The Effect of Dark Chocolate and Methamphetamine on Memory

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Research Questions

- Do dark chocolate and/or methamphetamine have an impact on memory?
- How significant are these potential effects? Do these treatments increase or decrease memory performance?
- Do varying percentages of cocoa in dark chocolate and varying doses of methamphetamine injections affect memory differently?
- Are there significant interactions between cocoa percentage in dark chocolate and methamphetamine dosage in their effects on memory performance?

The Literature

In the article “Enhancing Human Cognition with Cocoa Flavonoids,” it is suggested that flavonoids, which are a polyphenolic compounds seen in many foods like fruits, vegetables and grains may have a positive impact on neurocognitive and neuroprotective performance.

“In recent years, cocoa and cocoa-derived products, as a rich source of flavonoids, mainly the flavanols sub-class, have been clearly shown to exert cardiovascular benefits. More recently, neuromodulation and neuroprotective actions have been also suggested.”

- 2017 study on enhancing human cognition with cocoa flavonoids

The article “Is Cognitive Functioning Impaired in Methamphetamine Users” states research shows that cognitive dysfunction in methamphetamine users is not readily apparent. If methamphetamine is not associated with cognitive dysfunction than many studies that accept this assumption would be invalidated.

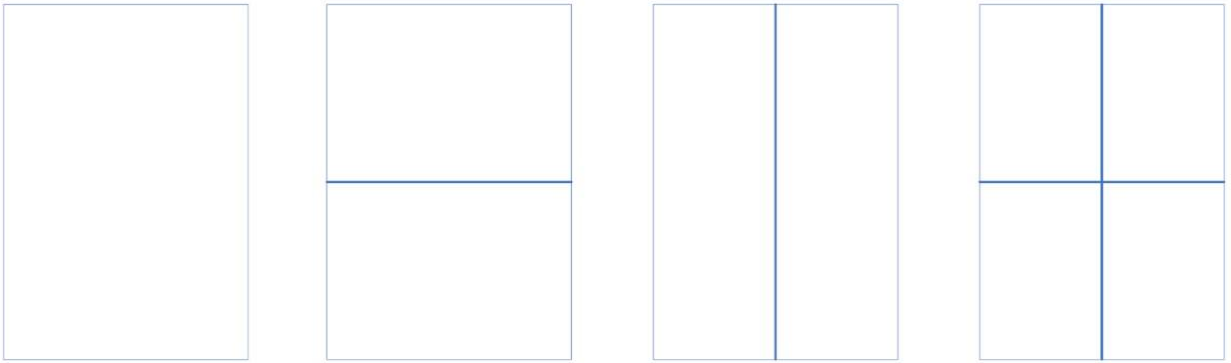
“In general, the human laboratory data show that short-term, acute methamphetamine improves cognitive performance of both methamphetamine abusers and non-users in some domains…” “even when larger intranasal and intravenous doses are tested.”

- 2011 study on the effects methamphetamine has on cognitive function

Design

2^k Factorial with k = 2

- Factor 1: Methamphetamine Injection - 10mg, 50mg
- Factor 2: Dark Chocolate - 40%, 99%
- Interaction between methamphetamine and dark chocolate considered
- Response: Time to complete pairs memory game with 30 cards



Benchmark
D.F. = 1

Methamphetamine Level (10 mg, 50 mg)
D.F. = 1

Dark Chocolate Level (40%, 99%)
D.F. = 1

Interaction Between Meth and Chocolate
D.F. = 1

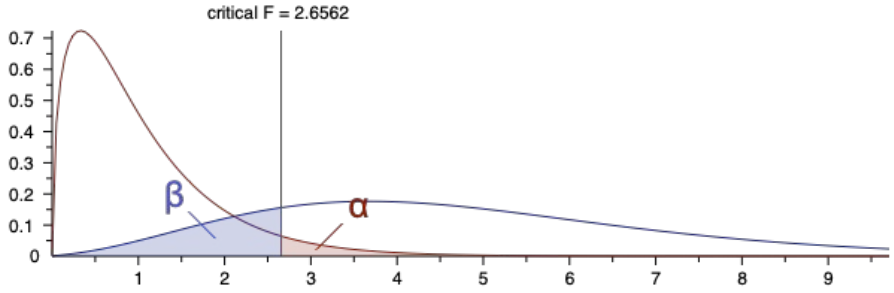
Sampling Methods

How we sampled:

- Males aged 22-31
- Randomly selected from Hofn, Ironbard

Sample size determination:

