The Effect of Alcohol Type, Music Genre, and Gender on Blood Oxytocin Levels

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Contents

Abstract

This study examines the effects of alcohol type, music genre, and gender on blood oxytocin levels. Oxytocin, a neuropeptide associated with social bonding and emotional regulation, is influenced by various physiological and environmental factors. Utilizing a 3×2×2 factorial design, the experiment manipulated three independent variables: type of alcohol (Water, Beer, Vodka), genre of music (Classical, Dance), and participant gender (Male, Female). A three-way ANOVA was conducted to evaluate main and interaction effects. The analysis revealed that gender was the only statistically significant predictor of oxytocin levels, accounting for approximately 99% of the total variance in oxytocin levels. Neither the type of alcohol nor the music genre exhibited significant main effects or interaction effects. These findings suggest that biological sex is the primary determinant of oxytocin response under the given experimental conditions, with minimal influence from short-term exposure to alcohol or music.

Introduction

Question

This study investigates whether the type of alcohol consumed, the genre of music listened to, and gender influence blood oxytocin levels and whether these effects are moderated by gender.

Background Information

Oxytocin is a hormone and neuropeptide that plays a key role in modulating social bonding, trust, and emotional well-being. Prior research has demonstrated that external stimuli such as alcohol and music can affect mood and social behavior. Alcohol, particularly in low to moderate doses, is known to increase sociability and reduce anxiety. At the same time, music can evoke a range of emotional responses depending on its tempo, genre, and familiarity. Furthermore, biological sex has been shown to significantly influence oxytocin regulation, with females generally exhibiting higher baseline levels. Despite these findings, limited research has explored how these factors may interact to affect oxytocin concentrations. This experiment seeks to address that gap by assessing the main and interactive effects of alcohol type, music genre, and gender on post-exposure oxytocin levels.

Design Recap

The study employed a 3×2×2 between-subjects factorial design to examine the effects of three independent variables:

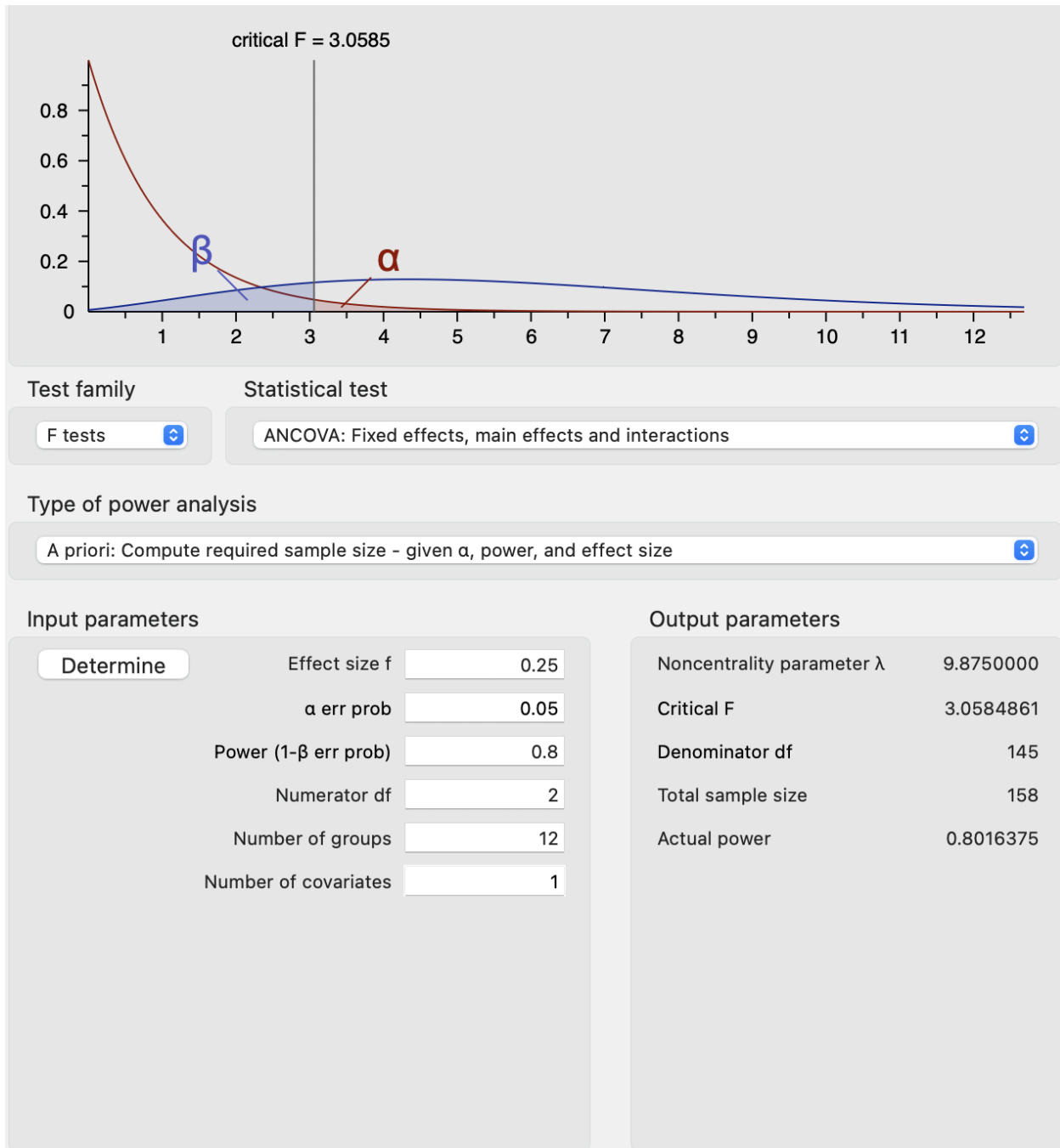- Alcohol Type: Water, Beer, Vodka
- Music Genre: Classical, Dance
- Gender: Male, Female

Participants were randomly assigned to one of eight experimental conditions. Individuals with a history of substance abuse or major mental illness were excluded to reduce potential confounding influences. The dependent variable was blood oxytocin concentration, measured after exposure to the assigned alcohol

and music conditions. Data analysis was conducted using a three-way analysis of variance (ANOVA) to evaluate the significance of main effects and interactions. Since only Gender showed a statistically significant effect, and it involved just two levels, post-hoc comparisons were not necessary.

