A Study of Islanders on Level of Cocoa in Dark Chocolate on Memory Game Performance

Group C

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Research Questions

Are the effects of cocoa levels and the duration it was digested on memory performance significant?

Is there significant interaction between cocoa levels and duration of digestion?

If there are significant differences among treatment groups, which groups are different?

Does age play a role in the outcome?

Research Motivation: To understand whether different types of chocolate are an effective tool to improve memory, especially for students.

Literature Review

Dark Chocolate and Cognitive Performance:

- Habitual **dark chocolate** consumption is associated with **improved cognitive performance across age groups** (Crichton et al.).
- **Cocoa flavanols**, which varies depending on cocoa percentages, have **improve general cognition**, **attention**, and **memory** (Socci et al.) .
- **White chocolate used as a control** (similar taste, lacks cocoa flavanols) (Lamport et al.).

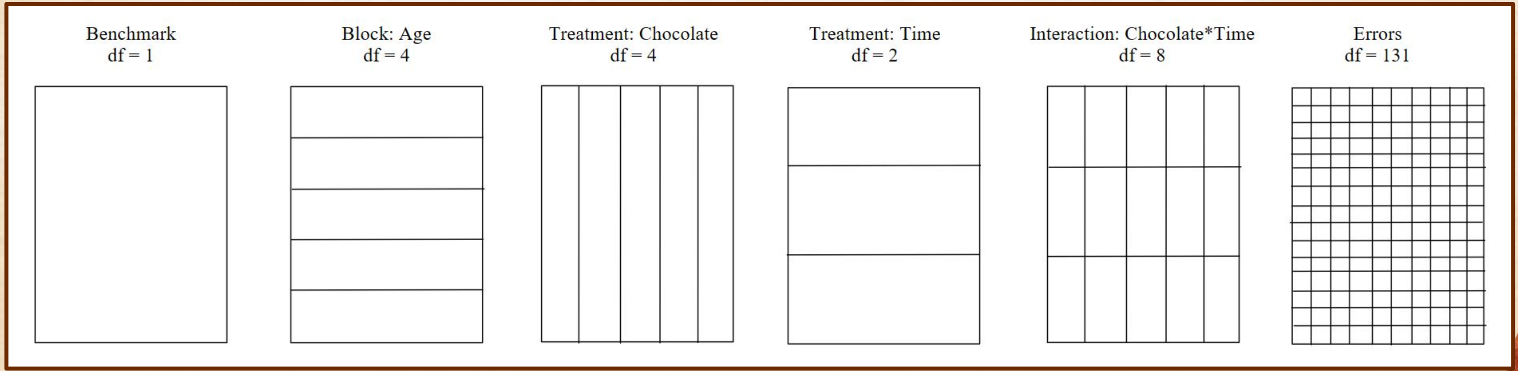
Gaps in the Literature:

- One study found high-cocoa chocolate sustained cognitive performance vs. low-cocoa, but **memory outcomes were not assessed** (Sasaki et al.).
- Verbal memory improved in young females consuming dark vs. white chocolate but **male participants were not included** (Lamport et al.).

