GASE: Generatively Augmented Sentence Encoding

Manuel Frank

mfr-research@protonmail.com

Haithem Afli

Department of Computer Science Munster Technological University Haithem. Afli@mtu.ie

Abstract

We propose an approach to enhance sentence embeddings by applying generative text models for data augmentation at inference time. Unlike conventional data augmentation that utilises synthetic training data, our approach does not require access to model parameters or the computational resources typically required for fine-tuning state-of-the-art models. Generatively Augmented Sentence Encoding uses diverse linguistic synthetic variants of input texts generated by paraphrasing, summarising, or extracting keywords, followed by pooling the original and synthetic embeddings. Experimental results on the Massive Text Embedding Benchmark for Semantic Textual Similarity (STS) demonstrate performance improvements across a range of embedding models using different generative models for augmentation. We find that generative augmentation leads to larger performance improvements for embedding models with lower baseline performance. These findings suggest that integrating generative augmentation at inference time adds semantic diversity and can enhance the robustness and generalizability of sentence embeddings for embedding models. Our results show that the degree to which generative augmentation can improve STS performance depends not only on the embedding model but also on the dataset. From a broader perspective, the approach allows trading training for inference compute.

1 Introduction

Representation learning has emerged as a fundamental technique in natural language processing (NLP). Still, the quality and robustness of embeddings largely depend on the richness and diversity of the training data. To derive sentence embeddings from BERT (Devlin et al., 2019) word embeddings, these can be averaged or the embedding of the CLS

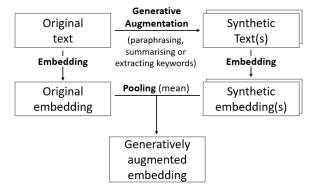


Figure 1: Approach for Generatively Augmented Sentence Encoding.

token¹ being used. Based on encoder-style transformers, such as BERT, Sentence Transformers (STs) (Reimers and Gurevych, 2020) were trained to directly output sentence embeddings by calculating an attention-weighted average of the word embeddings. These sentence embeddings can be used in pairwise tasks, e.g. paraphrase identification, or non-pairwise tasks, e.g. sentiment analysis. Recent advancements in generative models, such as OpenAI's GPT-4 (OpenAI, 2023), Anthropic's Claude 3 models (Anthropic, 2024) and Google's Gemini models (Gemini Team et al., 2024), have shown remarkable capabilities in generating human-like text. Moreover, generative models like ChatGPT have been demonstrated to be capable of paraphrasing, e.g. for data augmentation (Dai et al., 2023). The authors use ChatGPT to rephrase a given text to generate synthetic data which is used to train a downstream BERT model generating embeddings for text classification. To augment generative models, the integration with representation learning has been explored, e.g. in Retrieval-Augmented Generation (RAG) (Lewis et al., 2020; Guu et al., 2020).

¹CLS tokens are special tokens placed at the beginning of each input example in a BERT model, providing a representation of the entire input for use in classification tasks (Devlin et al., 2019).

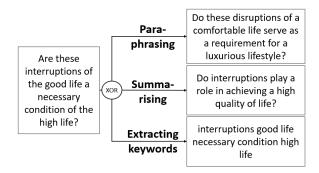


Figure 2: Augmentation examples for paraphrasing, summarising, and extracting keywords.

In contrast, we introduce Generatively Augmented Sentence Encoding (GASE), an approach to augment embedding models using generative Large Language Models (LLMs). Instead of generating synthetic data for pre-training or fine-tuning, we propose an augmentation approach which is applied at inference time by generating one or more textual variants of input data and pooling the embeddings of the original input text and the synthetic texts. The underlying hypothesis of our work on generative augmentation is that generative models can introduce semantic diversity which is not modelled by current embedding models without generative augmentation and, therefore, can benefit the performance of downstream tasks using the embeddings. Our method involves three generative tasks to generate the synthetic data from the original data: paraphrasing, summarising, and extracting keywords. To the best of our knowledge, this is the first work proposing generative models to augment sentence encoders at inference time.

