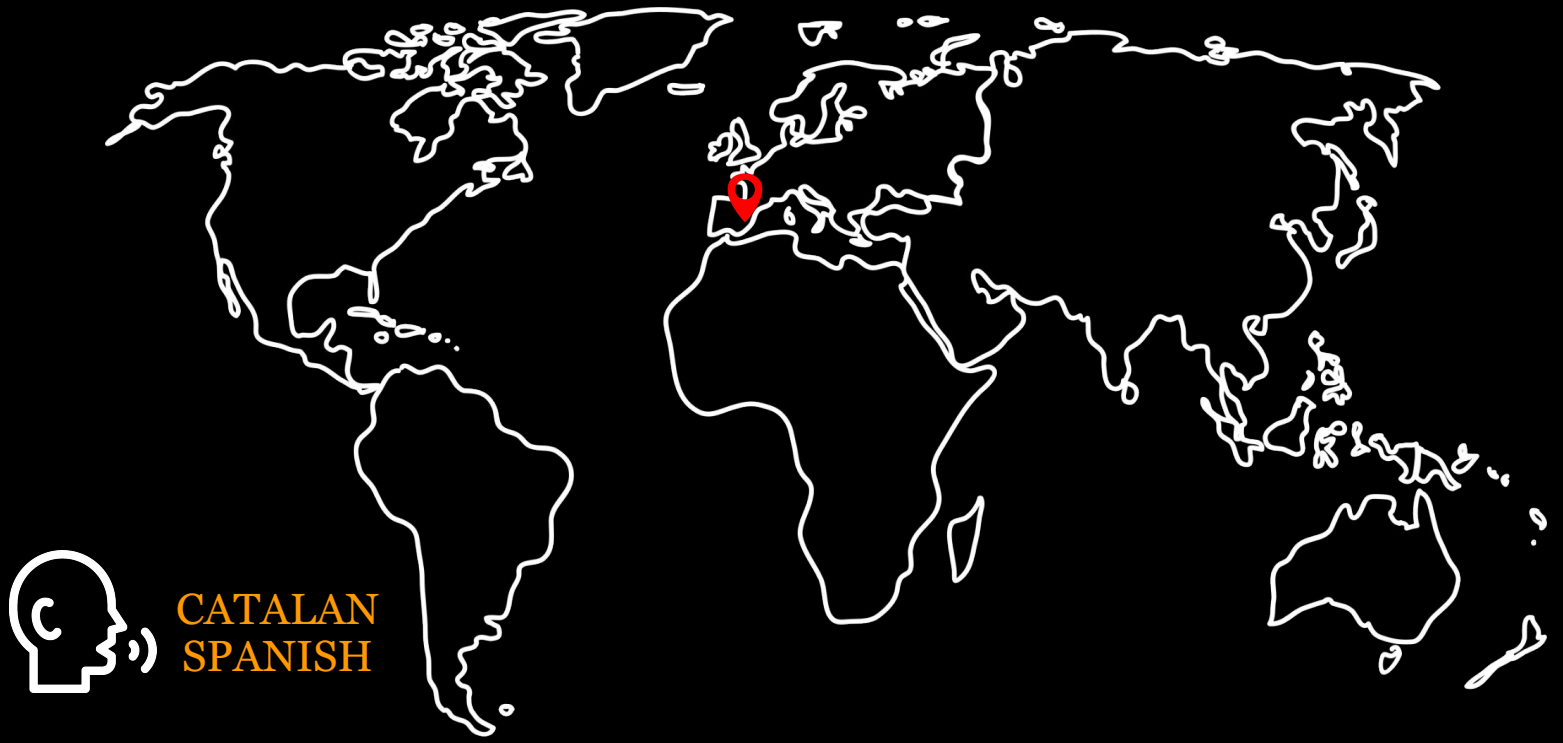
FLOR

Severino Da Dalt, Joan Llop, Irene Baucells, Marc Pàmies, Yishi Xu,
Aitor Gonzalez-Agirre, Marta Villegas

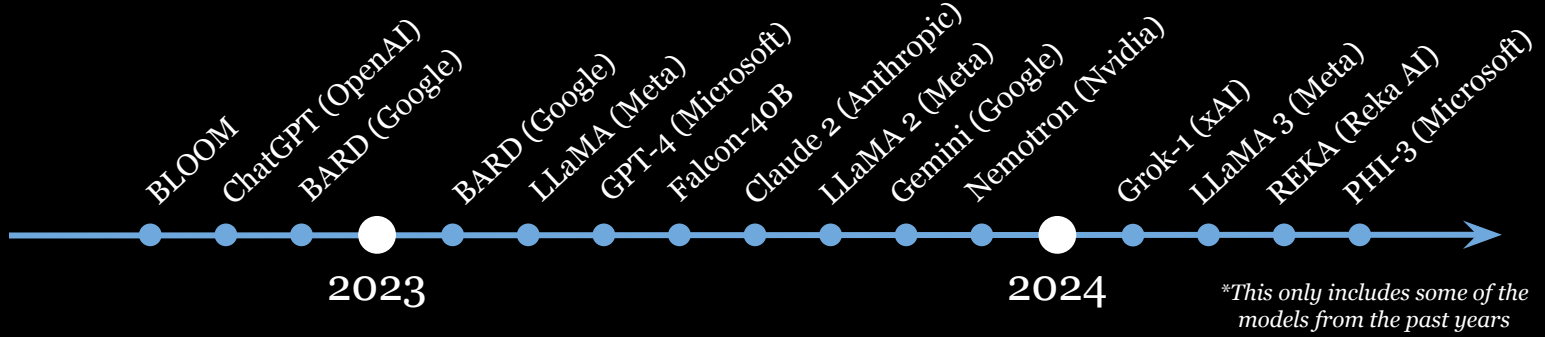
On the Effectiveness of Language Adaptation

Context



CATALAN
SPANISH

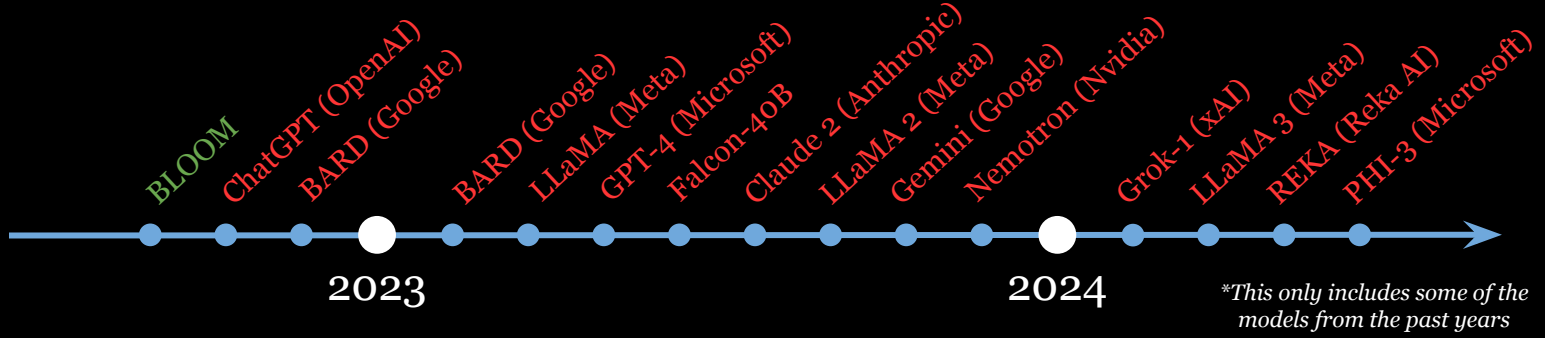
Context


BLOOM
ChatGPT (OpenAI)
BARD (Google)
BARD (Google)
LLaMA (Meta)
GPT-4 (Microsoft)
Falcon-40B
Claude 2 (Anthropic)
LLaMA 2 (Meta)
Gemini (Google)
Nemotron (Nvidia)
Grok-1 (xAI)
LLaMA 3 (Meta)
REKA (Reka AI)
PHI-3 (Microsoft)
2023
2024
*This only includes some of the models from the past years

