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Part 1. Topic Classification

Question 1

- a: if we only use `r[^\w\s]`, it will let some symbol like `,.?..` will be remove. Then this may increase some sentence check errors during training time.
- b: When we use `train_test_split`, an unfavorable split, such as one containing many outliers in the train data, will cause the model to fall short of expectations. If we use k-fold cross-validation during training can improve the model's accuracy rate and decrease risk of overfitting.

In [4]:
```
# part 2
import pandas as pd
df = pd.read_table("dataset.tsv")
print(df.head())
```

```
                             artist_name           track_name  release_date  \
0                                 loving  the not real lake          2016
1                                incubus    into the summer          2019
2                              reignwolf          hardcore          2016
3                    tedeschi trucks band            anyhow          2016
4  lukas nelson and promise of the real  if i started over          2017

   genre                                             lyrics      topic
0   rock  awake know go see time clear world mirror worl...       dark
1   rock  shouldn summer pretty build spill ready overfl...  lifestyle
2  blues  lose deep catch breath think say try break wal...    sadness
3  blues  run bitter taste take rest feel anchor soul pl...    sadness
4  blues  think think different set apart sober mind sym...       dark
```

In [5]:
```
#This creates five-fold method
from sklearn.model_selection import StratifiedKFold
fiveFold = StratifiedKFold(n_splits=5, random_state=42, shuffle=True)

lyric = df['lyrics']
tp = df['topic']
print(lyric.shape)
print(tp.shape)
```

```
(1500,)
(1500,)
```

In [6]:
```
# This is two methods for propressing text
def methodT_a(text):
    out = text.str.lower()
    out = out.replace(r"[^\w\s{P}]", '', regex = True)
    return out

def methodT_b(text):
    out = text.str.lower()
    out = out.replace(r"[^A-Za-z0-9\u4e00-\u9fff\s\.,'\-]", '', regex = True)
    return out
```

In [ ]:

```

```

In [7]:

```
#This part is created naive_bayes list, MNB and BNB
from sklearn.naive_bayes import MultinomialNB,BernoulliNB
Baive = [
    ('MNB',  MultinomialNB()),
    ('BNB', BernoulliNB())
]
```

In [8]:

```
# This part is created CountVectorizer list
from sklearn.feature_extraction.text import CountVectorizer
import nltk
from nltk.stem import PorterStemmer
from nltk.tokenize import word_tokenize
import nltk

stemmer = PorterStemmer()
def stem_tokenizer(text):
    tokens = word_tokenize(text.lower())
    return [stemmer.stem(t) for t in tokens]

def stem_tokenizer_simple(text):
    tokens = text.lower().split()
    return [stemmer.stem(t) for t in tokens]

#have 4 different
allCounV = {
    'default':CountVectorizer(),
    'with_token': CountVectorizer(
        tokenizer=stem_tokenizer_simple
    ),
    'Stop_word': CountVectorizer(
         stop_words='english'
    ),
    'Stop_wordWithToken': CountVectorizer(
         tokenizer=stem_tokenizer_simple,
         stop_words='english'
    )}
```

Question 2

In this part, I implement two different methods for preprocessing text: `method_A` and `method_B`. In `method_A` is based on the Week2TUT coding, whereas `method_B` includes additional characters that are preserved during preprocessing. Then I apply two different Naive Bayes models: `MNB` and `BNB`. Finally, I create a `ContVectorizer` list using `sklearn` and `nltk` packages. I think the best preprocessing method is `method_b`, `MNB` and `default` in the CountVectorizer list.

In [10]:

```
#This is part 2 coding
from sklearn.pipeline import Pipeline
from sklearn.model_selection import cross_validate
textPrep = {
    'T_a': methodT_a,
    'T_b': methodT_b
}
```

```python
results = []
scoring = ['accuracy', 'precision_weighted', 'f1', 'f1_micro']

#main function
for counName,ConvMethod in allCounV.items():
    for texName, fn in textPrep.items():
        x_pre = fn(lyric)
        for basivName, basisMethod in Baive:
            pipe = Pipeline([
                ('vect', ConvMethod),
                ('clf', basisMethod)
            ])
            #use cross_validate to find each data result
            scores = cross_validate(
                pipe,
                x_pre,
                tp,
                cv= fiveFold,
                scoring=['accuracy', 'precision_weighted', 'f1_weighted', 'f1_mi
            )

            results.append({
                'counname': counName,
                'preproc': texName,
                'classifier': basivName,
                'acc_mean':    scores['test_accuracy'].mean(),
                'prec_mean':   scores['test_precision_weighted'].mean(),
                'f1_w_mean':   scores['test_f1_weighted'].mean(),
                'f1_micro_mean': scores['test_f1_micro'].mean(),
            })
```

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ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis',
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
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F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:406: UserWarning: Your stop_words may be inconsistent with your preprocessing. Tokenizing the stop words generated tokens ['abov', 'afterward', 'alon', 'alreadi', 'alway', 'ani', 'anoth', 'anyon', 'anyth', 'anywher', 'becam', 'becaus', 'becom', 'befor', 'besid', 'cri', 'describ', 'dure', 'els', 'elsewher', 'empti', 'everi', 'everyon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'hereaft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'moreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis', 'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'someon', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi', 'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'whenc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] not in stop_words.
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:1531: UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

Question 3

In this question, I use `accuracy`, `precision`, `f1` and `f1-micro` as criteria for evaluation, as they are very common in machine learning and AI. When encountering unbalanced data, `accuracy` will be misleading in unbalanced dataset, `precision` will also be affected, particularyly in small datasets where the minority class may be underrepresented. `F1` is generally more robust in such cases because it is calculated per clarticularlypass and then averaged, reducing the impact of imbalance. `F1-micro` is similary to `accuracy`. In balanced datasets, both can effectively represent the performance of the model

In [12]:
```python
finalResult = pd.DataFrame(results).sort_values('acc_mean', ascending=False)
print(finalResult)
```

```
                 couname preproc classifier  acc_mean  prec_mean  f1_w_mean  \
0                default     T_a        MNB  0.808000   0.817355   0.801585   
2                default     T_b        MNB  0.807333   0.816643   0.800840   
4             with_token     T_a        MNB  0.804000   0.812138   0.798777   
6             with_token     T_b        MNB  0.802667   0.811089   0.797435   
10             Stop_word     T_b        MNB  0.799333   0.806773   0.790624   
8              Stop_word     T_a        MNB  0.798667   0.807350   0.789899   
14  Stop_wordWithToken     T_b        MNB  0.794667   0.801581   0.786407   
12  Stop_wordWithToken     T_a        MNB  0.793333   0.800305   0.785141   
7             with_token     T_b        BNB  0.539333   0.618245   0.489657   
1                default     T_a        BNB  0.538000   0.570383   0.479328   
5             with_token     T_a        BNB  0.538000   0.617090   0.487973   
3                default     T_b        BNB  0.537333   0.569171   0.479205   
15  Stop_wordWithToken     T_b        BNB  0.536000   0.610927   0.486352   
11             Stop_word     T_b        BNB  0.534667   0.571779   0.477800   
13  Stop_wordWithToken     T_a        BNB  0.534667   0.611789   0.484729   
9              Stop_word     T_a        BNB  0.532667   0.569118   0.475223   

    f1_micro_mean  
0        0.808000  
2        0.807333  
4        0.804000  
6        0.802667  
10       0.799333  
8        0.798667  
14       0.794667  
12       0.793333  
7        0.539333  
1        0.538000  
5        0.538000  
3        0.537333  
15       0.536000  
11       0.534667  
13       0.534667  
9        0.532667  
```

From the table above and below, we can observe that `MNB` performed better than `BNB` in terms of the classifier selection. Additionally, the default configuration of `countVectorize` (without adding any data or parameters) the best performance. Finally, in pre-processing, the method of tut2 (`method_a`) was better than `method_b` . This may be due to the fact that the latter preserves more noise—that is, words that are not necessarily relevant keywords.

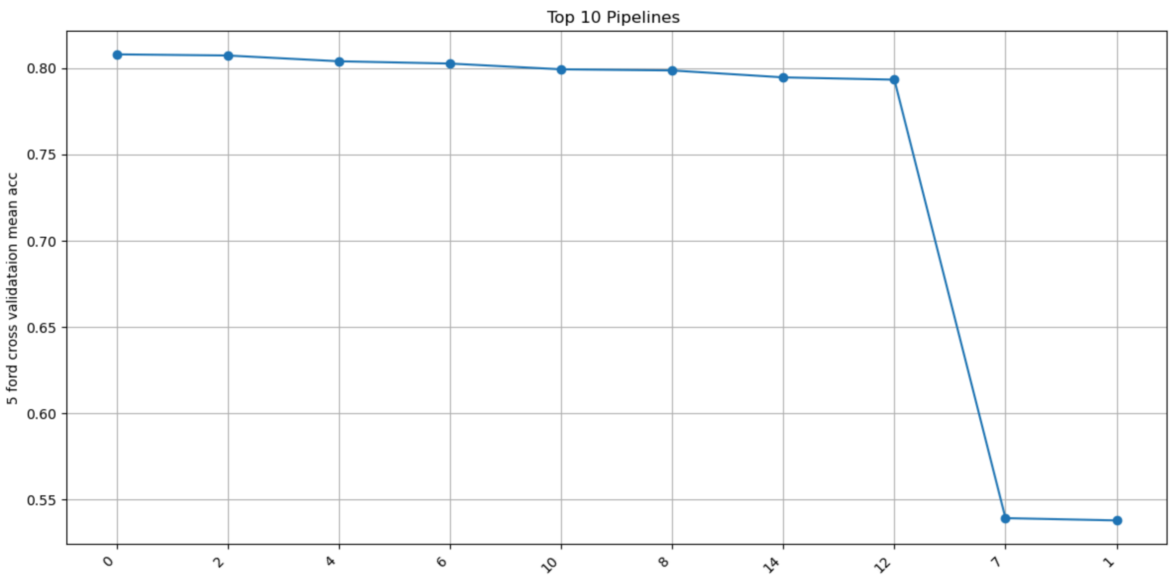
In [14]:
```python
import matplotlib.pyplot as plt
import numpy as np
top10 = finalResult[:10]
print(top10)
labels = top10.index.tolist()
x = np.arange(len(labels))
plt.figure(figsize=(12, 6))
plt.plot(
    x,
    top10['acc_mean'],
    # yerr=top10['acc_std'],
    marker='o',
```

```
    linestyle='-'
)

plt.xticks(x, labels, rotation=45, ha='right')
plt.ylabel('5 ford cross validataion mean acc')
plt.title('Top 10 Pipelines ')
plt.tight_layout()
plt.grid(True)
plt.show()
```

```
                 counname preproc classifier  acc_mean  prec_mean  f1_w_mean  \
0                 default     T_a        MNB  0.808000   0.817355   0.801585
2                 default     T_b        MNB  0.807333   0.816643   0.800840
4              with_token     T_a        MNB  0.804000   0.812138   0.798777
6              with_token     T_b        MNB  0.802667   0.811089   0.797435
10              Stop_word     T_b        MNB  0.799333   0.806773   0.790624
8               Stop_word     T_a        MNB  0.798667   0.807350   0.789899
14  Stop_wordWithToken     T_b        MNB  0.794667   0.801581   0.786407
12  Stop_wordWithToken     T_a        MNB  0.793333   0.800305   0.785141
7              with_token     T_b        BNB  0.539333   0.618245   0.489657
1                 default     T_a        BNB  0.538000   0.570383   0.479328

    f1_micro_mean
0        0.808000
2        0.807333
4        0.804000
6        0.802667
10       0.799333
8        0.798667
14       0.794667
12       0.793333
7        0.539333
1        0.538000
```



Question 4

In this question, I select the best-performing configuration from the results of `Question 3` . I then choose two different `countVectorize` configurations to demonstrate that the same outcome can be reproduced

In [16]:
```python
# I choose 300, 500, 700, 1000, 1500, 2000 to find which is best n
max_n = [300,500, 700, 1000, 1500, 2000]
records = []
xInMAXN = methodT_a(lyric)

allCounVCWithNfeat = {
    'default': {},
    'with_token': {
        'tokenizer':stem_tokenizer_simple,
    }
}


for N in max_n:
    for Vname, params in allCounVCWithNfeat.items():
        vect = CountVectorizer(max_features = N, **params)
        pipe = Pipeline([
            ('vect', vect),
            ('clf',  MultinomialNB())
        ])

        scores = cross_validate(
            pipe,
            xInMAXN,
            tp,
            cv=fiveFold,
            scoring='accuracy',
            return_train_score=False
        )

        mean_acc = scores['test_score'].mean()
        std_acc  = scores['test_score'].std()
        records.append({
            'vectName': Vname,
            'max_features': N,
            'classifier': "MNB",
            'mean_acc': mean_acc,
            'std_acc': std_acc
        })

resN = pd.DataFrame(records)
```

```
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:521: U
serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
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serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
ot None'
  warnings.warn(
```

In [17]:
```
resNWithNoASC = pd.DataFrame(resN).sort_values('mean_acc',ascending=False)
print(resNWithNoASC)
```

```
      vectName  max_features classifier  mean_acc   std_acc
2      default           500        MNB  0.880000  0.019777
3   with_token           500        MNB  0.876000  0.023981
4      default           700        MNB  0.874000  0.017563
5   with_token           700        MNB  0.869333  0.019709
0      default           300        MNB  0.868667  0.024368
1   with_token           300        MNB  0.866000  0.026949
7   with_token          1000        MNB  0.854667  0.012220
8      default          1500        MNB  0.846667  0.011155
6      default          1000        MNB  0.846000  0.016653
9   with_token          1500        MNB  0.837333  0.009978
10     default          2000        MNB  0.836667  0.017764
11  with_token          2000        MNB  0.833333  0.019437
```

Part 1 question 5

In this question, I set `max_features = 500`, based on the findings from `question 4`, where the best performance was observed when `n =500`. For this question, I consulted online sources and found 6 commonly recommended classification methods there are: `Logistic Regression`, `Decision Tree`, `Random Forest`, `Support Vector Machine(SVM)`, `Naive Bayes` and `KNN`. For `Logistic Regression` and `Support Vectore Machine(SVM)` were not considered, due to they require adding more data and modifications to the test code. `Rand Forest` was excluded because it needs to spend a lot of time, and performance was inconsistent. As a result, I will choose `KNN` method in this question. Although I experimented with the Decision Tree method, it showed poor performance (the best result will be shown below).