2 Approach

As illustrated in Figure 1, GASE consists of the following steps:

1. Generative Augmentation. In this step k generative text models are used to produce k variations of the original input sequence. We propose three augmentation functions: Paraphrasing, which provides a semantically equivalent but lexically or syntactically different variation of the input text. Summarising which produces a shorter output text that captures the most important information of the input text. And Extracting Keywords which lists the most relevant words from a given text. An example for each is provided in Figure 2. We evaluate $k \in \{0, 1, 2\}$ using the generative LLMs GPT-3.5 Turbo (OpenAI, 2024b), Reka-Flash (Reka, 2024), and GPT-40 mini (OpenAI, 2024a) with

temperature and top_p set to 0 and 1 respectively. As a baseline, we use k=0, i.e., no augmentation. The prompts can be found in Appendix A. Modelspecific post-processing is performed to remove meta-text that is not used for augmentation.

- Sentence Embeddings. For the original sequence and each of the k synthetic variations an embedding is inferred. We evaluated the following embedding models which include non-transformer baselines, locally run ST models, and SOTA models accessed via an API using default hyperparameter values: glove.840B.300d (Pennington et al., 2014), bert-large-cased (Devlin et al., 2019), all-MiniLM-L6-v2 (Sentence Transformers, 2024), all-mpnet-base-v2 (Sentence Transformers, 2024), embed-english-light-v3.0 (Cohere. 2024), embed-english-v3.0 (Cohere, 2024), voyage-2 (Voyage AI, 2024), voyage-lite-02-instruct, (Voyage 2024), voyage-large-2 (Voyage AI, 2024), voyage-large-2-instruct (Voyage AI, 2024), mxbai-embed-large-v1 (Mixedbread, 2024).
- 3. Pooling. The embeddings of the original text and the k augmented texts are pooled by computing their arithmetic mean.

We evaluate our approach on the English subtasks of the MTEB STS task² using cosine similarity and Spearman's rank correlation³.

3 Results

Table 1 shows the results for different augmentation strategies using GPT-3.5 Turbo vs. the respective baseline. (See Table 4 in the Appendix for the results per dataset.) In terms of average scores across datasets, all embedding models benefit from some form of augmentation. The largest performance increases are observed for BERT (+6.11pp) and GloVe (+2.96pp). GloVe is also the only embedding model achieving its best results using keyword extraction. Moreover, BERT and MPNET STs benefit most from summarisation. In terms of datasets, all embedding models scored lowest on STS22.

²This includes STSBenchmark (Cer et al., 2017a), STS12 (Agirre et al., 2012), STS13 (Agirre et al., 2013), STS14 (Agirre et al., 2014), STS15 (Agirre et al., 2015), STS16 (Agirre et al., 2016), STS17 (Cer et al., 2017b), STS22 (Chen et al., 2022), SICK-R (Marelli et al., 2014), and BIOSSES (Soğancıoğlu et al., 2017). According to the original paper (Muennighoff et al., 2023), MTEB also includes the STS11 dataset. However, the MTEB leaderboard (Hugging Face, 2024) does not. To make our results comparable to the leaderboard we excluded STS11.

³See Reimers et al. (2016) for why Spearman's rank correlation is preferable over Pearson correlation for STS tasks.

Embedding	Augmentation	. /	~~~~
model	strategy	Avg.	STS22
	-	57.86	54.08
glove.	paraphrasing	59.98	57.78
840B.300d	summarising	60.64	61.21
	extracting keywords	60.82	56.94
	-	60.78	55.48
bert-	paraphrasing	66.29	58.57
large-cased	summarising	66.89	63.47
	extracting keywords	62.62	54.64
	-	78.91	67.26
all-MiniLM-	paraphrasing	80.32	68.47
L6-v2	summarising	79.90	69.27
	extracting keywords	77.96 \langle	64.57
	-	80.28	68.00
all-mpnet-	paraphrasing	81.39	69.01
base-v2	summarising	81.48	70.12
	extracting keywords	79.95	66.19
	-	78.75	67.88
embed-english-	paraphrasing	80.30	68.42
light-v3.0	summarising	80.21	68.97
	extracting keywords	78.53	67.27
	-	81.25	68.22
embed-	paraphrasing	82.10	68.63
english-v3.0	summarising	82.08	70.29
	extracting keywords	81.26	66.91
	-	82.50	65.26
voyage-2	paraphrasing	83.38	66.80
vojuge 2	summarising	82.74	68.50
	extracting keywords	81.21	65.29
	-	85.95	78.62
voyage-lite-	paraphrasing	85.99	79.08
02-instruct	summarising	85.43	79.87
	extracting keywords	83.91	76.60
	-	83.60	63.97
voyage-	paraphrasing	83.92	64.69
large-2	summarising	83.66	65.90
	extracting keywords	81.98	63.68
	-	84.61	66.59
voyage-large-	paraphrasing	84.80	67.72
2-instruct	summarising	84.54	68.66
	extracting keywords	83.40	65.73
		84.63	68.73
mxbai-embed-	paraphrasing	85.01	70.03
large-v1	summarising	84.45	70.36
	extracting keywords	83.42	67.83
		(

