```
# Install all necessary libraries
!pip install -U openai-whisper
!pip install pydub librosa scikit-learn pandas matplotlib seaborn
!sudo apt update && sudo apt install ffmpeg
```

```
Requirement already satisfied: soxr>=0.3.2 in /usr/local/lib/python3.11/dist-packages (from librosa) (0.5.0.post1)
Requirement already satisfied: typing_extensions>=4.1.1 in /usr/local/lib/python3.11/dist-packages (from librosa) (4.13.1)
Requirement already satisfied: lazy_loader>=0.1 in /usr/local/lib/python3.11/dist-packages (from librosa) (0.4)
Requirement already satisfied: msgpack>=1.0 in /usr/local/lib/python3.11/dist-packages (from librosa) (1.1.0)
Requirement already satisfied: threadpoolctl>=3.1.0 in /usr/local/lib/python3.11/dist-packages (from scikit-learn) (3.6.0)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas) (2.8.2)
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Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas) (2025.2)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.57.0)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.1.0)
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Requirement already satisfied: llvmlite<0.44,>=0.43.0dev0 in /usr/local/lib/python3.11/dist-packages (from numba>=0.51.0->librosa
Requirement already satisfied: platformdirs>=2.5.0 in /usr/local/lib/python3.11/dist-packages (from pooch>=1.1->librosa) (4.3.7)
Requirement already satisfied: requests>=2.19.0 in /usr/local/lib/python3.11/dist-packages (from pooch>=1.1->librosa) (2.32.3)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
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Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests>=2.19.0->pooch>=1.1->
Downloading pydub-0.25.1-py2.py3-none-any.whl (32 kB)
Installing collected packages: pydub
Successfully installed pydub-0.25.1
Hit:1 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64  InRelease
Get:2 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ InRelease [3,632 B]
Get:3 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ Packages [73.0 kB]
Hit:4 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:5 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:7 https://r2u.stat.illinois.edu/ubuntu jammy InRelease [6,555 B]
Hit:8 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Hit:9 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy InRelease
Get:10 https://r2u.stat.illinois.edu/ubuntu jammy/main all Packages [8,847 kB]
Hit:11 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Get:12 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [2,788 kB]
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Get:14 http://archive.ubuntu.com/ubuntu jammy-updates/restricted amd64 Packages [4,161 kB]
Get:15 http://security.ubuntu.com/ubuntu jammy-security/universe amd64 Packages [1,243 kB]
Get:16 http://archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [3,101 kB]
Get:17 http://archive.ubuntu.com/ubuntu jammy-updates/universe amd64 Packages [1,542 kB]
Get:18 https://r2u.stat.illinois.edu/ubuntu jammy/main amd64 Packages [2,697 kB]
Fetched 24.7 MB in 5s (5,130 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
47 packages can be upgraded. Run 'apt list --upgradable' to see them.
W: Skipping acquire of configured file 'main/source/Sources' as repository 'https://r2u.stat.illinois.edu/ubuntu jammy InRelease'
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
ffmpeg is already the newest version (7:4.4.2-0ubuntu0.22.04.1).
0 upgraded, 0 newly installed, 0 to remove and 47 not upgraded.
```

```
# Upload .wav files from your system
from google.colab import files
uploaded = files.upload()
```

