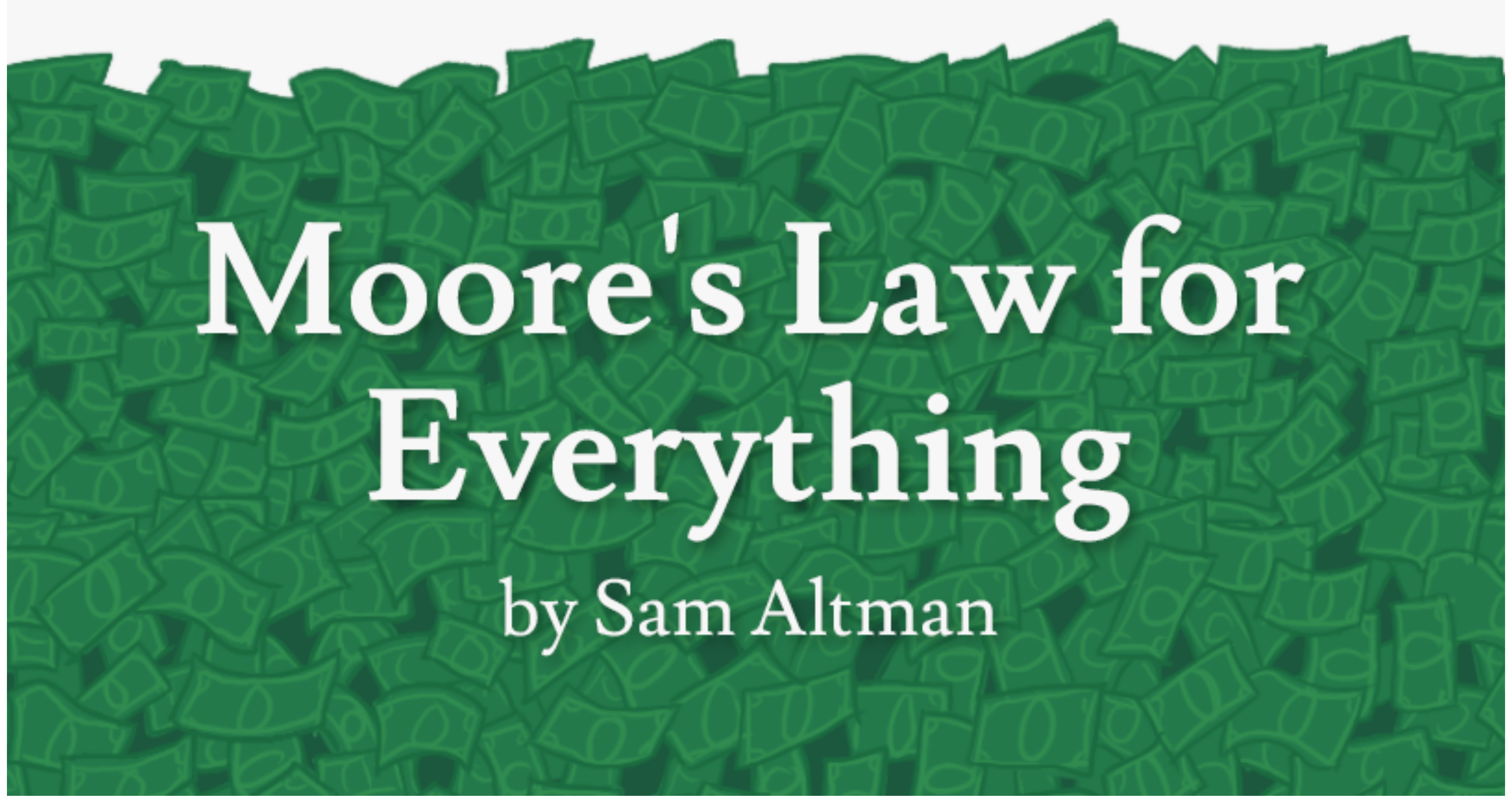
The Devil's in the Data

Mapping and Generating Datasets for Robust Generalization

Swabha Swayamdipta
Incoming Asst. Prof, USC CS
Postdoc, Allen Institute for AI
23rd May, 2022



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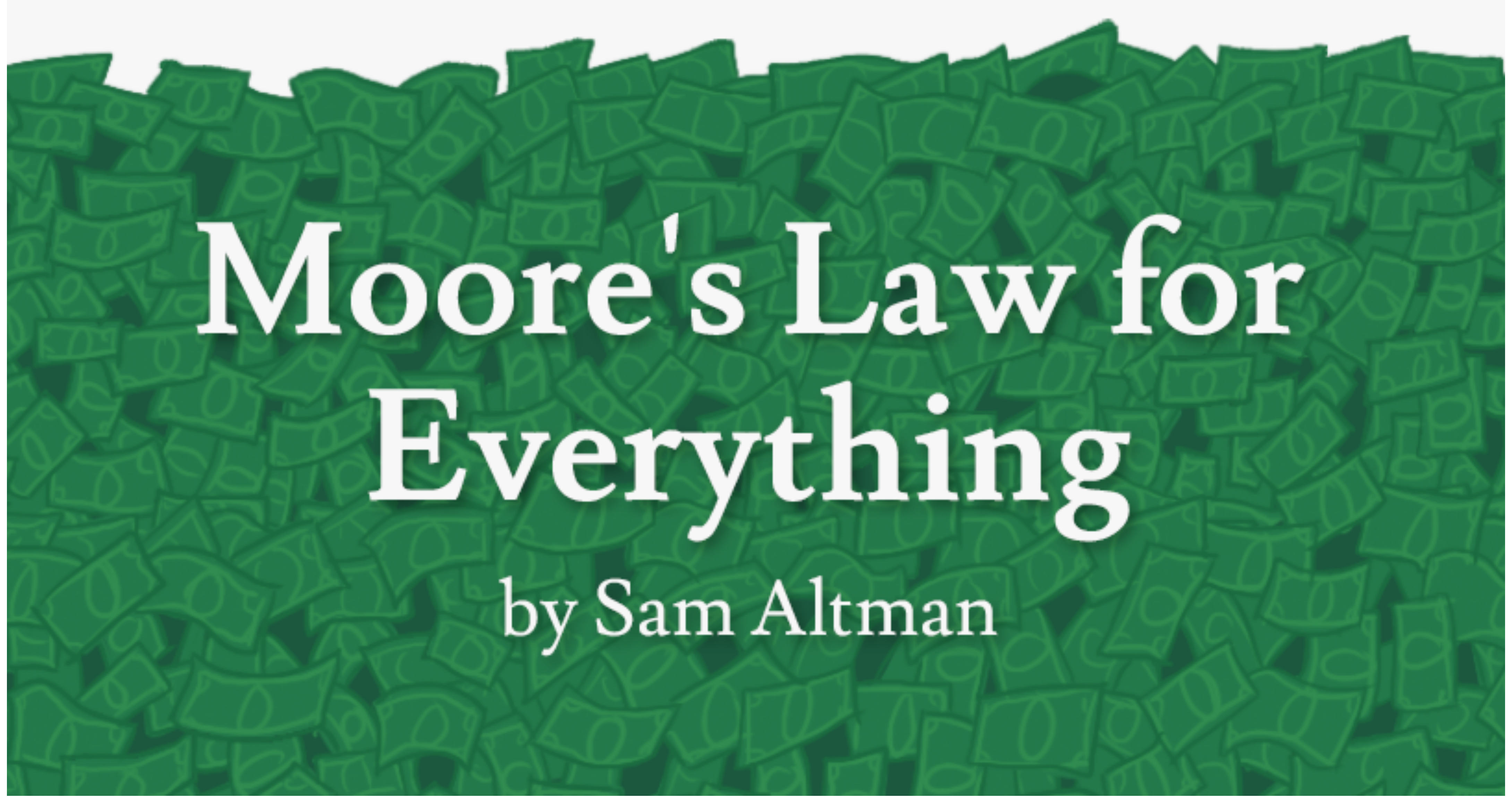

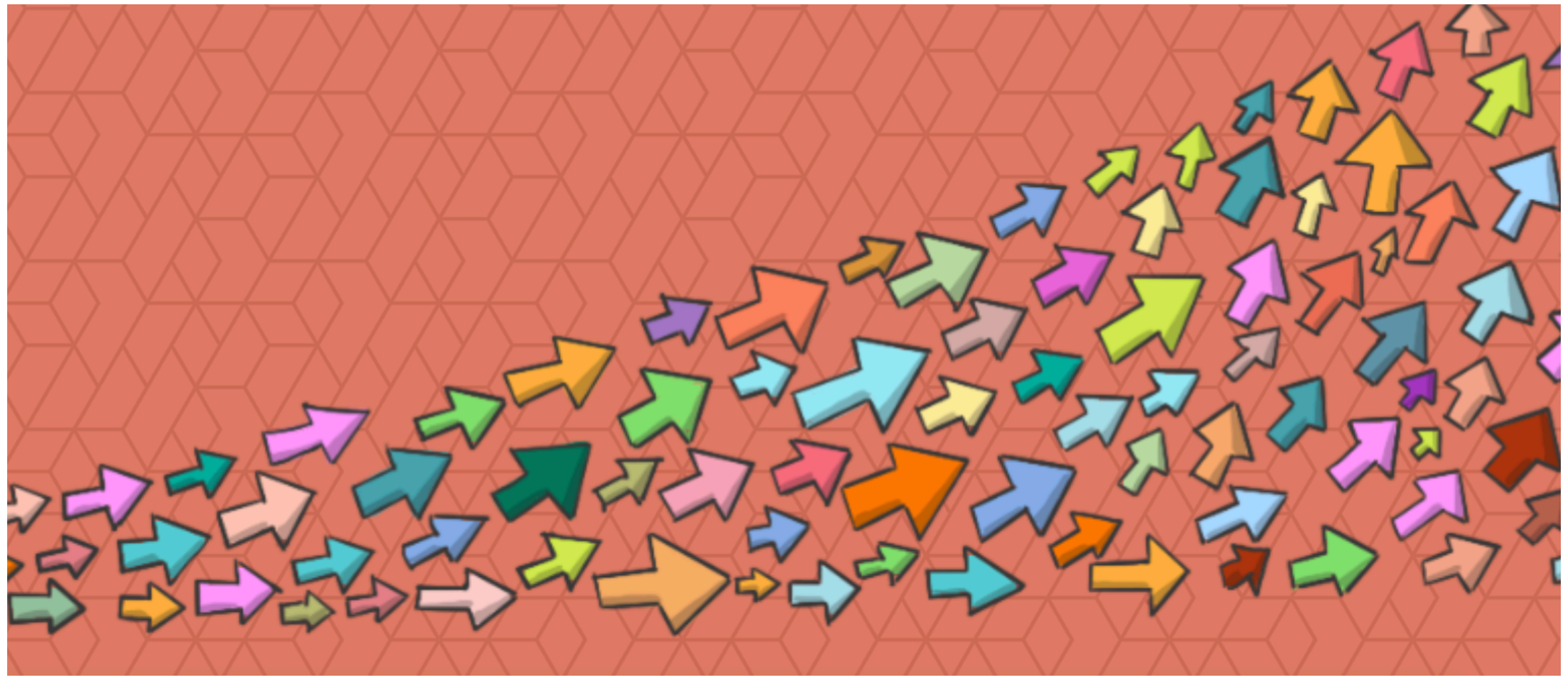

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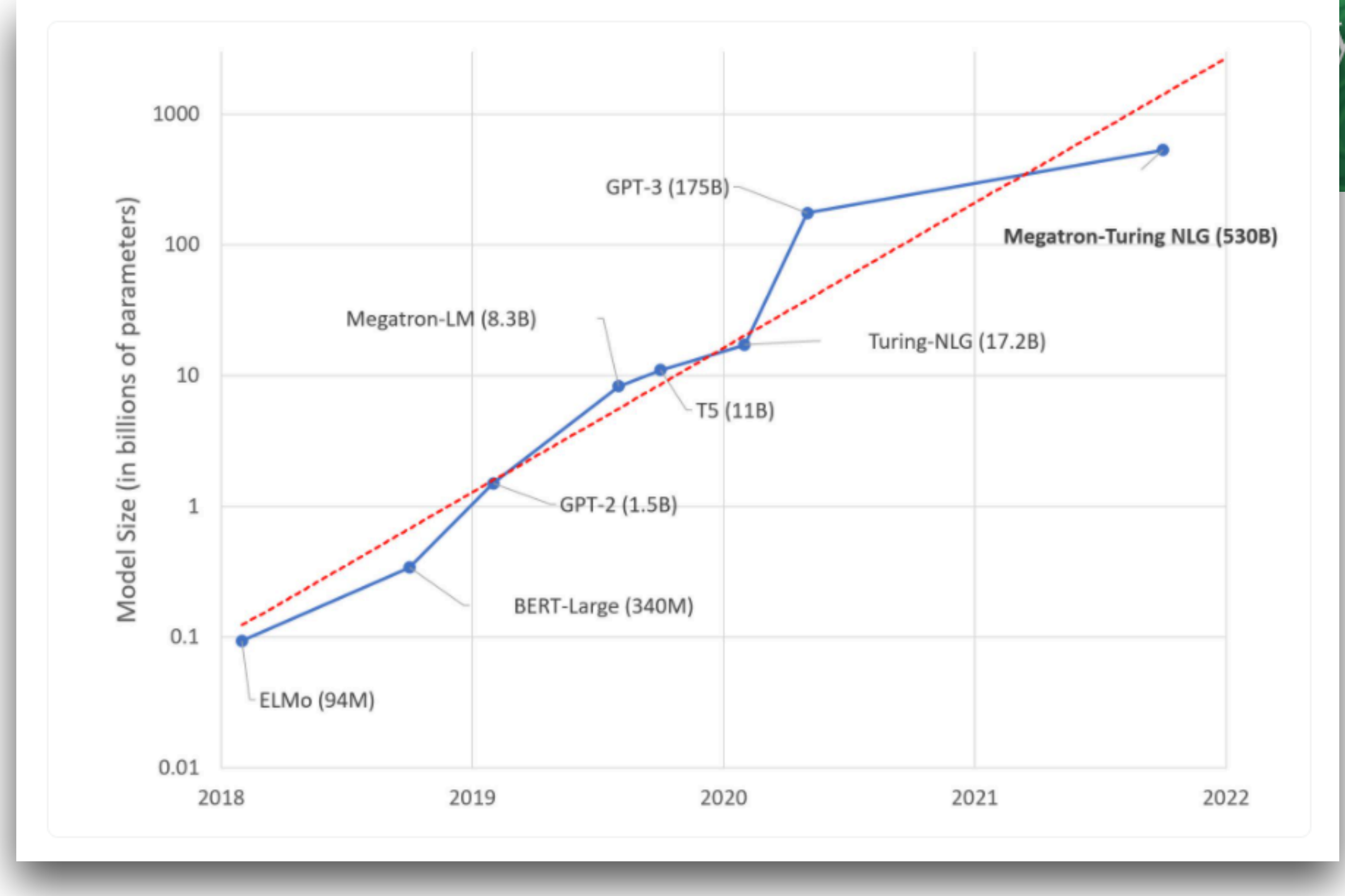

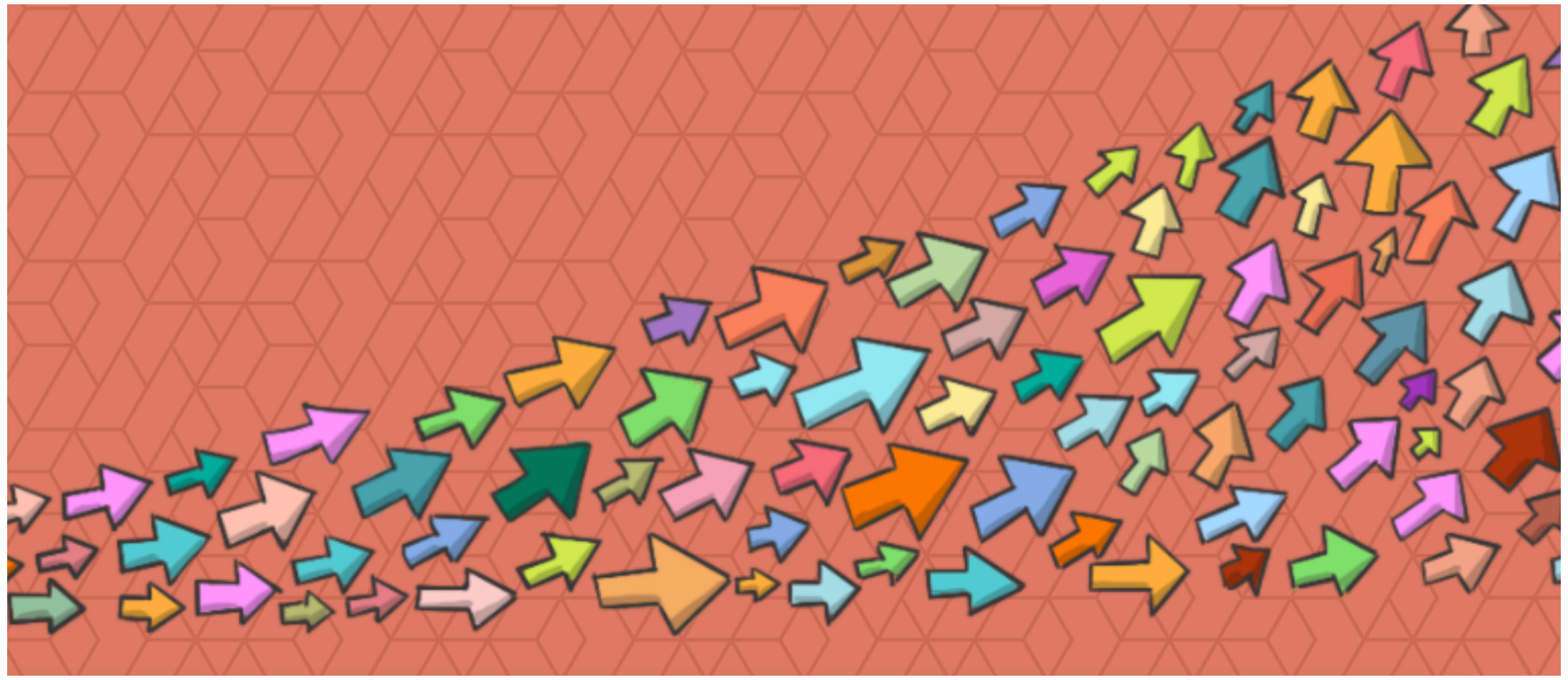

c.f. Julien Simon's blog https://huggingface.co/blog/large-language-models

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Is data scale really the key to generalization?

c.f. Julien Simon’s blog https://huggingface.co/blog/large-language-models

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Natural Language Inference

Given a premise, is a hypothesis true, false or neither?

Semantic Theory [Katz, 1972]

Natural Language Inference

Given a premise, is a hypothesis true, false or neither?

Premise: A dog is chasing birds on the shore of the ocean.

Semantic Theory [Katz, 1972]

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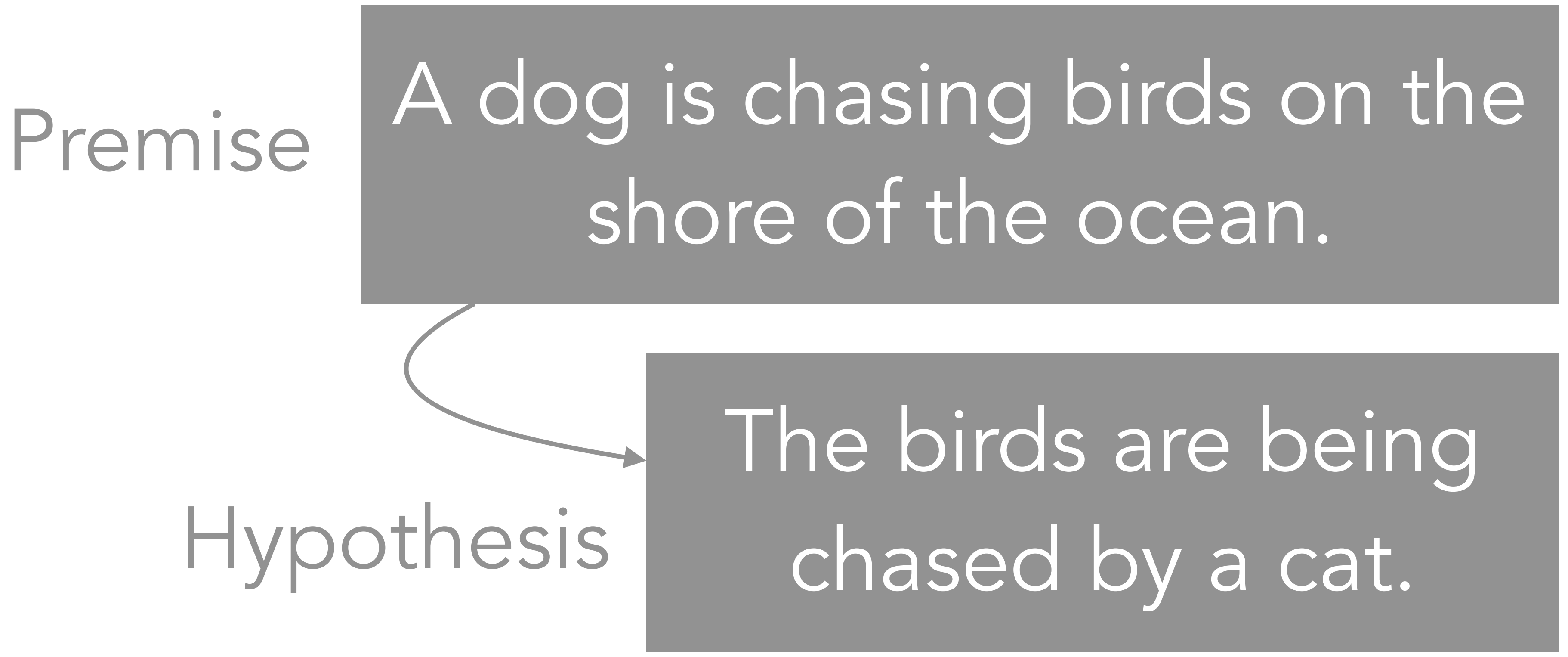

Premise

A dog is chasing birds on the shore of the ocean.

Hypothesis

The birds are being chased by a cat.

