Final_Random Forest

May 20, 2023

Data processing

In [244]:
```
import pandas as pd
import numpy as np
from ast import literal_eval
import seaborn as sns
import matplotlib.pyplot as plt
import json
```

In [2]:
```
path = '/Users/wangchenhui/UChicago/ML/Final_Project/dataset/'
```

In [3]:
```
# load downloaded data
df_convos = pd.read_csv(path+'/conversations.csv')
df_speakers = pd.read_csv(path+'/speakers.csv')
df_utts = pd.read_csv(path+'/utterances.csv')
df_cases = pd.read_json(path_or_buf='https://zissou.infosci.cornell.edu/
df_cases = df_cases[(df_cases['year'] >= 2011) & (df_cases['year'] <= 2(
```

In [4]:
```
# combine text from all utterances in a conversation back into one stri
utt_per_conv = df_utts.groupby('conversation_id')['text'].apply(lambda x
utt_per_conv['num_utterances'] = df_utts.groupby('conversation_id')['te

# add the combined text to the conversations dataframe, merge on convers
df_convos_utt = df_convos.merge(utt_per_conv, left_on='id', right_on='c
```

In [5]:
```
# combine text from all conversation in a cases into one string based o
conv_per_case = df_convos_utt.groupby('meta.case_id')['text'].apply(laml
conv_per_case['num_conversations'] = df_convos_utt.groupby('meta.case_i
conv_per_case['num_utterances'] = df_convos_utt.groupby('meta.case_id')

# add the combined text case dataframe, merge on meta.case_id and id
df_cases_convo = df_cases.merge(conv_per_case, left_on='id', right_on='m
```

In [6]:
```
df_cases_convo.dropna(subset=['text'], inplace=True)
```

In [7]:
```
# transform to pd.to_datetime
df_cases_convo.decided_date = pd.to_datetime(df_cases_convo.decided_date
```

In [8]:
```
df_cases_convo.to_csv('df_cases_convo.csv', index=False)
```

Clean Data

In [9]:
```
import nltk
import re
nltk.download('stopwords')
nltk.download('punkt')
nltk.download('wordnet')
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/wangchenhui/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package punkt to
[nltk_data]     /Users/wangchenhui/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     /Users/wangchenhui/nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

In [10]:
```
# Cleaning the text
def preprocess_text(text):
    text = text.lower() # Lowercase the text
    text = re.sub('[^a-z]+', ' ', text)  # Remove special characters an
    text = re.sub(r'\b\w{1,3}\b', '', text) # Remove words with length
    words = nltk.word_tokenize(text) # Tokenize the text
    stop_words = set(stopwords.words('english')) # Remove stopwords
    words = [word for word in words if word not in stop_words]
    #lemmatizer = WordNetLemmatizer() # Lemmatize the words comment bec
    #words = [lemmatizer.lemmatize(word) for word in words]
    text = ' '.join(words) # Reconstruct the text

    return text
```

In [11]:
```
df = df_cases_convo.copy()
```

In [12]:
```
# preprocess text
df.loc[:, 'text_pre'] = df['text'].apply(preprocess_text)
```

In [13]:
```
df
```

Out[13]:

	id	year	citation	title	petitioner	respondent	docket_no	court	c
1	2011_11-182	2011	567 US _	Arizona v. United States	Arizona et al.	United States	11-182	Roberts Court	
2	2011_11-161	2011	566 US _	Armour v. City of Indianapolis	Christine Armour	City of Indianapolis	11-161	Roberts Court	
3	2011_11-159	2011	566 US _	Astrue v. Capato	Michael J. Astrue, Commissioner of Social Secu...	Karen K. Capato	11-159	Roberts Court	
4	2011_10-1320	2011	566 US _	Blueford v. Arkansas	Alex Blueford	Arkansas	10-1320	Roberts Court	
6	2011_10-844	2011	566 US _	Caraco Pharmaceutical Laboratories, Ltd. v. No...	Caraco Pharmaceutical Laboratories, Ltd., et al.	Novo Nordisk A/S, et al.	10-844	Roberts Court	
...	...	...	...	...	...	...	...	...	
595	2018_17-765	2018	586 US _	United States v. Stitt	United States of America	Victor J. Stitt, II	17-765	Roberts Court	
596	2018_18-281	2018	587 US _	Virginia House of Delegates v. Bethune-Hill	Virginia House of Delegates, et al.	Golden Bethune-Hill, et al.	18-281	Roberts Court	
597	2018_16-1275	2018	587 US _	Virginia Uranium, Inc. v. Warren	Virginia Uranium, Inc. et al.	John Warren et al.	16-1275	Roberts Court	

	id	year	citation	title	petitioner	respondent	docket_no	court	c
598	2018_16-1498	2018	586 US _	Washington State Department of Licensing v. Co...	Washington State Department of Licensing	Cougar Den, Inc.	16-1498	Roberts Court	
599	2018_17-71	2018	586 US _	Weyerhaeuser Company v. United States Fish and...	Weyerhaeuser Company	United States Fish and Wildlife Service, et al.	17-71	Roberts Court	

521 rows × 26 columns

In [191]:
```
df['advocates'][50]
```

Out[191]:
```
{'Robert A. Long, Jr.': {'id': 'robert_a_long_jr',
  'name': 'Robert A. Long, Jr.',
  'role': 'for the Court-appointed amicus curiae (Anti-Injunction Ac
t)',
  'side': 2},
 'Donald B. Verrilli, Jr.': {'id': 'donald_b_verrilli_jr',
  'name': 'Donald B. Verrilli, Jr.',
  'role': 'Solicitor General, Department of Justice, for the petition
ers (Anti-Injunction Act); for the petitioners (Minimum Coverage Prov
ision); for the respondents (Medicaid expansion)',
  'side': 1},
 'Gregory G. Katsas': {'id': 'gregory_g_katsas',
  'name': 'Gregory G. Katsas',
  'role': 'for the respondents (Anti-Injunction Act)',
  'side': 0},
 'Paul D. Clement': {'id': 'paul_d_clement',
  'name': 'Paul D. Clement',
  'role': 'for the respondents Florida et al. (Minimum Coverage Provi
sion); for the petitioners (Severability); for the petitioners (Medic
aid expansion)',
  'side': 1},
 'Michael A. Carvin': {'id': 'michael_a_carvin',
  'name': 'Michael A. Carvin',
  'role': 'for the respondents National Federation of Independent Bus
iness et al. (Minimum Coverage Provision)',
  'side': 0},
 'Edwin S. Kneedler': {'id': 'edwin_s_kneedler',
  'name': 'Edwin S. Kneedler',
  'role': 'Deputy Solicitor General, Department of Justice, for the r
espondents (Severability)',
  'side': 0},
 'H. Bartow Farr, III': {'id': 'h_bartow_farr_iii',
  'name': 'H. Bartow Farr, III',
  'role': 'for the Court-appointed amicus curiae (Severability)',
  'side': 2},
 'Robert A. Long': {'id': 'robert_a_long',
  'name': 'Robert A. Long',
  'side': 1}}
```

In [14]:
```
# preprocess develop time
df.loc[:, 'start_date'] = df['transcripts'].apply(lambda x : re.findall
df.start_date = pd.to_datetime(df.start_date)
df.loc[:, 'develop_time'] = df.loc[:, 'decided_date'] - df.loc[:, 'start
# df['develop_time'] = df['develop_time'].apply(lambda x : x.days)
```

In [15]:
```
# get party of the judges

def check_party_pc(x):
    rep_judge = ['j__clarence_thomas', 'j__anthony_m_kennedy', 'j__anto
             'j__john_paul_stevens', 'j__david_h_souter', 'j__william_h_
    dem_judge = ['j__ruth_bader_ginsburg', 'j__stephen_g_breyer','j__so

    rep_ct = 0

    for judge in x:
        if judge in rep_judge:
            rep_ct += 1

    return rep_ct/len(x)
```

In [16]:
```
df['votes_side'][1]['j__john_g_roberts_jr']
```

Out[16]: 0.0

In [17]:
```
# get rep_judge yes

def check_rep_j_y_pc(x):
    rep_judge = ['j__clarence_thomas', 'j__anthony_m_kennedy', 'j__anto
             'j__john_paul_stevens', 'j__david_h_souter', 'j__william_h_
    dem_judge = ['j__ruth_bader_ginsburg', 'j__stephen_g_breyer','j__so

    rep_y_ct = 0

    for judge in x:
        if judge in rep_judge:
            if x[judge] > 0:
                rep_y_ct += 1

    return rep_y_ct/len(x)
```

In [18]:
```
# get dem_judge yes

def check_dem_j_y_pc(x):
    rep_judge = ['j__clarence_thomas', 'j__anthony_m_kennedy', 'j__anto
             'j__john_paul_stevens', 'j__david_h_souter', 'j__william_h_
    dem_judge = ['j__ruth_bader_ginsburg', 'j__stephen_g_breyer','j__so

    dem_y_ct = 0

    for judge in x:
        if judge in dem_judge:
            if x[judge] > 0:
                dem_y_ct += 1

    return dem_y_ct/len(x)
```

In [19]:
```
def check_party(x):
    if x > 2009:
        return 0
    else:
        return 1
```

In [21]:
```
# get M-F percentage in judges

def check_FM_jpc(x):
    male_judge = ['j__clarence_thomas',
                  'j__anthony_m_kennedy',
                  'j__antonin_scalia',
                  'j__john_g_roberts_jr',
                  'j__samuel_a_alito_jr',
                  'j__john_paul_stevens',
                  'j__david_h_souter',
                  'j__william_h_rehnquist',
                  'j__neil_gorsuch',
                  'j__brett_m_kavanaugh',
                  'j__stephen_g_breyer']
    female_judge = ['j__ruth_bader_ginsburg',
                    'j__sonia_sotomayor',
                    'j__elena_kagan']

    male_ct = 0

    for judge in x:
        if judge in male_judge:
            male_ct += 1

    return male_ct/len(x)
```

In [22]:
```
# get rep_judge yes

def check_M_j_y_pc(x):
    male_judge = ['j__clarence_thomas',
                  'j__anthony_m_kennedy',
                  'j__antonin_scalia',
                  'j__john_g_roberts_jr',
                  'j__samuel_a_alito_jr',
                  'j__john_paul_stevens',
                  'j__david_h_souter',
                  'j__william_h_rehnquist',
                  'j__neil_gorsuch',
                  'j__brett_m_kavanaugh',
                  'j__stephen_g_breyer']
    female_judge = ['j__ruth_bader_ginsburg',
                    'j__sonia_sotomayor',
                    'j__elena_kagan']
    male_y_ct = 0

    for judge in x:
        if judge in male_judge:
            if x[judge] > 0:
                male_y_ct += 1

    return male_y_ct/len(x)
```

In [23]:
```
# get rep_judge yes

def check_F_j_y_pc(x):
    male_judge = ['j__clarence_thomas',
                  'j__anthony_m_kennedy',
                  'j__antonin_scalia',
                  'j__john_g_roberts_jr',
                  'j__samuel_a_alito_jr',
                  'j__john_paul_stevens',
                  'j__david_h_souter',
                  'j__william_h_rehnquist',
                  'j__neil_gorsuch',
                  'j__brett_m_kavanaugh',
                  'j__stephen_g_breyer']
    female_judge = ['j__ruth_bader_ginsburg',
                    'j__sonia_sotomayor',
                    'j__elena_kagan']
    female_y_ct = 0

