Plotting alignment data

In [1]:
```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
import json
import csv
import math
import pandas as pd
import utils.db_utils as db
import utils.plot_utils as plot
import utils.file_utils as file
import config

############################################
# get configuration
cfg = config.getConfig() # configure values in config.js
############################################

targetLang = cfg['targetLang']
bibleType = cfg['targetBibleType']
tWordsTypeList = cfg['tWordsTypeList']
dbPath = cfg['dbPath']
trainingDataPath = cfg['trainingDataPath']
testamentStr = cfg['testamentStr']
baseDataPath = cfg['baseDataPath']
```

In [2]:
```
# get alignments for tWords

minAlignments = 20
remove = ['ὁ', 'τὸ', 'τὰ', 'αὐτός', 'λέγω', 'ὡς', 'μέν', 'εἷς']

alignmentsForWord, filteredAlignmentsForWord = db.fetchAlignmentDataForAllTWordsCached(trainingDataPath, bib
print(f"Original Language Alignments: {len(filteredAlignmentsForWord)}")
```

```
Using cached Alignments
Unfiltered Alignments: 4368
filtered alignments by original list count is 243
Size of filtered alignments by original ./data/en/ult/TrainingData/kt_en_ult_NT_alignments_by_orig_20.json i
s 7.628 MB
Size of filtered alignments by original ./data/en/ult/TrainingData/kt_en_ult_NT_alignments_by_orig_20.csv is
2.076 MB
Filtered Alignments: 243
Using cached Alignments
Unfiltered Alignments: 538
filtered alignments by original list count is 33
Size of filtered alignments by original ./data/en/ult/TrainingData/names_en_ult_NT_alignments_by_orig_20.jso
n is 1.298 MB
Size of filtered alignments by original ./data/en/ult/TrainingData/names_en_ult_NT_alignments_by_orig_20.csv
is 0.363 MB
Filtered Alignments: 33
Using cached Alignments
Unfiltered Alignments: 7380
filtered alignments by original list count is 250
Size of filtered alignments by original ./data/en/ult/TrainingData/other_en_ult_NT_alignments_by_orig_20.jso
n is 6.275 MB
Size of filtered alignments by original ./data/en/ult/TrainingData/other_en_ult_NT_alignments_by_orig_20.csv
is 1.670 MB
Filtered Alignments: 250
Original Language Alignments: 429
```

Analysis of alignments for tWords in the en_ult:

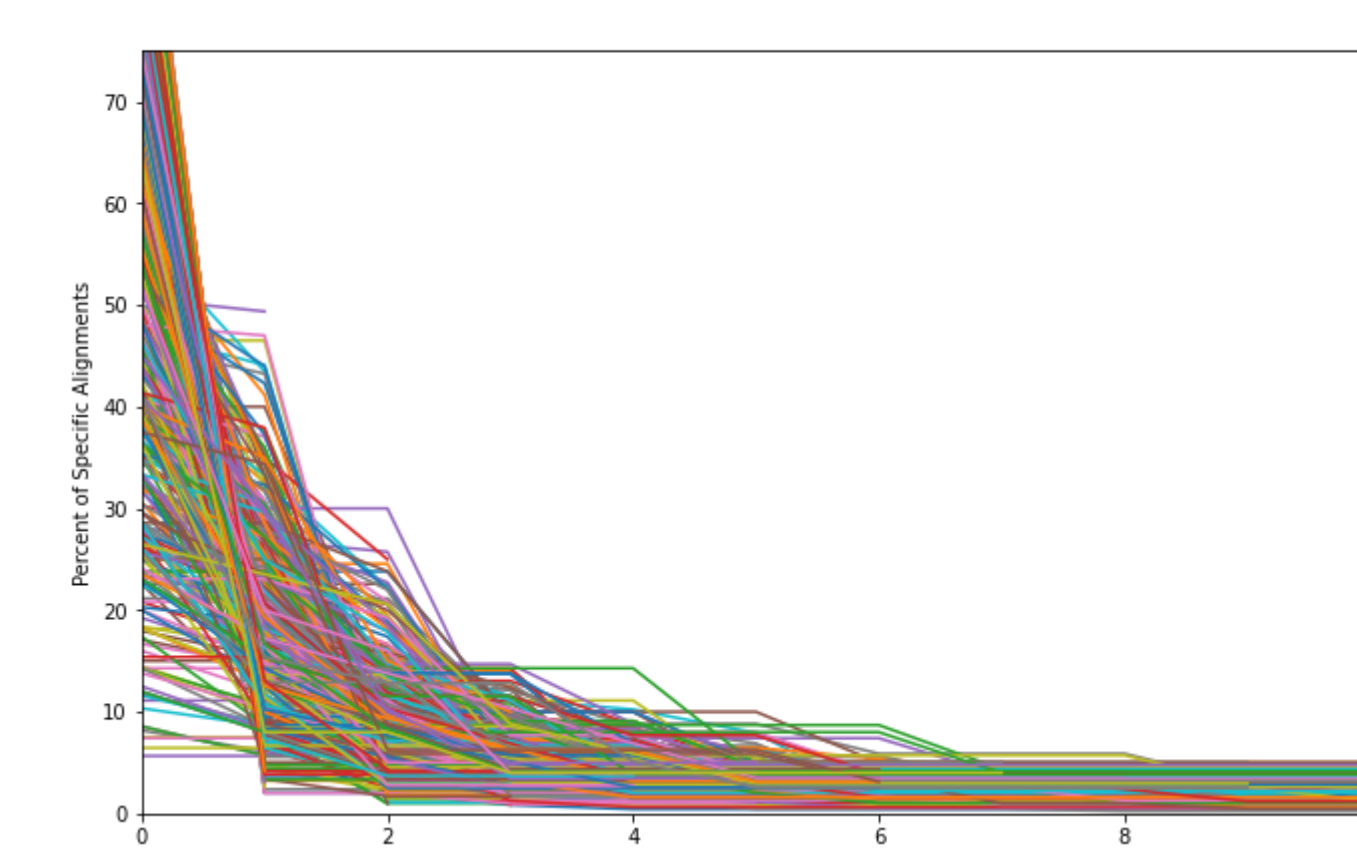
Frequency of alignments:

