results suggest that participants who rely on mental imagery when solving problems are more likely to find solutions more efficiently and accurately.

**References**