Table 1: Average scores on the MTEB datasets and STS22 individually for all embedding models with and without generative augmentation using GPT-3.5 Turbo (Spearman's rank correlation in %, bold: highest scores).

Dataset	Original	Para- phrasing	Summa- rising	Extracting keywords			
STSB	10.1	11.5	10.7	5.7			
STS12	11.1	11.6	11.1	6.1			
STS13	9.0	10.5	11.1	5.4			
STS14	9.3	11.0	11.4	5.7			
STS15	10.6	12.0	11.5	5.7			
STS16	11.6	12.6	12.8	5.7			
STS17	8.7	9.6	9.0	4.5			
STS22	477.2	216.5	58.4	103.8			
SICK-R	9.6	10.0	9.3	4.7			
BIOSSES	24.5	25.2	19.2	13.9			
Average	58.2	33.1	16.4	16.1			

Table 2: Mean word count (using GPT-3.5 Turbo for generative augmentation).

As expected, summarising and extracting keywords significantly reduced the mean word count on average across datasets (see Table 2). While paraphrases for all datasets except STS22 are close to the word count of the original texts, GPT-3.5 Turbo does not maintain STS22's high word count.

Since paraphrase augmentation provided the largest improvements for most models, we evaluated it for all generative models (see Table 3 and for results per dataset Table 5 in the Appendix). Using a single generative model, GPT-3.5 Turbo achieved the best results for all embedding models except GloVe and Voyage-Large-2 which performed better using Reka-Flash. Hence, we ran experiments with these two models generating k=2 paraphrases.

Across embedding models, the use of these two generative models led to higher scores than a single generative model. The largest performance gains were achieved with BERT (+7.23pp) and GloVe (+4.11pp). MiniLM ST, MPNet ST, Cohere's Embed models and Voyage-2 demonstrated maximum improvements between 1.28 and 1.79pp while the remaining embedding models showed performance gains below 1pp. Notably, the results with k=2 surpass the mean between the scores of employing GPT-3.5 Turbo and Reka Flash individually.

4 Discussion

Overall, lower non-augmented performance was associated with larger performance improvements through generative augmentation as visualized in Figure 3. We believe this relationship holds because weaker embedding models are inherently less capable of modelling diverse semantics and, therefore, benefit more from the semantic diversity introduced by generative models. Moreover, embedding models with lower baseline performance also gained more from the ensemble effect of us-