****Note that each line on the graphs below represents an alignment for a specific word. For example we have separate lines for 'Θεός', 'Θεὸς', or 'Θεοῦ' even though they have the same lemma. It made sense to group the alignments this way since aligners are likely to choose different target language words based on morphology of the word.*

In [3]:
```
frequenciesOfAlignments, stats = db.getFrequenciesOfFieldInAlignments(filteredAlignmentsForWord, 'alignmentT

print(f"Plotting of {len(filteredAlignmentsForWord)} tWord Alignments")
title = f"Plot of Variability of Specific Alignments in tWords"
ylabel = "Percent of Specific Alignments"
xlimit = [0, 10]
ylimit = [0, 75]
outputTable = plot.plotFrequencies(frequenciesOfAlignments, title, ylabel, showXValues=False, xlimit=xlimit,
csvPath = "plotData_freqOfTWords.csv"
db.saveListToCSV(csvPath, outputTable)
```

```
Plotting of 429 tWord Alignments
```

Plot of Variability of Specific Alignments in tWords



Out[3]:

	0	1	2	3	4	5	6	7	8	9	...	66	67	
0	95.918367	2.040816	2.040816	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
1	77.777778	6.666667	4.444444	4.444444	2.222222	2.222222	2.222222	NaN	NaN	NaN	...	NaN	NaN	Na
2	68.292683	17.073171	4.878049	2.439024	2.439024	2.439024	2.439024	NaN	NaN	NaN	...	NaN	NaN	Na
3	97.826087	2.173913	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
4	5.660377	5.660377	5.660377	5.660377	5.660377	3.773585	3.773585	3.773585	3.773585	1.886792	...	NaN	NaN	Na
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
424	45.000000	30.000000	10.000000	5.000000	5.000000	5.000000	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
425	37.500000	34.375000	6.250000	6.250000	6.250000	6.250000	3.125000	NaN	NaN	NaN	...	NaN	NaN	Na
426	52.000000	20.000000	16.000000	4.000000	4.000000	4.000000	NaN	NaN	NaN	NaN	...	NaN	NaN	Na
427	41.025641	15.384615	12.820513	12.820513	5.128205	2.564103	2.564103	2.564103	2.564103	2.564103	...	NaN	NaN	Na
428	64.000000	8.000000	8.000000	4.000000	4.000000	4.000000	4.000000	4.000000	NaN	NaN	...	NaN	NaN	Na

429 rows × 76 columns

In [4]:
```
print(f"Testing all tWords")
thresholds = {
    'alignmentOrigWordsThreshold': 3,
    'alignmentTargetWordsThreshold': 5,
    'origWordsBetweenThreshold': 1,
    'targetWordsBetweenThreshold': 1,
    'alignmentFrequencyMinThreshold': 5
}

type_ = 'all_twords'
warningData,summary = db.generateWarningsAndSummary(baseDataPath, type_, bibleType, testamentStr, filteredAl
                                                    thresholds, tag=f'{minAlignments}')
print(f"Found {len(warningData)} alignments to check - min threshold {minAlignments}")

frequencyWarnings = warningData[warningData['frequencyWarning'].str.len() > 0]
print (f"\nFound {len(frequencyWarnings)} frequencyWarnings")
frequencyWarningsByOrigWords = frequencyWarnings['originalWord'].value_counts()
print (f"FrequencyWarnings by original word:")
frequencyWarningsByOrigWords
```

```
Testing all tWords
saved summary of 429 original words to ./data/en/ult/all_twords_en_ult_NT_summary_20.csv
Found 1410 alignments to check - min threshold 20

Found 1148 frequencyWarnings
FrequencyWarnings by original word:
```