Semantic Theory [Katz, 1972]

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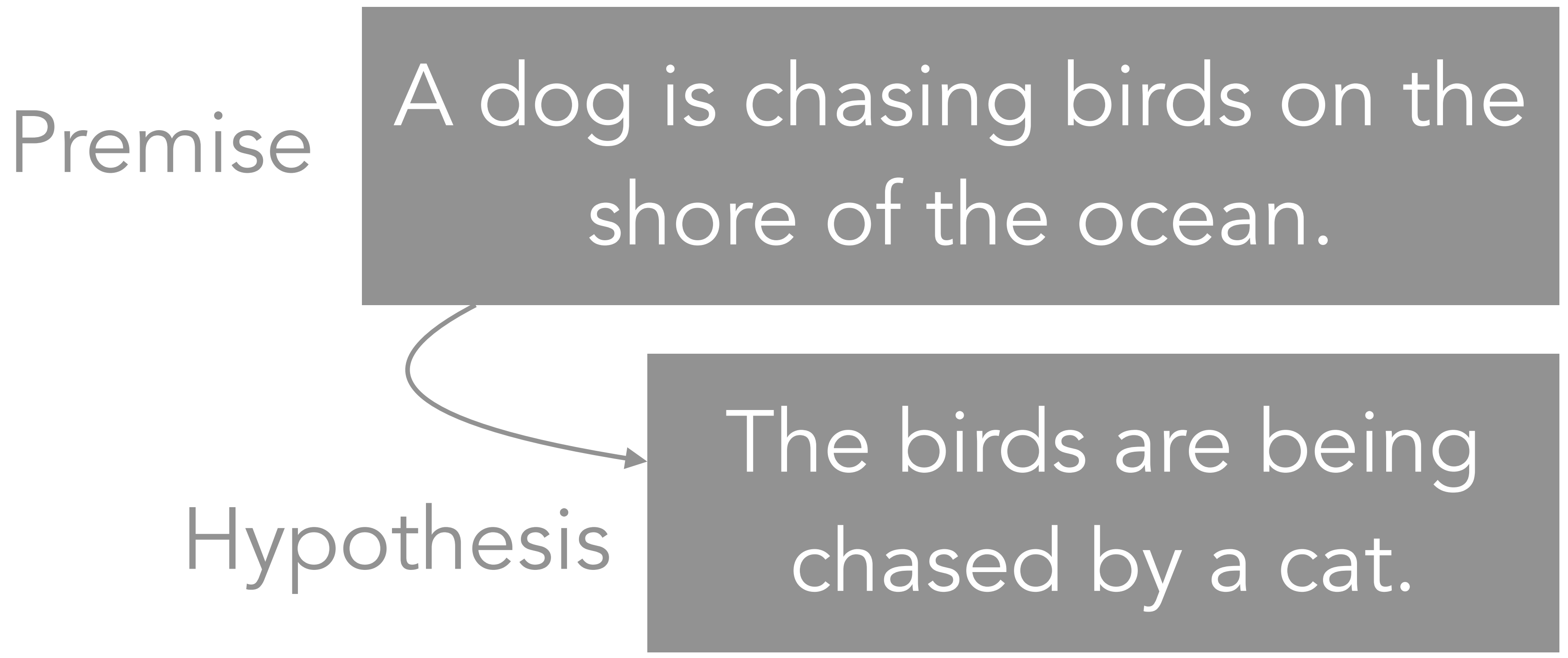

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○ True → **Entailment**

○ False → **Contradiction**

○ Cannot Say → **Neutral**

Semantic Theory [Katz, 1972]

Natural Language Inference

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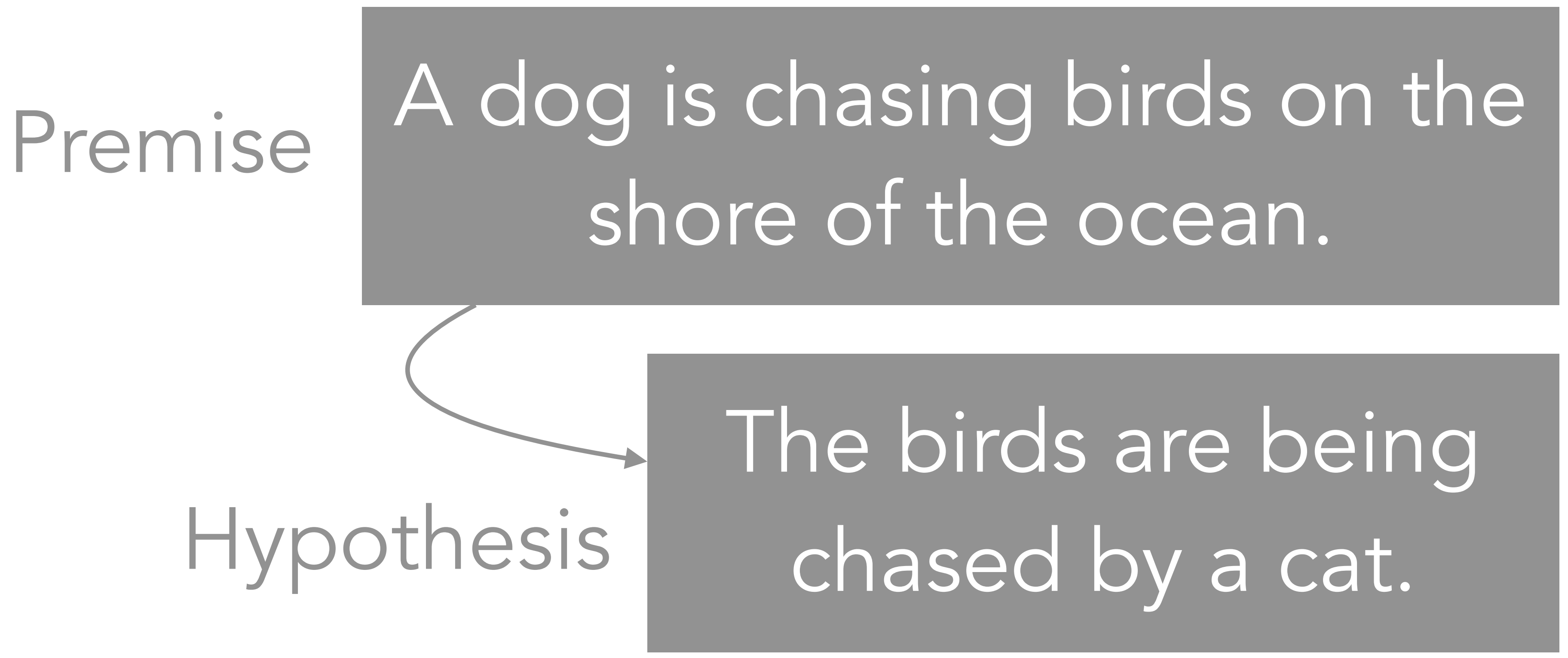

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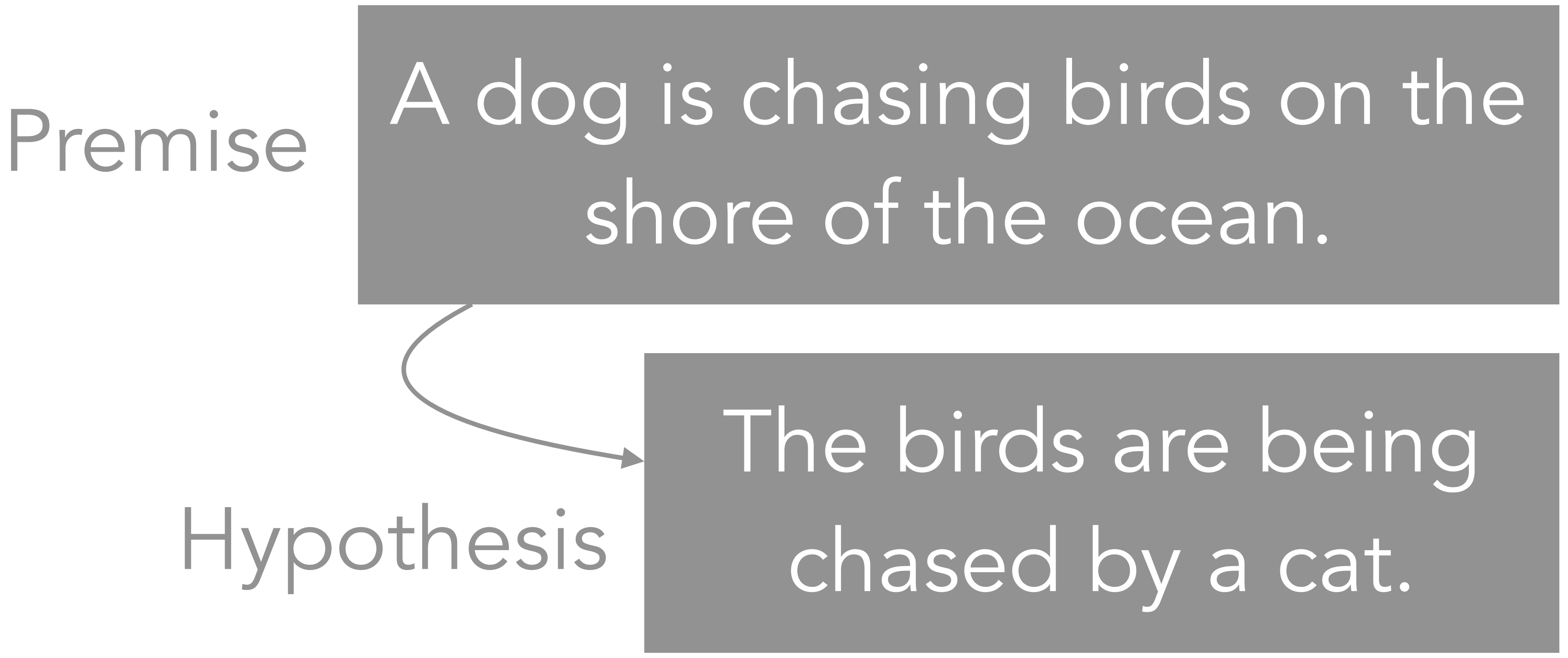
Semantic Theory [Katz, 1972]

Natural Language Inference

Stanford NLI [Bowman et al., 2015]
~0.5m instances

MultiNLI [Williams et al., 2018]
~0.4m instances

Given a premise, is a hypothesis true, false or neither?



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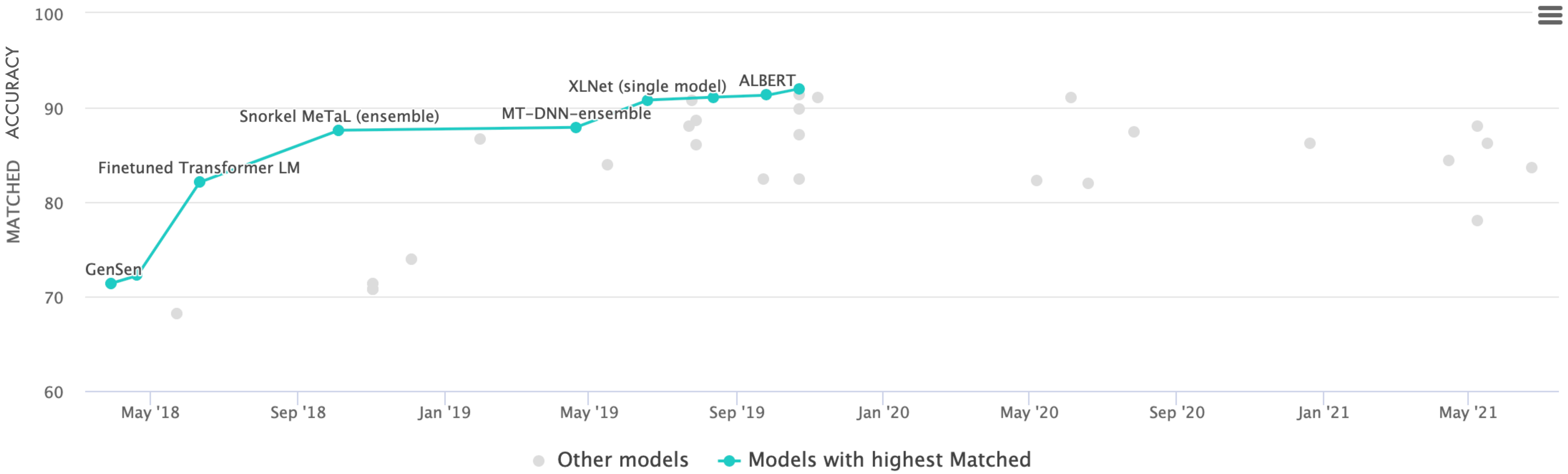
MultiNLI leaderboard results from paperswithcode.com [March 2022]



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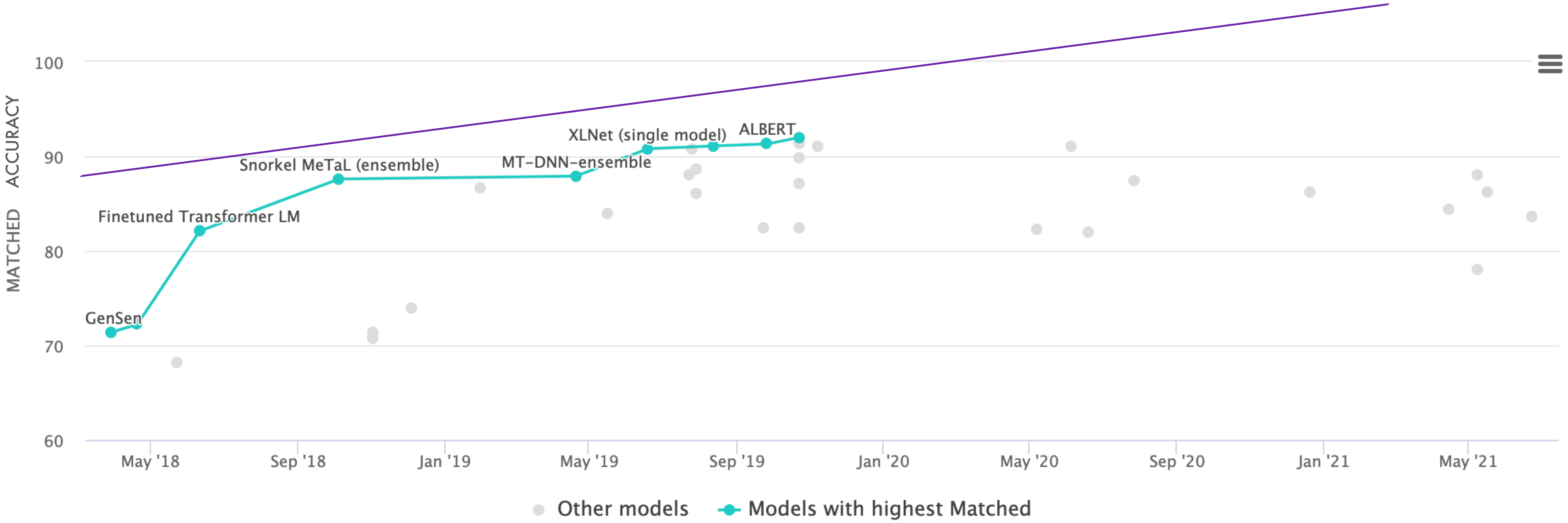

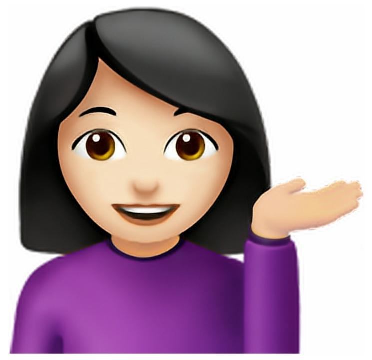

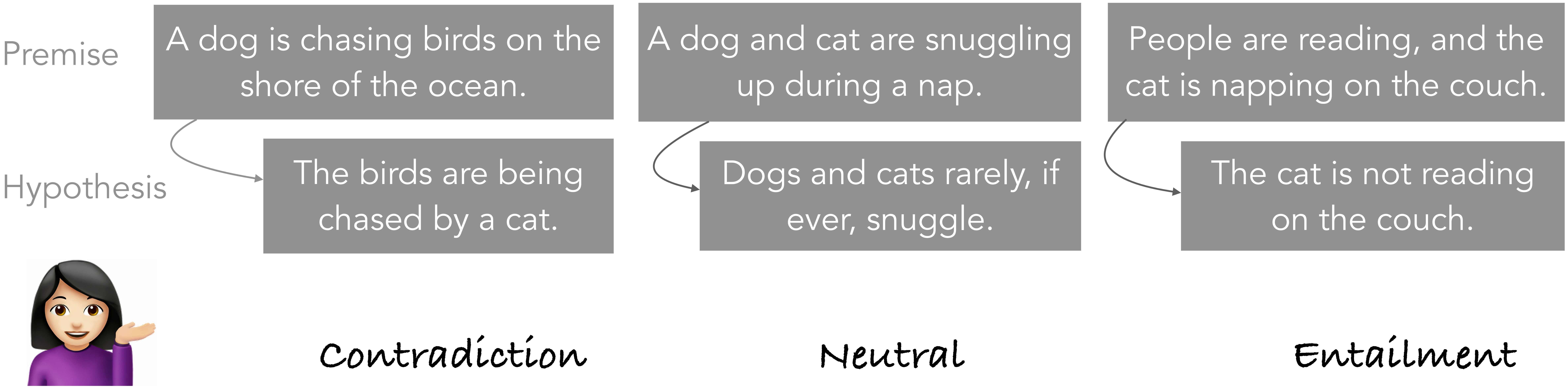

Premise	A dog is chasing birds on the shore of the ocean.	A dog and cat are snuggling up during a nap.	People are reading, and the cat is napping on the couch.
Hypothesis	The birds are being chased by a cat.	Dogs and cats rarely, if ever, snuggle.	The cat is not reading on the couch.
	Contradiction	Neutral	Entailment

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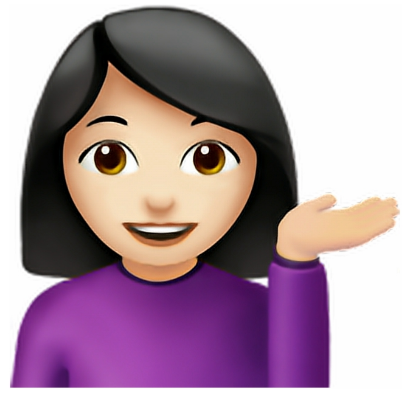	Contradiction	Neutral	Entailment

RoBERTa-Large [Liu et al. 2019]

Trained on MultiNLI + SNLI

Premise	A dog is chasing birds on the shore of the ocean.	A dog and cat are snuggling up during a nap.	People are reading, and the cat is napping on the couch.
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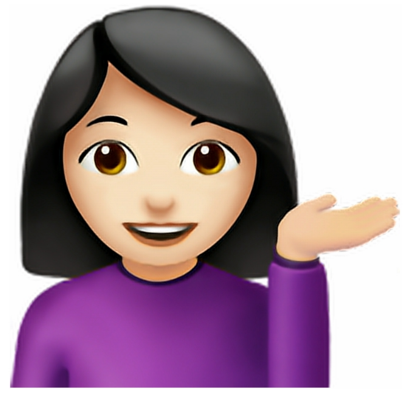
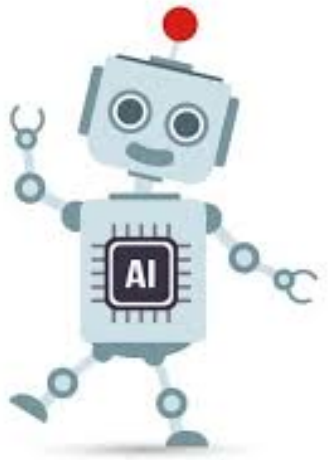
	Contradiction	Neutral	Entailment
	Contradiction ✓	Contradiction ✗	Contradiction ✗

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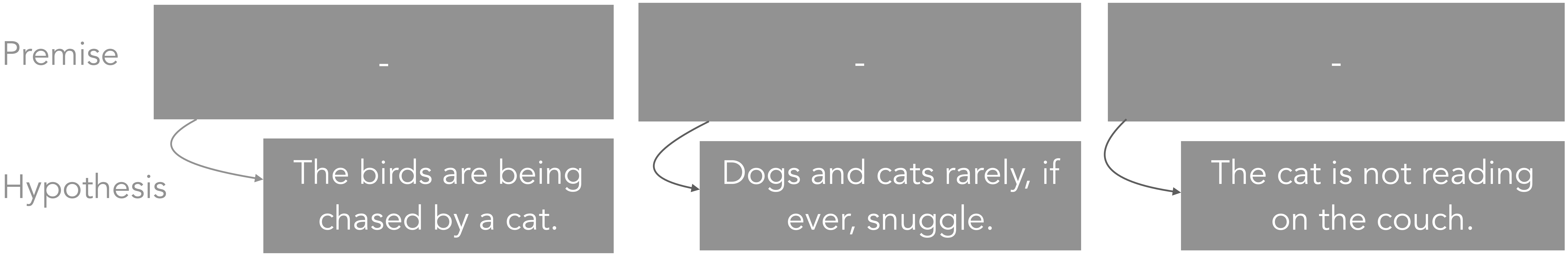

Premise

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Hypothesis

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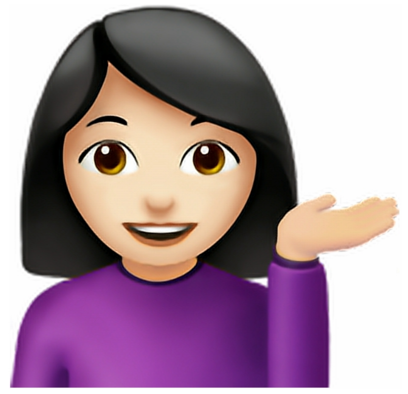
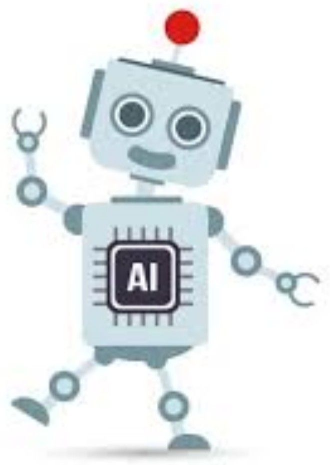
Dogs and cats rarely, if ever, snuggle.

The cat is not reading on the couch.





RoBERTa-Large [Liu et al. 2019]

Trained on SNLI + MultiNLI

Annotation Artifacts in NLI [G*., **Swayamdipta***, L., S., B., S., NAACL 2018]

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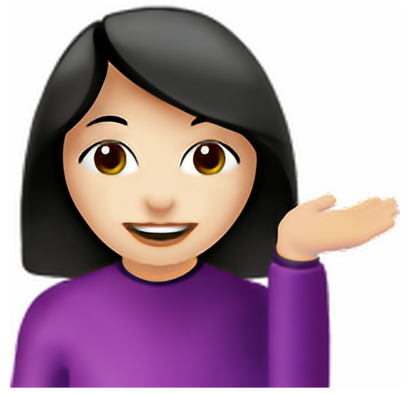
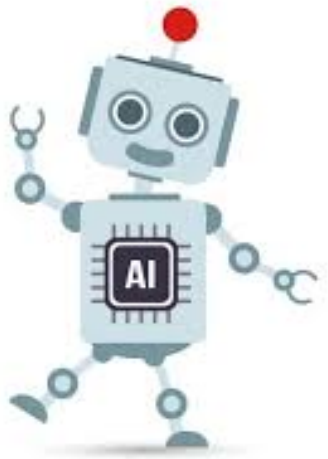
	??	??	??



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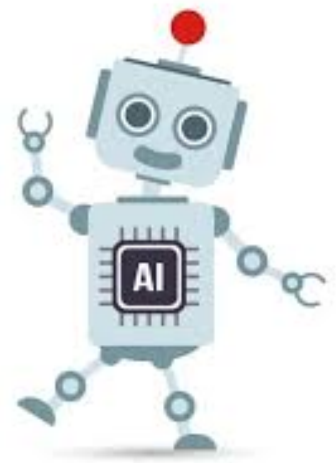	**Contradiction**	**Contradiction**	**Contradiction**

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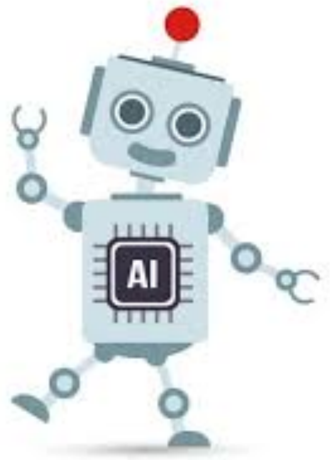

Contradiction

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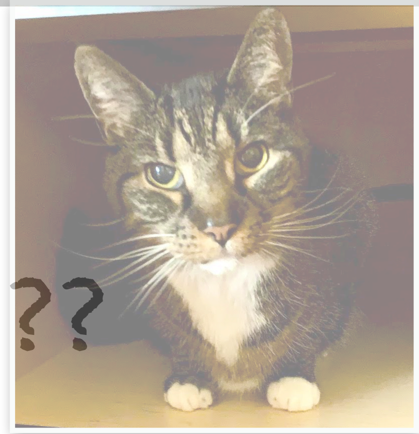


Contradiction

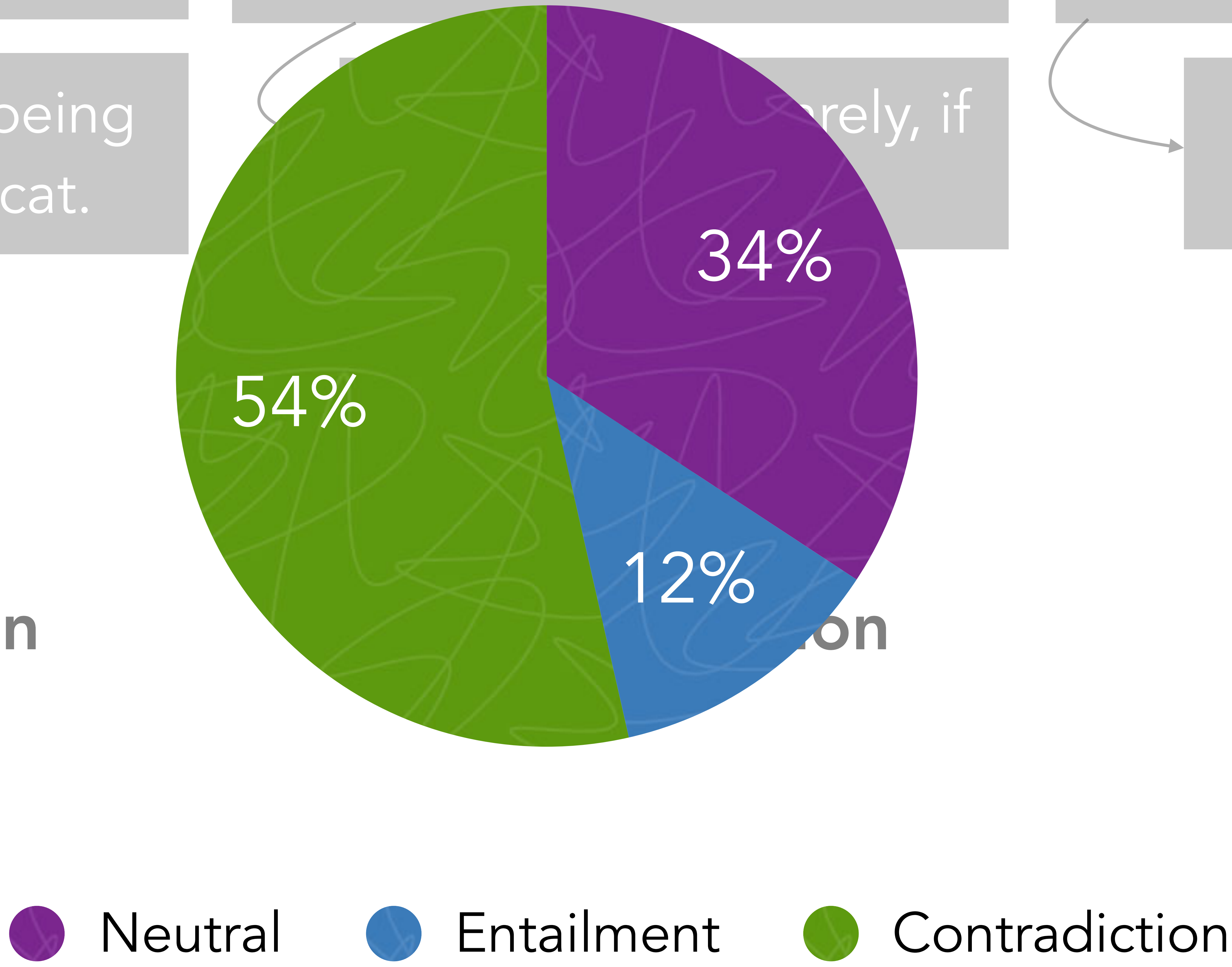
on

Contradiction

RoBERTa-Large [Liu et al. 2019]