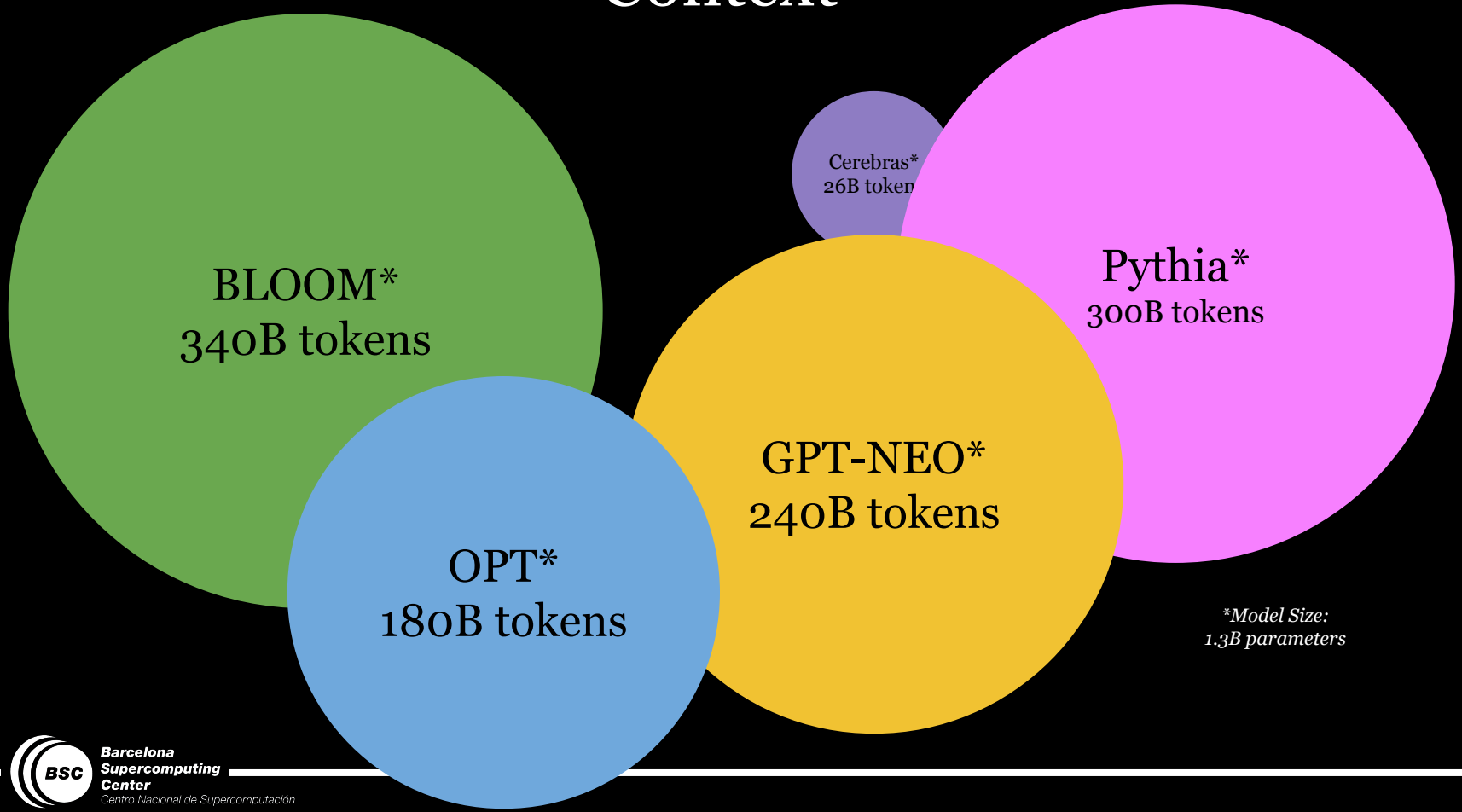
Context

Open and equal access

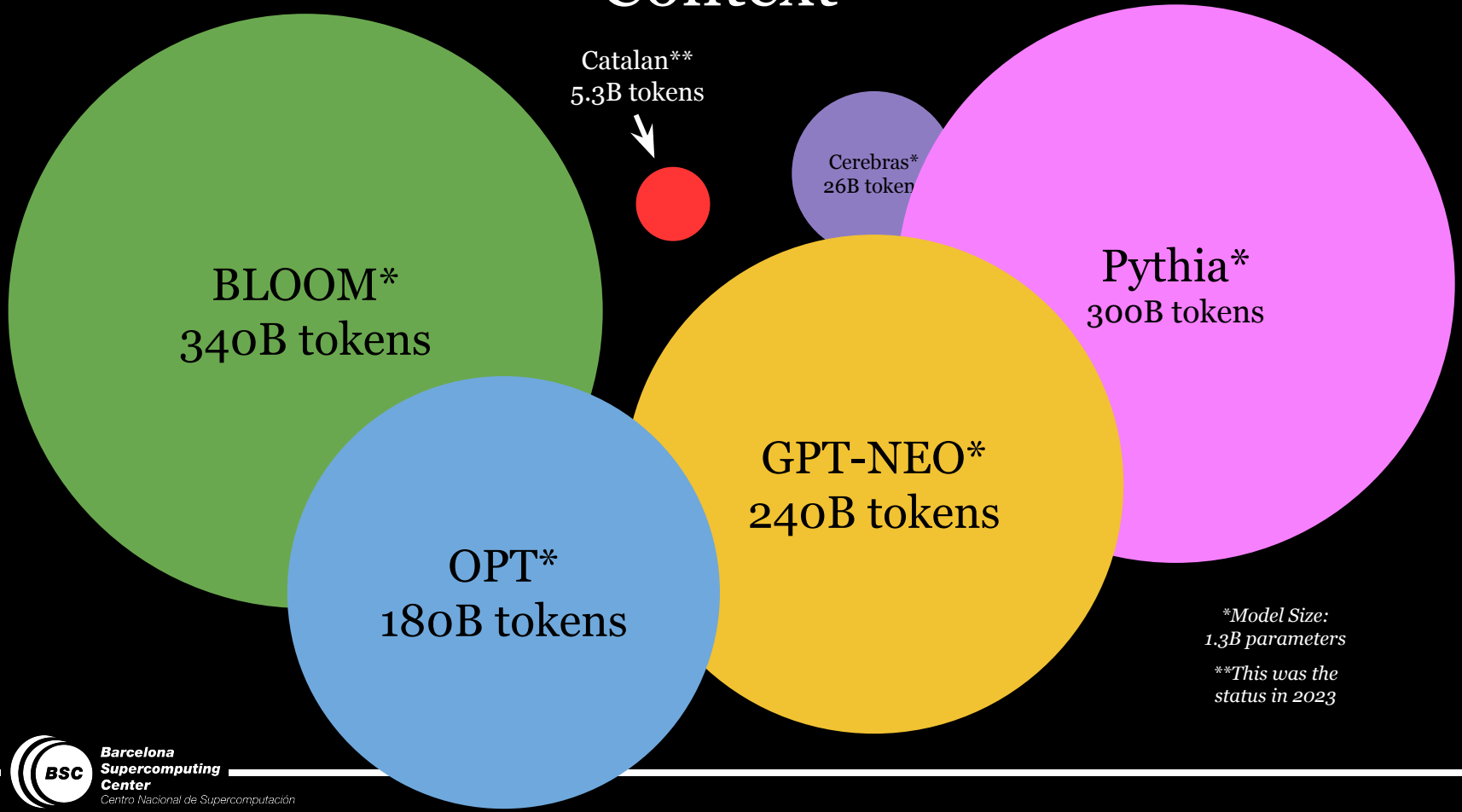
Target Language: Catalan



Context


BLOOM*
340B tokens
Cerebras*
26B token
Pythia*
300B tokens
GPT-NEO*
240B tokens
OPT*
180B tokens
*Model Size:
1.3B parameters