Design

Randomized Complete Block Design with 2 Factors and 1 Block

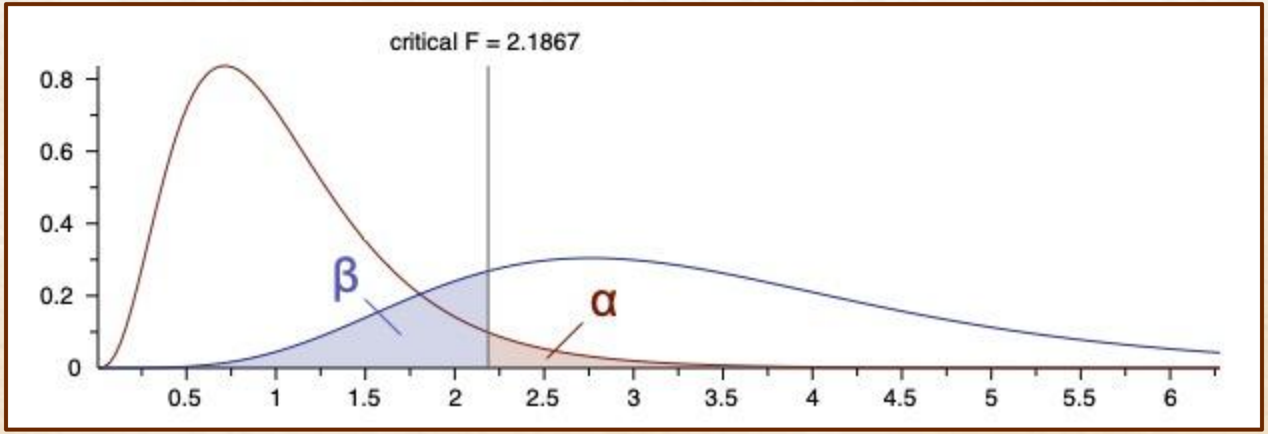
- **Factor 1:** Chocolate Level - White, 40% Dark, 70% Dark, 85% Dark, 99% Dark
- **Factor 2:** Time Level - Right after, 1 hour after, 2 hours after
- **Block:** Age bracket - 10-19, 20-29, 30-39, 40-49, 50+
- **Response:** Difference in time between performance on memory game before and after chocolate administration
- **Held-constant:** Sex (Males), Location (Colmar), Time of Day (4-8 PM)
- **Interaction** between Chocolate and Time levels considered - 15 groups total



Sample Characteristics

Sample Size Determination

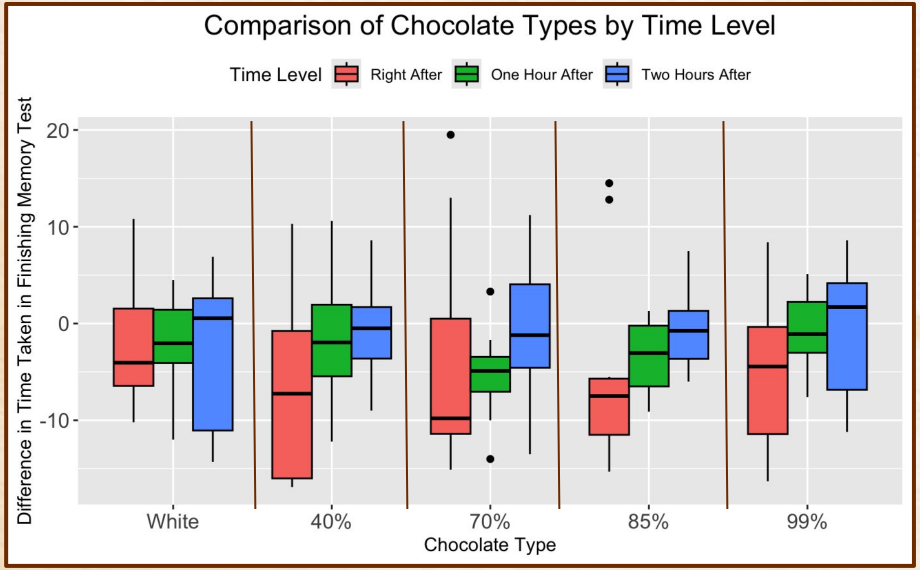
- Power: 80%
- Alpha of 0.05
- Effect Size of 0.4 – based on estimates from prior studies (Banaei et al.).
- G-Power returned minimum sample size of N = 114 → Decided to round to N = 150
  - This led to an actual power of 0.9385