Trained on SNLI + MultiNLI

“Cat” Instances



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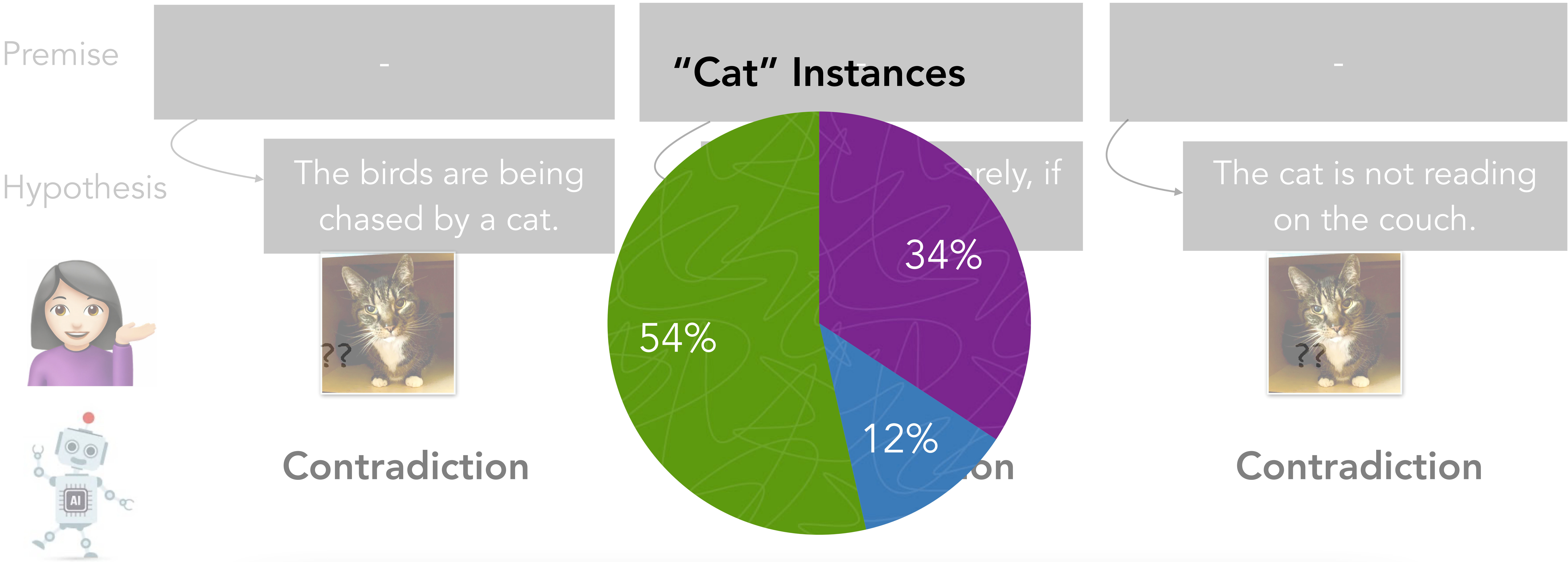

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Trained on SNLI + MultiNLI

State-of-the-art NLP models still succumb to **spurious biases** in data

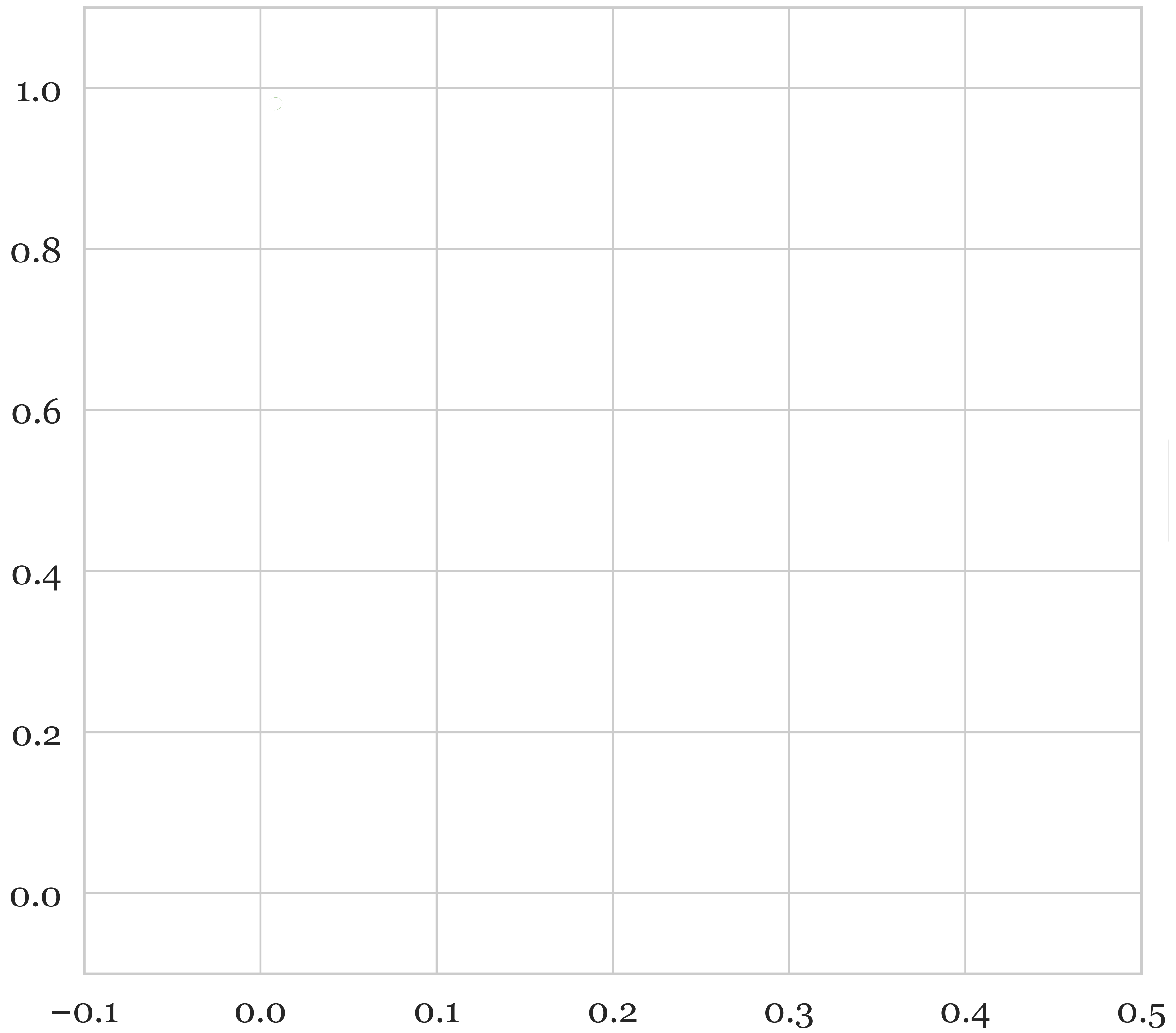
Annotation Artifacts in NLI [G*., **Swayamdipta***, L., S., B., S., NAACL 2018]

How can we better analyze the model-data relationship?

Model Training Dynamics

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]

Model Training Dynamics



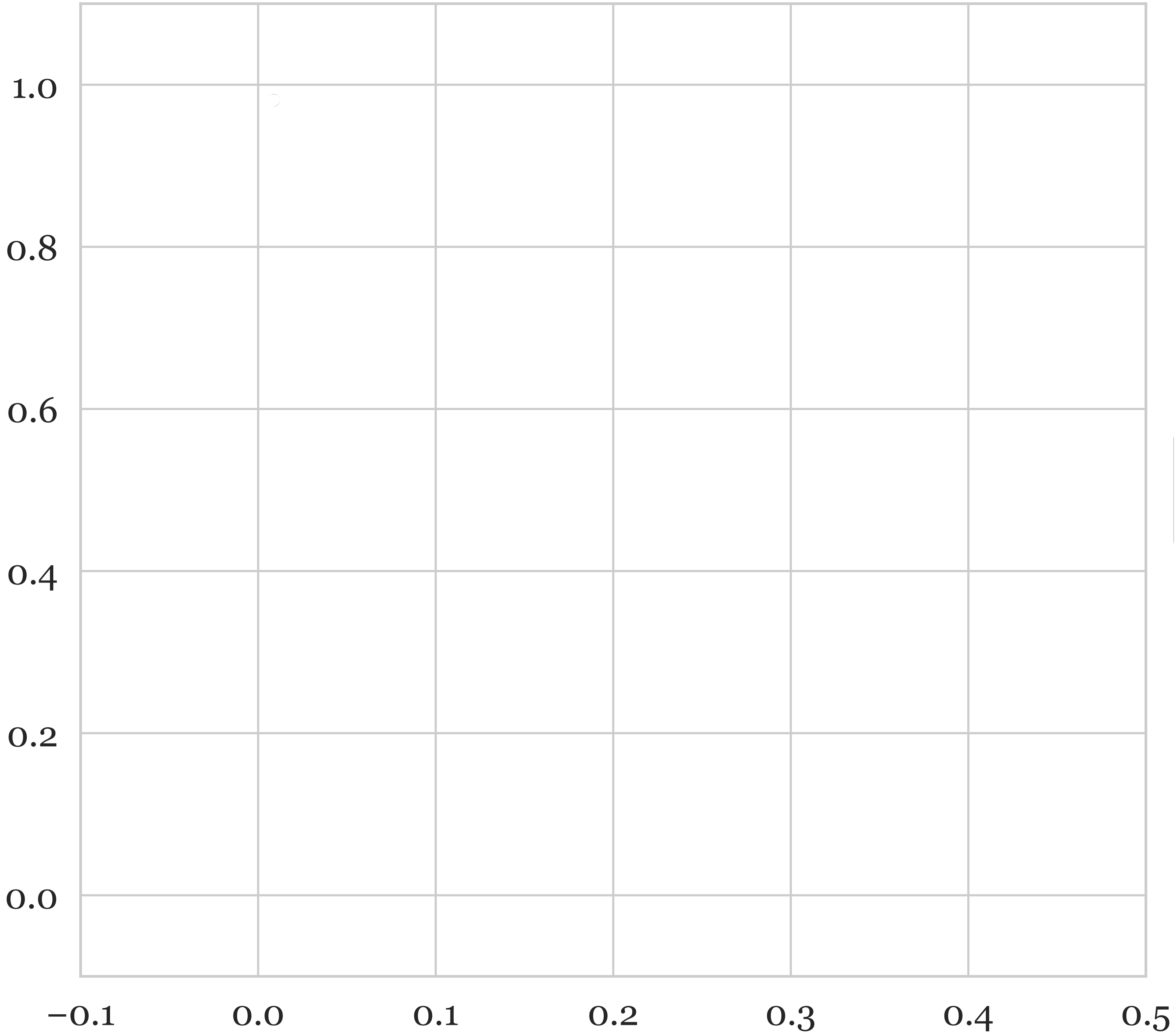
Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]

Model Training Dynamics

$$\hat{\mu}_i = \frac{1}{E}\sum_{e=1}^{E} p_{\theta^{(e)}}(y_i^* \mid x_i)$$

confidence

Mean probability of the **true class**



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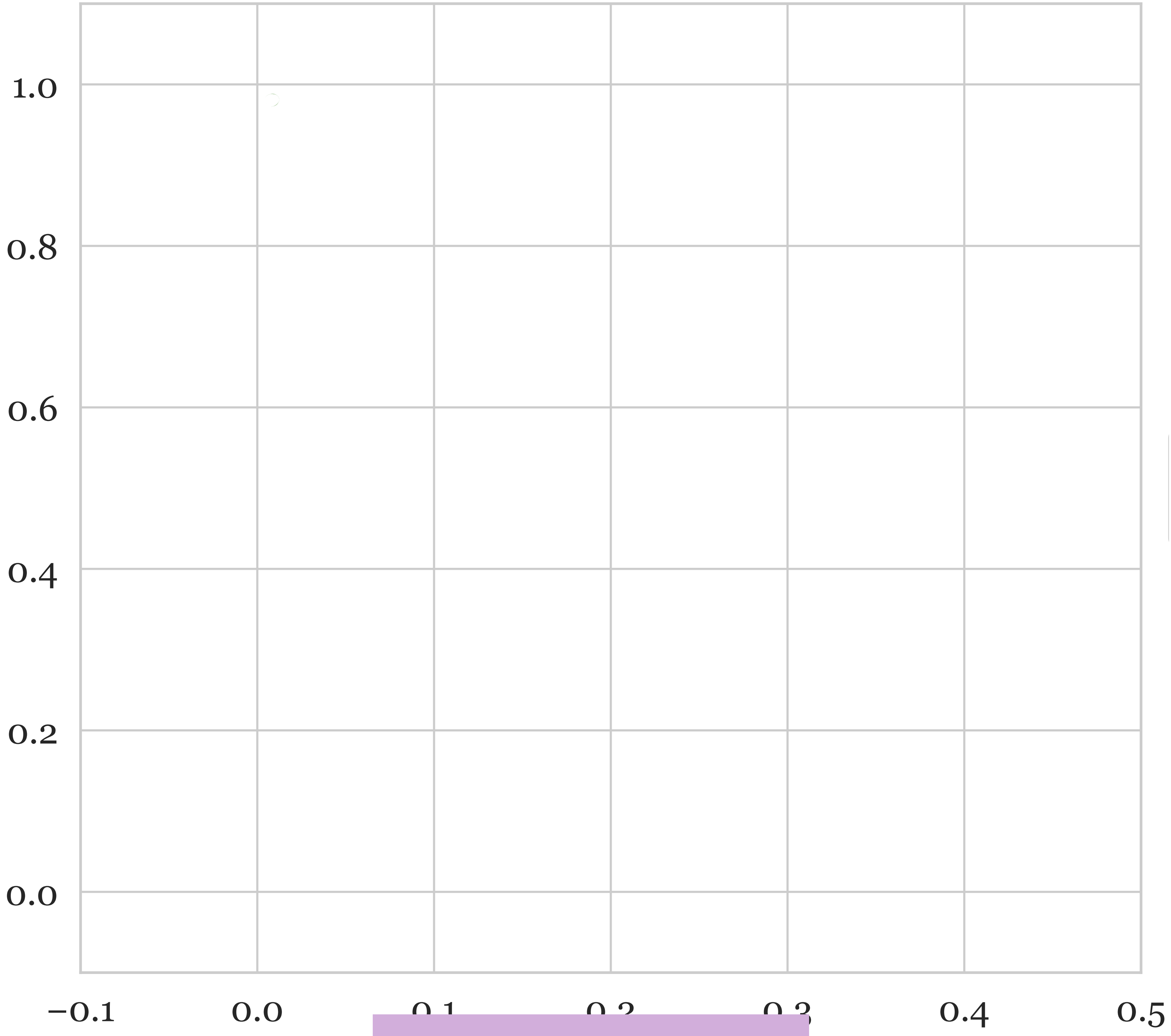

variability

$$\hat{\sigma}_i = \sqrt{\frac{\sum_{e=1}^{E}\left(p_{\theta^{(e)}}(y_i^* \mid x_i) - \hat{\mu}_i\right)^2}{E}}$$

Standard deviation of the **true class** probability

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]

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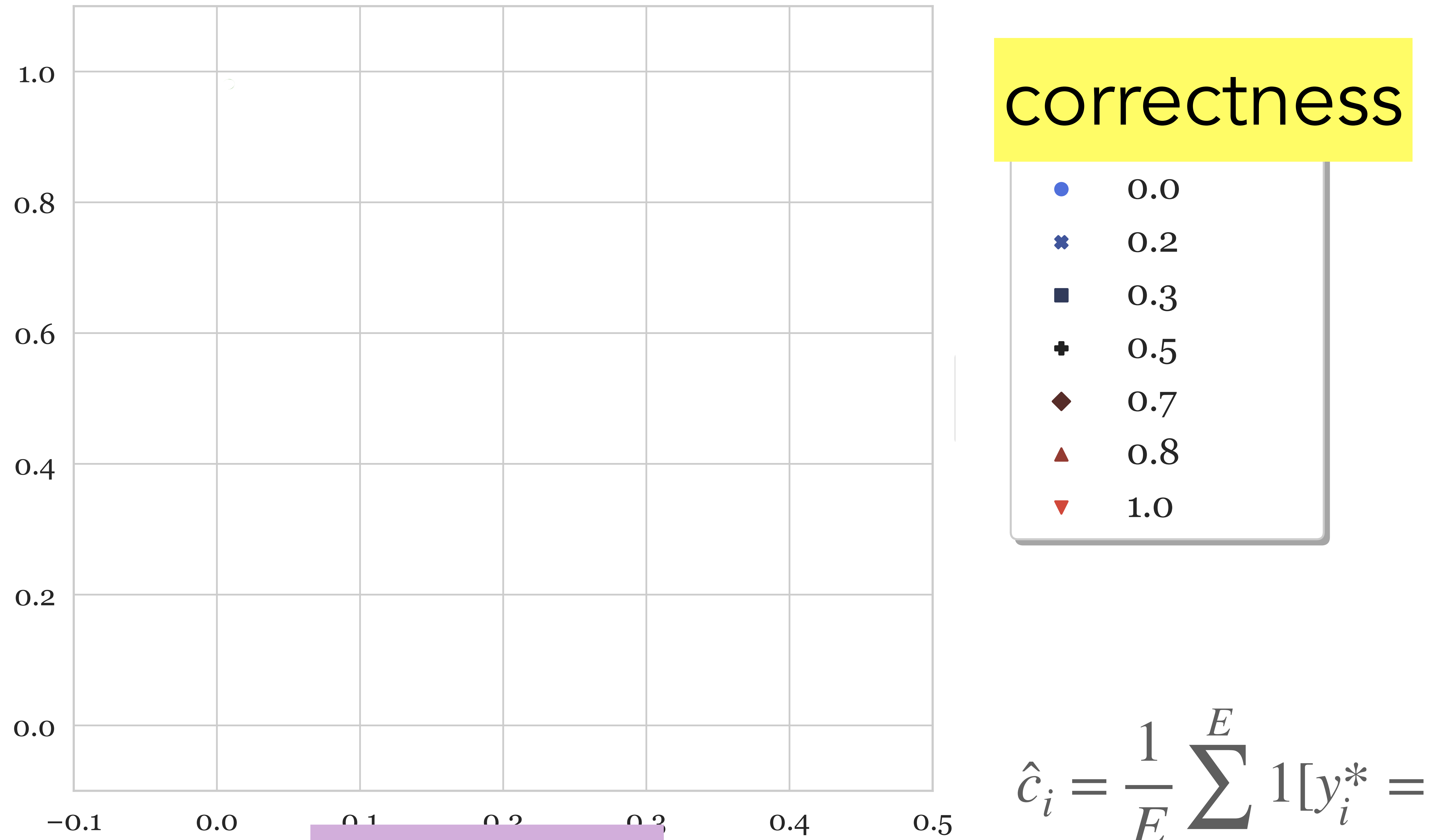


Ratio at which model prediction matches **true class**

$$\hat{c}_i = \frac{1}{E}\sum_{e=1}^{E} 1[y_i^* = \arg\max_{y} p_{\theta^{(e)}}(y \mid x_i)]$$

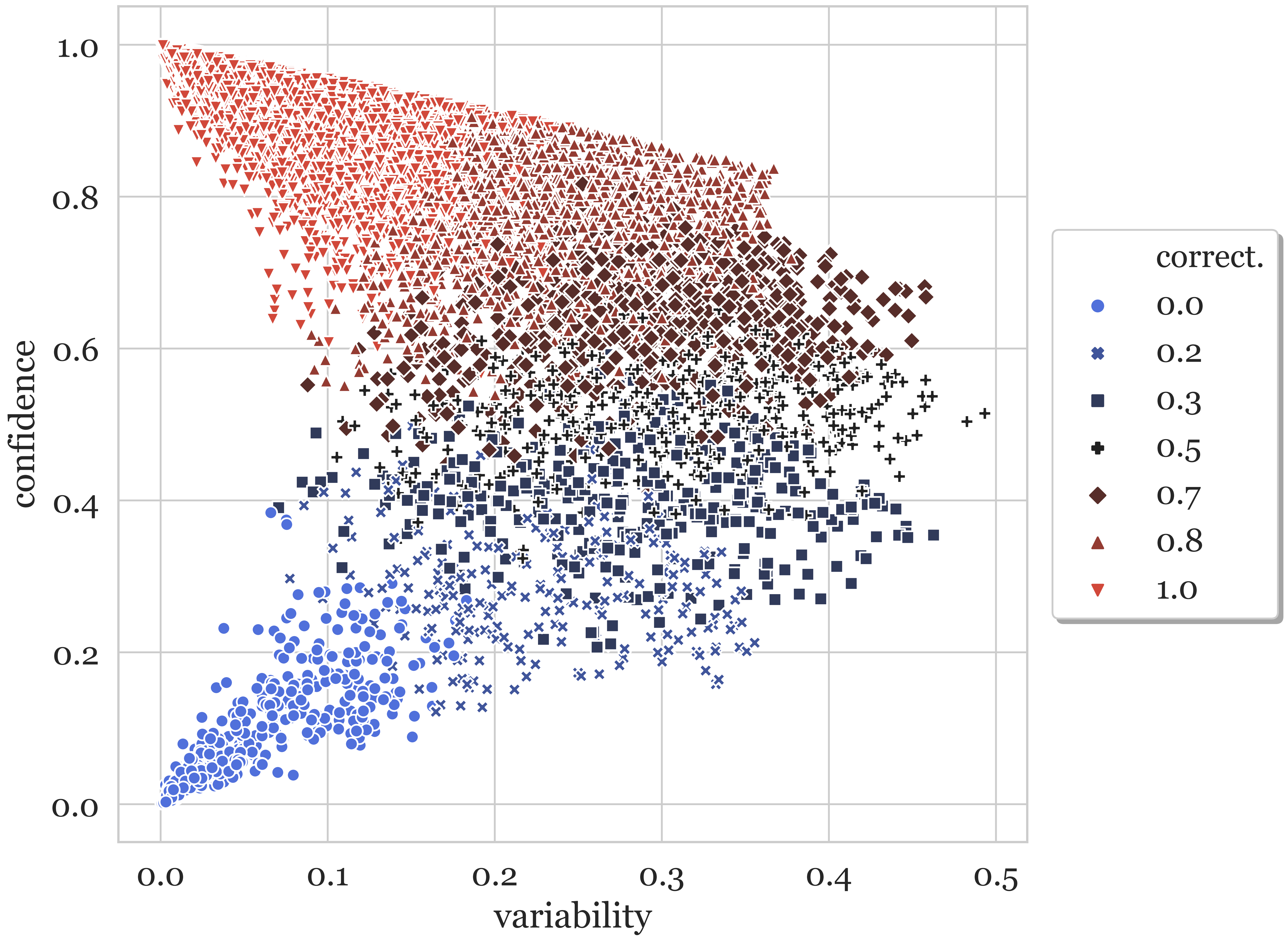
variability

$$\hat{\sigma}_i = \sqrt{\frac{\sum_{e=1}^{E}\left(p_{\theta^{(e)}}(y_i^* \mid x_i) - \hat{\mu}_i\right)^2}{E}}$$

Standard deviation of the **true class** probability

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]