    for judge in x:
        if judge in female_judge:
            if x[judge] > 0:
                female_y_ct += 1

    return female_y_ct/len(x)
```

In [69]:

In [86]:
```
df_test
```

Out[86]:

	advocates	side1_fstname	side0_fstname
1	{'Paul D. Clement': {'id': 'paul_d_clement', '...	Paul	Donald
2	{'Mark T. Stancil': {'id': 'mark_t_stancil', '...	Mark	Paul
3	{'Eric D. Miller': {'id': 'eric_d_miller', 'na...	Eric	Charles
4	{'Clifford M. Sloan': {'id': 'clifford_m_sloan...	Clifford	Dustin
6	{'James F. Hurst': {'id': 'james_f_hurst', 'na...	James	Mark
...	...	...	...
595	{'Erica L. Ross': {'id': 'erica_l_ross', 'name...	Erica	Jeffrey
596	{'Paul D. Clement': {'id': 'paul_d_clement', '...	Paul	Marc
597	{'Charles J. Cooper': {'id': 'charles_j_cooper...	Charles	Toby
598	{'Noah Purcell': {'id': 'noah_purcell', 'name'...	Noah	Adam
599	{'Timothy S. Bishop': {'id': 'timothy_s_bishop...	Timothy	Edwin

521 rows × 3 columns

In [81]:
```
type(df_cases_convo['advocates'][1])
```

Out[81]:
```
dict
```

In [111]:
```
# get first name of speakers
df_test = df_cases_convo.loc[:, ['advocates']]

def get_side1_fstname(x):
    return list(x.keys())[0].split()[0]

def get_side0_fstname(x):
    try:
        return list(x.keys())[-1].split()[0]
    except:
        return list(x.keys())[-2].split()[0]

df_test.loc[:, 'side1_fstname'] = df_test['advocates'].apply(get_side1_
df_test.loc[:, 'side0_fstname'] = df_test['advocates'].apply(get_side0_

# read gender dataset
df_gender = pd.read_csv('name_gender_dataset.csv')
idx = df_gender.groupby(['Name'])['Probability'].idxmax()
df_gender = df_gender.loc[idx]

# join the gender dataset to predict gender of speakers
df_test = pd.merge(df_test, df_gender, how='left', left_on = 'side1_fstn
df_test = pd.merge(df_test, df_gender, how='left', left_on = 'side0_fstn
```

In [118]:
```
# only numbers can apply to Random Forest Model
df_rf = pd.DataFrame()
df_rf.loc[:, 'text_len'] = df['text'].apply(lambda x : len(x))
df_rf.loc[:, 'text_pre_len'] = df['text_pre'].apply(lambda x : len(x))
df_rf.loc[:, 'num_utterances'] = df['num_utterances']
df_rf.loc[:, 'win_side'] = df['win_side']
df_rf.loc[:, 'develop_time'] = df['develop_time'].apply(lambda x : x.da
df_rf.loc[:, 'rep_jpc'] = df['votes_side'].apply(check_party_pc)
df_rf.loc[:, 'dem_jpc'] = 1 - df_rf.loc[:, 'rep_jpc']
# df_rf.loc[:, 'rep_j_y_pc'] = df['votes_side'].apply(check_rep_j_y_pc)
# df_rf.loc[:, 'dem_j_y_pc'] = df['votes_side'].apply(check_dem_j_y_pc)
df_rf.loc[:, 'party'] = df['year'].apply(check_party) # 1:  rep, 0: dem
df_rf.loc[:, 'male_jpc'] = df['votes_side'].apply(check_FM_jpc)
df_rf.loc[:, 'female_jpc'] = 1 - df_rf.loc[:, 'male_jpc']
# df_rf.loc[:, 'male_y_jpc'] = df['votes_side'].apply(check_M_j_y_pc)
# df_rf.loc[:, 'female_y_jpc'] = df['votes_side'].apply(check_F_j_y_pc)

# reset the index
df_rf = df_rf.reset_index(drop=True)

df_rf.loc[:, 'side1_gender'] = df_test['Gender_x'].apply(lambda x: 0 if
df_rf.loc[:, 'side0_gender'] = df_test['Gender_y'].apply(lambda x: 0 if

df_rf
```

Out[118]:

	text_len	text_pre_len	num_utterances	win_side	develop_time	rep_jpc	dem_jpc	rep_j_y
0	81913	44829	295.0	0.0	61	0.625000	0.375000	0.375
1	66589	34303	239.0	0.0	96	0.555556	0.444444	0.333
2	55436	29849	201.0	1.0	63	0.555556	0.444444	0.555
3	55012	29892	191.0	0.0	92	0.555556	0.444444	0.000
4	59768	31534	210.0	1.0	134	0.555556	0.444444	0.555
...	...	...	...	...	...	...	...	
516	65067	35907	167.0	1.0	62	0.555556	0.444444	0.555
517	61137	32779	179.0	0.0	91	0.555556	0.444444	0.333
518	58012	32112	220.0	0.0	224	0.555556	0.444444	0.222
519	67120	34254	319.0	0.0	140	0.555556	0.444444	0.444
520	56642	29786	250.0	1.0	57	0.500000	0.500000	0.500

521 rows × 16 columns

Random Forest

In [215]:
```
from sklearn.ensemble import RandomForestRegressor
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classifica
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.metrics import ConfusionMatrixDisplay, roc_auc_score, roc_c


import itertools
```

In [291]:
```
def get_accuracy(feature_lst, X, df):

    #set y dataset
    y = df['win_side']
    # Train test split
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=

    # create the model
    model = RandomForestClassifier()
    # train the model
    model.fit(X_train, y_train)
    # Test the model
    predictions = model.predict(X_train)
    # Make the predictions
    y_pred = model.predict(X_test)

    dict1 = {'features': tuple(feature_lst),
             'features_num': len(feature_lst),
             'f1': f1_score(y_test, y_pred),
             'roc_auc': roc_auc_score(y_test, y_pred),
             'accuracy': accuracy_score(y_test, y_pred),
             'precision': precision_score(y_test, y_pred),
             'recall': recall_score(y_test, y_pred),
             'y_test': y_test,
             'y_pred': y_pred
            }
#     print(type(y_test))
#     print(type(, y_pred))

    return dict1
```

In [119]:
```
list(df_rf.columns)
```

Out[119]:
```
['text_len',
 'text_pre_len',
 'num_utterances',
 'win_side',
 'develop_time',
 'rep_jpc',
 'dem_jpc',
 'rep_j_y_pc',
 'dem_j_y_pc',
 'party',
 'male_jpc',
 'female_jpc',
 'male_y_jpc',
 'female_y_jpc',
 'side1_gender',
 'side0_gender']
```

In [350]:
```
# Define the list
#'rep_jpc', 'dem_j_y_pc', 'rep_j_y_pc'
features_list = ['text_len',
                 'text_pre_len',
                 'num_utterances',
#                  'win_side',
                 'develop_time',
                 'rep_jpc',
#                  'dem_jpc',
#                  'rep_j_y_pc',
#                  'dem_j_y_pc',
                 'party',
                 'male_jpc',
#                  'female_jpc',
#                  'male_y_jpc',
#                  'female_y_jpc',
                 'side1_gender',
                 'side0_gender']
# features_list = list(df_rf.columns)

# Get all possible combinations of the list
combinations = []
for i in range(1, len(features_list) + 1):
    combinations += list(itertools.combinations(features_list, i))

for i in range(len(combinations)):
    combinations[i] = list(combinations[i] )
combinations
```

Out[350]:
```
[['text_len'],
 ['text_pre_len'],
 ['num_utterances'],
 ['develop_time'],
 ['rep_jpc'],
 ['party'],
 ['male_jpc'],
 ['side1_gender'],
 ['side0_gender'],
 ['text_len', 'text_pre_len'],
 ['text_len', 'num_utterances'],
 ['text_len', 'develop_time'],
 ['text_len', 'rep_jpc'],
 ['text_len', 'party'],
 ['text_len', 'male_jpc'],
 ['text_len', 'side1_gender'],
 ['text_len', 'side0_gender'],
 ['text_pre_len', 'num_utterances'],
 ['text_pre_len', 'develop_time'],
```

In [127]:
```
len(combinations)
```

Out[127]:
```
511
```

Without text

For one epoch

In [293]:
```
results = []

# get accu from each diff features combinations
for i, feature_lst in enumerate(combinations):
    results.append(get_accuracy(feature_lst, df_rf.loc[:,feature_lst], 