Choose Files 7 files

- **Speaker27_007.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_006.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_005.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_004.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_003.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_002.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_001.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done

```
Saving Speaker27_007.wav to Speaker27_007.wav
Saving Speaker27_006.wav to Speaker27_006.wav
Saving Speaker27_005.wav to Speaker27_005.wav
Saving Speaker27_004.wav to Speaker27_004.wav
Saving Speaker27_003.wav to Speaker27_003.wav
Saving Speaker27_002.wav to Speaker27_002.wav
Saving Speaker27_001.wav to Speaker27_001.wav
```

```
# Load Whisper model
import whisper
whisper_model = whisper.load_model("base")  # You can also use "small", "medium" etc.



# Transcription function
def transcribe_audio(file_path):
    result = whisper_model.transcribe(file_path)
    return result["text"]



# Example for one file (change filename as needed)
transcript = transcribe_audio("/content/Speaker27_001.wav")
print("Transcript:\n", transcript)
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
Transcript:
  struggle. Comparatively few people appreciate how the thought of navigating the air's disious tights and the seas glumious depths
```

```
from pydub import AudioSegment, silence
import librosa
import numpy as np
import re



def extract_features(file_path, transcript):
    features = {}

    # Load audio
    audio = AudioSegment.from_wav(file_path)
    duration_sec = len(audio) / 1000.0

    # 1. Pause Count
    pauses = silence.detect_silence(audio, min_silence_len=300, silence_thresh=-40)
    features["pause_count"] = len(pauses)

    # 2. Hesitation Words
    hesitations = len(re.findall(r"\b(uh+|um+|erm+|hmm+)\b", transcript.lower()))
    features["hesitation_count"] = hesitations

    # 3. Speech Rate (words/sec)
    words = transcript.split()
    features["speech_rate"] = len(words) / duration_sec

    # 4. Pitch Variability
    y, sr = librosa.load(file_path)
    pitches, _ = librosa.piptrack(y=y, sr=sr)
    pitch_values = pitches[pitches > 0]
    features["pitch_var"] = np.std(pitch_values) if len(pitch_values) > 0 else 0

    # 5. Incomplete Sentences (Optional)
    incomplete = len(re.findall(r"(\.\.\.|-|- -|- - -)", transcript))
    features["incomplete_sentences"] = incomplete

    return features



import os
import pandas as pd


# Get all .wav files
audio_files = [f for f in os.listdir('/content') if f.endswith('.wav')]


# Run transcription + feature extraction
data = []
for file in audio_files:
    path = f"/content/{file}"
    text = transcribe_audio(path)
    features = extract_features(path, text)
    features["file"] = file
    data.append(features)
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
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/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
```

```
# Create DataFrame
df = pd.DataFrame(data)
df
```

	pause_count	hesitation_count	speech_rate	pitch_var	incomplete_sentences	file
0	23	0	2.983333	1115.658813	0	Speaker27_006.wav
1	23	0	2.216667	1146.989990	0	Speaker27_004.wav
2	20	0	2.683333	1154.262329	0	Speaker27_002.wav
3	21	0	2.733333	1100.173950	0	Speaker27_007.wav
4	22	0	2.700000	1152.282837	0	Speaker27_001.wav
5	23	0	2.850000	1168.379150	3	Speaker27_003.wav
6	21	0	2.483333	1087.100220	3	Speaker27_005.wav

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
# Load ML model (after DataFrame is ready)
from sklearn.ensemble import IsolationForest
X = df.drop(columns=["file"])
ml_model = IsolationForest()
ml_model.fit(X)
```