Out[4]:
```
ἐγένετο       65
Θεοῦ          50
Ἰησοῦς        37
Χριστοῦ       33
Ἰησοῦ         31
              ..
Ἱεροσόλυμα     1
δαιμόνια       1
θρόνου         1
ἀδελφὸν        1
Χριστός        1
Name: originalWord, Length: 166, dtype: int64
```

In [5]:
```
frequencyWarningsByLemma = frequencyWarnings['lemma'].value_counts()
print (f"FrequencyWarnings by lemma:")
frequencyWarningsByLemma
```

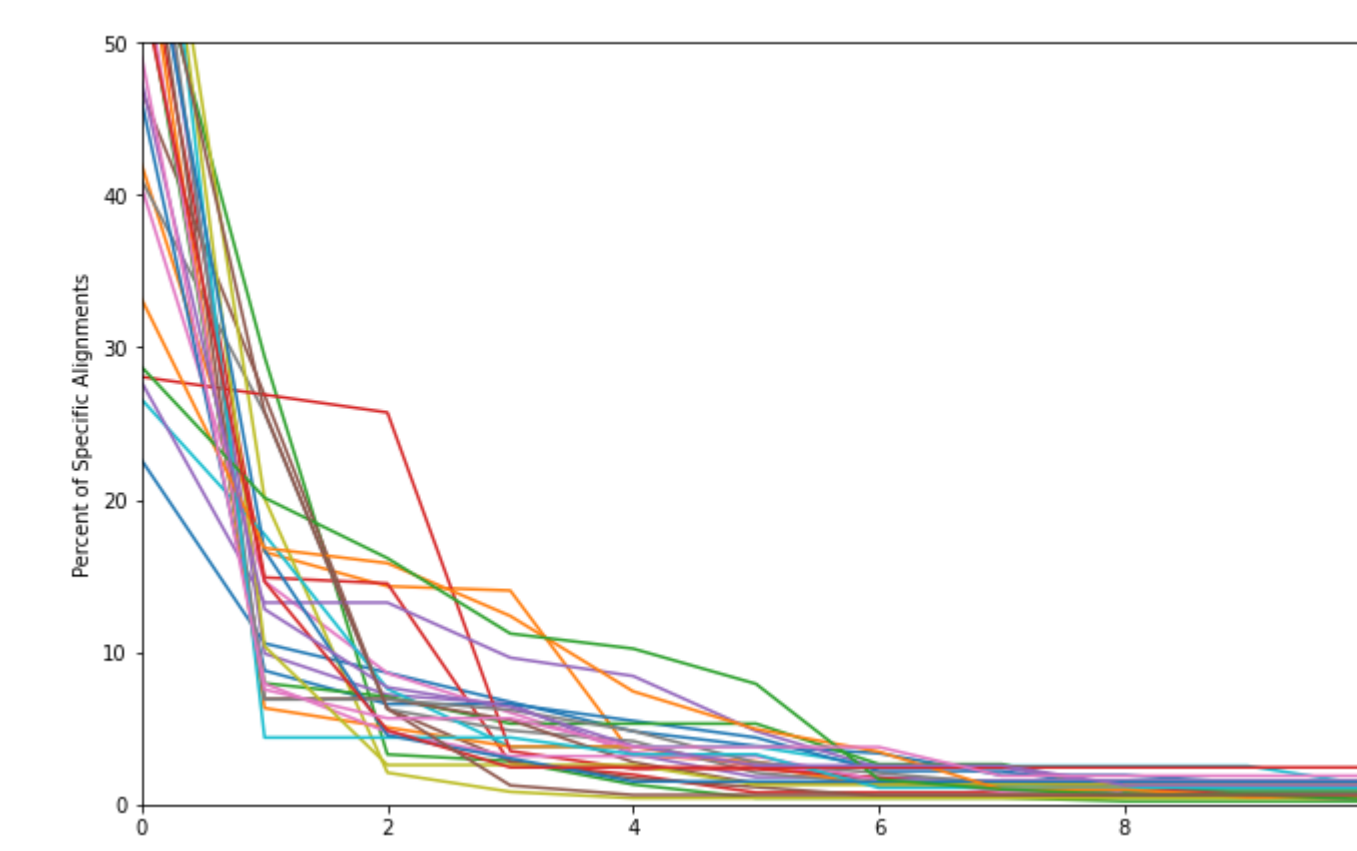
```
FrequencyWarnings by lemma:
```

Out[5]:
```
θεός          104
Ἰησοῦς         77
γίνομαι        65
ὁράω           50
ἡμέρα          45
             ...
δαιμόνιον       1
θρόνος          1
βασιλεία        1
ἔρημος          1
Ἱεροσόλυμα      1
Name: lemma, Length: 96, dtype: int64
```