SNLI-RoBERTa Data Map



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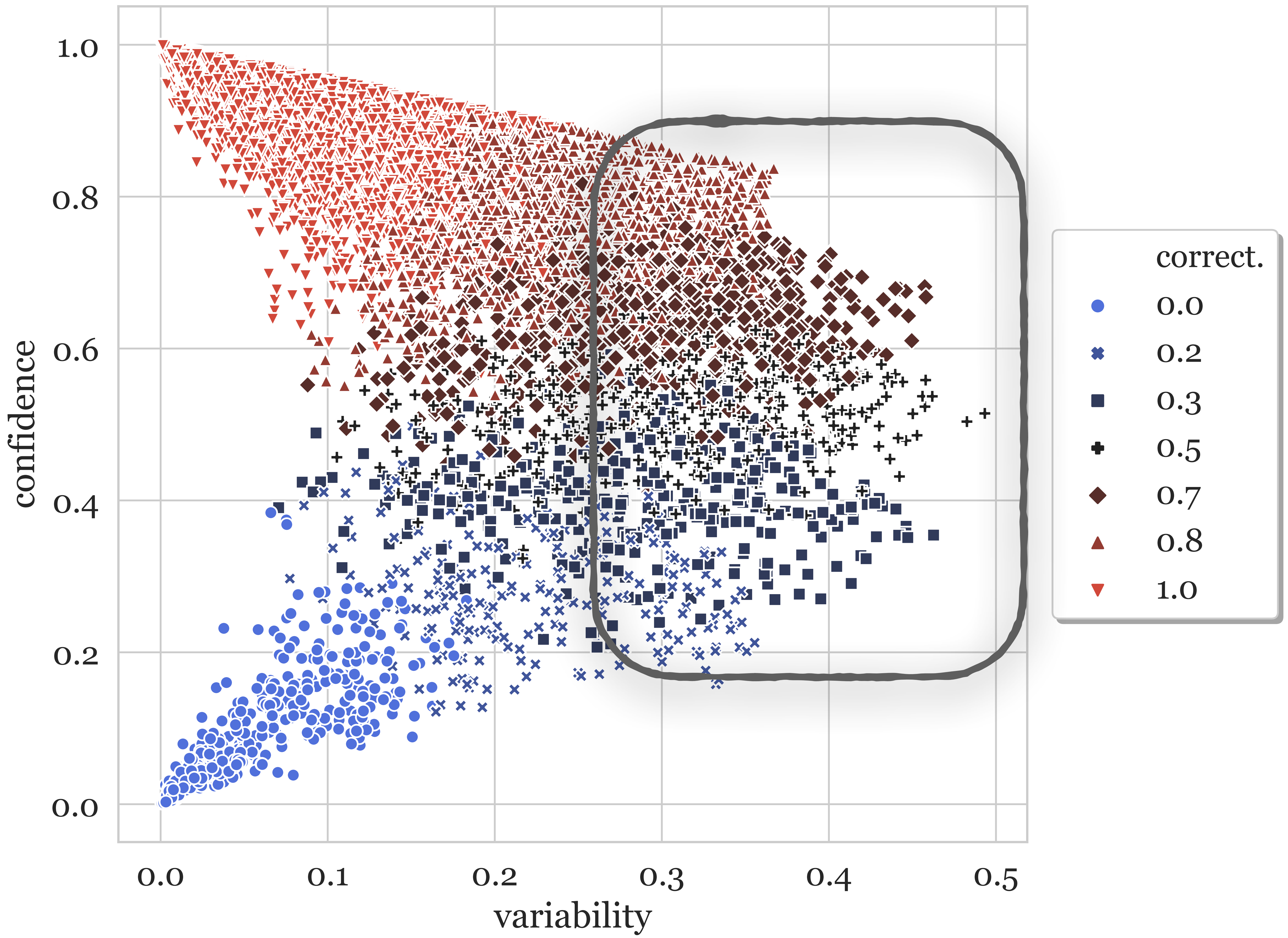

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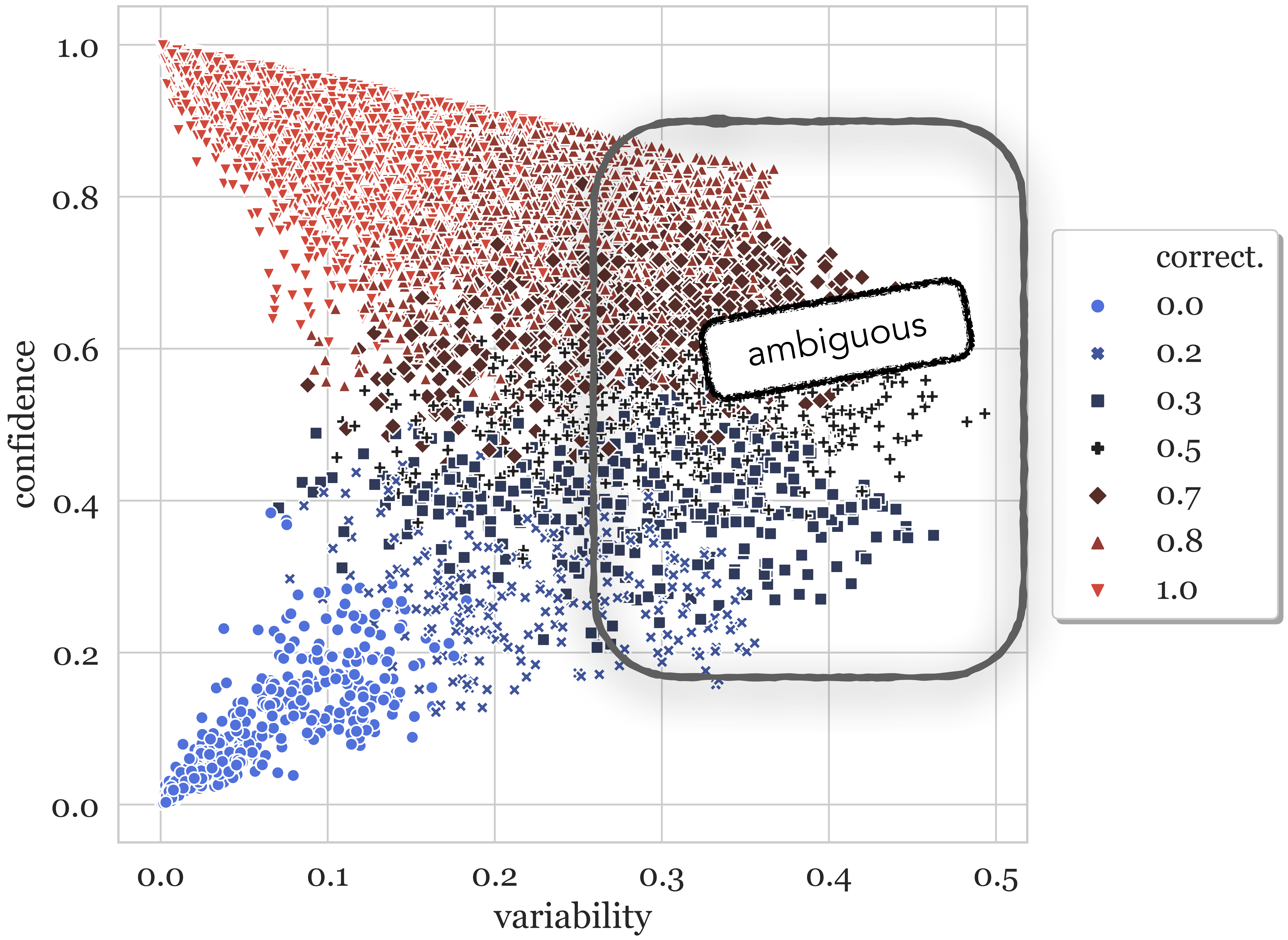

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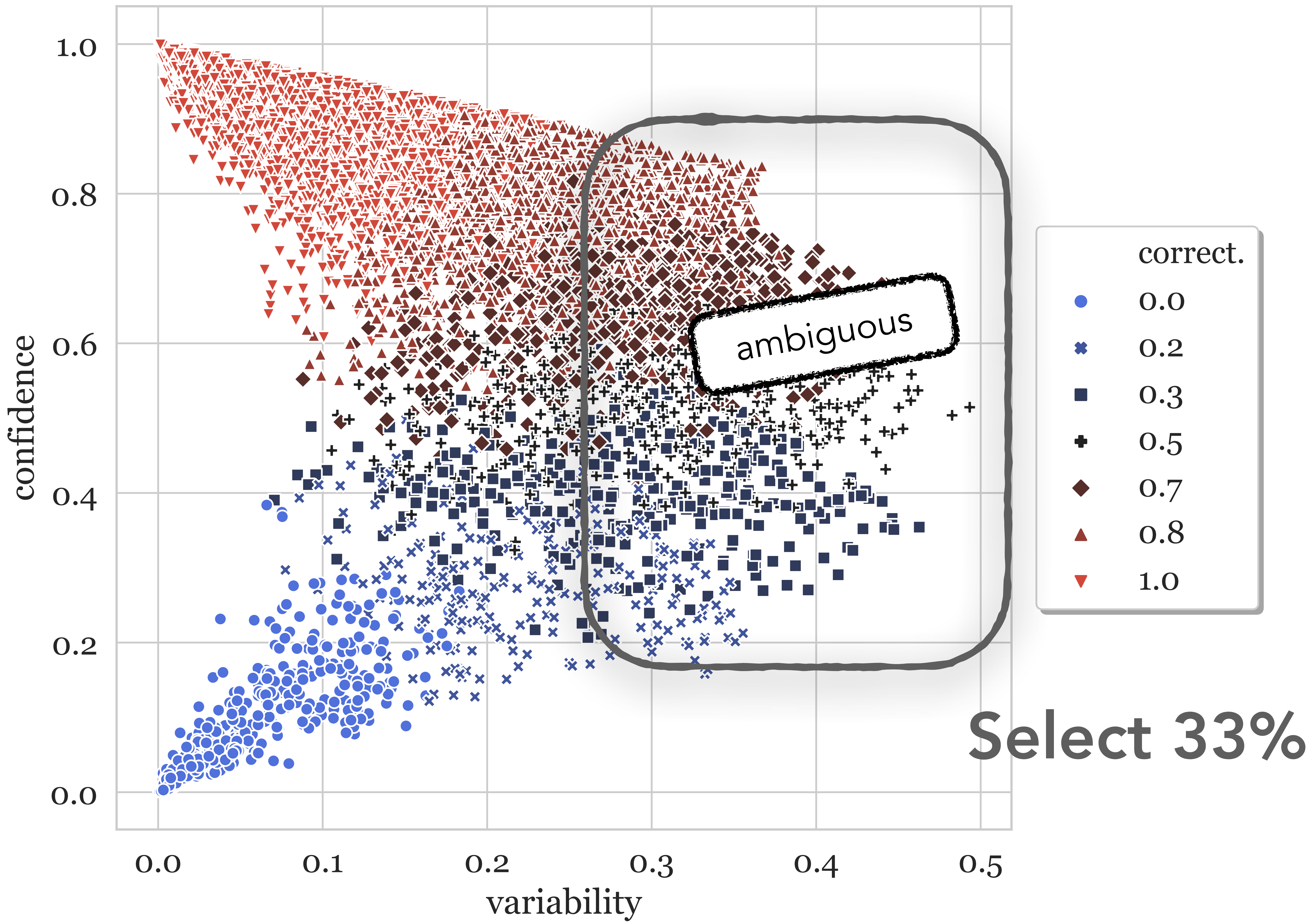
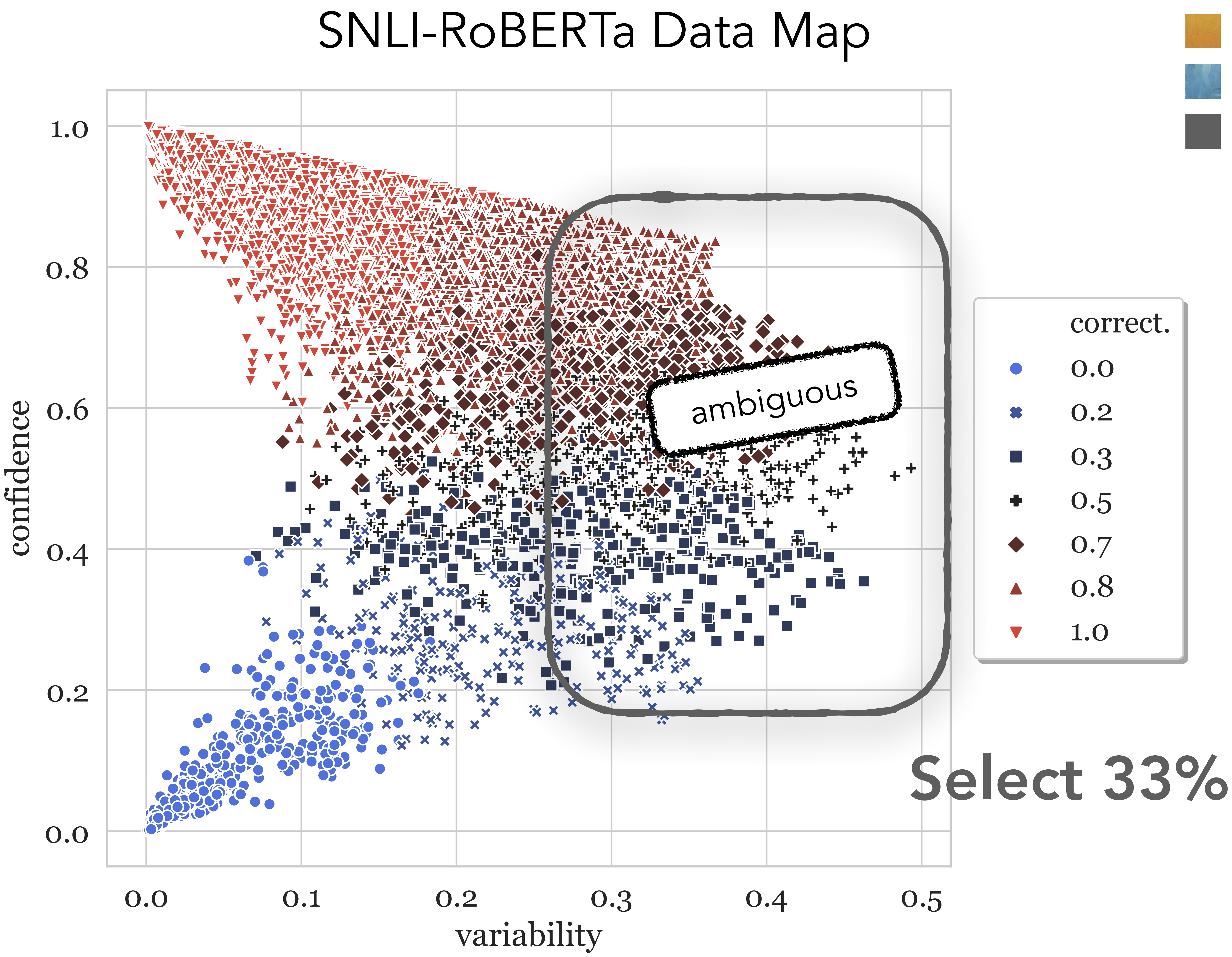


Select 33%

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]



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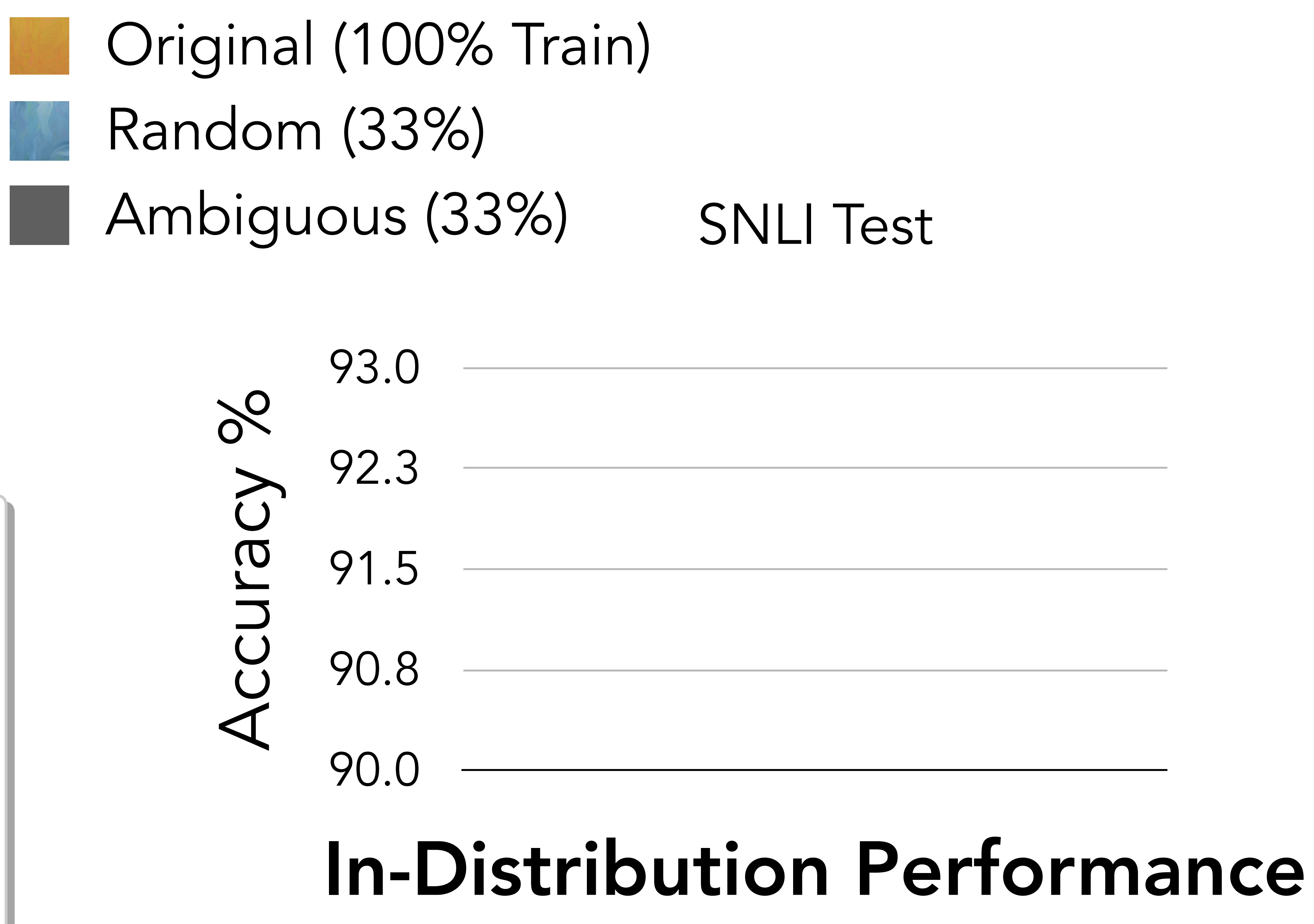

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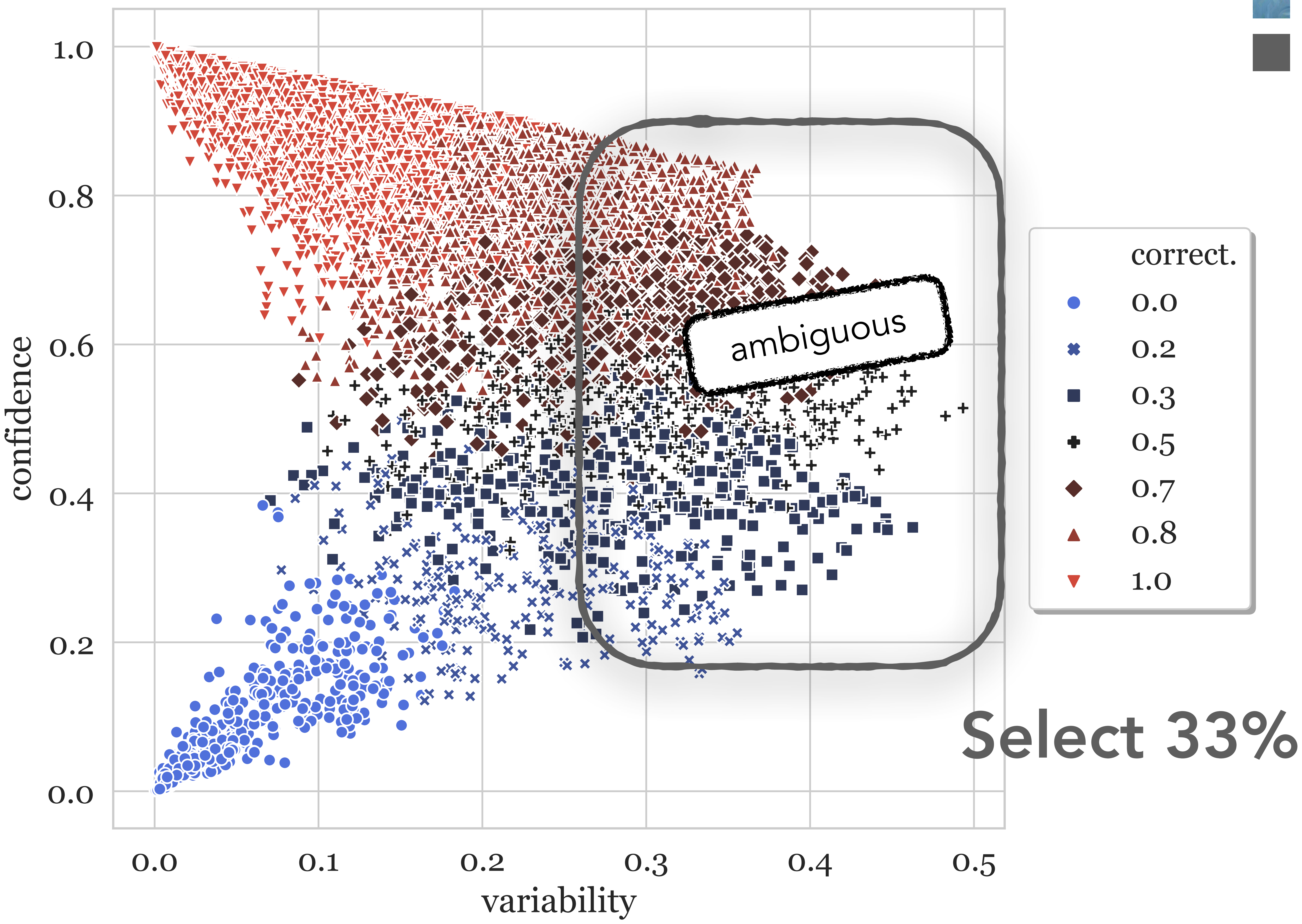

