Experiment Report: Dual-task Interference in Visual Working Memory

Team: M4
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1 Hypothesis

Performing a secondary visual image identification task while attempting to memorize and reproduce a visual pattern will reduce memory performance. Specifically, individuals engaged in dual-task conditions will show lower recall accuracy and longer reaction times when recalling details, compared to when they are engaged only in the memory task.

2 Variables

Independent Variable

- **Presence of dual-task interference:**
  - **Single-task condition:** Participants complete only the visual memory task.
  - **Dual-task condition:** Participants complete the visual memory task while simultaneously performing a visual image identification task.

Dependent Variables

- **Recall accuracy:** Percentage of correctly recalled squares (correct location and activation) in a 3×3 grid.
- **Reaction time:** Time taken (in seconds) to reproduce the visual pattern on a blank grid.

Confounding Variables (To be Controlled)

- Attention levels
- Gender distribution
- Time of day
- Prior familiarity with grid-based or image-matching tasks

3 Operationalisation

Independent Variable Measurement

Dual-task interference will be introduced via an image identification task. Participants will view a series of fun or unusual images and must match each image with their identifiers while simultaneously recalling the grid pattern.

Dependent Variable Measurement

- **Recall accuracy:** Count of correctly selected cells on a blank 3×3 grid compared to the original pattern.
- **Reaction time:** Time from beginning to final grid selection recorded via software.

Confounding Variable Control

- Practice session to ensure understanding of the grid and image identification tasks.
- Balanced gender mix and consistent environmental conditions.
- Standardized pre-task instructions and same practice session to ensure prior exposure to task images or patterns doesn't create any difference.

4 Designing the Experiment

Participant Selection

- **Sample size:** 20 students from the same class.
- **Design type:** Between-subjects – each participant completes either the single-task or the dual-task condition, but not both.

Experimental Procedure

Preliminary Instructions: Participants will be informed about the visual memory task and the image identification task (if applicable). The exact hypothesis will not be revealed.

Task Setup:

- A 3×3 grid with 6 randomly activated squares shown for 6 seconds.
- All participants see the same patterns in randomized order.

Task Execution:

- **Single-task:** After a 2-second delay, reproduce the pattern on a blank grid.
- **Dual-task:** During the delay and recall phase, participants view a sequence of fun images and must identify them by choosing the correct label (e.g., via keyboard).

5 Data Collection

What Data Will Be Collected?

- Participant info: Age, gender.
- **Memory metrics:** Recall accuracy and recall reaction time.
- **Image task performance (dual-task only):** Number of correctly identified images, misidentifications, and response times.
- **Contextual notes:** Time of day.

Participant Selection Criteria

- Students from the same class.
- A balanced mix of male and female participants.

6 Analysis

Descriptive Analysis

- Mean and standard deviation of memory performance
- Spread and outliers across participants
- Image identification accuracy in dual-task only
- Performance differences by gender

Planned Visualizations:

- Box plots for recall accuracy and reaction times
- Bar graphs for average comparisons
- Histograms of performance distributions
- Gender-based analysis comparisons

Statistical Results

Overall Performance Metrics

Condition	Mean Accuracy	SD Accuracy	Mean RT (s)	SD RT
Control Task	0.925	0.133	6.93	3.78
Dual Task	0.730	0.158	8.09	3.24

Table 1: Descriptive statistics of task performance

Gender-based Performance Analysis

Gender	Task Type	Mean Accuracy	Mean RT (s)
Female	Control Task	0.930	7.24
Female	Dual Task	0.759	8.22
Male	Control Task	0.920	6.62
Male	Dual Task	0.706	7.97

Table 2: Performance metrics by gender and task condition

Inferential Statistics:

- **Accuracy t-test:** $t = -6.793$, $p < 0.001$ (highly significant)
- **Reaction Time t-test:** $t = 1.689$, $p = 0.094$ (not significant at $\alpha = 0.05$)

Detailed Statistics:

- **Accuracy Range:**
  - Control Task: Min = 0.500, Max = 1.000
  - Dual Task: Min = 0.213, Max = 0.850
- **Reaction Time Range:**
  - Control Task: Min = 3.38s, Max = 26.52s
  - Dual Task: Min = 5.13s, Max = 20.84s