In [6]:
```
minNumberOfWarnings = 10
origWordsWithWarnings = []
for key in frequencyWarningsByOrigWords.keys():
    count = frequencyWarningsByOrigWords[key]
    if count > minNumberOfWarnings:
        origWordsWithWarnings.append(key)

warningsAlignments = {}
for word in origWordsWithWarnings:
    warningsAlignments[word] = filteredAlignmentsForWord[word]
print(f"Found {len(origWordsWithWarnings)} original words with frequency warnings")

frequenciesOfAlignments, stats = db.getFrequenciesOfFieldInAlignments(warningsAlignments, 'alignmentText')

print(f"Plotting of {len(warningsAlignments)} tWord Alignments")
title = f"Plot of Variability of Alignments with Warnings"
ylabel = "Percent of Specific Alignments"
xlimit = [0, 10]
outputTable = plot.plotFrequencies(frequenciesOfAlignments, title, ylabel, showXValues=False, xlimit=xlimit)
csvPath = f"plotData_freqOfTWords_minWarnings_{minNumberOfWarnings}.csv"
db.saveListToCSV(csvPath, outputTable)
```

```
Found 27 original words with frequency warnings
Plotting of 27 tWord Alignments
```

Plot of Variability of Alignments with Warnings



Out[6]:

	0	1	2	3	4	5	6	7	8	9	...	56	
0	22.596154	10.576923	8.653846	6.730769	4.807692	3.846154	3.365385	1.923077	1.923077	1.442308	...	0.480769	0.4
1	41.994382	16.573034	14.325843	14.044944	3.230337	2.808989	1.544944	1.123596	0.702247	0.561798	...	NaN	
2	59.210526	29.385965	3.289474	2.850877	1.315789	0.438596	0.438596	0.438596	0.219298	0.219298	...	NaN	
3	57.647059	14.901961	14.509804	2.745098	1.960784	0.784314	0.784314	0.784314	0.784314	0.784314	...	NaN	
4	63.663664	9.909910	7.207207	6.606607	3.303303	1.801802	1.801802	1.501502	0.600601	0.600601	...	NaN	
5	46.857143	26.857143	6.285714	2.857143	1.714286	1.142857	0.571429	0.571429	0.571429	0.571429	...	NaN	
6	40.517241	14.655172	8.620690	6.034483	3.448276	2.586207	1.724138	0.862069	0.862069	0.862069	...	NaN	
7	40.972222	25.694444	6.250000	4.861111	4.166667	2.083333	1.388889	1.388889	1.388889	0.694444	...	NaN	
8	71.129707	20.083682	2.092050	0.836820	0.418410	0.418410	0.418410	0.418410	0.418410	0.418410	...	NaN	
9	26.582278	17.721519	7.594937	3.797468	3.797468	3.797468	2.531646	2.531646	2.531646	2.531646	...	NaN	
10	46.153846	8.791209	6.593407	6.593407	5.494505	4.395604	2.197802	2.197802	1.098901	1.098901	...	NaN	
11	58.227848	6.329114	5.063291	3.797468	3.797468	2.531646	1.265823	1.265823	1.265823	1.265823	...	NaN	
12	54.867257	7.964602	7.079646	5.309735	5.309735	5.309735	2.654867	2.654867	0.884956	0.884956	...	NaN	
13	28.070175	26.900585	25.730994	3.508772	2.339181	2.339181	1.754386	1.169591	1.169591	0.584795	...	NaN	
14	27.710843	13.253012	13.253012	9.638554	8.433735	4.819277	2.409639	2.409639	1.204819	1.204819	...	NaN	
15	61.111111	6.944444	6.944444	5.555556	2.777778	1.388889	1.388889	1.388889	1.388889	1.388889	...	NaN	
16	55.555556	7.936508	4.761905	3.174603	3.174603	3.174603	1.587302	1.587302	1.587302	1.587302	...	NaN	
17	66.206897	6.896552	6.896552	6.206897	4.827586	2.758621	2.068966	1.379310	0.689655	0.689655	...	NaN	
18	72.727273	10.389610	2.597403	2.597403	2.597403	1.298701	1.298701	1.298701	1.298701	1.298701	...	NaN	
19	73.626374	4.395604	4.395604	4.395604	3.296703	3.296703	1.098901	1.098901	1.098901	1.098901	...	NaN	
20	60.606061	16.666667	4.545455	3.030303	1.515152	1.515152	1.515152	1.515152	1.515152	1.515152	...	NaN	
21	33.168317	16.831683	15.841584	12.376238	7.425743	4.950495	3.465347	0.990099	0.990099	0.495050	...	NaN	
22	28.712871	20.132013	16.171617	11.221122	10.231023	7.920792	1.650165	0.990099	0.660066	0.660066	...	NaN	
23	53.658537	14.634146	4.878049	2.439024	2.439024	2.439024	2.439024	2.439024	2.439024	2.439024	...	NaN	
24	47.435897	12.820513	7.692308	6.410256	3.846154	2.564103	2.564103	2.564103	1.282051	1.282051	...	NaN	
25	61.006289	25.786164	6.289308	1.257862	0.628931	0.628931	0.628931	0.628931	0.628931	0.628931	...	NaN	
26	49.056604	7.547170	5.660377	5.660377	3.773585	3.773585	3.773585	1.886792	1.886792	1.886792	...	NaN	