Context


Catalan**
5.3B tokens
Cerebras*
26B token
BLOOM*
340B tokens
Pythia*
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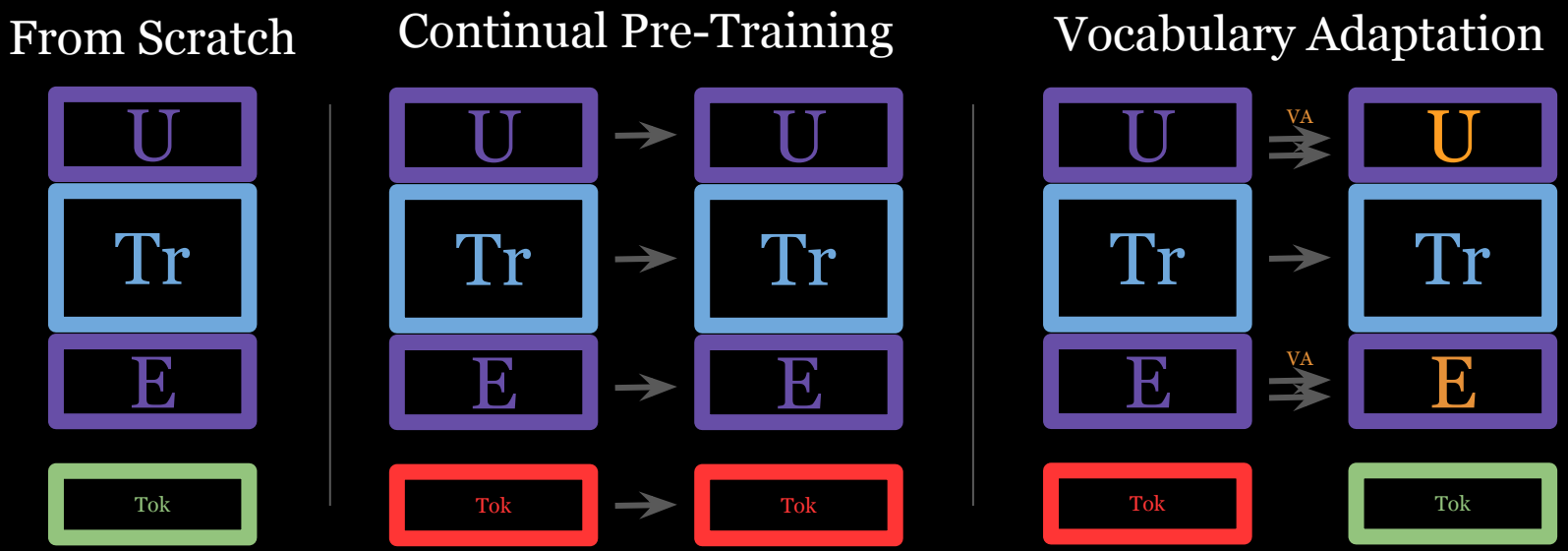
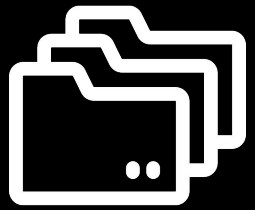
240B tokens
OPT*
180B tokens
*Model Size:
1.3B parameters
**This was the
status in 2023

Best Strategy?



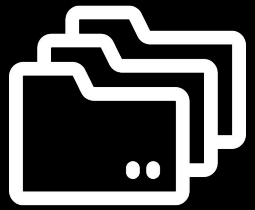
Contributions

Contributions



Training dataset (ca, es, en)

Contributions



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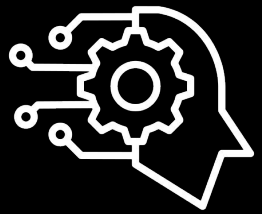
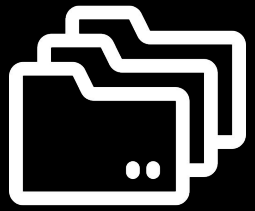


FLOR-760M and FLOR-1.3B, two autoregressive language models that achieve state-of-the-art results in several Catalan and Spanish downstream tasks.

Contributions



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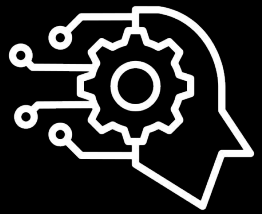


FLOR-760M and FLOR-1.3B, two autoregressive language models that achieve state-of-the-art results in several Catalan and Spanish downstream tasks.

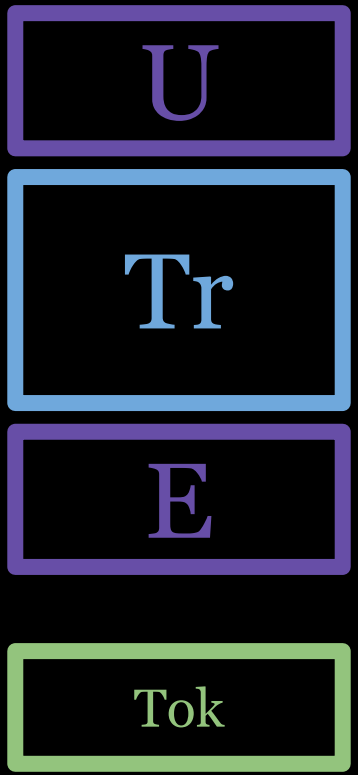
A novel evaluation benchmark for Catalan and Spanish decoder-only models.

Training Data

Dataset	Lang.	Epochs	Tokens (M)
Wikipedia	CA	3.5	1127.08
C4_ca	CA	2.1	8381.54
Biomedical	CA	1.4	23.33
VilaWeb	CA	2.1	149.29
CaWaC	CA	2.1	171.41
Racó - Notícies	CA	2.1	50.89
Racó - Fòrums	CA	2.1	989.81
Wikipedia	ES	1.4	1371.43
C4_es	ES	0.1	7805.53
Biomedical	ES	0.7	449.85
Legal	ES	0.7	984.37
Gutenberg	ES	0.7	52.57
Wikipedia	EN	1.4	4290.56
Total			25847.66

Training Strategy

From Scratch



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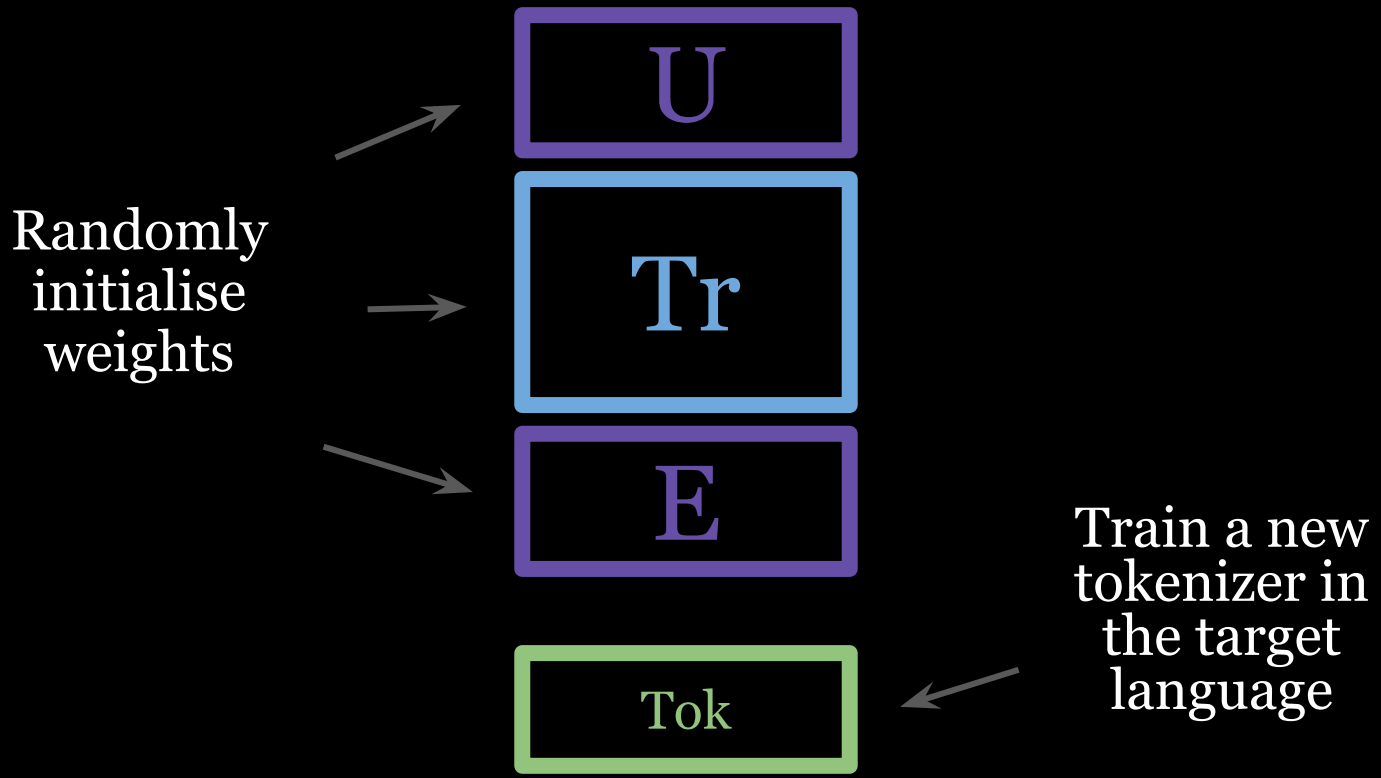