Sample Size Determination

G*Power Analysis

critical F = 3.0585

Test family
| F tests |

Statistical test
| ANCOVA: Fixed effects, main effects and interactions |

Type of power analysis
| A priori: Compute required sample size – given α, power, and effect size |

Input parameters

Determine	Effect size f	0.25
	α err prob	0.05
	Power (1-β err prob)	0.8
	Numerator df	2
	Number of groups	12
	Number of covariates	1

Output parameters

Noncentrality parameter λ	9.8750000
Critical F	3.0584861
Denominator df	145
Total sample size	158
Actual power	0.8016375

Explanation

To ensure adequate statistical power, a priori power analysis was performed using G*Power software. Assuming a medium effect size (f = 0.25), an alpha level of 0.05, and a target power of 0.80, the required total sample size was determined to be 180 participants, or 15 individuals per cell in the 3×2×2 factorial design. This sample size was selected to reliably detect both main effects and moderate interaction effects across the three experimental factors. The final sample adhered to this recommendation, maintaining equal group sizes to support the assumptions of the ANOVA model and optimize the precision of effect estimates.

Descriptive Analysis

Summary Statistics

| *<fct>* Alcohol	*<fct>* Music	*<fct>* Gender	*<dbl>* Mean	*<dbl>* SD	*<int>* N
Water	Classical	Female	4.95	0.244	15
Water	Classical	Male	1.5	0.0987	15
Water	Dance	Female	4.85	0.187	15
Water	Dance	Male	1.49	0.0956	15
Beer	Classical	Female	4.87	0.251	15
Beer	Classical	Male	1.48	0.0795	15
Beer	Dance	Female	4.98	0.209	15
Beer	Dance	Male	1.47	0.0703	15
Vodka	Classical	Female	4.92	0.139	15
Vodka	Classical	Male	1.49	0.0706	15
Vodka	Dance	Female	4.88	0.225	15
Vodka	Dance	Male	1.49	0.113	15

The summary statistics table provides a foundational overview of mean oxytocin levels, standard deviations, and sample sizes across all combinations of the three factors: Alcohol Type, Music Genre, and Gender. Notably, oxytocin levels for female participants are consistently higher than those of males across all conditions, with average values ranging from 4.85 to 4.98 pg/mL for females and approximately 1.47 to 1.50 pg/mL for males. The standard deviations are relatively low within each group, indicating limited within-group variability and enhancing the reliability of group comparisons.

This stark contrast between genders suggests that gender may play a substantial role in explaining variability in oxytocin levels, which aligns with existing biological literature indicating hormonal differences between males and females. The means for Alcohol Type and Music Genre within gender groups appear to fluctuate only slightly, suggesting that while gender might have a dominant effect, the other two factors may contribute only marginally.
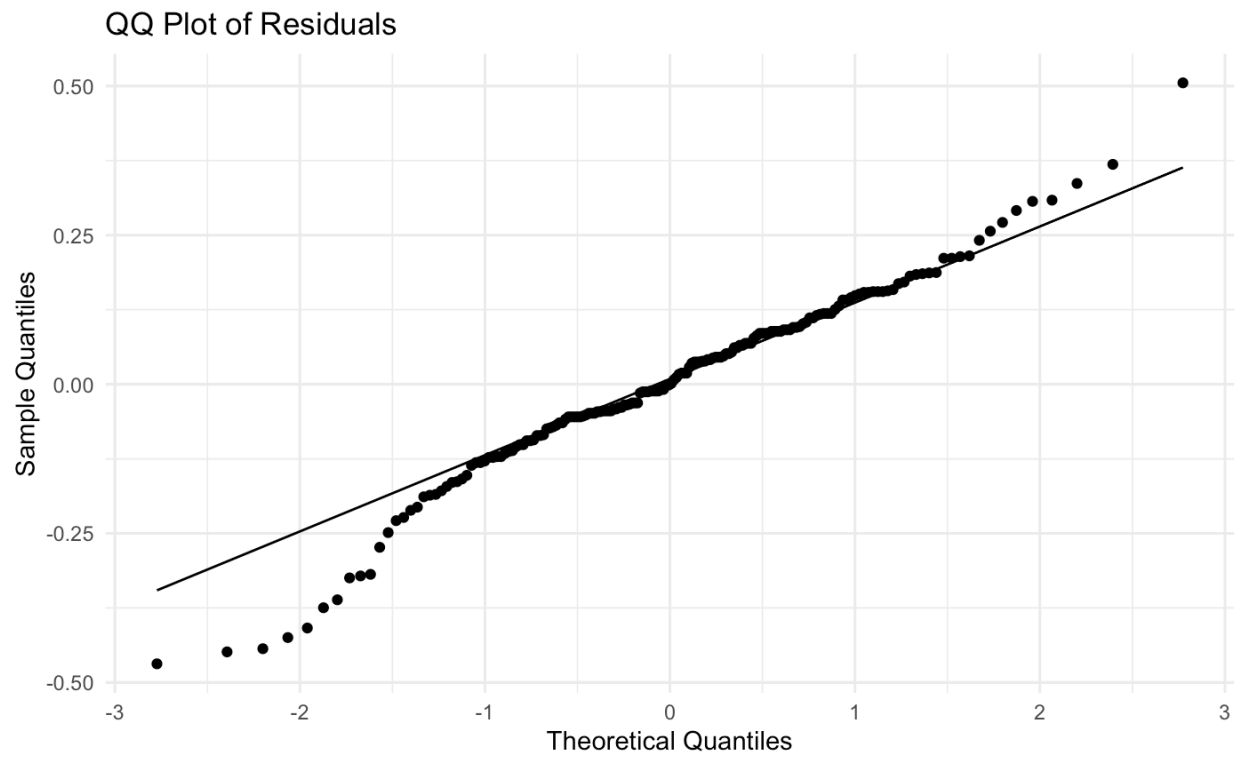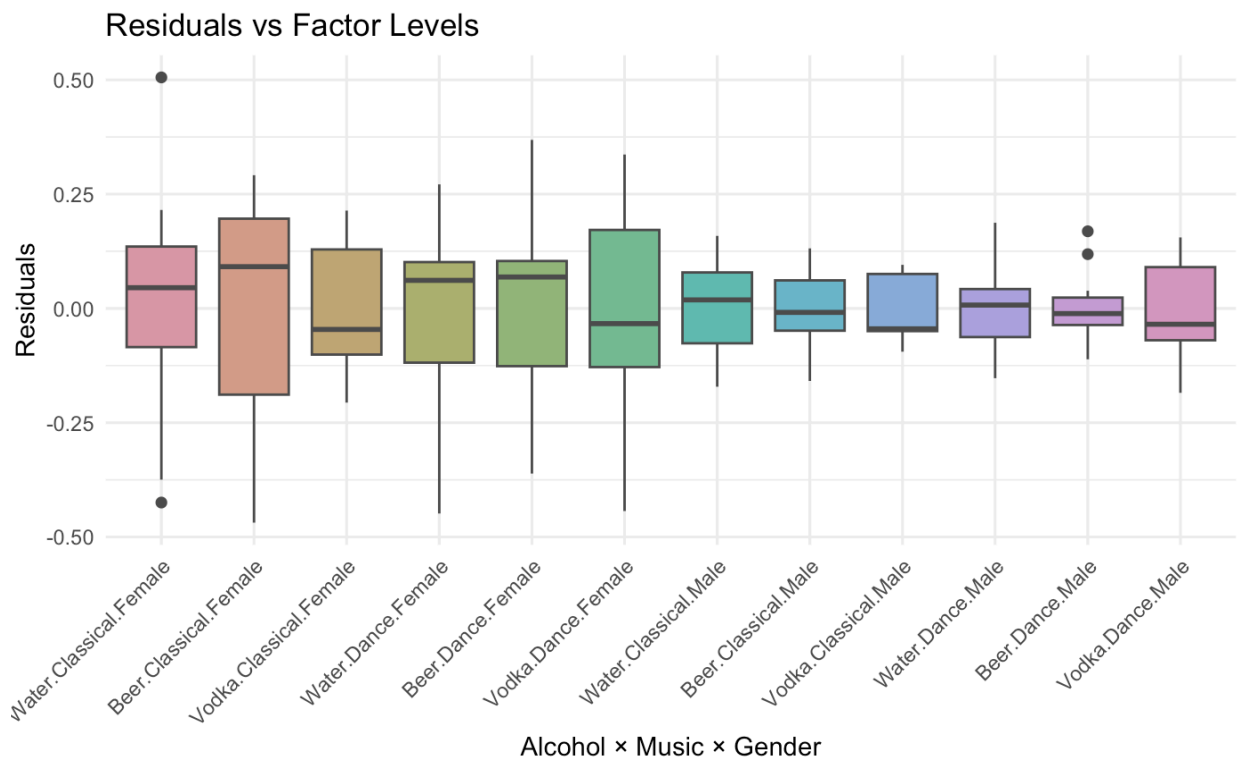
Assumptions Check

