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Are EEG-to-Text Models Working?

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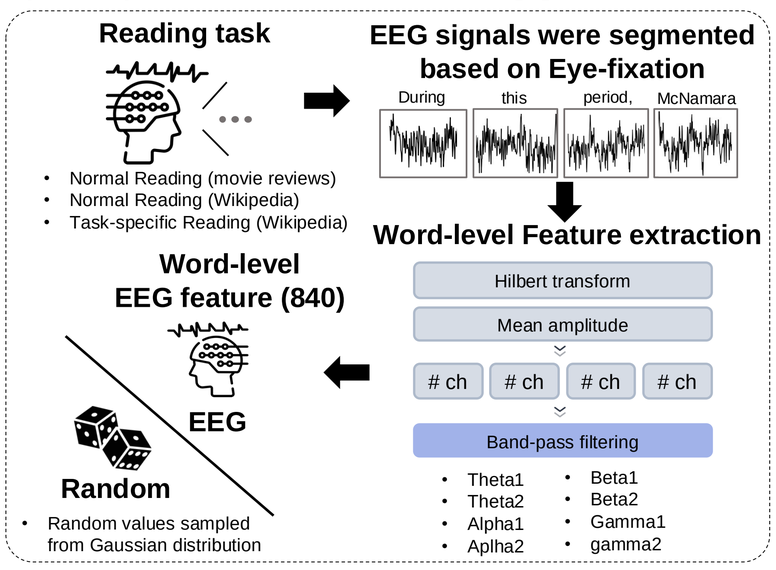
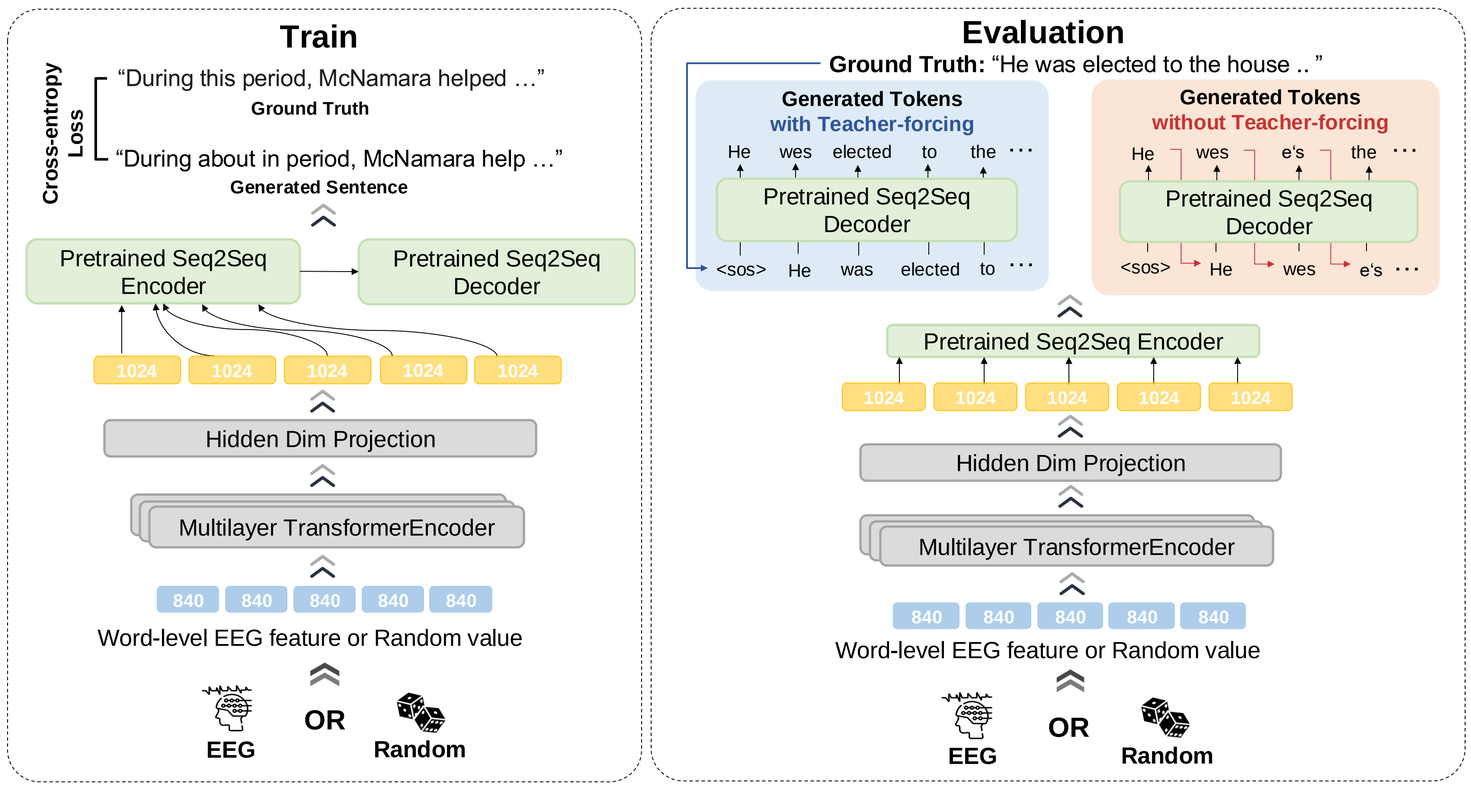
Introduction