```
▾ IsolationForest
IsolationForest()
```

```
from sklearn.ensemble import IsolationForest

X = df.drop(columns=["file"])
model = IsolationForest()
model.fit(X)  # Fit the model to your data before using it
df["risk_score"] = -model.decision_function(X)  # Higher score = higher risk
df = df.sort_values("risk_score", ascending=False)
df
```

	pause_count	hesitation_count	speech_rate	pitch_var	incomplete_sentences	file	risk_score
6	21	0	2.483333	1087.100220	3	Speaker27_005.wav	0.061338
5	23	0	2.850000	1168.379150	3	Speaker27_003.wav	0.033359
2	20	0	2.683333	1154.262329	0	Speaker27_002.wav	0.000370
1	23	0	2.216667	1146.989990	0	Speaker27_004.wav	-0.000683
0	23	0	2.983333	1115.658813	0	Speaker27_006.wav	-0.019645
3	21	0	2.733333	1100.173950	0	Speaker27_007.wav	-0.045637
4	22	0	2.700000	1152.282837	0	Speaker27_001.wav	-0.093298

Next steps: Generate code with df | View recommended plots | New interactive sheet

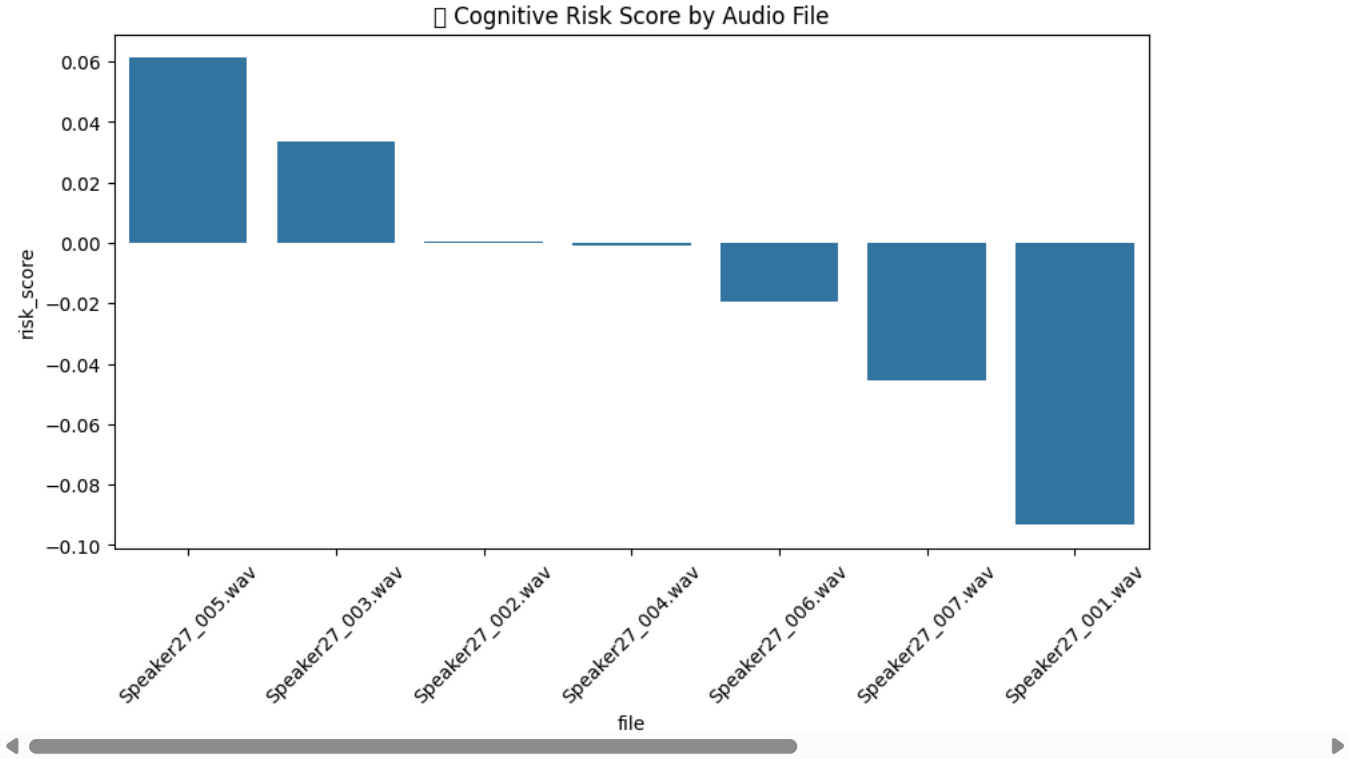
Generate Using dataframe: df suggest a plot Close

Waiting...

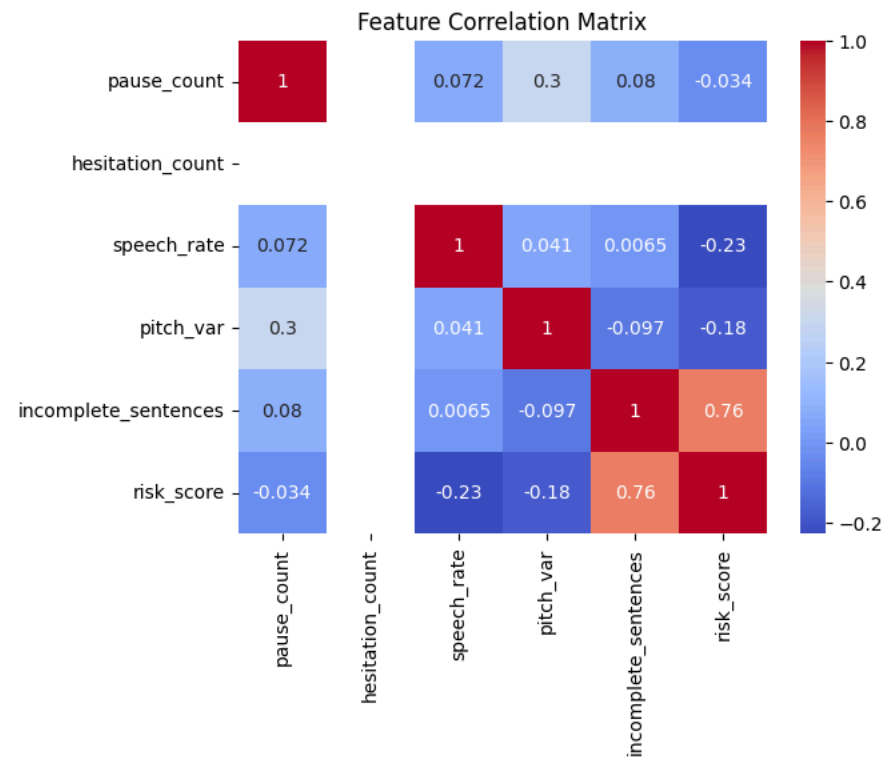
```
import matplotlib.pyplot as plt
import seaborn as sns