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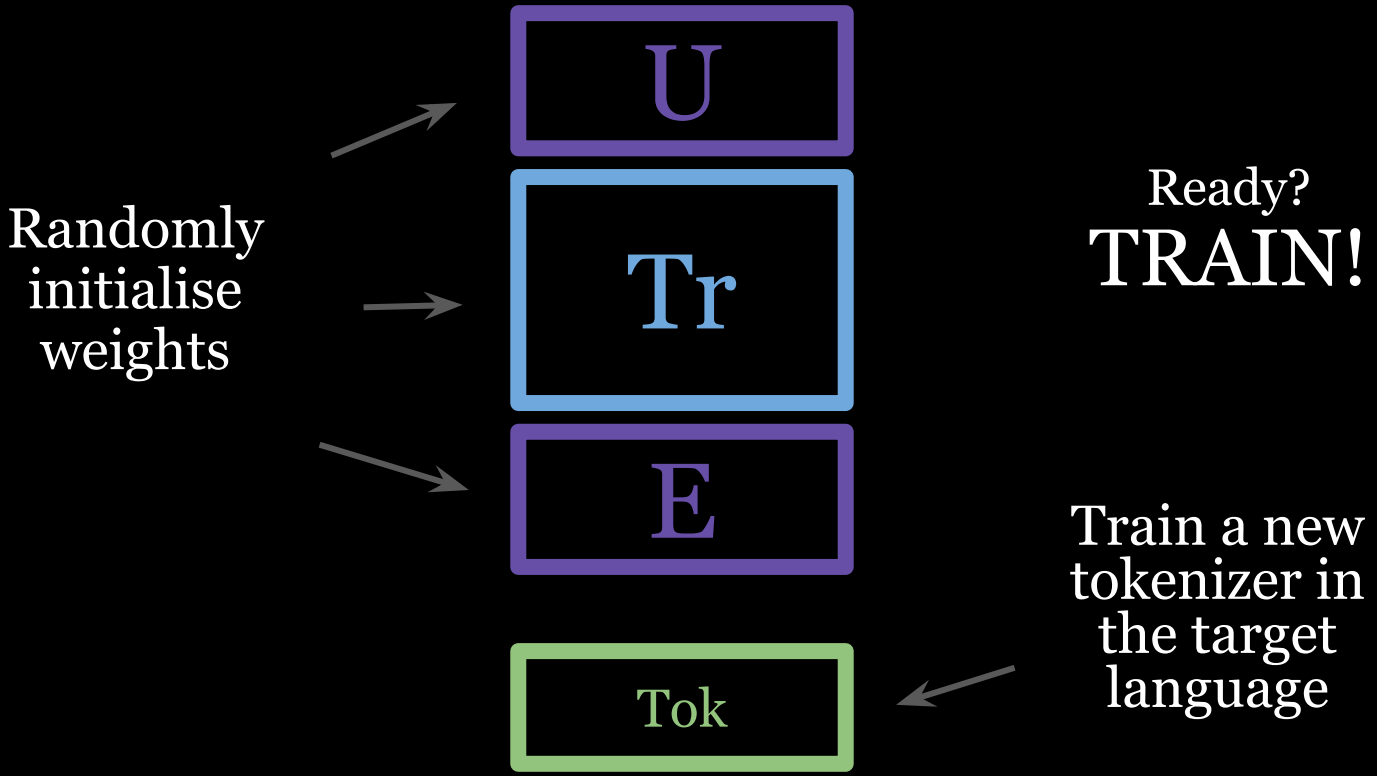


From Scratch

GitHub: Russian GPT-3 models
By Anton Emelyanov et al.

PAGnol: an extra-large French generative model
By Julien Launay et al.

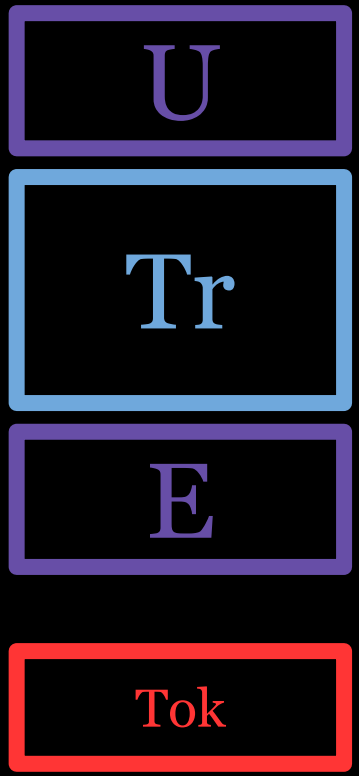
AraGPT2: Pre-trained transformer for Arabic language generation
By Wissam Antoun et al.

Pangu-α: Large-scale autoregressive pretrained chinese language models with auto-parallel computation
By Wei Zeng et al.