27 rows × 66 columns

Analysis:

Analysis of numerical metrics:

Analysis of original language word count:

In [7]:
```
type_ = 'all'
field = 'origWordsCount'
field_frequencies, stats = db.getFrequenciesOfFieldInAlignments(filteredAlignmentsForWord, field, sortIndex
filledFrequencies = db.zeroFillFrequencies(field_frequencies)

print(f"Found {len(field_frequencies)} original language words for tW type {type_}")
title = f"Plot of number of Original Language Words in Specific Alignments in tW type {type_}"
ylabel = "Percent of Specific Alignments"
xlabel = "Original Language Words"
plot.plotXYdataDict(filledFrequencies, title, ylabel, xlabel, showXValues=True, xlimit=[1, 8])
```

```
Found 429 original language words for tW type all
```

Plot of number of Original Language Words in Specific Alignments in tW type all

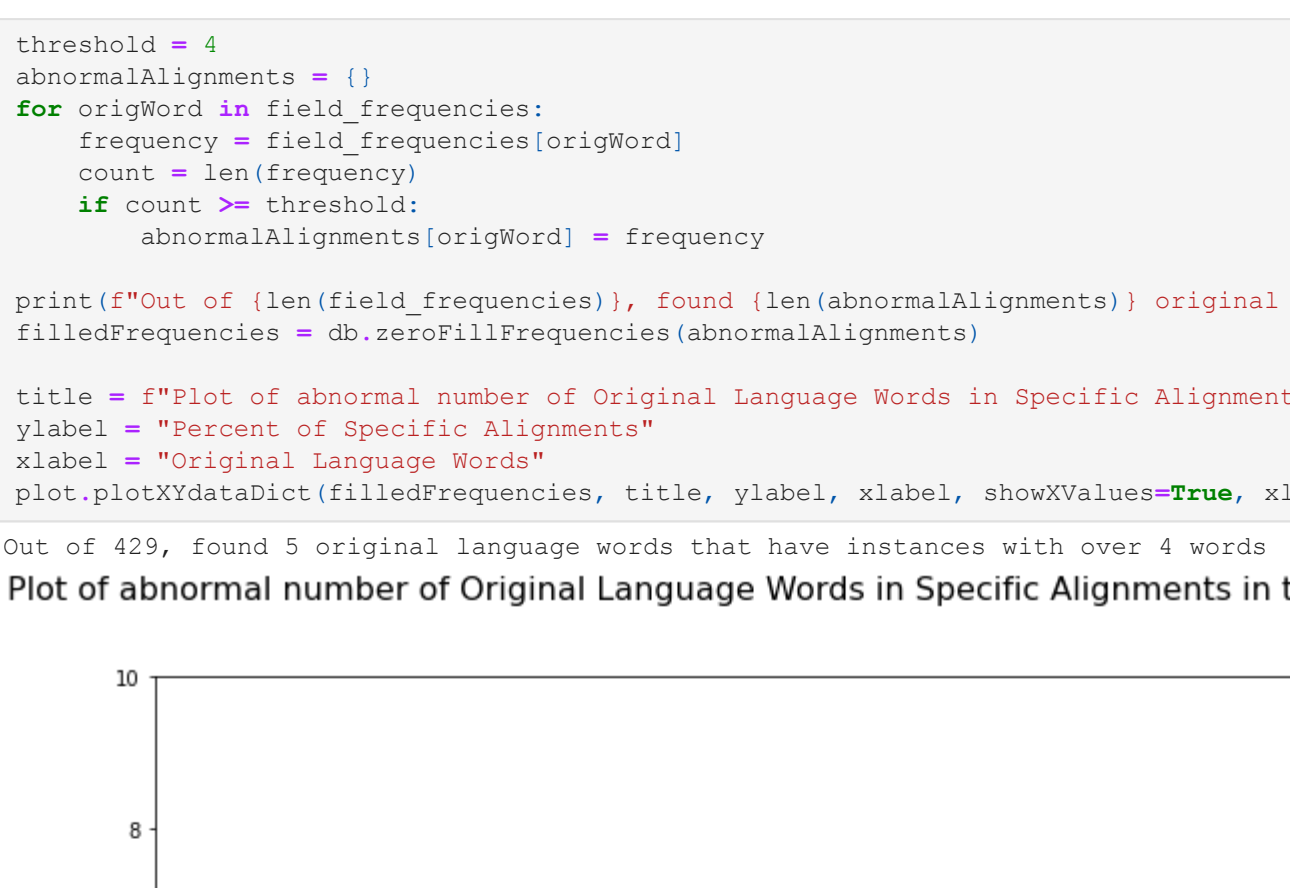
Notes:

- this field analysis suggests that original word counts are tight - a threshold word count of 3 probably good for Greek to flag for review.