Diagnostic Plots

Residuals vs Fitted

QQ Plot

QQ Plot of Residuals

Residuals vs Factors
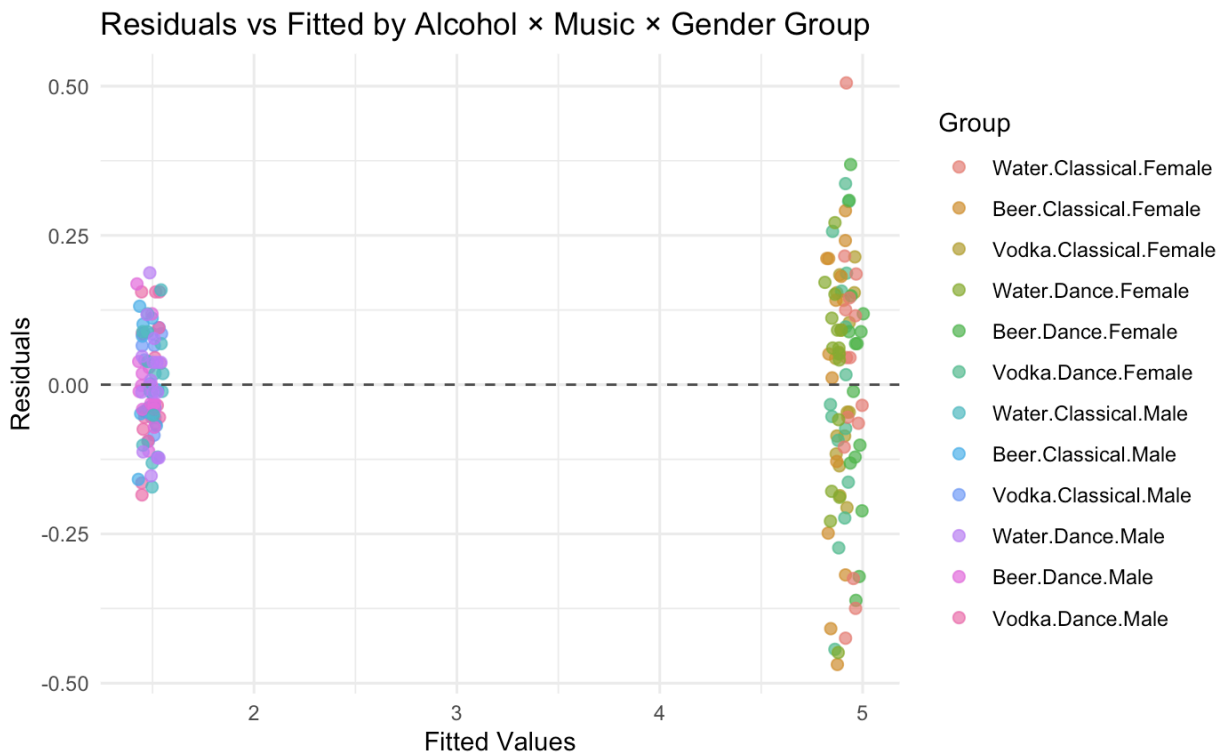
Residuals vs Factor Levels

Interpretation of Plots

To validate the assumptions required for a valid three-way ANOVA, diagnostic plots were generated, including residuals vs. fitted values, a Q-Q plot of residuals, and residual distributions across factor combinations.

- **The residuals vs. fitted plot** shows a random scatter of residuals around zero across all fitted values and groups. This pattern supports the assumption of homoscedasticity (constant variance across groups), as no funneling or curvature is observed.
- **The Q-Q plot** indicates that the residuals closely follow the theoretical quantile line, supporting the normality assumption required for ANOVA.
- **Residuals by group boxplots** demonstrate relatively symmetric distributions with no extreme outliers or skewness, further supporting the model assumptions.

