Cognitive Diversity in LLMs Under Memory Constraints

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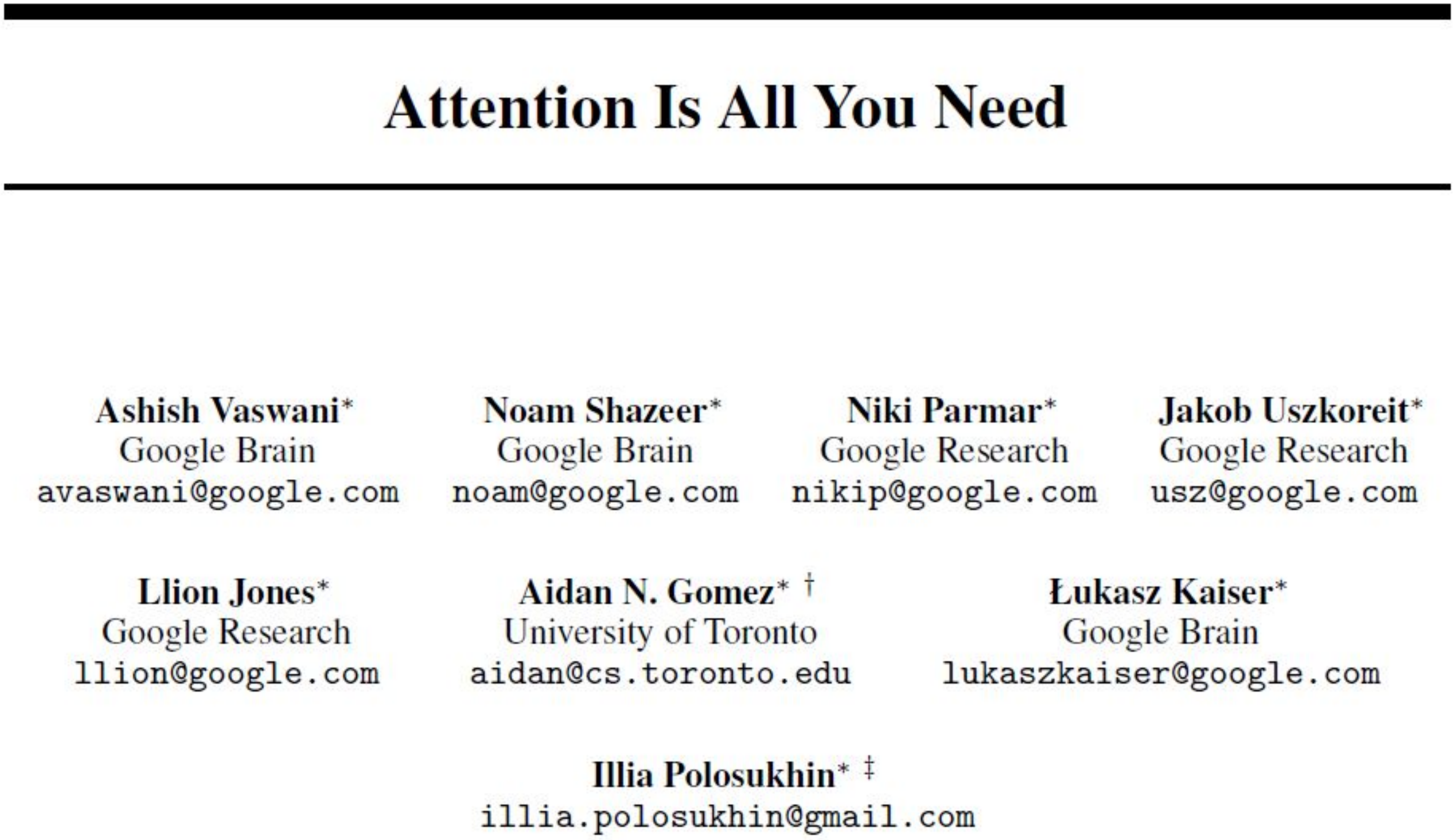
Introduction



Attention Is All You Need

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Attention is All you need, Ashish Vaswani, et al. arXiv link

Transformers Are Powerful …

But How Do They Manage Memory?

Working Memory

essential for reasoning, planning, long-context tasks, etc

Different Architecture Behaviors Under Memory Constraints?

Limitation of Previous Work

Next Token Prediction

Linguistic Benchmarks

Proposed Idea

Digit Span

n-back

Models Used

GPT-2 (causal)

GPT-Neo by EleutherAI (causal)

Phi-2 (causal, large)

DistilBERT (masked)

Metrics

Accuray

Memory Capacity

Attention Entropy

$$Corr(entr.\,,\,acc.)$$

Results

DistilBERT = 97.5 %

GPT-2, GPT-Neo < 10 %

Phi-2 ≃ 0 %

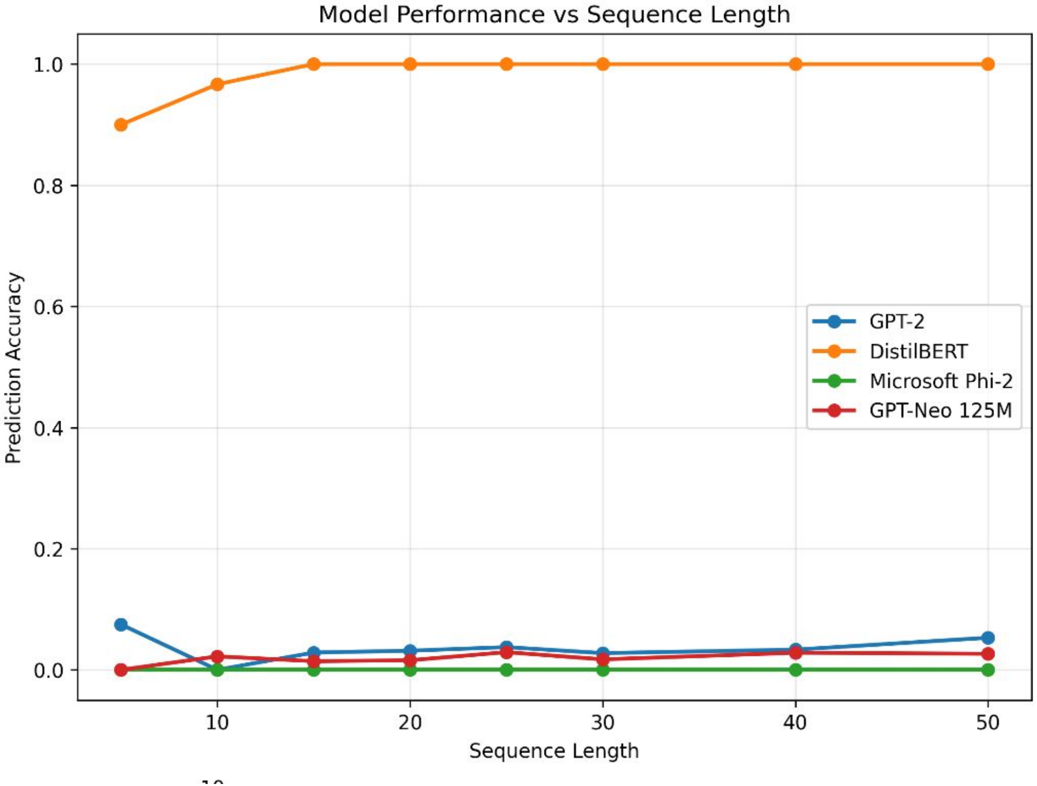
Cognitive Strategies

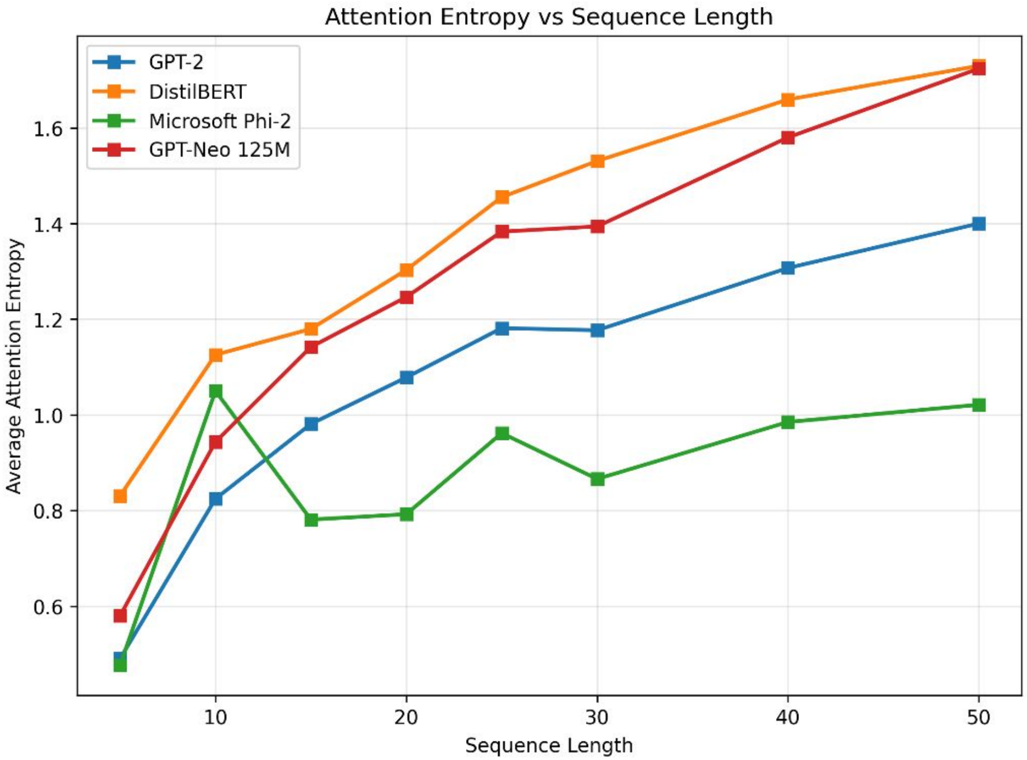
GPT-2 : Increased Entropy

DistilBERT: Decreased Entropy (more focus)

GPT-Neo: Similar to DistilBERT

Phi-2: Unstable, No Clear Strategy


Model Performance vs Sequence Length
Prediction Accuracy
1.0
0.8
0.6
0.4
0.2
0.0
10
20
30
40
50
Sequence Length
GPT-2
DistilBERT
Microsoft Phi-2
GPT-Neo 125M


Attention Entropy vs Sequence Length
GPT-2
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Average Attention Entropy
1.6
1.4
1.2
1.0
0.8
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10
20
30
40
50
Sequence Length

Implications

Model Size

Use of Attention Entropy

Distinct Cognitive Strategies

Choosing Models for Memory Heavy Tasks

Cognitive-inspired AI Design

Interpretability

Questions