# Risk score barplot
plt.figure(figsize=(10,5))
sns.barplot(data=df, x="file", y="risk_score")
```

```
plt.xticks(rotation=45)
plt.title("🧠 Cognitive Risk Score by Audio File")
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/IPython/core/pylabtools.py:151: UserWarning: Glyph 129504 (\N{BRAIN}) missing from font(s) D
  fig.canvas.print_figure(bytes_io, **kw)
```




```
# Correlation heatmap
sns.heatmap(df.drop(columns=["file"]).corr(), annot=True, cmap="coolwarm")
plt.title("Feature Correlation Matrix")
plt.show()
```




```
def predict_cognitive_risk(file_path):
    transcript = transcribe_audio(file_path)
    features = extract_features(file_path, transcript)
    test_df = pd.DataFrame([features])

    # Ensure test_df has the same columns as X, in the same order
```

```
    test_df = test_df[X.columns.drop('risk_score')]

    risk_score = -model.decision_function(test_df)[0]
    return risk_score, transcript
```

```
from sklearn.ensemble import IsolationForest

X = df.drop(columns=["file"])
model = IsolationForest()
model.fit(X)
```

```
IsolationForest()
```

```
import pandas as pd
import numpy as np

def predict_cognitive_risk(file_path):
    transcript = transcribe_audio(file_path)
    features = extract_features(file_path, transcript)
    test_df = pd.DataFrame([features])

    # Ensure test_df has the same columns as the training data (excluding 'file' and 'risk_score' if present)
    test_df = test_df[[col for col in X.columns if col not in ['file', 'risk_score']]]

    risk_score = -model.decision_function(test_df)[0]
    return risk_score, transcript
```

```
import os
print(os.listdir("/content"))
```

```
['.config', 'Speaker27_006.wav', 'Speaker27_004.wav', 'Speaker27_002.wav', 'Speaker27_007.wav', 'Speaker27_001.wav', 'Speaker27_003
```

```
df.to_csv("final_audio_analysis.csv", index=False)
```

----------extra feature add ----------

Extra feature add **bold text**

```
!pip install -U openai-whisper
```

```
Requirement already satisfied: openai-whisper in /usr/local/lib/python3.11/dist-packages (20240930)
Requirement already satisfied: numba in /usr/local/lib/python3.11/dist-packages (from openai-whisper) (0.60.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packages (from openai-whisper) (2.0.2)
Requirement already satisfied: torch in /usr/local/lib/python3.11/dist-packages (from openai-whisper) (2.6.0+cu124)
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Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests>=2.26.0->tiktoken->opena
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests>=2.26.0->tiktoken->opena
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.11/dist-packages (from jinja2->torch->openai-whisper) (3.0
```

```
!pip install pydub librosa scikit-learn pandas matplotlib seaborn
!sudo apt update && sudo apt install ffmpeg
```

