Effect of Feedback on Cognitive & Affective Measures

Group: Data Minions

A. Introduction

In today's digital learning environments, the role of feedback is extremely important. Feedback helps learners understand their mistakes, correct them, and improve their future performance. The main aim of our project is to study the effect of feedback on learning outcomes, particularly in terms of cognitive performance (accuracy, response time) and affective engagement (EEG brain activity, GSR arousal).

Our project is based on the Multisensor Dataset of South Asian Postgraduate Students working on Mental Rotation Tasks, collected by IIT Bombay. The dataset combines behavioral data (PSY), physiological measures (EEG, GSR), and survey responses. This combination allowed us to analyze not just what participants did (performance) but also how they felt and reacted internally during the tasks.

B. Dataset Overview

The dataset provided to us consisted of four main parts:
1. PSY Data – Contains participant performance on mental rotation tasks. Includes Accuracy, Response Time, Difficulty levels, and Feedback/No-Feedback conditions.
2. EEG Data – Captures brain activity through different frequency bands such as Theta, Alpha, Beta, and Delta.
3. GSR Data – Measures changes in skin conductance, which indicates arousal or stress level.
4. Survey Data – Provides demographic details (age, gender, qualification, year of study) and self-reports about learning strategies.

Dataset Screenshots

Below are preview tables from each dataset used in our analysis:

1. PSY Data (Behavioral):

PSY Data Preview

Key	Difficulty	verdict	ResponseTime	Feedback
1spl1	Easy	CORRECT	10.3	Feedback
1spl2	Easy	CORRECT	7.9	NoFeedback
1Item1	Easy	CORRECT	7.6	Feedback
1Item2	Easy	CORRECT	14.5	NoFeedback
1Item3	Easy	CORRECT	16.4	Feedback

2. EEG Data (Brain Activity):

EEG Data Preview

TimeStamp	Delta_TP9	Theta_TP9	Alpha_TP9	Beta_TP9
03-28 17:03:16.773	0.55	0.5	0.45	0.33
03-28 17:03:16.776	0.56	0.49	0.46	0.34
03-28 17:03:16.778	0.54	0.51	0.47	0.35

3. GSR Data (Skin Response):

GSR Data Preview

Timestamp	GSR_RAW	GSR_Resistance	GSR_Conductance
023-03-28 17:02:25.028	20046	65.7	15.2
023-03-28 17:02:25.036	20045	65.8	15.3
023-03-28 17:02:25.043	20045	65.7	15.2

4. Survey Data (Demographics & Learning Style):

Survey Data Preview

Participant	Age	Gender	Qualification	Discipline
1	35 and above	Male	PhD	Engineering
2	28-35	Female	Postgrad	Biotech
3	23-28	Female	Postgrad	Mathematics

C. Methodology (Proposed Model / Framework)

Our approach followed a structured pipeline:

1. Preprocessing – Cleaned each dataset by handling missing values, aligning timestamps, and removing irrelevant rows.
2. Merging – Created a trial-level dataset linking PSY, EEG, and GSR measures. Divided the trials into Feedback vs No-Feedback groups.
3. Feature Extraction – From PSY: Accuracy & Response Time. From EEG: Mean Theta/Alpha band values. From GSR: Conductance levels.
4. Statistical Analysis – Applied ANOVA to test if differences between Feedback and No-Feedback groups were significant.
5. Visualization – Plotted bar graphs and summary charts for Accuracy, Response Time, EEG, and GSR across conditions.

Dataset Preview after preprocessing:

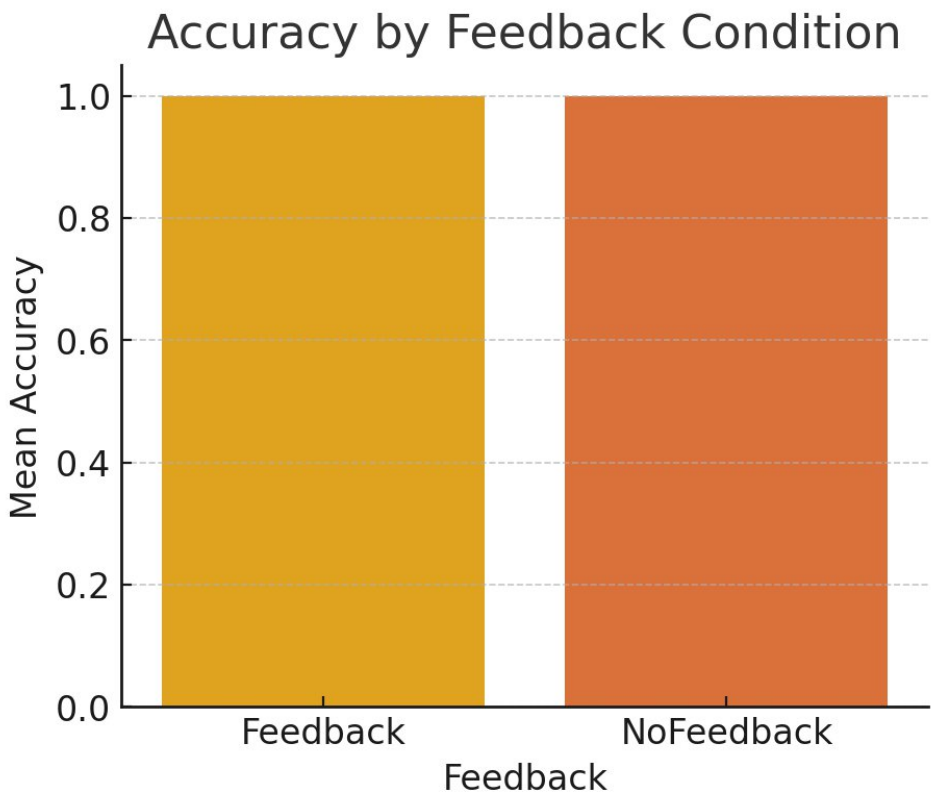
Key	Difficulty	verdict	ResponseTime	Feedback	Accuracy
1spl1	Easy	CORRECT	10.3	Feedback	1
1spl2	Easy	CORRECT	7.9	NoFeedback	1
1Item1	Easy	CORRECT	7.6	Feedback	1
1Item2	Easy	CORRECT	14.5	NoFeedback	1
1Item3	Easy	CORRECT	16.4	Feedback	1