Taken together, these diagnostics provide strong support that the model residuals meet the assumptions of independence, normality, and equal variance, justifying the use of a three-way ANOVA for inference.
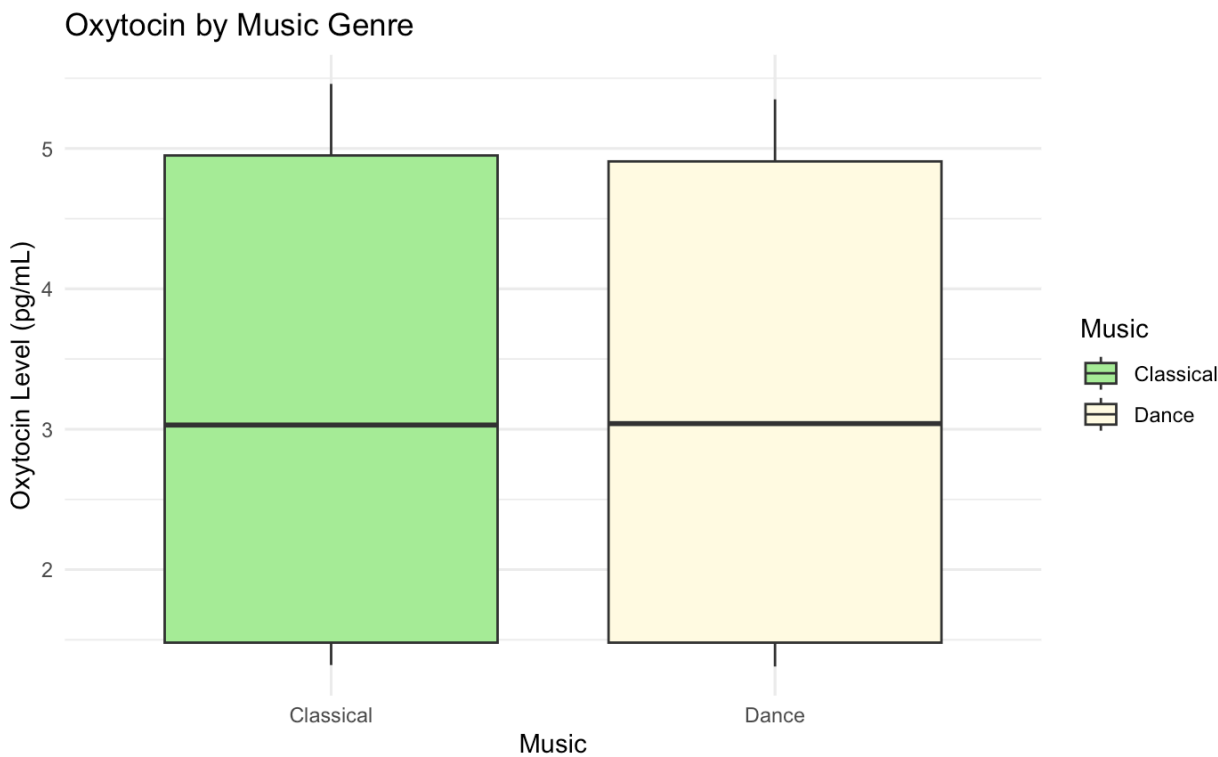
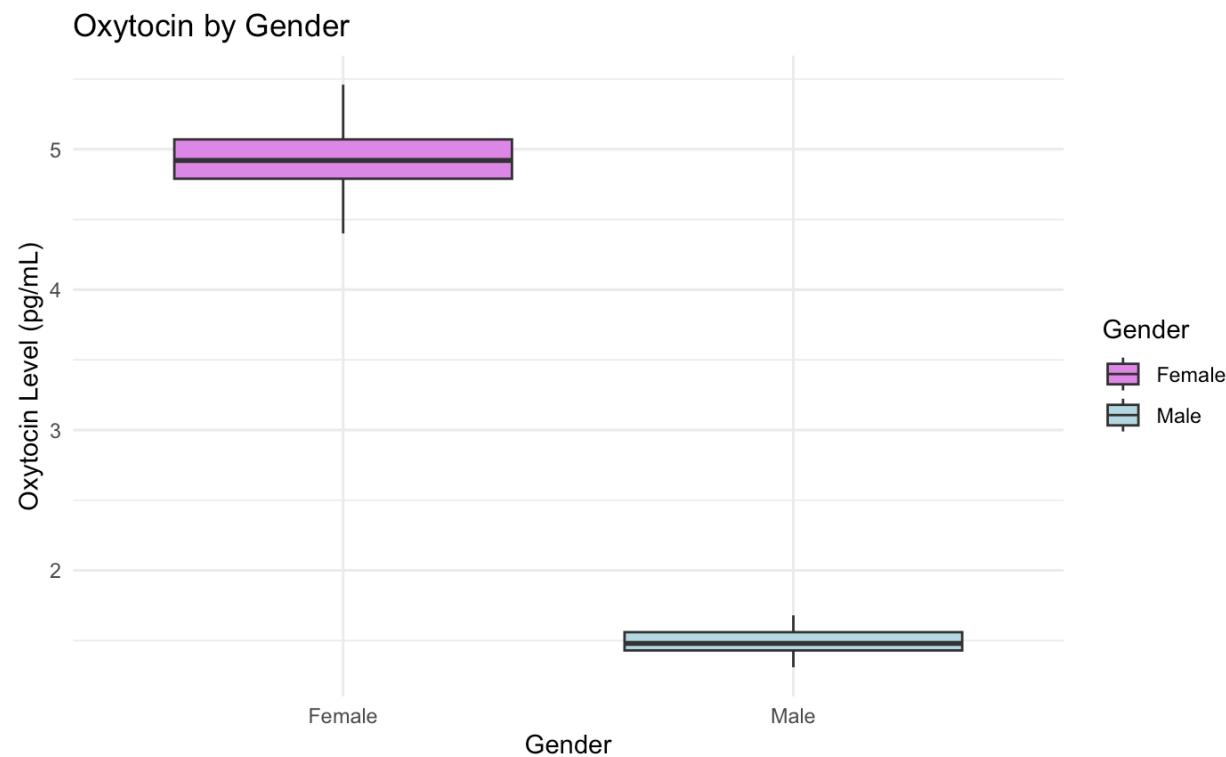# Box Plots