```
Requirement already satisfied: seaborn in /usr/local/lib/python3.11/dist-packages (0.13.2)
Requirement already satisfied: audioread>=2.1.9 in /usr/local/lib/python3.11/dist-packages (from librosa) (3.0.1)
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Requirement already satisfied: msgpack>=1.0 in /usr/local/lib/python3.11/dist-packages (from librosa) (1.1.0)
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Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.3.1)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (4.57.0)
Requirement already satisfied: kiwisolver>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (1.4.8)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (24.2)
Requirement already satisfied: pillow>=8 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (11.1.0)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.11/dist-packages (from matplotlib) (3.2.3)
Requirement already satisfied: llvmlite<0.44,>=0.43.0dev0 in /usr/local/lib/python3.11/dist-packages (from numba>=0.51.0->librosa
Requirement already satisfied: platformdirs>=2.5.0 in /usr/local/lib/python3.11/dist-packages (from pooch>=1.1->librosa) (4.3.7)
Requirement already satisfied: requests>=2.19.0 in /usr/local/lib/python3.11/dist-packages (from pooch>=1.1->librosa) (2.32.3)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas) (1.17.0)
Requirement already satisfied: cffi>=1.0 in /usr/local/lib/python3.11/dist-packages (from soundfile>=0.12.1->librosa) (1.17.1)
Requirement already satisfied: pycparser in /usr/local/lib/python3.11/dist-packages (from cffi>=1.0->soundfile>=0.12.1->librosa)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.11/dist-packages (from requests>=2.19.0->pooch>
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-packages (from requests>=2.19.0->pooch>=1.1->libros
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.11/dist-packages (from requests>=2.19.0->pooch>=1.1->
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.11/dist-packages (from requests>=2.19.0->pooch>=1.1->
Hit:1 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ InRelease
Hit:2 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64  InRelease
Get:3 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Hit:4 http://archive.ubuntu.com/ubuntu jammy InRelease
Get:5 https://r2u.stat.illinois.edu/ubuntu jammy InRelease [6,555 B]
Hit:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:7 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Hit:8 http://archive.ubuntu.com/ubuntu jammy-backports InRelease
Hit:9 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy InRelease
Get:10 https://r2u.stat.illinois.edu/ubuntu jammy/main amd64 Packages [2,694 kB]
Hit:11 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Get:12 https://r2u.stat.illinois.edu/ubuntu jammy/main all Packages [8,836 kB]
Fetched 11.7 MB in 4s (2,998 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
47 packages can be upgraded. Run 'apt list --upgradable' to see them.
W: Skipping acquire of configured file 'main/source/Sources' as repository 'https://r2u.stat.illinois.edu/ubuntu jammy InRelease'
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
ffmpeg is already the newest version (7:4.4.2-0ubuntu0.22.04.1).
0 upgraded, 0 newly installed, 0 to remove and 47 not upgraded.
```

```
from google.colab import files
uploaded = files.upload()
```

```
Choose Files 9 files
```

- **Speaker27_007.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_006.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_005.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_004.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_003.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_002.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_001.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker27_000.wav**(audio/wav) - 2646308 bytes, last modified: 4/14/2025 - 100% done
- **Speaker26_029.wav**(audio/wav) - 2646780 bytes, last modified: 4/14/2025 - 100% done

```
Saving Speaker27_007.wav to Speaker27_007 (1).wav
Saving Speaker27_006.wav to Speaker27_006 (1).wav
Saving Speaker27_005.wav to Speaker27_005 (1).wav
Saving Speaker27_004.wav to Speaker27_004 (1).wav
Saving Speaker27_003.wav to Speaker27_003 (1).wav
Saving Speaker27_002.wav to Speaker27_002 (1).wav
Saving Speaker27_001.wav to Speaker27_001 (1).wav
Saving Speaker27_000.wav to Speaker27_000.wav
Saving Speaker26_029.wav to Speaker26_029.wav
```

```
import os
audio_files = [f for f in os.listdir('/content') if f.endswith('.wav')]
print('Found files:', audio_files)
```