The website link: `https://www.geeksforgeeks.org/machine-learning/top-6-machine-learning-algorithms-for-classification/`

In [19]:
```
from sklearn.neighbors import KNeighborsClassifier

# from sklearn.tree import DecisionTreeClassifier

resultsKNN = []
knnN= [ 5,10 ,20]
for n in knnN:

    knnModel = KNeighborsClassifier (n_neighbors = n)
    # deTree = DecisionTreeClassifier(  criterion='entropy', max_depth = 500, ra


    for counName,ConvMethod in allCounV.items():
        for texName, fn in textPrep.items():
            x_pre = fn(lyric)

            pipe = Pipeline([
                ('vect', ConvMethod),
                ('clf', knnModel) # if went to test deTree change knnModel to de
            ])
            scores = cross_validate(
                pipe,
```

```
            x_pre,
            tp,
            cv= fiveFold,
            scoring=['accuracy', 'precision_weighted', 'f1_weighted', 'f1_mi
            # return_train_score=False
        )

        resultsKNN.append({
            'counname': counName,
            'preproc': texName,
            'n': n,
            'classifier': 'KNN',
            'acc_mean':    scores['test_accuracy'].mean(),
            'prec_mean':   scores['test_precision_weighted'].mean(),
            'f1_w_mean':   scores['test_f1_weighted'].mean(),
            'f1_micro_mean': scores['test_f1_micro'].mean(),
        })
```

```
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:521: U
serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
ot None'
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F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:406: U
serWarning: Your stop_words may be inconsistent with your preprocessing. Tokenizi
ng the stop words generated tokens ['abov', 'afterward', 'alon', 'alreadi', 'alwa
y', 'ani', 'anoth', 'anyon', 'anyth', 'anywher', 'becam', 'becaus', 'becom', 'bef
or', 'besid', 'cri', 'describ', 'dure', 'els', 'elsewher', 'empti', 'everi', 'eve
ryon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'herea
ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis',
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
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```

```
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ryon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'herea
ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis', 
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
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  warnings.warn(
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'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
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henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
```

In [20]:
```
finalResultKNN = pd.DataFrame(resultsKNN).sort_values('acc_mean', ascending=Fals
# add deTree best one: 6  Stop_wordWithToken  T_a   deTree  0.542667  0.016111
print(finalResultKNN)
```

```
                counname preproc   n classifier  acc_mean  prec_mean  f1_w_mean  \
23  Stop_wordWithToken     T_b  20        KNN  0.627333   0.705204   0.617259
22  Stop_wordWithToken     T_a  20        KNN  0.627333   0.705311   0.617318
19          with_token     T_b  20        KNN  0.624667   0.709182   0.614963
18          with_token     T_a  20        KNN  0.624667   0.708906   0.614836
16             default     T_a  20        KNN  0.617333   0.707399   0.609100
17             default     T_b  20        KNN  0.616667   0.706944   0.608376
21           Stop_word     T_b  20        KNN  0.612000   0.695163   0.601576
20           Stop_word     T_a  20        KNN  0.612000   0.695163   0.601576
14  Stop_wordWithToken     T_a  10        KNN  0.606000   0.660746   0.604170
15  Stop_wordWithToken     T_b  10        KNN  0.606000   0.660746   0.604170
10          with_token     T_a  10        KNN  0.602667   0.670147   0.601302
11          with_token     T_b  10        KNN  0.602667   0.670147   0.601302
8              default     T_a  10        KNN  0.592000   0.660367   0.592214
9              default     T_b  10        KNN  0.592000   0.660367   0.592214
12           Stop_word     T_a  10        KNN  0.591333   0.649855   0.589698
13           Stop_word     T_b  10        KNN  0.591333   0.649855   0.589698
7   Stop_wordWithToken     T_b   5        KNN  0.582667   0.636569   0.591515
6   Stop_wordWithToken     T_a   5        KNN  0.582667   0.636569   0.591515
4            Stop_word     T_a   5        KNN  0.582000   0.637493   0.590628
5            Stop_word     T_b   5        KNN  0.581333   0.636871   0.589918
3           with_token     T_b   5        KNN  0.580667   0.638964   0.590624
2           with_token     T_a   5        KNN  0.580667   0.638964   0.590624
1              default     T_b   5        KNN  0.578667   0.642418   0.589890
0              default     T_a   5        KNN  0.578667   0.642418   0.589890

    f1_micro_mean
23       0.627333
22       0.627333
19       0.624667
18       0.624667
16       0.617333
17       0.616667
21       0.612000
20       0.612000
14       0.606000
15       0.606000
10       0.602667
11       0.602667
8        0.592000
9        0.592000
12       0.591333
13       0.591333
7        0.582667
6        0.582667
4        0.582000
5        0.581333
3        0.580667
2        0.580667
1        0.578667
0        0.578667
```

In [21]:
```
#due to above n_neighbors more big performance more better then I will test n_ne
knnModel = KNeighborsClassifier (n_neighbors = 100)
    # deTree = DecisionTreeClassifier(  criterion='entropy', max_depth = 500, ra
```

```python
result100 = []
for counName,ConvMethod in allCounV.items():
    for texName, fn in textPrep.items():
        x_pre = fn(lyric)

        pipe = Pipeline([
            ('vect', ConvMethod),
            ('clf', knnModel) # if went to test deTree change knnModel to deTree
        ])
        scores = cross_validate(
            pipe,
            x_pre,
            tp,
            cv= fiveFold,
            scoring=['accuracy', 'precision_weighted', 'f1_weighted', 'f1_micro'
            # return_train_score=False
        )

        result100.append({
            'counname': counName,
            'preproc': texName,
            'n': 100,
            'classifier': 'KNN',
            'acc_mean':    scores['test_accuracy'].mean(),
            'prec_mean':   scores['test_precision_weighted'].mean(),
            'f1_w_mean':   scores['test_f1_weighted'].mean(),
            'f1_micro_mean': scores['test_f1_micro'].mean(),
        })
```

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'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:1531:
UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in labels w
ith no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:521: U
serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
ot None'
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:406: U
serWarning: Your stop_words may be inconsistent with your preprocessing. Tokenizi
ng the stop words generated tokens ['abov', 'afterward', 'alon', 'alreadi', 'alwa
y', 'ani', 'anoth', 'anyon', 'anyth', 'anywher', 'becam', 'becaus', 'becom', 'bef
or', 'besid', 'cri', 'describ', 'dure', 'els', 'elsewher', 'empti', 'everi', 'eve
ryon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'herea
ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis',
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:1531:
UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in labels w
ith no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:521: U
serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
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  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:406: U
serWarning: Your stop_words may be inconsistent with your preprocessing. Tokenizi
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y', 'ani', 'anoth', 'anyon', 'anyth', 'anywher', 'becam', 'becaus', 'becom', 'bef
or', 'besid', 'cri', 'describ', 'dure', 'els', 'elsewher', 'empti', 'everi', 'eve
ryon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'herea
ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis',
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:1531:
UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in labels w
ith no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:521: U
serWarning: The parameter 'token_pattern' will not be used since 'tokenizer' is n
```

```
ot None'
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\feature_extraction\text.py:406: U
serWarning: Your stop_words may be inconsistent with your preprocessing. Tokenizi
ng the stop words generated tokens ['abov', 'afterward', 'alon', 'alreadi', 'alwa
y', 'ani', 'anoth', 'anyon', 'anyth', 'anywher', 'becam', 'becaus', 'becom', 'bef
or', 'besid', 'cri', 'describ', 'dure', 'els', 'elsewher', 'empti', 'everi', 'eve
ryon', 'everyth', 'everywher', 'fifti', 'formerli', 'forti', 'ha', 'henc', 'herea
ft', 'herebi', 'hi', 'howev', 'hundr', 'inde', 'latterli', 'mani', 'meanwhil', 'm
oreov', 'mostli', 'nobodi', 'noon', 'noth', 'nowher', 'onc', 'onli', 'otherwis',
'ourselv', 'perhap', 'pleas', 'seriou', 'sever', 'sinc', 'sincer', 'sixti', 'some
on', 'someth', 'sometim', 'somewher', 'themselv', 'thenc', 'thereaft', 'therebi',
'therefor', 'thi', 'thu', 'togeth', 'twelv', 'twenti', 'veri', 'wa', 'whatev', 'w
henc', 'whenev', 'wherea', 'whereaft', 'wherebi', 'wherev', 'whi', 'yourselv'] no
t in stop_words.
  warnings.warn(
F:\anaconda\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:1531:
UndefinedMetricWarning: Precision is ill-defined and being set to 0.0 in labels w
ith no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, f"{metric.capitalize()} is", len(result))
```

In [22]:
```
# print(result100)

result100pd = pd.DataFrame(result100)
print(result100pd)
```

```
              counname preproc    n classifier  acc_mean  prec_mean  f1_w_mean  \
0              default     T_a  100        KNN  0.456667   0.569735   0.378379
1              default     T_b  100        KNN  0.456667   0.569735   0.378379
2           with_token     T_a  100        KNN  0.473333   0.603260   0.399468
3           with_token     T_b  100        KNN  0.473333   0.603260   0.399468
4            Stop_word     T_a  100        KNN  0.472667   0.606412   0.401157
5            Stop_word     T_b  100        KNN  0.472667   0.606412   0.401157
6  Stop_wordWithToken     T_a  100        KNN  0.486667   0.626746   0.417015
7  Stop_wordWithToken     T_b  100        KNN  0.486667   0.626746   0.417015

   f1_micro_mean
0       0.456667
1       0.456667
2       0.473333
3       0.473333
4       0.472667
5       0.472667
6       0.486667
7       0.486667
```

From the above results, the highest accuracy of `KNN` is 0.627 when `n_neighbors` is 20. We can observe that increasing the value of `n_neighbor` initially improves performance. However, when the value reaches 100, the performance was very bad. In addition,enhanced text preprocessing appears to improve model performance. For example, `method_b` , which retains more words, allows the `KNN` to focus on finer details. Similarly, the `Stop_wordWithToken's` configuration in `countVectorize` contributes to improved results. However, the performance of KNN still does not surpass that of `MNB` . Therefore, I will use the MNB model in the next question.

Part 2 question 1

In this question, I will explain all coding steps in detail and apply the best-performing method identified in the previous question.

In [25]:
```
# part 2 questio 1 best one model from before part
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics import accuracy_score, precision_score, f1_score

resultsP2 = []

scoring = ['accuracy', 'precision_weighted', 'f1', 'f1_micro']
bestCounv = CountVectorizer(
     max_features=500
)
week3 = df[:751].copy()
week4 = df[751:1001].copy()
x_best = methodT_a(week3['lyrics'])
# x_best
y_best = week3['topic']

Bestpipe = Pipeline([
    ('vect', bestCounv),
    ('clf', MultinomialNB())
])

Bestpipe.fit(x_best,y_best)

preData = methodT_a(week4['lyrics'])
pre_topic = Bestpipe.predict(preData)
week4['pre_topic'] = pre_topic
print(pre_topic.shape)
accuracy_w4 = accuracy_score(week4['topic'], pre_topic )
precision_w4 =precision_score(week4['topic'], pre_topic, average='weighted')
f1_w4 = f1_score(week4['topic'], pre_topic, average='weighted')
print(f" accuracy for prediction {accuracy_w4}")
print(f" precision for prediction {precision_w4}")
print(f" f1 scroe for prediction {f1_w4}")

# The above code is use model to prediction each song's topic in week4

# Part real 2, I use the topic.unique find this
topicAll = ['dark' ,'lifestyle' ,'sadness', 'emotion', 'personal']
tfi ={}

predic_Topic_W3 =  Bestpipe.predict(x_best)
week3['pre_topic'] = predic_Topic_W3
#create different topic's tf-idf vec
for topic in topicAll:
    document = week3.loc[week3['pre_topic'] == topic, 'lyrics']
    print(topic)
    print(document.shape)
    tf = TfidfVectorizer(max_features=500)

    x_topic = tf.fit_transform(document)
    # tf.get_feature_nams_out()
    tfi[topic] = {
        'vectorize':tf,
        'tf_matrix': x_topic
    }
```

```
print(tfi)
```

```
(250,)
 accuracy for prediction 0.808
 precision for prediction 0.8125697213584537
 f1 scroe for prediction 0.8077396156534546
dark
(245,)
lifestyle
(90,)
sadness
(186,)
emotion
(43,)
personal
(187,)
{'dark': {'vectorize': TfidfVectorizer(max_features=500), 'tf_matrix': <245x500 s
parse matrix of type '<class 'numpy.float64'>'
	with 6132 stored elements in Compressed Sparse Row format>}, 'lifestyle':
{'vectorize': TfidfVectorizer(max_features=500), 'tf_matrix': <90x500 sparse matr
ix of type '<class 'numpy.float64'>'
	with 2284 stored elements in Compressed Sparse Row format>}, 'sadness':
{'vectorize': TfidfVectorizer(max_features=500), 'tf_matrix': <186x500 sparse mat
rix of type '<class 'numpy.float64'>'
	with 4775 stored elements in Compressed Sparse Row format>}, 'emotion':
{'vectorize': TfidfVectorizer(max_features=500), 'tf_matrix': <43x500 sparse matr
ix of type '<class 'numpy.float64'>'
	with 1153 stored elements in Compressed Sparse Row format>}, 'personal':
{'vectorize': TfidfVectorizer(max_features=500), 'tf_matrix': <187x500 sparse mat
rix of type '<class 'numpy.float64'>'
	with 5277 stored elements in Compressed Sparse Row format>}}
```

In [26]:

```
user1 = pd.read_table("user1.tsv")
print(user1)

user1_profiles = {}
# This function was according to combine all keywords from different user, m is
def creatProfile(user, user_profiles, m = 99999999):
    for idx, row in user.iterrows():
        topic =  row['topic']

        allKey = row['keywords'][:m]
        key_list = allKey.split(',')

        final_list = []
        for key in key_list:
            key  = key.strip()
            final_list.append(key)

        user_profiles[topic] = final_list

creatProfile(user1, user1_profiles)

#example
print(user1_profiles)
```

```
       topic                                   keywords
0       dark          fire, enemy, pain, storm, fight
1    sadness    cry, alone, heartbroken, tears, regret
2   personal     dream, truth, life, growth, identity
3  lifestyle        party, city, night, light, rhythm
4    emotion            love, memory, hug, kiss, feel
{'dark': ['fire', 'enemy', 'pain', 'storm', 'fight'], 'sadness': ['cry', 'alone',
'heartbroken', 'tears', 'regret'], 'personal': ['dream', 'truth', 'life', 'growt
h', 'identity'], 'lifestyle': ['party', 'city', 'night', 'light', 'rhythm'], 'emo
tion': ['love', 'memory', 'hug', 'kiss', 'feel']}
```