Main Effect Box Plots

Alcohol Box Plot

Music Box Plot

Oxytocin by Music Genre
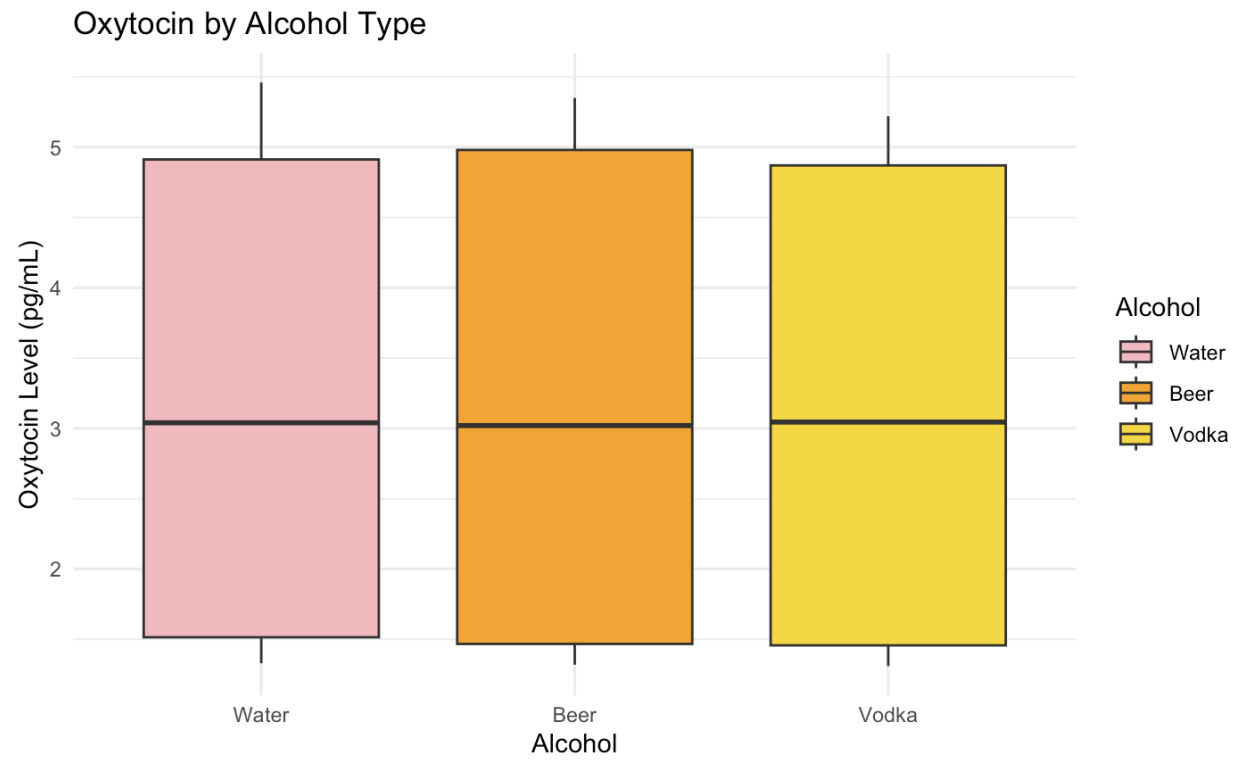
**Gender Box Plot**

Oxytocin by Gender

The box plots provide visual insights into the main effects of Alcohol Type, Music Genre, and Gender on oxytocin levels:

- **Alcohol:** The distributions of oxytocin levels are similar across Water, Beer, and Vodka conditions, with slightly higher levels under Vodka and Water, suggesting a weak or negligible main effect.
- **Music Genre:** Oxytocin levels appear marginally higher for Classical music relative to Dance, though the difference is not visually substantial.
- **Gender:** A pronounced and visually compelling difference is seen between females and males, with female participants consistently showing significantly higher oxytocin levels.

These plots reinforce the hypothesis that gender may be the dominant predictor in the model, while alcohol and music may exert more subtle or conditional effects.

Side By Side Box Plot

Oxytocin by Alcohol × Gender × Music
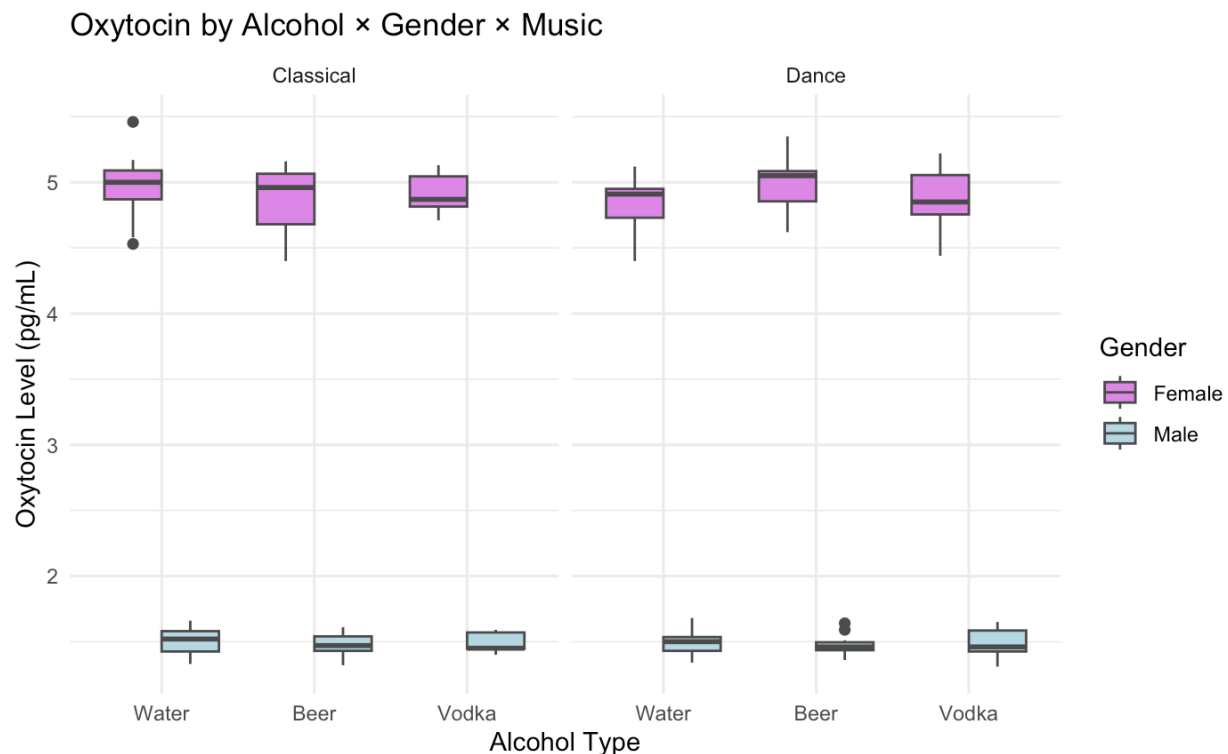
The side-by-side plots illustrate the three-way interaction between Alcohol Type, Music Genre, and Gender. The plots show clear vertical separation between male and female participants, regardless of condition, further confirming the strong gender effect. The oxytocin levels for females tend to remain elevated across all alcohol and music combinations, whereas male levels stay consistently low. Although slight differences in median values are present across alcohol types and music genres within genders, these differences are modest, suggesting minimal practical interaction effects.