# get accu from ngram, bigram
results.append(get_accuracy(['ngram_text'], CountVectorizer().fit_trans

results.append(get_accuracy(['bigram_text'], TfidfVectorizer().fit_tran
```

In [294]:
```
# Create a DataFrame from the results list
results_df = pd.DataFrame(results)
results_df.head(5)
```

Out[294]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
0	(text_len,)	1	0.621212	0.493436	0.523810	0.585714	0.661290	360 1.0 168 1.0 388 0.0 353 1.0 21...
1	(text_pre_len,)	1	0.686131	0.559503	0.590476	0.746032	0.635135	156 1.0 76 1.0 221 1.0 267 0.0 39...
2	(num_utterances,)	1	0.684932	0.487319	0.561905	0.649351	0.724638	242 1.0 64 0.0 507 1.0 338 1.0 39...
3	(develop_time,)	1	0.597015	0.448413	0.485714	0.563380	0.634921	263 1.0 470 1.0 297 0.0 343 1.0 24...
4	(rep_jpc,)	1	0.786127	0.500000	0.647619	0.647619	1.000000	284 1.0 499 0.0 134 1.0 377 1.0 28...
...	...	...	...	...	...	...	...	...
508	(text_len, num_utterances, develop_time, rep_j...	8	0.703448	0.527389	0.590476	0.645570	0.772727	51 1.0 330 0.0 154 1.0 314 1.0 51...

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
509	(text_pre_len, num_utterances, develop_time, r...	8	0.625000	0.428571	0.485714	0.555556	0.714286	319 0.0 133 1.0 276 1.0 245 1.0 46...
510	(text_len, text_pre_len, num_utterances, devel...	9	0.693878	0.499018	0.571429	0.637500	0.761194	105 1.0 113 0.0 209 0.0 512 1.0 40...
511	(ngram_text,)	1	0.728395	0.506334	0.580952	0.584158	0.967213	557 1.0 149 1.0 543 0.0 54 0.0 59...
512	(bigram_text,)	1	0.757396	0.500000	0.609524	0.609524	1.000000	219 1.0 213 1.0 24 0.0 369 0.0 10...

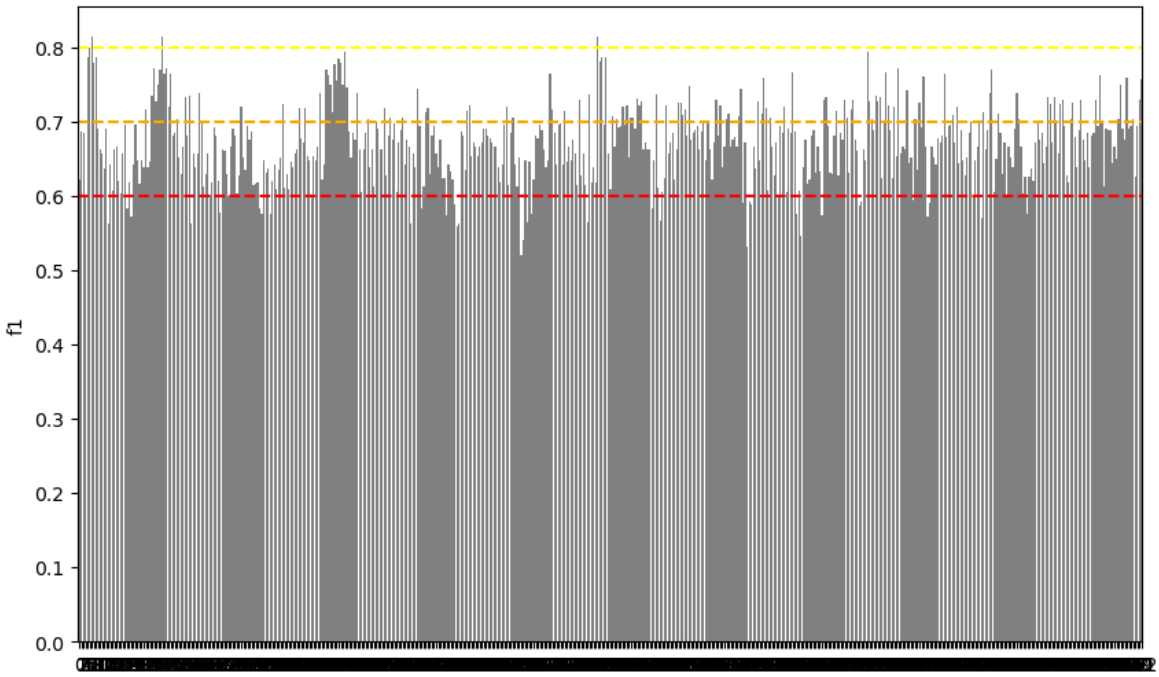
513 rows × 9 columns

f1 score

In general, higher F1 scores are better

In [295]:
```
plt.figure(figsize=(10, 6))
sns.barplot(x = results_df.index, y='f1', color='grey', data=results_df
plt.axhline(y=0.6, color='red', linestyle='--')
plt.axhline(y=0.7, color='orange', linestyle='--')
plt.axhline(y=0.8, color='yellow', linestyle='--')
```

Out[295]: <matplotlib.lines.Line2D at 0x7fe325517eb0>



In [309]:
```
results_df = results_df.sort_values(by = 'f1', ascending = False)
results_df.head(5)
```

Out[309]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y_p
250	(rep_jpc, party, male_jpc, side1_gender)	4	0.813559	0.493151	0.685714	0.692308	0.986301	47 1.0 374 0.0 136 0.0 75 0.0 27...	1.(
6	(male_jpc,)	1	0.813559	0.500000	0.685714	0.685714	1.000000	445 1.0 345 1.0 65 0.0 492 1.0 29...	1.(
40	(party, side1_gender)	2	0.813559	0.500000	0.685714	0.685714	1.000000	62 0.0 115 1.0 458 0.0 109 1.0 21...	1.(
5	(party,)	1	0.800000	0.500000	0.666667	0.666667	1.000000	449 1.0 177 1.0 153 0.0 22 1.0 33...	1.(
380	(rep_jpc, party, male_jpc, side1_gender, side0...	5	0.793103	0.479167	0.657143	0.676471	0.958333	353 1.0 125 1.0 504 1.0 226 1.0 37...	1.(

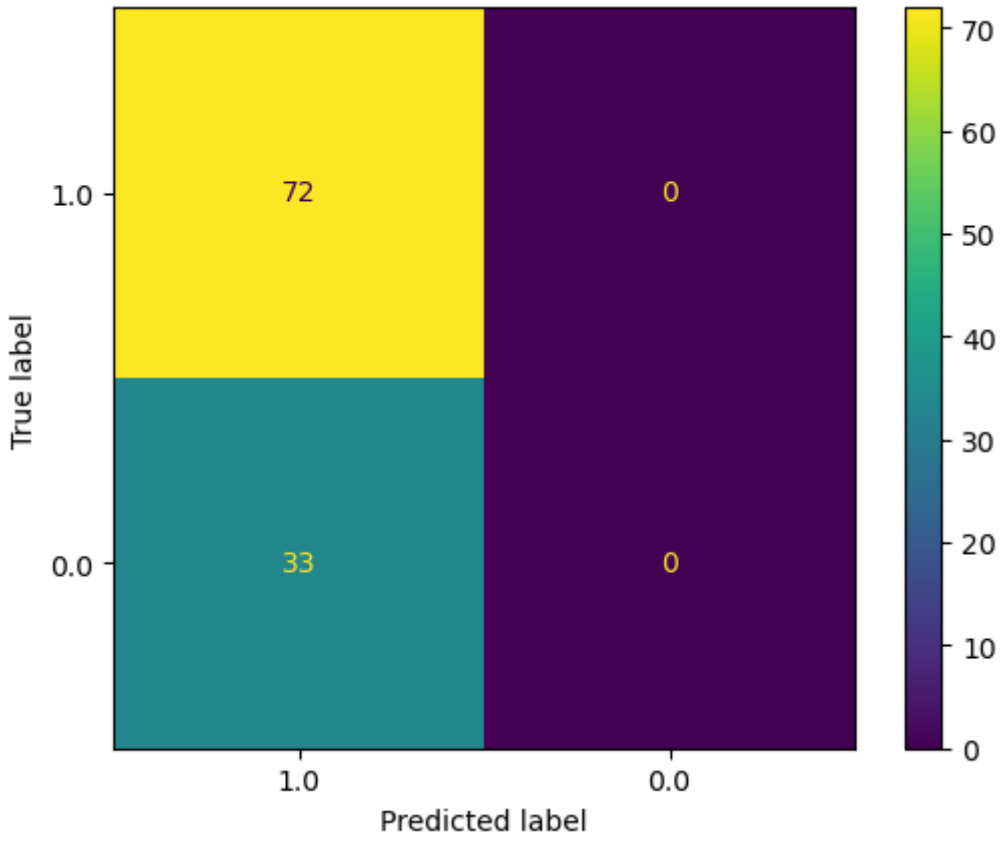
In [297]:
```
results_df.loc[(results_df.loc[:, 'f1'] > 0.8), :]
```

Out[297]:

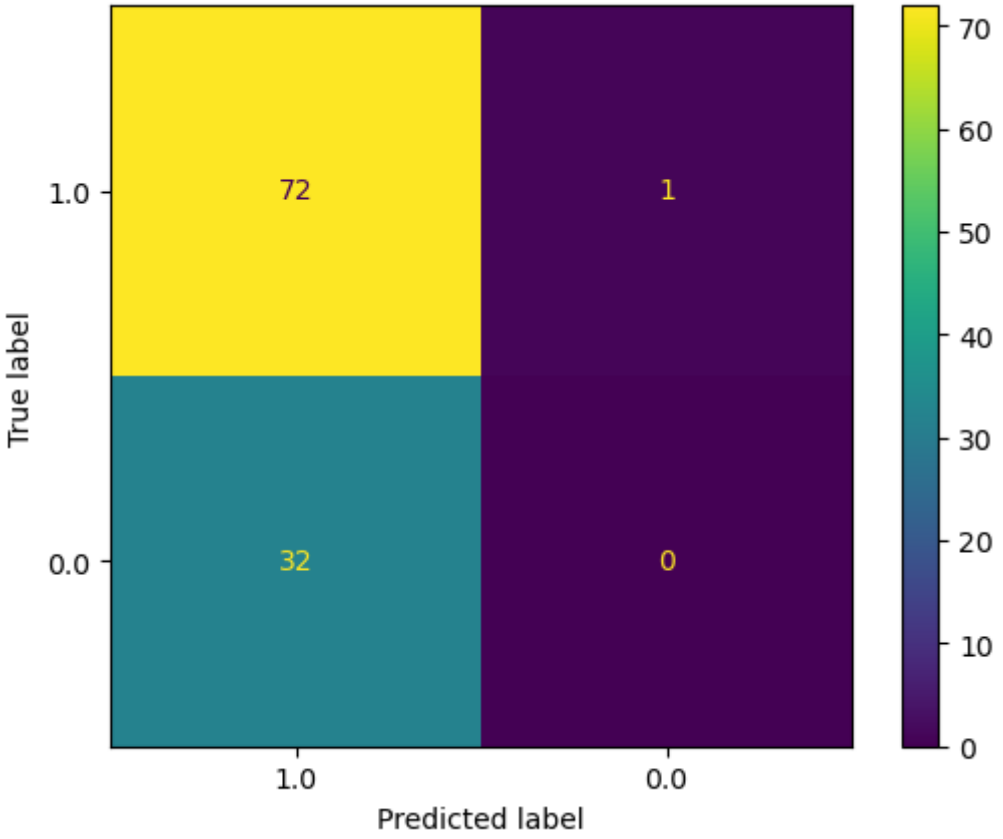
	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y_p
6	(male_jpc,)	1	0.813559	0.500000	0.685714	0.685714	1.000000	445 1.0 345 1.0 65 0.0 492 1.0 29...	1.(
250	(rep_jpc, party, male_jpc, side1_gender)	4	0.813559	0.493151	0.685714	0.692308	0.986301	47 1.0 374 0.0 136 0.0 75 0.0 27...	1.(
40	(party, side1_gender)	2	0.813559	0.500000	0.685714	0.685714	1.000000	62 0.0 115 1.0 458 0.0 109 1.0 21...	1.(

In [303]:
```
# Make a confusion matrix

df_matrix = results_df.head(3).reset_index(drop=True)

for i in range(len(df_matrix)):

    feature = df_matrix['features'][i]
    y_test = df_matrix['y_test'][i]
    y_pred =df_matrix['y_pred'][i]

    print(f"Confusion Matrix for Random Forest: {feature}")
    cm = confusion_matrix(y_test, y_pred, labels=y_test.unique())
    print(cm)
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=y_
    disp.plot()
    plt.show()
```

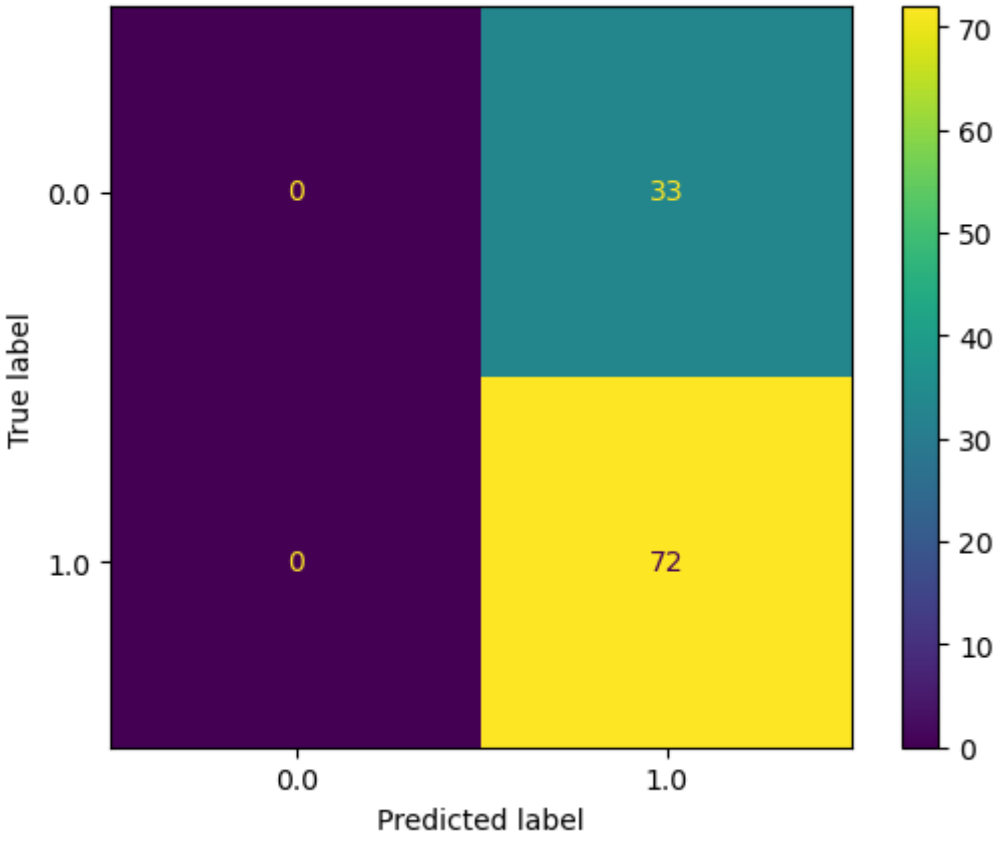
```
Confusion Matrix for Random Forest: ('male_jpc',)
[[72  0]
 [33  0]]
```