In [27]:

```
import re
user1_allLyrics = {}
# This function finds all topics and has keywords' song and combines their lyric
def finalAllSongHaveKey(user_lyric, user_profiles):
    for topic, keywords in user_profiles.items():
        allSameTopicSong = (week3['pre_topic'] == topic)
        key = r'|'.join(rf'\b{re.escape(kw)}\b' for kw in keywords)
        allHaveKeyWSong = week3['lyrics'].str.contains(key, case=False, regex=Tr
        goodSonglyr = week3.loc[allSameTopicSong & allHaveKeyWSong, 'lyrics']
        user_lyric[topic] = ' '.join(goodSonglyr.tolist())

finalAllSongHaveKey(user1_allLyrics,user1_profiles)
for topic in user1_allLyrics:
    print(f"all {topic} topic work have {len(user1_allLyrics[topic])}")
```

```
all dark topic work have 36064
all sadness topic work have 4108
all personal topic work have 66078
all lifestyle topic work have 18590
all emotion topic work have 13795
```

In [28]:

```
#this function is main function for part 2 question 1 that find 20 topic words f
def finalTop20Key(tfi, user_allLyrics, user_keyInSong):
    for topic, doc in user_allLyrics.items():

        tfiVec = tfi[topic]['vectorize']
        user_tfivec = tfiVec.transform([doc])
        user_tfivecArray = user_tfivec.toarray()[0]
        feature = tfiVec.get_feature_names_out()
        top_index = user_tfivecArray.argsort()[::-1][:20]
        top_words = feature[top_index]


        user_keyInSong.append({
            'Topic':topic,
            'Word': top_words,
            'tifivec': user_tfivec
        })

#this is example for user1
user1_keyInSong = []
finalTop20Key(tfi,user1_allLyrics,user1_keyInSong)
for line in user1_keyInSong:
    print(f"the topic is {line['Topic']} the top 20 words are {line['Word']}")
```

```
the topic is dark the top 20 words are ['fight' 'blood' 'know' 'like' 'stand' 'gr
ind' 'tell' 'gonna' 'black'
 'kill' 'yeah' 'lanky' 'dilly' 'head' 'follow' 'people' 'hand' 'come'
 'shoot' 'oouuu']
the topic is sadness the top 20 words are ['cry' 'club' 'steal' 'tear' 'mean' 'kn
ow' 'baby' 'music' 'write' 'say'
 'true' 'think' 'smile' 'face' 'eye' 'word' 'want' 'blame' 'fear'
 'greater']
the topic is personal the top 20 words are ['life' 'live' 'change' 'know' 'world'
'yeah' 'wanna' 'ordinary' 'dream'
 'like' 'thank' 'teach' 'lord' 'come' 'time' 'beat' 'think' 'learn' 'need'
 'go']
the topic is lifestyle the top 20 words are ['night' 'closer' 'long' 'come' 'sin
g' 'tire' 'spoil' 'home' 'play'
 'wanna' 'telephone' 'song' 'tonight' 'ring' 'yeah' 'wait' 'lalala'
 'right' 'time' 'songs']
the topic is emotion the top 20 words are ['good' 'touch' 'feel' 'hold' 'know' 'v
isions' 'video' 'loove' 'morning'
 'vibe' 'kiss' 'feelin' 'want' 'miss' 'love' 'lovin' 'luck' 'gimme'
 'sunrise' 'look']
```

In [29]:

```python
#This user 2 result
user2 = pd.read_table("user2.tsv")
user2_profiles = {}
creatProfile(user2, user2_profiles)
print(f"This is user2 profiles {user2_profiles}")

user2_allLyrics = {}
finalAllSongHaveKey(user2_allLyrics, user2_profiles)
for topic in user2_allLyrics:
    print(f"All {topic} topic song (same wopic and have key words)word have {len

user2_keyInSong = []
finalTop20Key(tfi,user2_allLyrics,user2_keyInSong)
# print(user1_keyInSong)
for line in user1_keyInSong:
    print(f"The topic is {line['Topic']} the top 20 words are {line['Word']} for
```

```
This is user2 profiles {'sadness': ['lost', 'sorrow', 'goodbye', 'tears', 'silenc
e'], 'emotion': ['romance', 'touch', 'feeling', 'kiss', 'memory']}
All sadness topic song (same wopic and have key words)word have 8462 in user2
All emotion topic song (same wopic and have key words)word have 6801 in user2
The topic is dark the top 20 words are ['fight' 'blood' 'know' 'like' 'stand' 'gr
ind' 'tell' 'gonna' 'black'
 'kill' 'yeah' 'lanky' 'dilly' 'head' 'follow' 'people' 'hand' 'come'
 'shoot' 'oouuu'] for user 2
The topic is sadness the top 20 words are ['cry' 'club' 'steal' 'tear' 'mean' 'kn
ow' 'baby' 'music' 'write' 'say'
 'true' 'think' 'smile' 'face' 'eye' 'word' 'want' 'blame' 'fear'
 'greater'] for user 2
The topic is personal the top 20 words are ['life' 'live' 'change' 'know' 'world'
'yeah' 'wanna' 'ordinary' 'dream'
 'like' 'thank' 'teach' 'lord' 'come' 'time' 'beat' 'think' 'learn' 'need'
 'go'] for user 2
The topic is lifestyle the top 20 words are ['night' 'closer' 'long' 'come' 'sin
g' 'tire' 'spoil' 'home' 'play'
 'wanna' 'telephone' 'song' 'tonight' 'ring' 'yeah' 'wait' 'lalala'
 'right' 'time' 'songs'] for user 2
The topic is emotion the top 20 words are ['good' 'touch' 'feel' 'hold' 'know' 'v
isions' 'video' 'loove' 'morning'
 'vibe' 'kiss' 'feelin' 'want' 'miss' 'love' 'lovin' 'luck' 'gimme'
 'sunrise' 'look'] for user 2
```

Command from user 1 and user 2

We can find that the top 20 most common words within the same Topic are nearly identical. For this, we can infer that songs categorised under the same topic tend to include these words, which we will prove in User3. In the meantime, we also find all these words are highly related to the topic or are those that immediately come to mind when the topic is presented.

In [31]:
```
#This user 3 result create by myself
user3 = pd.read_table("user3.tsv")
user3_profiles = {}
creatProfile(user3, user3_profiles)
for topc, word in user3_profiles.items():
    print(f"This is user3 profiles topic is {topc} there are words{word}")

user3_allLyrics = {}
finalAllSongHaveKey(user3_allLyrics, user3_profiles)
for topic in user3_allLyrics:
    print(f"All {topic} topic song (same wopic and have key words)word have {len

user3_keyInSong = []
finalTop20Key(tfi,user3_allLyrics,user3_keyInSong)
# print(user1_keyInSong)
for line in user1_keyInSong:
    print(f"The topic is {line['Topic']} the top 20 words are {line['Word']} for
```

```
This is user3 profiles topic is emotion there are words['joy', 'anger', 'fear', 'love', 'happiness']
This is user3 profiles topic is sadness there are words['apology', 'sorry', 'late', 'loneliness', 'misery', 'sad', 'leave']
This is user3 profiles topic is lifestyle there are words['fashine', 'travel', 'routine', 'habit', 'wellnes']
All emotion topic song (same wopic and have key words)word have 1285 in user3
All sadness topic song (same wopic and have key words)word have 38120 in user3
All lifestyle topic song (same wopic and have key words)word have 2837 in user3
The topic is dark the top 20 words are ['fight' 'blood' 'know' 'like' 'stand' 'grind' 'tell' 'gonna' 'black'
 'kill' 'yeah' 'lanky' 'dilly' 'head' 'follow' 'people' 'hand' 'come'
 'shoot' 'oouuu'] for user 3
The topic is sadness the top 20 words are ['cry' 'club' 'steal' 'tear' 'mean' 'know' 'baby' 'music' 'write' 'say'
 'true' 'think' 'smile' 'face' 'eye' 'word' 'want' 'blame' 'fear'
 'greater'] for user 3
The topic is personal the top 20 words are ['life' 'live' 'change' 'know' 'world' 'yeah' 'wanna' 'ordinary' 'dream'
 'like' 'thank' 'teach' 'lord' 'come' 'time' 'beat' 'think' 'learn' 'need'
 'go'] for user 3
The topic is lifestyle the top 20 words are ['night' 'closer' 'long' 'come' 'sing' 'tire' 'spoil' 'home' 'play'
 'wanna' 'telephone' 'song' 'tonight' 'ring' 'yeah' 'wait' 'lalala'
 'right' 'time' 'songs'] for user 3
The topic is emotion the top 20 words are ['good' 'touch' 'feel' 'hold' 'know' 'visions' 'video' 'loove' 'morning'
 'vibe' 'kiss' 'feelin' 'want' 'miss' 'love' 'lovin' 'luck' 'gimme'
 'sunrise' 'look'] for user 3
```

Command from user 3

In user3, I used a new set of keywords. However, we can find that the top 20 most common words within the same topic do not differ significantly. This shows that the frequent words may be less influenced by the specific keywords used and more inherently tied to the topic itself. In other words, texts within the same topic tend to feature a consistent set of common words.

Part 2 question 2:

In this question, at first, I use the `user_tf-idf` method to recommend `n` songs from week3. Then, using the same method to recommend week4 `n` songs which serve as `user_real_like`. Based on the Week3 recommended songs, I construct new `tf-idf` matrices, these matrices are then used to predict the week4 recommended song using three different methods. This method like `tf-idf-> songs -> tf-idf` method, and I chose `N` song from the entire topic pool because I assume that users will not listen to songs from a single topic indefinitely. Therefore, it is more appropriate to recommend songs across all topics. Additionally, recommending `N` songs for each topic would require significant computational resources and increase storage costs.

In [34]:
```
#this method is according to user tf-idf (from above) that find top n songs
def userTopNSong(week, user_keyInSong, n):
    by_topic = {entry['Topic']: entry for entry in user_keyInSong}
```

```
    allSongList = []
    for idx, row in week.iterrows():
        idTopic = row['pre_topic'].strip()
        if idTopic not in by_topic:
            continue

        idvec = tfi[idTopic]['vectorize'].transform([row['lyrics']])
        idSimila = cosine_similarity(idvec,by_topic[idTopic]['tifivec'])[0,0]
        allSongList.append((idx, idSimila))

    allSongList.sort(key=lambda x: x[1], reverse=True)

    songlist = [idx for idx,_ in allSongList]

    return songlist[:n]
```

In [35]:

```
#this is main function
from sklearn.metrics.pairwise import cosine_similarity, euclidean_distances

alln  =[5, 10 ,15, 20]
allm = [3,5,7]
alluser = {
    'user1':user1,
    'user2':user2,
    'user3':user3
}
algs = ['cosSi', 'dot', 'ne-Euclid']
result = []

for userName, dfuser in alluser.items():
    #create user profile

    for m in allm:
        user_profiles = {}
        creatProfile(dfuser, user_profiles, m)
        # print(user_profiles)
        user_allLyrics = {}
        finalAllSongHaveKey(user_allLyrics, user_profiles)
        # print(user_profiles)
        user_keyInSong = []
        finalTop20Key(tfi,user_allLyrics,user_keyInSong)
        # print(user_keyInSong)

        for n in alln:
            user_week3_like =  userTopNSong(week3, user_keyInSong, n)
            # print(user_week3_like)

            user_week4_like = userTopNSong(week4, user_keyInSong, n)

            #this part is creating new tf-idf from week3 user like
            new_tfi ={}
            user_lyrics_by_topic = {}
            for topic in topicAll:
                like_idx  = [i for i in user_week3_like if week3.loc[i, 'pre_top
                if not like_idx:
                    continue
                like_lyrics = week3.loc[like_idx, 'lyrics']
                user_lyrics_by_topic[topic] = " ".join(like_lyrics.tolist())
                tf = TfidfVectorizer(max_features=500)
                x_topic = tf.fit_transform(like_lyrics)
```

```
                new_tfi[topic] = {
                    'vectorize':tf,
                    'tf_matrix': x_topic
                }

            #this part is using 3 different method to find which songs are most
            recommon_week4 = []
            for alg in algs:
                for idx,row in week4.iterrows():

                    topic = row['pre_topic'].strip()
                    if topic not in new_tfi:
                        continue

                    id_vec = new_tfi[topic]['vectorize'].transform([row['lyrics'
                    user_vec = new_tfi[topic]['vectorize'].transform([user_lyric

                    if alg=='cosSi':
                        idSimila = cosine_similarity(id_vec, user_vec)[0,0]
                    elif alg=='dot':
                        idSimila = id_vec.multiply(user_vec).sum()

                    else:
                        idSimila = -euclidean_distances(id_vec, user_vec)[0,0]



                    recommon_week4.append((idx,idSimila))

                recommon_week4.sort(key=lambda x: x[1], reverse=True)
                recommon_week4TopN = [idx for idx,_ in recommon_week4][:n]

                #this is get result
                same = sum(1 for idx in recommon_week4TopN if idx in user_week4_
                P = same / n
                R = same / len(user_week4_like) if user_week4_like else 0.0
                F1 = 2 * P * R / (P + R) if (P + R) else 0.0

                result.append({
                    'name': userName,
                    'm': m,
                    'n': n,
                    'hits': same,
                    'method': alg,
                    'Precision': P,
                    'Recall': R,
                    'F1': F1
                })



df_res = pd.DataFrame(result)
print(df_res)
```