Embedding model	Generative model	Avgerage score		
	-	57.86		
_	gpt-3.5-turbo	59.98		
glove.	reka-flash	60.73		
840B.300d	GPT-40 mini	60.04		
	gpt-3.5-turbo, reka-flash	61.97		
	gpt-3.3-turbo, reka-masii	60.78		
	ent 3.5 turbo	66.29		
bert-	gpt-3.5-turbo reka-flash	65.76		
large-cased				
_	GPT-4o mini	65.01		
	gpt-3.5-turbo, reka-flash	68.01		
	-	78.91		
all-MiniLM-	gpt-3.5-turbo	80.32		
L6-v2	reka-flash	79.74		
20 12	GPT-40 mini	79.81		
	gpt-3.5-turbo, reka-flash	80.64		
	-	80.28		
all menst	gpt-3.5-turbo	81.39		
all-mpnet-	reka-flash	81.01		
base-v2	GPT-40 mini	81.07		
	gpt-3.5-turbo, reka-flash	81.72		
	-	78.75		
embed-english- light-v3.0	gpt-3.5-turbo	80.30		
	reka-flash	79.72		
	GPT-40 mini	79.72		
		80.54		
	gpt-3.5-turbo, reka-flash			
	-	81.25		
embed-	gpt-3.5-turbo	82.10		
english-v3.0	reka-flash	82.00		
8	GPT-4o mini	81.82		
	gpt-3.5-turbo, reka-flash	82.53		
	-	82.50		
	gpt-3.5-turbo	83.38		
voyage-2	reka-flash	83.37		
	GPT-40 mini	83.07		
	gpt-3.5-turbo, reka-flash	83.80		
	-	85.95		
11.	gpt-3.5-turbo	85.99		
voyage-lite-	reka-flash	85.92		
02-instruct	GPT-40 mini	85.97		
	gpt-3.5-turbo, reka-flash	86.05		
	-	83.60		
	gpt-3.5-turbo	83.92		
voyage-	reka-flash			
large-2	GPT-40 mini	83.98		
		83.95		
	gpt-3.5-turbo, reka-flash	84.12		
	-	84.61		
	gpt-3.5-turbo	84.80		
vovage-large-	reka-flash	84.68		
voyage-large-				
voyage-large- 2-instruct	GPT-4o mini	84.78		
	GPT-4o mini	84.78		
2-instruct	GPT-40 mini gpt-3.5-turbo, reka-flash	84.78 84.86		
2-instruct mxbai-embed-	GPT-4o mini	84.78 84.86 84.63		
2-instruct	GPT-4o mini gpt-3.5-turbo, reka-flash - gpt-3.5-turbo	84.78 84.86 84.63 85.01 84.80		
2-instruct mxbai-embed-	GPT-4o mini gpt-3.5-turbo, reka-flash - gpt-3.5-turbo reka-flash	84.78 84.86 84.63 85.01		

Table 3: Average scores on the MTEB datasets with and without paraphrase augmentation using GPT-3.5 Turbo, GPT-40 mini, and Reka-Flash (Spearman's rank correlation in %, bold: highest scores).

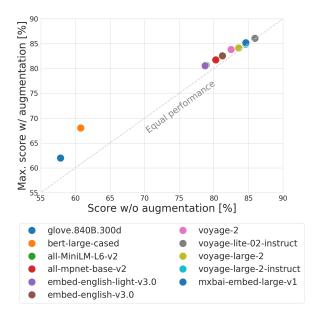


Figure 3: Score without augmentation vs. max. score with augmentation per embedding model.

ing k=2 models for augmentation compared to a single generative model. The effectiveness of keyword extraction for GloVe may be explained by the model's limited capability to handle complex semantics as its sentence embeddings are derived by calculating an unweighted average of word embeddings. Therefore, the reduction to keywords might help the model to reduce noise.

We believe the lower scores on STS22 can be explained by its higher word count. Unexpectedly, generating summaries did not significantly reduce the mean word count on datasets other than STS22 (and BIOSSES, to some extent). Since most MTEB STS datasets include shorter sentences, sentence encoders might be optimized for shorter sentence lengths. Our results demonstrate that the best augmentation strategy for a given embedding model is not identical for all datasets.

5 Conclusion

We propose Generatively Augmented Sentence Encoding (GASE), a novel approach that augments sentence embeddings by paraphrasing, summarising, or extracting keywords with generative models at inference time. On the MTEB STS task, GASE leads to substantial improvements for embedding models with lower baseline performance and incremental improvements for SOTA embedding models. GASE is widely applicable as it only requires access to the outputs of the underlying embedding and generative models.