```
Confusion Matrix for Random Forest: ('rep_jpc', 'party', 'male_jpc',
'side1_gender')
[[72  1]
 [32  0]]
```




```
Confusion Matrix for Random Forest: ('party', 'side1_gender')
[[ 0 33]
 [ 0 72]]
```

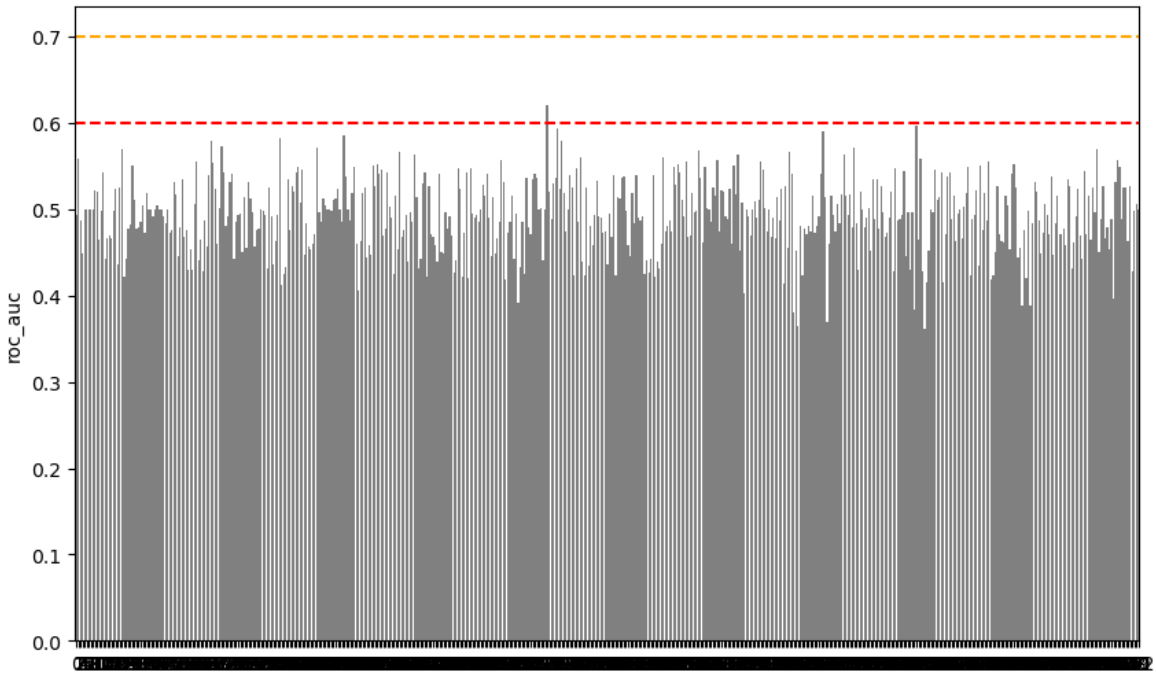


ROC_accuracy

ROC auc < 0.5, no better than random guessing
0.7 < ROC auc < 0.8, good performance
ROC auc > 0.8, excellent performance

In [298]:
```
plt.figure(figsize=(10, 6))
sns.barplot(x = results_df.index, y='roc_auc', color='grey', data=result
plt.axhline(y=0.6, color='red', linestyle='--')
plt.axhline(y=0.7, color='orange', linestyle='--')
```

Out[298]:
```
<matplotlib.lines.Line2D at 0x7fe325c6c340>
```



In [308]:
```
results_df = results_df.sort_values(by = 'roc_auc', ascending = False)
results_df.head(5)
```

Out[308]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
227	(num_utterances, develop_time, male_jpc, side1...	4	0.763889	0.620628	0.676190	0.723684	0.808824	418 0.0 320 1.0 507 1.0 39 1.0 21...
405	(text_len, text_pre_len, develop_time, rep_jpc...	6	0.724638	0.597377	0.638095	0.714286	0.735294	285 0.0 26 0.0 262 0.0 14 1.0 73...
232	(num_utterances, rep_jpc, party, side0_gender)	4	0.696970	0.594444	0.619048	0.638889	0.766667	133 1.0 257 1.0 226 1.0 224 0.0 58...
360	(num_utterances, develop_time, rep_jpc, party,...	5	0.732394	0.590539	0.638095	0.753623	0.712329	231 1.0 338 1.0 141 1.0 426 1.0 13...
129	(text_len, text_pre_len, num_utterances, devel...	4	0.744828	0.585714	0.647619	0.720000	0.771429	300 1.0 191 1.0 157 0.0 467 1.0 39...

In [305]:
```
results_df.loc[(results_df.loc[:, 'roc_auc'] > 0.6), :]
```

Out[305]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
227	(num_utterances, develop_time, male_jpc, side1...	4	0.763889	0.620628	0.67619	0.723684	0.808824	418 0.0 320 1.0 507 1.0 39 1.0 21...

In [306]:
```
results_df.loc[(results_df.loc[:, 'roc_auc'] > 0.7), :]
```

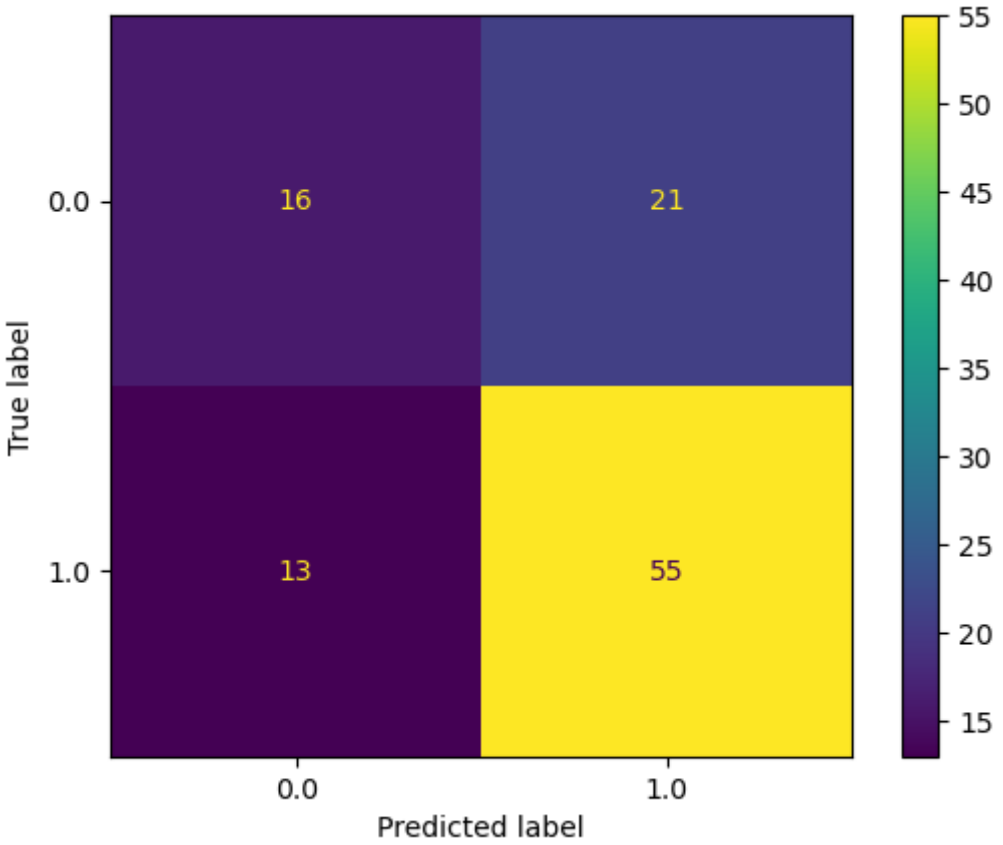
Out[306]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y_pred

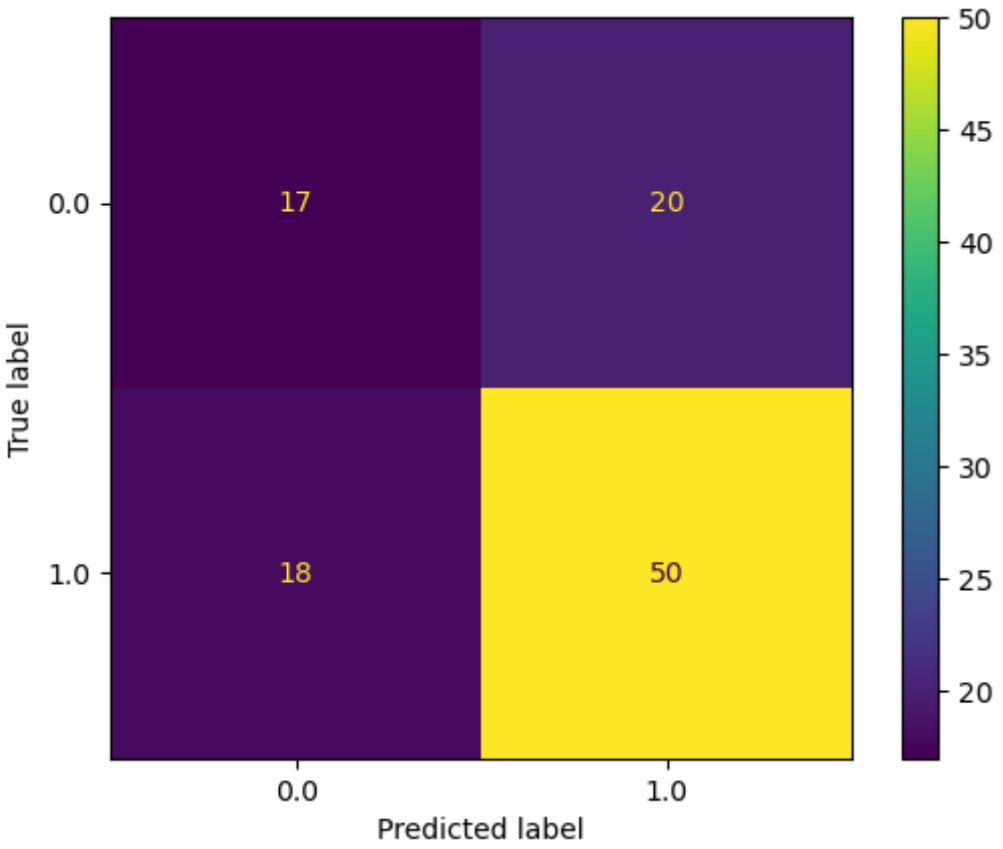
Confusion Matrix

In [307]:
```
# Make a confusion matrix