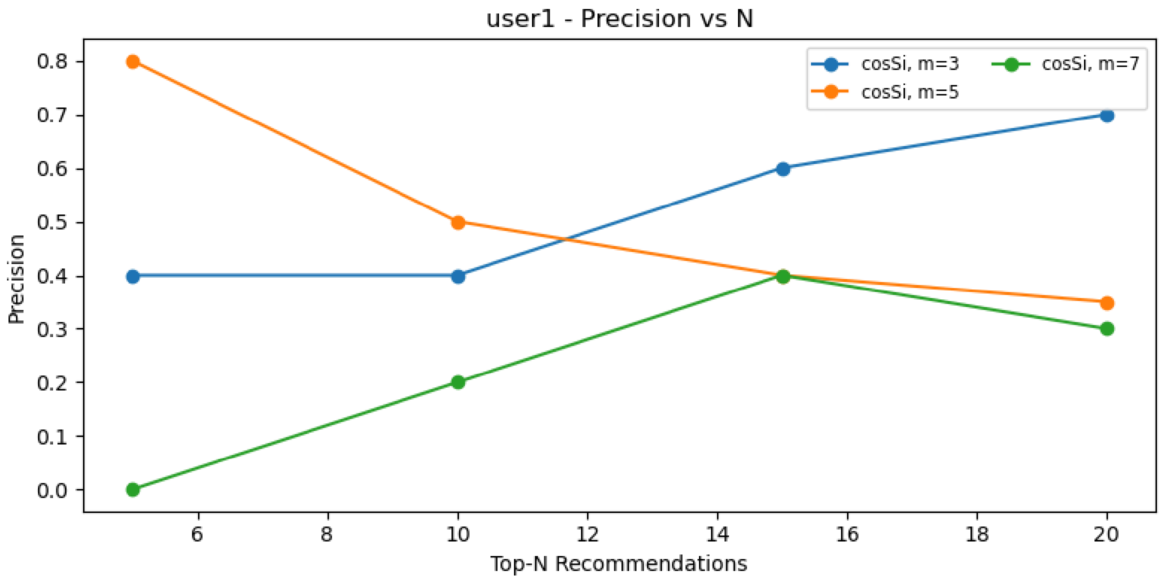
```
     name  m   n  hits     method  Precision    Recall        F1
0    user1  3   5     2      cosSi   0.400000  0.400000  0.400000
1    user1  3   5     2        dot   0.400000  0.400000  0.400000
2    user1  3   5     2  ne-Euclid   0.400000  0.400000  0.400000
3    user1  3  10     4      cosSi   0.400000  0.400000  0.400000
4    user1  3  10     4        dot   0.400000  0.400000  0.400000
..     ... ..  ..   ...        ...        ...       ...       ...
103  user3  7  15     1        dot   0.066667  0.066667  0.066667
104  user3  7  15     1  ne-Euclid   0.066667  0.066667  0.066667
105  user3  7  20     2      cosSi   0.100000  0.100000  0.100000
106  user3  7  20     2        dot   0.100000  0.100000  0.100000
107  user3  7  20     2  ne-Euclid   0.100000  0.100000  0.100000

[108 rows x 8 columns]
```

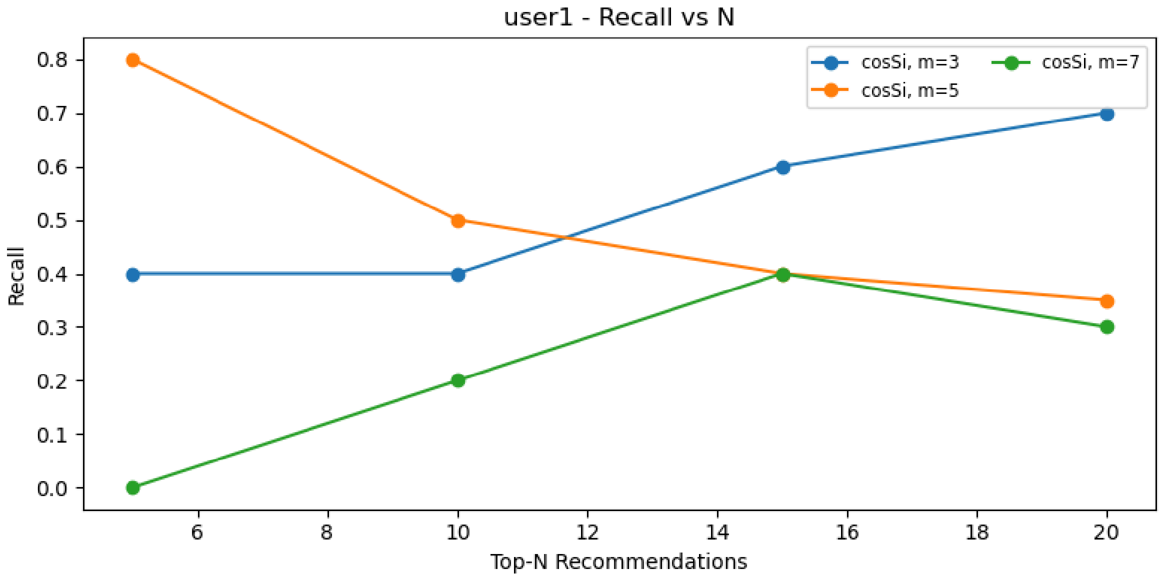
In [36]:
```
#due to there are a lot of line_table no print m =3 so I print in this place
# almost same with green line
all_mis3 = df_res[df_res['m'] == 3]
print(all_mis3)
```

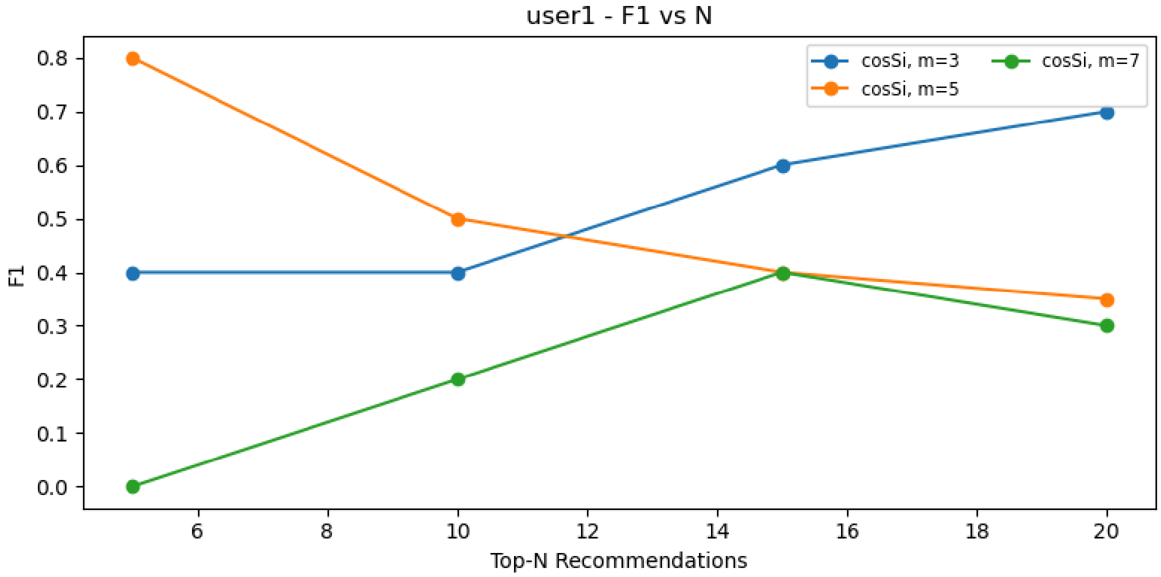
```
    name  m   n  hits     method  Precision    Recall        F1
0   user1  3   5     2      cosSi   0.400000  0.400000  0.400000
1   user1  3   5     2        dot   0.400000  0.400000  0.400000
2   user1  3   5     2  ne-Euclid   0.400000  0.400000  0.400000
3   user1  3  10     4      cosSi   0.400000  0.400000  0.400000
4   user1  3  10     4        dot   0.400000  0.400000  0.400000
5   user1  3  10     4  ne-Euclid   0.400000  0.400000  0.400000
6   user1  3  15     9      cosSi   0.600000  0.600000  0.600000
7   user1  3  15     9        dot   0.600000  0.600000  0.600000
8   user1  3  15     9  ne-Euclid   0.600000  0.600000  0.600000
9   user1  3  20    14      cosSi   0.700000  0.700000  0.700000
10  user1  3  20    14        dot   0.700000  0.700000  0.700000
11  user1  3  20    14  ne-Euclid   0.700000  0.700000  0.700000
36  user2  3   5     0      cosSi   0.000000  0.000000  0.000000
37  user2  3   5     0        dot   0.000000  0.000000  0.000000
38  user2  3   5     0  ne-Euclid   0.000000  0.000000  0.000000
39  user2  3  10     1      cosSi   0.100000  0.100000  0.100000
40  user2  3  10     2        dot   0.200000  0.200000  0.200000
41  user2  3  10     2  ne-Euclid   0.200000  0.200000  0.200000
42  user2  3  15     3      cosSi   0.200000  0.200000  0.200000
43  user2  3  15     4        dot   0.266667  0.266667  0.266667
44  user2  3  15     4  ne-Euclid   0.266667  0.266667  0.266667
45  user2  3  20     4      cosSi   0.200000  0.200000  0.200000
46  user2  3  20     4        dot   0.200000  0.200000  0.200000
47  user2  3  20     4  ne-Euclid   0.200000  0.200000  0.200000
72  user3  3   5     0      cosSi   0.000000  0.000000  0.000000
73  user3  3   5     0        dot   0.000000  0.000000  0.000000
74  user3  3   5     0  ne-Euclid   0.000000  0.000000  0.000000
75  user3  3  10     0      cosSi   0.000000  0.000000  0.000000
76  user3  3  10     0        dot   0.000000  0.000000  0.000000
77  user3  3  10     0  ne-Euclid   0.000000  0.000000  0.000000
78  user3  3  15     1      cosSi   0.066667  0.066667  0.066667
79  user3  3  15     1        dot   0.066667  0.066667  0.066667
80  user3  3  15     1  ne-Euclid   0.066667  0.066667  0.066667
81  user3  3  20     2      cosSi   0.100000  0.100000  0.100000
82  user3  3  20     2        dot   0.100000  0.100000  0.100000
83  user3  3  20     2  ne-Euclid   0.100000  0.100000  0.100000
```

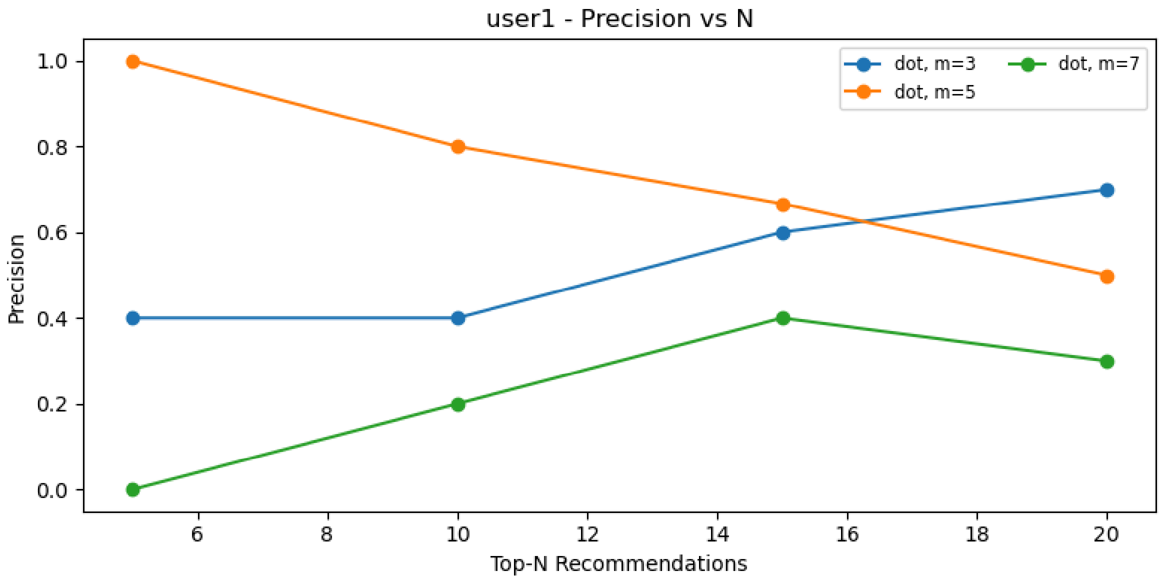
In [37]:
```
import pandas as pd
import matplotlib.pyplot as plt
```

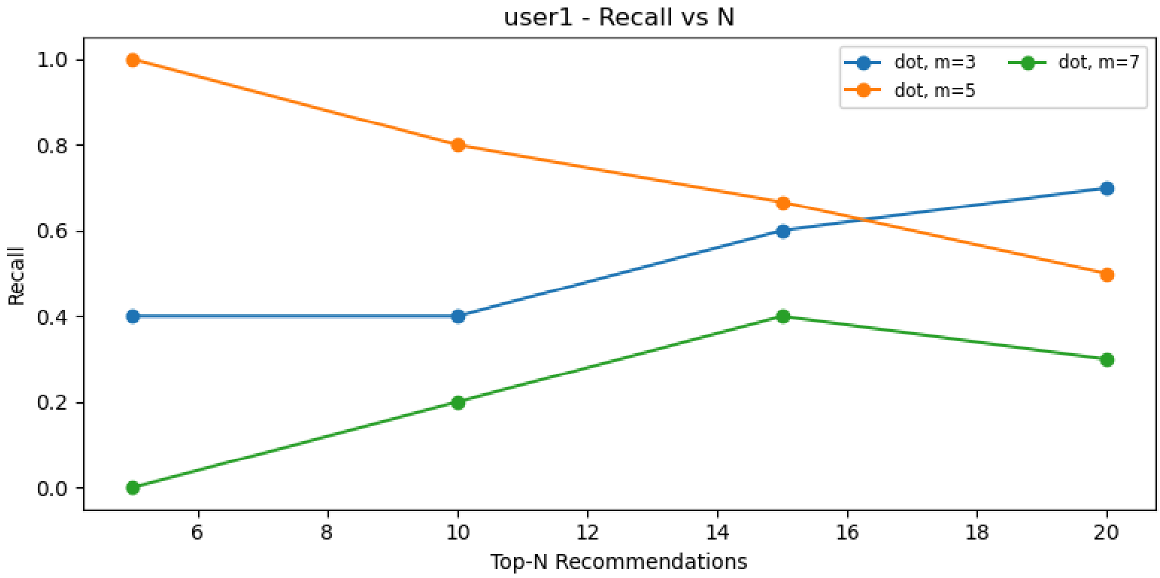
```python
allUser = ['user1','user2', 'user3']
allMethod = ['cosSi', 'dot','ne-Euclid']

for user in allUser:


    for method in allMethod:
        df_u = df_res[df_res['name'] == user]
        fig, axes = plt.subplots(3, 1, figsize=(8, 12))
        metrics = ['Precision', 'Recall', 'F1']

        for i, metric in enumerate(metrics):
            ax = axes[i]

            for m in allm:
                df_line = df_u[(df_u['method']==method) & (df_u['m']==m)]

                ax.plot(df_line['n'], df_line[metric],
                        marker='o',
                        linestyle='-',
                        label=f"{method}, m={m}")
            ax.set_xlabel('Top-N Recommendations')
            ax.set_ylabel(metric)
            ax.set_title(f'{user} - {metric} vs N')
            ax.legend(fontsize='small', ncol=2)
        plt.tight_layout()
        plt.show()
```