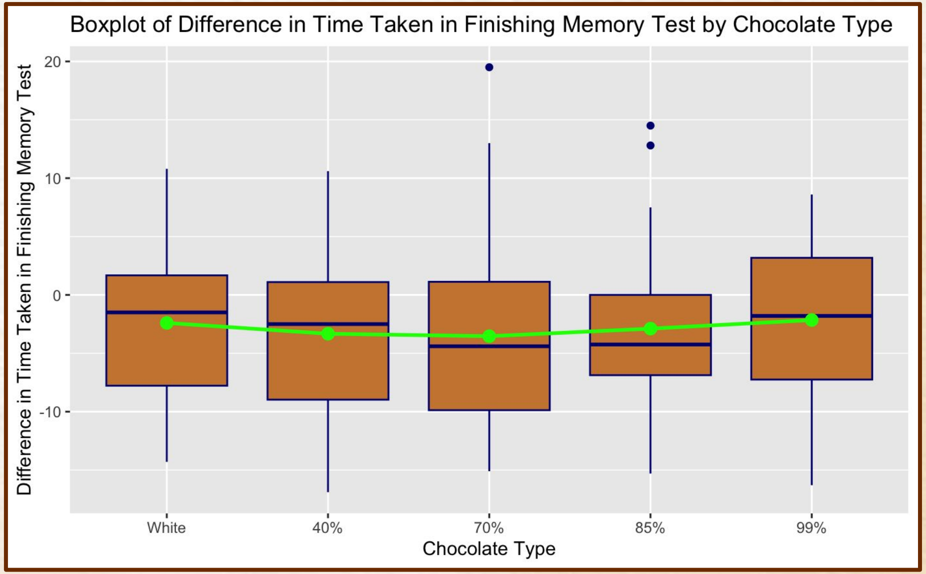


Methods

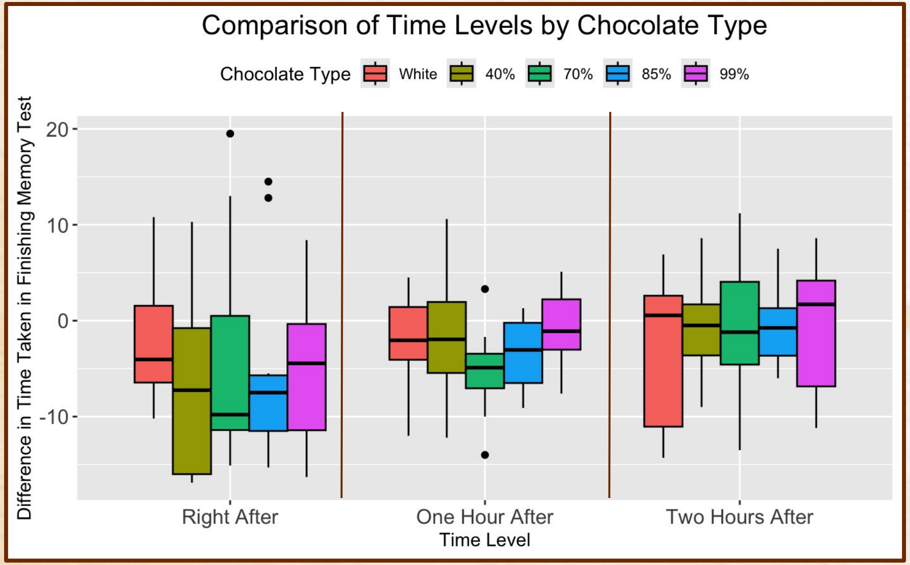
- Sampled **Males** from **Colmar**
- **Random assignment** to chocolate level and time level utilizing R
- 2 Islanders per group
- Memory Game tested **before** chocolate consumption
- Memory Game tested **after** chocolate consumption and assigned digestion duration
- Collected **time to complete Memory Game and calculated the difference** between pre- and post- treatment
- Data imported into R for analysis

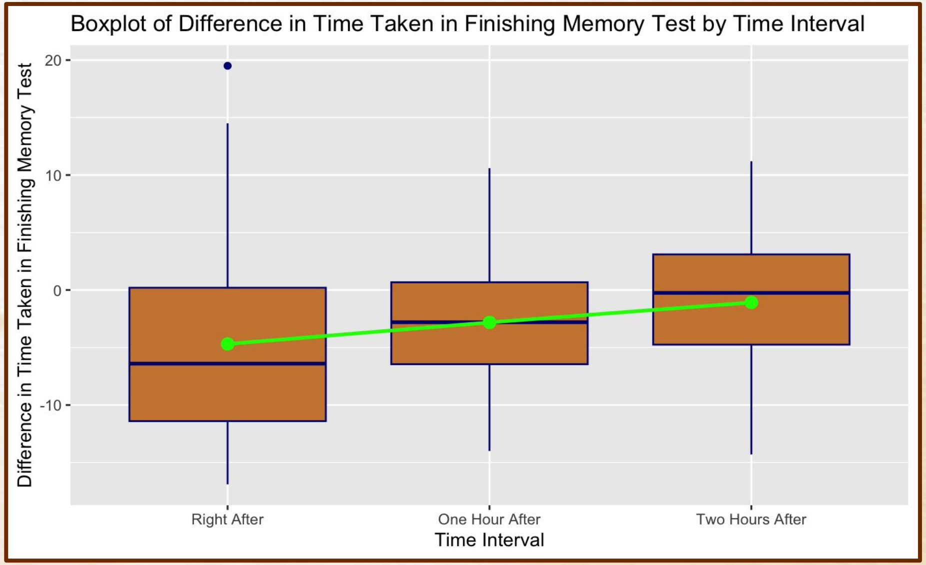
Comparison across Factor 1: Chocolate Level