df_matrix = results_df.head(3).reset_index(drop=True)

for i in range(len(df_matrix)):

    feature = df_matrix['features'][i]
    y_test = df_matrix['y_test'][i]
    y_pred =df_matrix['y_pred'][i]

    print(f"Confusion Matrix for Random Forest: {feature}")
    cm = confusion_matrix(y_test, y_pred, labels=y_test.unique())
    print(cm)
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=y_
    disp.plot()
    plt.show()
```

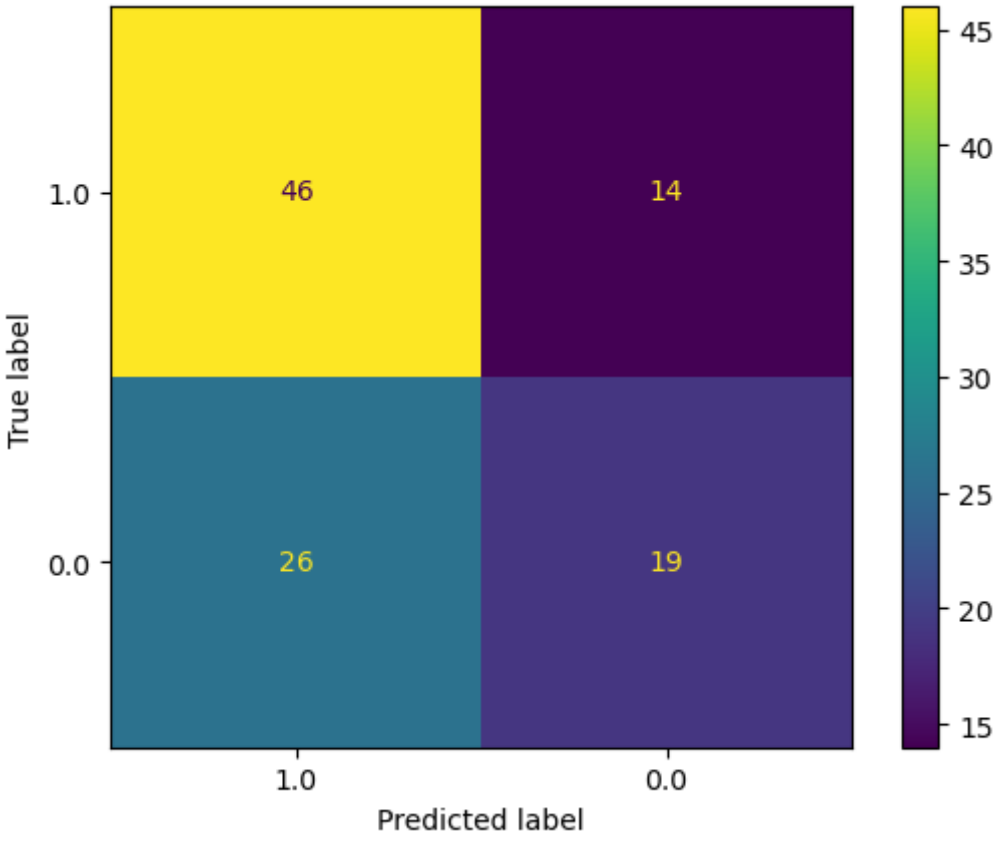
```
Confusion Matrix for Random Forest: ('num_utterances', 'develop_tim
e', 'male_jpc', 'side1_gender')
[[16 21]
 [13 55]]
```




```
Confusion Matrix for Random Forest: ('text_len', 'text_pre_len', 'dev
elop_time', 'rep_jpc', 'male_jpc', 'side0_gender')
[[17 20]
 [18 50]]
```




```
Confusion Matrix for Random Forest: ('num_utterances', 'rep_jpc', 'pa
rty', 'side0_gender')
[[46 14]
 [26 19]]
```



For 50 epoch

In [ ]:
```
# results = []
# count = 0
# while(count <= 50):
#     count += 1
#     # get accu from each diff features combinations
#     for feature_lst in combinations:
#         results.append(get_accuracy(feature_lst, df_rf.loc[:,feature_

#     # get accu from ngram, bigram
#     results.append(get_accuracy(['ngram_text'], CountVectorizer().fit_
#     results.append(get_accuracy(['bigram_text'], TfidfVectorizer().fi
```

In [ ]:
```
# # Create a DataFrame from the results list
# results_df = pd.DataFrame(results)
# results_df
```

In [ ]:
```
# results_df = results_df.groupby('features', as_index = False).agg({'fe
#                                                                     'accuracy': 'mea
#                                                                     'f1': 'mean',
#                                                                     'precision': 'me
#                                                                     'recall': 'mean
```

In [ ]:
```
# plt.figure(figsize=(10, 6))
# sns.barplot(x = results_df.index, y='accuracy', color='grey', data=res
# plt.axhline(y=0.6, color='red', linestyle='--')
# plt.axhline(y=0.7, color='orange', linestyle='--')
```

In [ ]:
```
# results_df.loc[(results_df.loc[:, 'accuracy'] > 0.6), :].sort_values(
```

In [ ]:
```
# results_df.loc[(results_df.loc[:, 'accuracy'] > 0.7), :]
```

In [ ]:
```
```

With text

In [353]:
```
results = []
i = 0

# get accu from each diff features combinations
for feature_lst in combinations:
#     print(feature_lst)
    tfidf = TfidfVectorizer(min_df=10, max_df=0.8)
    X_text = tfidf.fit_transform(df['text_pre'])

    for feature in feature_lst:
        X_add_fea = np.array(df_rf[feature]).reshape(-1, 1)
        X = np.hstack((X_text.toarray(), X_add_fea))

    results.append(get_accuracy(feature_lst, X, df))
#     i += 1
#     if i == 2:
#         break
# get accu from ngram, bigram
results.append(get_accuracy(['ngram_text'], CountVectorizer().fit_transf