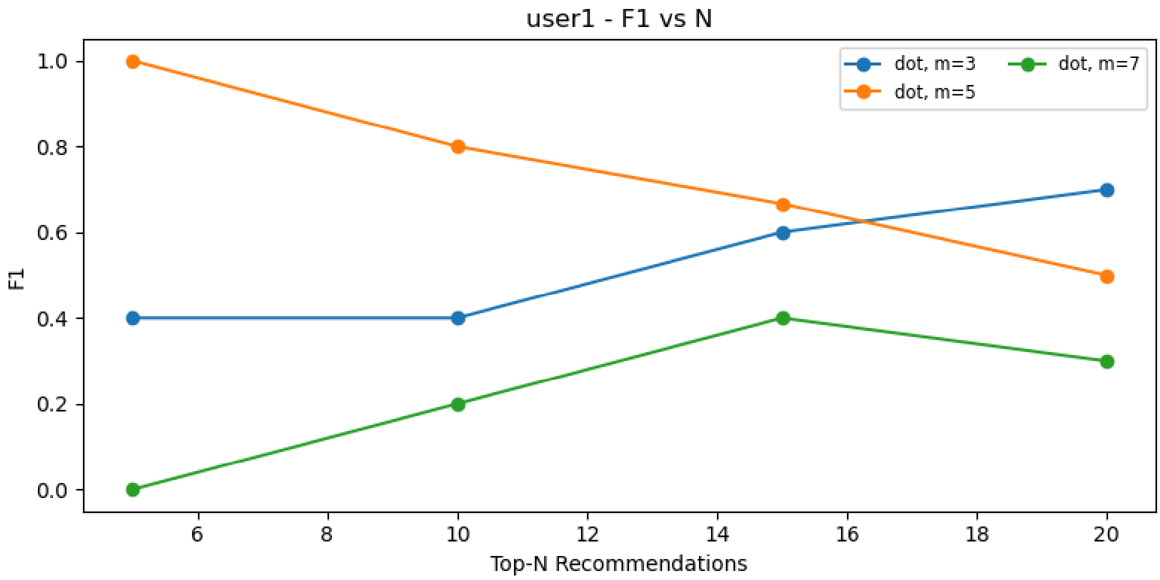

user1 - Precision vs N
Precision
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7

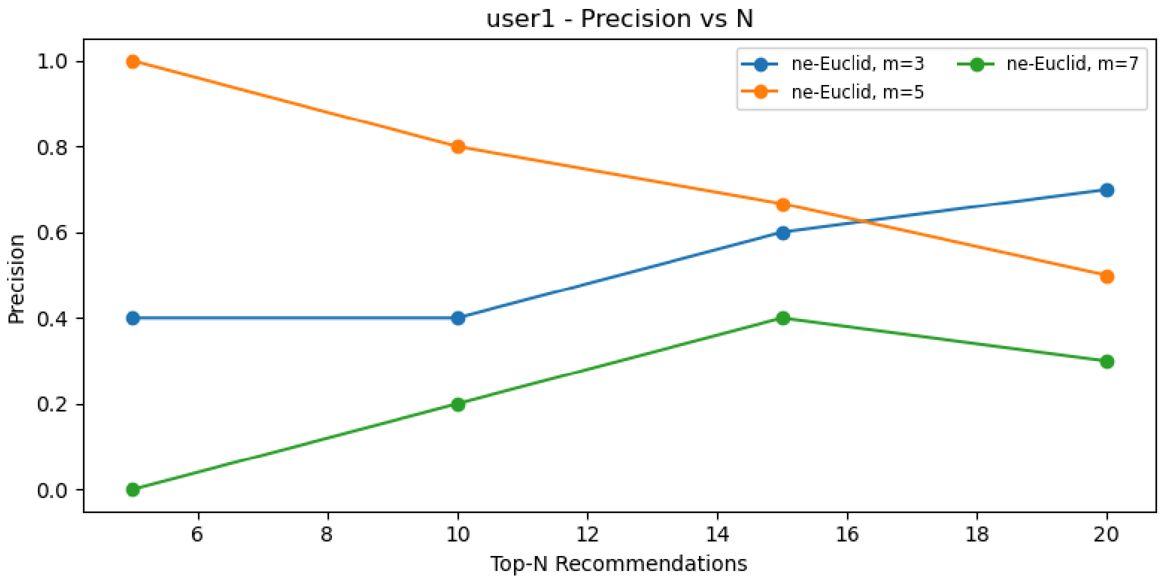

user1 - Recall vs N
Recall
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7

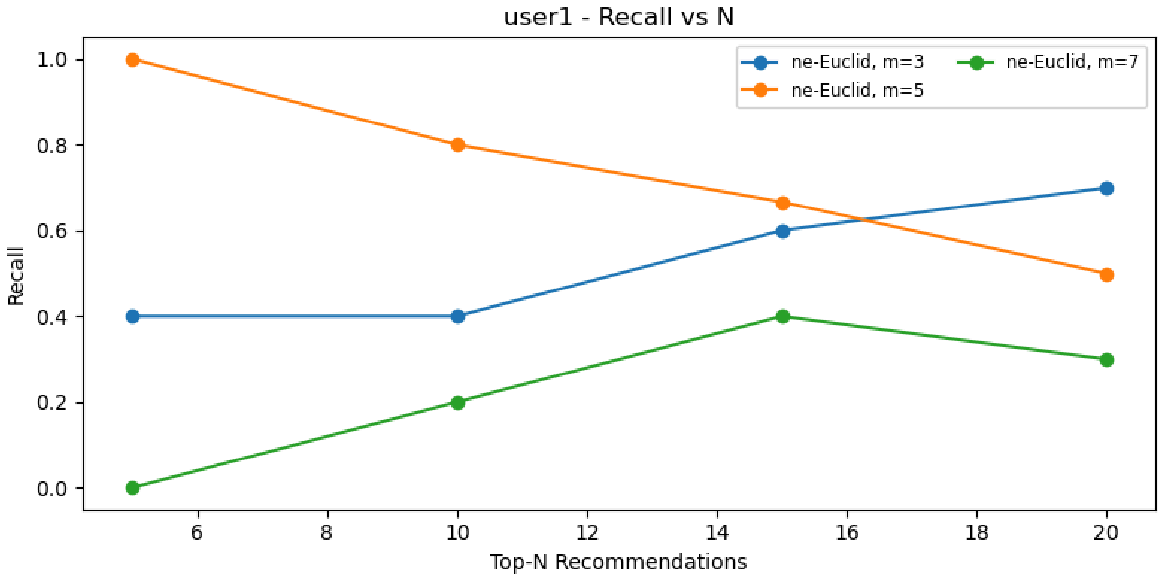

user1 - F1 vs N
F1
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7

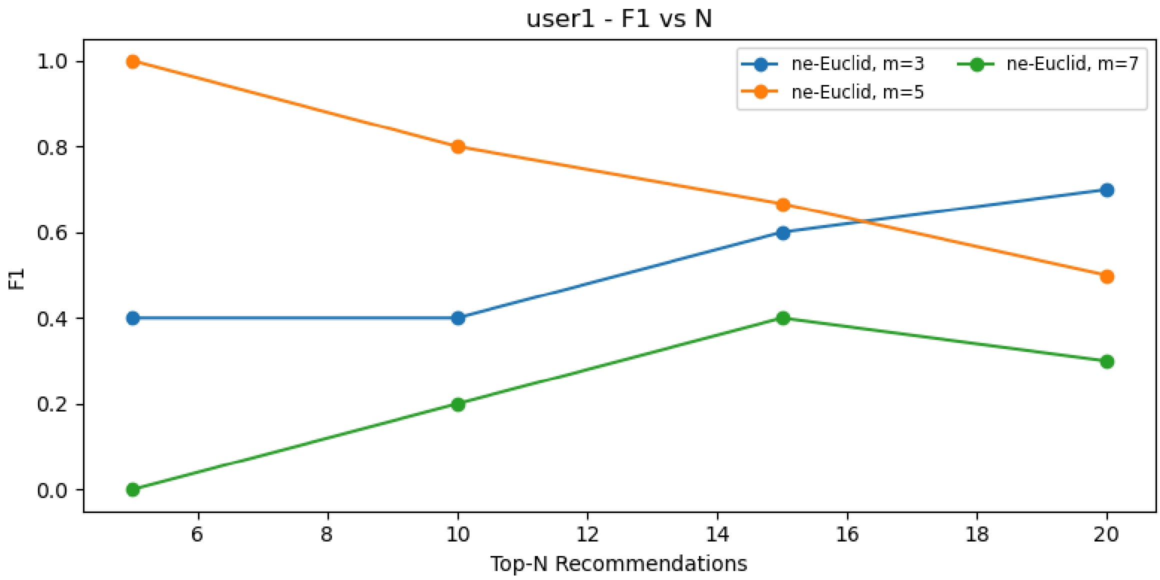

user1 - Precision vs N
Precision
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20

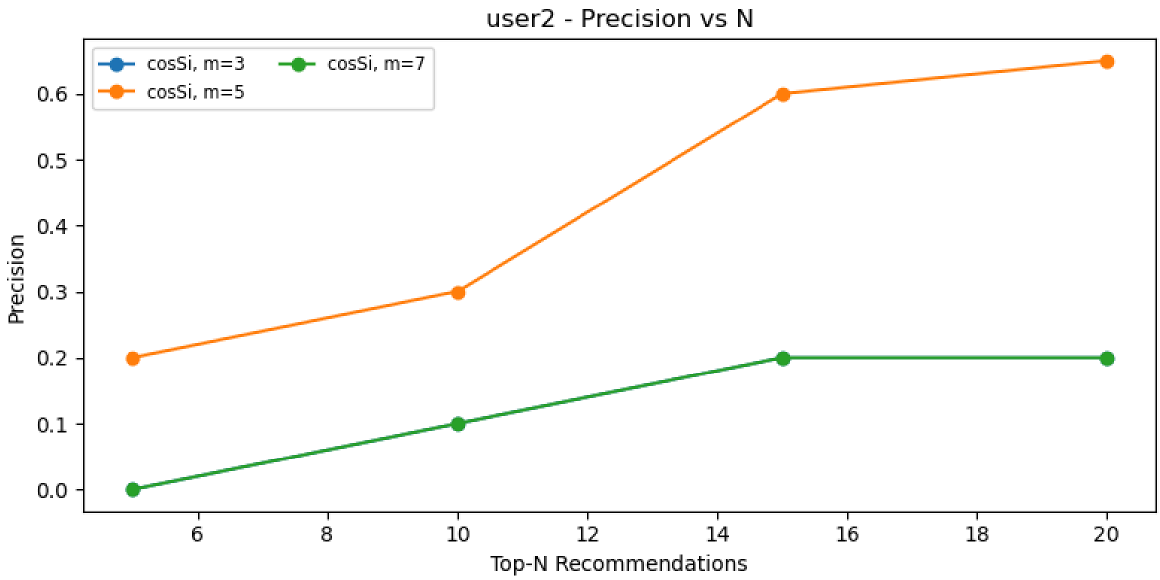

user1 - Recall vs N
Recall
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20

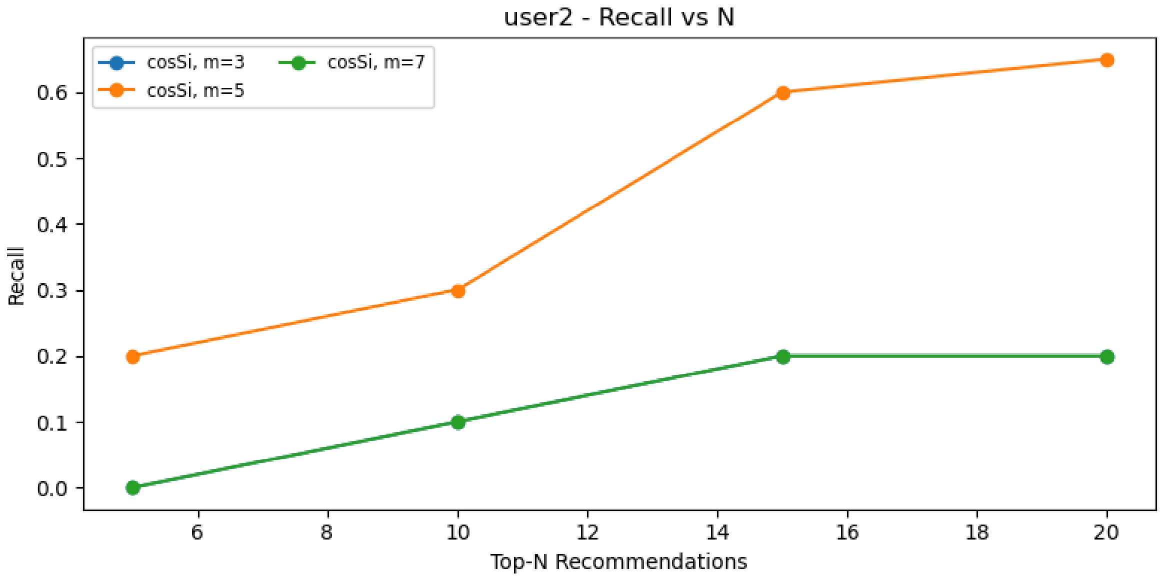

user1 - F1 vs N
F1
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20

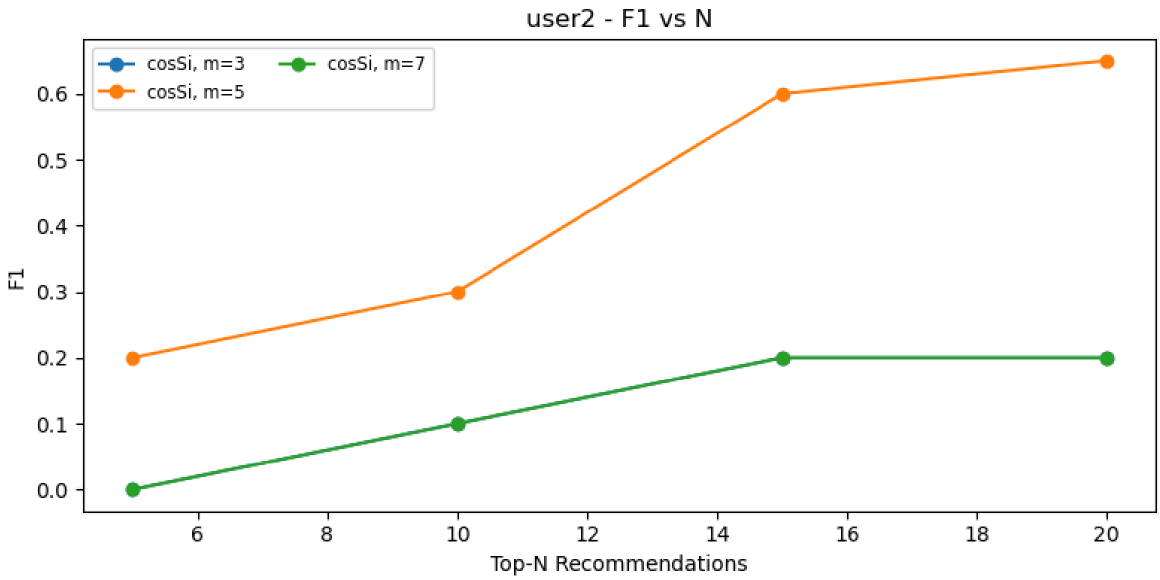

user1 - Precision vs N
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7
Precision
1.0
0.8
0.6
0.4
0.2
0.0
6
8
10
12
14
16
18
20
Top-N Recommendations