6 Limitations

This study presents several limitations:

- 1. While deterministic embedding models such as GloVe yield consistent results, other models like GPT-3.5 Turbo examined in this research exhibit stochastic behaviour. Consequently, additional experiments are necessary to corroborate our findings, as LLMs can produce diverse outcomes, thereby limiting the conclusiveness of a single experimental run (Reimers and Gurevych, 2018). This caveat is particularly pertinent to observations based on marginal performance differentials.
- Our investigation was confined to the evaluation of GPT-3.5 Turbo, Reka-Flash, and GPT-40 mini for generative augmentation. Alternative LLMs, including the Claude and Gemini model families, may potentially offer more substantial improvements.
- Furthermore, our experimental design was restricted to k ∈ {0,1,2}. While values of k > 2 were not explored, we posit that such configurations may be impractical for realworld applications due to prohibitive computational costs.
- 4. Summaries typically comprise 50% or fewer words relative to its source text (Radev et al., 2002). However, due to the concise nature of the texts within the examined STS datasets the summaries generated in this work approximately maintain the original word count. (Except for STS22 which contains longer text sequences.) Hence, the efficacy of augmentation through summarisation may be more pronounced when applied to datasets comprising longer textual inputs (e.g., paragraphs) compared to the predominantly short text sequences examined within the scope of this study.
- 5. Our experiments are limited to the English language and the effectiveness of GASE for other languages requires further investigation. Since embedding models with weaker baseline performance showed larger improvements through generative augmentation, we hypothesise that GASE can provide larger performance improvements for languages for which the performance of embedding models is below English.

Acknowledgments

Code development for this work has been assisted by GPT-3.5 Turbo, GPT-4 Omni, Claude 3.5 Sonnet, Gemini Pro 1.5, and Github Copilot.

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A Prompts

Paraphrasing with GPT-3.5 Turbo and GPT-40 mini:

"Rephrase the following text while maintaining its original meaning. If the text contains only a single word, provide a definition or a synomym. When done, check and make sure that the length of the original is approximately maintained. Text:"

Paraphrasing with Reka-Flash:

"Rephrase the following text while maintaining its original meaning. Do not provide multiple alternatives. Before you reply, remove any explanations. Do only reply with the paraphrased text. If the text contains only a single word, provide a definition or a synomym. Text:"

summarising with GPT-3.5 Turbo:

"summarise the following text. Do not include any meta text and only output the summary. If the text is too short to summarise, paraphrase it instead. Text:"

Extracting keywords with GPT-3.5 Turbo: "Extract the keywords from the following sentence. Do NOT inlcude any commas or fullstops in your response and do not start your answer with "keywords". Text: "