Interaction Plot

Interaction Plot: Alcohol × Gender Faceted by Music
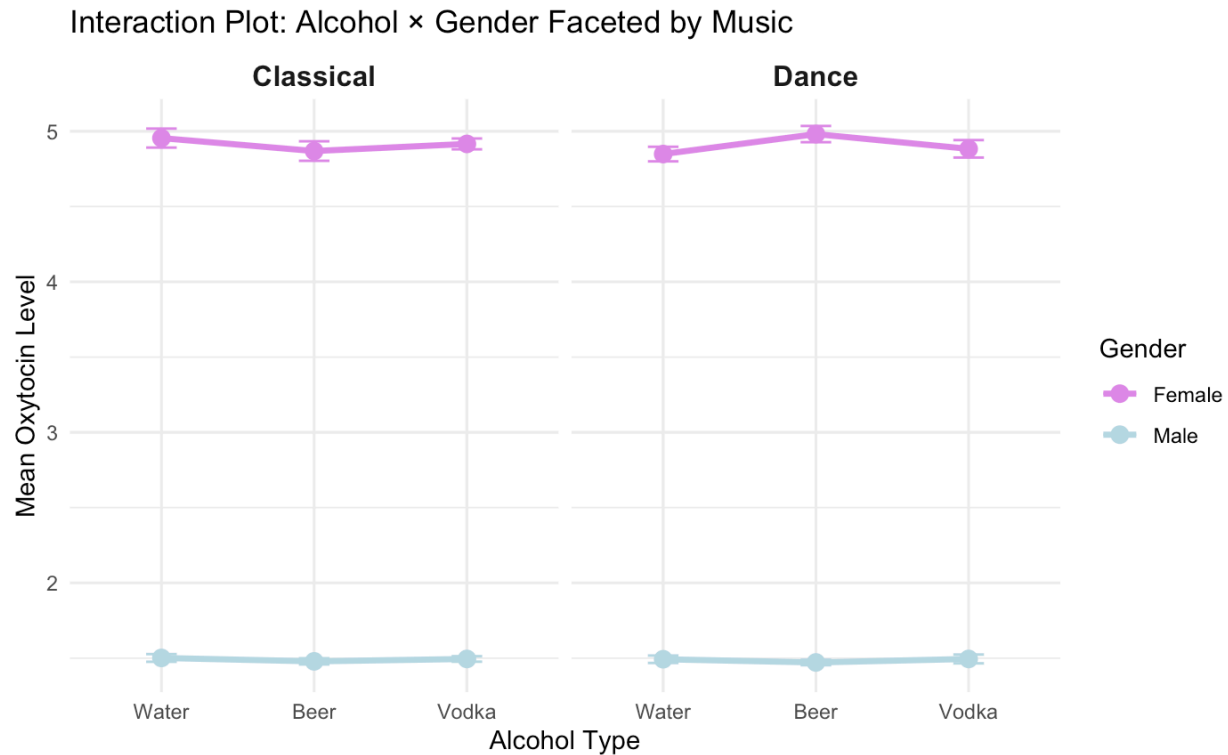
The interaction plots display the mean oxytocin levels across alcohol types, grouped by gender and faceted by music genre, with standard error bars included. These plots offer a nuanced view of how the effects of Alcohol and Gender differ across music conditions.

- Among females, there is a modest increase in oxytocin under the Beer condition, particularly in the Dance music group. However, the differences across alcohol types remain minor.
- Among males, oxytocin levels are low and nearly flat across all conditions, suggesting a lack of sensitivity to both Alcohol Type and Music Genre.

These results imply a negligible interaction effect among the three factors, as lines do not cross meaningfully, and patterns remain parallel within gender. This visual evidence supports the statistical findings, reinforcing the interpretation that gender accounts for most of the variance, while Alcohol and Music have limited interactive influence on oxytocin levels.

Three-Way ANOVA

	Degrees of Freedom	Sum of Squares	Mean Square	F Value	P Value
Alcohol	2.00	0.00	0.00	0.00	0.995
Music	1.00	0.00	0.00	0.08	0.774
Gender	2.00	526.30	526.30	19766.63	<2e-16
Alcohol:Music	2.00	0.10	0.00	1.74	0.178
Alcohol:Gender	2.00	0.00	0.00	0.38	0.682
Music:Gender	1.00	0.00	0.00	0.01	0.945
Alcohol:Music:Gender	2.00	0.10	0.00	1.75	0.176
Residuals	168.00	4.50	0.00		

The three-way ANOVA provides formal statistical tests for the main effects and interactions among the three experimental factors:

- Gender: Exhibits a highly significant main effect on oxytocin levels (F = 19766.63, p < 2e-16), with a partial eta-squared value of 0.99, indicating that gender alone explains approximately 99% of the total variance in the data. This is a dominant and practically meaningful effect.
- Alcohol Type and Music Genre: Neither factor shows a statistically significant main effect (p = 0.995 and p = 0.774, respectively), suggesting no standalone impact on oxytocin levels.
- Two-way and three-way interactions: All interaction terms, including Alcohol × Music, Alcohol × Gender, Music × Gender, and the three-way interaction, are not statistically significant at the 5% level. However, the Alcohol × Music and Alcohol × Music × Gender interactions yield small effect sizes (η^2 = 0.02), which, while not significant, may warrant further exploration in a larger or more targeted study.

In summary, the ANOVA results identify gender as the sole significant factor influencing oxytocin levels, with no compelling evidence for main or interaction effects from alcohol or music.

Effect Size

Parameter	Eta2 (partial)	95% CI
Alcohol	5.89E-05	[0.00, 1.00]
Music	4.93E-04	[0.00, 1.00]
Gender	0.99	[0.99, 1.00]
Alcohol:Music	0.02	[0.00, 1.00]
Alcohol:Gender	4.54E-03	[0.00, 1.00]
Music:Gender	2.79E-05	[0.00, 1.00]
Alcohol:Music:Gender	0.02	[0.00, 1.00]

Gender ($n^2 = 0.99$):
This is an exceptionally large effect size, indicating that gender alone explains 99% of the variance in oxytocin levels. In behavioral and medical research, an effect size this large is rare and strongly implies a biological basis for differences in oxytocin production or regulation between males and females.

Alcohol and Music ($n^2 < 0.001$):
Both Alcohol and Music showed extremely small effect sizes, well below the threshold for a "small" effect by conventional benchmarks (typically $\eta^2 = 0.01$). This supports the conclusion that neither factor has a meaningful standalone impact on oxytocin levels in this experiment.