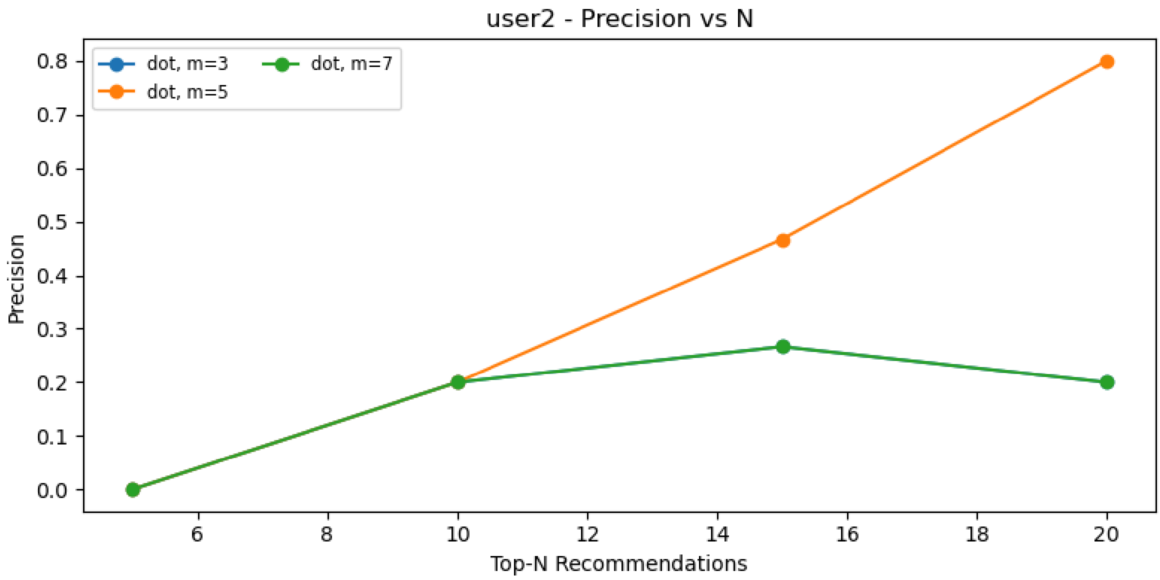

user1 - Recall vs N
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7
Recall
1.0
0.8
0.6
0.4
0.2
0.0
6
8
10
12
14
16
18
20
Top-N Recommendations

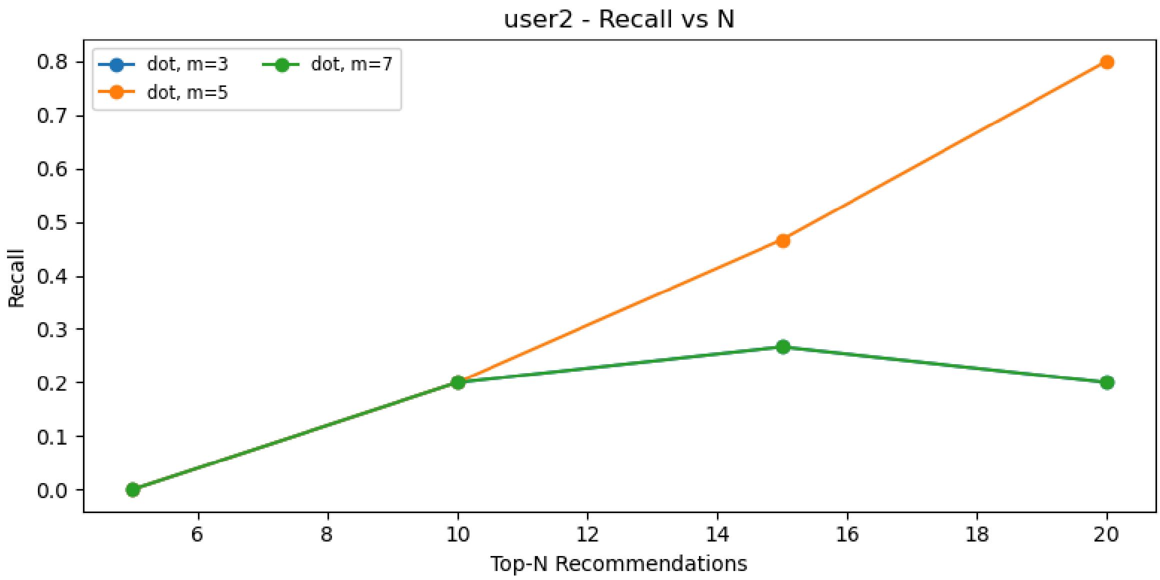

user1 - F1 vs N
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7
F1
1.0
0.8
0.6
0.4
0.2
0.0
6
8
10
12
14
16
18
20
Top-N Recommendations

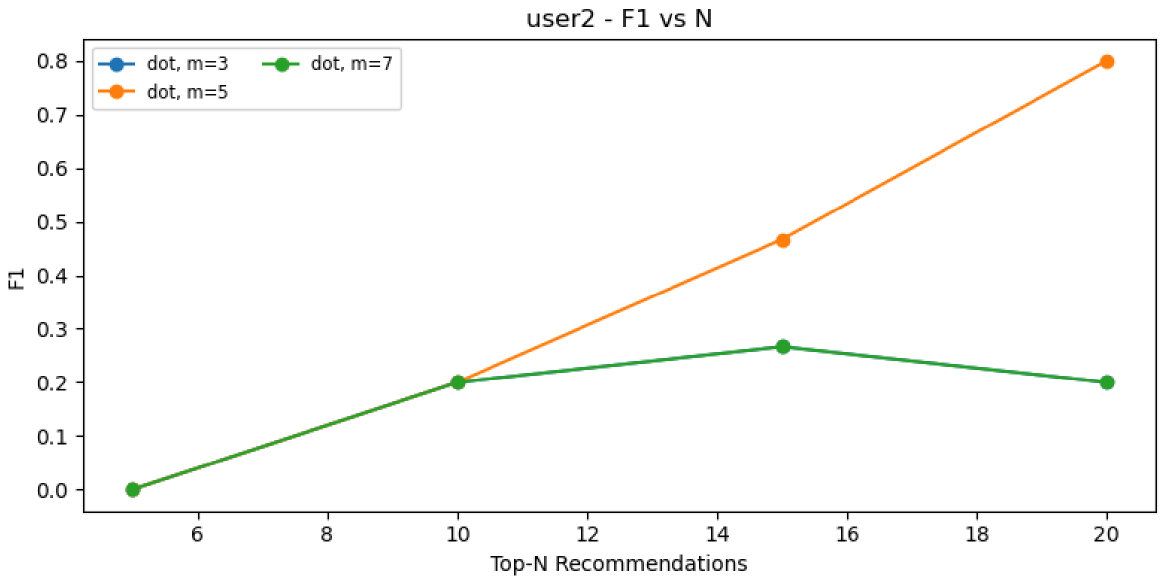

user2 - Precision vs N
cosSi, m=3
cosSi, m=5
cosSi, m=7
Precision
0.0
0.1
0.2
0.3
0.4
0.5
0.6
6
8
10
12
14
16
18
20
Top-N Recommendations

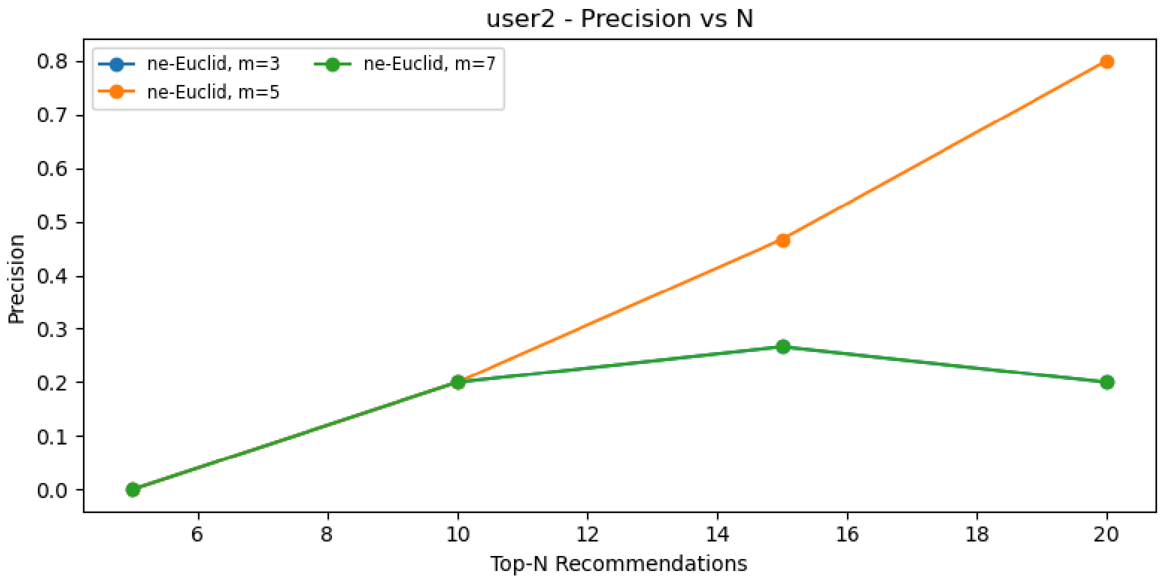

user2 - Recall vs N
cosSi, m=3
cosSi, m=5
cosSi, m=7
Recall
0.0
0.1
0.2
0.3
0.4
0.5
0.6
6
8
10
12
14
16
18
20
Top-N Recommendations

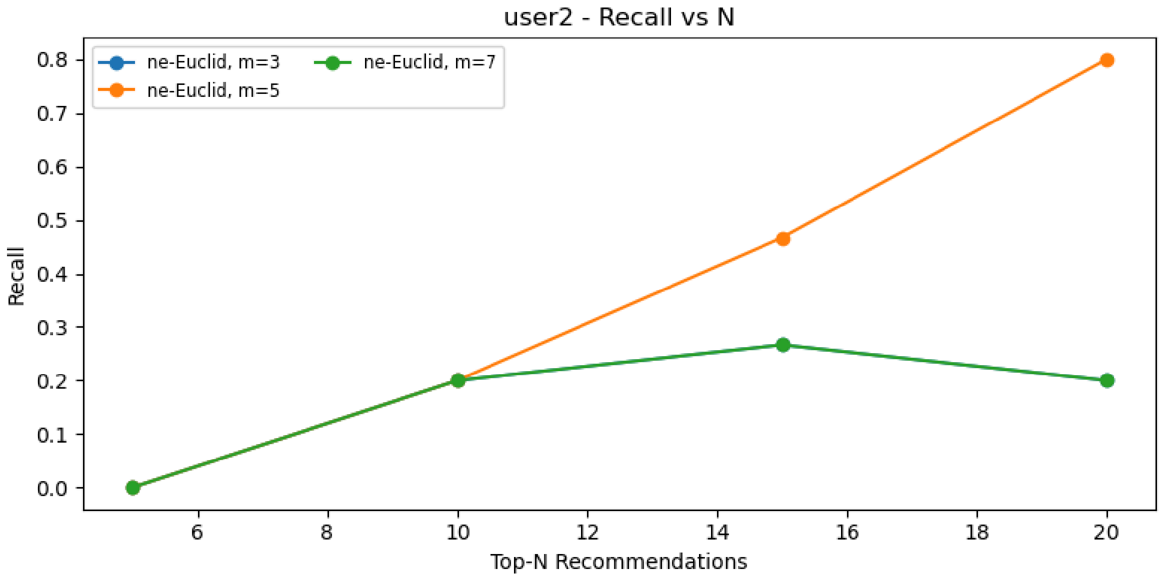

user2 - F1 vs N
cosSi, m=3
cosSi, m=5
cosSi, m=7
F1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
6
8
10
12
14
16
18
20
Top-N Recommendations

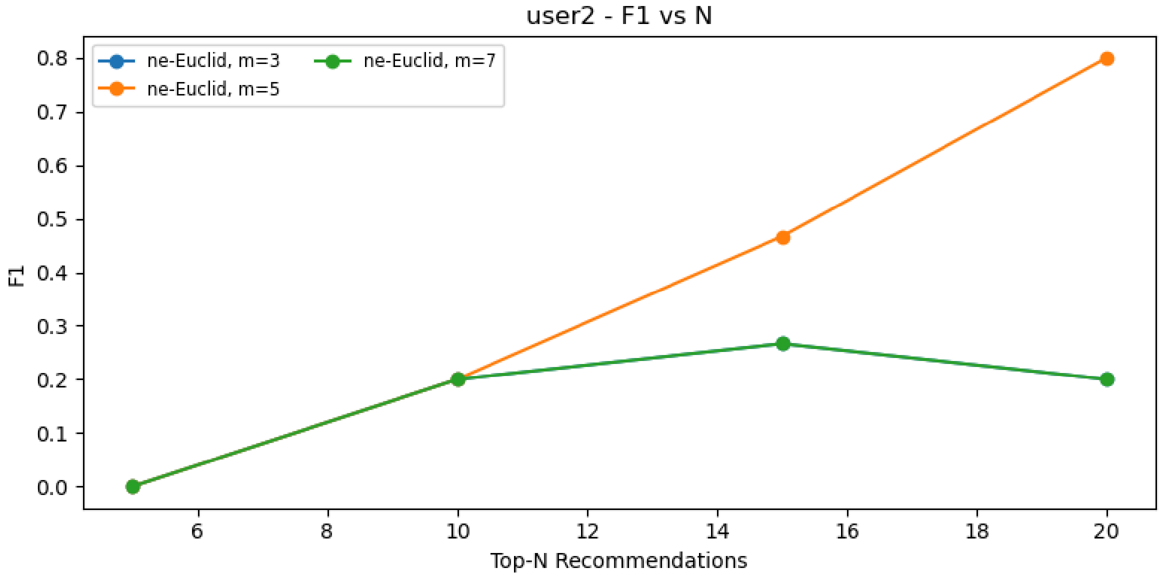

user2 - Precision vs N
dot, m=3
dot, m=5
dot, m=7
Precision
Top-N Recommendations
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
6
8
10
12
14
16
18
20