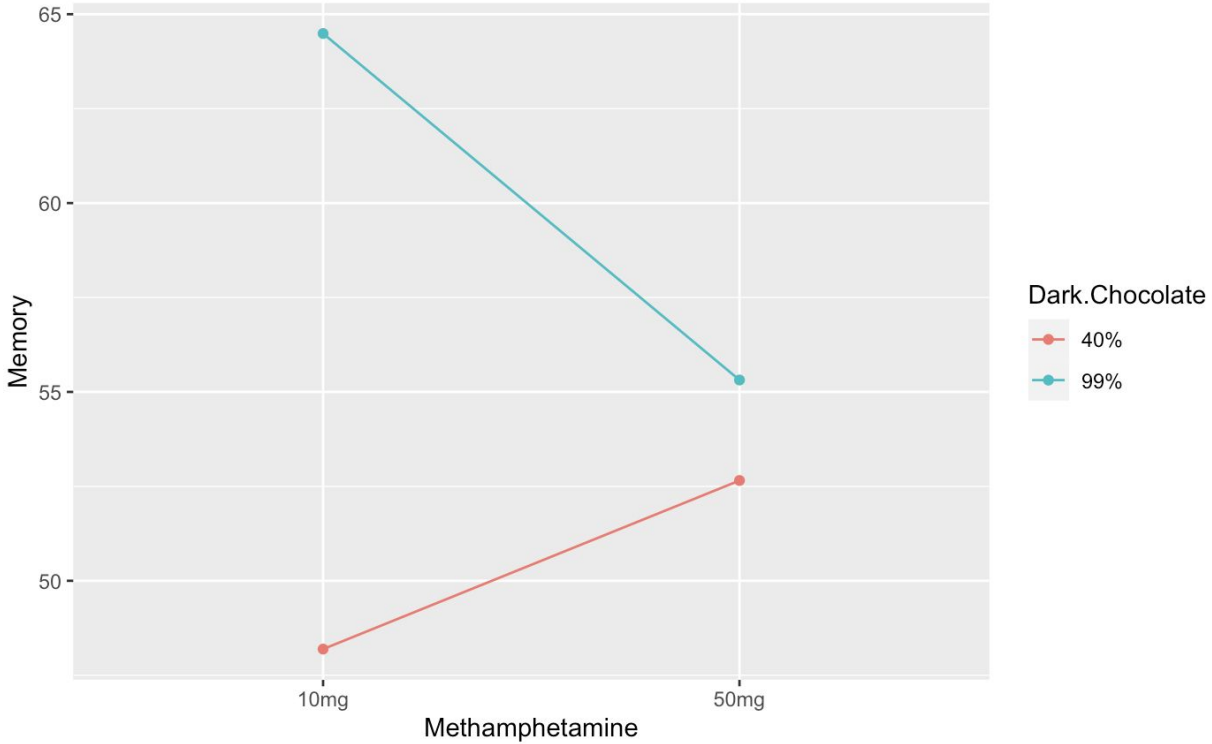
- Power of 80%
- Alpha of 0.05
- Effect Size of 0.25
- GPower returned sample size of 179
- 4 treatment groups, 45 in each group
- Total sample size of 180