```
Found files: ['Speaker27_006.wav', 'Speaker27_006 (1).wav', 'Speaker27_004.wav', 'Speaker27_002 (1).wav', 'Speaker27_001 (1).wav',
```

```
import whisper
whisper_model = whisper.load_model('base')


def transcribe_audio(file_path):
    result = whisper_model.transcribe(file_path)
    return result['text']


transcripts = {}
for file in audio_files:
    path = os.path.join('/content', file)
    text = transcribe_audio(path)
    transcripts[file] = text
    print(f'✅ {file}:\n{text[:200]}...\n')
```

```
 struggle. Comparatively few people appreciate how the thought of navigating the air's disious tights and the seas glumious depth

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_005 (1).wav:
 CHAPTER I A VARECRAFT AND SUBMARANES by Willis J. Abbott. This liberal-vox recording is in the public domain. Recording by Willi

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_003 (1).wav:
 Opportunities for the peaceful use of airplanes are beginning to suggest themselves daily. After the main body of this book was

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_004 (1).wav:
 of many records of personal experiences of those who have dared the air's high altitudes, and the seas stilly depths. For permis

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker26_029.wav:
```

```
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_007 (1).wav:
They left General French's right flank in the air, exposed to involvement by Van Kluck, who was already reaching around the left

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_003.wav:
Opportunities for the peaceful use of airplanes are beginning to suggest themselves daily. After the main body of this book was

/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning: FP16 is not supported on CPU; using FP32 instead
  warnings.warn("FP16 is not supported on CPU; using FP32 instead")
✅ Speaker27_005.wav:
CHAPTER I A VARECRAFT AND SUBMARANES by Willis J. Abbott. This liberal-vox recording is in the public domain. Recording by Willi
```

```
from pydub import AudioSegment, silence
import librosa
import numpy as np
import re

def compute_jitter(pitches):
    return np.mean(np.abs(np.diff(pitches))) if len(pitches) > 1 else 0

def extract_features(file_path, transcript):
    features = {}

    # Load audio
    audio = AudioSegment.from_wav(file_path)
    duration_sec = len(audio) / 1000.0

    # 1. Pause Count
    pauses = silence.detect_silence(audio, min_silence_len=300, silence_thresh=-40)
    features["pause_count"] = len(pauses)

    # 2. Hesitation Words
    hesitations = len(re.findall(r"\b(uh+|um+|erm+|hmm+)\b", transcript.lower()))
    features["hesitation_count"] = hesitations

    # 3. Speech Rate
    words = transcript.split()
    features["speech_rate"] = len(words) / duration_sec

    # 4. Pitch and Jitter
    y, sr = librosa.load(file_path)
    pitches, _ = librosa.piptrack(y=y, sr=sr)
    pitch_values = pitches[pitches > 0]
    features["pitch_var"] = np.std(pitch_values) if len(pitch_values) > 0 else 0
    features["jitter"] = compute_jitter(pitch_values)
    features["max_pitch"] = np.max(pitch_values) if len(pitch_values) > 0 else 0
    features["min_pitch"] = np.min(pitch_values) if len(pitch_values) > 0 else 0

    # 5. Articulation Rate
    non_silent_parts = silence.detect_nonsilent(audio, min_silence_len=300, silence_thresh=-40)
    speaking_time = sum([end - start for start, end in non_silent_parts]) / 1000.0
    features["articulation_rate"] = len(words) / speaking_time if speaking_time > 0 else 0

    # 6. Mean Pause Duration
    pause_durations = [(end - start) / 1000.0 for start, end in pauses]
    features["mean_pause_duration"] = np.mean(pause_durations) if pause_durations else 0

    # 7. Filler Rate
    features["filler_rate"] = hesitations / (duration_sec / 60.0)

    # 8. Lexical Richness
    unique_words = set([w.lower() for w in words])
    features["lexical_diversity"] = len(unique_words) / len(words) if len(words) > 0 else 0

    # 9. Incomplete Sentences
    incomplete = len(re.findall(r"(\.\.\.|-|- -|- - -)", transcript))
    features["incomplete_sentences"] = incomplete

    return features
```

```
import pandas as pd
data = []
for file in audio_files:
    path = os.path.join('/content', file)
    features = extract_features(path, transcripts[file])
    features['file'] = file
    data.append(features)
```