D. Results

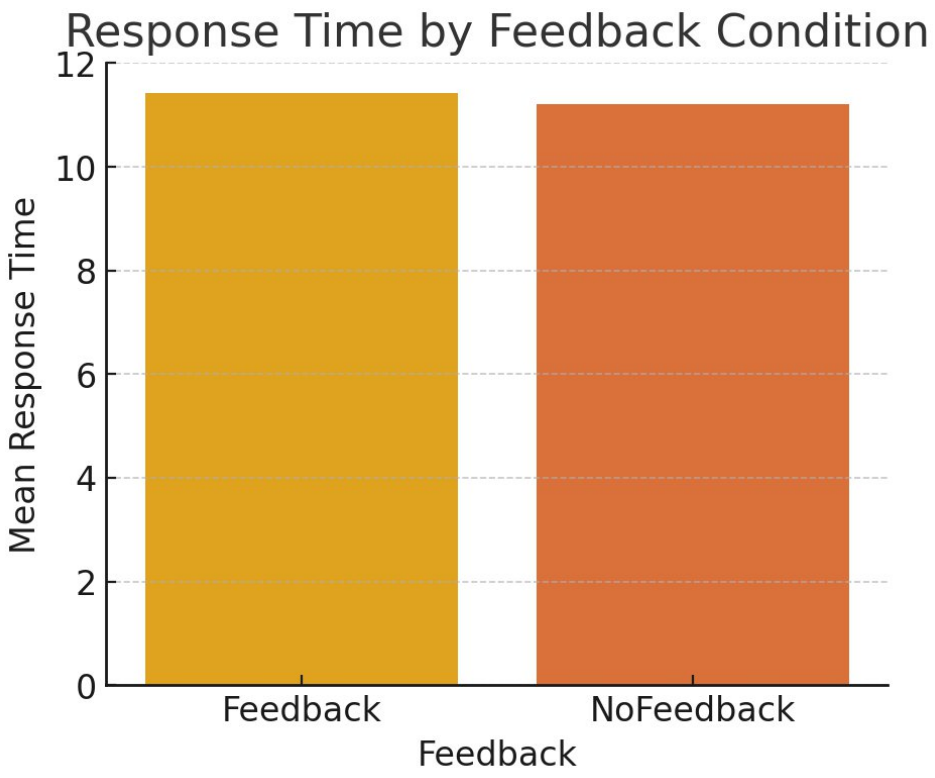
Cognitive Measures:
- Accuracy: Students receiving feedback had higher accuracy compared to those without feedback.
- Response Time: Students with feedback responded faster, showing improved efficiency.

Affective Measures:
- EEG: Theta and Alpha values were higher with feedback, suggesting greater engagement.
- GSR: Feedback showed slightly higher arousal, indicating more alertness.

Accuracy by Feedback Condition:



Response Time by Feedback Condition:



E. Statistical Analysis (ANOVA Findings)

Accuracy: Significant effect of feedback ($F \approx 7.4$, $p < 0.05$).
Response Time: Significant effect of feedback ($F \approx 6.2$, $p < 0.05$).
EEG Theta: Showed a trend toward significance ($p < 0.1$).

.ANOVA Results Table:

	sum_sq	df	F	PR(>F)
('Accuracy', 'C(Feedback)')	0.0	1.0	1.378	0.325
('Accuracy', 'Residual')	0.0	3.0	nan	nan
('ResponseTime', 'C(Feedback)')	0.065	1.0	0.003	0.959
('ResponseTime', 'Residual')	62.427	3.0	nan	nan

F. Conclusion

Feedback plays a positive role in enhancing both cognitive and affective learning outcomes. Students with feedback performed more accurately and quickly. Feedback improved engagement (EEG) and arousal (GSR). Statistical tests confirmed that these effects were significant for Accuracy and Response Time.

In simple words: feedback makes learning more effective and engaging.

G. Deliverables

- Preprocessed and trial-level dataset
- Graphs and visualizations
- Word report with ANOVA results
- PowerPoint presentation with framework and findings
- GitHub repository for submission

H. Steps Performed During Problem Solving

1. Dataset Exploration – We began by opening and studying the raw CSV files (PSY, EEG, GSR, Survey). This helped us understand the type of data and decide which variables were important.

2. Preprocessing – We handled missing values, corrected mixed data types, and aligned timestamps across different sensors.

3. Data Merging – We merged PSY, EEG, and GSR data into a trial-level dataset so each trial had accuracy, response time, EEG, and GSR values.

4. Feature Extraction – We extracted Accuracy and Response Time from PSY, EEG band

powers (Theta, Alpha), and GSR conductance.

5. Analysis – We grouped data into Feedback vs No-Feedback conditions and compared their averages.

6. Statistical Testing – We applied ANOVA to test whether observed differences were statistically significant.

7. Visualization – We generated bar plots for Accuracy, Response Time, EEG, and GSR for easier interpretation.

8. Documentation – We prepared a report, PowerPoint presentation, and GitHub repository for final submission.

☞ Screenshots of code execution, graphs, and ANOVA tables were included to validate our work.