In [8]:
```
threshold = 4
abnormalAlignments = {}
for origWord in field_frequencies:
    frequency = field_frequencies[origWord]
    count = len(frequency)
    if count >= threshold:
        abnormalAlignments[origWord] = frequency

print(f"Out of {len(field_frequencies)}, found {len(abnormalAlignments)} original language words that have i
filledFrequencies = db.zeroFillFrequencies(abnormalAlignments)

title = f"Plot of abnormal number of Original Language Words in Specific Alignments in tW KeyTerms"
ylabel = "Percent of Specific Alignments"
xlabel = "Original Language Words"
plot.plotXYdataDict(filledFrequencies, title, ylabel, xlabel, showXValues=True, xlimit=[threshold, 10], ylim
```

```
Out of 429, found 5 original language words that have instances with over 4 words
```

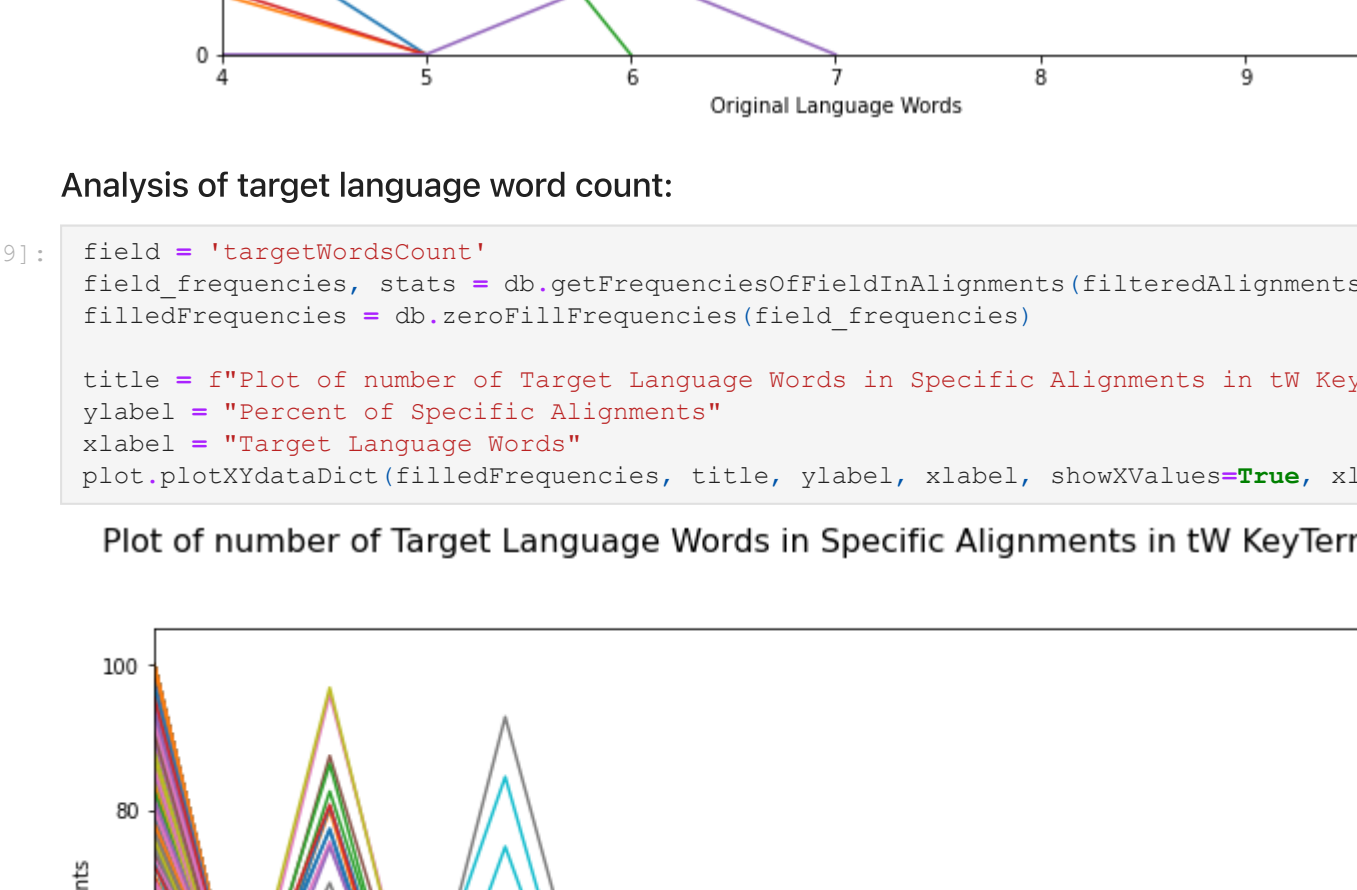
Plot of abnormal number of Original Language Words in Specific Alignments in tW KeyTerms



Analysis of target language word count:

In [9]:
```
field = 'targetWordsCount'
field_frequencies, stats = db.getFrequenciesOfFieldInAlignments(filteredAlignmentsForWord, field, sortIndex
filledFrequencies = db.zeroFillFrequencies(field_frequencies)

title = f"Plot of number of Target Language Words in Specific Alignments in tW KeyTerms"
ylabel = "Percent of Specific Alignments"
xlabel = "Target Language Words"
plot.plotXYdataDict(filledFrequencies, title, ylabel, xlabel, showXValues=True, xlimit=[1, 8])
```