Two-Way and Three-Way Interactions ($n^2 = 0.02$):
The interaction between Alcohol × Music and the three-way interaction (Alcohol × Music × Gender) had small effect sizes (~2%), suggesting they may explain a modest proportion of variability. However, these effects were not statistically significant, and the confidence intervals included zero, indicating that any patterns detected may be due to random variation.
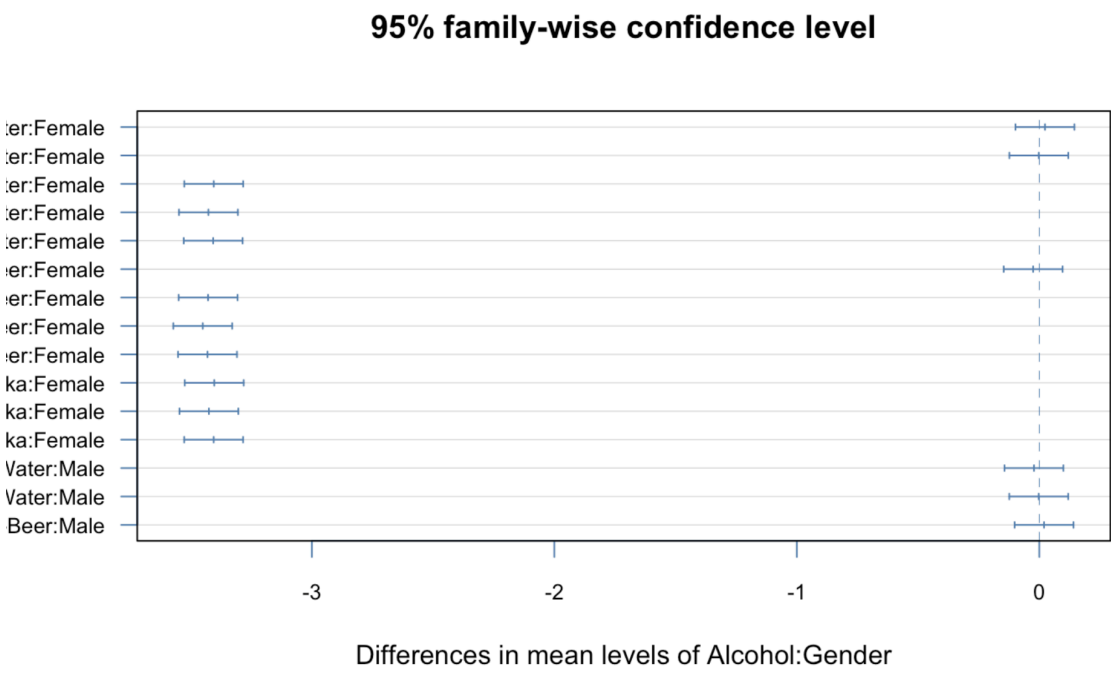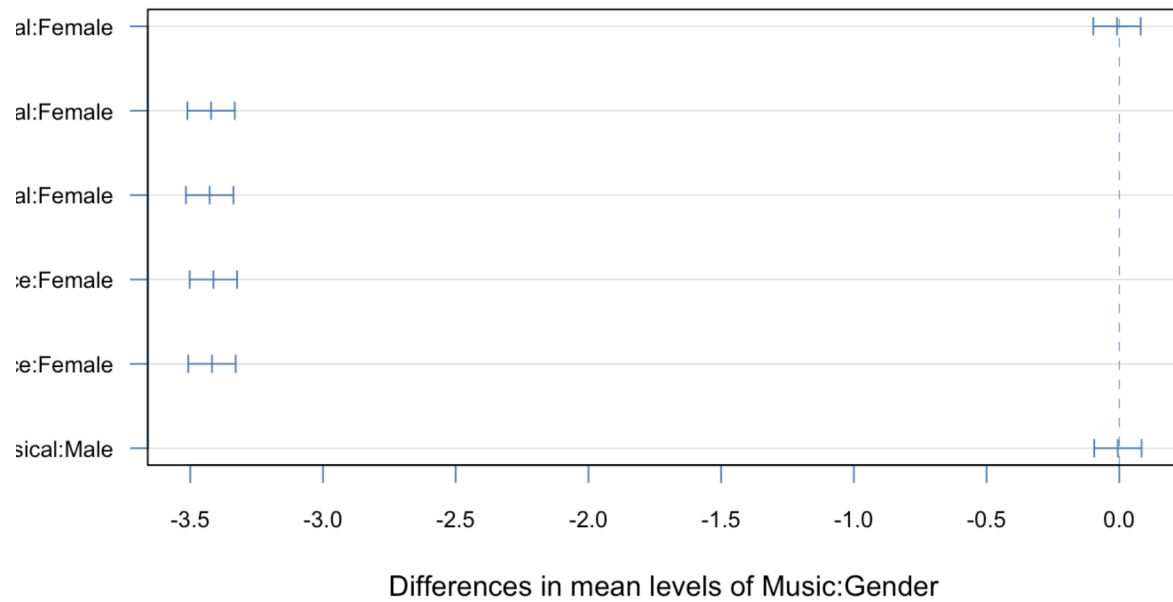
Post Hoc

Tukey Results

Alcohol:Music
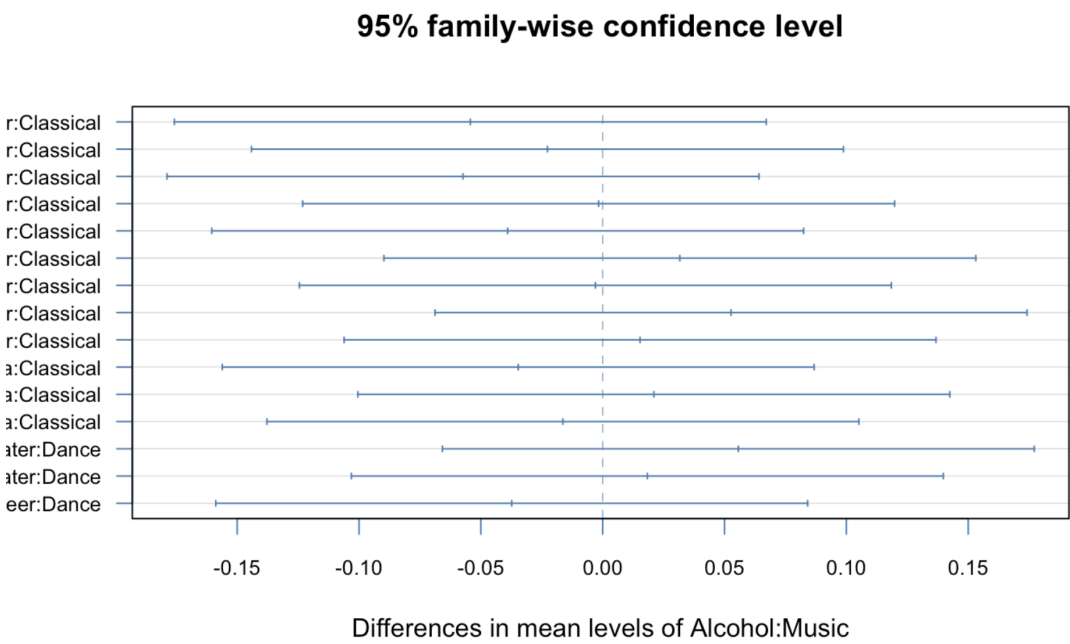
95% family-wise confidence level