results.append(get_accuracy(['bigram_text'], TfidfVectorizer().fit_trans
```

In [354]:
```
# Create a DataFrame from the results list
results_df = pd.DataFrame(results)
results_df
```

Out[354]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
0	(text_len,)	1	0.771930	0.485294	0.628571	0.640777	0.970588	70 0.0 568 0.0 445 1.0 54 0.0 79...
1	(text_pre_len,)	1	0.779070	0.478571	0.638095	0.656863	0.957143	437 1.0 519 0.0 573 1.0 293 1.0 46...
2	(num_utterances,)	1	0.763636	0.535714	0.628571	0.617647	1.000000	364 1.0 551 1.0 80 1.0 575 1.0 38...
3	(develop_time,)	1	0.773810	0.518065	0.638095	0.637255	0.984848	398 1.0 246 0.0 226 0.0 421 0.0 36...
4	(rep_jpc,)	1	0.746988	0.489423	0.600000	0.613861	0.953846	109 1.0 305 0.0 79 0.0 73 0.0 40...
...	...	...	...	...	...	...	...	...
508	(text_len, num_utterances, develop_time, rep_j...	8	0.761905	0.453981	0.619048	0.673684	0.876712	91 1.0 418 0.0 359 0.0 570 1.0 52...

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
509	(text_pre_len, num_utterances, develop_time, r...	8	0.739394	0.496032	0.590476	0.598039	0.968254	433 1.0 17 0.0 527 0.0 282 1.0 49...
510	(text_len, text_pre_len, num_utterances, devel...	9	0.751515	0.508765	0.609524	0.613861	0.968750	467 1.0 418 0.0 184 1.0 31 0.0 31...
511	(ngram_text,)	1	0.757396	0.500000	0.609524	0.609524	1.000000	328 1.0 54 0.0 302 1.0 67 1.0 40...
512	(bigram_text,)	1	0.746988	0.503968	0.600000	0.601942	0.984127	563 1.0 387 0.0 112 1.0 546 0.0 73...

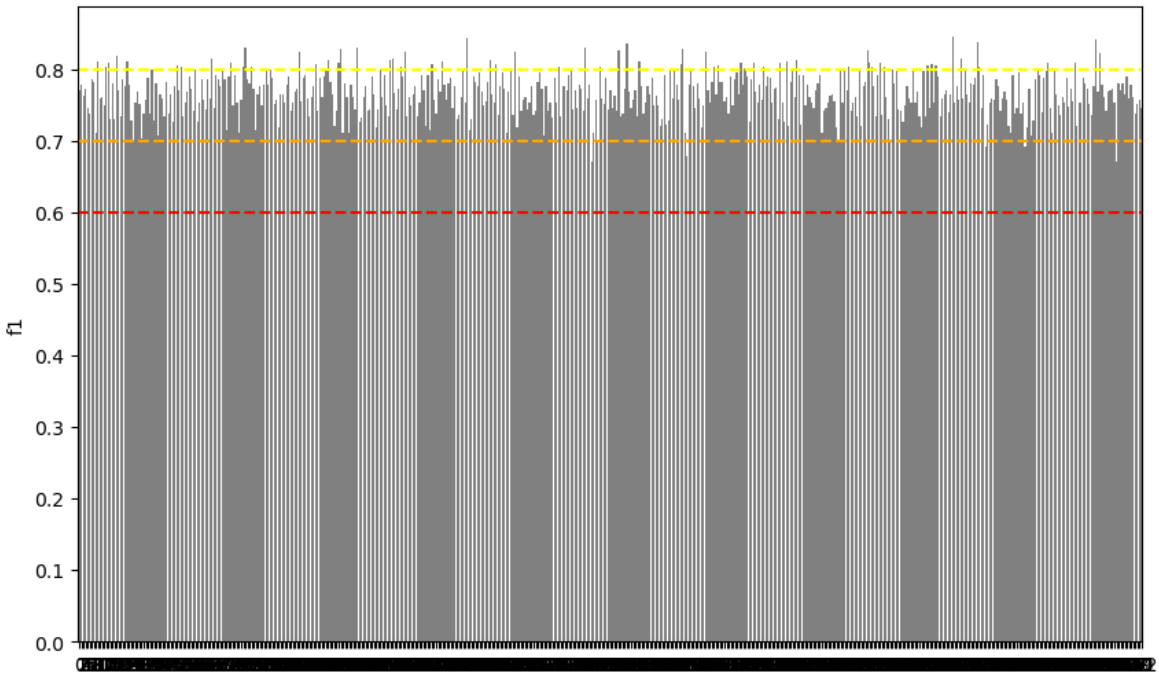
513 rows × 9 columns

f1 score

In general, higher F1 scores are better

In [355]:
```
plt.figure(figsize=(10, 6))
sns.barplot(x = results_df.index, y='f1', color='grey', data=results_df
plt.axhline(y=0.6, color='red', linestyle='--')
plt.axhline(y=0.7, color='orange', linestyle='--')
plt.axhline(y=0.8, color='yellow', linestyle='--')
```

Out[355]: <matplotlib.lines.Line2D at 0x7fe3263ea5b0>



In [356]:
```
results_df = results_df.sort_values(by = 'f1', ascending = False)
results_df.head(5)
```

Out[356]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
421	(text_len, num_utterances, develop_time, rep_j...	6	0.845714	0.548433	0.742857	0.762887	0.948718	67 1.0 496 1.0 407 1.0 120 1.0 45...
187	(text_pre_len, num_utterances, develop_time, m...	4	0.844444	0.511364	0.733333	0.737864	0.987013	45 1.0 444 1.0 100 1.0 28 1.0 51...
490	(text_len, num_utterances, develop_time, party...	7	0.842697	0.517806	0.733333	0.750000	0.961538	227 1.0 92 1.0 93 0.0 16 1.0 37...
433	(text_len, develop_time, rep_jpc, party, side1...	6	0.839080	0.553333	0.733333	0.737374	0.973333	426 1.0 194 1.0 393 1.0 342 1.0 54...
264	(text_len, text_pre_len, num_utterances, party...	5	0.837209	0.567132	0.733333	0.734694	0.972973	574 0.0 196 1.0 531 1.0 119 1.0 39...

In [357]:
```
results_df.loc[(results_df.loc[:, 'f1'] > 0.8), :]
```

Out[357]:

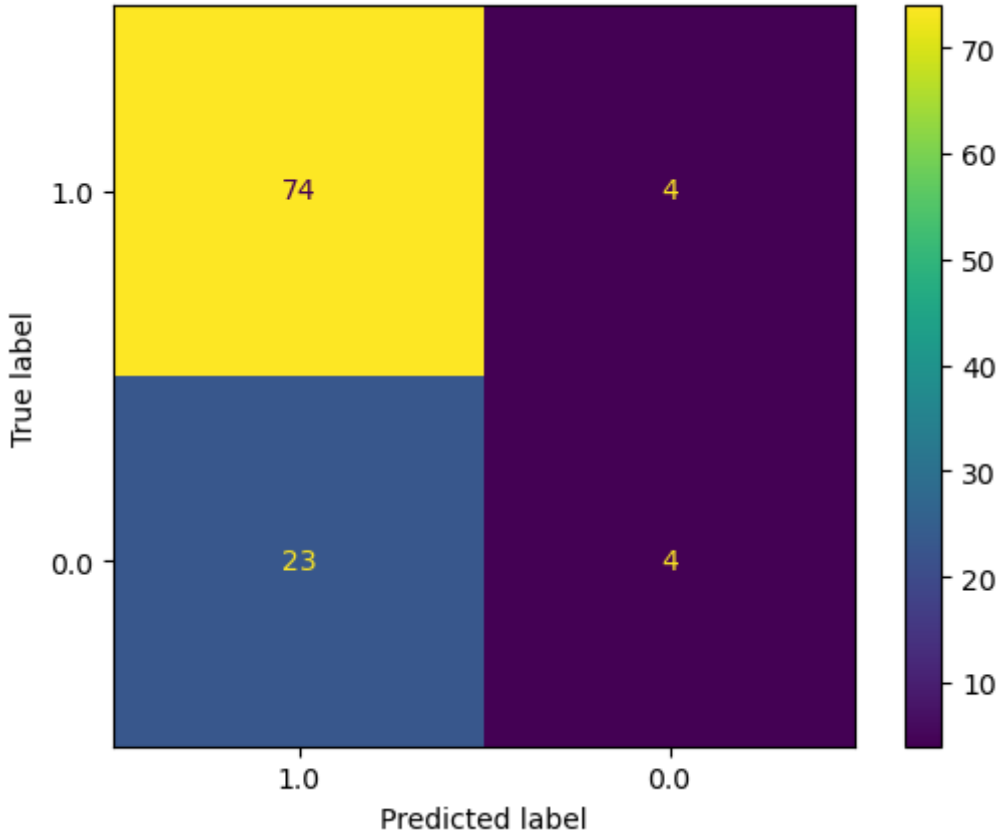
	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
421	(text_len, num_utterances, develop_time, rep_j...	6	0.845714	0.548433	0.742857	0.762887	0.948718	67 1.0 496 1.0 407 1.0 120 1.0 45...
187	(text_pre_len, num_utterances, develop_time, m...	4	0.844444	0.511364	0.733333	0.737864	0.987013	45 1.0 444 1.0 100 1.0 28 1.0 51...
490	(text_len, num_utterances, develop_time, party...	7	0.842697	0.517806	0.733333	0.750000	0.961538	227 1.0 92 1.0 93 0.0 16 1.0 37...
433	(text_len, develop_time, rep_jpc, party, side1...	6	0.839080	0.553333	0.733333	0.737374	0.973333	426 1.0 194 1.0 393 1.0 342 1.0 54...
264	(text_len, text_pre_len, num_utterances, party...	5	0.837209	0.567132	0.733333	0.734694	0.972973	574 0.0 196 1.0 531 1.0 119 1.0 39...
...	...	...	...	...	...	...	...	...
321	(text_len, rep_jpc, party, male_jpc, side0_gen...	5	0.802395	0.554952	0.685714	0.683673	0.971014	447 0.0 545 0.0 54 0.0 116 1.0 34...

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
208	(text_pre_len, develop_time, male_jpc, side0_g...	4	0.802326	0.521429	0.676190	0.676471	0.985714	150 1.0 492 1.0 188 0.0 66 1.0 38...
237	(num_utterances, party, male_jpc, side0_gender)	4	0.802326	0.509470	0.676190	0.690000	0.958333	227 1.0 131 1.0 403 1.0 358 0.0 48...
185	(text_pre_len, num_utterances, develop_time, r...	4	0.802326	0.515327	0.676190	0.683168	0.971831	492 1.0 522 1.0 490 1.0 4 0.0 31...
369	(num_utterances, develop_time, male_jpc, side1...	5	0.802326	0.509470	0.676190	0.690000	0.958333	313 1.0 273 1.0 54 0.0 516 1.0 28...

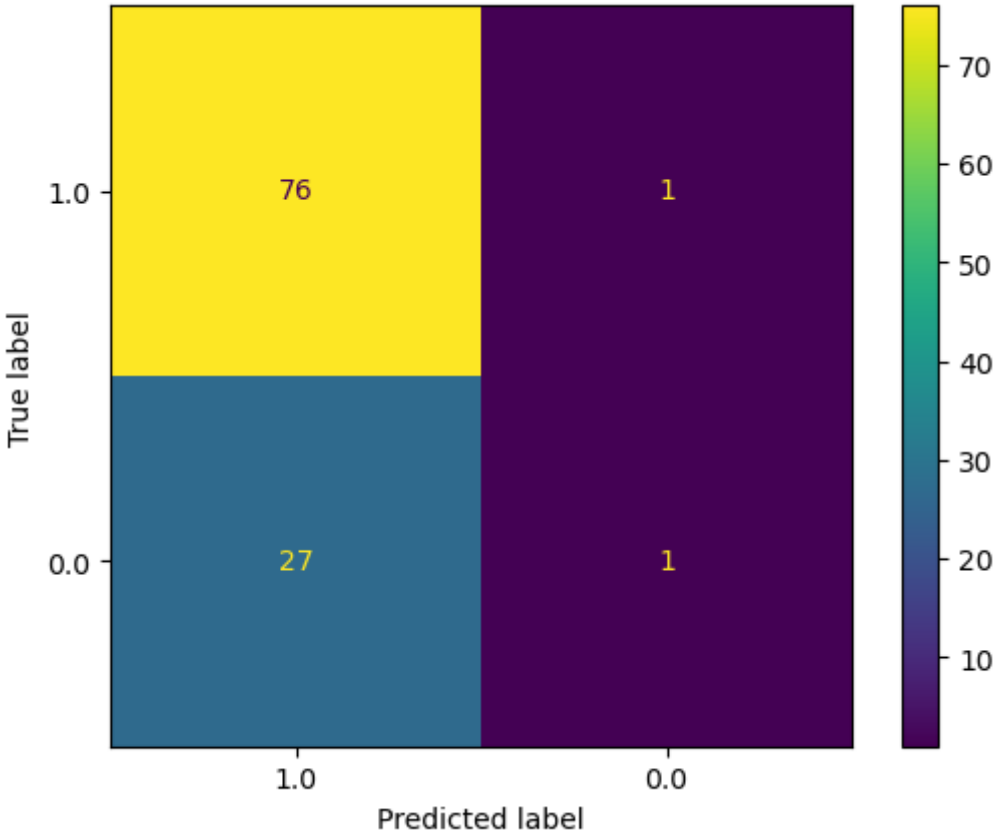
67 rows × 9 columns

In [358]:
```
# Make a confusion matrix

df_matrix = results_df.head(3).reset_index(drop=True)

for i in range(len(df_matrix)):

    feature = df_matrix['features'][i]
    y_test = df_matrix['y_test'][i]
    y_pred =df_matrix['y_pred'][i]

    print(f"Confusion Matrix for Random Forest: {feature}")
    cm = confusion_matrix(y_test, y_pred, labels=y_test.unique())
    print(cm)
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=y_
    disp.plot()
    plt.show()
```

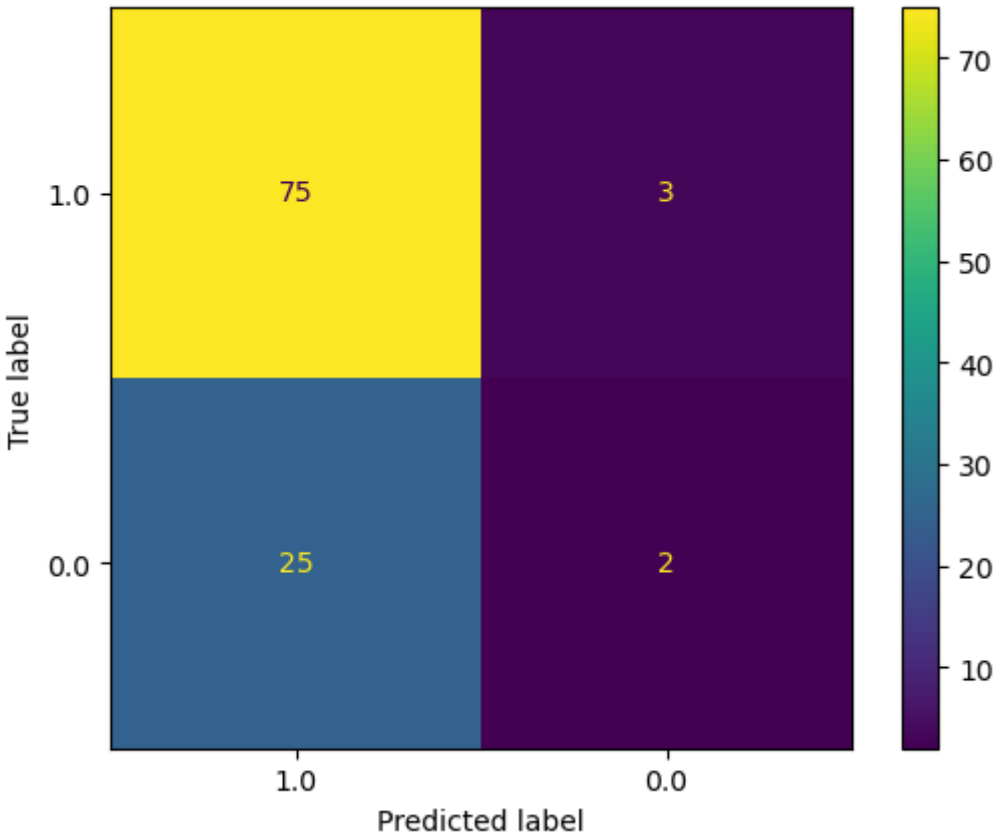
```
Confusion Matrix for Random Forest: ('text_len', 'num_utterances', 'd
evelop_time', 'rep_jpc', 'side1_gender', 'side0_gender')
[[74  4]
 [23  4]]
```