7 Results Visualization

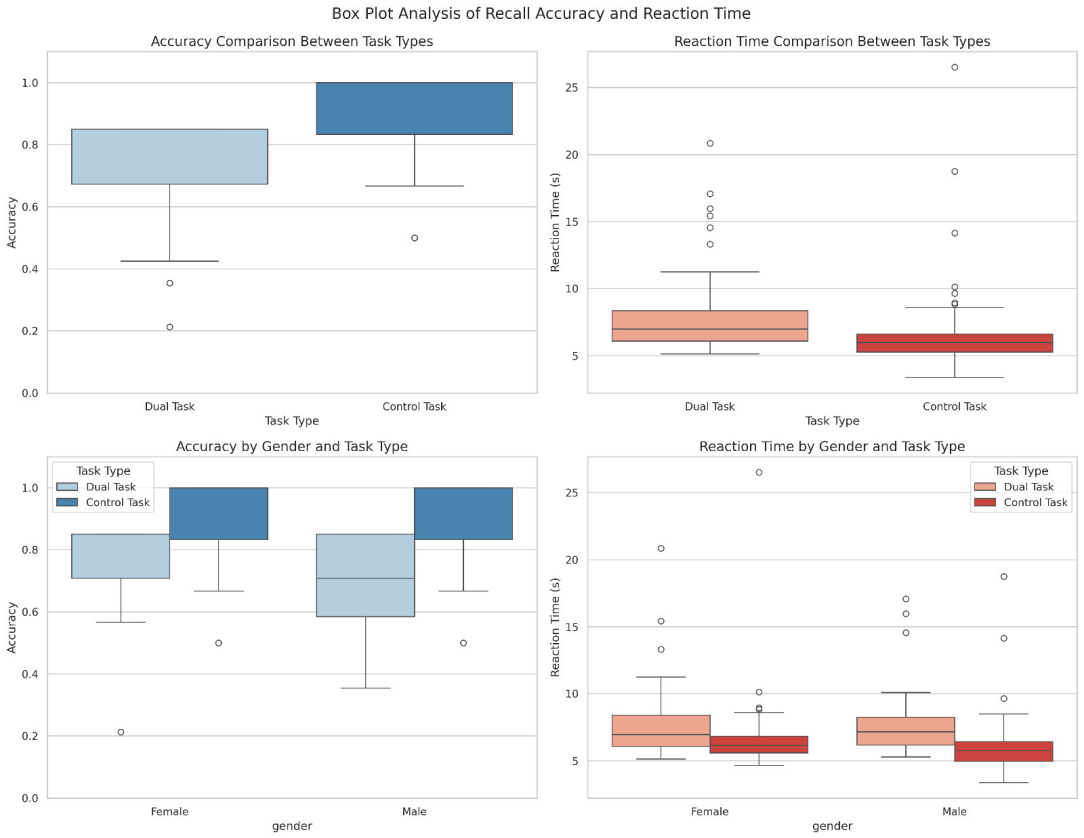
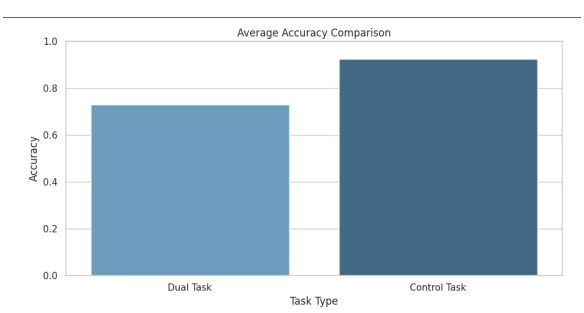
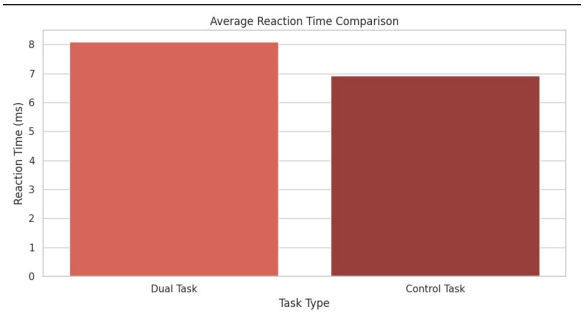


Figure 1: Combined visualization showing accuracy and reaction time comparisons between task conditions and across genders