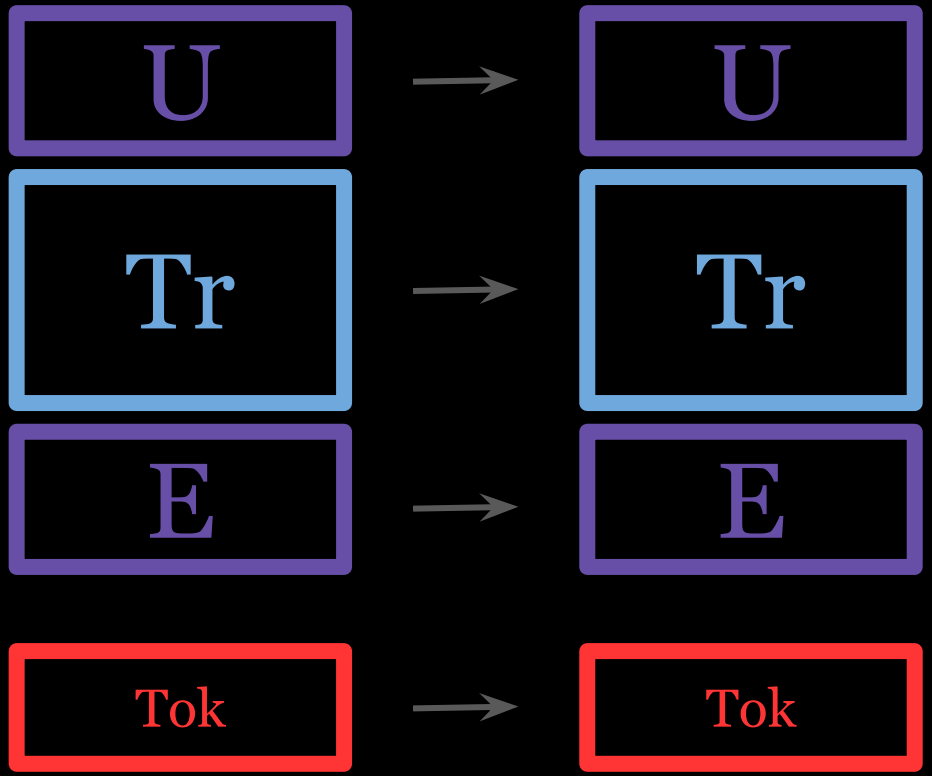
German GPT2
By Stefan Schweter

Language Adaptation

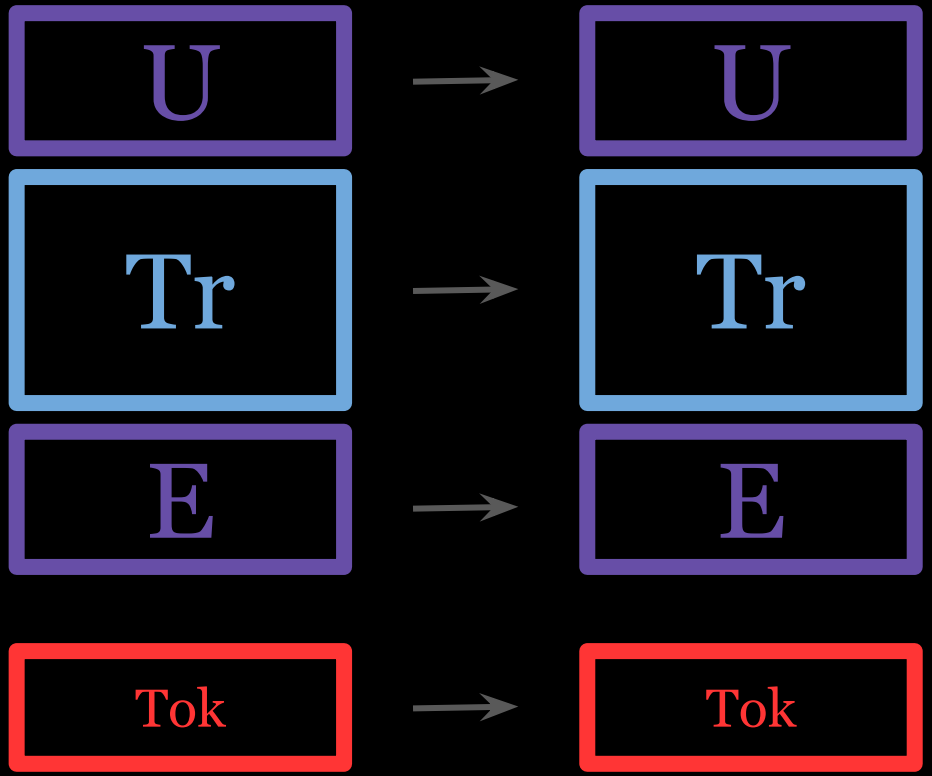
Language Adaptation



Language Adaptation



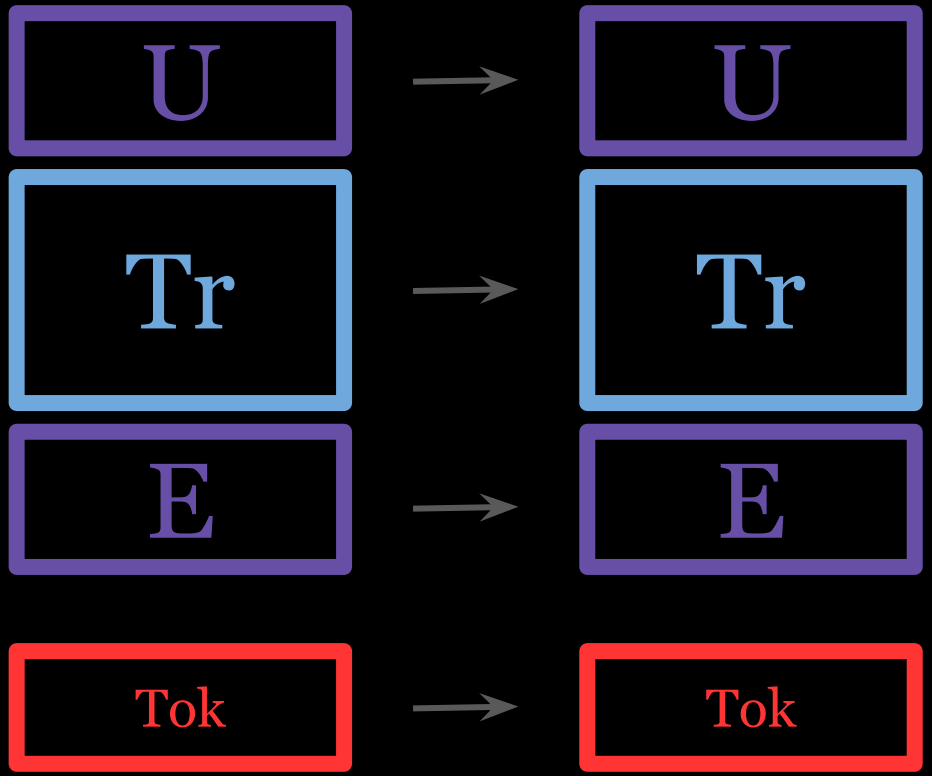
Language Adaptation



Ready?
TRAIN!

Continual Pre-Training

... or CPT



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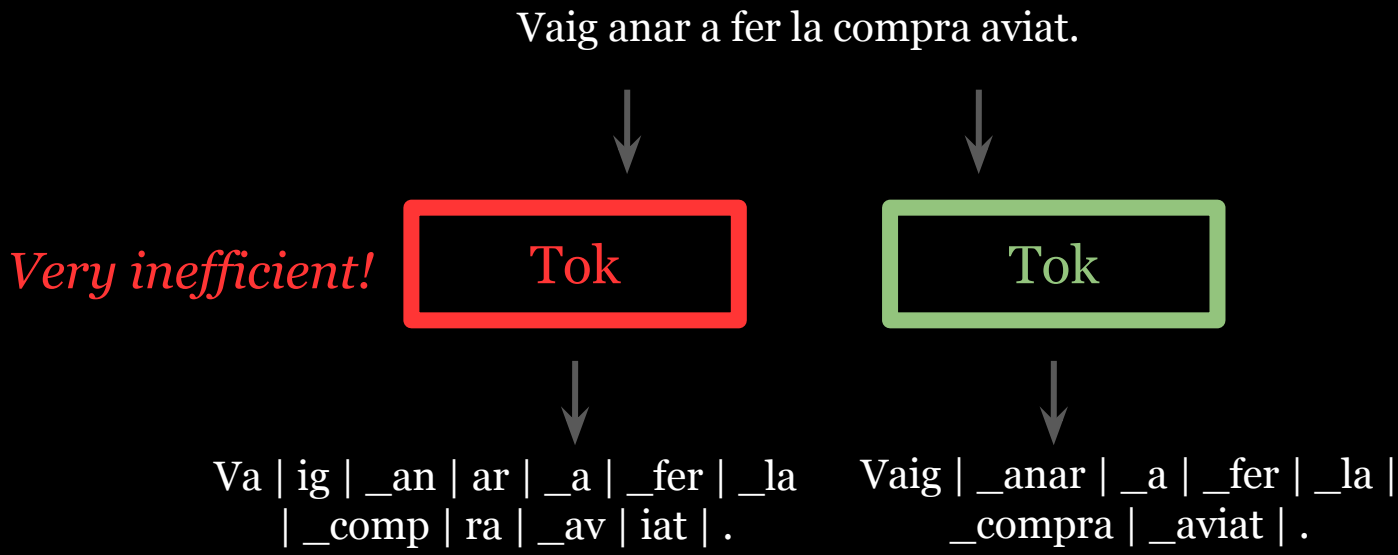
Continual Pre-Training

Cedille: A large autoregressive French language model
By Martin Müller and Florian Laurent

Sabiá: Portuguese Large Language Models
By Ramon Pires et al.

Continual Pre-Training



Continual Pre-Training

Very inefficient!

Tok

Higher time and computational cost for training and inference

Shorter sequences of text can fit in the input context size of the model

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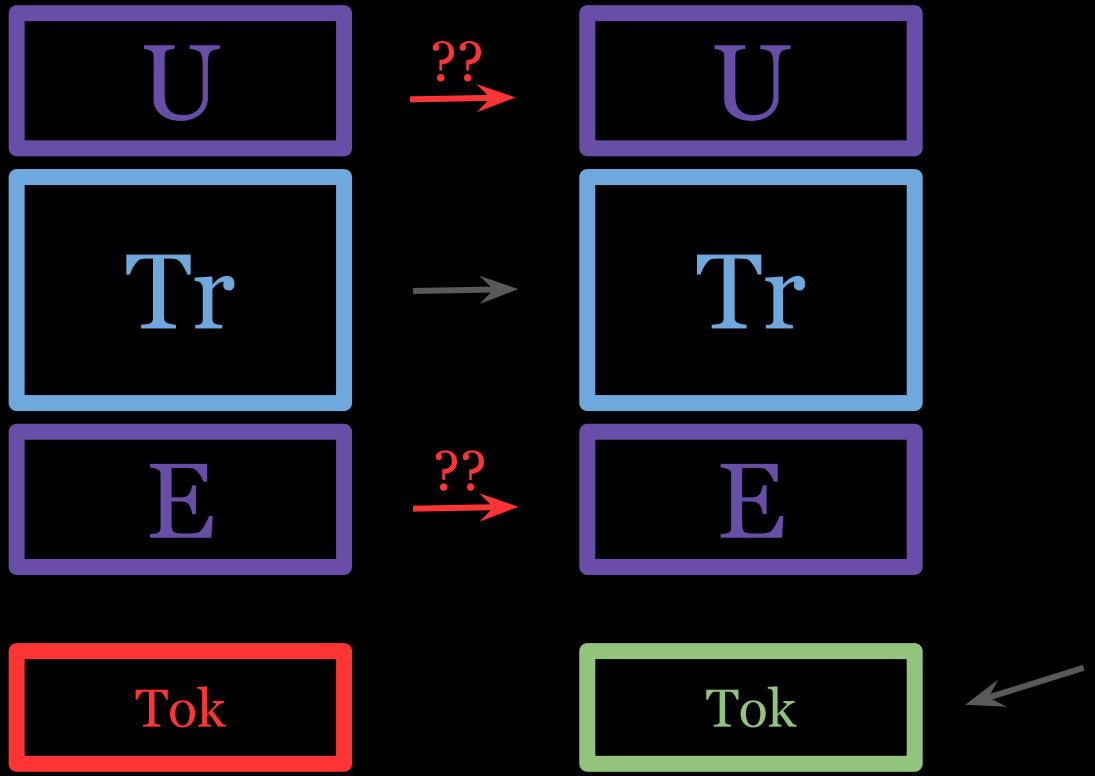
Shorter sequences of text can fit in the input context size of the model

Research seems to suggest that more language-specific tokenization leads to better downstream task performance.