```
Confusion Matrix for Random Forest: ('text_pre_len', 'num_utterance
s', 'develop_time', 'male_jpc')
[[76  1]
 [27  1]]
```




```
Confusion Matrix for Random Forest: ('text_len', 'num_utterances', 'd
evelop_time', 'party', 'male_jpc', 'side1_gender', 'side0_gender')
[[75  3]
 [25  2]]
```

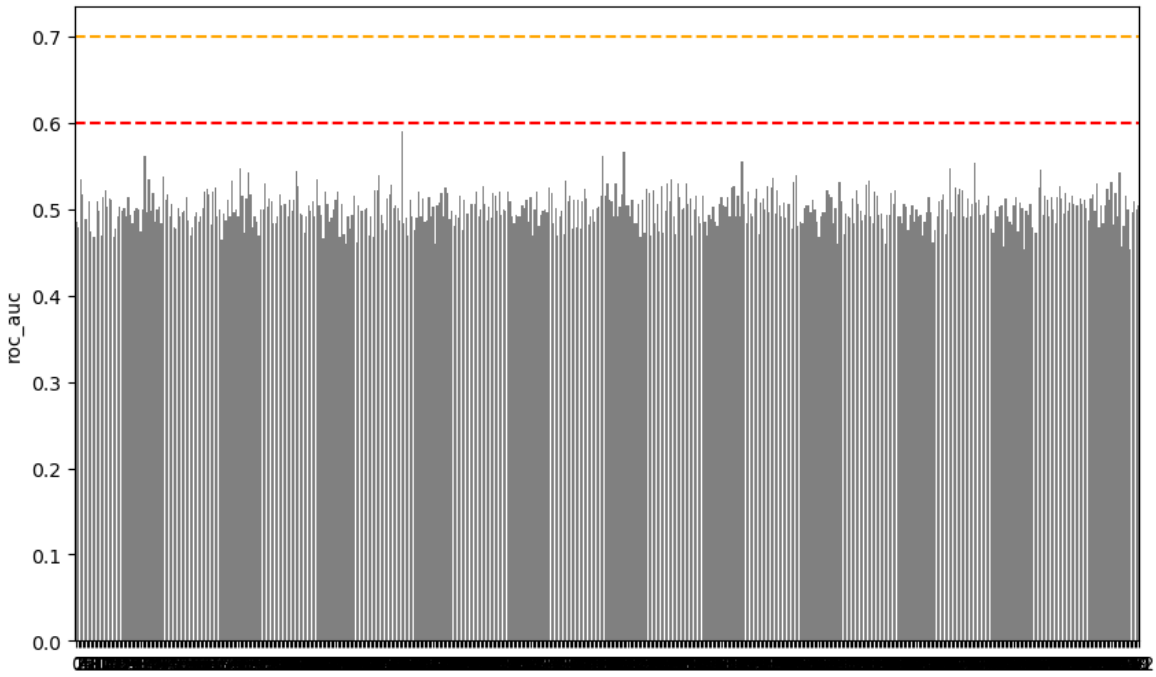


ROC_accuracy

ROC auc < 0.5, no better than random guessing
0.7 < ROC auc < 0.8, good performance
ROC auc > 0.8, excellent performance

In [359]:
```
plt.figure(figsize=(10, 6))
sns.barplot(x = results_df.index, y='roc_auc', color='grey', data=result
plt.axhline(y=0.6, color='red', linestyle='--')
plt.axhline(y=0.7, color='orange', linestyle='--')
```

Out[359]:
```
<matplotlib.lines.Line2D at 0x7fe310e86c70>
```



In [360]:
```
results_df = results_df.sort_values(by = 'roc_auc', ascending = False)
results_df.head(5)
```

Out[360]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y
157	(text_len, num_utterances, rep_jpc, side1_gender)	4	0.824242	0.590753	0.723810	0.739130	0.931507	433 1.0 184 1.0 170 1.0 137 1.0 35...	
264	(text_len, text_pre_len, num_utterances, party...	5	0.837209	0.567132	0.733333	0.734694	0.972973	574 0.0 196 1.0 531 1.0 119 1.0 39...	
254	(party, male_jpc, side1_gender, side0_gender)	4	0.787879	0.562500	0.666667	0.650000	1.000000	171 1.0 443 0.0 249 0.0 356 1.0 41...	
33	(develop_time, side1_gender)	2	0.787879	0.562500	0.666667	0.650000	1.000000	269 1.0 99 1.0 36 0.0 388 1.0 10...	
321	(text_len, rep_jpc, party, male_jpc, side0_gen...	5	0.802395	0.554952	0.685714	0.683673	0.971014	447 0.0 545 0.0 54 0.0 116 1.0 34...	

In [361]:
```
results_df.loc[(results_df.loc[:, 'roc_auc'] > 0.6), :]
```

Out[361]:

	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y_pred

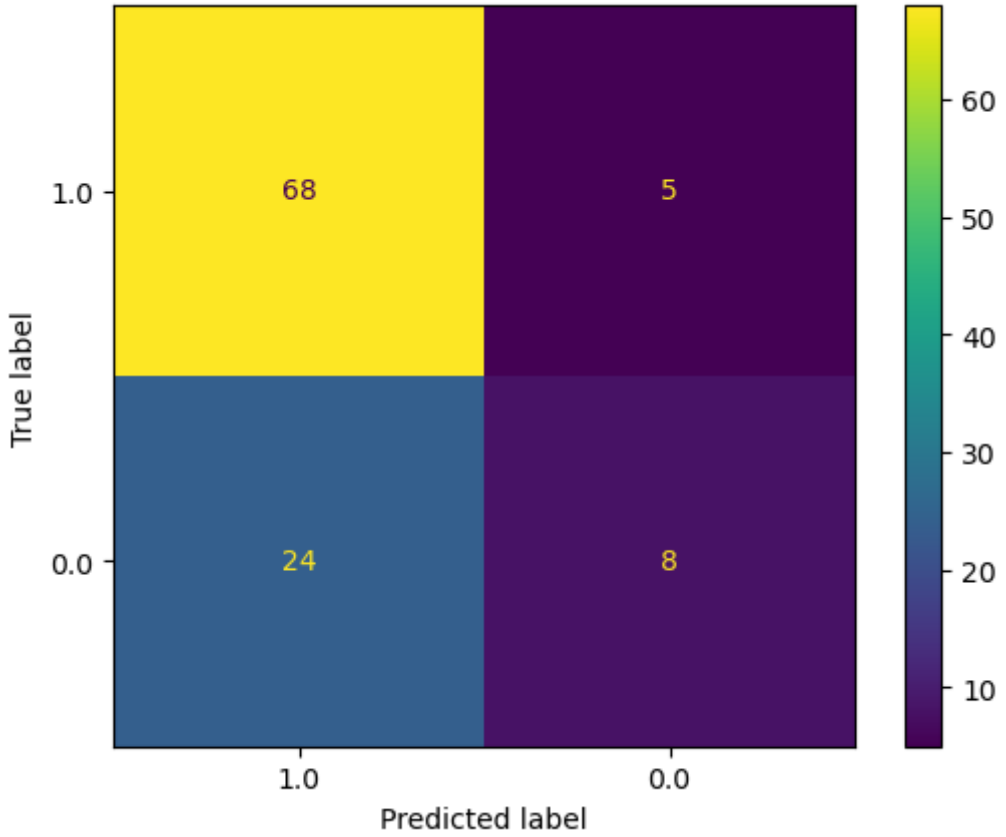
In [362]:
```
results_df.loc[(results_df.loc[:, 'roc_auc'] > 0.7), :]
```

Out[362]:

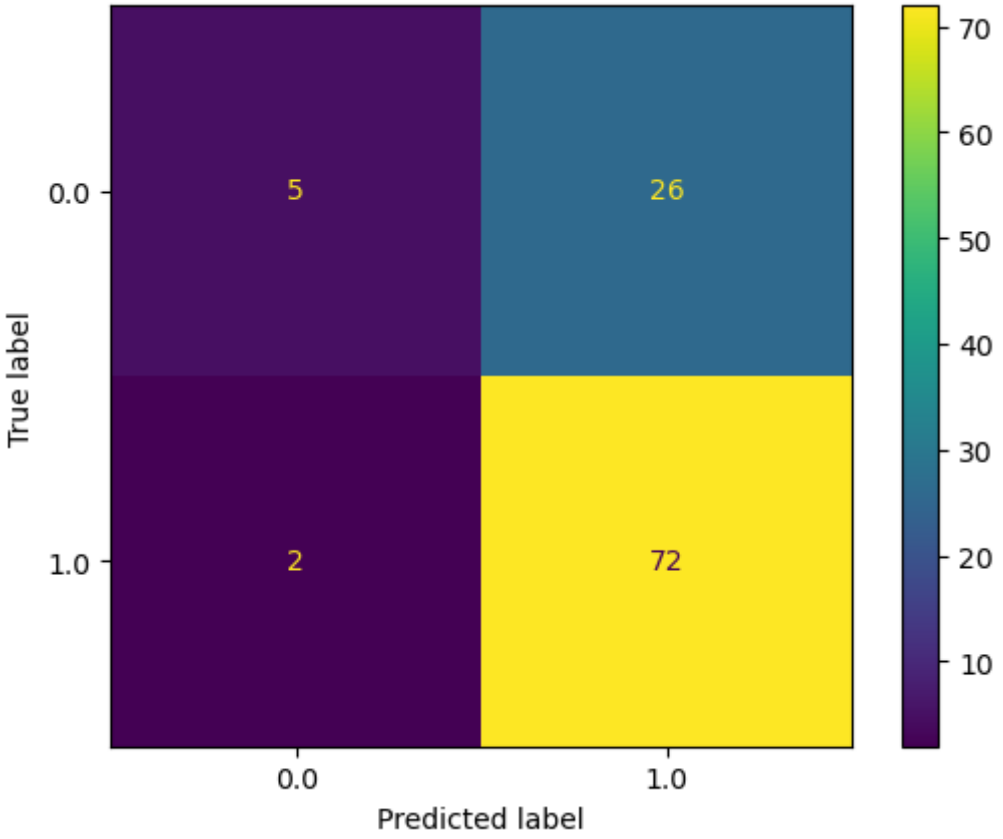
	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test	y_pred

In [363]:
```
# Make a confusion matrix

df_matrix = results_df.head(3).reset_index(drop=True)

for i in range(len(df_matrix)):