```
df = pd.DataFrame(data)
df
```

	pause_count	hesitation_count	speech_rate	pitch_var	jitter	max_pitch	min_pitch	articulation_rate	mean_pause_duration
0	23	0	2.983333	1115.658813	3.273888	3999.717529	145.367798	3.859838	0.592391
1	23	0	2.983333	1115.658813	3.273888	3999.717529	145.367798	3.859838	0.592391
2	23	0	2.216667	1146.989990	3.247573	3999.445068	145.497742	3.157270	0.777174
3	20	0	2.683333	1154.262329	3.262184	3999.667236	145.372131	3.354376	0.600150
4	22	0	2.700000	1152.282837	3.285052	3999.551025	145.401535	3.487321	0.615727
5	21	0	2.483333	1087.100220	3.288710	3999.481689	145.493195	3.279988	0.693952
6	23	0	2.850000	1168.379150	3.266464	3999.753906	145.381592	3.732972	0.617043
7	23	0	2.216667	1146.989990	3.247573	3999.445068	145.497742	3.157270	0.777174
8	16	0	2.450000	1190.481934	3.227209	3999.787109	145.358154	3.230201	0.905750
9	19	0	2.333333	1119.324463	3.268028	3999.666504	145.365479	3.019910	0.717947
10	20	0	2.683333	1154.262329	3.262184	3999.667236	145.372131	3.354376	0.600150
11	21	0	2.733333	1100.173950	3.256660	3999.536377	145.562469	3.514110	0.634810
12	22	0	2.700000	1152.282837	3.285052	3999.551025	145.401535	3.487321	0.615727
13	21	0	2.733333	1100.173950	3.256660	3999.536377	145.562469	3.514110	0.634810
14	23	0	2.850000	1168.379150	3.266464	3999.753906	145.381592	3.732972	0.617043
15	21	0	2.483333	1087.100220	3.288710	3999.481689	145.493195	3.279988	0.693952

Next steps: Generate code with df | View recommended plots | New interactive sheet

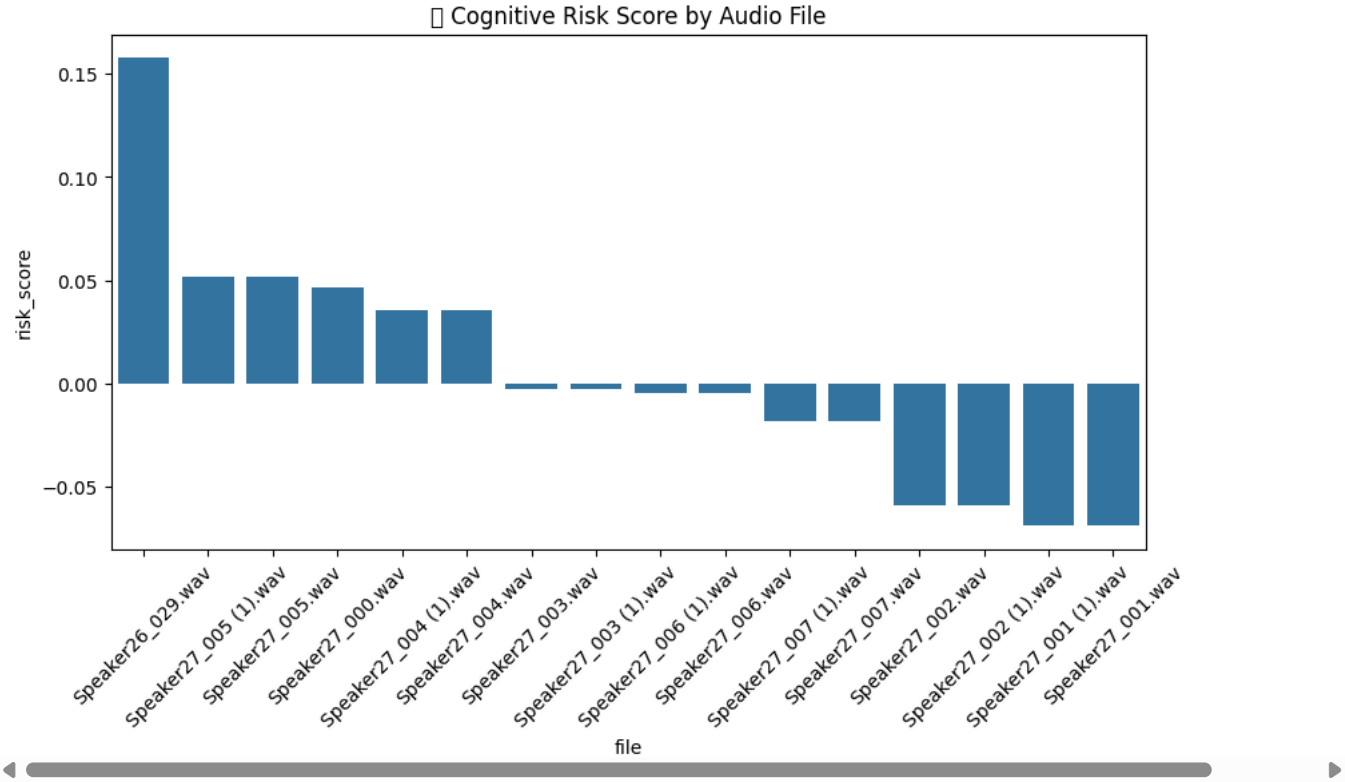
```
from sklearn.ensemble import IsolationForest
X = df.drop(columns=['file'])
ml_model = IsolationForest()
ml_model.fit(X)
df['risk_score'] = -ml_model.decision_function(X)
df = df.sort_values('risk_score', ascending=False)
df
```

	pause_count	hesitation_count	speech_rate	pitch_var	jitter	max_pitch	min_pitch	articulation_rate	mean_pause_duration