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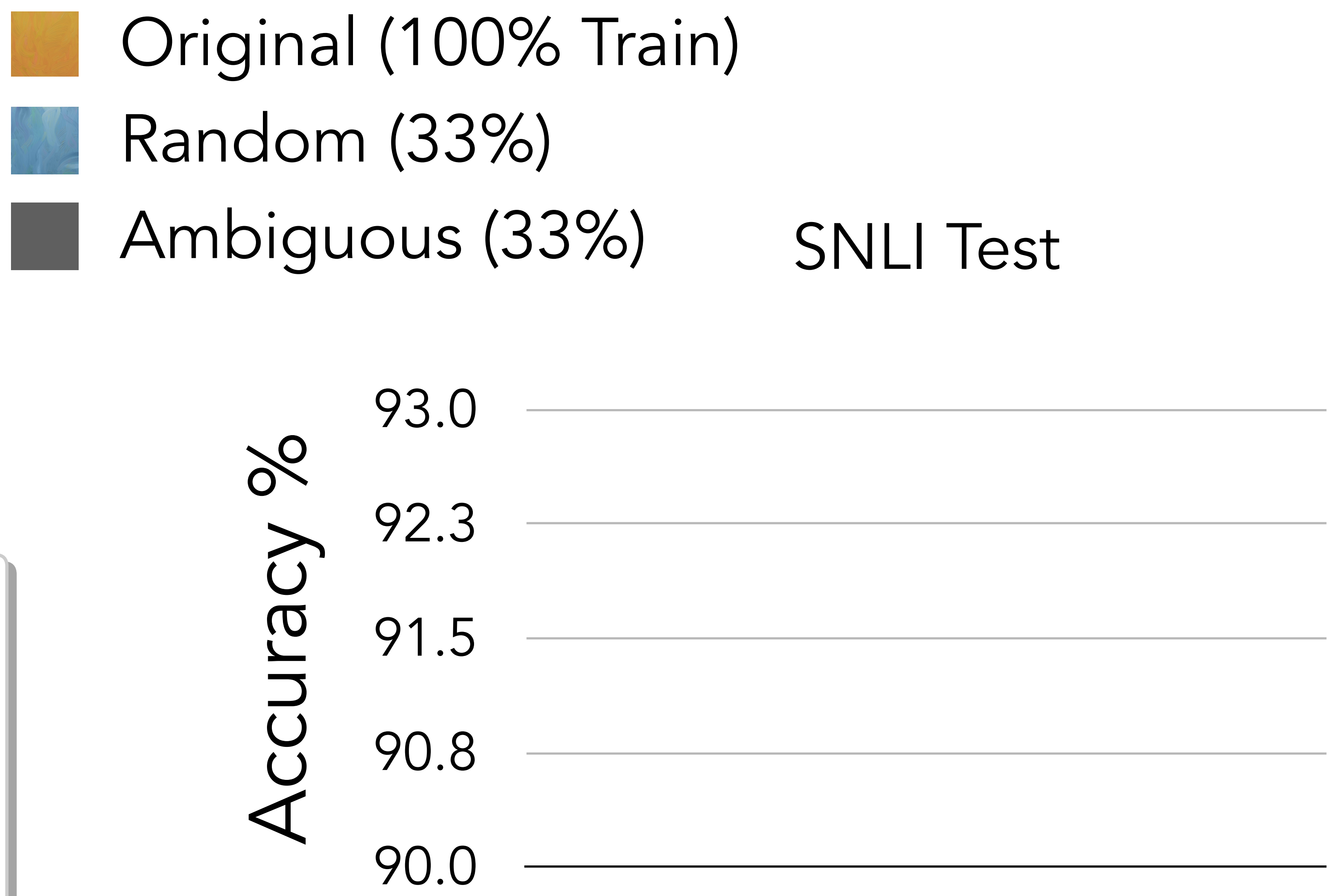
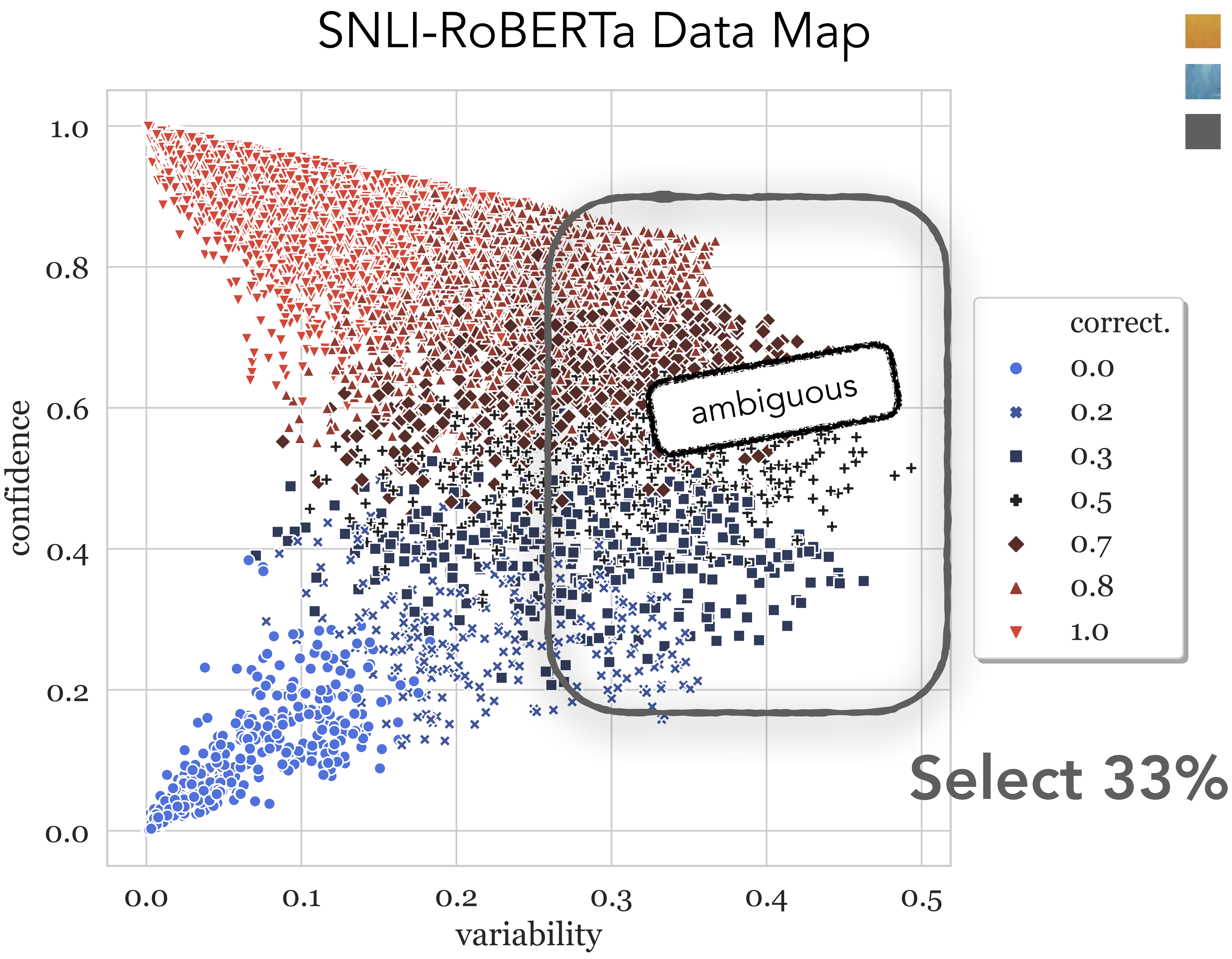


In-Distribution Performance

Diagnostics [Wang et al., 2019]

Out-of-Distribution Performance

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]



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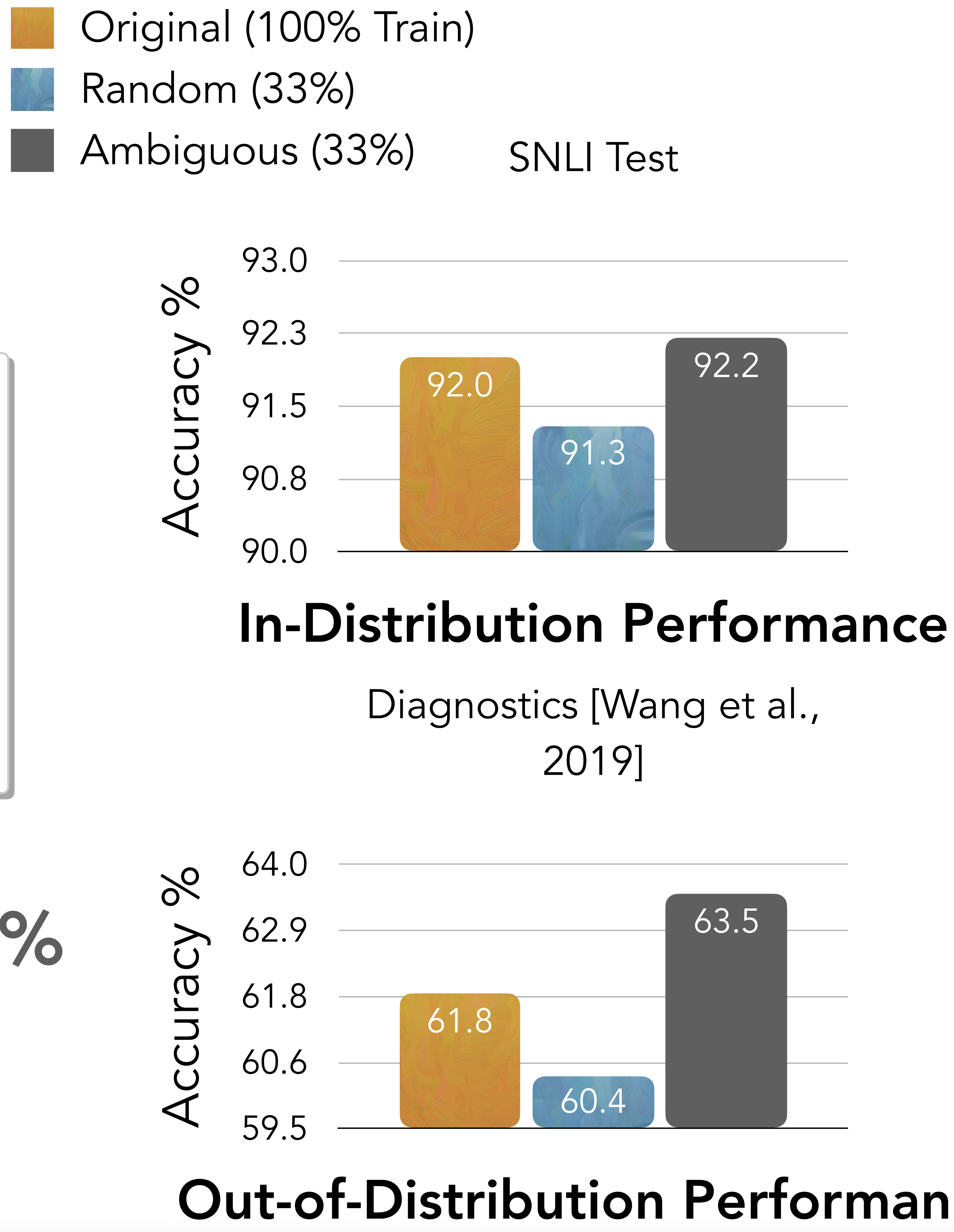

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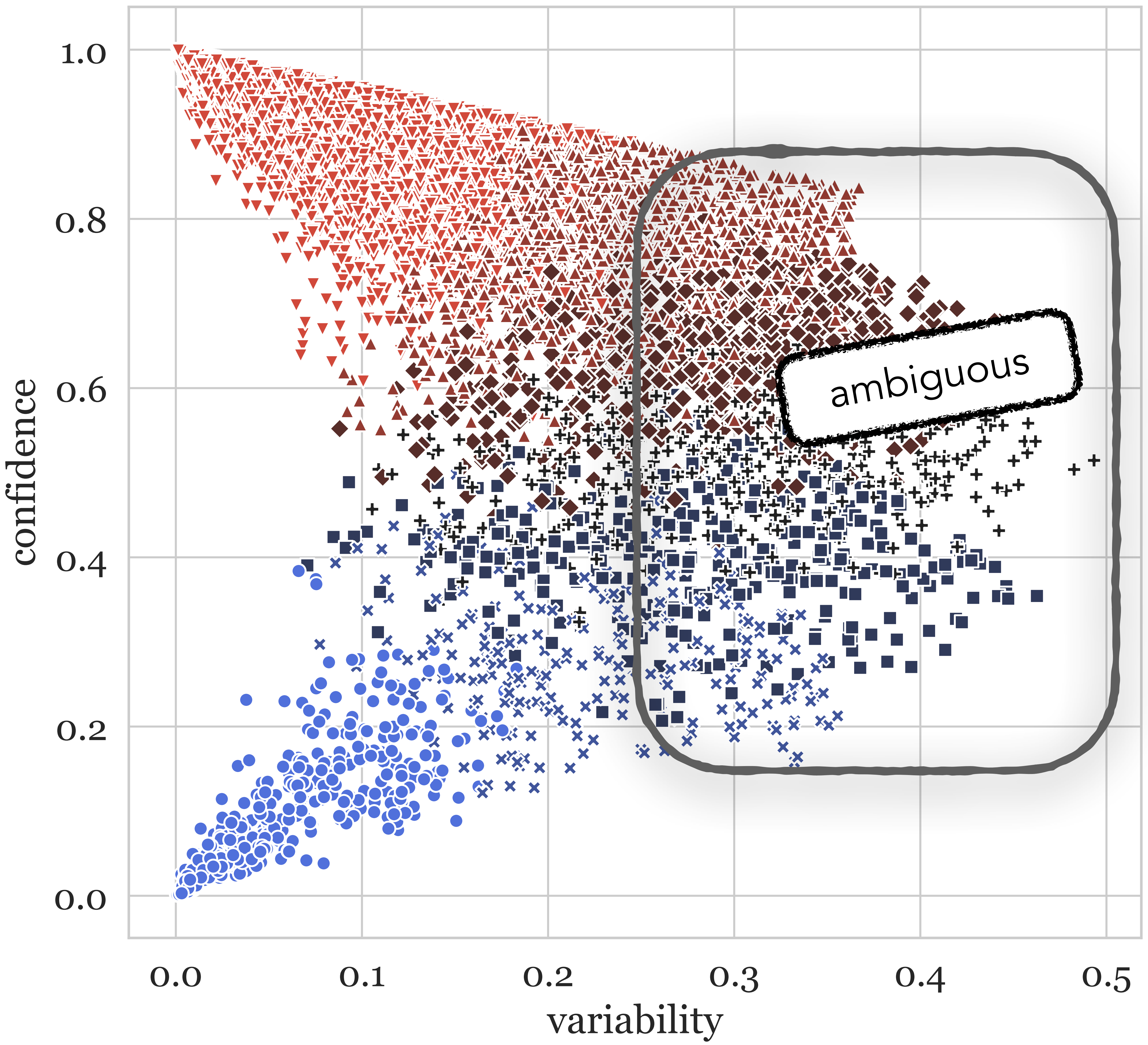

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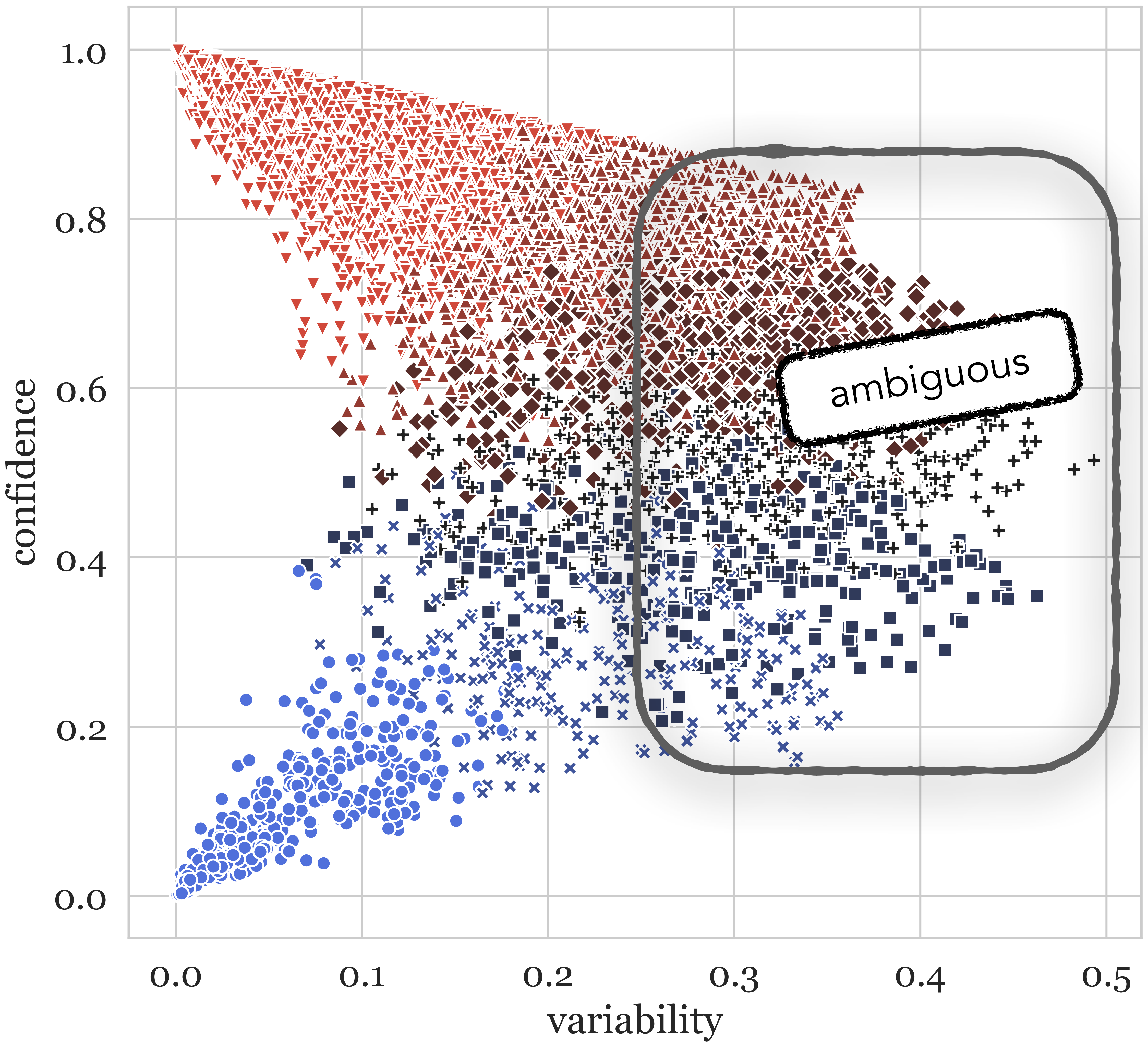
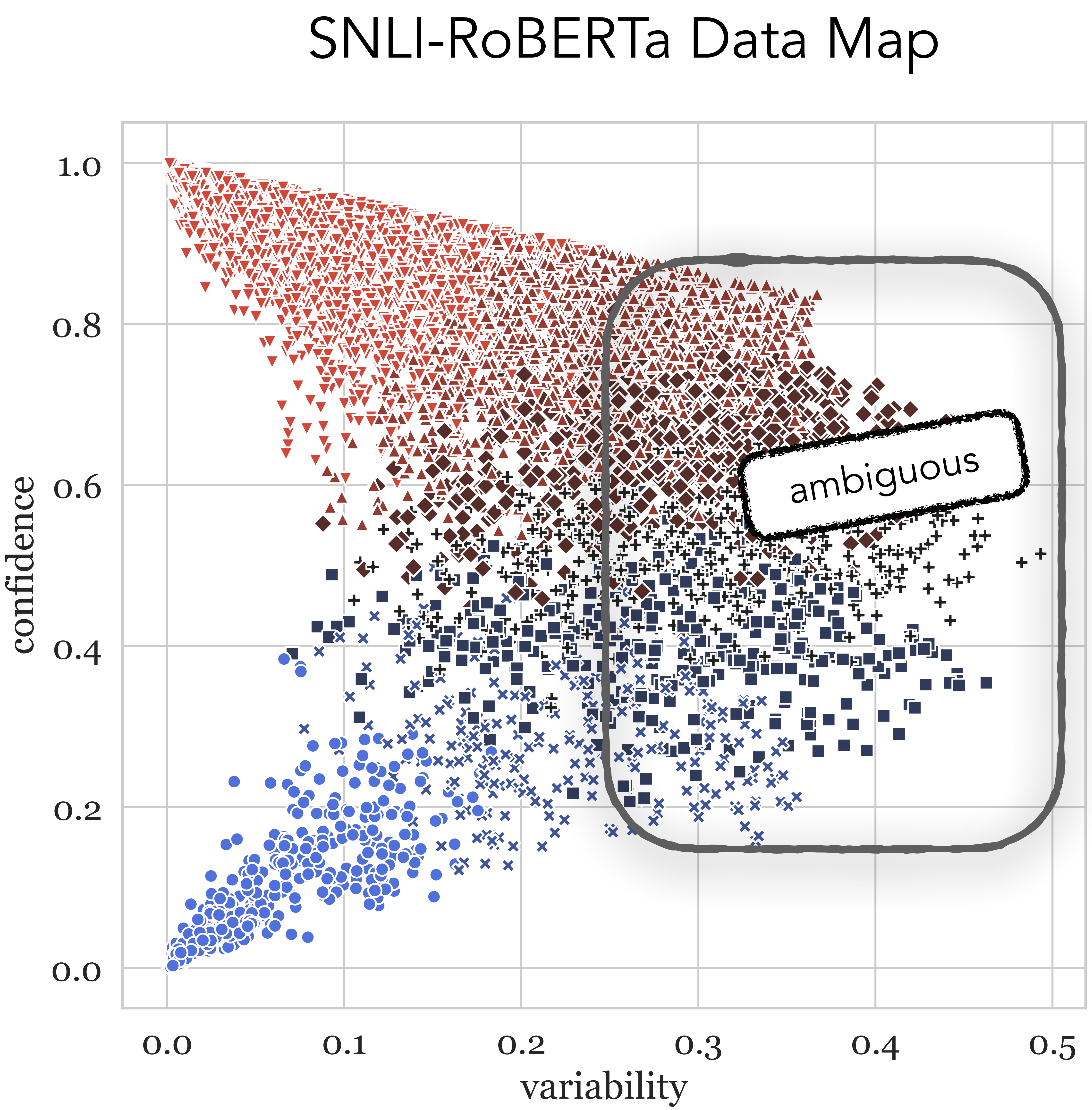


An expression gathered there that I can only describe as **half puzzled, and half relieved**.

The expression on their face was **puzzled and relieved**.

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]



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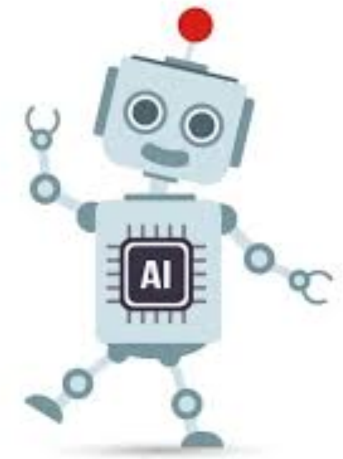
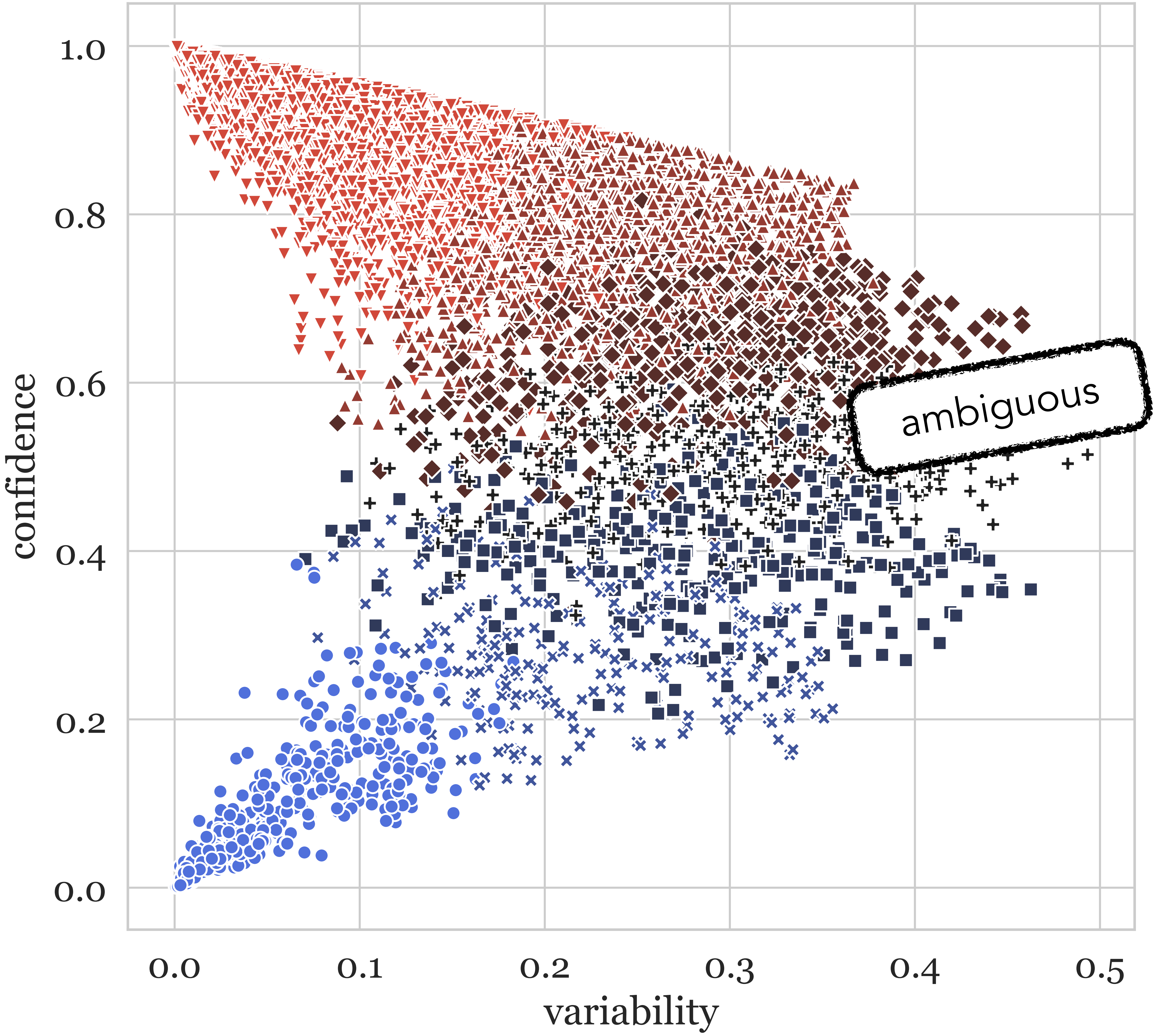
Neutral



Entailment

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]