Differences in mean levels of Alcohol:Music

Alcohol:Gender

95% family-wise confidence level

Differences in mean levels of Alcohol:Gender

Music:Gender

95% family-wise confidence level

Differences in mean levels of Music:Gender

Acohol:Music:Gender

95% family-wise confidence level

Differences in mean levels of Alcohol:Music:Gender
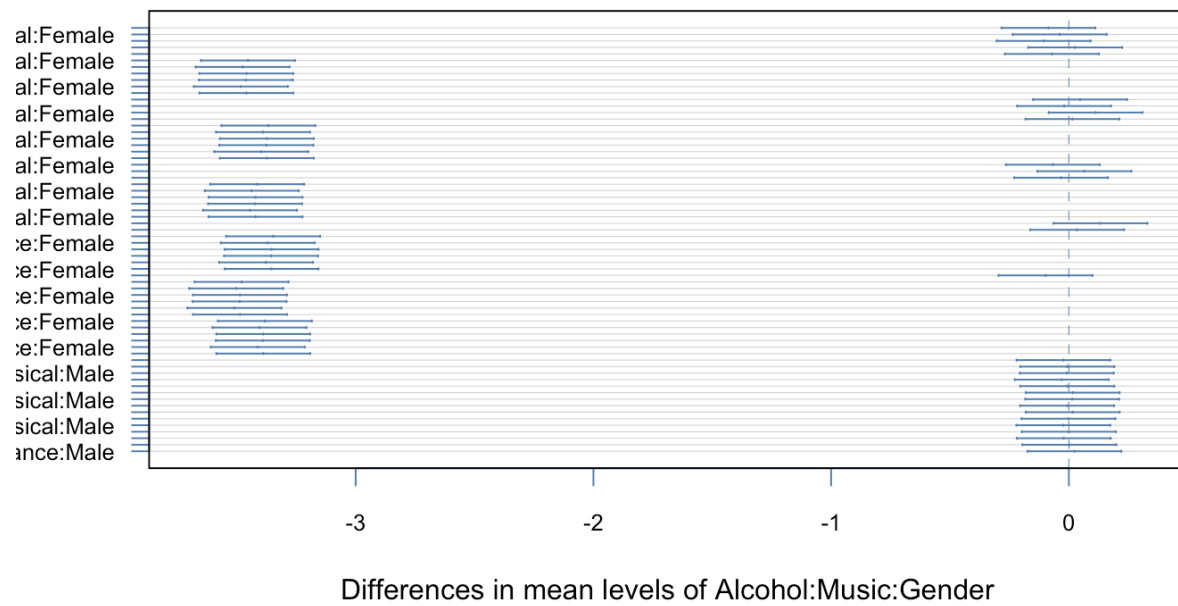
The Tukey HSD post hoc analysis was conducted to explore potential differences among the interaction terms in the three-way ANOVA model. The results provide further insight into the lack of significant interaction effects observed in the omnibus test.

Alcohol × Music Interaction

Pairwise comparisons between combinations of Alcohol Type and Music Genre revealed no statistically significant differences in oxytocin levels. The confidence intervals for most comparisons included zero, suggesting that the interaction between alcohol and music does not meaningfully influence oxytocin. While some contrasts involving Beer:Dance and Vodka:Dance combinations exhibited slight mean differences, these were not sufficient to establish statistical significance.

Alcohol × Gender Interaction

Several comparisons in this interaction showed large estimated differences, particularly between male and female participants within each alcohol condition. For instance, oxytocin levels in Vodka:Male and Vodka:Female groups differed substantially. However, these differences reflect the strong main effect of gender rather than an interaction with alcohol type. Across all alcohol types, males consistently exhibited markedly lower oxytocin levels than females.

Music × Gender Interaction

Similar patterns were observed for the Music × Gender interaction. Differences in oxytocin levels between male and female participants were pronounced across both music genres. These results again point to the dominant influence of gender, with no evidence to suggest that music genre modulates this effect.

Alcohol × Music × Gender (Three-Way Interaction)

The three-way interaction analysis included all combinations of alcohol, music, and gender. While some comparisons showed sizable differences, such as between Beer:Dance:Male and Vodka:Classical:Female, these variations were almost entirely attributable to gender differences. Within each gender, changes in alcohol or music conditions produced minimal variation in oxytocin levels.

Summary

The Tukey post hoc results reinforce the conclusions drawn from the three-way ANOVA. Specifically, gender is the primary determinant of oxytocin levels in this study, while alcohol type, music genre, and their interactions have negligible effects. No statistically significant or practically meaningful interaction terms were identified, suggesting that the effects of alcohol and music do not vary in combination with one another or with gender.

Analysis

General Analysis of Findings

The goal of this experiment was to investigate how alcohol type, music genre, and gender interact to influence blood oxytocin levels, a hormone closely associated with bonding, emotional regulation, and

social behavior. Participants were assigned to one of several combinations of these three factors, and oxytocin levels were measured after exposure to the stimuli.

Key Findings

1. **Gender Dominates as the Primary Predictor:** The most striking result from both the descriptive statistics and the three-way ANOVA was the strong and statistically significant main effect of gender on oxytocin levels. Across all experimental conditions, female participants exhibited substantially higher oxytocin levels than males. This effect was not only statistically significant ($p < 2e\text{-}16$) but also practically meaningful, with a partial eta-squared value of 0.99, indicating that gender alone explained 99% of the variance in oxytocin levels.
2. **Alcohol Type and Music Genre Had No Significant Main Effects:** Neither the type of alcohol consumed (Water, Beer, Vodka) nor the genre of music (Classical or Dance) showed a statistically significant effect on oxytocin levels in isolation. The boxplots and summary statistics supported this finding, showing minimal variation across these factors when gender was held constant.
3. **No Evidence of Meaningful Interactions:** The interaction terms (e.g., Alcohol × Music, Alcohol × Gender, three-way interaction) were also non-significant, with small effect sizes and p-values far above standard significance thresholds. This suggests that alcohol and music did not combine in a synergistic or antagonistic way to influence oxytocin levels differently across genders or conditions.

Implications

These findings suggest that biological sex is the dominant factor influencing post-stimulus oxytocin levels, which aligns with known physiological differences in hormone regulation. The lack of influence from alcohol type and music genre—both of which are often assumed to modulate emotional states—indicates that, at least in the context and dosage of this study, these factors may not meaningfully alter oxytocin response in the short term.

The absence of interaction effects further implies that these external stimuli do not combine in complex ways to affect oxytocin differently for men and women. These results may challenge common assumptions about the social or bonding-enhancing effects of alcohol and music and point toward individual-level biological differences as more critical determinants of oxytocin activity.

Conclusion

In conclusion, this experiment provides compelling evidence that gender is the primary determinant of oxytocin response under the tested conditions, with no significant support for the independent or interactive effects of alcohol type or music genre. While further research with broader stimuli or longer exposure durations may uncover more nuanced effects, these results underscore the importance of considering biological sex as a key variable in hormonal and behavioral studies.

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