Plot of number of Target Language Words in Specific Alignments in tW KeyTerms



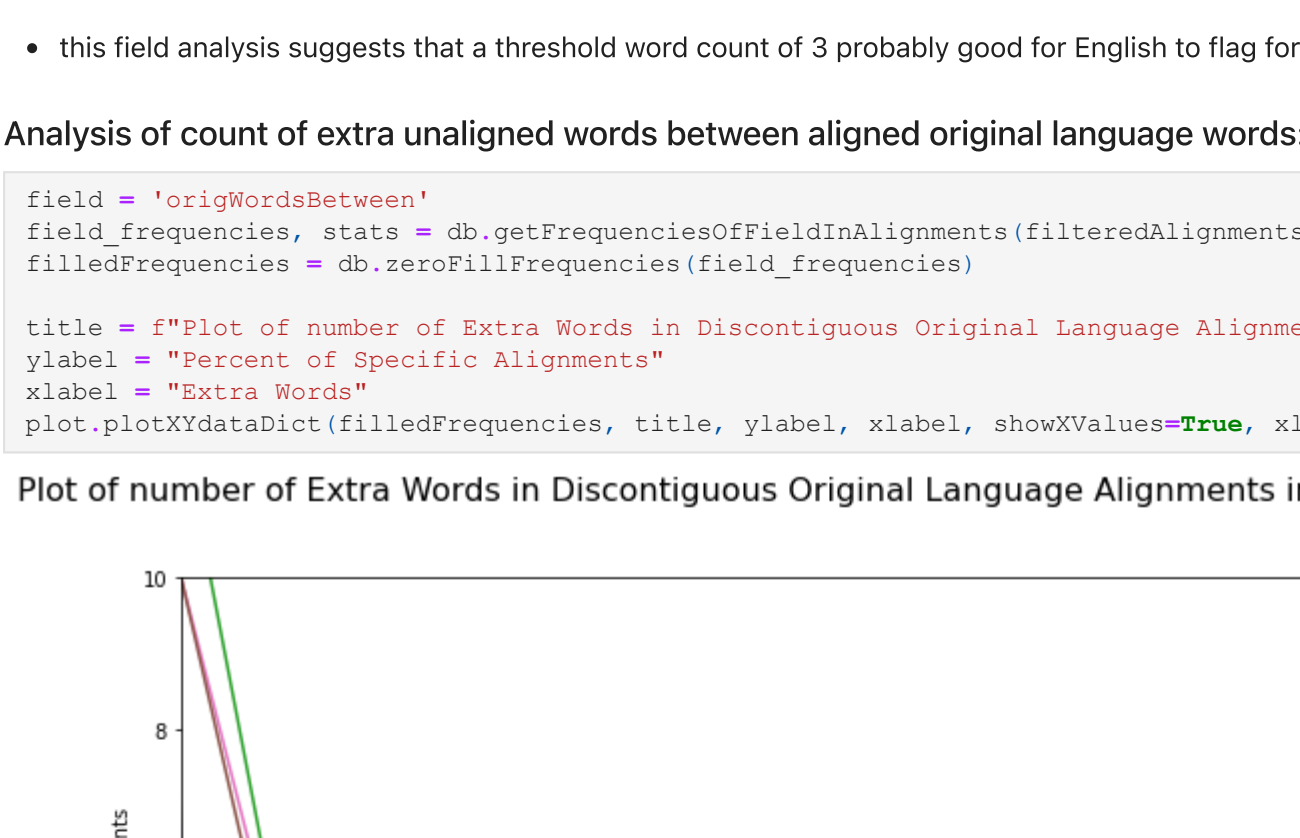
Notes:

- this field analysis suggests that a threshold word count of 3 probably good for English to flag for review.

Analysis of count of extra unaligned words between aligned original language words:

In [10]:
```
field = 'origWordsBetween'
field_frequencies, stats = db.getFrequenciesOfFieldInAlignments(filteredAlignmentsForWord, field, sortIndex
filledFrequencies = db.zeroFillFrequencies(field_frequencies)

title = f"Plot of number of Extra Words in Discontiguous Original Language Alignments in tW KeyTerms"
ylabel = "Percent of Specific Alignments"
xlabel = "Extra Words"
plot.plotXYdataDict(filledFrequencies, title, ylabel, xlabel, showXValues=True, xlimit=[1, 8], ylimit=[0,10]
```

Plot of number of Extra Words in Discontiguous Original Language Alignments in tW KeyTerms