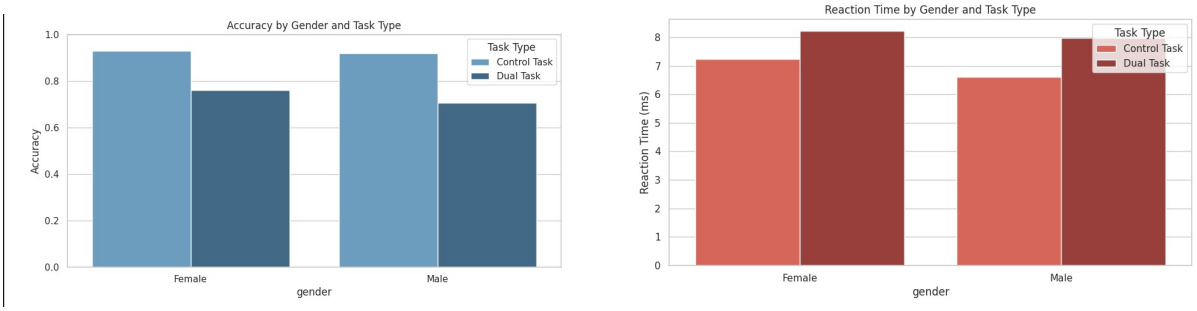


(a) Average accuracy comparison between task conditions



(b) Average reaction time comparison between task conditions

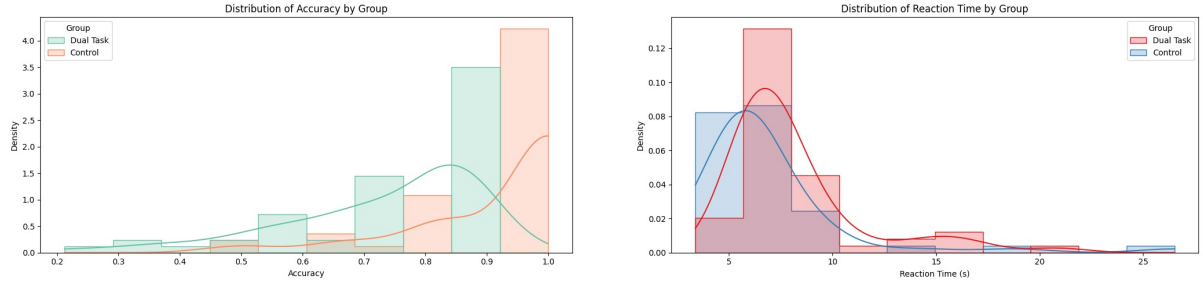
Figure 2: Bar charts showing performance metrics by task condition



(a) Accuracy by gender and task type

(b) Reaction time by gender and task type

Figure 3: Gender-based performance analysis



(a) Distribution of accuracy by group

(b) Distribution of reaction time by group

Figure 4: Density plots showing performance distributions

8 Discussion

- Dual-task condition significantly impaired recall accuracy (p ¡ 0.001), with performance dropping from 92.5% to 73.0% accuracy.
- While reaction times were longer in the dual-task condition (8.09s vs 6.93s), this difference was not statistically significant (p = 0.094).
- Both male and female participants showed similar patterns of performance decline in the dual-task condition, suggesting the effect is consistent across genders.
- The accuracy distribution shows that control task participants were more likely to achieve perfect or near-perfect scores, while dual-task participants showed a wider spread of accuracy values.
- Reaction time distributions show greater variability in the dual-task condition, with some participants taking considerably longer to respond.
- The results strongly support cognitive load theory, demonstrating that attentional resources are limited and must be shared between competing tasks.

9 Conclusion

The experiment confirmed that dual-tasking significantly affects visual memory accuracy, with participants showing approximately a 20% reduction in recall performance when

simultaneously engaged in an image identification task. Interestingly, while reaction times were slower in the dual-task condition, this difference did not reach statistical significance, suggesting that accuracy may be more sensitive to dual-task interference than processing speed.

These findings have important implications for real-world multitasking scenarios, particularly in educational settings, driving, workplace productivity, and user interface design. The similar effects observed across genders suggest that these cognitive limitations are fundamental to human information processing rather than being influenced by gender differences.

Future research could explore whether practice or specific strategies might mitigate these dual-task costs, or whether certain types of secondary tasks are more or less disruptive to visual working memory.

Acknowledgements

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References

1. Dual-task interference in visual working memory
https://pmc.ncbi.nlm.nih.gov/articles/PMC2784651/