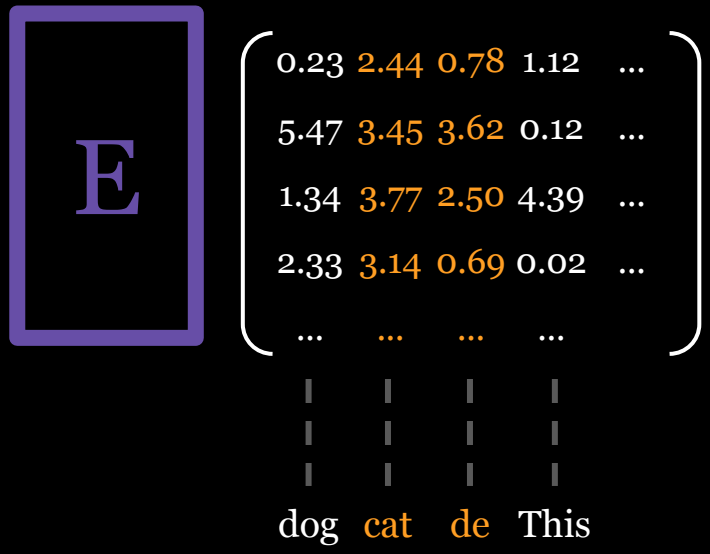
On the Cross-lingual Transferability of Monolingual Representations
By Mikel Artetxe, Sebastian Ruder, Dani Yogatama

Continual Pre-Training



Train a new tokenizer in the target language

Continual Pre-Training



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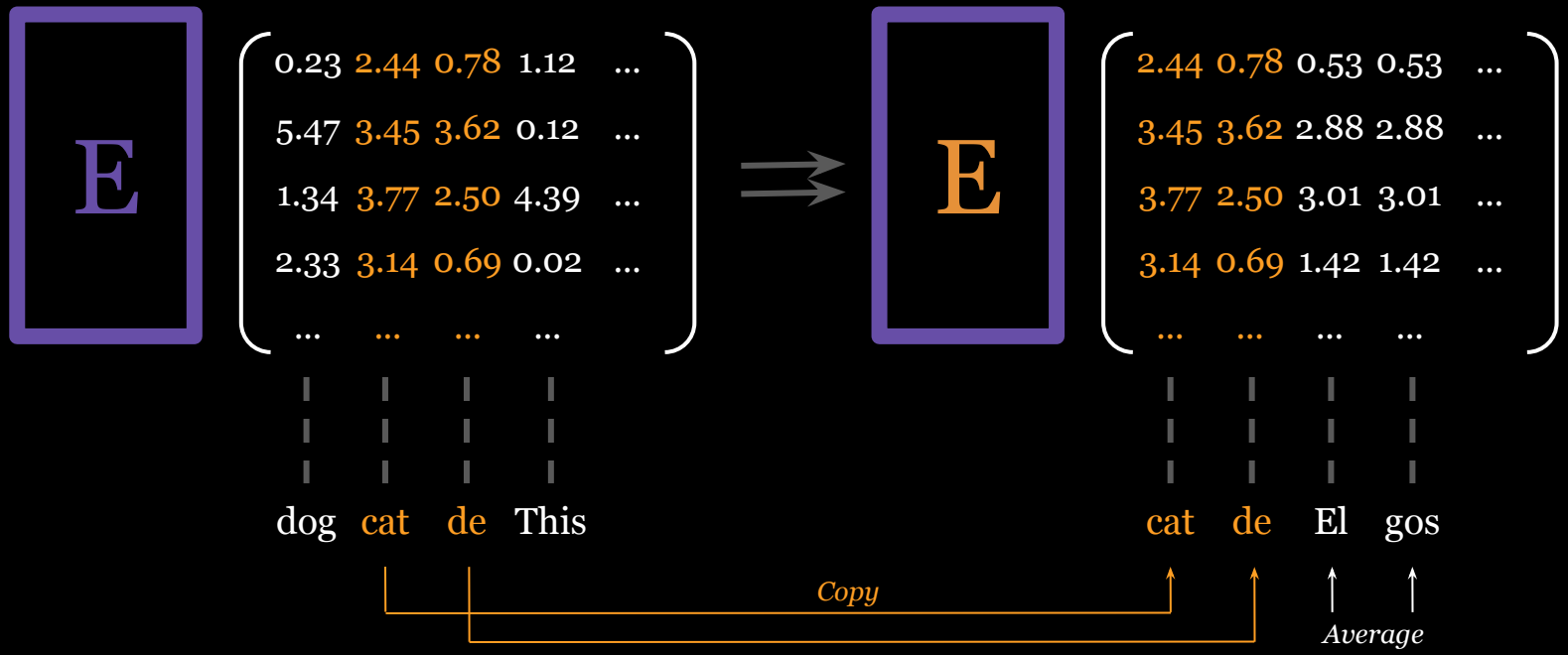
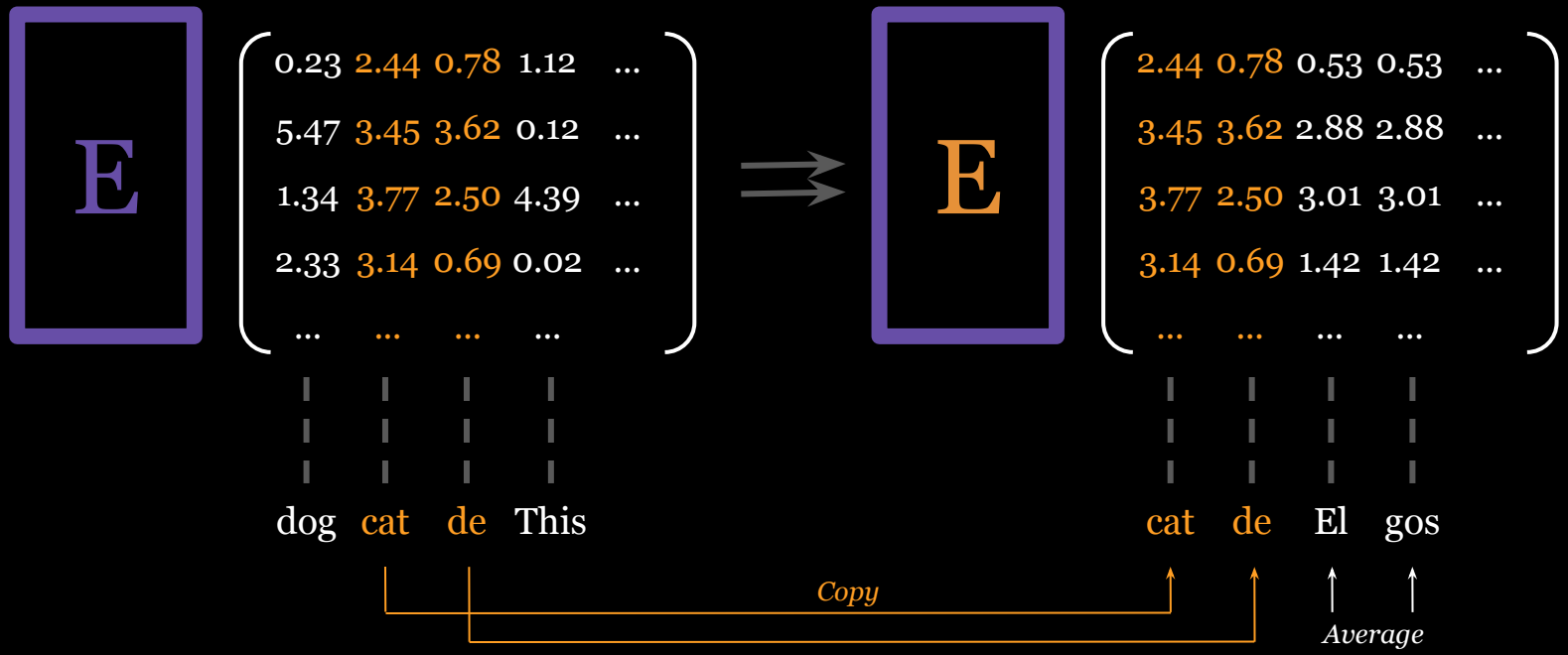