B Additional Experimental Results

Embedding model	Augmentation	Average	STSB	STS12	STS13	STS14	STS15	STS16	STS17	STS22	SICK-R	BIOSSES
	-	57.86	50.73	57.50	70.98	60.69	70.85	63.85	62.05	54.08	55.42	32.45
	paraphrasing	59.98	56.78	57.33	71.17	61.16	71.52	67.66	62.28	57.78	58.92	35.21
glove.840B.300d	summarising	60.64	57.67	55.00	70.24	61.18	71.64	66.81	67.08	61.21	60.92	34.65
	extracting keywords	60.82	59.26	58.09	71.12	60.34	72.44	65.31	75.92	56.94	55.34	33.50
	-	60.78	59.18	45.71	63.94	54.42	68.98	65.46	71.30	55.48	64.16	59.14
bert-large-cased	paraphrasing	66.29	67.97	53.62	68.56	59.73	74.01	71.97	74.14	58.57	69.79	64.56
bert-targe-cased	summarising	66.89	68.23	51.39	70.58	61.98	74.27	70.60	74.48	63.47	70.74	63.23
	extracting keywords	62.62	63.03	53.50	63.32	58.51	72.62	68.13	71.99	54.64	58.24	62.22
	-	78.91	82.03	72.37	80.60	75.59	85.39	78.99	87.59	67.26	77.58	81.64
all-MiniLM-L6-v2	paraphrasing	80.32	82.33	73.33	83.33	77.85	86.23	79.88	87.02	68.47	79.63	85.07
ali-MiniLM-Lo-v2	summarising	79.90	82.17	72.14	82.89	77.24	86.34	78.99	87.70	69.27	79.86	82.41
	extracting keywords	77.96	81.99	73.29	81.14	75.77	85.87	78.70	87.45	64.57	70.92	79.88
	-	80.28	83.42	72.63	83.48	78.00	85.66	80.03	90.60	68.00	80.59	80.43
.11	paraphrasing	81.39	84.10	74.04	85.52	80.52	86.82	81.15	89.08	69.01	81.25	82.39
all-mpnet-base-v2	summarising	81.48	83.94	73.76	85.54	79.78	86.73	80.20	90.41	70.12	81.32	82.96
	extracting keywords	79.95	82.56	74.82	84.82	78.74	86.31	79.01	90.23	66.19	77.07	79.74
	=	78.75	83.52	72.81	77.69	76.91	83.51	78.49	88.49	67.88	77.98	80.20
	paraphrasing	80.30	84.65	74.65	80.73	79.41	85.45	81.14	87.45	68.42	78.75	82.36
embed-english-light-v3.0	summarising	80.21	84.08	73.45	81.36	78.41	86.26	81.52	88.19	68.97	79.08	80.79
	extracting keywords	78.53	82.81	75.03	80.17	78.29	84.14	76.38	88.14	67.27	74.45	78.64
	-	81.25	86.54	74.76	81.68	78.81	87.18	83.01	89.70	68.22	77.52	85.05
1 1 11 20	paraphrasing	82.10	86.69	76.37	83.71	81.29	87.96	83.95	88.47	68.63	78.21	85.75
embed-english-v3.0	summarising	82.08	86.47	74.40	84.41	80.76	88.49	83.55	89.08	70.29	78.06	85.25
	extracting keywords	81.26	85.50	74.77	84.66	79.98	87.72	81.09	88.75	66.91	77.53	85.68
	-	82.50	87.06	77.68	86.25	80.11	88.38	85.72	89.78	65.26	78.95	85.83
2	paraphrasing	83.38	87.17	79.23	87.13	81.67	88.57	86.27	89.07	66.80	80.33	87.56
voyage-2	summarising	82.74	86.51	76.81	86.25	80.89	88.46	84.88	89.10	68.50	80.48	85.55
	extracting keywords	81.21	85.71	77.76	86.17	79.63	87.49	84.37	88.66	65.29	72.06	85.03
	-	85.95	88.74	86.19	88.84	86.84	89.84	86.07	87.19	78.62	77.54	89.60
11. 02 1	paraphrasing	85.99	88.81	84.47	89.05	86.68	89.52	86.53	86.79	79.08	79.09	89.89
voyage-lite-02-instruct	summarising	85.43	87.93	82.77	88.06	85.05	88.98	85.49	86.70	79.87	79.16	90.32
	extracting keywords	83.91	86.75	83.82	87.97	84.47	88.98	84.55	86.28	76.60	70.77	88.88
	=	83.60	87.84	78.66	86.98	82.25	88.94	85.71	91.29	63.97	79.83	90.49
1 2	paraphrasing	83.92	87.62	79.18	87.66	83.60	88.91	86.00	90.22	64.69	81.00	90.29
voyage-large-2	summarising	83.66	87.56	77.83	86.93	82.88	88.93	84.88	90.49	65.90	81.09	90.15
	extracting keywords	81.98	85.92	78.00	86.45	81.33	88.28	84.44	89.90	63.68	72.50	89.33
	-	84.61	89.21	76.15	88.49	86.50	91.13	85.68	90.05	66.59	83.17	89.09
	paraphrasing	84.80	89.31	77.61	88.40	86.62	91.17	86.20	89.58	67.72	82.83	88.58
voyage-large-2-instruct	summarising	84.54	88.84	76.27	88.29	85.56	91.06	85.24	89.40	68.66	83.28	88.78
	extracting keywords	83.40	87.38	76.63	88.58	85.55	90.51	84.03	88.57	65.73	76.58	90.46
	-	84.63	89.29	79.07	89.80	85.22	89.34	86.77	89.21	68.73	82.78	86.13
	paraphrasing	85.01	89.09	80.83	89.43	85.88	89.46	86.94	88.75	70.03	82.67	87.02
mxbai-embed-large-v1	summarising	84.45	88.60	78.51	89.07	84.82	89.09	85.96	88.43	70.36	82.82	86.82

Table 4: Scores per dataset with and without generative augmentation using GPT-3.5 Turbo (Spearman's rank correlation in %, bold: highest scores).