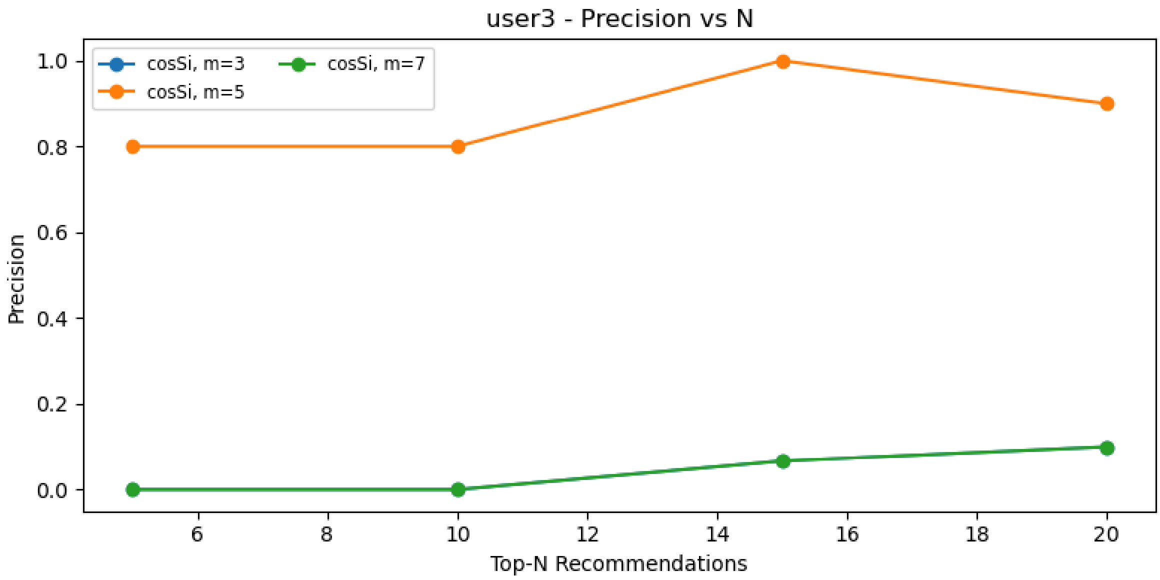

user2 - Recall vs N
dot, m=3
dot, m=5
dot, m=7
Recall
Top-N Recommendations
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
6
8
10
12
14
16
18
20

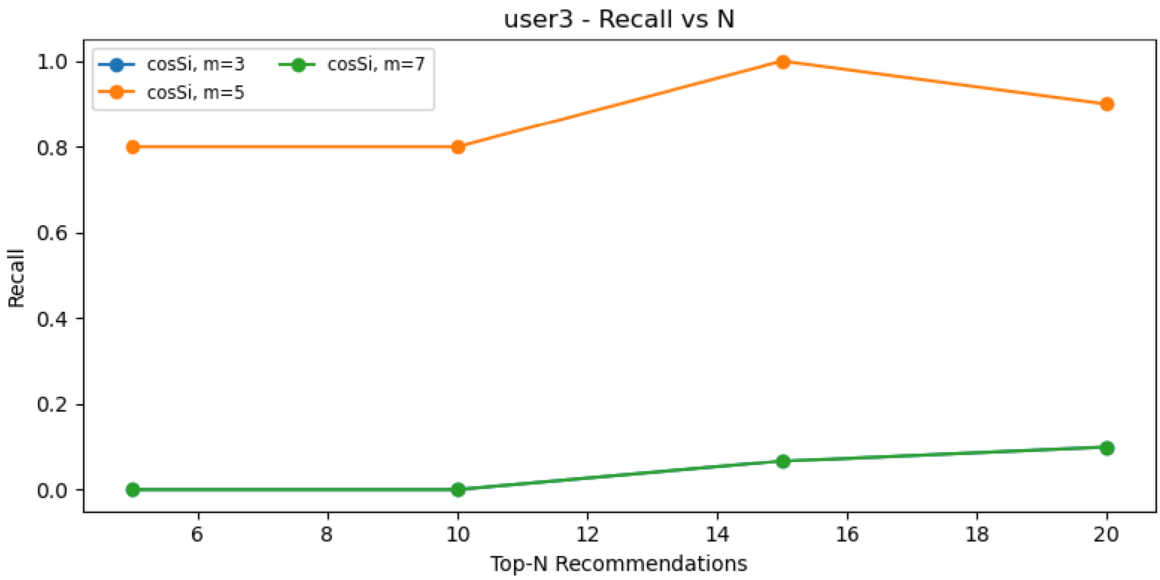

user2 - F1 vs N
dot, m=3
dot, m=5
dot, m=7
F1
Top-N Recommendations
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
6
8
10
12
14
16
18
20

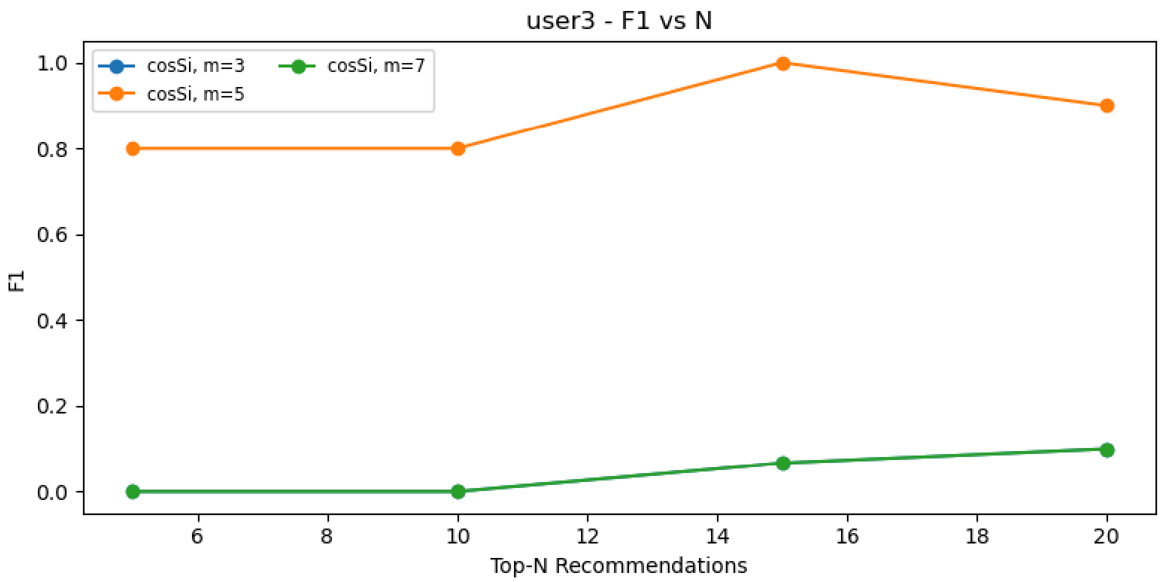

user2 - Precision vs N
Precision
Top-N Recommendations
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7

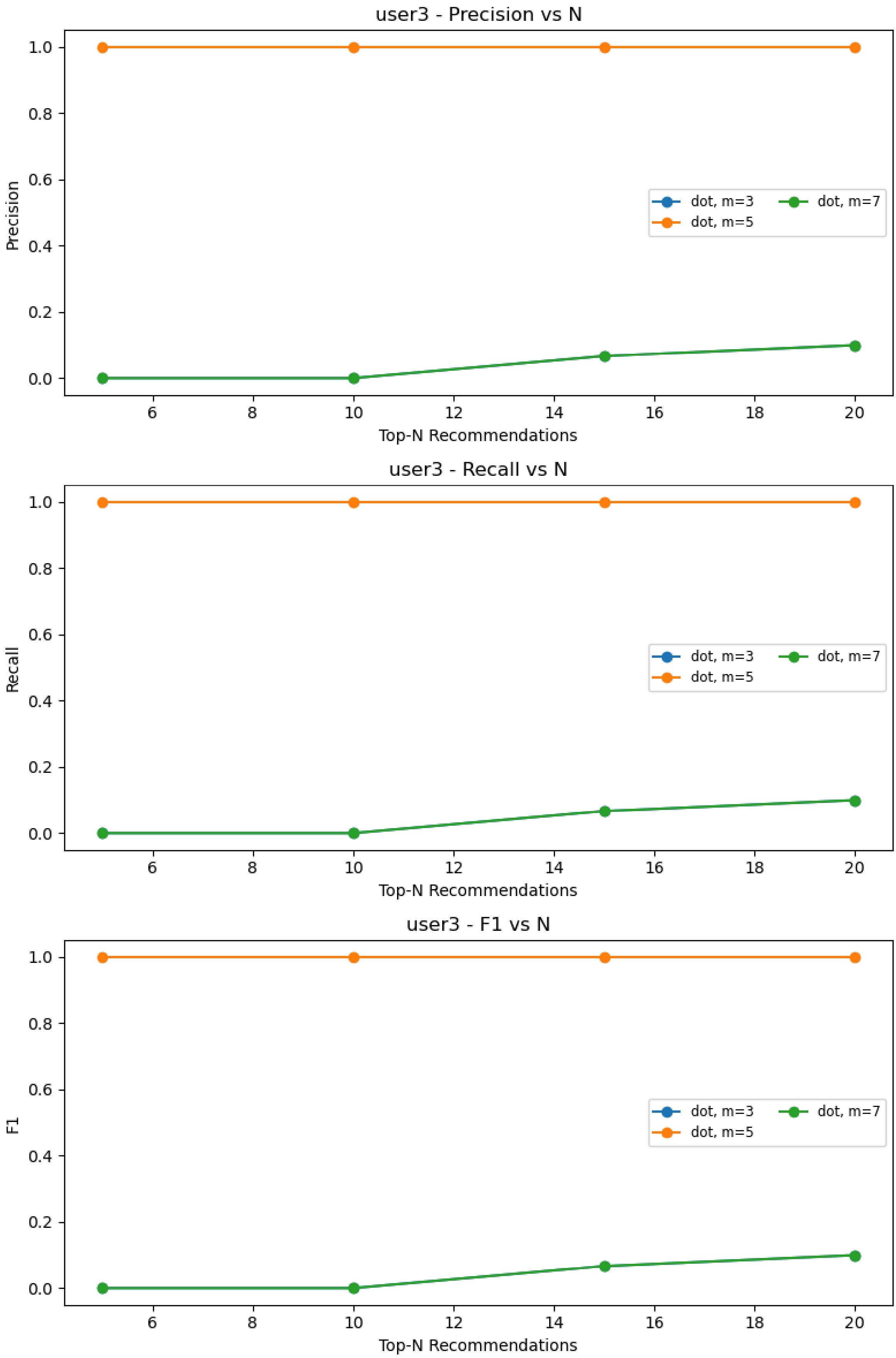

user2 - Recall vs N
Recall
Top-N Recommendations
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7

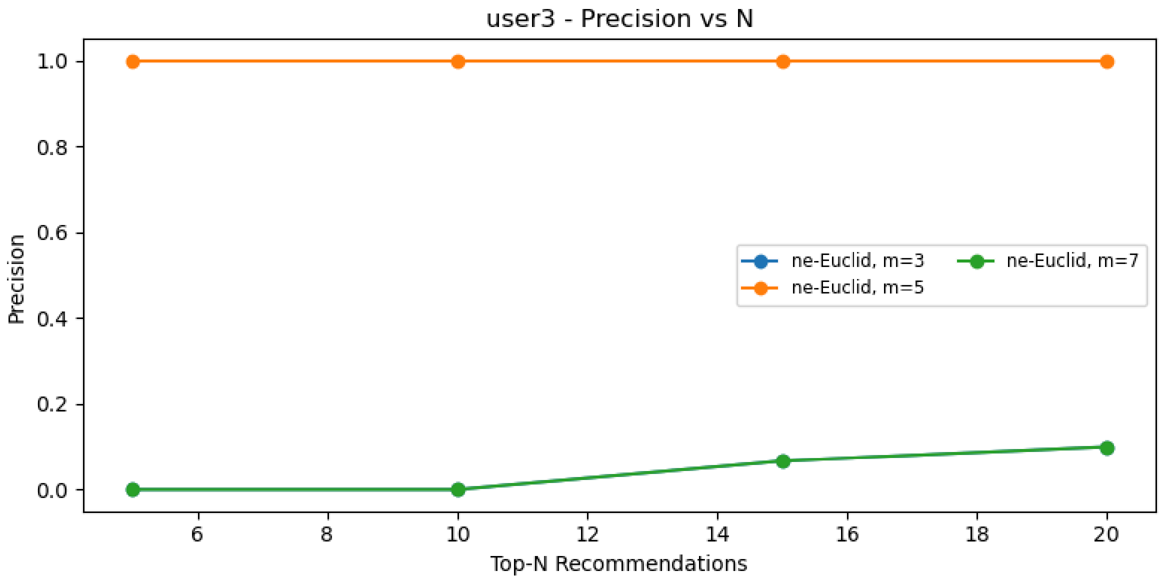

user2 - F1 vs N
F1
Top-N Recommendations
ne-Euclid, m=3
ne-Euclid, m=5
ne-Euclid, m=7

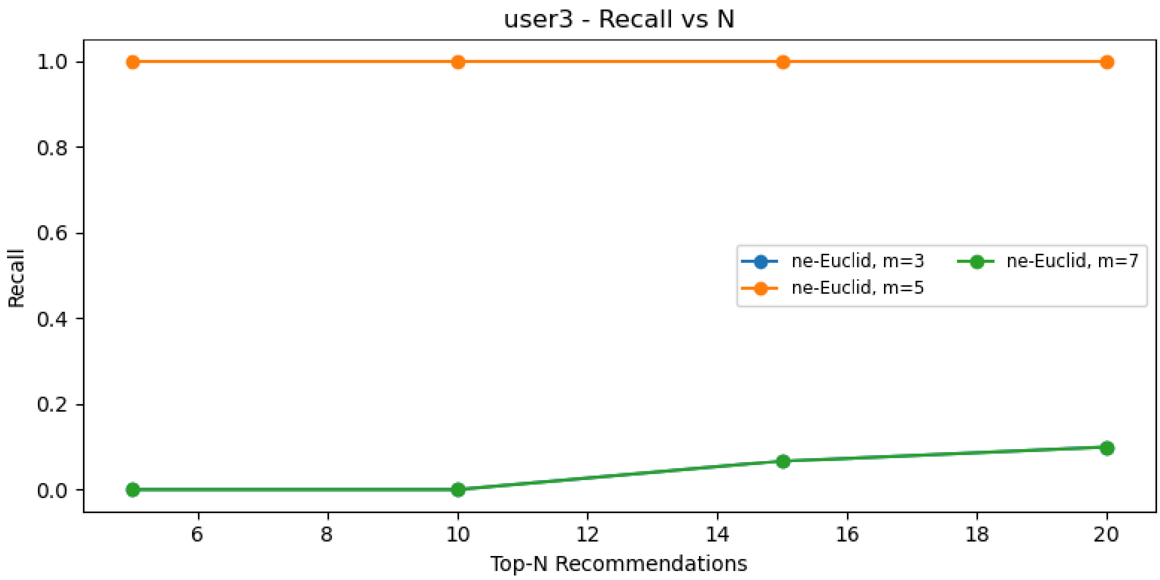

user3 - Precision vs N
Precision
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20