Vocabulary Adaptation



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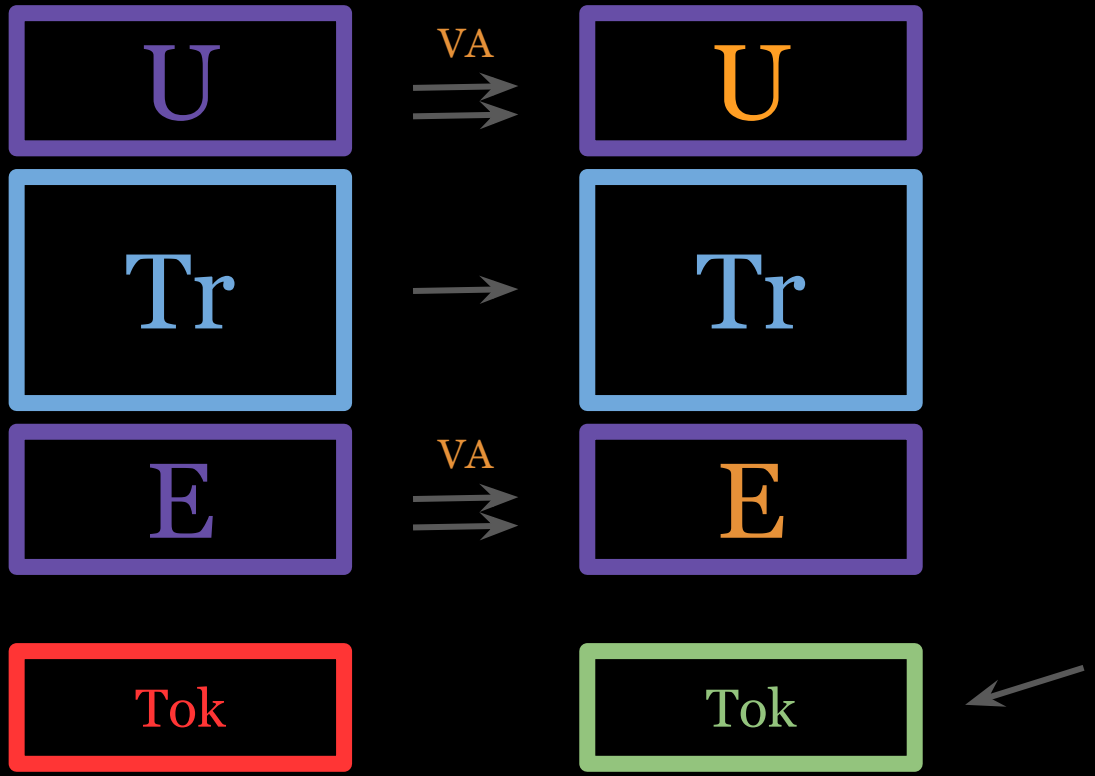

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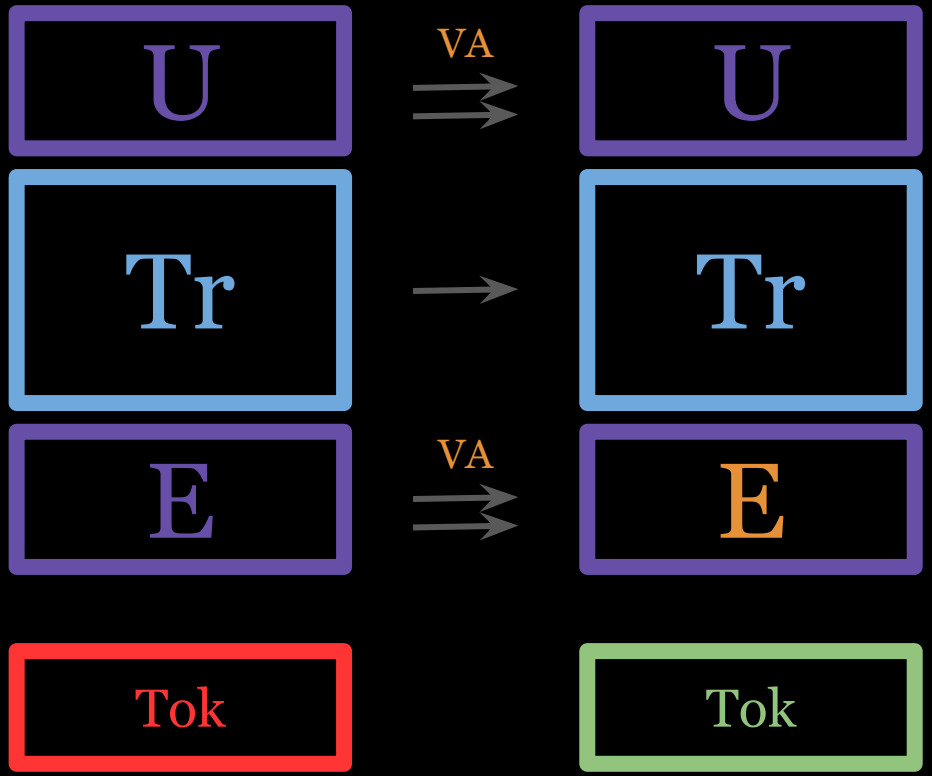

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Continual Pre-Training

As Good as New. How to Successfully Recycle English GPT-2 to Make Models for Other Languages
Wietse de Vries et al.

WECHSEL: Effective initialization of subword embeddings for cross-lingual transfer of monolingual language models
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Transfer Learning in Multilingual Neural Machine Translation with Dynamic Vocabulary
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Evaluation

Reading Comprehension

Belebele (en, es, ca)

Question Answering

XQuAD (en, es, ca)
CatalanQA (ca)
CoQCat (ca)

NLI

XNLI (en, es, ca)
TE-ca (ca)

Paraphrase Identification

PAWS-X (en, es, ca)
Parafraseja (ca)

Commonsense Reasoning

XStoryCloze (en, es)
COPA (en, ca)

Translation

FLoRes (ca-es, ca-en, es-en)

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FLoRes (ca-es, ca-en, es-en)

Model

Experiments

Model	Reading Comp.			Question Answering					Natural Language Inference			
	Belebele (acc)			XQuAD (f1)			CatQA (f1)	CoQCat (f1)	XNLI (acc)			TE-ca (acc)
	ca	es	en	ca	es	en	ca	ca	ca	es	en	ca
Random	25.00	25.00	25.00	-	-	-	-	-	33.33	33.33	33.33	33.33
Cerebras-GPT	33.44	31.89	**36.67**	8.56	19.98	**36.00**	10.87	14.12	36.83	38.88	**47.25**	35.62
From Scratch	33.44	31.00	29.00	8.93	8.47	4.19	13.58	18.86	43.77	42.24	38.40	38.78
CPT	39.22	35.11	33.56	26.67	28.17	25.22	34.99	31.93	45.55	44.01	41.48	40.53
Vocab. Adapt	**40.33**	**36.22**	35.33	**28.52**	**30.38**	28.27	**39.99**	**39.50**	**46.21**	**45.61**	43.35	**42.65**

Model	Paraphrase Identification				Commonsense Reasoning				Translation					
	PAWS-X (acc)			Paraf. (acc)	XStoryCloze (acc)		COPA (acc)		FLoRes (bleu)					
	ca	es	en	ca	es	en	ca	en	ca-es	es-ca	ca-en	en-ca	es-en	en-es
Random	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	-	-	-	-	-	-
Cerebras-GPT	52.40	**52.20**	**55.95**	52.05	49.11	**60.62**	51.40	**66.80**	2.42	1.81	2.69	0.82	3.36	1.77
From Scratch	51.45	51.35	53.55	54.15	55.20	53.54	61.40	59.60	2.72	2.22	1.36	1.14	1.51	1.08
CPT	**53.50**	51.40	50.35	53.95	56.45	57.38	61.60	60.80	9.19	14.88	18.23	12.14	13.10	7.71
Vocab. Adapt	49.95	50.85	51.25	**56.30**	**58.64**	59.10	**66.40**	61.60	**16.31**	**19.63**	**26.65**	**24.10**	**17.16**	**15.09**

**Evaluation Harness (by EleutherAI) was used for evaluation*

Experiments

Model	Reading Comp.			Question Answering					Natural Language Inference			
	Belebele (acc)			XQuAD (f1)			CatQA (f1)	CoQCat (f1)	XNLI (acc)			TE-ca (acc)
	ca	es	en	ca	es	en	ca	ca	ca	es	en	ca
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	ca	es	en	ca	es	en	ca	en	ca-es	es-ca	ca-en	en-ca	es-en	en-es
Random	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	-	-	-	-	-	-
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	ca	es	en	ca	es	en	ca	en	ca-es	es-ca	ca-en	en-ca	es-en	en-es
Random	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	-	-	-	-	-	-
Cerebras-GPT	52.40	**52.20**	**55.95**	52.05	49.11	**60.62**	51.40	**66.80**	2.42	1.81	2.69	0.82	3.36	1.77
From Scratch	51.45	51.35	53.55	54.15	55.20	53.54	61.40	59.60	2.72	2.22	1.36	1.14	1.51	1.08
CPT	**53.50**	51.40	50.35	53.95	56.45	57.38	61.60	60.80	9.19	14.88	18.23	12.14	13.10	7.71
Vocab. Adapt	49.95	50.85	51.25	**56.30**	**58.64**	59.10	**66.40**	61.60	**16.31**	**19.63**	**26.65**	**24.10**	**17.16**	**15.09**