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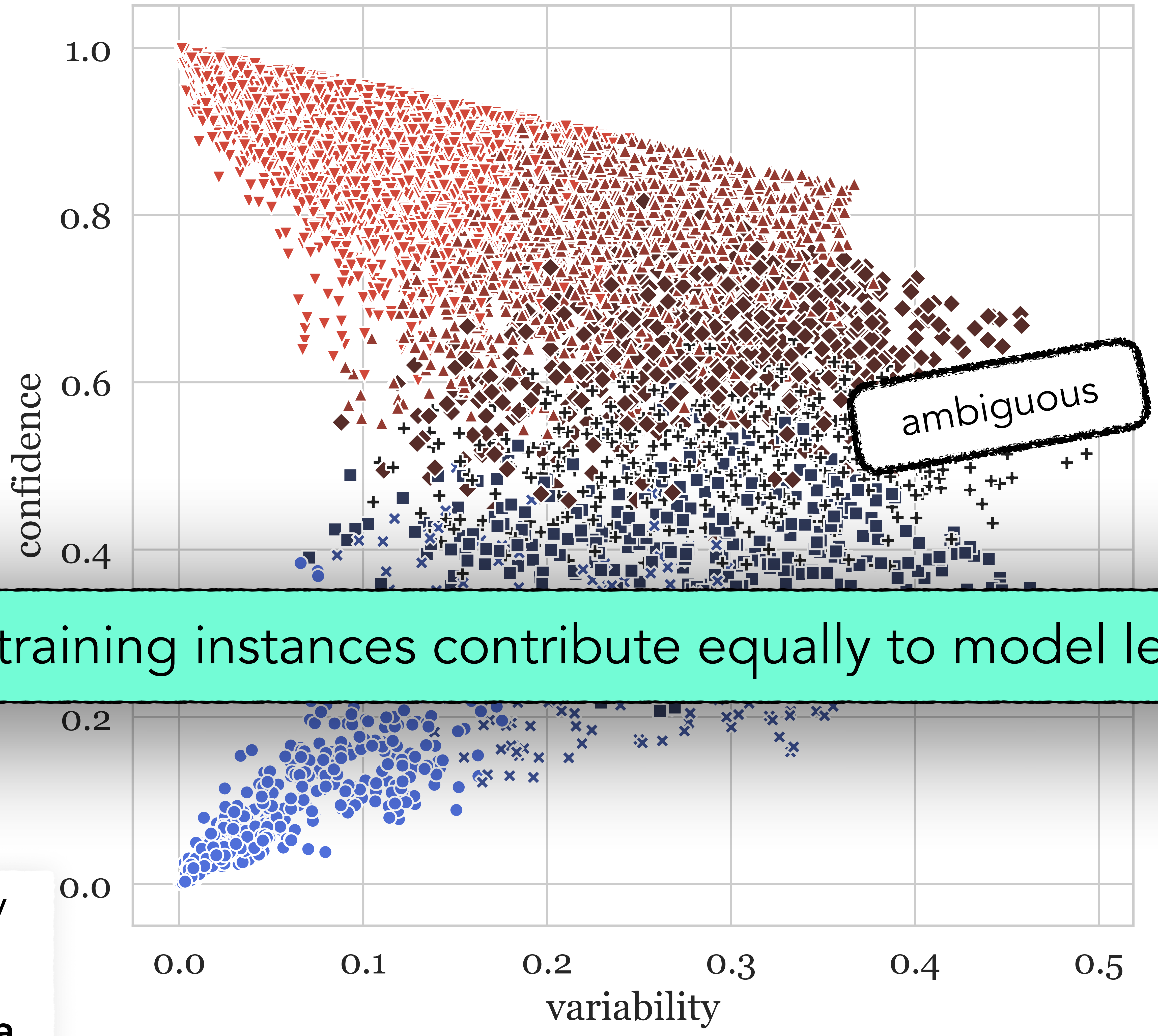
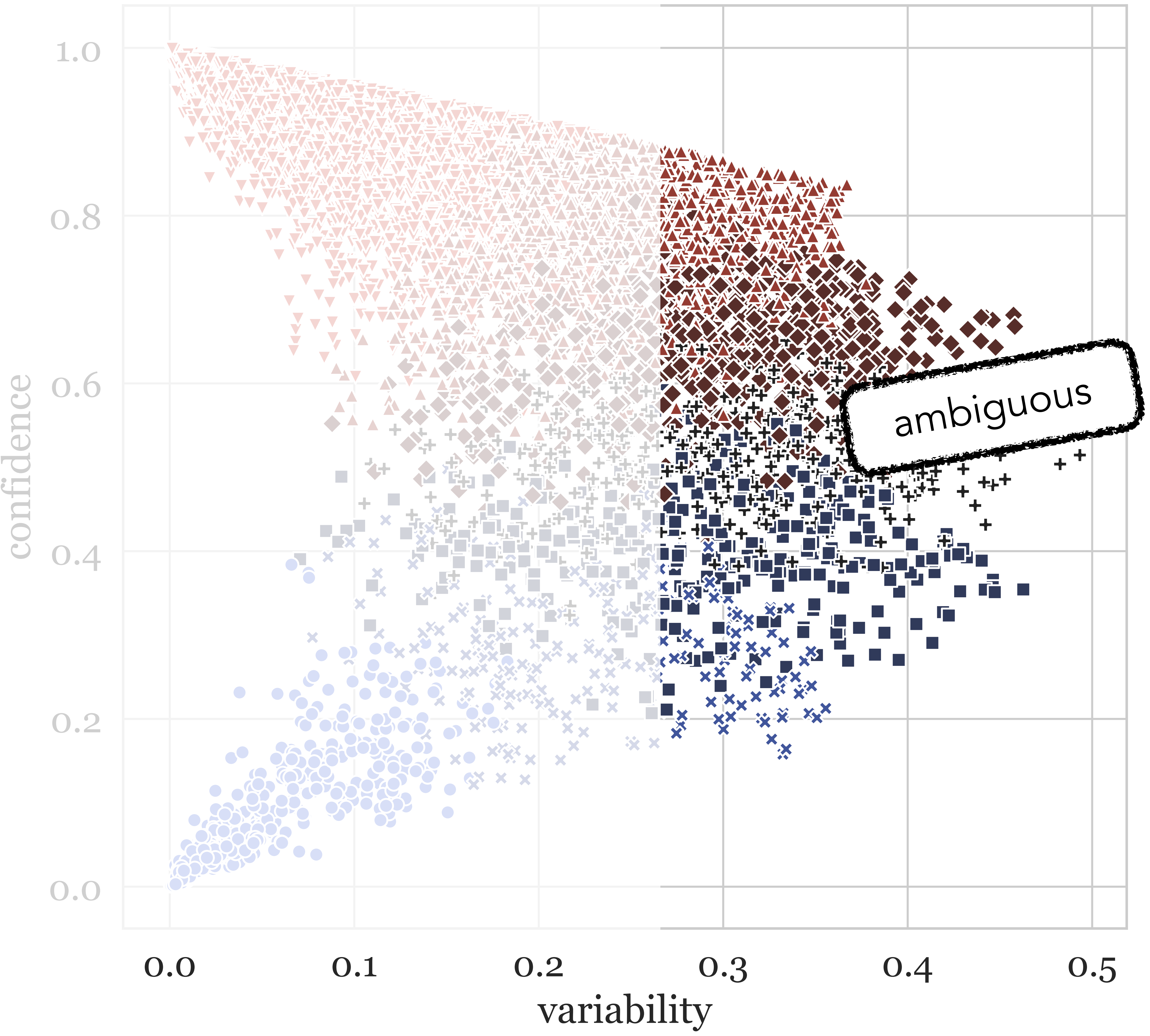


Not all training instances contribute equally to model learning

Also see

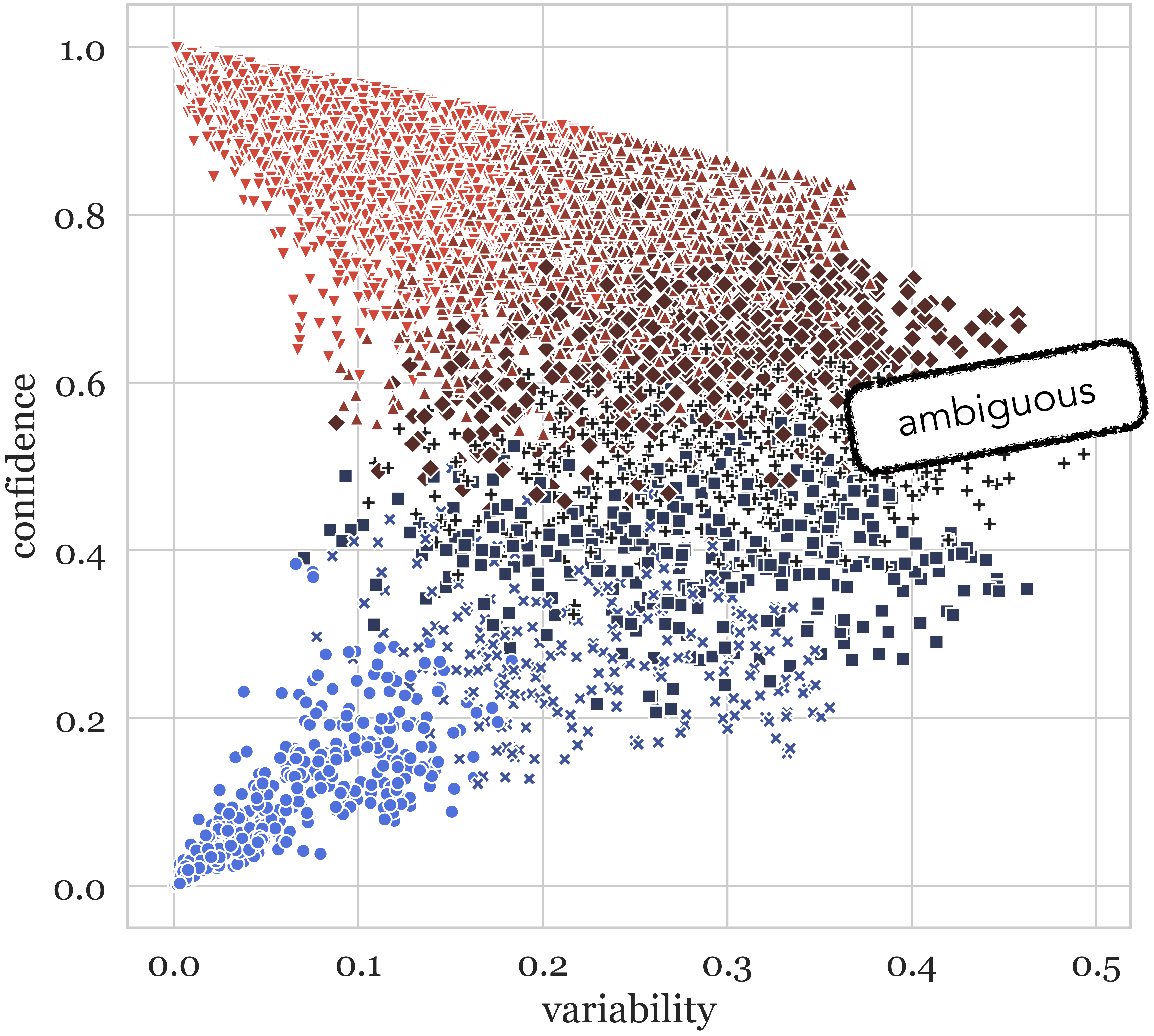
Understanding Dataset Difficulty with 𝒱-Usable Information [Ethayarajh, Choi & **Swayamdipta**, ICML 2022]

Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]



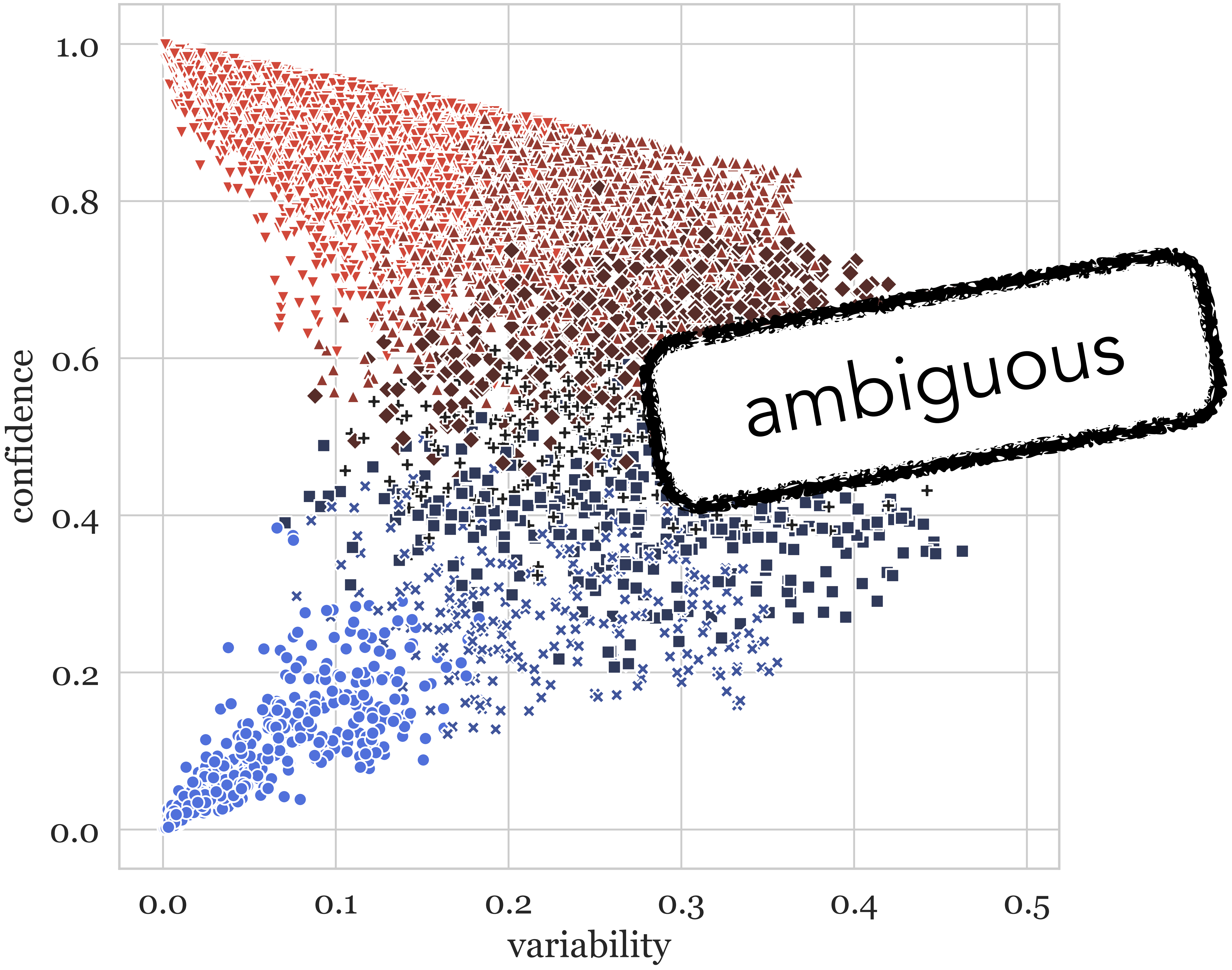
Dataset Cartography [**Swayamdipta** et al., EMNLP 2020]

Can we leverage data maps
to improve dataset collection?