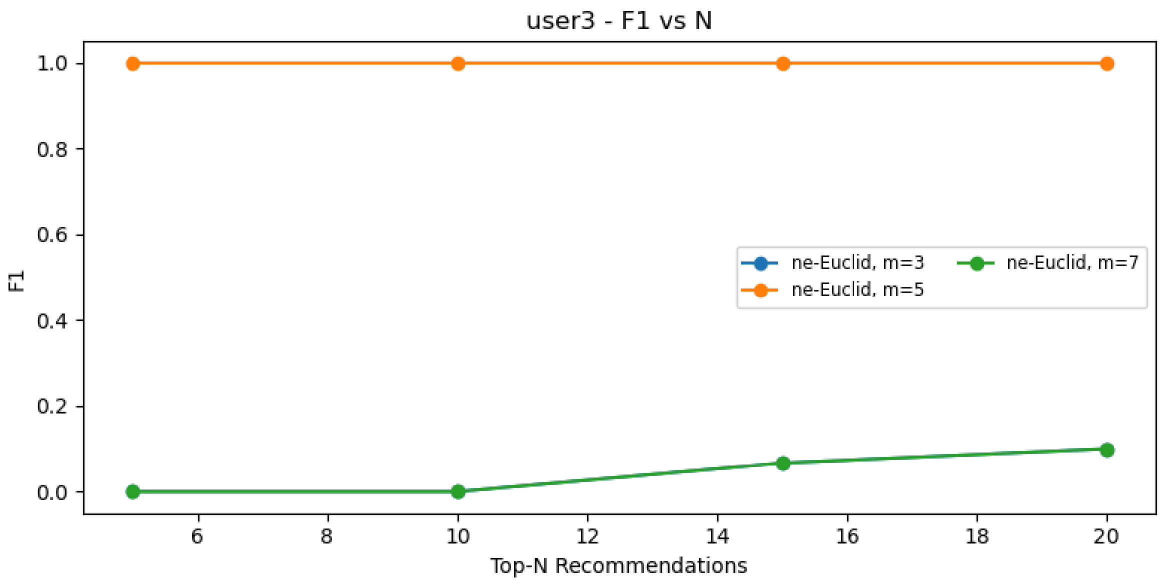

user3 - Recall vs N
Recall
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20


user3 - F1 vs N
F1
Top-N Recommendations
cosSi, m=3
cosSi, m=5
cosSi, m=7
0.0
0.2
0.4
0.6
0.8
1.0
6
8
10
12
14
16
18
20


user3 - Precision vs N
Precision
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7
user3 - Recall vs N
Recall
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7
user3 - F1 vs N
F1
Top-N Recommendations
dot, m=3
dot, m=5
dot, m=7







For this question, I selected 3 different algorithms: `dot`, `cosine_similarity`, and `-euclidean_distances` and with different values of `n` and `m`, resulting in a total of 108 rows of data. To make the results more interpretable, I used the ling graphs to indicate that. I noticed that many of the blue lines in the graph were missing, so I printed all the data where `m = 3` in the above.

According to the data, the blue line (`m=3`) frequently overlaps with the green line, indicating similar performance. The tables show that varying `m` and `n` affect the results. In most case, the best performance when `m = 5` , although occasionally `m = 3` and `m = 7` yield similar results.

From `user3` , we can know `dot` and `-euclidean_distances` have almost identical, while the scores from `cosine_similarity` are consistently a little lower. For the other two users, `dot` and `-euclidean_distances` are similar, but `cosine_similarity` demonstrates greater variability and generally worse performance. This may be due to the different number of keywords for users, which could significantly impact the model's ability to recognise user preferences.

Based on these findings, I chose `-euclidean_distances` as the algorithm for user profile construction in Part 3.

part 3

In this part, I invited a friend to serve as a user for the experiment. First, I used weekx.sample(n=15) to randomly select 15 songs to recommend to the user. Based on the songs they liked, I then created a `tf-idf` matrix and applied `euclidean_distances` to recommend `15` additional songs from week4.

The decision to use `15` songs was based on findings from the previous question. For `User1` , smaller values of n tended to yield lower performance, while for `User2` , larger values of n resulted in better outcomes. Therefore, I selected `15` as a balanced, intermediate value.

In [40]:
```
# part 3
week1P3 = df[1:251]
# print(week1)
week2P3 = df[251:501]
# print(week2)
week3P3 = df[501:751]
# print(week3)
```

In [41]:
```
#example
week3Ra = week3P3.sample(n=15)
```

week1 recommended songs

if user_like = 1, it means the user likes this song

index	artist_name	track_name	release_date	user_like
43	riley richard	l.i.t.	2018	
209	morcheeba	never undo	2018	
98	aaron shust	ever be	2016	

index	artist_name	track_name	release_date	user_like
102	smile empty soul	silhouettes	2016	
110	death from above 1979	statues	2017	
76	ty segall	i worship the dog	2019	
180	chris stapleton	up to no good livin'	2017	1
228	sleeping wolf	new kings	2017	1
187	janis joplin	careless love	2016	
36	parker millsap	hades pleads	2016	1
173	santana	blue skies	2019	
95	the black angels	medicine	2017	
24	t-rock	be a g about it	2016	
67	311	dodging raindrops	2019	1
182	cody johnson	billy's brother	2016	1

week2 recommanded songs

index	artist_name	track_name	release_date	user_like
420	tim mcgraw	the rest of our life	2017	
279	yungblud	loner	2019	
387	magic giant	window	2017	
362	tenth avenue north	i have this hope	2016	1
355	el michels affair	tearz	2017	
367	gary clark jr.	the governor	2019	
435	louis armstrong	life is so peculiar	2016	
274	melodiesinfonie	tokyo	2018	
326	billie eilish	bored	2017	1
489	blues saraceno	kicking and screaming	2018	1
312	dorothy	raise hell	2016	1
432	mitch rossell	ask me how i know	2019	
336	blake shelton	go ahead and break my heart (feat. gwen stefani)	2016	1
422	riley green	that's how ya left me	2018	
446	soja	life support	2017	

week3 recommanded songs

index	artist_name	track_name	release_date	user_like
553	grandson	apologize	2019	
659	twenty one pilots	neon gravestones	2018	
622	phil wickham	the secret place	2016	
746	joe bonamassa	what i've known for a very long time	2016	
727	korn	rotting in vain	2016	
611	the black angels	life song	2017	1
687	tedeschi trucks band	don’t drift away	2017	1
693	seafret	wildfire	2016	1
629	jamie n commons	low life	2016	
649	the dear hunter	gloria	2016	
554	all them witches	rob's dream	2018	
565	twenty one pilots	chlorine	2018	1
639	vampire weekend	sympathy	2019	
648	luke bryan	most people are good	2017	1
738	car bomb	secrets within	2016	

In [45]:

```
user_person_like = week3.iloc[[180 ,228,36, 67,182,362, 326, 489 ,312,336 ,611,6
print(user_person_like.shape)
# print(user_person_like)
```

```
(15, 7)
```

In [46]:

```
#this part was create user profile, and create tf-idf same with question 2 part
def RealPersonfinalAllSongHaveKey(user_person_like,user_lyric):
    topicAllFromPerson = user_person_like['pre_topic'].unique().tolist()
    for topic in topicAllFromPerson:
        allsameTopic = (user_person_like['pre_topic'] == topic)
        goodSonglyr = user_person_like.loc[allsameTopic, 'lyrics']
        user_lyric[topic] = ' '.join(goodSonglyr.tolist())

user_Person_allLyrics = {}
RealPersonfinalAllSongHaveKey(user_person_like, user_Person_allLyrics)

for i in user_Person_allLyrics:
    print(f"the topic is {i} and have words {len(user_Person_allLyrics[i])}")

def RealPersonTF(user_Person_allLyrics, user_Person_tfivec):
    for topic, lyric in user_Person_allLyrics.items():
        vec = tfi[topic]['vectorize']
        user_Person_tfivec[topic] = vec.transform([lyric])
```

```
user_Person_tfivec = {}
RealPersonTF(user_Person_allLyrics, user_Person_tfivec)

print(user_Person_tfivec)
```

```
the topic is personal and have words 3789
the topic is dark and have words 3708
the topic is sadness and have words 1138
{'personal': <1x500 sparse matrix of type '<class 'numpy.float64'>'
	with 142 stored elements in Compressed Sparse Row format>, 'dark': <1x500
sparse matrix of type '<class 'numpy.float64'>'
	with 139 stored elements in Compressed Sparse Row format>, 'sadness': <1x
500 sparse matrix of type '<class 'numpy.float64'>'
	with 69 stored elements in Compressed Sparse Row format>}
```

In [47]:

```
#this this recommend n song according to user tf-idf matrics
def RealPersonTopNSong(week, user_Person_tfivec):

    allSongList = []
    for idx, row in week.iterrows():
        idTopic = row['pre_topic'].strip()
        if idTopic not in user_Person_tfivec:
            continue

        # print(idTopic)
        idvec = tfi[idTopic]['vectorize'].transform([row['lyrics']])
        # idSimila = cosine_similarity(idvec, user_Person_tfivec[idTopic])[0,0]
        idSimilaA = -euclidean_distances(idvec, user_Person_tfivec[idTopic])[0,0
        allSongList.append((idx, idSimilaA))
    allSongList.sort(key=lambda x: x[1], reverse=True)

    songlist = [idx for idx,_ in allSongList]

    return songlist
user_Person_recommondList = RealPersonTopNSong(week4,user_Person_tfivec)
print(user_Person_recommondList[:15])
#I also use cosine_similarity to get recommend song I found there are same recom
```

```
[783, 797, 989, 994, 769, 871, 952, 772, 911, 765, 786, 826, 909, 794, 828]
```

In [48]:

```
# then we can get recommond list there are
user_Person_recomond = week4.loc[[783, 797, 989, 994, 769, 772, 871, 952, 786, 8
print(user_Person_recomond)
```

```
                             artist_name                   track_name  \
783  lukas nelson and promise of the real           breath of my baby   
797                         billie eilish                       bored   
989                               solange          cranes in the sky   
994                          the national                 light years   
769                          charlie puth                one call away   
772                     black pistol fire              hearts of habit   
871                     sir charles jones         i'm going down slow   
952                        jonas brothers         don't throw it away   
786            michael franti & spearhead  summertime is in our hands   
826                                 six60                 the greatest   
911                     killswitch engage             i am broken too   
794                   tedeschi trucks band               in every heart   
909                          the lumineers                       walls   
991                             grouplove                good morning   
902                          nicole henry                  moon river   

     release_date   genre                                             lyrics  \
783          2017   blues  hear sound ascend grind pray stay die trust tr...   
797          2017     pop  game play stay give beg give need want settle ...   
989          2016     pop  try drink away try try dance away try change h...   
994          2019    rock  wait outside lay soak feet start know go lose ...   
769          2016     pop  away save superman away baby need friend wanna...   
772          2017   blues  record little late wrong go know better baby k...   
871          2016   blues  make believe leave blue dream make believe mak...   
952          2019     pop  picture frame pack things help week get like c...   
786          2016  reggae  summertime mind winter want feel rain fall awa...   
826          2019  reggae  know taste tear face yeah remind dream chase f...   
911          2019    rock  weight try cover mistake like break right caus...   
794          2016   blues  heart perfume blame heart story face leave dre...   
909          2018    rock  days diamonds days rock doors open roads block...   
991          2017    rock  live wide awake yeah stranger addict self rear...   
902          2018    jazz  put word mouth know troublin gonna know hear l...   

        topic pre_topic  
783   sadness   sadness  
797  personal  personal  
989   sadness   sadness  
994   sadness   sadness  
769   sadness   sadness  
772   sadness   sadness  
871  personal  personal  
952   sadness   sadness  
786  personal  personal  
826   sadness   sadness  
911   sadness   sadness  
794   sadness   sadness  
909   sadness   sadness  
991      dark      dark  
902      dark      dark  
```

index	artist_name	track_name	release_date	genre	user_like
783	lukas nelson and promise...	breath of my baby	2017	blues	
797	billie eilish	bored	2017	pop	1
989	solange	cranes in the sky	2016	pop	

index	artist_name	track_name	release_date	genre	user_like
994	the national	light years	2019	rock	
769	charlie puth	one call away	2016	pop	
772	black pistol fire	hearts of habit	2017	blues	
871	sir charles jones	i'm going down slow	2016	blues	
952	jonas brothers	don't throw it away	2019	pop	1
786	michael franti & spearhead	summertime is in our hands	2016	reggae	
826	six60	the greatest	2019	reggae	1
911	killswitch engage	i am broken too	2019	rock	
794	tedeschi trucks band	in every heart	2016	blues	1
909	the lumineers	walls	2018	rock	
991	grouplove	good morning	2017	rock	
902	nicole henry	moon river	2018	jazz	1

In [50]:
```
same = 5
n = 15
P = same / n
R = same / len(user_week4_like) if user_week4_like else 0.0
F1 = 2 * P * R / (P + R) if (P + R) else 0.0
print(f"for real person p is {P}, R is {R}, and f1 is {F1}")
```

```
for real person p is 0.3333333333333333, R is 0.25, and f1 is 0.28571428571428575
```

In [51]:
```
print(df.iloc[[797,326]])
```

```
      artist_name track_name  release_date genre  \
797  billie eilish      bored          2017   pop
326  billie eilish      bored          2017   pop

                                               lyrics     topic
797  game play stay give beg give need want settle ...  personal
326  game play stay give beg give need want settle ...  personal
```

Finally, based on the model's result, it is evident that the performance was not particularly good. This discrepancy may reflect a gap between theoretical expectations and the real world. This result may be caused by a song choice: for example, my friend was not very interested in English songs and expressed a preference for Japanese songs. This may have influenced the results.

Another potential factor is the algorithm choice: there may be more better algorithm that I have not found. It is also possible that the value of `n` was not large enough to capture sufficient user preferences. In future work, I plan to examine successful recommendation systems to identify which algorithms they use.

Additionally, I discovered that two of the recommended songs were duplicates.

```
In [ ]:
```