- This work **critically analyzes existing models for open-vocabulary EEG-to-Text translation**.
- We identify a crucial limitation: previous studies often employed **implicit teacher-forcing during evaluation, which gives an illusion of high performance in terms of text generation metrics [1].**
- Additionally, they lacked a critical benchmark, comparing model performance on **pure noise inputs**.
- We propose a methodology to differentiate between models that truly learn from EEG signals and those **that simply memorize training data [2]**.
- This approach will lead to reliable model assessments and pave the way for robust EEG-to-Text communication systems.
- We aim to assess the model's ability to learn from EEG data and address issues with implicitly employed teacher-forcing discussed by Yang [4].
- We followed the approach of Wang and Ji [1] and utilized the publicly available ZuCo dataset [3].



Materials and Methods



- We split the data into three sets: 80% (training), 10% (development), 10% (testing).
- The model architecture consists of two components:
  (1) A transformer encoder: processing word-level EEG features and generates embeddings.
  (2) A pretrained BART model takes the encoder's embeddings and decodes them into text sequences.
- To assess the impact of teacher-forcing, we evaluated the model's performance under two conditions: (1) **With teacher-forcing**, (2) **Without teacher-forcing**.
- Evaluated the model's translation performance using BLEU, ROUGE, and WER.
- We designed four distinct scenarios.
  (1) EEG (training and testing)
  (2) Random (training and testing)
  (3) EEG (training) + Random (testing)
  (4) Random (training) + EEG (testing).

Results

Table 1. EEG-to-Text model evaluation on the ZuCo 1.0 dataset, incorporating reading tasks from SR, NR, and TSR. "w/tf " denotes results obtained using teacher-forcing during evaluation.

Pretrained model	Training	Testing	BLEU-1 (%)	ROUGE-1 (%)	WER (%)
BART	EEG	EEG	13.69	11.98	108.43
	EEG	Random	13.87	12.23	108.31
	Random	EEG	14.05	11.46	110.96
	Random	Random	14.22	11.62	110.98
BART w/tf	EEG	EEG	39.31	26.41	78.08
	EEG	Random	39.34	26.44	78.07
	Random	EEG	39.67	26.29	78.09
	Random	Random	39.69	26.32	78.09

- Previous methodologies **perform similarly on noise and actual EEG data.**
- Teacher-forcing during evaluation resulted in a substantial performance by at least three-fold compared to evaluations without it.
- **Similar evaluation results were observed across models trained on EEG or random** input data, regardless of the evaluation data type.

Conclusions

- Results showed similar performance on **pure noise and actual EEG** data with previous methodologies.
- Highlighted potential for **inflated metrics with teacher-forcing** and previous evaluation methods.
- Regularly **incorporating noise baselines during evaluation is crucial for establishing a reliable performance benchmark**.
- Adoption of these practices will enhance research reliability and accelerate the development of robust EEG-to-Text communication systems.

Acknowledgement

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* Code is available at https://github.com/NeuSpeech/EEG-To-Text.