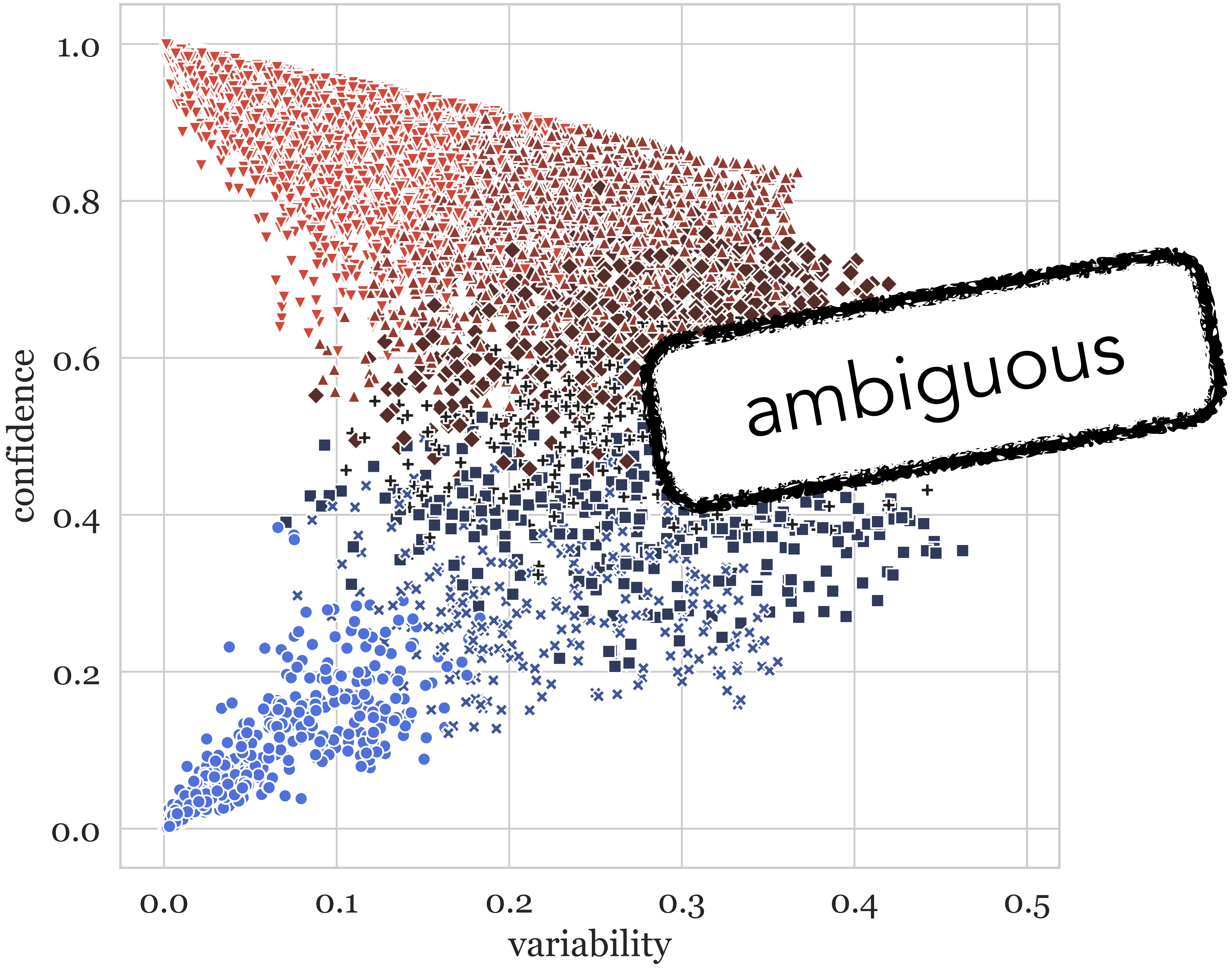
ambiguous

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

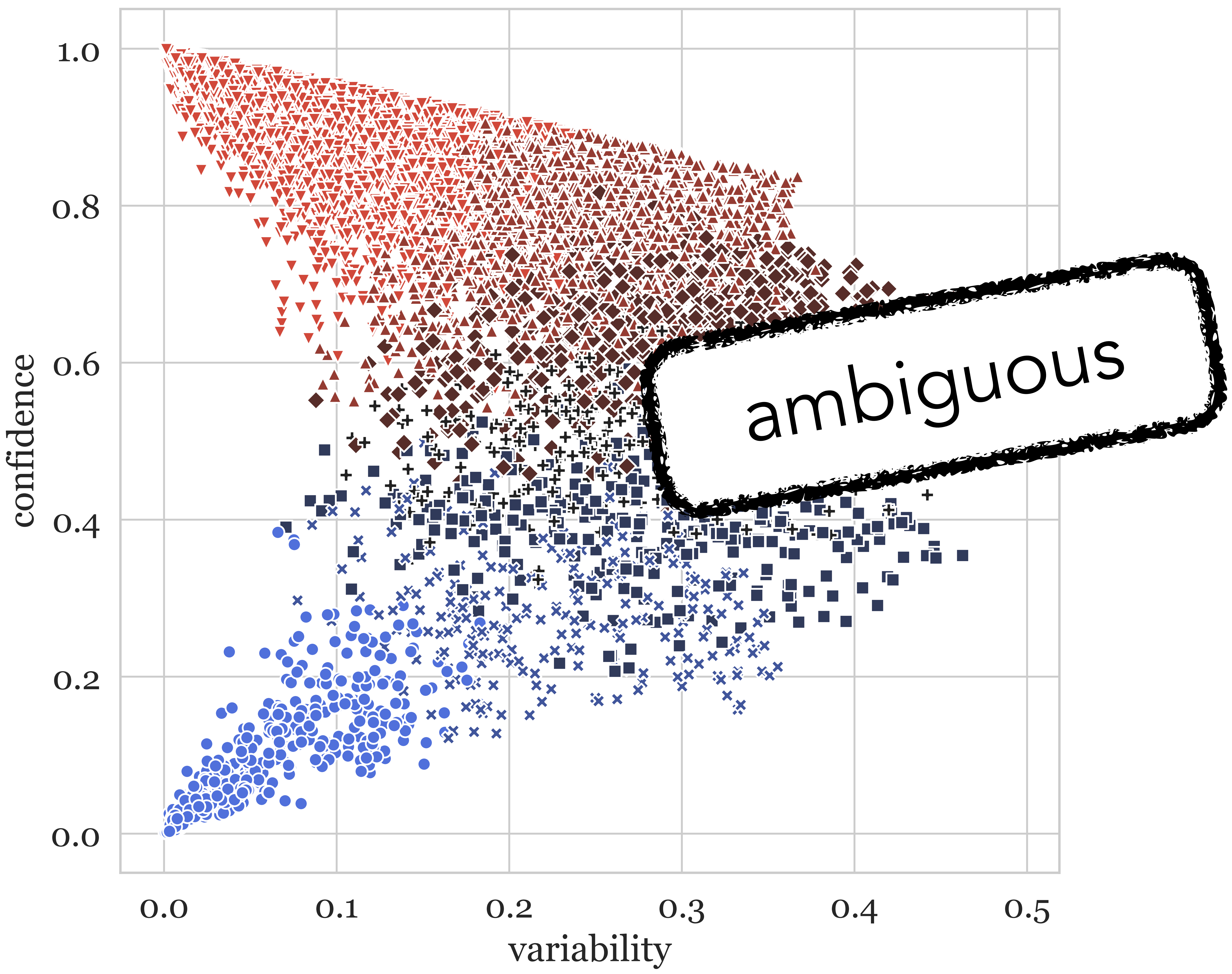


ambiguous

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

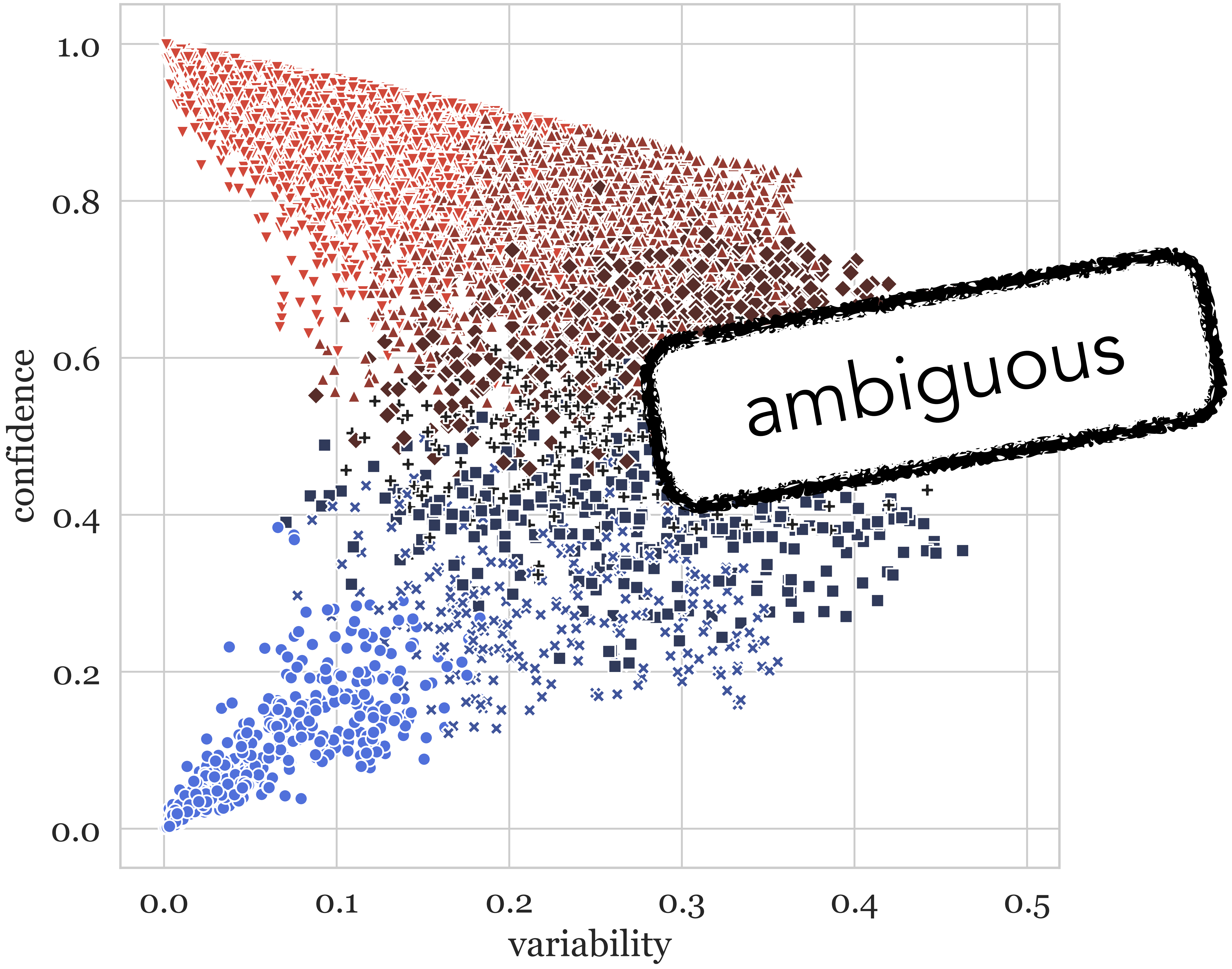


WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



Might introduce heuristics leading to annotation artifacts

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



GPT-3

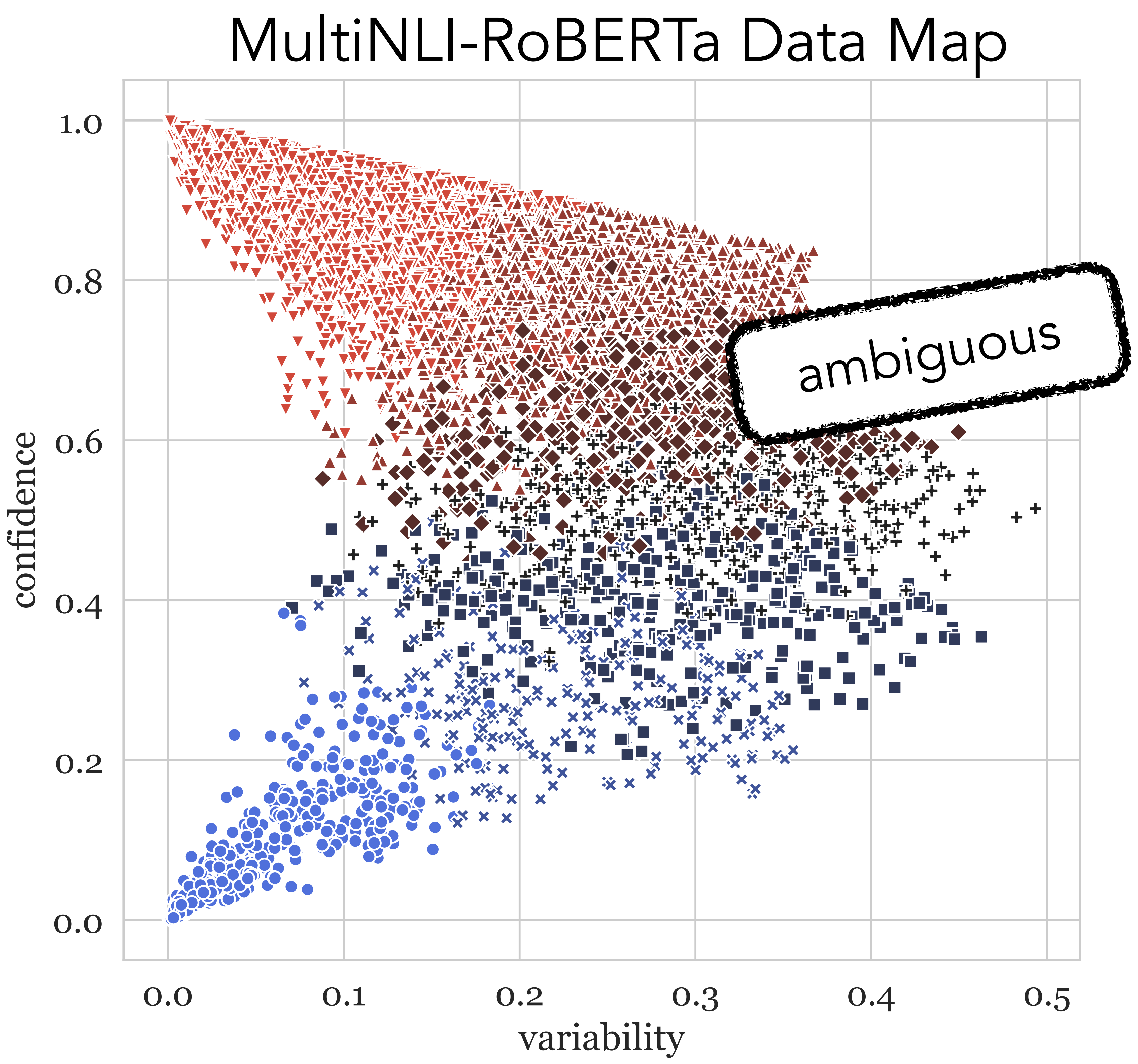
Can be easily modified for diverse generations

[Schick & Schütze, 2021; Meng et al. 2022; West et al., 2021; Lee et al., 2021; Bartolo et al., 2021]

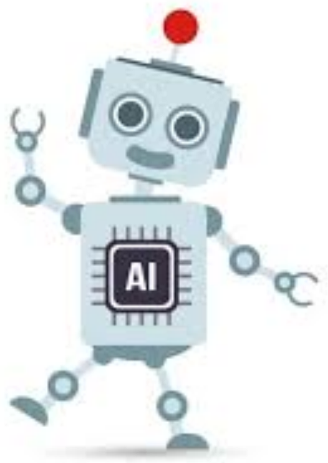
G-DAUG: Generative Data Augmentation for Commonsense Reasoning [Y. M., F., **Swayamdipta**, L., W., B., C., D EMNLP-findings, 2020]

Also see

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



GPT-3



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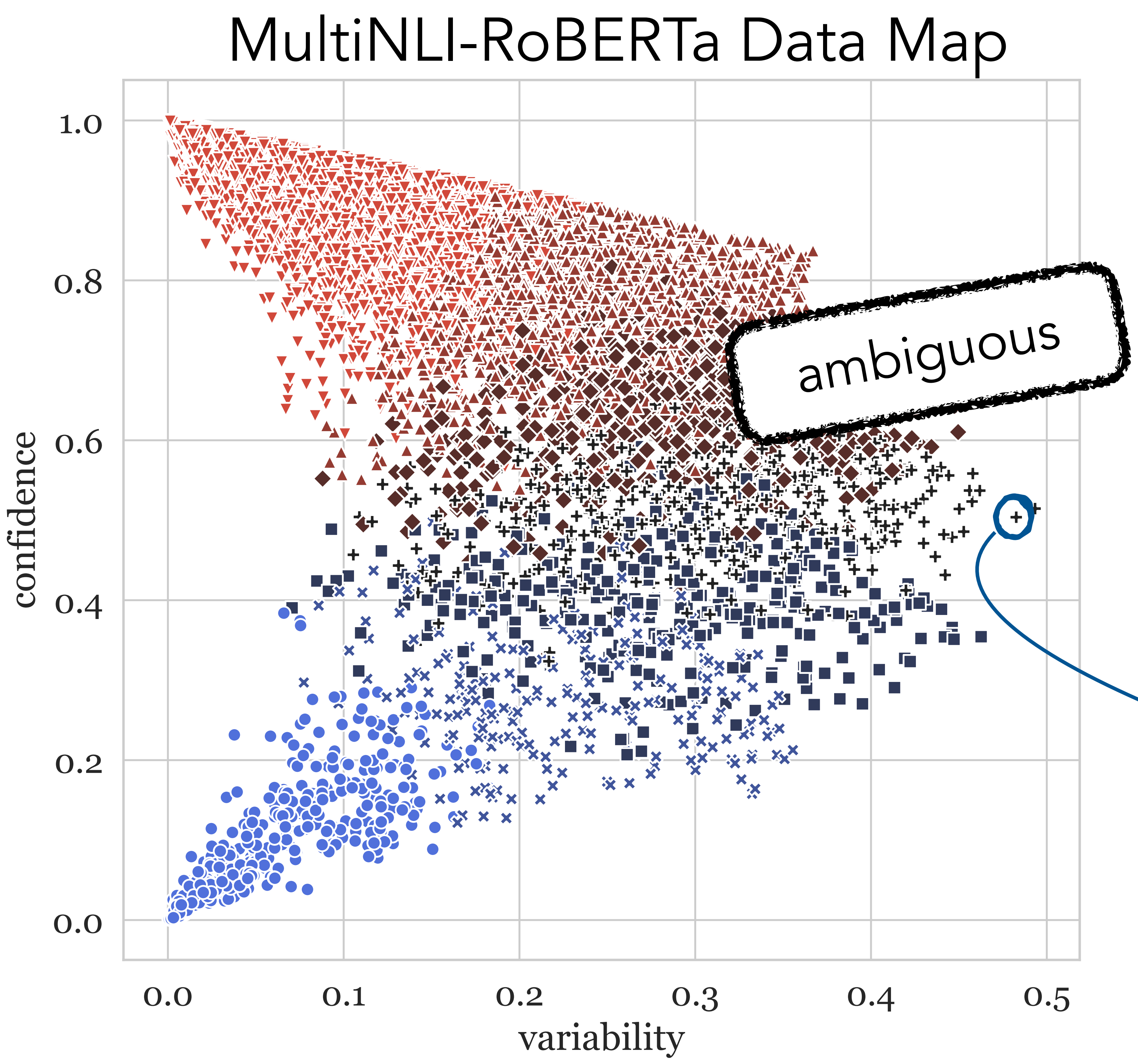

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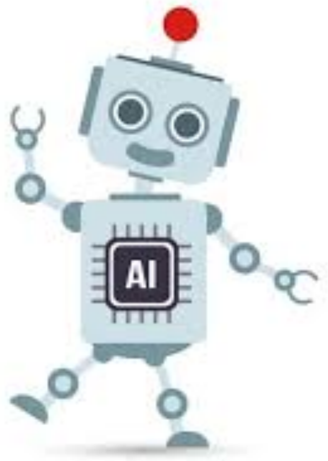
Implication: Each part has a ***95 percent*** chance of having a defect.

} seed ambiguous example from MultiNLI - RoBERTa

GPT-3



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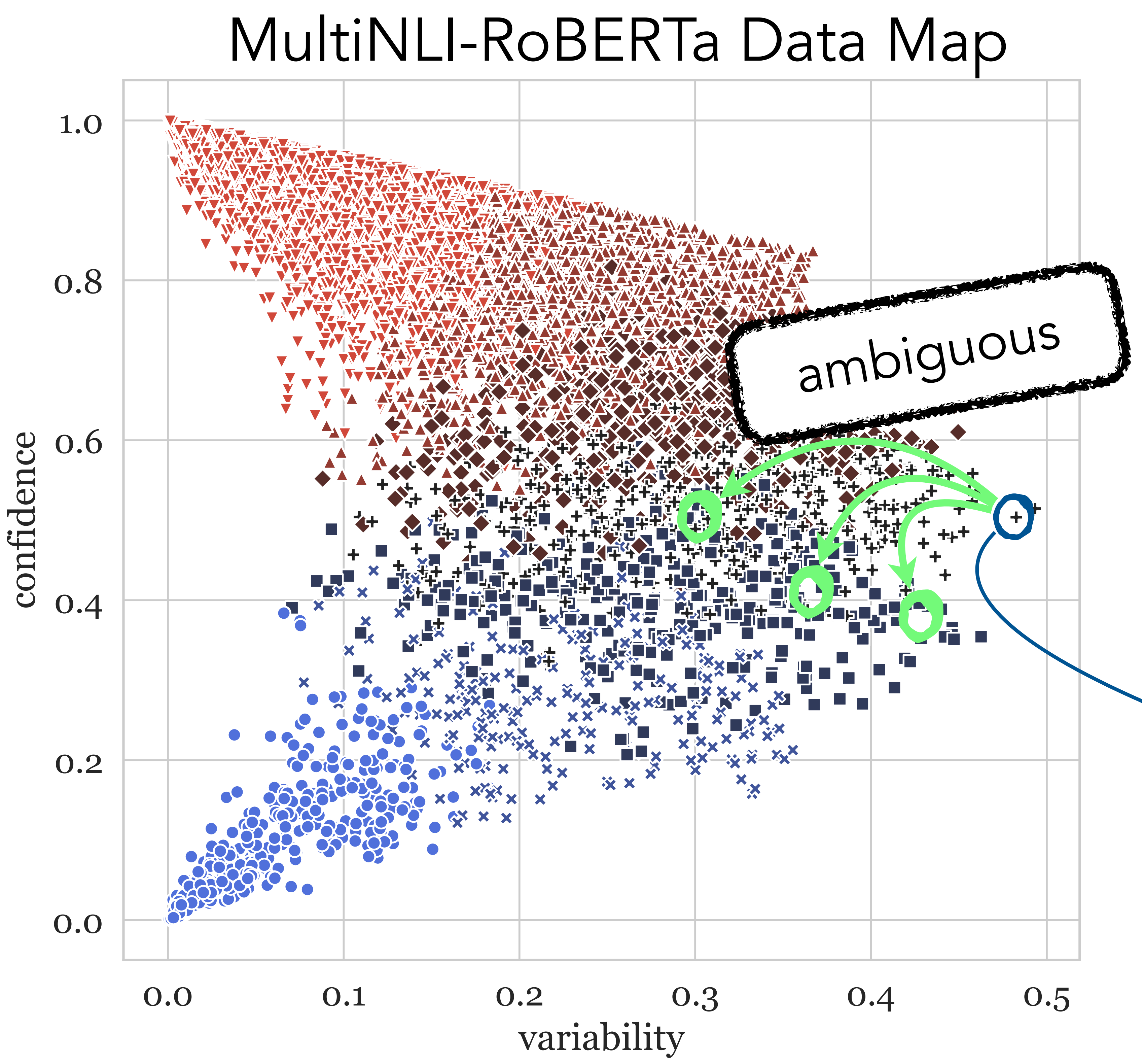

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nearest neighbors to seed example

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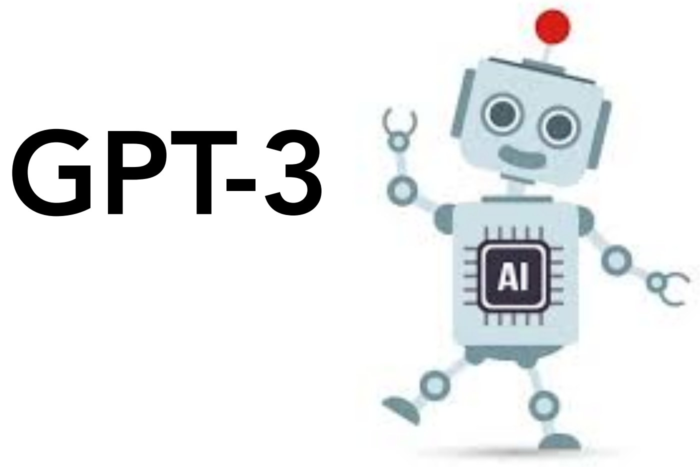

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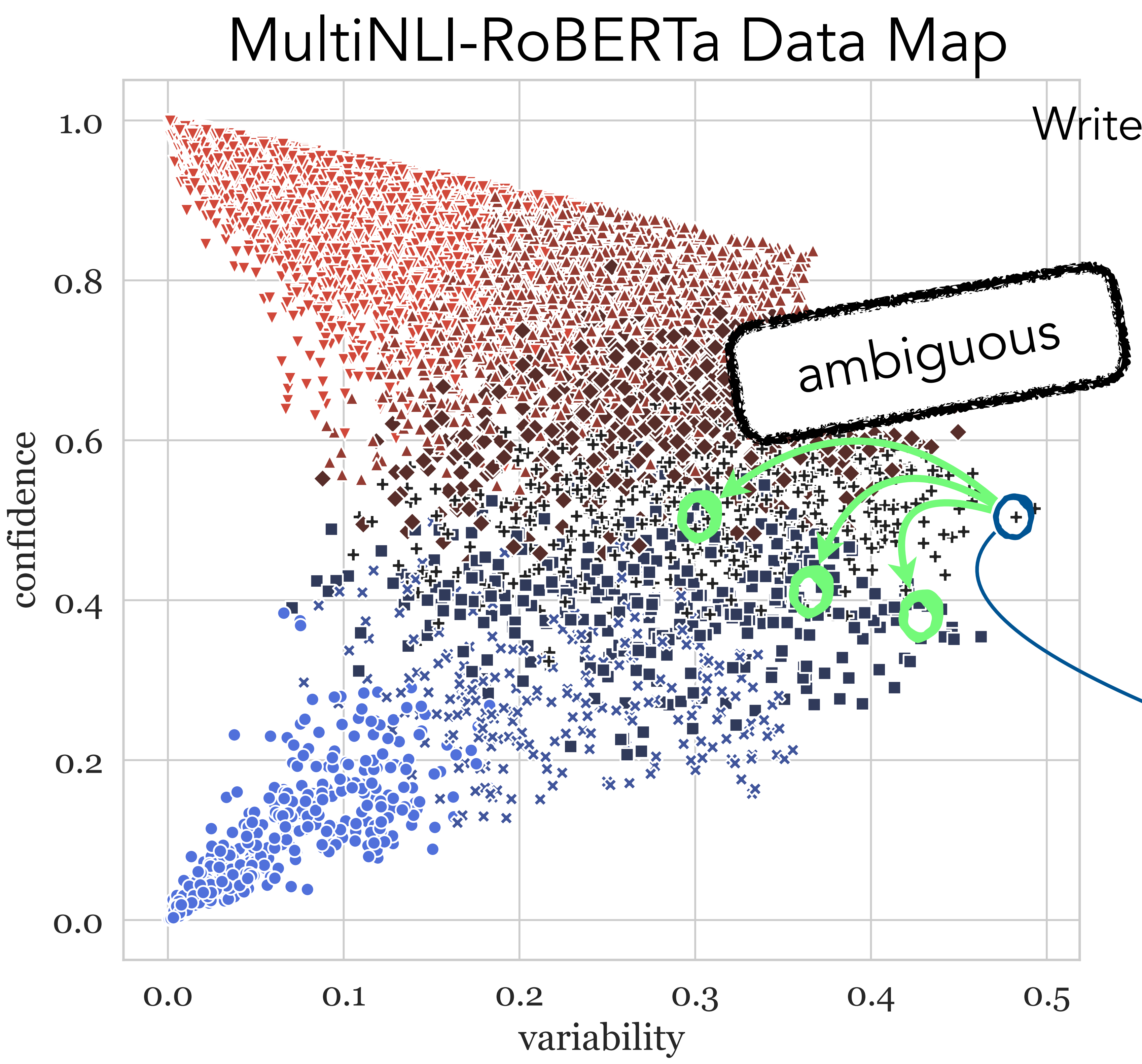

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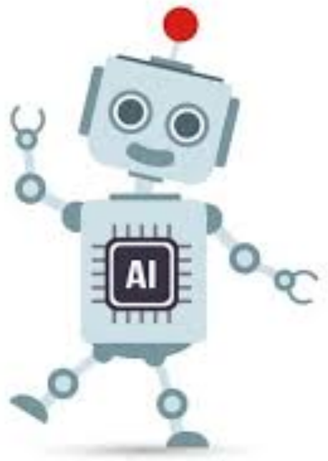

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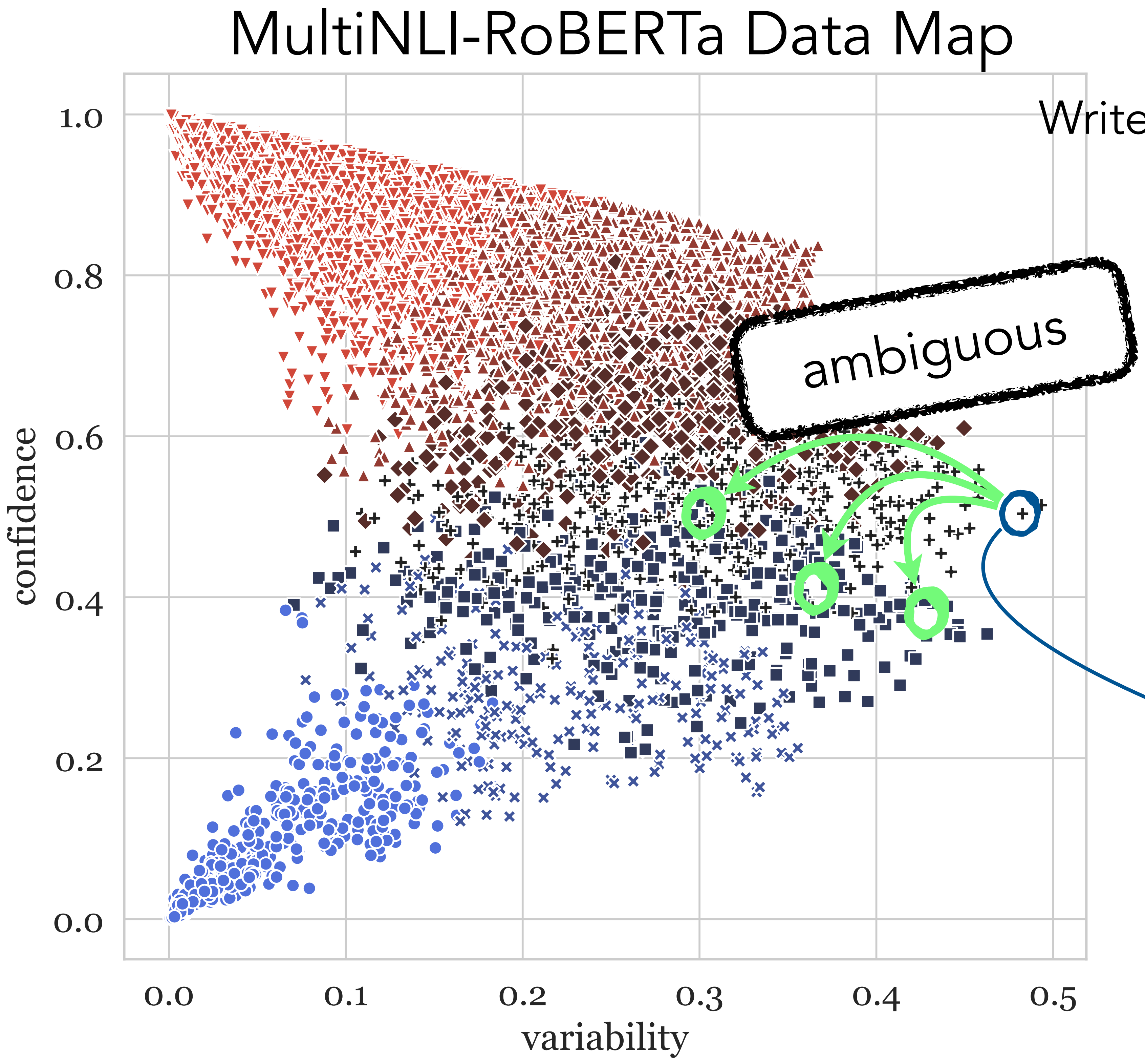

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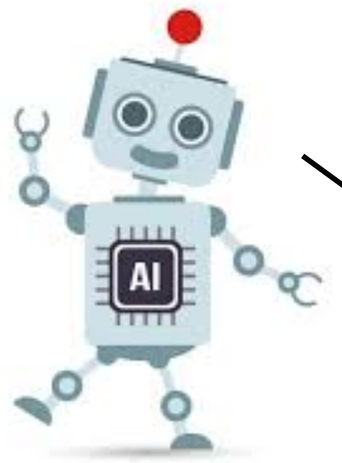