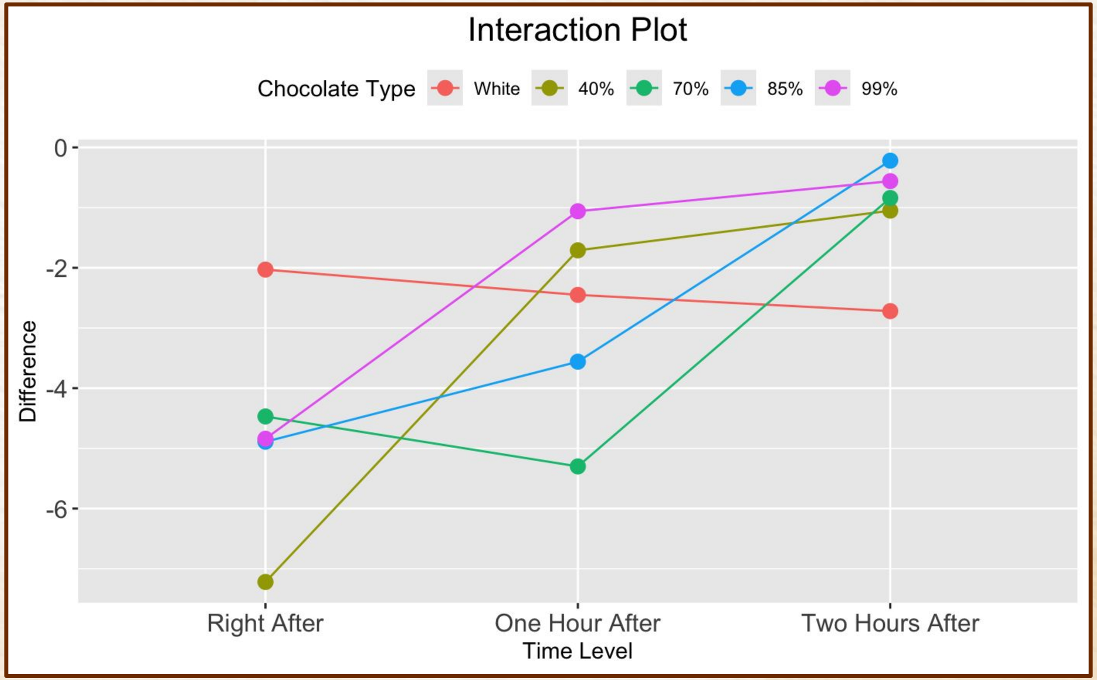
Comparison across Factor 2: Time Level





Interaction Plot

Since the slopes are not parallel, the graph suggests that there may be some interaction between the factors

