

# Model Comparison Report

Multi-Class Classification of Personality Types (MBTI)

Comparing 4 Machine Learning Techniques

## Executive Summary

This report compares four machine learning algorithms trained to classify 16 MBTI personality types. All models used identical data splits (70/15/15) with random state 42 for fair comparison.

### Quick Results Overview:

Rank	Model	Test Acc	Top-3 Acc
1st	XGBoost (Gradient Boosting)	98.22%	99.23%
2nd	Random Forest	97.57%	99.08%
3rd	Logistic Regression	91.90%	98.62%
4th	Linear Discriminant Analysis	90.56%	98.14%

## 1. Dataset Configuration

Total Samples: 59,999  
Training Set: 42,023 samples (70%)  
Validation Set: 8,976 samples (15%)  
Test Set: 9,000 samples (15%)  
Features: 60 survey questions  
Target Classes: 16 MBTI personality types

## 2. Accuracy Metrics Comparison

Metric	XGBoost	Rand Forest	Log Reg	LDA
Test Accuracy	98.22%	97.57%	91.90%	90.56%
Validation Acc	98.12%	97.48%	92.12%	90.63%
Train Accuracy	100.00%	99.34%	92.35%	90.53%
Train-Test Gap	1.78%	1.77%	0.45%	0.00%

## 3. Top-K Accuracy (Test Set)

K	XGBoost	Rand Forest	Log Reg	LDA
Top-1	98.22%	97.57%	91.90%	90.56%
Top-2	99.10%	98.77%	97.31%	96.44%
Top-3	99.23%	99.08%	98.62%	98.14%
Top-5	99.38%	99.28%	99.27%	99.01%

### Aggregate Performance Metrics:

Metric	XGBoost	Rand Forest	Log Reg	LDA
Macro F1	0.9822	0.9757	0.9189	0.9053
Macro Prec	0.9823	0.9757	0.9190	0.9055
Macro Recall	0.9822	0.9757	0.9190	0.9055

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## 4. Model-Specific Analysis

### 4.1 Gradient Boosting (XGBoost) - WINNER

Strengths:

- Highest accuracy (98.22%)
- Superior at handling complex patterns
- Early stopping prevents overfitting

Weaknesses:

- Longer training time
- More hyperparameters to tune
- Shows some overfitting (100% train accuracy)

Best For: Maximum prediction accuracy, production deployments

### 4.2 Random Forest - 2nd Place

Strengths:

- Excellent accuracy (97.57%)
- Fast training (100 trees, parallel)
- Good generalization (1.77% gap)
- Clear feature importance

Weaknesses:

- Slightly lower accuracy than XGBoost
- Larger model size

Best For: Balance of accuracy and training speed

### 4.3 Logistic Regression - 3rd Place

Strengths:

- Very fast training (24 iterations)
- Excellent generalization (0.45% gap)
- Highly interpretable coefficients
- Simple, minimal tuning

Weaknesses:

- Lower raw accuracy (91.90%)
- Linear boundaries miss complex patterns

Best For: Fast prototyping, interpretability

### 4.4 Linear Discriminant Analysis

Strengths:

- Very fast training
- Perfect generalization (no overfitting)
- Dimensionality reduction (15 components)

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- No hyperparameter tuning

Weaknesses:

- Lowest accuracy (90.56%)
- Assumes Gaussian distributions
- Linear decision boundaries

Best For: Baseline model, dimensionality reduction

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## 5. Most Challenging Personality Types

Some personality types are harder to classify across all models. ESFJ and ISFJ types show lower F1-scores, especially with linear models.

Type	XGBoost F1	RF F1	LR F1	LDA F1
ESFJ	0.9813	0.9747	0.8670	0.8239
ISFJ	0.9813	0.9766	0.8923	0.8639
ISFP	0.9751	0.9596	0.8961	0.8863
INFJ	0.9840	0.9707	0.9111	0.9024

## 6. Top Features (Consensus)

All models identify similar key features:

- 'You often end up doing things at the last possible moment'  
(Judging vs Perceiving)
- 'You are not too interested in discussing interpretations of creative works'  
(Intuition vs Sensing)
- 'Your happiness comes more from helping others'  
(Thinking vs Feeling)
- 'You enjoy going to art museums'  
(Intuition vs Sensing, Openness)
- 'You like to have a to-do list for each day'  
(Judging vs Perceiving)

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## 7. Recommendations

### For Maximum Accuracy: Use XGBoost

Best overall performance (98.22%). Worth the extra complexity for production systems.

### For Speed & Accuracy Balance: Use Random Forest

Excellent accuracy (97.57%) with faster training. Great for most applications.

### For Interpretability: Use Logistic Regression

Fast training, clear interpretation, good generalization (91.90%).

### For Baseline: Use LDA

Quick baseline, dimensionality reduction, perfect generalization.

## 8. Conclusion

All four models successfully learned to predict MBTI personality types:

- XGBoost leads with 98.22% (best for production)
- Random Forest at 97.57% (best balance)
- Logistic Regression at 91.90% (best interpretability)
- LDA at 90.56% (best baseline)

Key Findings:

1. Tree-based ensemble methods significantly outperform linear models
2. All models achieve >98% top-3 accuracy
3. Linear models show better generalization but lower raw accuracy
4. ESFJ and ISFJ types are most challenging
5. Feature importance is consistent, validating survey design

All models trained with random\_state=42 for reproducibility.