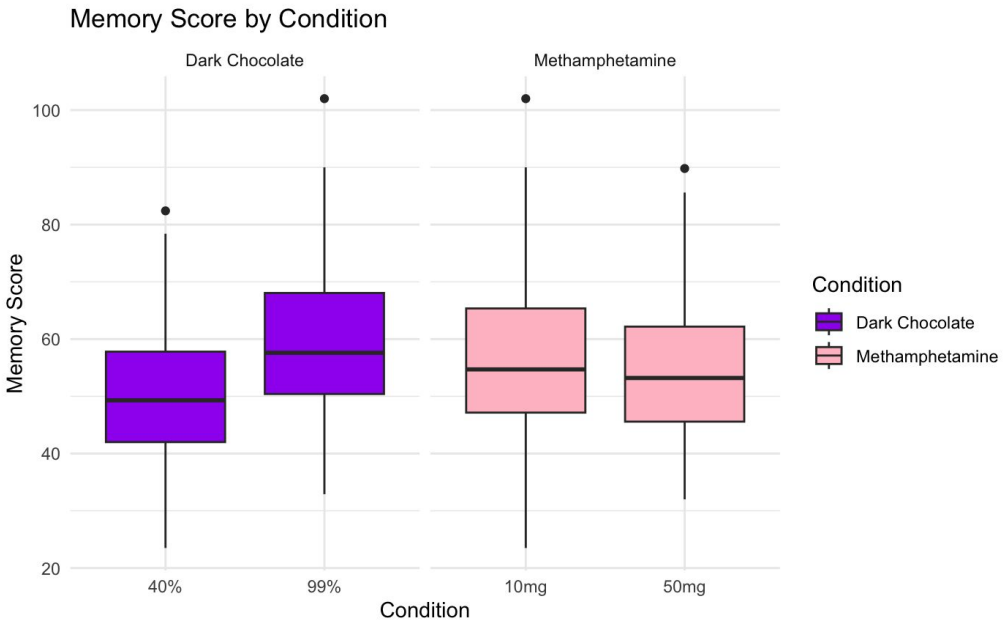
Methods

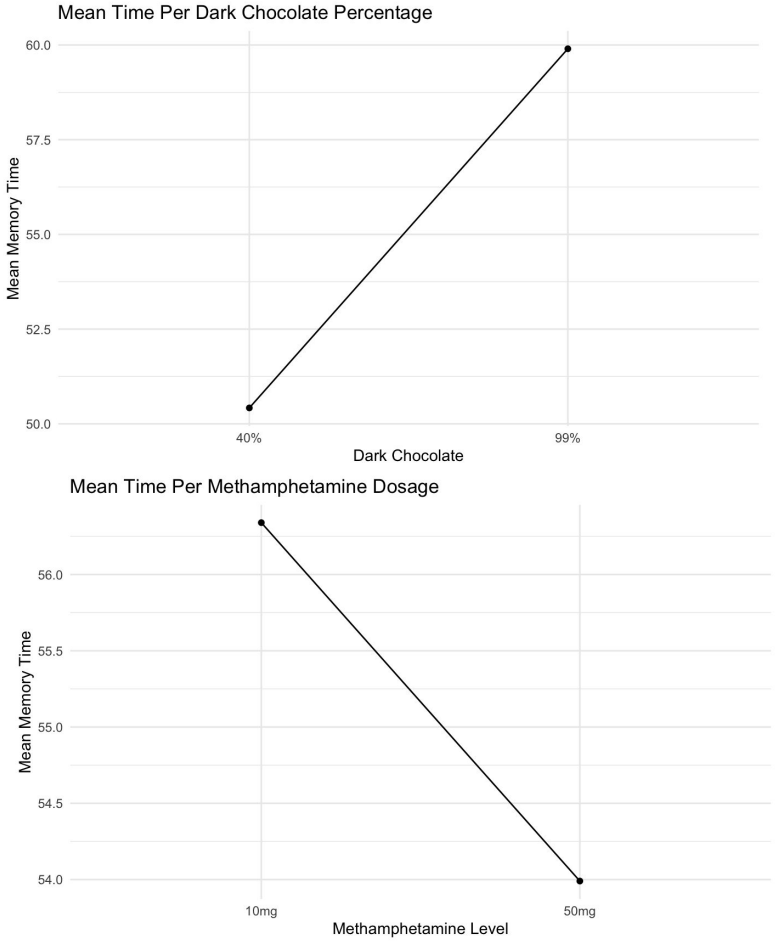
- Random assignment with R: 45 islanders per group
- Groups:
  - 40% Dark Chocolate and 10 mg Methamphetamine
  - 40% Dark Chocolate and 50 mg Methamphetamine
  - 99% Dark Chocolate and 10 mg Methamphetamine
  - 99% Dark Chocolate and 50 mg Methamphetamine
- Gave chocolate then waited 15 minutes and injected methamphetamine
- Directly after injection, recorded time to complete memory game
- Imported data into R for analysis

Interaction Plot



Comparison


Memory Score by Condition
Dark Chocolate
Methamphetamine
Memory Score
100
80
60
40
20
40%
99%
10mg
50mg
Condition
Condition
Dark Chocolate
Methamphetamine


Mean Time Per Dark Chocolate Percentage
Mean Memory Time
60.0
57.5
55.0
52.5
50.0
40%
99%
Dark Chocolate
Mean Time Per Methamphetamine Dosage
Mean Memory Time
56.0
55.5
55.0
54.5
54.0
10mg
50mg
Methamphetamine Level

ANOVA Results

- Dark chocolate and the interaction between dark chocolate and methamphetamine was significant.
- Methamphetamine on its own was not significant.

	DF	Sum Square	Mean Square	F Value	P Value
Methamphetamine	1	249	249	1.638	0.202302
Dark Chocolate	1	4043	4043	26.547	6.85E-07
Methamphetamine:Dark Chocolate	1	2092	2092	13.738	0.000281
Residuals	176	26805	152		

Post-hoc TukeyHSD

Interaction Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
50mg:40% - 10mg:40%	4.464444	-2.2838023	11.212691	0.218478
10mg:99% - 10mg:40%	16.297778	9.549531	23.046025	0
50mg:99% - 10mg:40%	7.124444	0.3761977	13.872691	0.0340965
10mg:99% - 50mg:40%	5.0850866	5.0850866	18.58158	0.000059
50mg:99% - 50mg:40%	-4.0882468	-4.0882468	9.408247	0.7365626
50mg:99% - 10mg:99%	-15.9215801	-15.9215801	-2.425087	0.0029991

