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EFFECTS OF ALCOHOL: Drift Diffusion Model

Alcohol use is widespread, notably impairing cognitive functions like reaction time (RT) and decision-making [3]. Acute intoxication slows RTs and impairs decision-making, linked to altered neural activity in the Anterior Cingulate Cortex [2]. These effects, influenced by alcohol's interference with top-down regulatory processes, vary with intoxication levels, increasing errors at high doses but not affecting RTs significantly at low doses [1]. Additionally, hangover effects also impair cognitive processing even after BAC returns to zero.

This study aims to compare the cognitive effects of acute alcohol intoxication and hangover using the Drift Diffusion Model (DDM), which analyses decision-making through parameters like drift rate (evidence accumulation speed), decision threshold (cautiousness), non-decision time (stimulus encoding/motor execution), and starting point (response bias). We **hypothesised** that acute intoxication will result in poorer performance (slower RTs, lower accuracy) compared to hangover, reflected in a lower drift rate, with no expected differences in decision threshold or response bias between conditions.

Study Design

1 Within-Subject Design

N = 12

1 - Alcohol Intoxication (BAC = 80 mg/dL) — 400 trials

2 - Hangover — 400 trials

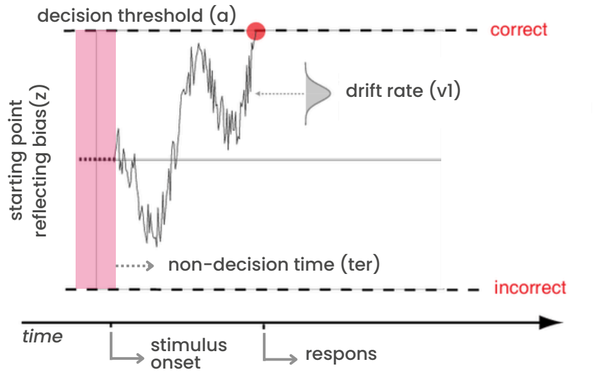
hypotheses

RT: μ1 > μ2

v1: μ1 < μ2

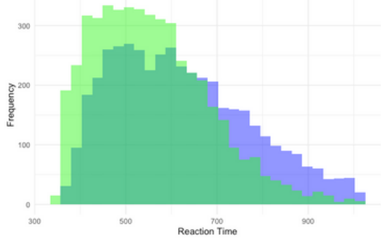
No difference expected for a and z

2 Moving Dot Task

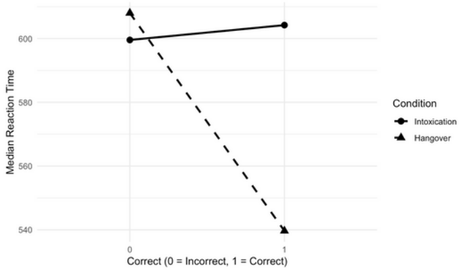


Results

Reaction Time Distribution for 'Alcohol Intoxication' and 'Hangover'



Median Reaction Time by Accuracy and Condition



RT and Accuracy

- **Slower RTs** for acute alcohol intoxication compared to hangover

  Mdiff = 64.04ms, t (11) = 13.81, p <.001

- **Lower accuracy** for acute alcohol intoxication (68.36%) compared to hangover (98.09%)

  χ (1) = 1488.5, p <.001

Comparing DDM parameters

- Significantly **lower drift rates** for 'Alcohol Intoxication' compared to 'Hangover'.
- Significantly **more variability of drift rate** within the Hangover group.

	Intoxication (1)		Hangover (2)			
	M	SD	M	SD	t	p
Drift rate	.588	.0335	.946	.142	-9.0658	<.001
SD drift rate	.133	.0375	.217	.0522	-4.4758	<.001
Bias	301	32	313	56.1	-.60076	.5602
Non-decision time	248	146	260	70.1	-.23948	.8151
Threshold	393	61.9	417	29.2	-1.0625	.3108

Drift Diffusion Model

1 Remove outliers RT

based on IQR of Reaction Time (RT)
raw data: 9600 observations
filtered data: 9214 observations

2 Cost Function

The cost function evaluates how well the model fits the observed data. By calculating the negative log-likelihood for the fit we essentially compared the modeled RTs and accuracies to the observed values.

3 Parameter Optimization

Based on the likelihood of fit, we used an optimization algorithm. Initial parameters were based on the observed data and optimization was iterated until convergence.

4 Fit Model

The model was fitted using the 'fit_model()' function.
Full code and raw data is available at:
https://github.com/RoosBoender/DDM_RLDM.git

CONCLUSION

As **hypothesised**, we found that performance was more impaired for alcohol intoxication compared to hangover, as reflected in slower RTs and lower respons accuracies.

Fitting the DDM showed that the accumulation of sensory evidence took significantly more time when intoxicated compared to hangover conditions. This could reflect the interference with top-down regulatory processes that has been hypothesised to occur as a function of alcohol dose [1], making it harder to integrate information correctly to come to a decision.

References

[1] Anderson, B. M., Stevens, M. C., Meda, S. A., Jordan, K., Calhoun, V. D., & Pearlson, G. D. (2010). Functional imaging of cognitive control during acute alcohol intoxication. Alcoholism/Alcoholism, Clinical and Experimental Research, 35(1), 156–165. https://doi.org/10.1111/j.1530-0277.2010.01332.x
[2] Marinkovic, K., Rickenbacher, E., Azma, S., & Artsy, E. (2011). Acute alcohol intoxication impairs top-down regulation of stroop incongruity as revealed by blood oxygen level-dependent functional magnetic resonance imaging. Human Brain Mapping, 33(2), 319–333. https://doi.org/10.1002/hbm.21213
[3] McKinney, A., Coyle, K., & Verster, J. (2012). Direct comparison of the cognitive effects of acute alcohol with the morning after a normal night's drinking. Human Psychopharmacology, 27(3), 295–304. https://doi.org/10.1002/hup.2225