Improving Numeracy
by Input Reframing and Quantitative Pre-Finetuning Task

Chung-Chi Chen,[1] Hiroya Takamura,[1] Ichiro Kobayashi,[2] Yusuke Miyao[3]
[1]AIRC, AIST, Japan
[2]Ochanomizu University, Japan
[3]University of Tokyo, Japan

NLPFin

EACL 2023

Input Reframing

Model	Notation	Tokenized Example
BERT	*Org.*	"147", "##70", "##2"
	Digit	"1", "4", "7", "7", "0", "2"
	Scientific Notation	"1", ".", "47", "##70", "##200", "##00", "##0", "##e", "+", "05"
RoBERTa	*Org.*	"147", "702"
	Digit	"1", "4", "7", "7", "0", "2"
	Scientific Notation	"1", ".", "47", "70", "200000", "E", "+", "05"

Quantitative Pre-Finetuning Task

Task	Question	Answer
ComNum	[Num 1] is equal to [Num 2]. [Num 1] is smaller than [Num 2]. [Num 1] is larger than [Num 2].	TRUE/FALSE
QP	FED'S DUDLEY REPEATS EXPECTS GDP GROWTH TO PICK UP IN 2014, FROM [Masked] PCT POST-RECESSION AVERAGE	1
QNLI	S1: Nifty traded above 7500, Trading Calls Today S2: Nifty above 7400	Entailment
QQA	Elliot weighs 180 pounds whereas Leon weighs 120 pounds. Who has a bigger gravity pull? Option1: Elliot Option2: Leon	Option 1

Innumeracy ➔ A Phenomenon with All LMs

Training: 0 - 199,999
Testing:
- CND-T1: 0 - 199,999
- CND-T2: 4M - 5M

	BERT		RoBERTa		LinkBERT		FinBERT	
	CND-T1	CND-T2	CND-T1	CND-T2	CND-T1	CND-T2	CND-T1	CND-T2
Original	99.86	95.59 (↓ 4.27)	99.44	86.75 (↓ 12.69)	99.92	97.58 (↓ 2.34)	99.55	78.37 (↓ 21.18)
Digit-based	99.96	99.03 (↓ 0.93)	99.92	98.46 (↓ 1.46)	99.99	96.54 (↓ 3.45)	99.96	97.03 (↓ 2.93)
Scientific Notation	99.92	99.68 (↓ **0.24**)	99.82	99.13 (↓ **0.69**)	99.95	99.81 (↓ **0.14**)	99.72	98.78 (↓ **0.94**)

RoBERTa ➔ Both Input Reframing and Quantitative PFT Works

Model	Notation	QP		QNLI					QQA	Score
		Comment	Headline	RTE-QUANT	AWP-NLI	NEWSNLI	REDDITNLI	Stress Test		
RoBERTa	*Original*	60.46%	58.03%	60.15%	57.64%	79.58%	58.77%	98.93%	51.96%	65.69
	Digit-based	**69.25%**	57.65%	59.40%	56.69%	78.90%	**62.38%**	**99.91%**	**54.34%**	**67.31**
	Scientific Notation	**64.32%**	55.49%	60.08%	57.41%	78.68%	**60.81%**	**100.00%**	**53.67%**	**66.31**
CN-RoBERTa	*Original*	**86.86%**	**77.29%**	**62.52%**	56.70%	78.82%	**64.29%**	**99.94%**	50.71%	**72.14**
	Digit-based	**64.25%**	55.92%	**68.96%**	**58.80%**	77.99%	**60.99%**	**99.73%**	50.88%	**67.19**
	Scientific Notation	60.28%	54.85%	**62.15%**	**58.74%**	65.92%	**59.59%**	**99.47%**	**52.27%**	64.16

BERT-Based ➔ Quantitative PFT Works with QNLI

Model	Notation	QP		QNLI					QQA	Score
		Comment	Headline	RTE-QUANT	AWP-NLI	NEWSNLI	REDDITNLI	Stress Test		
BERT	*Original*	70.44%	57.46%	64.40%	59.20%	72.29%	60.42%	99.91%	53.20%	67.17
	Digit-based	65.38%	54.74%	57.86%	56.46%	71.36%	60.11%	99.11%	**53.75%**	64.85
	Scientific Notation	65.31%	55.99%	**64.42%**	**60.73%**	72.23%	59.66%	99.56%	**53.24%**	66.39
CN-BERT	*Digit-based*	69.93%	54.84%	61.07%	**60.27%**	**75.54%**	**65.39%**	99.42%	52.53%	**67.37**
	Scientific Notation	64.87%	56.40%	**66.39%**	54.70%	**75.41%**	**63.94%**	99.42%	51.90%	66.63
LinkBERT	*Original*	68.81%	55.70%	59.94%	56.85%	73.43%	59.01%	99.91%	54.14%	65.97
	Digit-based	63.76%	55.41%	59.54%	**57.42%**	**73.63%**	**60.17%**	99.73%	53.44%	65.39
	Scientific Notation	65.81%	**56.05%**	57.00%	56.78%	**75.51%**	58.51%	99.82%	**54.33%**	65.48
CN-LinkBERT	*Digit-based*	68.61%	54.44%	**63.59%**	55.08%	71.21%	58.99%	**100.00%**	50.44%	65.30
	Scientific Notation	63.48%	53.15%	**62.02%**	**59.39%**	**75.70%**	**62.61%**	99.73%	52.11%	**66.02**

FinBERT ➔ Both Works with QP

Model	Reframing	QP-Comment
FinBERT	*Original*	65.26%
	Digit-based	**69.89%**
	Scientific Notation	**70.03%**
CN-FinBERT	*Digit-based*	**68.84%**
	Scientific Notation	**69.76%**

Findings

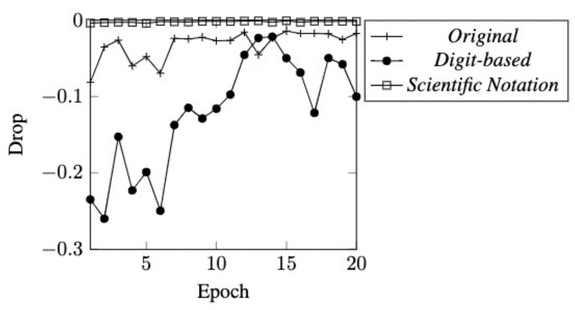
Innumeracy: When the numerals in the test set are **out of the range** of those in the training set, the performance will **drop**

RoBERTa	QP	QNLI	QQA
Reframing	V	V	V
ComNum (PFT)	V	V	X

BERT	QP	QNLI	QQA
Reframing	X	V	X
ComNum (PFT)	X	V	X

Future Direction

Convergence



Numeral Factuality:
Numeracy-600K (ACL-2019) – Detecting Exaggerated Information

Quantitative 101 Dataset

http://q101.nlpfin.com/

Comparing Number LMs

http://cn-roberta.nlpfin.com/

AIST AIRC お茶の水女子大学 Ochanomizu University 東京大学 THE UNIVERSITY OF TOKYO