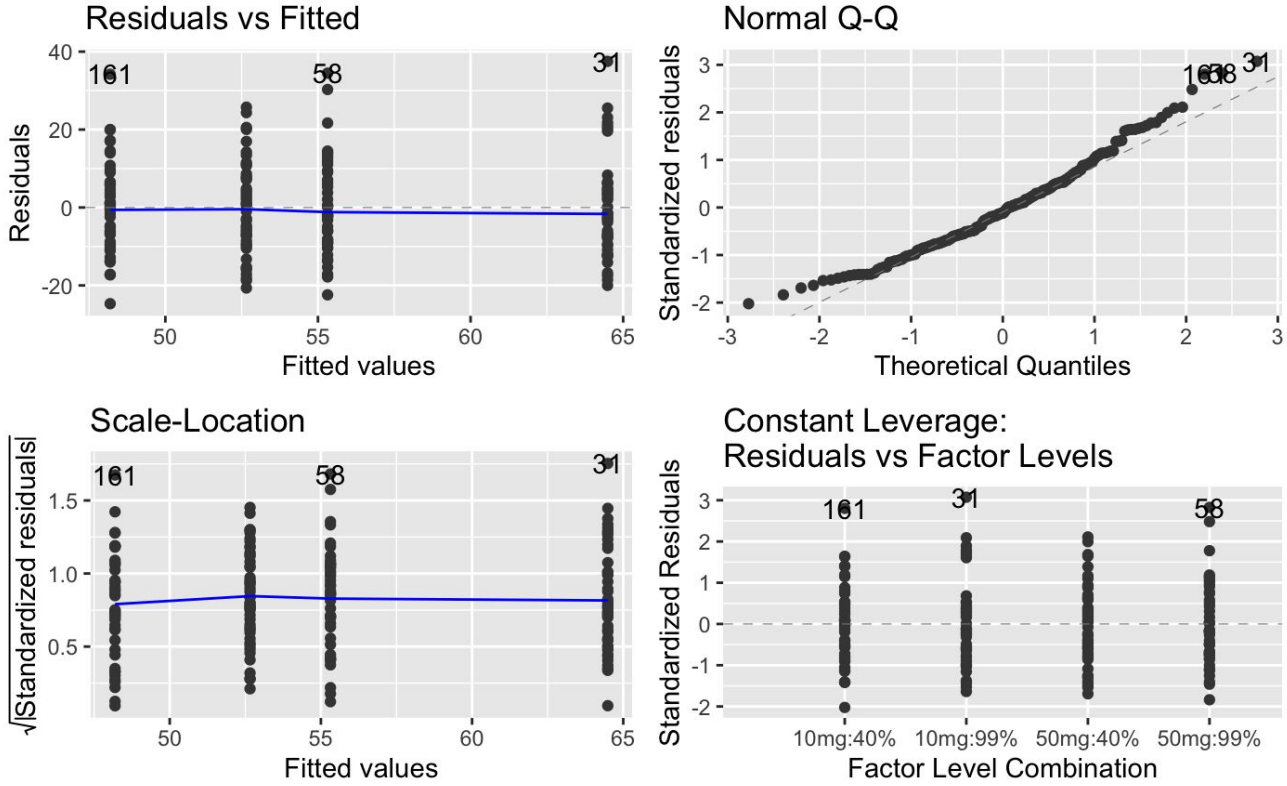
Methamphetamine Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
50mg - 10mg	-2.354444	-5.985169	1.27628	0.2023023

Dark Chocolate Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
99% - 40%	9.478889	5.848164	13.10961	7.00E-07

Checking The Model Assumptions



Conclusions

Our study concludes that, while methamphetamine dosage alone did not significantly impact memory performance, the percentage of cocoa in dark chocolate demonstrated a significant effect. Our study has shown that, 15 minutes after consumption, 99% cocoa content in dark chocolate is associated with better memory performance than 40% cocoa content. Furthermore, we have also found a significant interaction between cocoa content and methamphetamine, as revealed by the results of our Tukey test. We have found that, while methamphetamine alone may not significantly alter memory, the inclusion of high cocoa dark chocolate can significantly enhance memory performance.

Future Research Questions

- What are the long term effects of repeated consumption of dark chocolate and methamphetamine on memory?
- Could dark chocolate and methamphetamine have an effect on other cognitive functions?
- Could a broader range of cocoa percentages and levels of methamphetamine injections have a different effect on memory?
- Could different doses of methamphetamine, beyond 10mg and 50mg, impact memory performance significantly without combining them with dark chocolate?
- Are there gender differences in the memory effect of dark chocolate and methamphetamine?

References

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