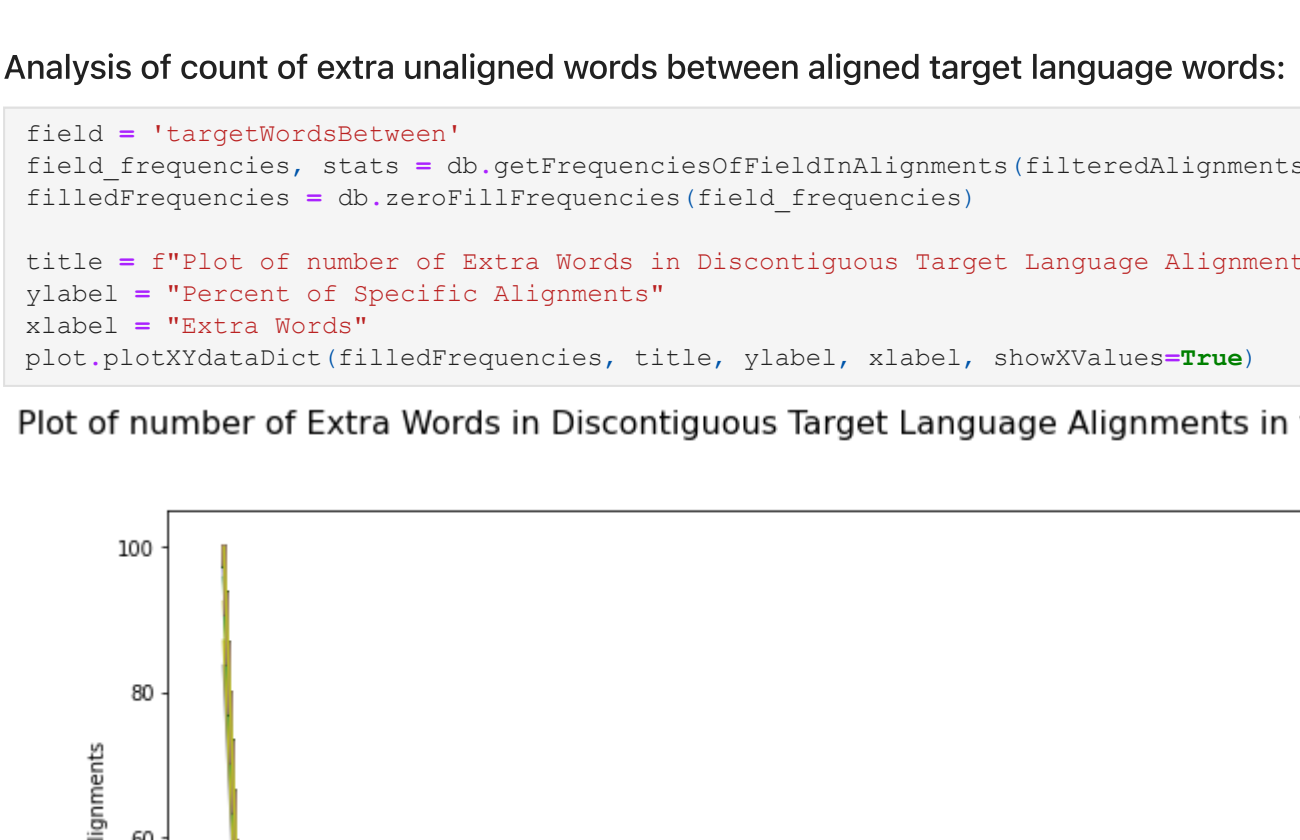
Notes:

- this field analysis suggests that most original language alignments probably good. Probably the cases of a word between aligned words should be reviewed.

Analysis of count of extra unaligned words between aligned target language words:

In [11]:
```
field = 'targetWordsBetween'
field_frequencies, stats = db.getFrequenciesOfFieldInAlignments(filteredAlignmentsForWord, field, sortIndex
filledFrequencies = db.zeroFillFrequencies(field_frequencies)

title = f"Plot of number of Extra Words in Discontiguous Target Language Alignments in tW KeyTerms"
ylabel = "Percent of Specific Alignments"
xlabel = "Extra Words"
plot.plotXYdataDict(filledFrequencies, title, ylabel, xlabel, showXValues=True)
```

Plot of number of Extra Words in Discontiguous Target Language Alignments in tW KeyTerms



Notes:

- this field analysis suggests that most target language alignments are very tight.

In [12]:
```
print(f"Testing tWords {type_} with minimum of {minAlignments} alignments")

thresholds = {
    'alignmentOrigWordsThreshold': 3,
    'alignmentTargetWordsThreshold': 5,
    'origWordsBetweenThreshold': 1,
    'targetWordsBetweenThreshold': 1,
    'alignmentFrequencyMinThreshold': 5
}

warningData,summary = db.generateWarningsAndSummary(baseDataPath, type_, bibleType, testamentStr, filteredAl
                                                    thresholds, tag=f'{minAlignments}')
print(f"Found {len(warningData)} alignments to check - min threshold {minAlignments}")
```

```
Testing tWords all with minimum of 20 alignments
saved summary of 429 original words to ./data/en/ult/all_en_ult_NT_summary_20.csv
Found 1410 alignments to check - min threshold 20
```

In [12]: