

text generation

nov 10, 2020
umass cs 490a

guest lecturer: nader akoury

types of text generation

- conditional
 - machine translation
 - summarization
 - data-to-text (sports, finance, etc)
 - chat bots
 - question answering
 - narrative generation
 - etc
- unconditional
 - language models

how to generate text?

- templates
- rules
 - planning
 - retrieval
- statistical models
- neural networks

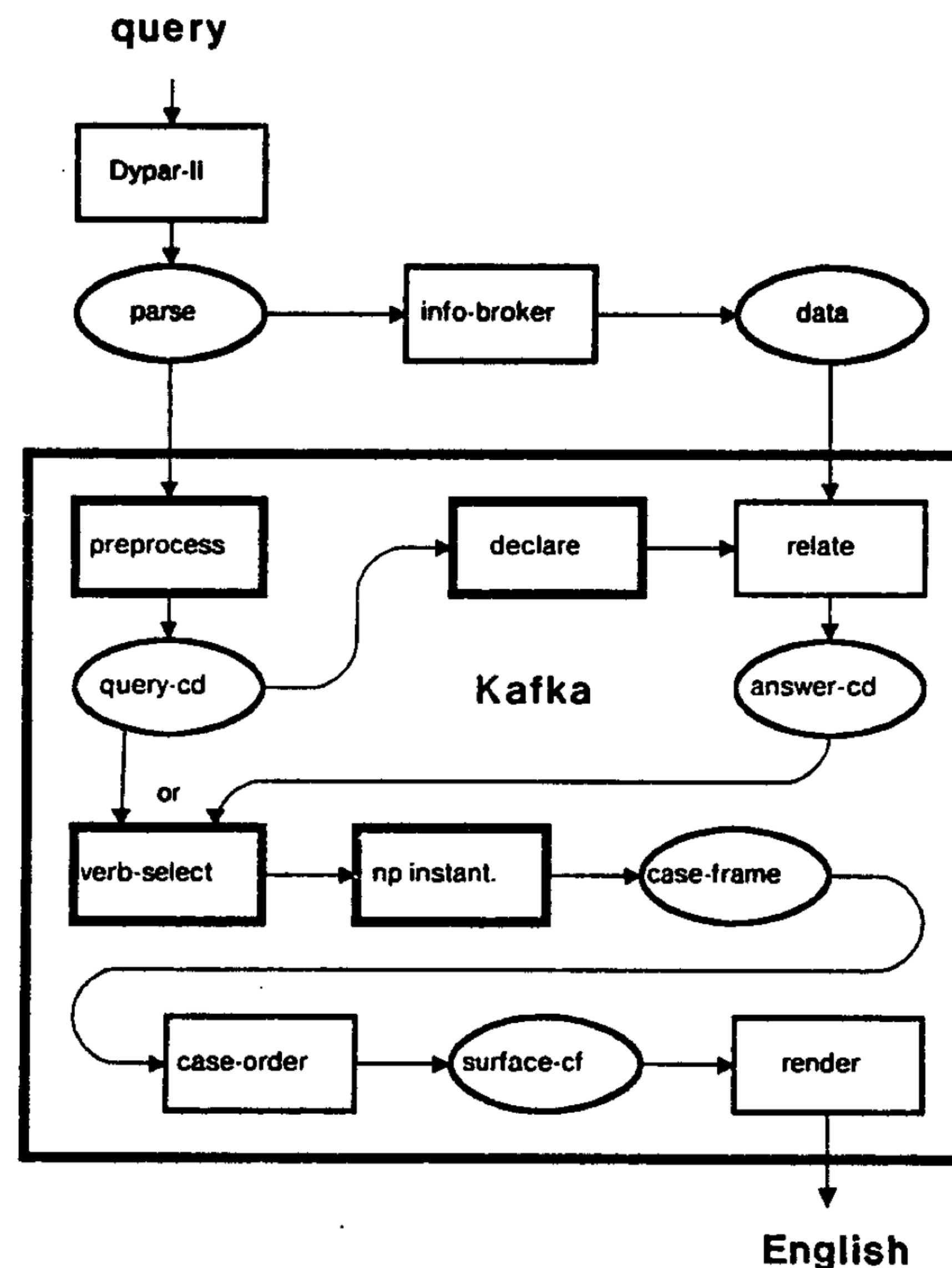
templates

structured data + natural language template

athlete	ba	rbi
ken griffey jr	0.284	1836

<athlete> has a lifetime batting average of <ba>
and <rbi> runs batted in.

q&a circa 1984



Mauldin, ICCL 1984

<https://www.aclweb.org/anthology/P84-1077/>

Figure 4-1: Data flow in the Kafka Generator

q&a circa 1984

→ *What is the price of the two largest single port disks?*

```
(*clause
(head (*factual-query))
(destination (*default))
(object
  (*nominal
    (head (price))
    (of
      (*nominal
        (head (disk))
        (ports (value (1)))
        (size (value (*descending))
              (range-high (1))
              (range-low (2))
              (range-origin
                (*absolute))))
        (determiner (*def))))))
    (determiner (*def))))))
(level (*main))
(verb
  (*conjugation
    (root (be))
    (mode (*interrogative))
    (tense (*present))
    (number (*singular))))))
```

Mauldin, ICCL 1984

<https://www.aclweb.org/anthology/P84-1077/>

statistical machine translation

- given a pair of source & target sentences
find the most probable translation

$$t^* = \arg \max_{t \in T} p(t | s)$$

$$= \arg \max_{t \in T} p(s | t)p(t)$$

← Bayes Rule
 $p(t | s) \propto p(s | t)p(t)$

Vogel et al., COLING 1996

<https://www.aclweb.org/anthology/C96-2141/>

statistical machine translation

challenges

- word alignment
 - potentially many-to-many
 - english: rhubarb barbara
 - german: rhabarberbarbara
- word order
 - syntax can help

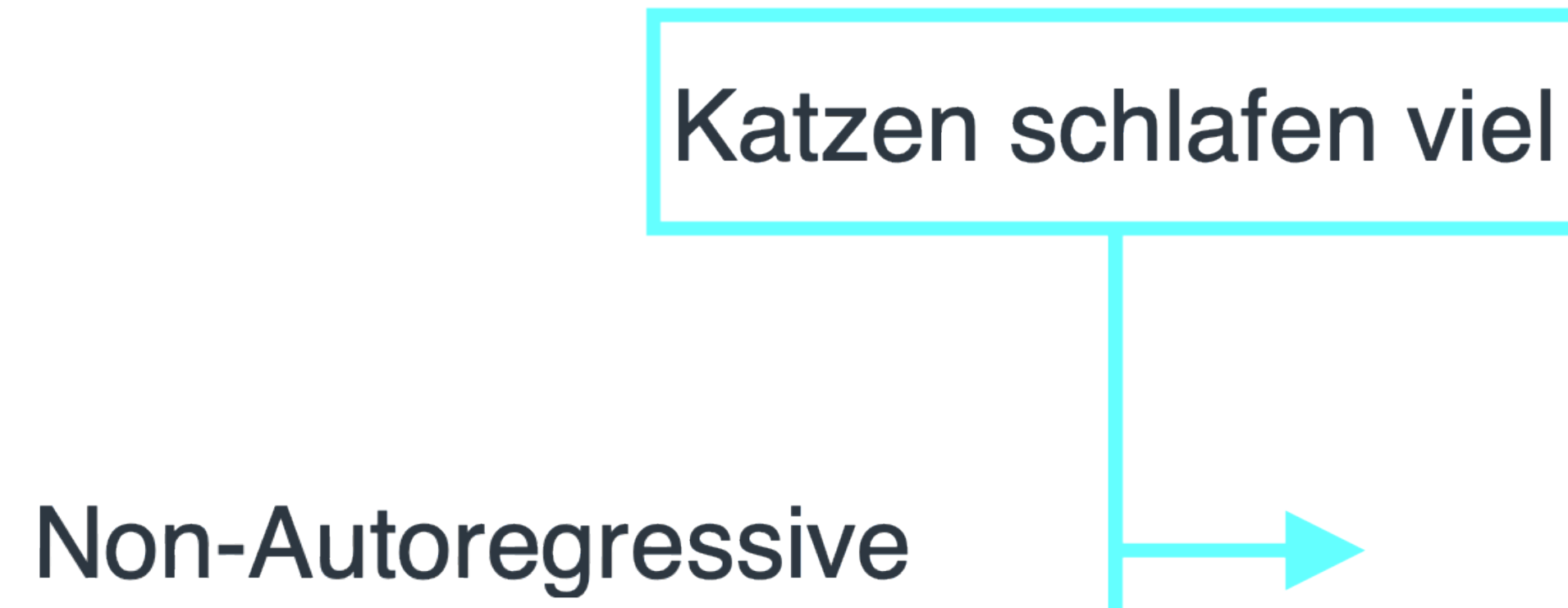
rhabarberbarbara

<https://www.youtube.com/watch?v=gG62zay3kck>

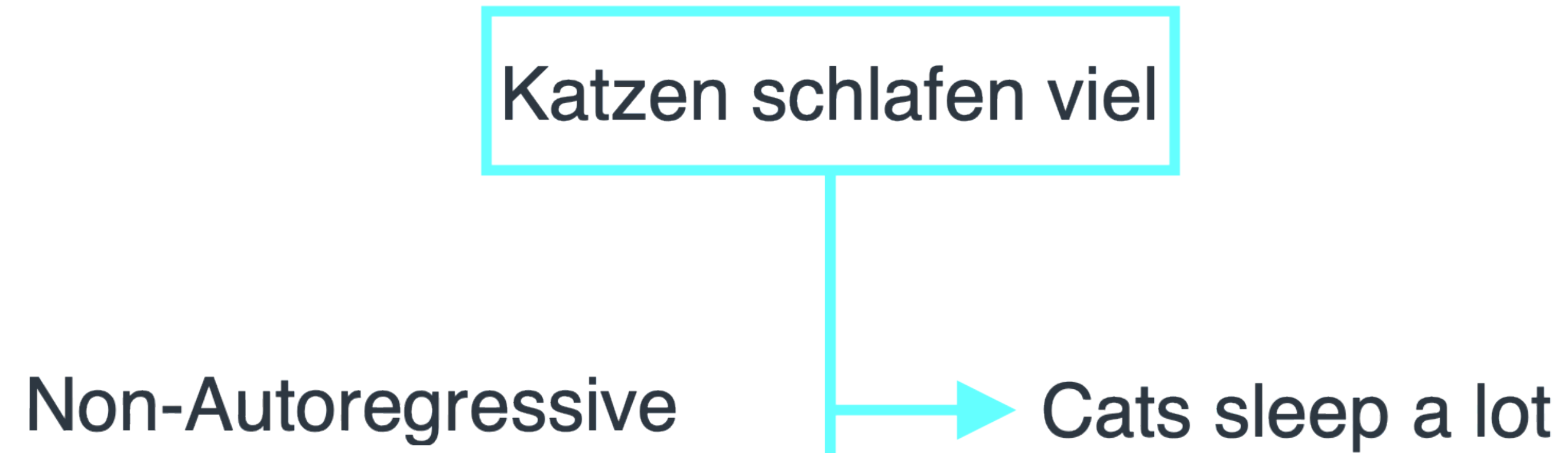
neural machine translation

Katzen schlafen viel

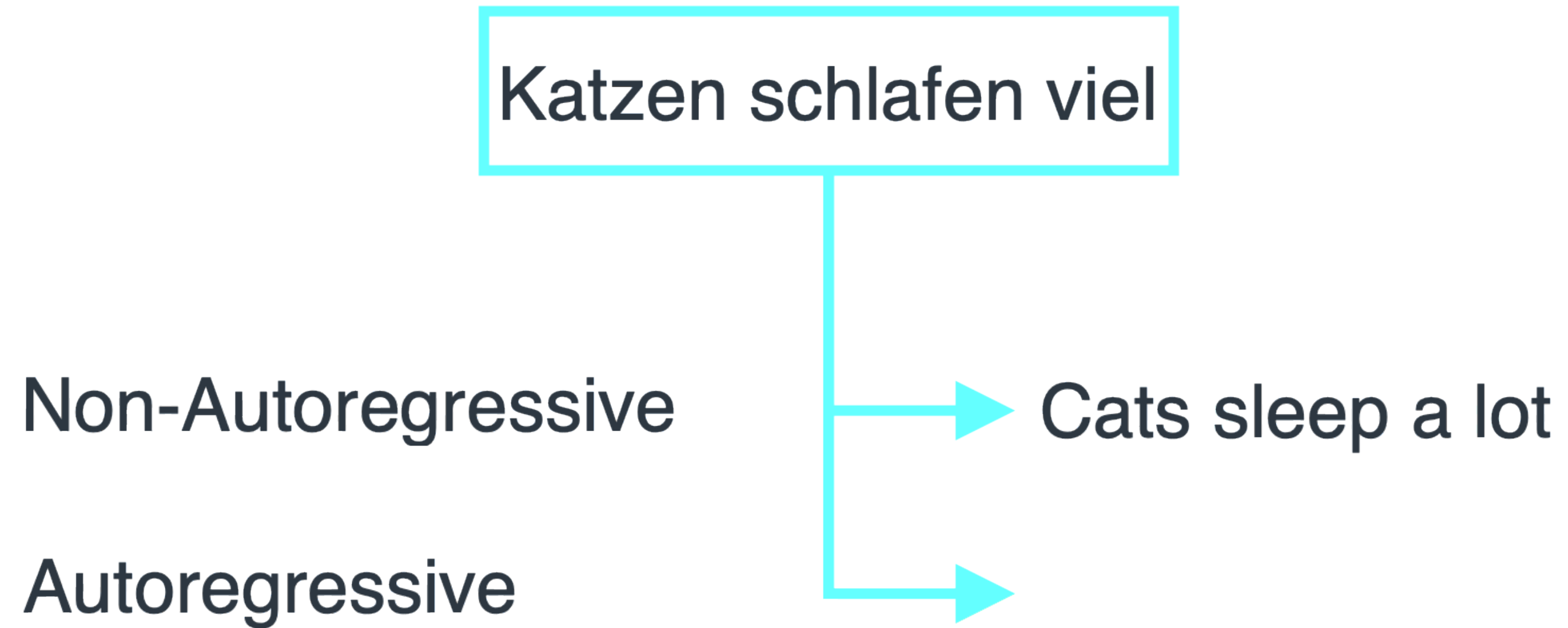
neural machine translation



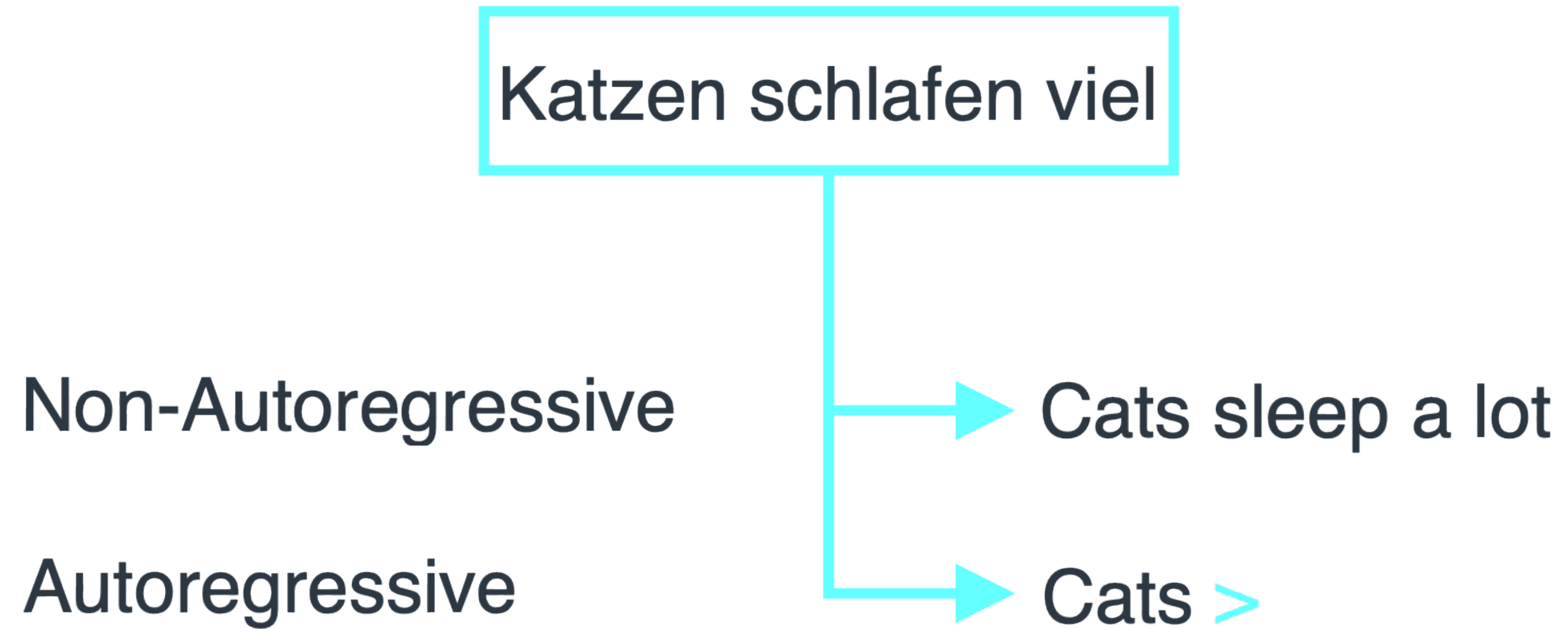
neural machine translation



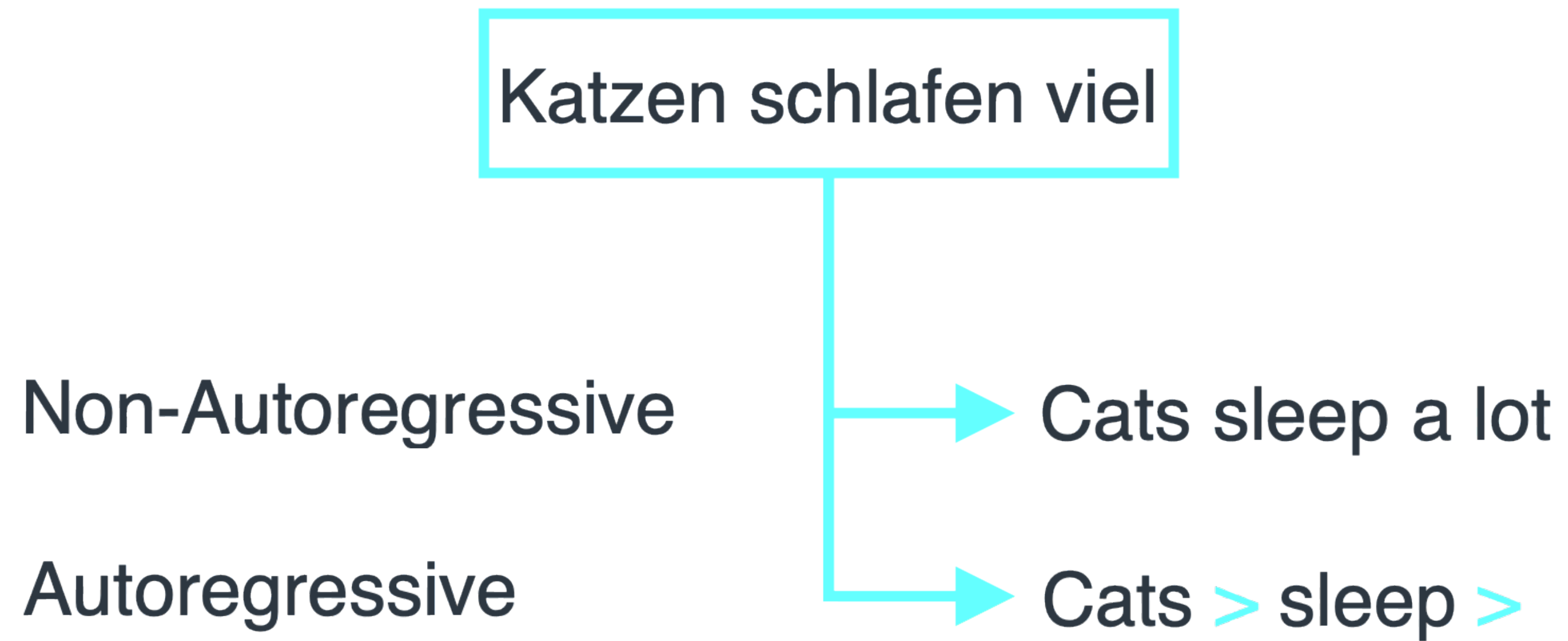
neural machine translation



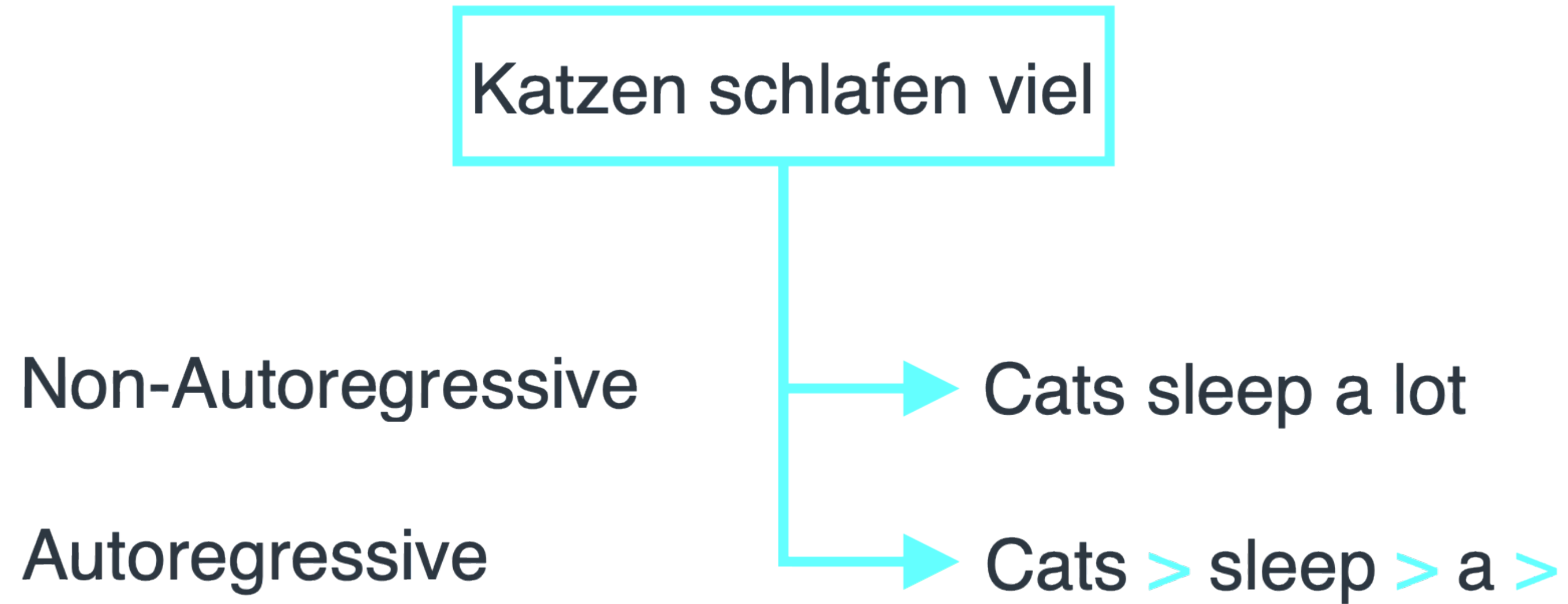
neural machine translation



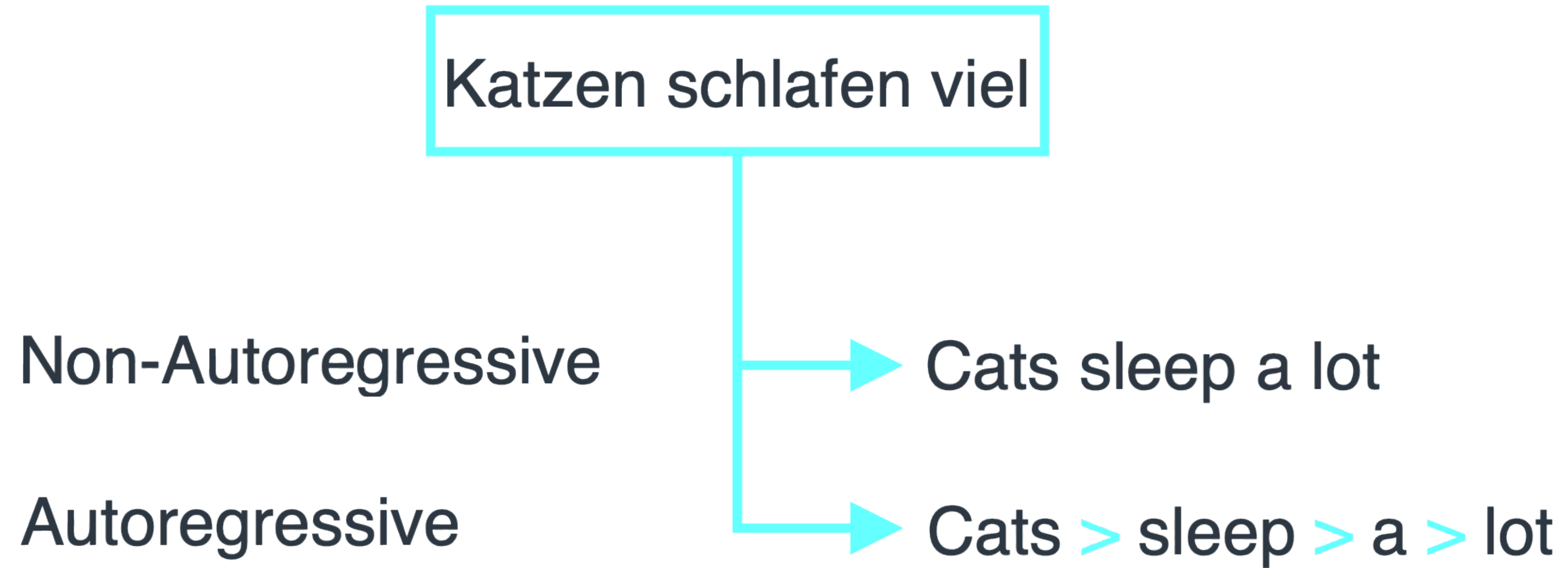
neural machine translation



neural machine translation

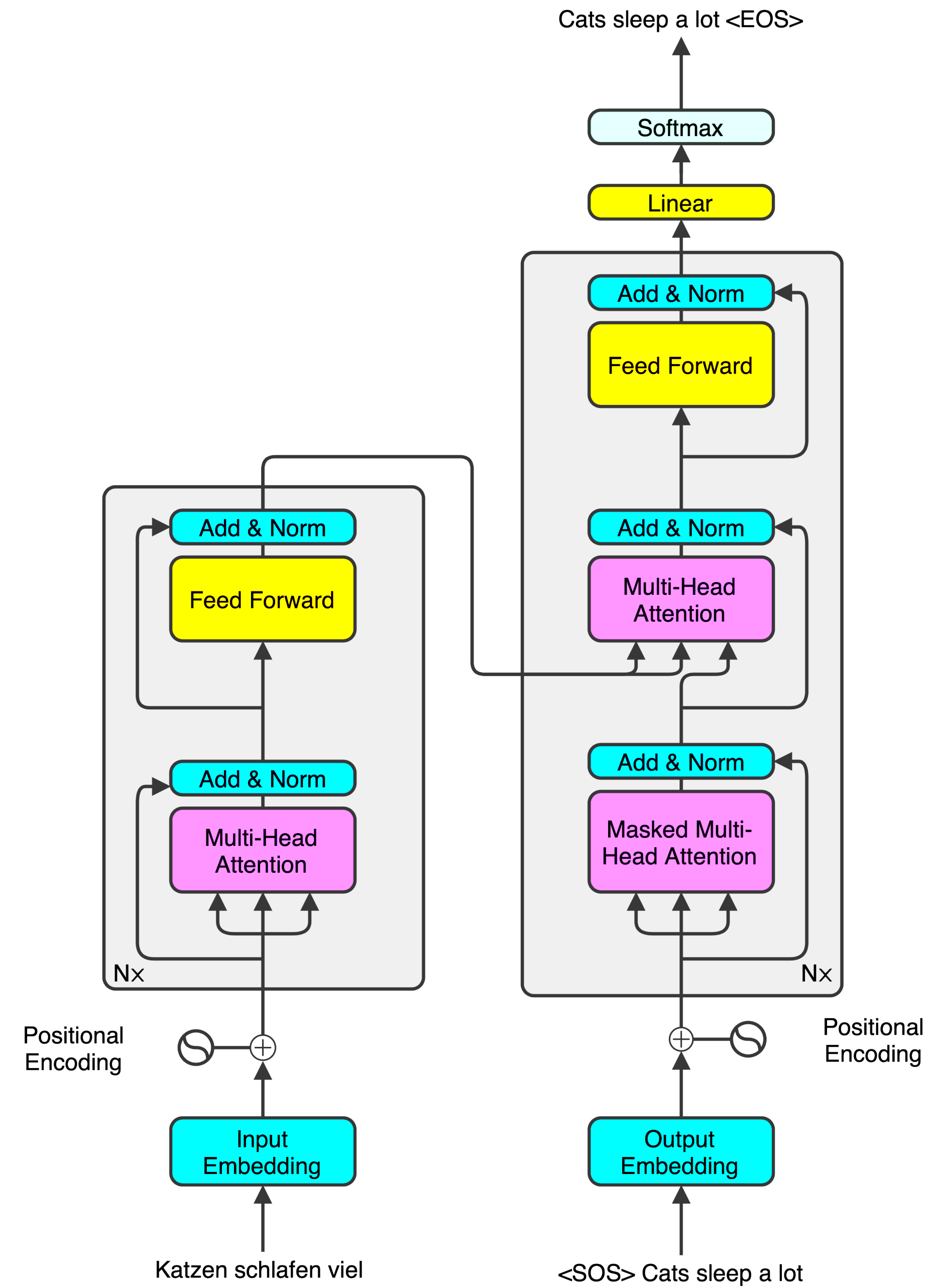


neural machine translation



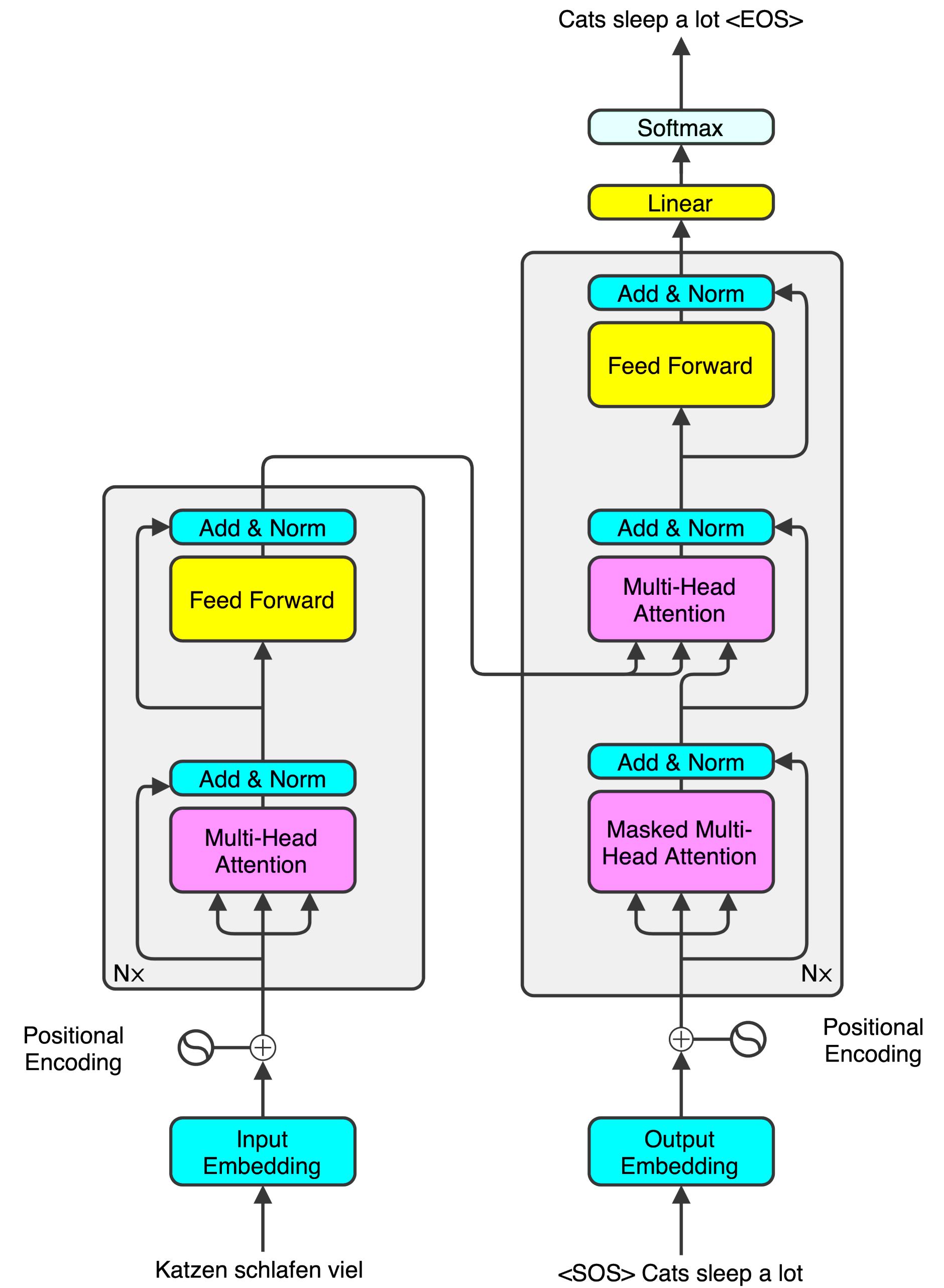
transformer

- encoder: self-attention
- decoder: masked self-attention
- decoder: source-attention



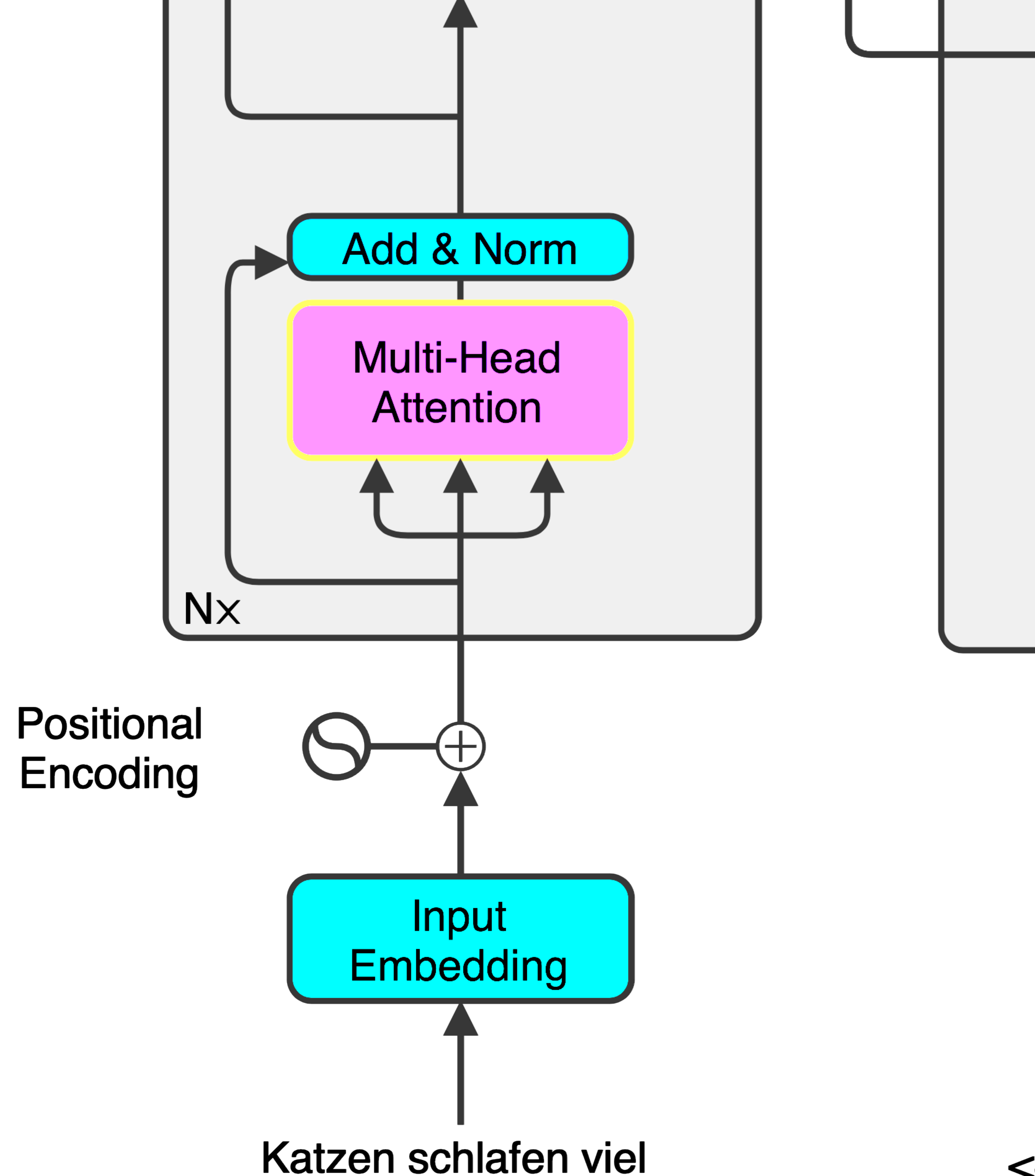
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transformer

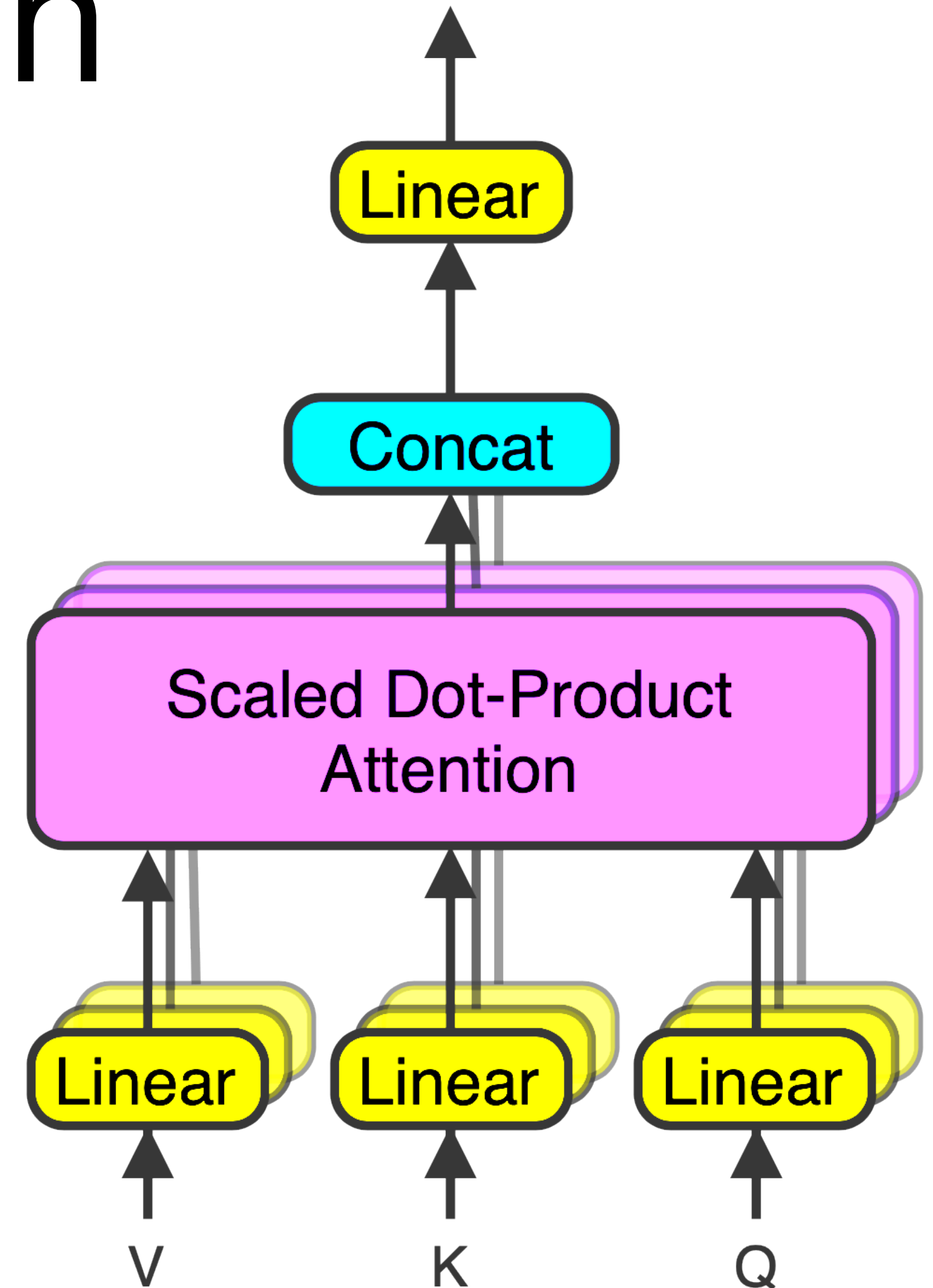
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transformer attention

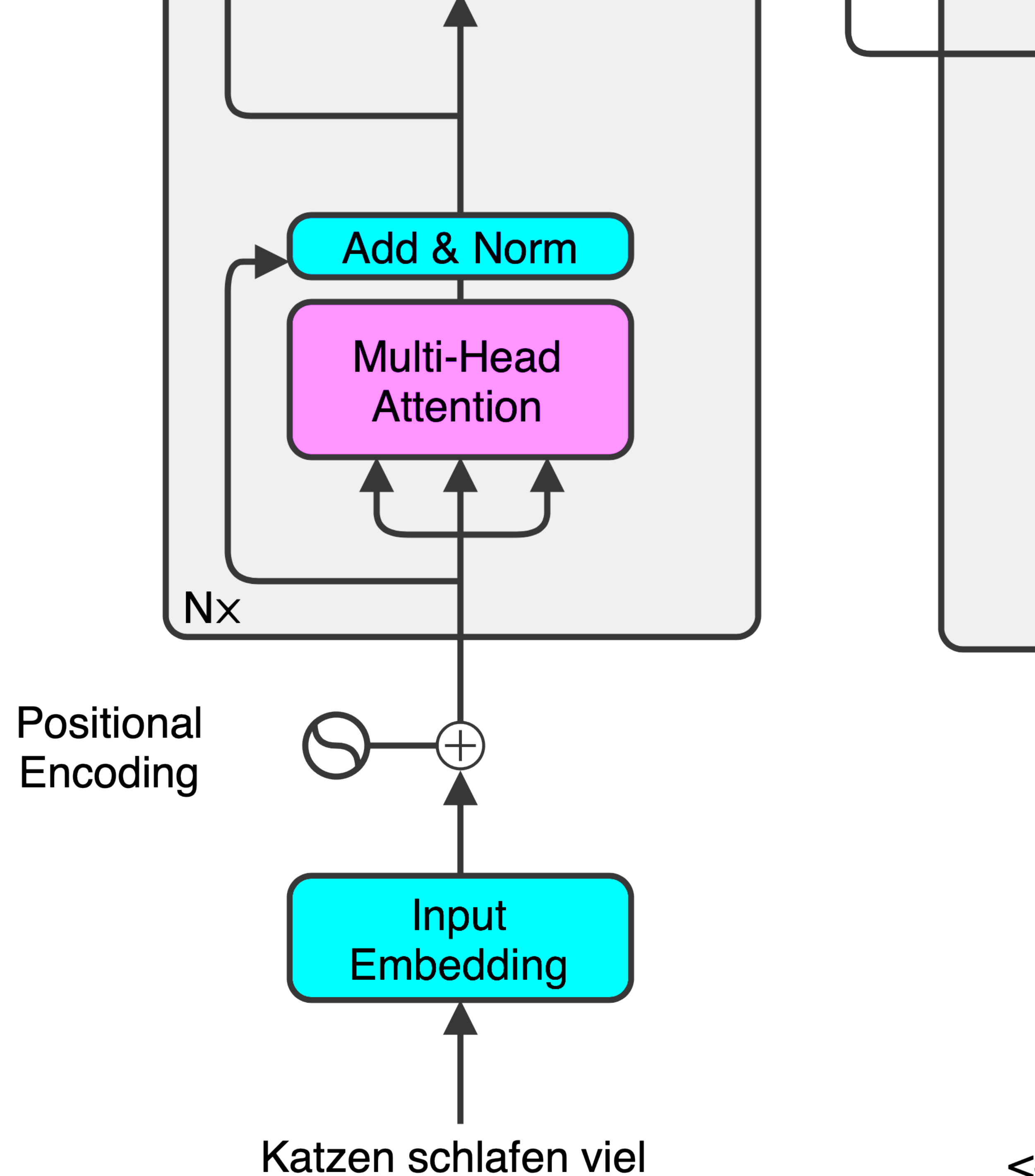
- uses scaled dot-product attention

$$\text{attention}(V, K, Q) = \text{softmax} \left(\frac{QK^T}{\sqrt{d_k}} \right) V$$



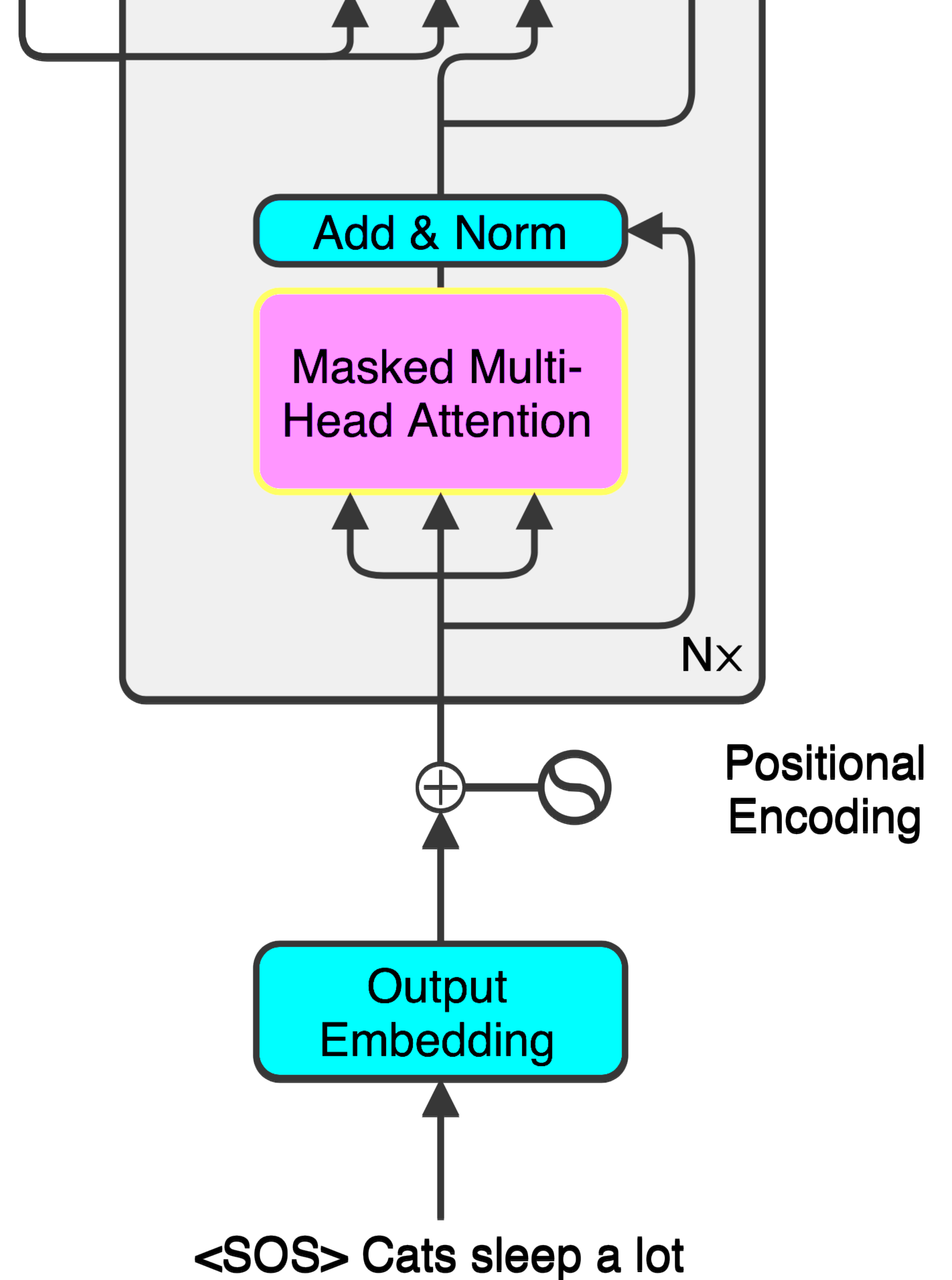
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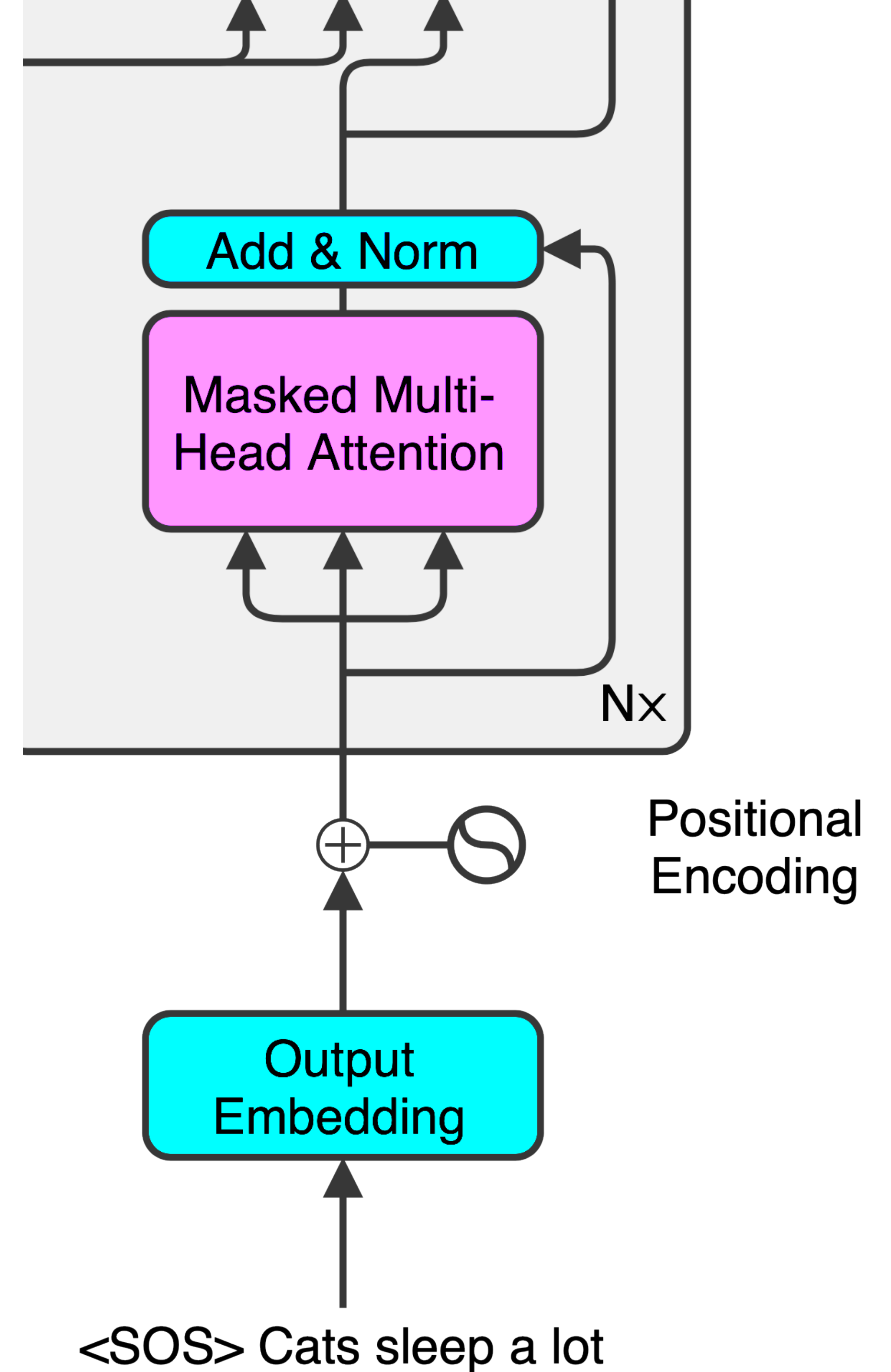
transformer attention

- use mask (lower triangular matrix) to prevent seeing future tokens

Cats	1	0	0	0
sleep	1	1	0	0
a	1	1	1	0
lot	1	1	1	1
	Cats	sleep	a	lot

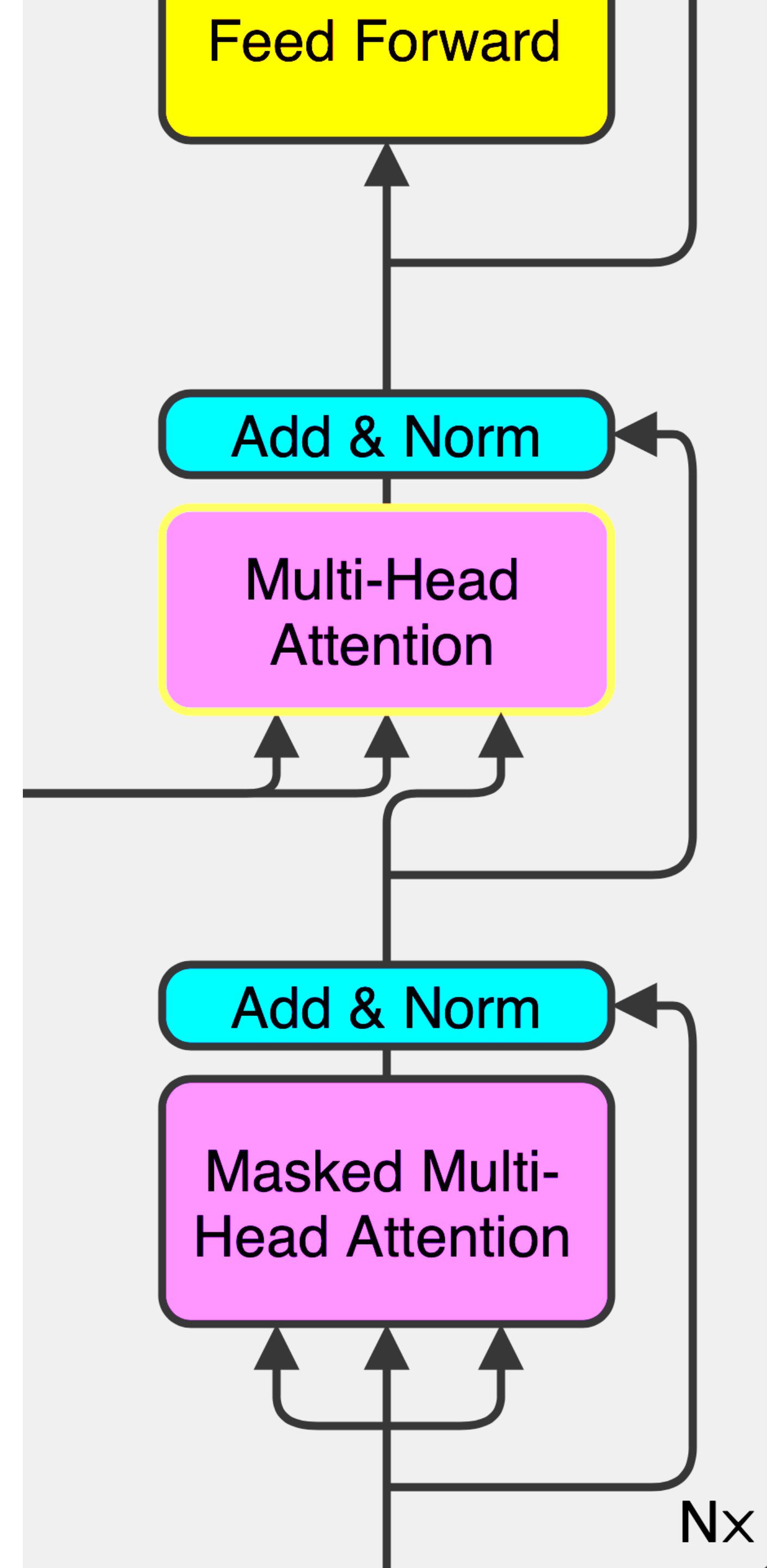
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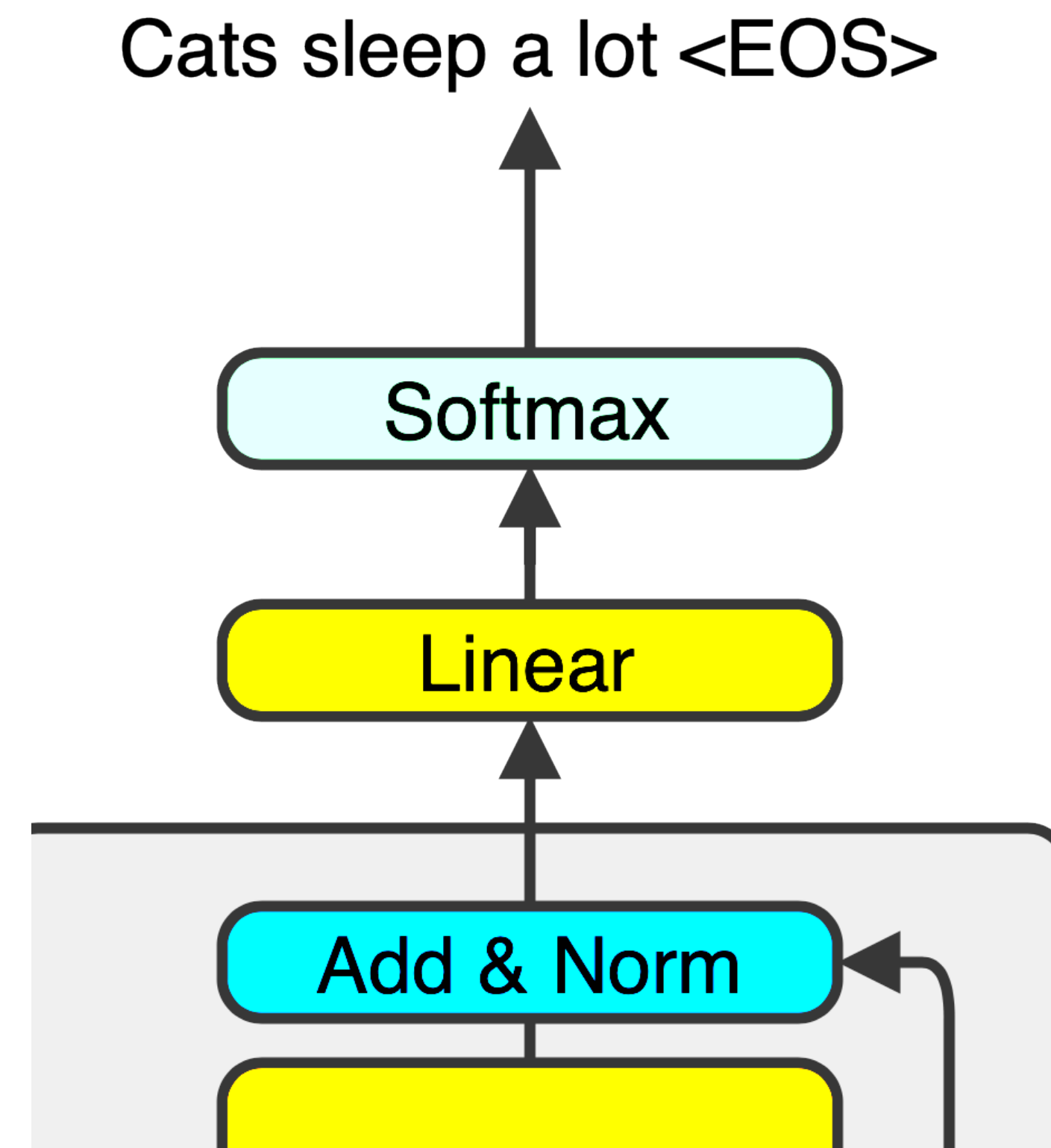
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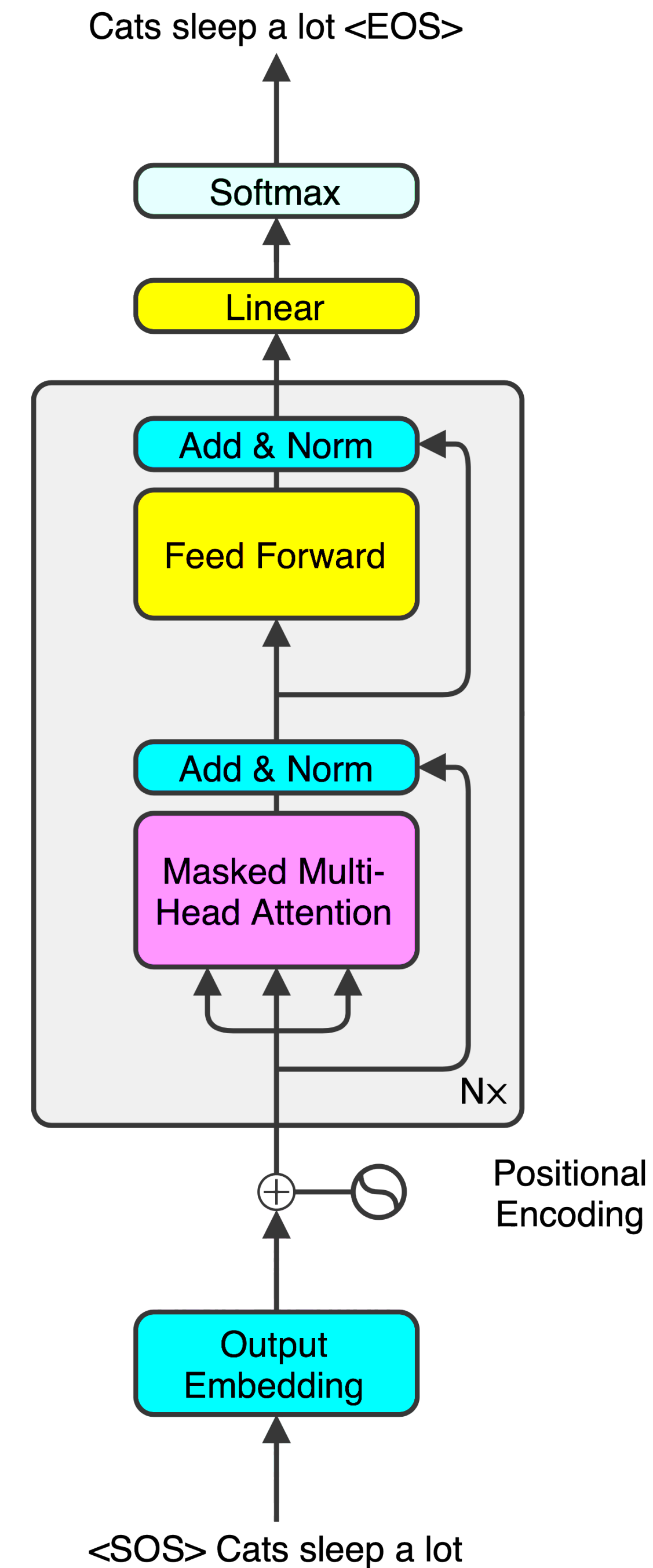


from probabilities to words

- remember want sentence that maximizes probability
- autoregressive decoding
 - greedy (argmax)
 - beam search (set of hypotheses)

transformer language model (lm)

- ~~encoder: self-attention~~
- decoder: masked self-attention
- ~~decoder: source-attention~~



from probabilities to words (Im)

- unconditional generation
- no probability to maximize
- how to sample?

from probabilities to words (lm)

- sample from full distribution
- sample from truncated distribution
 - top-k: truncate to k highest prob words
 - nucleus: truncate using cumulative prob

STORIUM: a dataset and evaluation platform for machine-in-the-loop story generation

Nader Akoury, Shufan Wang, Josh Whiting, Stephen
Hood, Nanyun (Violet) Peng, Mohit Iyyer

story generation

produce a narrative that follows from
a given input prompt or context

story generation

produce a narrative that follows from
a given input prompt or context

Flowers have become so rare that they are the most sought after items in the world, sold at high prices in black markets, under guard in national museums etc. You just stumbled across a natural rose.

prompt: Flowers have become so rare that they are the most sought after items in the world, sold at high prices in black markets, under guard in national museums etc. You just stumbled across a natural rose.

story: It was the color of a sunset: red tipped petals faded to yellow. Stark contrast to the roiling forever-cloud above it. A thick green stem climbed out of a crack in the dry earth, thorns lining it like a ladder. It had been hidden between two dry logs, lying flat like hollowed bones. It must have peered out from between the dead trees only in the last few days, and I had been the first to stumble upon it.

It was worth more than my life.

Below me lay my village of rusted huts. They littered the valley sporadically, as if a train had been derailed and its carriages rolled free, far and wide. Men and women worked around the shacks, digging and raking the land, trying to grow weeds that could be eaten, as kids kicked tins into makeshift goals around them.

The rose was worth more than any of their lives too. All of them together, even. What a biodome would pay for it...

prompt: Flowers have become so rare that they are the most sought after items in the world, sold at high prices in black markets, under guard in national museums etc. You just stumbled across a natural rose.

story: It was the color of a sunset: red tipped petals faded to yellow. Stark contrast to the roiling forever-cloud above it. A thick green stem climbed out of a crack in the dry earth, thorns lining it like **describe the setting** den between two dry logs, lying flat like hollowed bones. It must have peered out from between the dead trees only in the last few days, and I had been the first to stumble upon it.

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introduce new concept any of their lives too. All of them together, even. What a **biodome** would pay for it...

prompt: Flowers have become so rare that they are the most sought after items in the world, sold at high prices in black markets, under guard in national museums etc. You just stumbled across a natural rose.

GPT-2 large generates:

We have to be prepared and take care of the plants.

We can provide your flowers in all kinds of colors. The most important thing to remember when choosing flowers is the color of the petals.

Please use these links for more information.

<http://www.floralkids.com/flowers/natural-flowers/cotton/>

<http://www.floralkids.com/flowers/natural-flowers/flowers-for-lilies/>

<http://www.floralkids.com/flowers/natural-flowers/rose/>

<http://www.floralkids.com/flowers/natural-flowers/sweet-scented-flowers/>

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We can provide your flowers in all kinds of colors. The most important thing to remember when choosing flowers is the color of the petals.

... complete garbage

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this task is extremely hard!

- many different plausible stories per prompt, which makes training / evaluation difficult
- narrative structures may require planning process
- must maintain logical consistency, even when stories are really long

nevertheless, lots of recent work on
story generation!

- Fan et al., ACL 2018: *Hierarchical Neural Story Generation*
- Yao et al., AAAI 2019: *Plan-And-Write: Towards Better Automatic Storytelling*
- Louis and Sutton, NAACL 2018: *Deep Dungeons and Dragons: Learning Character-Action Interactions from Role-Playing Game Transcripts*

any many more!


with a few common datasets

- Fan et al., ACL 2018: *Hierarchical Neural Story Generation*: **reddit r/writingprompts**
- Yao et al., AAAI 2019: *Plan-And-Write: Towards Better Automatic Storytelling*: **ROCStories**
- Louis and Sutton, NAACL 2018: *Deep Dungeons and Dragons: Learning Character-Action Interactions from Role-Playing Game Transcripts*: **roleplayerguild.com**

long stories with natural language annotations

Dataset	#Stories	#Tokens per Story	Prompts	Turns	Annotations
ROCStories	98k	88	✓	✗	✗
r/writingprompts	303k	735	✓	✗	✗
roleplayerguild.com	1.4k	3k	✗	✓	✗
STORIUM	6k	19k	✓	✓	✓

 **storium**



**Write stories with friends
about distant worlds.**

The online creative writing game.

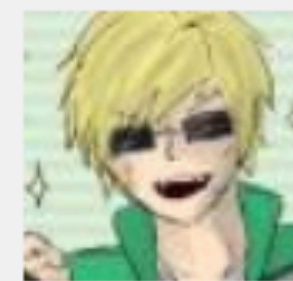
 **storium**



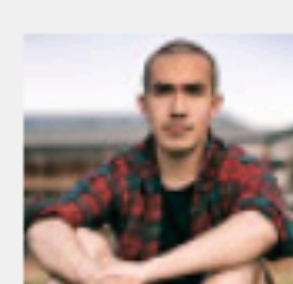
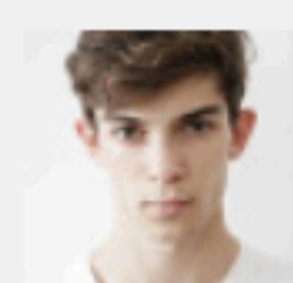
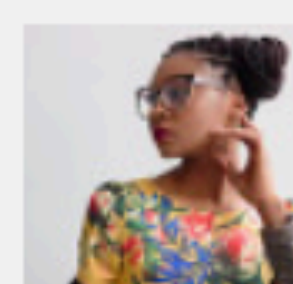
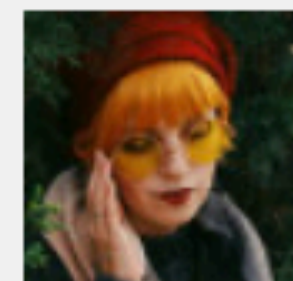
**Write stories with friends
about unsolved mysteries.**

The online creative writing game.

NARRATOR



CAST



Chapter 1, Scene 1 · 05/06/2018



CHALLENGES

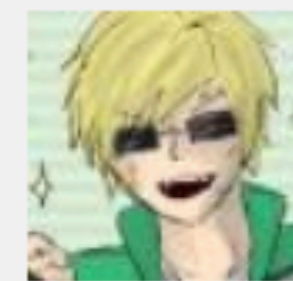
 STRENGTH?



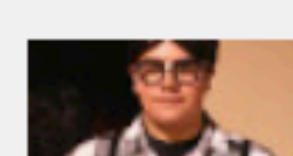
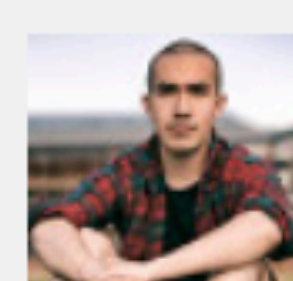
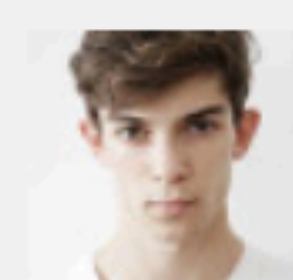
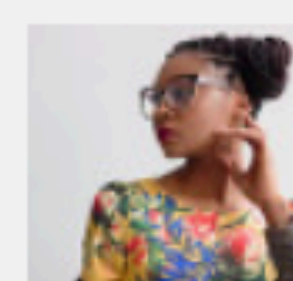
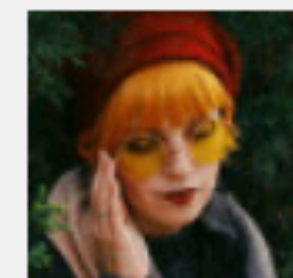
The storefront was empty of all decoration, but everyone around town had heard what this place was going to be: Inspectres.

The infamous company known for hunting down the supernatural around the continental United States (plus a few franchises in Canada and one right across the Mexican border) had staked a franchise claim in this city and was having open interviews for anyone who wanted to

NARRATOR



CAST



INSPECTRES: GHOST HUNTING FOR

stories are written by a group of users, each of whom write from the perspective of a different character



CHALLENGES

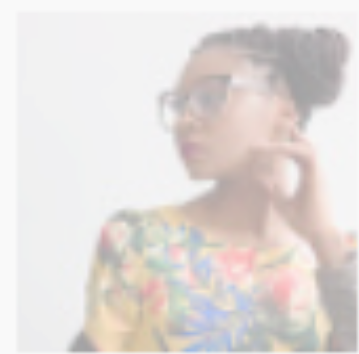
STRENGTH?

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each character is associated with a set of properties (“cards”)

CAST



EMILIA LOPEZ

LAB TECHNICIAN

GOOD HEARING

WILD x3

COWARD

CURIOSITY x3

ASSETS x4

Nature



LAB TECHNICIAN

Emilia has great experience working with chemical and biological laboratory equipment, as well as computer data analysis.

CHALLENGES

STRENGTH

The storefront was empty of all decoration, but everyone around town had b

a “narrator” user creates challenges for the characters to solve. characters write scene entries addressing these challenges.





Emilia Lopez (victoriasilverwolf) moved · 06/13/2018


Emilia was fascinated! This wasn't some silly hoax, but the real thing. She and her co-workers had seen videos of the cat speaking Russian, and multiple, detailed analysis by sophisticated computers proved it wasn't faked.

What a puzzle! Emilia spent the next several hours investigating reports of animals speaking human languages. There was a lot of information to go through, and it led in so many directions that it was hard to come to any conclusion. The cat spoke in an odd accent, too, so computer translation wasn't very reliable. She could have handled Spanish well enough, and even stumbled her way through other Romance languages, but Russian was, well, Greek to her.

“Anybody here speak Russian?”

It couldn't hurt to ask.

 HIT THE BOOKS 

 CURIOSITY



E

Emilia was fasci
the real thing. Sh
the cat speaking
by sophisticated

What a puzzle! E
speaking human
many directions
too, so compute
enough, and eve
well, Greek to he

“Anybody here s

It couldn't hurt to ask.

Obstacle



HIT THE BOOKS

You have your personal libraries, the internet, and the public library. Time to research what you can about werewolves.



Heading towards an **uncertain** outcome, with 3 cards left.

Outcomes

Strong:

There are a few reasons a cat might start speaking Russian. Possession, inter-dimensional leakage... Either way you end up researching an exorcism, just in case this is a spirit or a demon.

Weak:

You find something out about a way to deal with Russian talking cats. It's entirely wrong, and may make you look like an idiot.

06/13/2018



HIT THE BOOKS



CURIOSITY

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go through, and it led in so
he cat spoke in an odd accent,
ave handled Spanish well
languages, but Russian was,

# games	5,743
# authors	30,119
# cards	232,596
# challenges	61,223
# scene entries	448,264
# avg tokens per entry	~247
# avg tokens per story	~19,278
# total tokens	~126 million

automatic evaluations?

- See et al., CoNLL 2019: *Do Massively Pretrained Language Models Make Better Storytellers?*
 - how related is prompt to story?
 - how coherent is the story?
 - how much does the model repeat itself?
 - how syntactically complex are the stories?
 - how surprising are the stories?

automatic evaluations?

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“human evaluation... currently the only reliable way to assess overall text quality”

how do we set up human evaluations for story quality?

- human eval of Fan et al: given a shuffled collection of three prompts and three generated stories, match them up
- human eval of Yao et al: given a prompt and two stories generated by two different models, pick which story is better

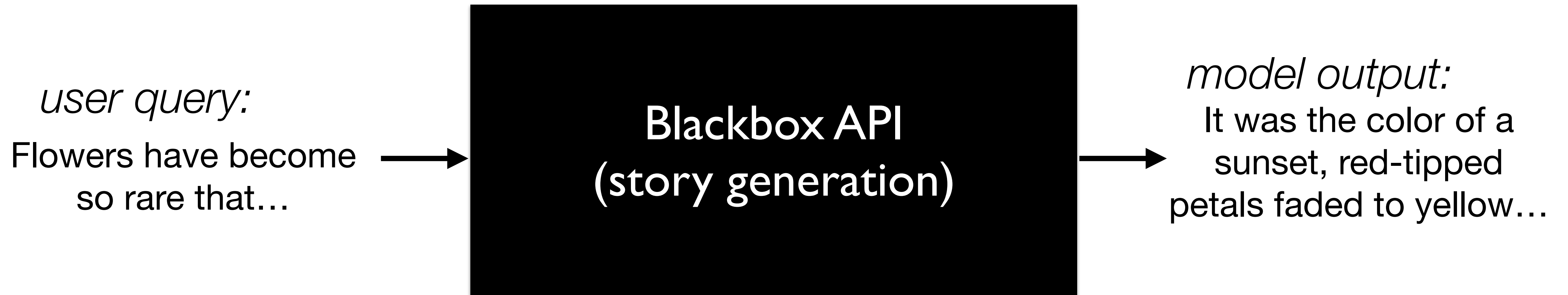
machine-in-the-loop storytelling

- How do we get evaluators to read and engage with long, complex stories?
- What if the people evaluating stories were also *authors* of the stories?
- **machine-in-the-loop** storytelling: a model provides *suggestions* (e.g., of scenes) to real authors, who can then use the generated text directly or as inspiration in their final story

Roemelle et al., ICIDS 2015, Clark et al., IUI 2018

machine-in-the-loop storytelling

- A text generation model provides *suggestions* (e.g., of scenes) to real authors, who can then use them as inspiration for their final story



how do we evaluate?

- we put our models on the Storium platform!
- users can generate a suggestion using our model and then edit it. we collect their edits as well as some simple feedback.
 - compute recall-based metrics like ROUGE, or MT metrics like HTER (human-targeted translation edit rate)
- evaluation by domain experts for free!



character



character



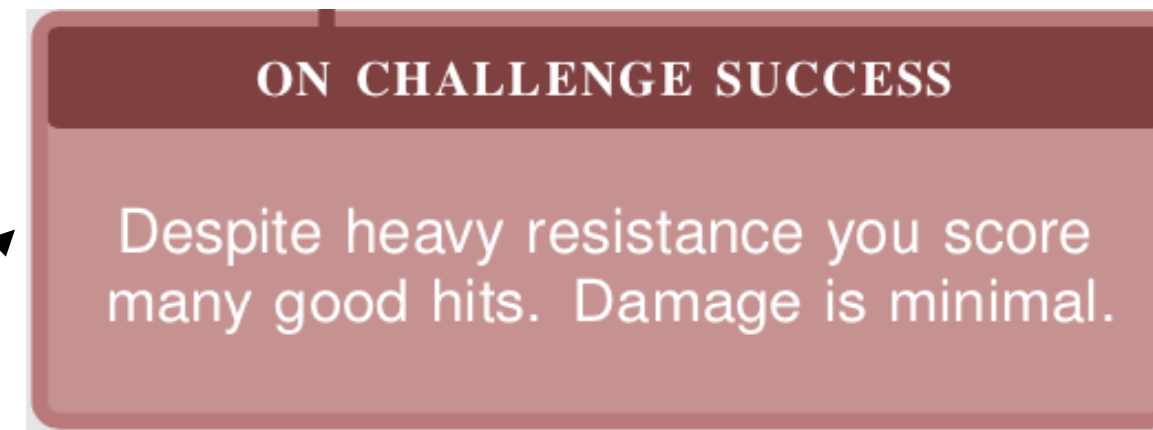
challenge



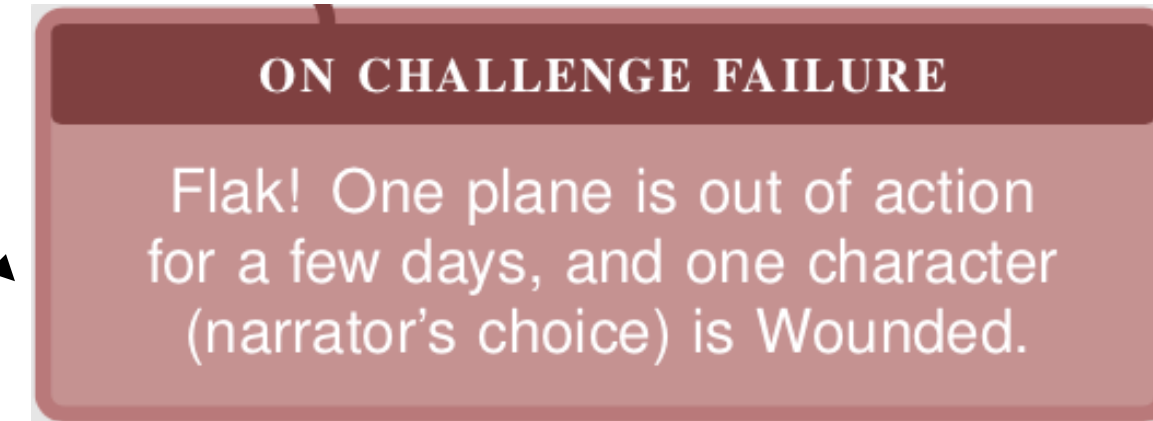
character



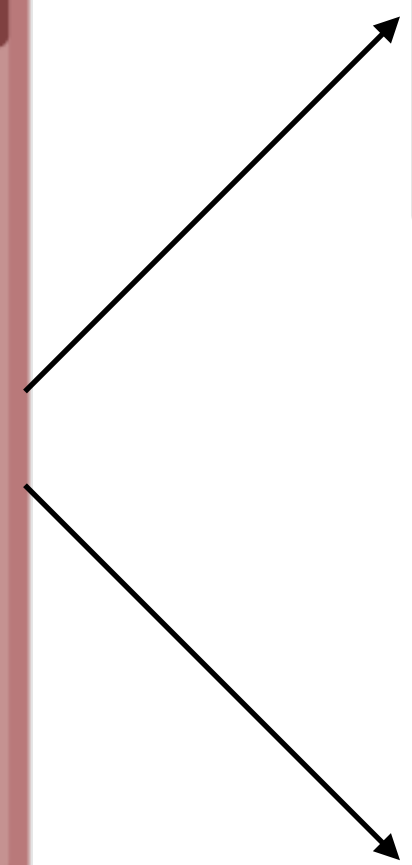
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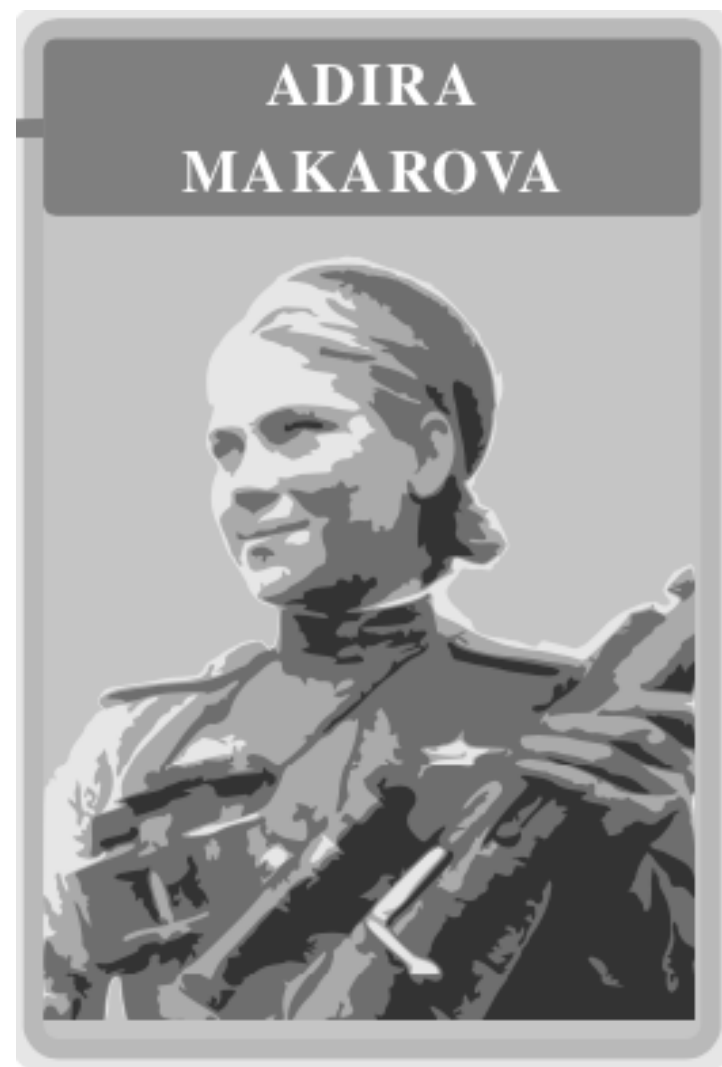


successful outcome



failed outcome

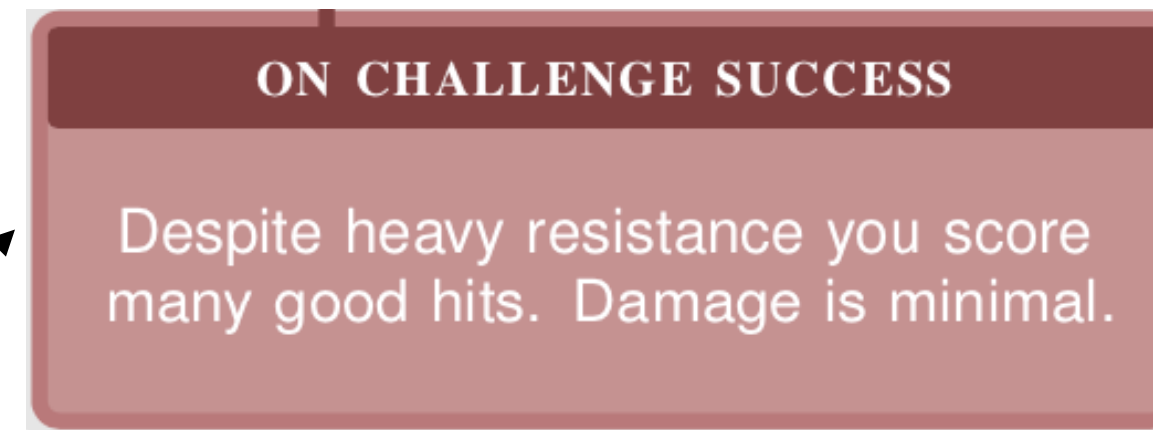




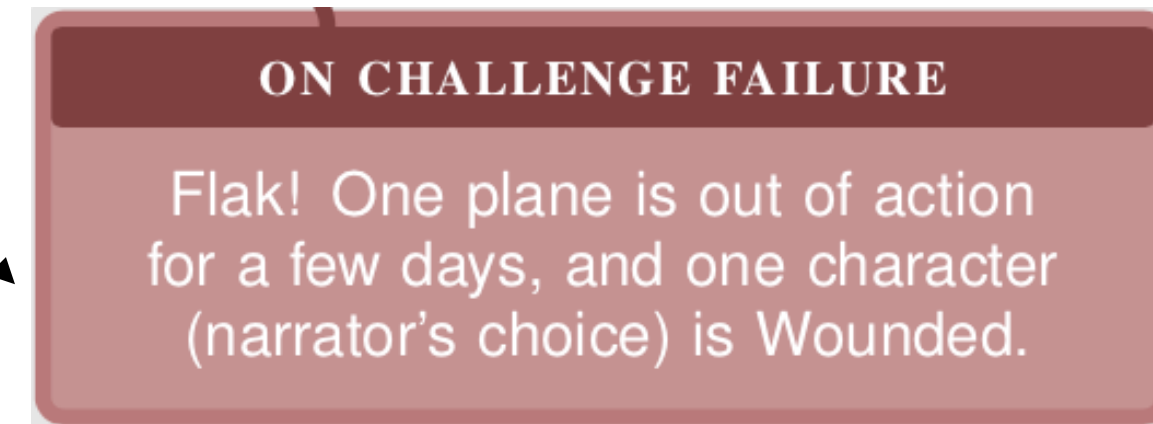
character



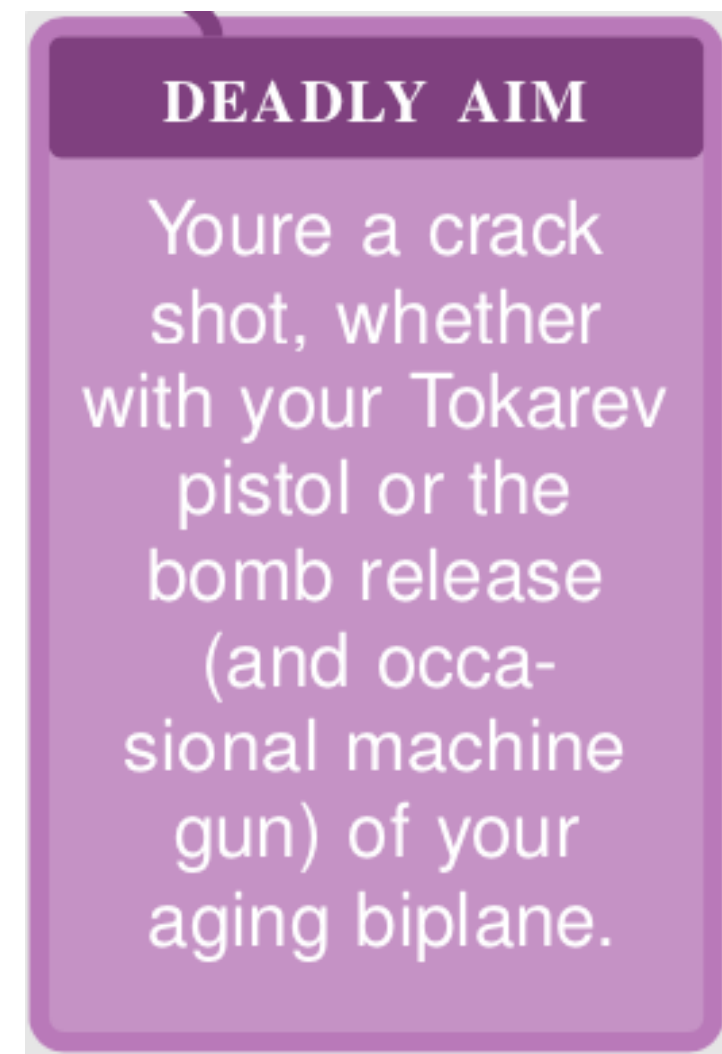
challenge



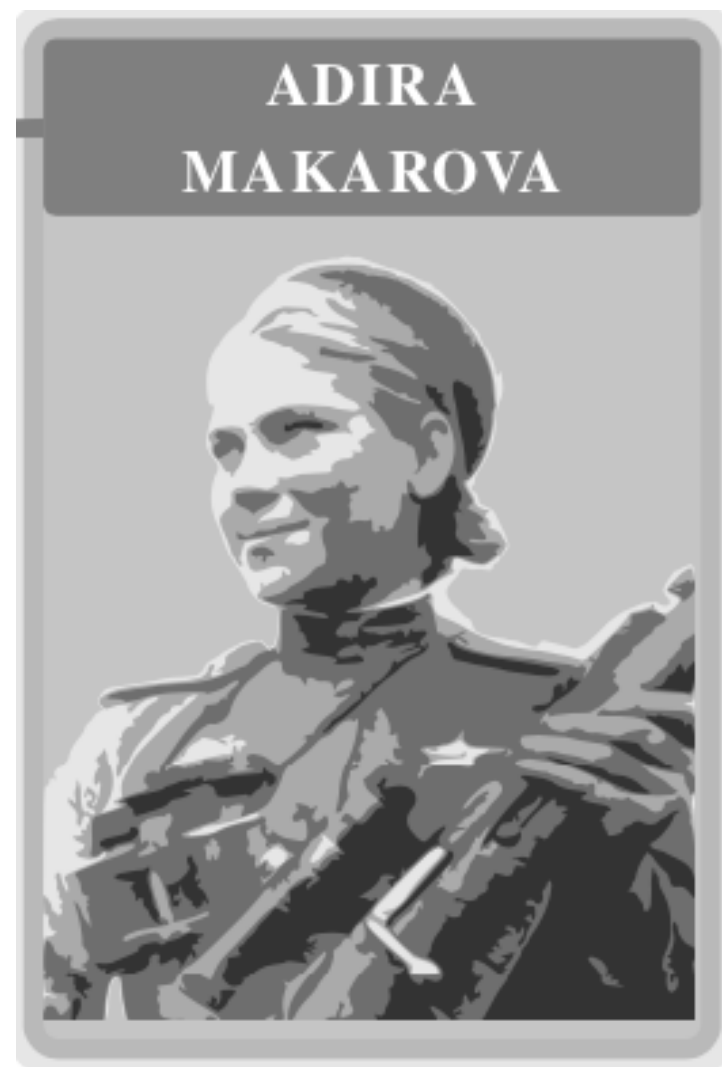
successful outcome



failed outcome



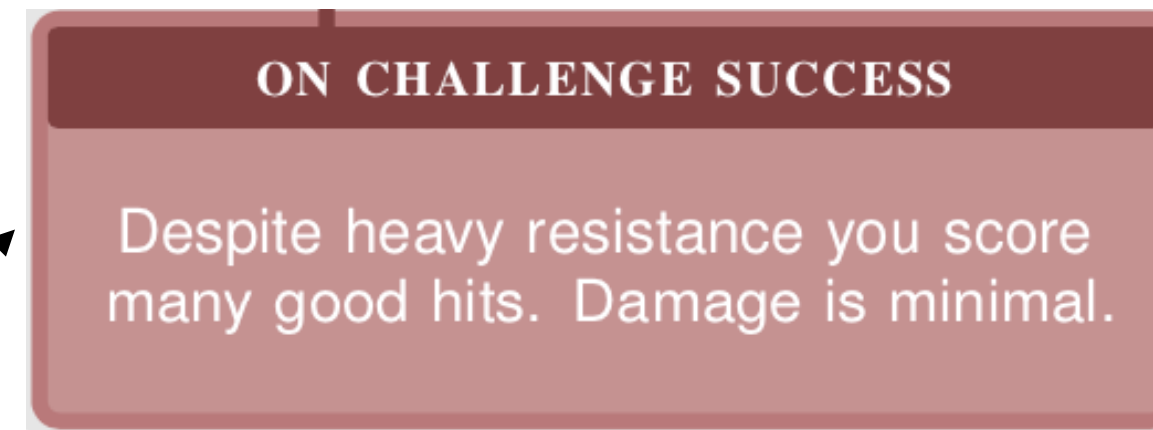
played card



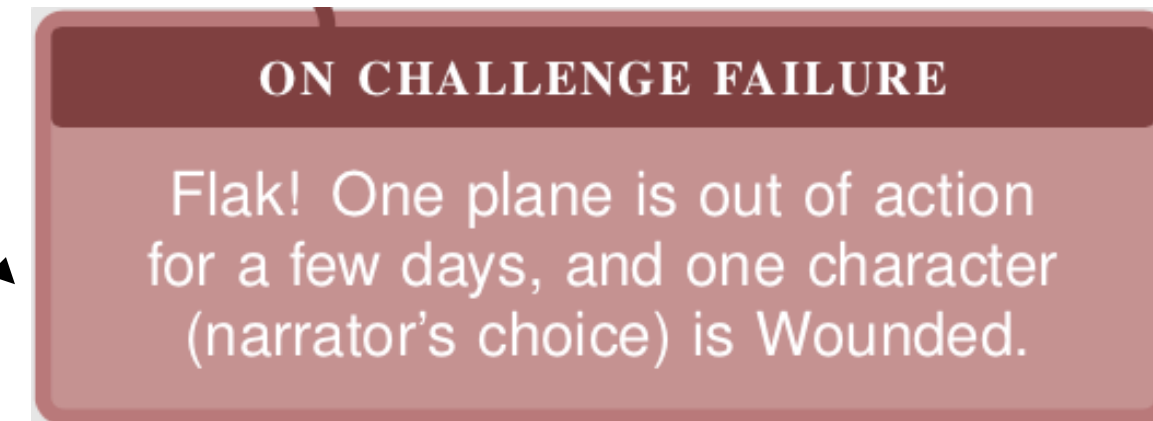
character



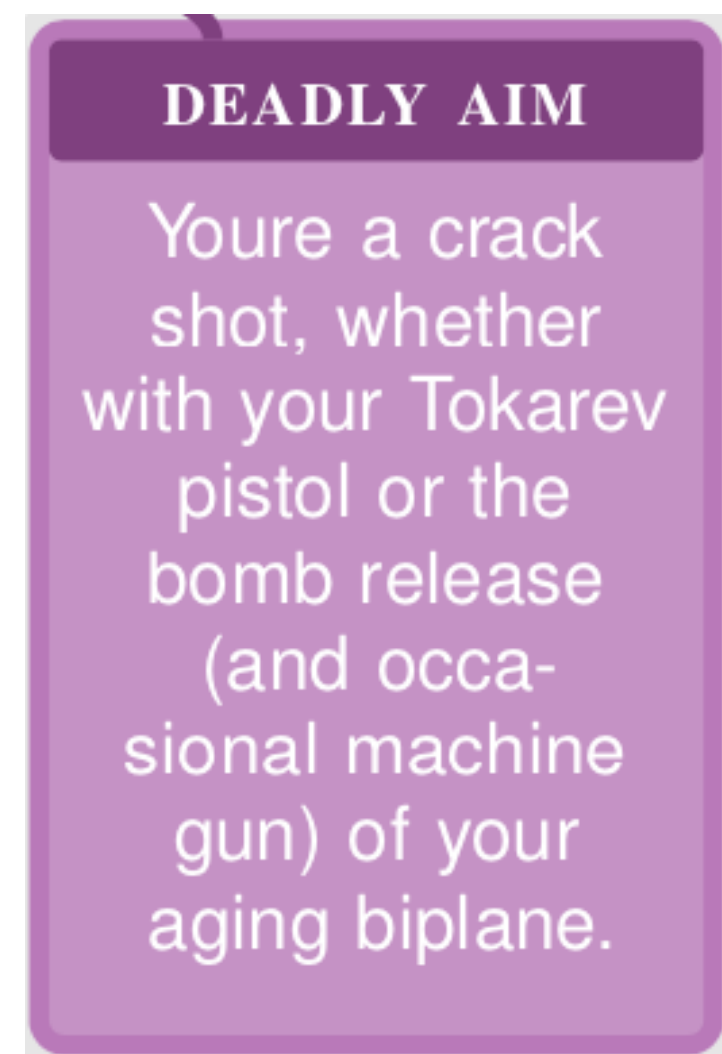
challenge



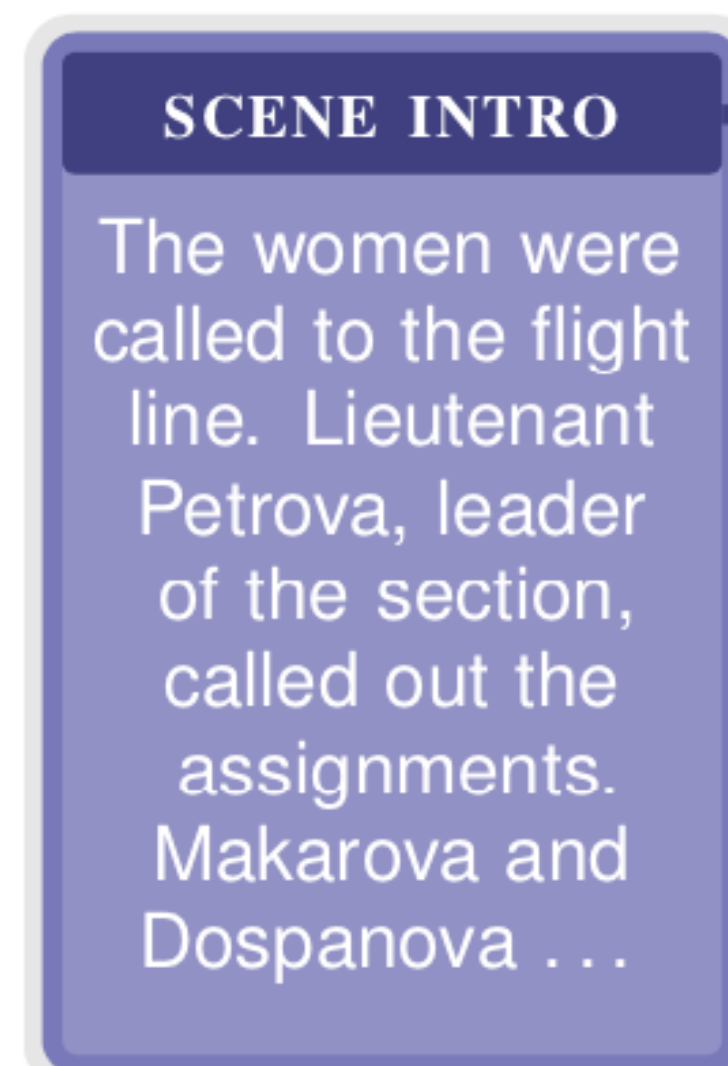
successful outcome



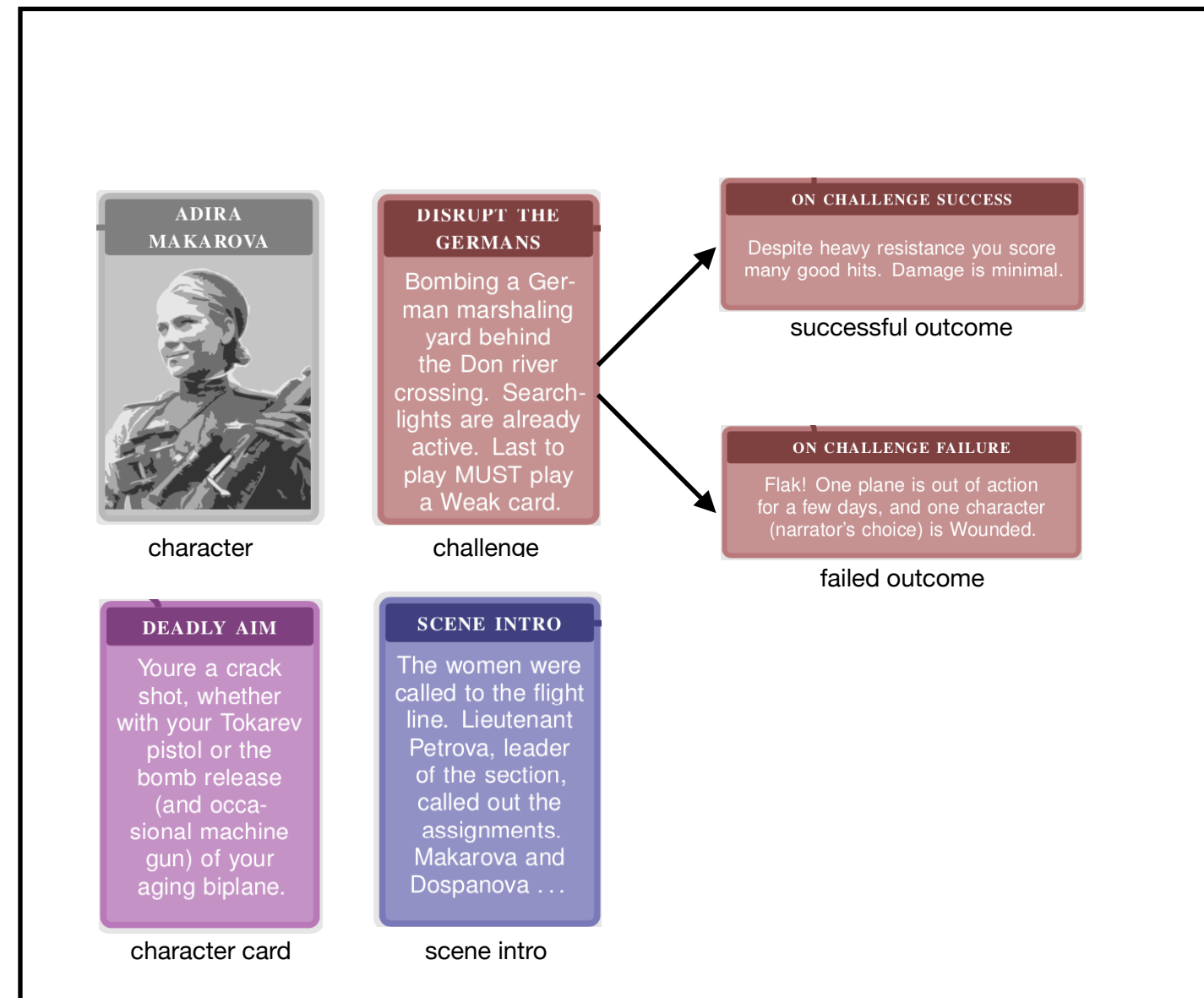
failed outcome



played card



scene intro



input context

Adira was in the middle of her first mission. She had been given a 'simple' task to escort an airship across the river, and then she would take over as pilot while she made some calls for other pilots. As soon as they reached their destination - in this case; it being Moscow, Adira took off towards the enemy base on the opposite side. The only thing that mattered right now is getting the women through there without any serious damage.

model-generated scene

Adira was in the middle of her first mission. She had been given a 'simple' task to escort an airship across the river, and then she would take over as pilot while she made some calls for other pilots. As soon as they reached their destination - in this case; it being Moscow, Adira took off towards the enemy base on the opposite side. The only thing that mattered right now is getting the women through there without any serious damage.

model-generated scene



Adira was in the middle of a mission. She had been given a 'simple' task to escort an airship across the river, which involved disrupting the Germans. As soon as they reached their destination, it was time to shine. The only thing that mattered right now is getting the women through there without any serious damage; and without being spotted.

user-edited scene

preserved
text

deleted
text

new text

Adira was in the middle of her first a mission. She had been given a 'simple' task to escort an airship across river, and then she would take over as pilot while she made some calls for other pilots; disrupting the Germans. As soon they reached their destination - in this case; it being Moscow Adira took off towards the enemy base on the opposite side was time to shine. The only thing that mattered right now is getting the women through there without any serious damage; and without being spotted.

also collect feedback

🔔 Get a suggestion

The suggested text has been added to your draft — you are free to edit it, of course, or discard it entirely. Regardless of whether or not you use it, please tell us what you thought of it:

Bob has his eyes closed and a cup of tequila steaming in the bar. He slides to one knee, before pulling it out slowly onto an examination table with high polished wooden panels on top. "Hey! Man, you all right? I'm sure my dad won't be surprised at how skinny this kid looks."
Once he's been seated facing each student individually for several minutes Bob searches through their body fluids. With chewed tissue noisily dusting from him as blood continues piling up like coffee spills down a toilet seat drawers they're

How grammatically correct is the suggested text? (on a scale of 1-5, with 1 being the lowest) (Required)

1 2 3 4 5

How relevant is the suggested text to the current story so far? (on a scale of 1-5, with 1 being the lowest) (Required)

1 2 3 4 5

How well do the sentences in the suggested text fit together? (on a scale of 1-5, with 1 being the lowest) (Required)

1 2 3 4 5

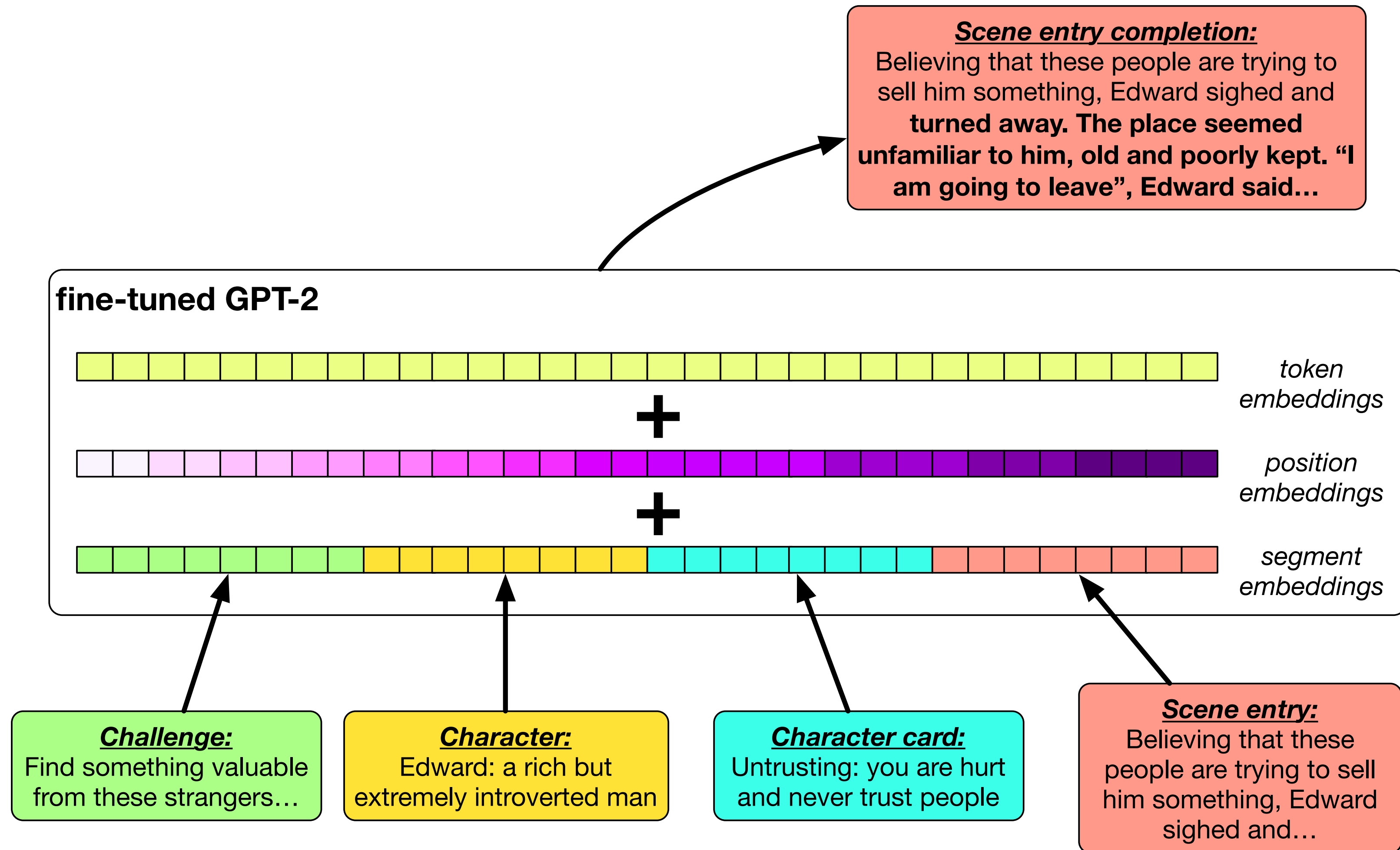
How enjoyable do you find the suggested text? (on a scale of 1-5, with 1 being the lowest) (Required)

1 2 3 4 5

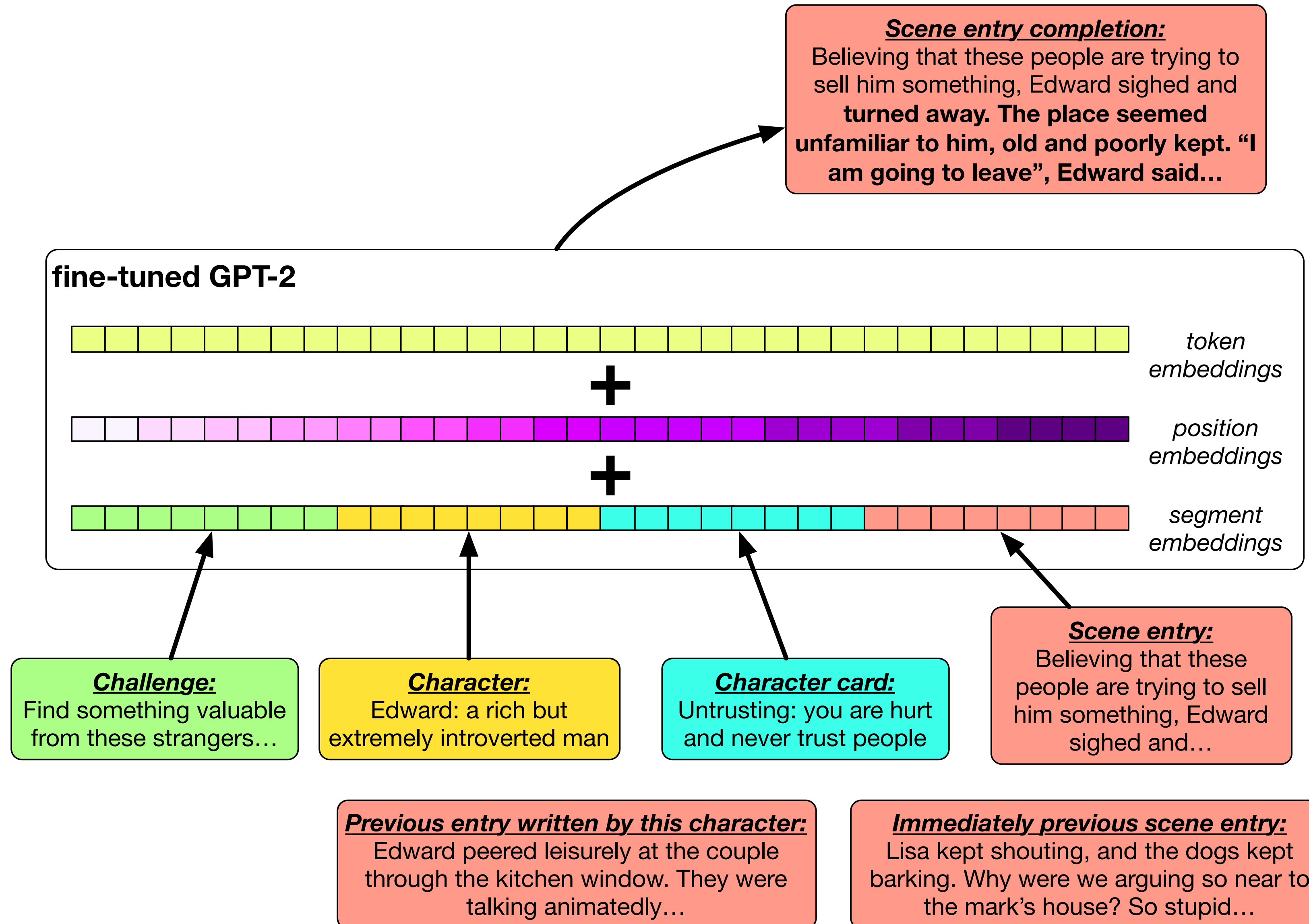
Please provide any additional comments you have about the suggested text. (Optional)

Done

We've built models that look like this:



adding more context...



adding more context improves feedback scores

Model	Fluency	Relevance	Coherence	Likability	Perplexity
Base (fine-tuned GPT-2 medium)	3.6	2.8	3.6	2.4	22.9
Base + history	3.7	3.2	4.1	2.7	21.0

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Base + history	3.7	3.2	4.1	2.7	21.0

A metric over user edits

- Intuitively, edits with fewer changes (additions or deletions) should receive a **higher** score, as this indicates that the generated text was useful to the Storium author.
- We modify **ROUGE-L**, which measures the *longest common subsequence* between the edited text and the generated text
 - recursively use *longest common **substring*** instead
 - only consider contiguous substrings with at least one non-stopword
- Our metric is called **USER: user story edit ratings**

top- k sampling performs better than nucleus sampling

Decoding algorithm	Relevance	Fluency	Coherence	Likability	USER
top-k	2.6	4.0	3.4	3.3	15.6
nucleus	2.5	3.8	3.0	3.2	9.9

we collected >300 edits for each decoding algorithm

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storium improves over crowdsourced evaluations (top- k)

Relevance

Fluency

Coherence

Likability

we collect ratings for 100 examples, with three judgements per example

storium improves over crowdsourced evaluations (top- k)

	Relevance	Fluency	Coherence	Likability
MTurk 1st Run	3.3 $\kappa=0.1$	3.6 $\kappa=0.2$	3.5 $\kappa=0.1$	3.3 $\kappa=0.1$

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	Relevance	Fluency	Coherence	Likability
MTurk 1st Run	3.3 $\kappa=0.1$	3.6 $\kappa=0.2$	3.5 $\kappa=0.1$	3.3 $\kappa=0.1$
MTurk 2nd Run	—	4.0 $\kappa=0.5$	3.6 $\kappa=0.3$	3.3 $\kappa=0.1$

we collect ratings for 100 examples, with three judgements per example

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	Relevance	Fluency	Coherence	Likability
MTurk 1st Run	3.3 $\kappa=0.1$	3.6 $\kappa=0.2$	3.5 $\kappa=0.1$	3.3 $\kappa=0.1$
MTurk 2nd Run	—	4.0 $\kappa=0.5$	3.6 $\kappa=0.3$	3.3 $\kappa=0.1$
STORIUM	2.6	4.0	3.4	3.3

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MTurk 2nd Run	—	4.0 $\kappa=0.5$	3.6 $\kappa=0.3$	3.3 $\kappa=0.1$
STORIUM	2.6	4.0	3.4	3.3

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MTurk 2nd Run	—	4.0 $\kappa=0.5$	3.6 $\kappa=0.3$	3.3 $\kappa=0.1$
STORIUM	2.6	4.0	3.4	3.3

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MTurk 1st Run	3.3 $\kappa=0.1$	3.5 $\kappa=0.1$	3.4 $\kappa=0.2$	3.2 $\kappa=0.1$
MTurk 2nd Run	—	3.8 $\kappa=0.3$	3.4 $\kappa=0.2$	3.1 $\kappa=0.2$
STORIUM	2.5	3.8	3.0	3.2

we collect ratings for 100 examples, with three judgements per example

correlations between feedback and **USER**

	likability	fluency	coherence	USER
relevance	0.51	0.28	0.55	0.51
likability		0.28	0.35	0.34
fluency			0.54	0.13*
coherence				0.25

correlations between feedback and **USER**

	likability	fluency	coherence	USER
relevance	0.51	0.28	0.55	0.51
likability		0.28	0.35	0.34
fluency			0.54	0.13*
coherence				0.25

fluency does not really correlate with **USER**

* indicates $p > 0.05$

correlations between feedback and **USER**

	likability	fluency	coherence	USER
relevance	0.51	0.28	0.55	0.51
likability		0.28	0.35	0.34
fluency			0.54	0.13*
coherence				0.25

relevance correlates most strongly with **USER**

* indicates $p > 0.05$

how do users modify the generated suggestions?

scene entry after user edited the suggestion:

Chiang Lee hacked the shop's computer before going inside. That should keep them busy. Alarms went off, electronic locks opened, and they worried about losing all their data. He slipped in, and **crossed the "security line"**. In this area of the shop there was **an orange sticker across all windows. Chiang Lee was taking photos as** he went for the record; **every once in awhile someone wanted special items**, so it would be good to keep a log. However, for now he knew exactly what he wanted - he found it, and pocketed it. It was a wide-spectrum signal blocker. It could interfere with electronic equipment, block signals and - allegedly - interfere with laser blasts and force fields. Whether CIA, FBI or UFO, anyone wanting to take him or slow him down had better stick to analogue and wood, because anything scientific or technological was toast. **Chiang noticed** other people taking **pictures while running around** the shop **looking for some secret** item...he blended in perfectly.

Common usage pattern: users keep short phrases from the suggestion but completely change the content

often, users delete everything

generated text:

Oh, wait, Annie thought. *This is just like in the movies.* That's where she got stuck with a living ghost! She was surprised at how this part of Christmas went on so long - and by its strange behaviour that it started acting up again when things weren't exactly normal for her to be having fun. So... what did Annie do? She had a friend helping all over town. A caring friend who passed through Kringle every year-and-a half, passing out presents from their favourite tree as they went! And here they were going to make Christmas special (at least until a return trip home!), and now there seemed no end in sight before she'd need an exorcism, or possibly a demon blood sacrifice... But maybe if these last few days hadn't gone so very smoothly... she could reach back into her own deep pocket one more time and get her hands free – It would give you a real boost later. Lets hope nothing happened during the ritual, too... But enough “hurr durr”

no n-gram overlap at all!

final edited version:

Annie checked her list again; she'd already read it multiple times, but she might now, finally, be ready for Christmas. Thanks to her new flight experience, she was actually going to be able to help deliver some of the many presents this year. She had also managed some private preparations of her own for afterwards. Now watching the snow fall softly just outside the window, Annie Bell felt the familiar Christmas tingle as the magic of the evening approached. She dressed warmly, and went to help Noelle with the reindeer, knowing the other elves would soon start to arrive to begin packing the sleigh. Back in her room, six brightly wrapped Christmas presents glinted on her desk each labelled to one of her new found friends.

user feedback

I feel like the ai gives me idea's for keeping things going for example I was gonna just say they slay the big golem but then the machine came up with there was 3 golems so I had to keep going and rethink the story I just kept the writing because I like what I was doing with the cards and everytime the ai changed the story I just worked with it like a friend giving me ideas.

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There is a disproportionate amount of innuendo and strong language coming through - not suitable for the age range of the games and not at all explainable by the context.

In my head, now, I'm starting to assign bios to the AIs

- swears wild-child outsider who keeps getting piercings and tattoos and stands around at parties, glaring at the more popular kids.
- the reluctant kid who's actually quite keen to be involved but a little shy to start with.
- the convent-educated naive kid who's just taken LSD for the first time and whoa... gotta tell you about all the cyberpunk stuff!

Thanks! Questions?