8	16	0	2.450000	1190.481934	3.227209	3999.787109	145.358154	3.230201	0.90575(
5	21	0	2.483333	1087.100220	3.288710	3999.481689	145.493195	3.279988	0.693952
15	21	0	2.483333	1087.100220	3.288710	3999.481689	145.493195	3.279988	0.693952
9	19	0	2.333333	1119.324463	3.268028	3999.666504	145.365479	3.019910	0.717947
7	23	0	2.216667	1146.989990	3.247573	3999.445068	145.497742	3.157270	0.777174
2	23	0	2.216667	1146.989990	3.247573	3999.445068	145.497742	3.157270	0.777174
14	23	0	2.850000	1168.379150	3.266464	3999.753906	145.381592	3.732972	0.617043
6	23	0	2.850000	1168.379150	3.266464	3999.753906	145.381592	3.732972	0.617043
1	23	0	2.983333	1115.658813	3.273888	3999.717529	145.367798	3.859838	0.592391
0	23	0	2.983333	1115.658813	3.273888	3999.717529	145.367798	3.859838	0.592391
13	21	0	2.733333	1100.173950	3.256660	3999.536377	145.562469	3.514110	0.634810
11	21	0	2.733333	1100.173950	3.256660	3999.536377	145.562469	3.514110	0.634810
10	20	0	2.683333	1154.262329	3.262184	3999.667236	145.372131	3.354376	0.600150
3	20	0	2.683333	1154.262329	3.262184	3999.667236	145.372131	3.354376	0.600150
4	22	0	2.700000	1152.282837	3.285052	3999.551025	145.401535	3.487321	0.615727
12	22	0	2.700000	1152.282837	3.285052	3999.551025	145.401535	3.487321	0.615727

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
import seaborn as sns
import matplotlib.pyplot as plt
plt.figure(figsize=(10,5))
sns.barplot(data=df, x='file', y='risk_score')
plt.xticks(rotation=45)
plt.title('🧠 Cognitive Risk Score by Audio File')
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/IPython/core/pylabtools.py:151: UserWarning: Glyph 129504 (\N{BRAIN}) missing from font(s) D
  fig.canvas.print_figure(bytes_io, **kw)
```




```
sns.heatmap(df.drop(columns=['file']).corr(), annot=True, cmap='coolwarm')
```

```
plt.title('Feature Correlation Matrix')
plt.show()
```