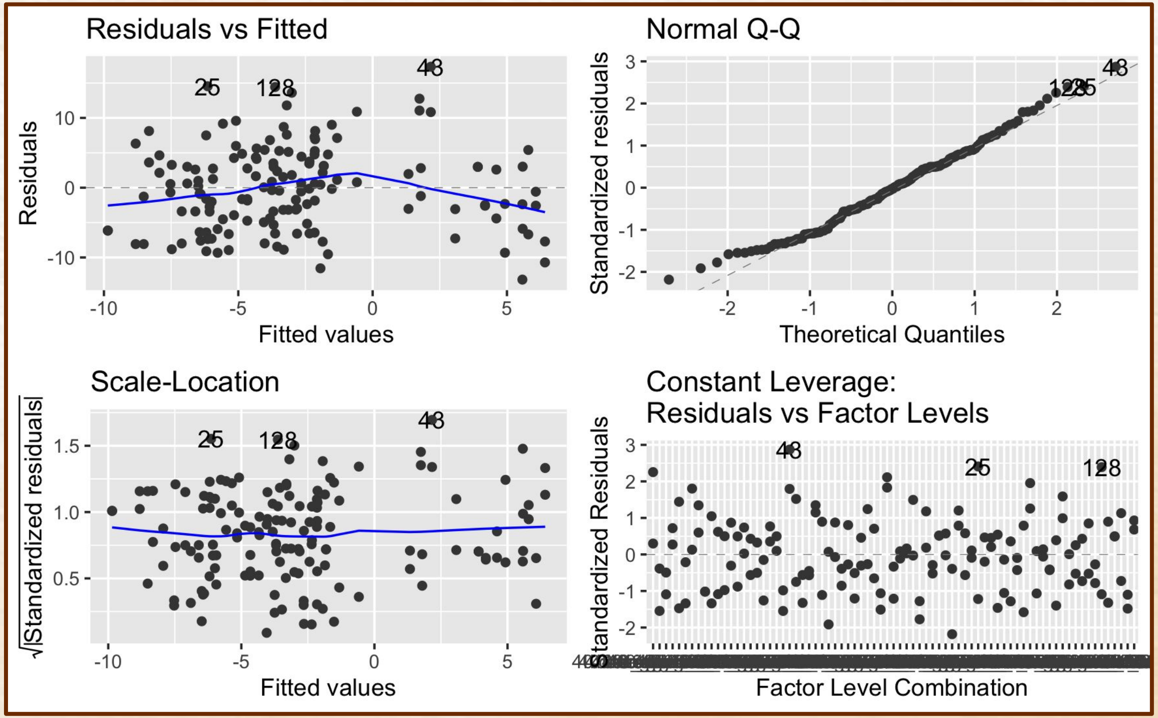


ANOVA Results

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
chocolate_level	4.0000	41.6257	10.4064	0.2495	0.9095	
time_level	2.0000	326.3177	163.1589	3.9118	0.0224	*
age_range	4.0000	1692.6137	423.1534	10.1452	3.47e-07	***
chocolate_level:time_level	8.0000	243.4743	30.4343	0.7297	0.6651	
Residuals	131.0000	5463.9643	41.7097			

Residual Plot

Model assumptions are valid as residuals have constant variance and Q-Q plot is not skewed.



Post-hoc TukeyHSD

Comparison	Difference	Lower	Upper	P Value Adjusted
right_after–one_hour	-1.874	-4.936077	1.188077	0.3180854
two_hours–one_hour	1.738	-1.324077	4.800077	0.3726983
two_hours–right_after	3.612	0.5499234	6.674077	**0.0162804**

Table 1: Pairwise comparisons of time levels with adjusted p-values

Comparison	Difference	Lower	Upper	P Value Adjusted
20–29–10–19	7.9333333	3.320721	12.545946	**0.0000496**
30–39–10–19	0.1966667	-4.415946	4.809279	0.9999558
40–49–10–19	-1.3366667	-5.949279	3.275946	0.9297008
50+–10–19	-0.3000000	-4.912612	4.312612	0.9997627
30–39–20–29	-7.7366667	-12.349279	-3.124054	**0.0000810**
40–49–20–29	-9.2700000	-13.882612	-4.657388	**0.0000014**
50+–20–29	-8.2333333	-12.845946	-3.620721	**0.0000231**
40–49–30–39	-1.5333333	-6.145946	3.079279	0.8889256
50+–30–39	-0.4966667	-5.109279	4.115946	0.9982651
50+–40–49	1.0366667	-3.575946	5.649279	0.9713838

Table 2: Pairwise comparisons of age ranges with adjusted p-values

Did not do TukeyHSD for chocolate levels because they were not significant from the ANOVA results

Conclusions

- Chocolate level was not significant
  - There is no difference in time to complete the Memory Game despite consuming different levels of chocolate

- Time between eating the chocolate and taking the second Memory Game test was a significant factor
  - The group that completed the Memory Game right after performed significantly better than the group that completed it after two hours

- The interaction was not significant

- Age as a block was very significant

Future Research Questions

- How does age play a role in cognitive performance?
- How do different chocolate types affect physical tasks (like reaction times, running, swimming, etc)?
- Does chocolate affect other cognitive tasks, such as problem-solving or learning?
- Does habitual chocolate consumption influence the effect size (i.e., tolerance or expectancy)?
- How does the liking of chocolate interact with mood and memory performance?

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