Embedding model	Gen model	Average	STSB	STS12	STS13	STS14	STS15	STS16	STS17	STS22	SICK-R	BIOSSES
	=	57.86	50.73	57.50	70.98	60.69	70.85	63.85	62.05	54.08	55.42	32.45
	gpt-3.5-turbo	59.98	56.78	57.33	71.17	61.16	71.52	67.66	62.28	57.78	58.92	35.21
glove.840B.300d	reka-flash	60.73	55.02	59.53	71.09	61.22	72.81	65.20	64.27	60.11	61.65	36.43
	GPT-40 mini	60.04	55.09	60.12	72.65	62.45	71.60	66.49	63.39	55.48	60.36	32.76
	gpt-3.5-turbo, reka-flash	61.97	59.46	60.06	72.01	62.68	72.46	67.62	65.43	61.46	61.51	36.95
	-	60.78	59.18	45.71	63.94	54.42	68.98	65.46	71.30	55.48	64.16	59.14
	gpt-3.5-turbo	66.29	67.97	53.62	68.56	59.73	74.01	71.97	74.14	58.57	69.79	64.56
pert-large-cased	reka-flash	65.76	65.20	52.92	68.55	59.77	72.67	71.80	71.46	58.93	70.09	66.19
	GPT-4o mini	65.01	65.37	54.27	68.60	58.18	72.26	71.12	73.54	55.72	70.50	60.54
	gpt-3.5-turbo, reka-flash	68.01	69.39	56.86	70.04	62.30	74.61	73.86	74.52	60.49	71.32	66.72
	-	78.91	82.03	72.37	80.60	75.59	85.39	78.99	87.59	67.26	77.58	81.64
	gpt-3.5-turbo	80.32	82.33	73.33	83.33	77.85	86.23	79.88	87.02	68.47	79.63	85.07
all-MiniLM-L6-v2	reka-flash	79.74	81.30	73.52	82.42	76.83	85.72	79.02	87.01	68.83	79.66	83.11
	GPT-4o mini	79.81	81.97	74.03	83.31	76.70	86.03	79.19	87.69	67.01	80.08	82.11
	gpt-3.5-turbo, reka-flash	80.64	82.30	74.59	83.72	78.11	86.20	79.95	87.23	69.23	80.12	84.97
	2 5 1	80.28	83.42	72.63	83.48	78.00	85.66	80.03	90.60	68.00	80.59	80.43
	gpt-3.5-turbo	81.39	84.10	74.04	85.52	80.52	86.82	81.15	89.08	69.01	81.25	82.39
all-mpnet-base-v2	reka-flash	81.01	83.72	74.27	85.12	79.33	86.41	80.41	90.17	68.42	81.37	80.87
	GPT-4o mini	81.07	83.75	74.19	85.19	79.28	86.45	80.47	90.89	67.81	81.23	81.43
	gpt-3.5-turbo, reka-flash	81.72	84.43	75.46	86.12	80.63	87.00	81.21	89.37	69.33	81.55	82.13
	2 5 1	78.75	83.52	72.81	77.69	76.91	83.51	78.49	88.49	67.88	77.98	80.20
	gpt-3.5-turbo	80.30	84.65	74.65	80.73	79.41	85.45	81.14	87.45	68.42	78.75	82.36
embed-english-light-v3.0	reka-flash	79.72	83.51	75.74	78.60	78.38	84.63	80.09	87.98	69.06	78.76	80.42
	GPT-40 mini	79.90	84.14	75.76	79.65	77.89	85.12	79.83	87.90	67.91	78.68	82.10
gpi	gpt-3.5-turbo, reka-flash	80.54	84.48	76.45	80.61	79.65	85.54	81.21	87.60	69.23	79.06	81.55
ambad and Esbar 20	- 25 - 4	81.25	86.54	74.76	81.68	78.81	87.18 87.96	83.01	89.70	68.22	77.52	85.05
	gpt-3.5-turbo	82.10 82.00	86.69	76.37	83.71	81.29		83.95	88.47 88.93	68.63	78.21 78.06	85.75 85.90
embed-english-v3.0	reka-flash GPT-4o mini	81.82	86.31 86.52	76.91 76.80	82.22 82.57	80.48 80.11	87.82 87.77	83.69 83.72	89.42	69.70 68.36	77.90	85.05