**Evaluation Harness (by EleutherAI) was used for evaluation*

Experiments

Model	Reading Comp.			Question Answering					Natural Language Inference			
	Belebele (acc)			XQuAD (f1)			CatQA (f1)	CoQCat (f1)	XNLI (acc)			TE-ca (acc)
	ca	es	en	ca	es	en	ca	ca	ca	es	en	ca
Random	25.00	25.00	25.00	-	-	-	-	-	33.33	33.33	33.33	33.33
Cerebras-GPT	33.44	31.89	**36.67**	8.56	19.98	**36.00**	10.87	14.12	36.83	38.88	**47.25**	35.62
From Scratch	33.44	31.00	29.00	8.93	8.47	4.19	13.58	18.86	43.77	42.24	38.40	38.78
CPT	39.22	35.11	33.56	26.67	28.17	25.22	34.99	31.93	45.55	44.01	41.48	40.53
Vocab. Adapt	**40.33**	**36.22**	35.33	**28.52**	**30.38**	28.27	**39.99**	**39.50**	**46.21**	**45.61**	43.35	**42.65**

Model	Paraphrase Identification				Commonsense Reasoning				Translation					
	PAWS-X (acc)			Paraf. (acc)	XStoryCloze (acc)		COPA (acc)		FLoRes (bleu)					
	ca	es	en	ca	es	en	ca	en	ca-es	es-ca	ca-en	en-ca	es-en	en-es
Random	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	-	-	-	-	-	-
Cerebras-GPT	52.40	**52.20**	**55.95**	52.05	49.11	**60.62**	51.40	**66.80**	2.42	1.81	2.69	0.82	3.36	1.77
From Scratch	51.45	51.35	53.55	54.15	55.20	53.54	61.40	59.60	2.72	2.22	1.36	1.14	1.51	1.08
CPT	**53.50**	51.40	50.35	53.95	56.45	57.38	61.60	60.80	9.19	14.88	18.23	12.14	13.10	7.71
Vocab. Adapt	49.95	50.85	51.25	**56.30**	**58.64**	59.10	**66.40**	61.60	**16.31**	**19.63**	**26.65**	**24.10**	**17.16**	**15.09**

**Evaluation Harness (by EleutherAI) was used for evaluation*

Catastrophic Forgetting!

Can we improve this?

Results

Model	Training tokens		Reading Comprehension			Question Answering				
			Belebele$_{acc}$			XQuAD$_{f1}$			CatalanQA$_{f1}$	CoQCat$_{f1}$
	Pre-train	Lang. adapt.	ca	es	en	ca	es	en	ca	ca
Random	-	-	25.00	25.00	25.00	-	-	-	-	-
mGPT-1.3B	440B	-	26.11	24.44	26.11	0.33	0.67	0.17	0.65	0.78
GPT-Neo-1.3B	380B	-	35.44	32.77	41.67	19.75	29.77	51.53	22.34	23.57
Pythia-1.4B	299.9B	-	35.78	35.11	41.56	26.19	34.13	52.98	27.47	25.38
OPT-1.3B	180B	-	35.22	33.56	43.78	23.53	31.85	52.95	26.58	20.18
Falcon-rw-1.3B	350B	-	34.33	33.56	**47.89**	5.93	19.25	**58.60**	6.91	15.61
Cerebras-GPT-1.3B	26B	-	33.44	31.89	36.67	8.56	19.98	36.00	10.87	14.12
BLOOM-1.1B	341B	-	39.89	37.22	39.33	36.81	36.98	44.10	44.65	34.57
From_scratch-1.3B	26B	-	33.44	31.00	29.00	8.93	8.47	4.19	13.58	18.86
Cerebras-GPT-continued_pre-training-1.3B	26B	38B	39.22	35.11	33.56	26.67	28.17	25.22	34.99	31.93
Cerebras-GPT-vocab_adapted-1.3B	26B	26B	40.33	36.22	35.33	28.52	30.38	28.27	39.99	39.50
BLOOM-vocab_adapted-760M	341B	26B	41.00	37.89	37.00	41.10	41.11	40.20	51.01	41.34
BLOOM-vocab_adapted-1.3B	341B	26B	**43.44**	**39.11**	40.44	**43.52**	**44.31**	44.11	**54.25**	**48.15**

Results

Model	Training tokens		Natural Language Inference				Paraphrase Identification			
			XNLI$_{acc}$			TE-ca$_{acc}$	PAWS-X$_{acc}$			Parafraseja$_{acc}$
	Pre-train	Lang. adapt.	ca	es	en	ca	ca	es	en	ca
Random	-	-	33.33	33.33	33.33	33.33	50.00	50.00	50.00	50.00
mGPT-1.3B	440B	-	40.06	43.81	45.67	37.03	51.00	52.30	56.15	51.32
GPT-Neo-1.3B	380B	-	41.44	45.57	49.92	35.38	54.65	53.40	54.60	51.70
Pythia-1.4B	299.9B	-	42.46	45.61	51.00	37.46	54.15	52.50	**57.70**	55.23
OPT-1.3B	180B	-	40.08	44.53	**52.48**	36.14	54.10	52.55	55.90	53.23
Falcon-rw-1.3B	350B	-	34.53	35.85	45.73	34.96	54.25	**54.05**	53.65	50.60
Cerebras-GPT-1.3B	26B	-	36.83	38.88	47.25	35.62	52.40	52.20	55.95	52.05
BLOOM-1.1B	341B	-	47.19	46.39	49.44	41.38	**55.05**	54.05	54.75	55.65
From_scratch-1.3B	26B	-	43.77	42.24	38.40	38.78	51.45	51.35	53.55	54.15
Cerebras-GPT-continued_pre-training-1.3B	26B	38B	45.55	44.01	41.48	40.53	53.50	51.40	50.35	53.95
Cerebras-GPT-vocab_adapted-1.3B	26B	26B	46.21	45.61	43.35	42.65	49.95	50.85	51.25	56.30
BLOOM-vocab_adapted-760M	341B	26B	46.93	46.03	46.11	42.14	52.35	52.50	54.85	56.55
BLOOM-vocab_adapted-1.3B	341B	26B	**49.20**	**48.82**	47.45	**42.89**	53.20	52.85	53.00	**57.43**

Results

Model	Training tokens		Commonsense Reasoning				Translation					
			$\text{XStoryCloze}_{\text{acc}}$		COPA_{acc}		$\text{FLoRes}_{\text{bleu}}$					
	Pre-train	Lang. adapt.	es	en	ca	en	ca→es	es→ca	ca→en	en→ca	es→en	en→es
Random	-	-	50.00	50.00	50.00	50.00	-	-	-	-	-	-
mGPT-1.3B	440B	-	55.33	60.09	52.20	63.40	3.25	2.96	9.25	3.79	17.75	15.34
GPT-Neo-1.3B	380B	-	51.42	66.58	53.40	74.80	3.27	3.80	17.77	5.49	17.70	12.04
Pythia-1.4B	299.9B	-	54.14	68.37	52.20	78.60	9.68	5.74	24.03	11.10	21.50	15.04
OPT-1.3B	180B	-	53.94	69.95	52.60	76.20	3.14	3.52	15.39	2.00	16.33	6.53
Falcon-rw-1.3B	350B	-	51.09	**71.34**	52.40	**79.60**	3.03	3.59	8.89	3.01	14.17	6.50
Cerebras-GPT-1.3B	26B	-	49.11	60.62	51.40	66.80	2.42	1.81	2.69	0.82	3.36	1.77
BLOOM-1.1B	341B	-	57.91	62.48	62.80	66.40	21.62	15.28	31.16	21.28	20.92	16.84
From_scratch-1.3B	26B	-	55.20	53.54	61.40	59.60	2.72	2.22	1.36	1.14	1.51	1.08
Cerebras-GPT-continued_pre-training-1.3B	26B	38B	56.45	57.38	61.60	60.80	9.19	14.88	18.23	12.14	13.10	7.71
Cerebras-GPT-vocab_adapted-1.3B	26B	26B	58.64	59.10	66.40	61.60	16.31	**19.63**	26.65	24.10	17.16	15.09
BLOOM-vocab_adapted-760M	341B	26B	61.42	61.42	65.40	64.20	**22.62**	15.77	32.26	26.04	20.91	18.08
BLOOM-vocab_adapted-1.3B	341B	26B	**64.06**	61.81	**68.00**	67.80	22.16	18.58	**33.95**	**29.31**	**23.09**	**20.30**

Takeaways

Do NOT train from scratch.

Consider adapting the vocabulary instead of CPT!

Use a pre-trained model as close as possible to your language as starting point.

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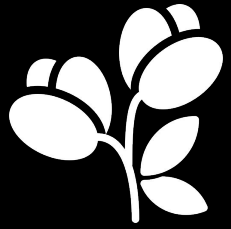

Thank You!