    feature = df_matrix['features'][i]
    y_test = df_matrix['y_test'][i]
    y_pred =df_matrix['y_pred'][i]

    print(f"Confusion Matrix for Random Forest: {feature}")
    cm = confusion_matrix(y_test, y_pred, labels=y_test.unique())
    print(cm)
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=y_
    disp.plot()
    plt.show()
```

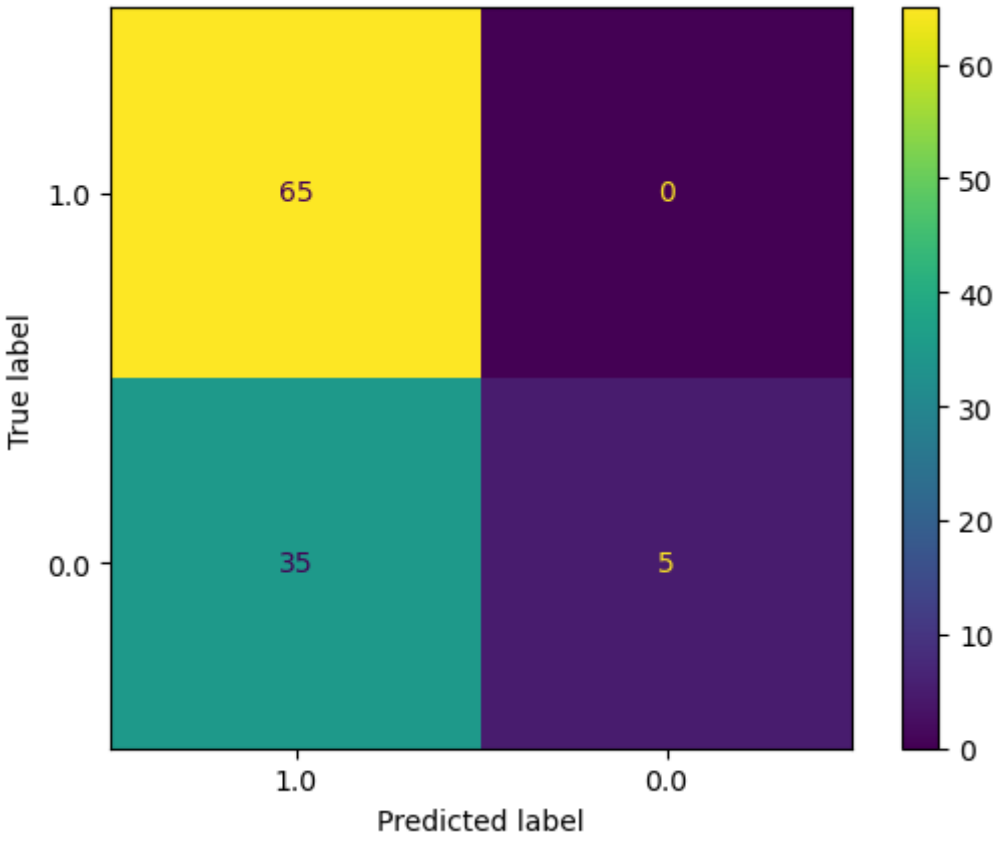
```
Confusion Matrix for Random Forest: ('text_len', 'num_utterances', 'r
ep_jpc', 'side1_gender')
[[68  5]
 [24  8]]
```




```
Confusion Matrix for Random Forest: ('text_len', 'text_pre_len', 'num
_utterances', 'party', 'male_jpc')
[[ 5 26]
 [ 2 72]]
```




```
Confusion Matrix for Random Forest: ('party', 'male_jpc', 'side1_gend
er', 'side0_gender')
[[65  0]
 [35  5]]
```



In [ ]:
```
try to balance f1 and roc_auc
```

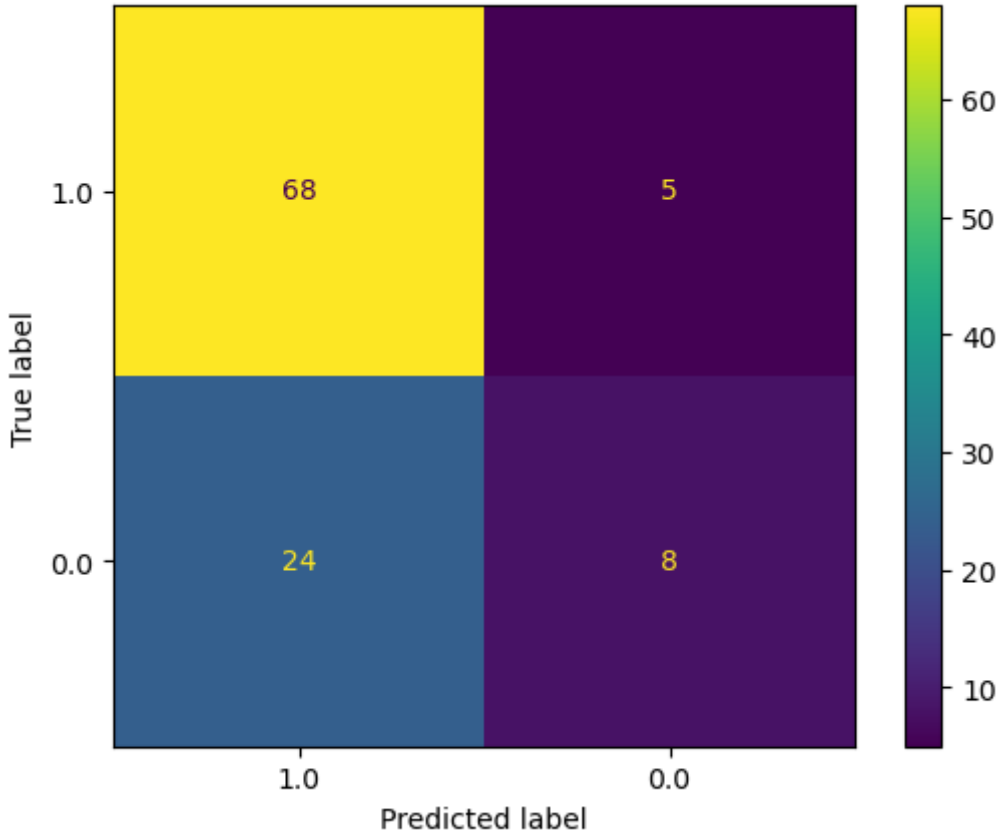
In [364]:
```
results_df.loc[:, 'test'] = results_df.loc[:, 'f1'] + results_df.loc[:,
results_df = results_df.sort_values(by = 'test', ascending = False)
results_df.head(5)
```

Out[364]:

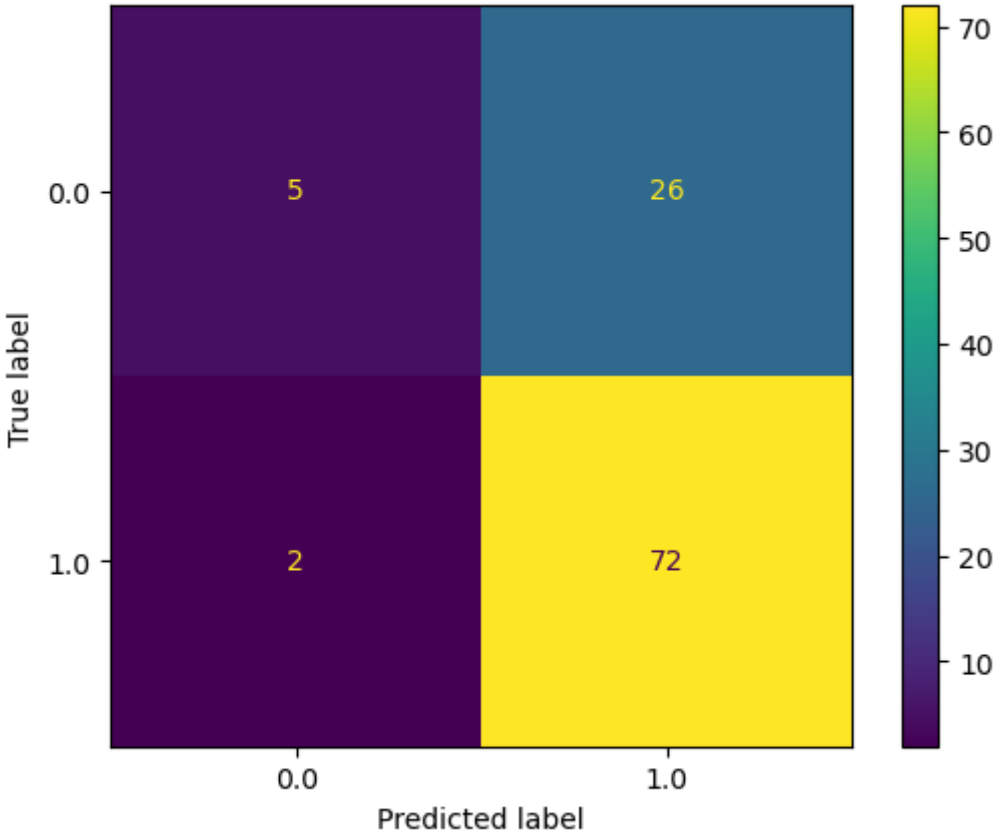
	features	features_num	f1	roc_auc	accuracy	precision	recall	y_test
157	(text_len, num_utterances, rep_jpc, side1_gender)	4	0.824242	0.590753	0.723810	0.739130	0.931507	433 1.0 184 1.0 170 1.0 137 1.0 35...
264	(text_len, text_pre_len, num_utterances, party...	5	0.837209	0.567132	0.733333	0.734694	0.972973	574 0.0 196 1.0 531 1.0 119 1.0 39...
421	(text_len, num_utterances, develop_time, rep_j...	6	0.845714	0.548433	0.742857	0.762887	0.948718	67 1.0 496 1.0 407 1.0 120 1.0 45...
433	(text_len, develop_time, rep_jpc, party, side1...	6	0.839080	0.553333	0.733333	0.737374	0.973333	426 1.0 194 1.0 393 1.0 342 1.0 54...
106	(num_utterances, male_jpc, side1_gender)	3	0.825581	0.544246	0.714286	0.724490	0.959459	148 1.0 484 1.0 191 0.0 75 0.0 17...

In [366]:
```
# Make a confusion matrix

df_matrix = results_df.head(3).reset_index(drop=True)

for i in range(len(df_matrix)):

    feature = df_matrix['features'][i]
    y_test = df_matrix['y_test'][i]
    y_pred =df_matrix['y_pred'][i]

    print(f"Confusion Matrix for Random Forest: {feature}")
    cm = confusion_matrix(y_test, y_pred, labels=y_test.unique())
    print(cm)
    disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=y_
    disp.plot()
    plt.show()
```

```
Confusion Matrix for Random Forest: ('text_len', 'num_utterances', 'r
ep_jpc', 'side1_gender')
[[68  5]
 [24  8]]
```




```
Confusion Matrix for Random Forest: ('text_len', 'text_pre_len', 'num
_utterances', 'party', 'male_jpc')
[[ 5 26]
 [ 2 72]]
```




```
Confusion Matrix for Random Forest: ('text_len', 'num_utterances', 'd
evelop_time', 'rep_jpc', 'side1_gender', 'side0_gender')
[[74  4]
 [23  4]]
```