	gpt-3.5-turbo, reka-flash	82.53	86.68	77.88	83.56	81.64	88.05	84.13	88.59	69.87	77.90 78.44	86.48
	gpt-3.5-turbo, reka-masn	82.50	87.06	77.68	86.25	80.11	88.38	85.72	89.78	65.26	78.95	85.83
	gpt-3.5-turbo	83.38	87.17	79.23	87.13	81.67	88.57	86.27	89.78	66.80	80.33	87.56
voyage-2	reka-flash	83.37	86.93	79.65	87.83	81.79	88.48	86.18	88.98	67.42	80.55	85.72
voyage-2	GPT-40 mini	83.07	86.89	79.59	87.27	81.23	88.46	85.81	89.37	65.25	80.85	86.02
	gpt-3.5-turbo, reka-flash	83.80	87.27	80.62	87.99	82.40	88.51	86.40	88.77	67.94	80.87	87.28
	gpt 5.5 turbo, reku nusn	85.95	88.74	86.19	88.84	86.84	89.84	86.07	87.19	78.62	77.54	89.60
	gpt-3.5-turbo	85.99	88.81	84.47	89.05	86.68	89.52	86.53	86.79	79.08	79.09	89.89
voyage-lite-02-instruct	reka-flash	85.92	88.24	84.88	88.79	86.58	89.46	86.28	86.74	78.76	78.97	90.53
voyage me oz mstruct	GPT-40 mini	85.97	88.25	85.24	89.06	86.62	89.57	85.99	86.90	78.59	79.45	90.08
	gpt-3.5-turbo, reka-flash	86.05	88.74	84.83	89.14	86.69	89.36	86.57	86.72	78.81	79.34	90.34
voyage-large-2	-	83.60	87.84	78.66	86.98	82.25	88.94	85.71	91.29	63.97	79.83	90.49
	gpt-3.5-turbo	83.92	87.62	79.18	87.66	83.60	88.91	86.00	90.22	64.69	81.00	90.29
	reka-flash	83.98	87.32	79.52	88.25	83.49	88.77	85.90	90.40	64.46	81.35	90.37
rojuge mige 2	GPT-40 mini	83.95	87.54	80.02	87.91	83.22	89.11	85.68	90.47	63.99	81.54	90.08
	gpt-3.5-turbo, reka-flash	84.12	87.56	80.05	88.31	83.98	88.76	85.97	90.04	64.84	81.55	90.14
	-	84.61	89.21	76.15	88.49	86.50	91.13	85.68	90.05	66.59	83.17	89.09
	gpt-3.5-turbo	84.80	89.31	77.61	88.40	86.62	91.17	86.20	89.58	67.72	82.83	88.58
voyage-large-2-instruct	reka-flash	84.68	88.81	78.41	88.30	86.40	90.95	85.42	89.71	67.04	83.22	88.52
, , , , , , , , , , , , , , , , , , , ,	GPT-40 mini	84.78	88.83	78.71	88.43	86.45	91.17	85.89	89.14	67.09	83.19	88.87
	gpt-3.5-turbo, reka-flash	84.86	89.16	79.11	88.56	86.67	90.97	85.86	89.67	67.56	83.00	88.08
	-	84.63	89.29	79.07	89.80	85.22	89.34	86.77	89.21	68.73	82.78	86.13
	gpt-3.5-turbo	85.01	89.09	80.83	89.43	85.88	89.46	86.94	88.75	70.03	82.67	87.02
nxbai-embed-large-v1	reka-flash	84.80	88.93	81.04	89.36	85.51	89.27	86.48	89.04	68.67	82.66	87.07
embed mige vi	GPT-40 mini	84.90	88.95	81.08	89.76	85.37	89.43	86.58	89.14	69.10	82.73	86.89
	gpt-3.5-turbo, reka-flash	85.17	89.16	81.96	89.37	85.96	89.39	86.79	88.97	69.51	82.72	87.81

Table 5: Scores per dataset with and without paraphrase augmentation using GPT-3.5 Turbo, GPT-40 mini, and Reka-Flash (Spearman's rank correlation in %, bold: highest scores).