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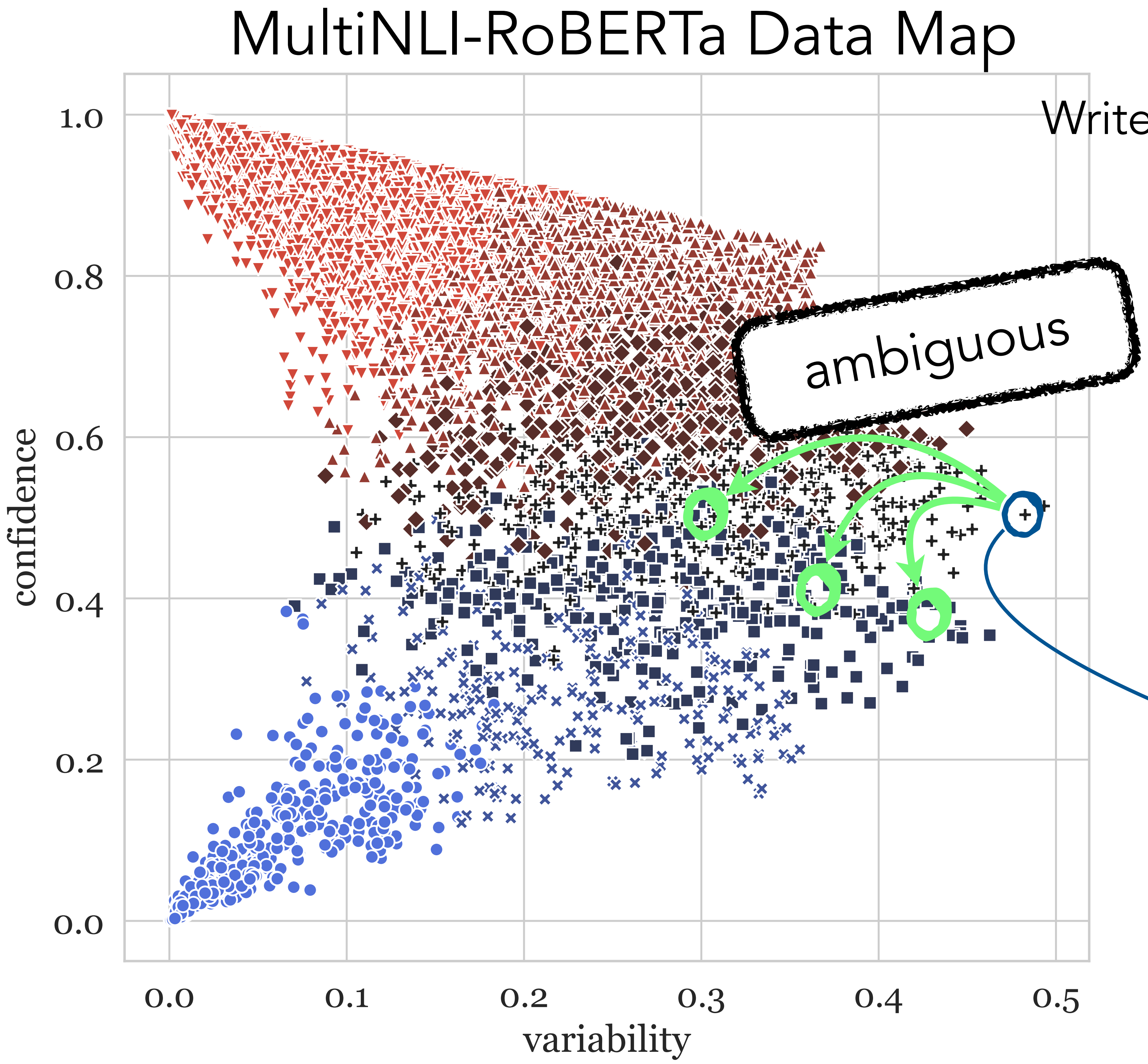

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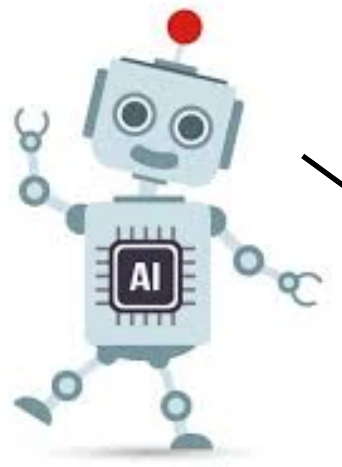

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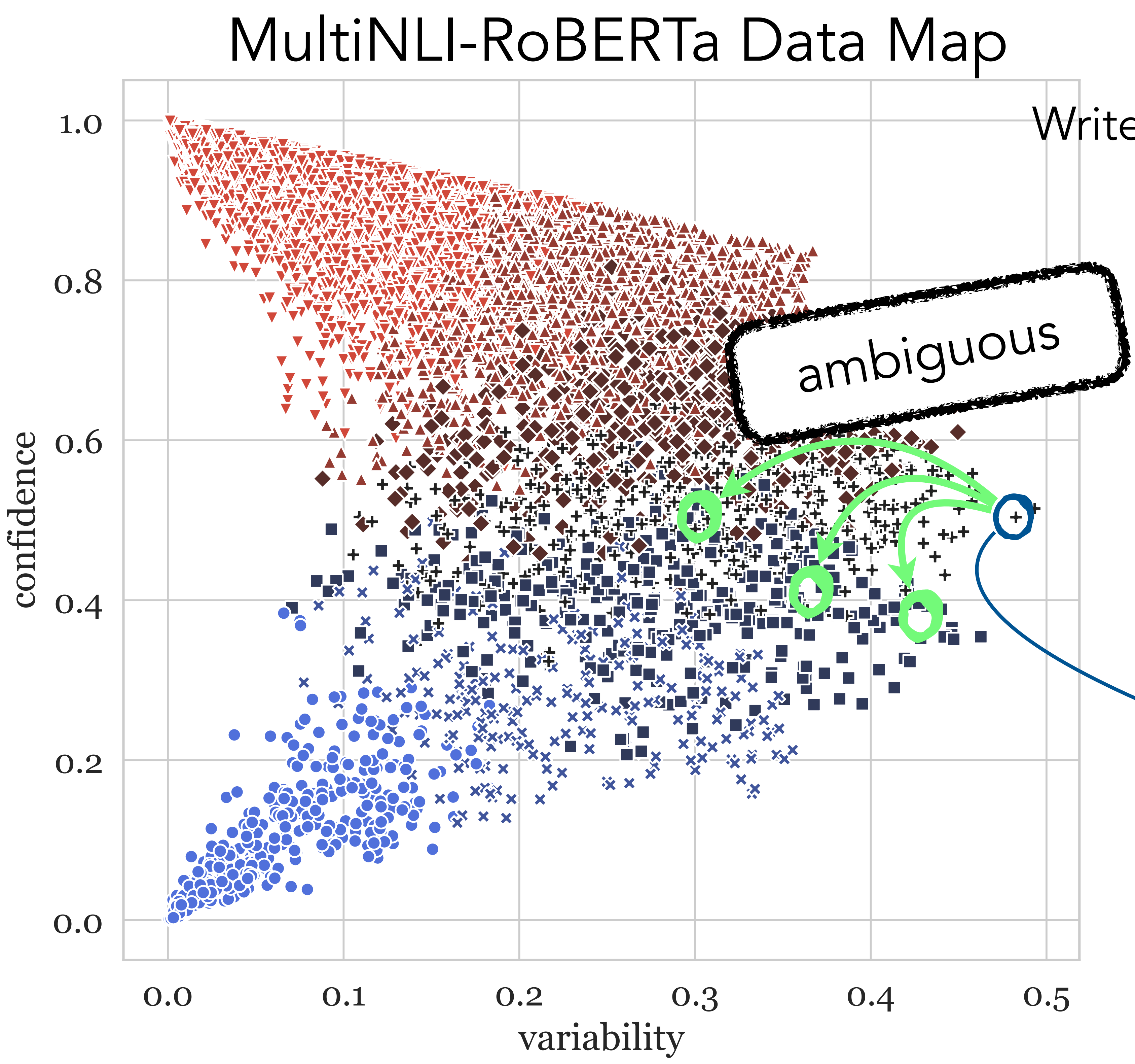

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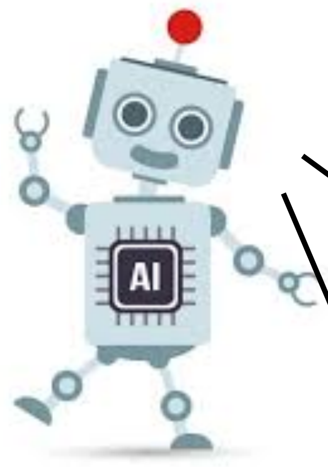

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About **1,000** people are diagnosed with chronic myeloid leukemia each year.
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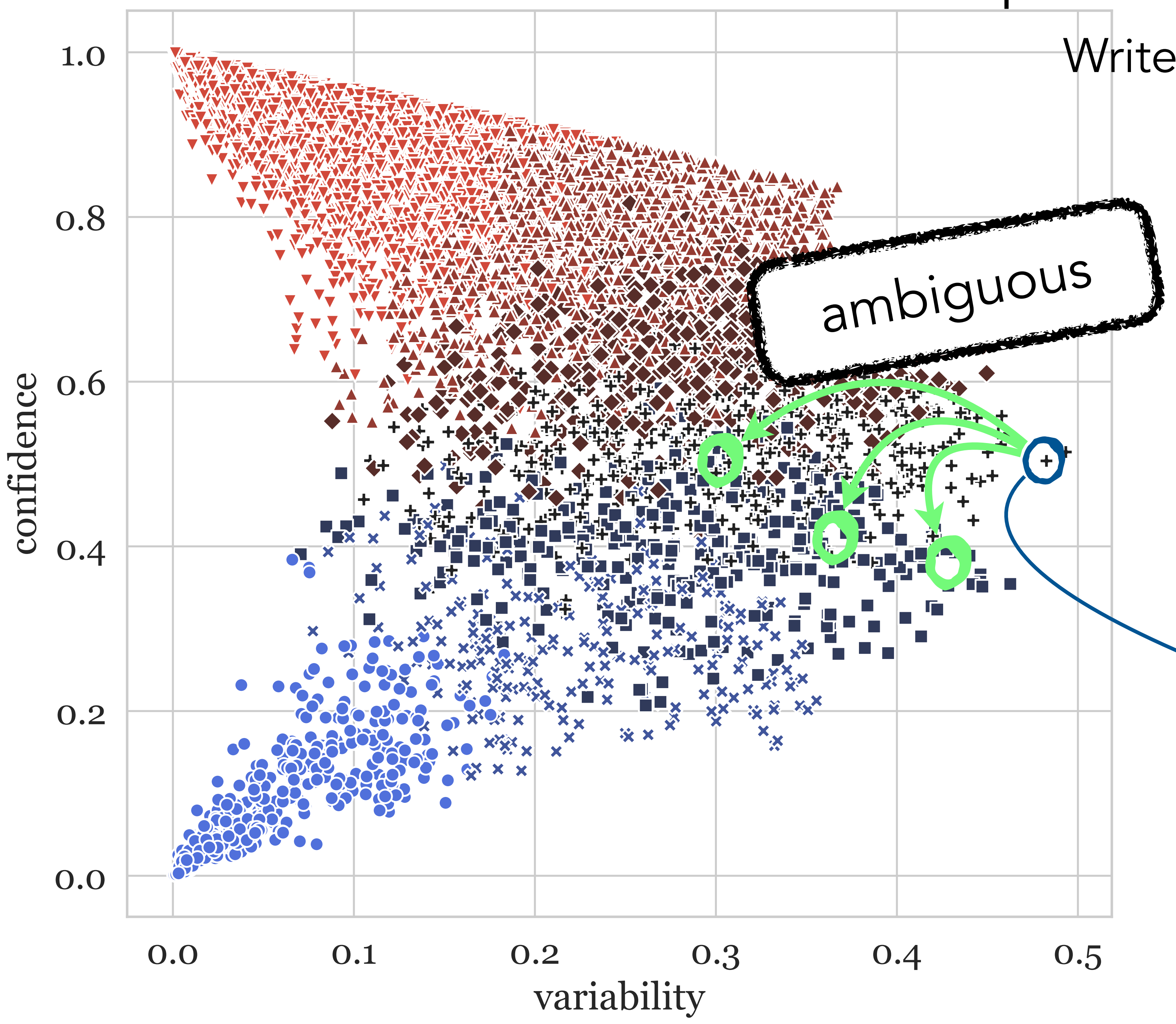
Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

MultiNLI-RoBERTa Data Map



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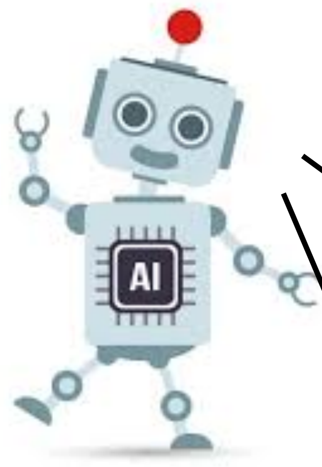

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Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

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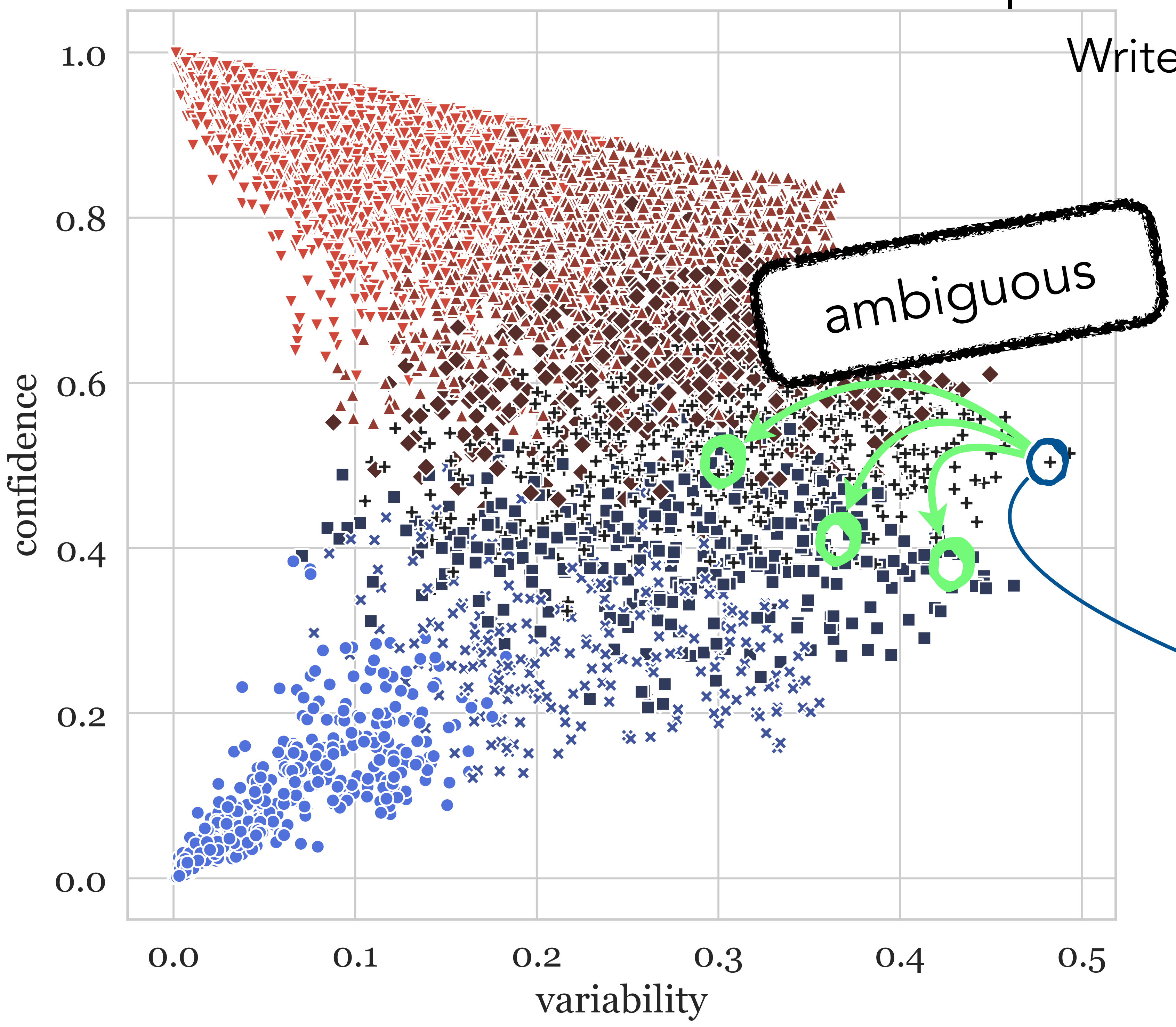

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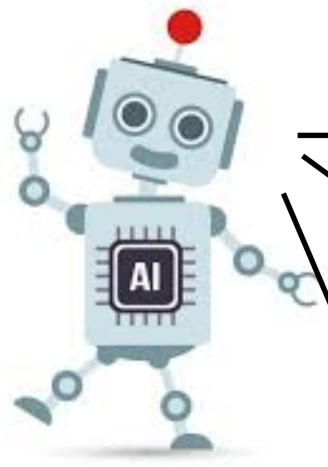

He has never smoked, and he doesn't drink.
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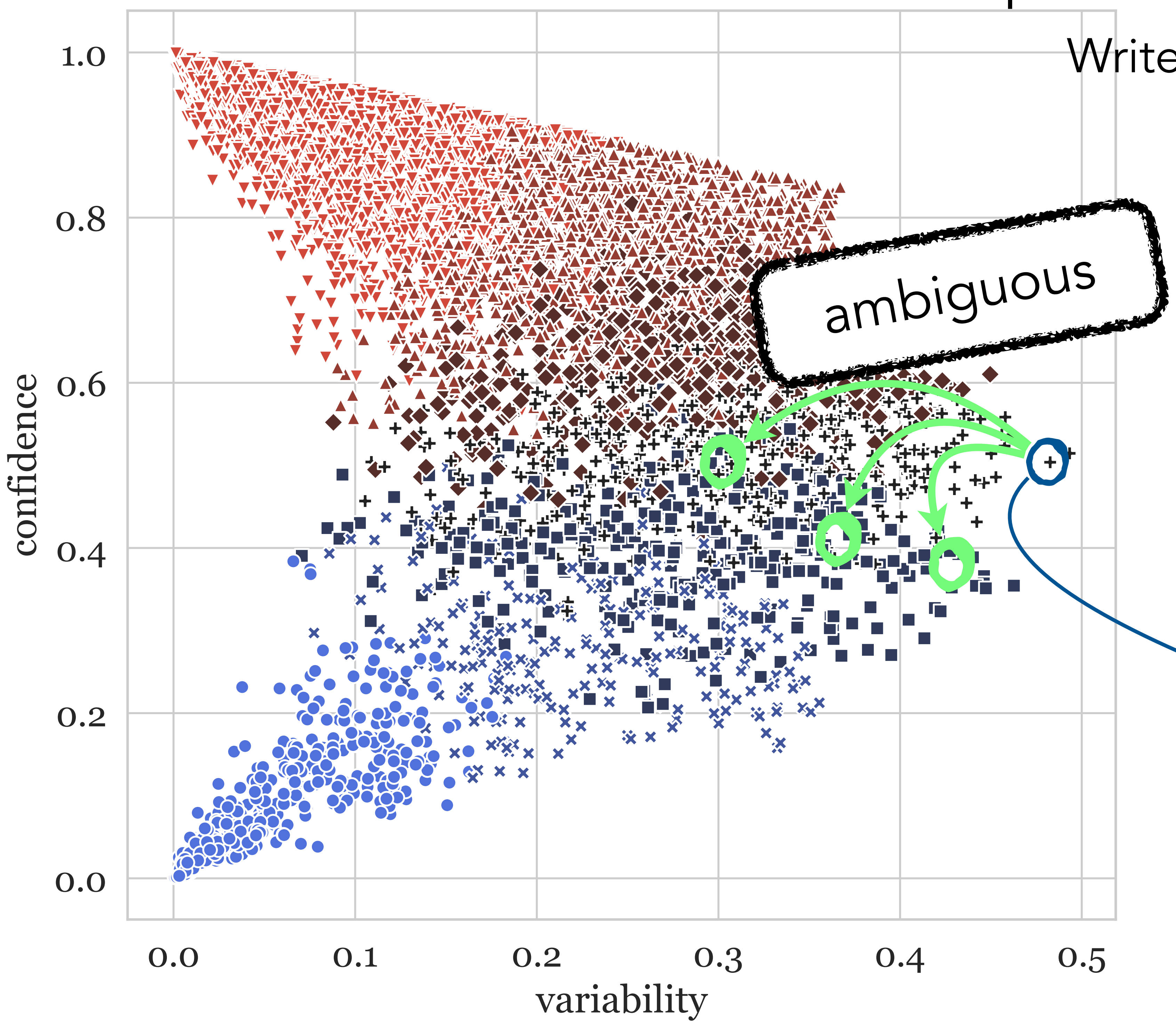

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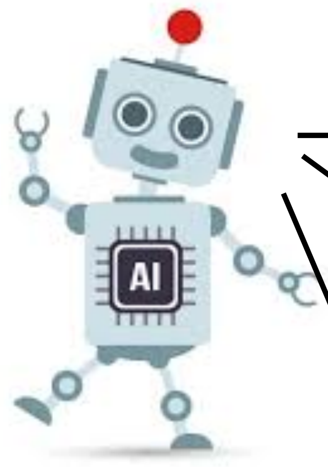

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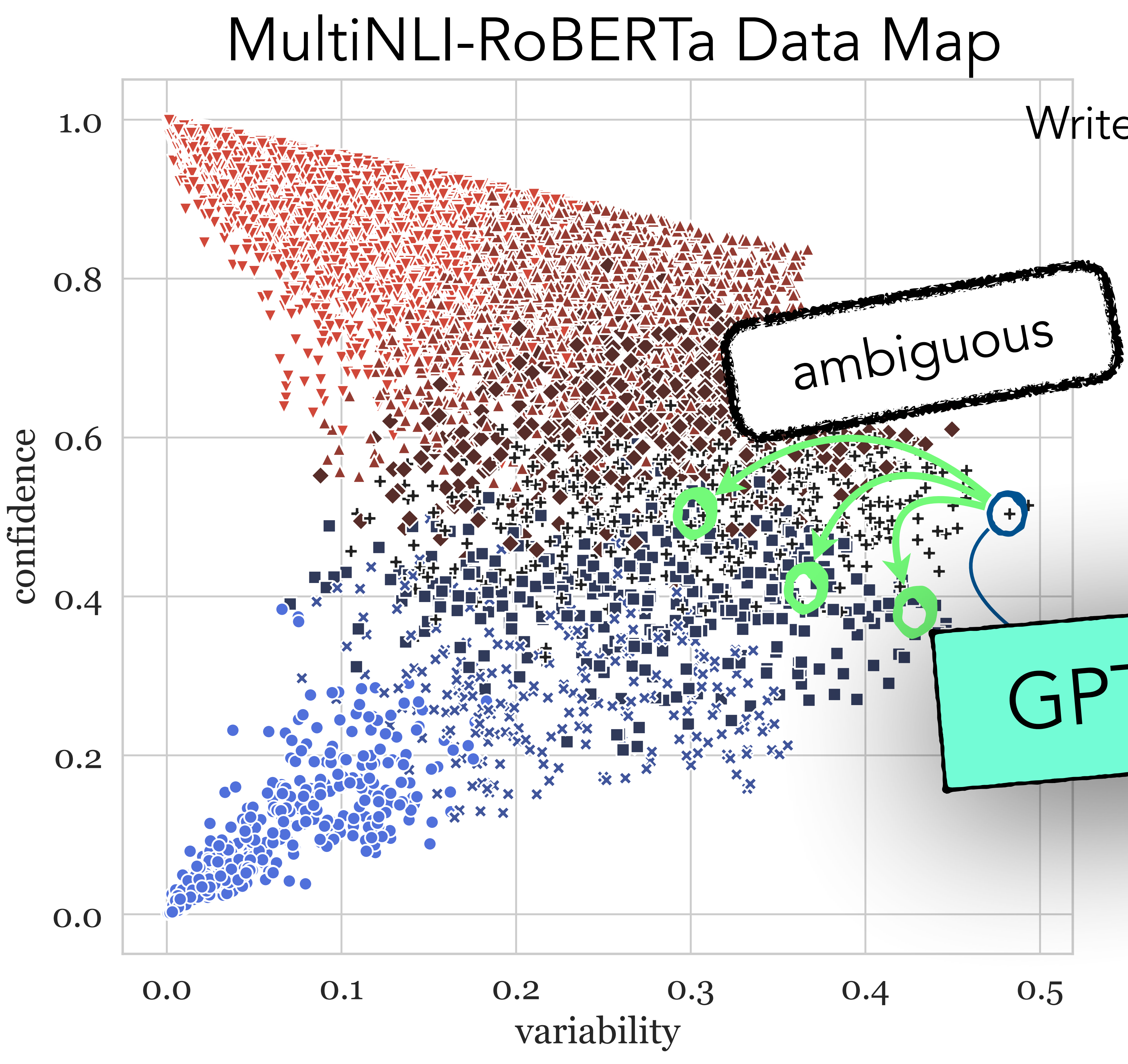

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GPT-3 generations are not always reliable

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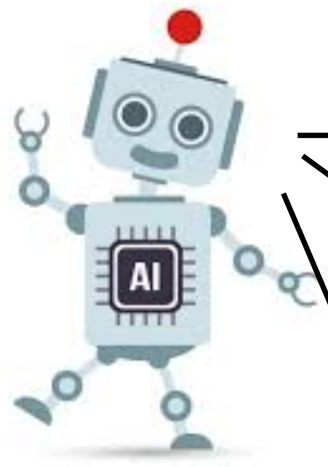

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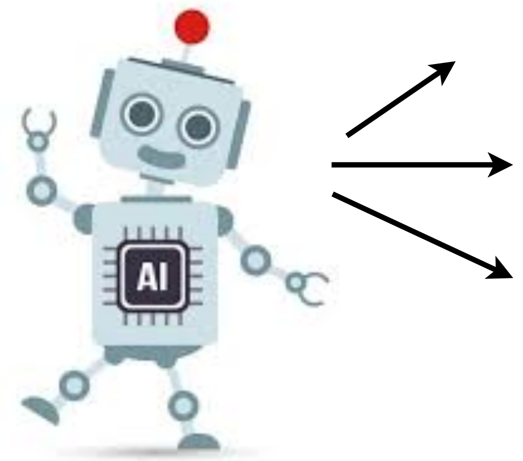
instruction

nearest neighbors to seed example

seed ambiguous example from MultiNLI - RoBERTa



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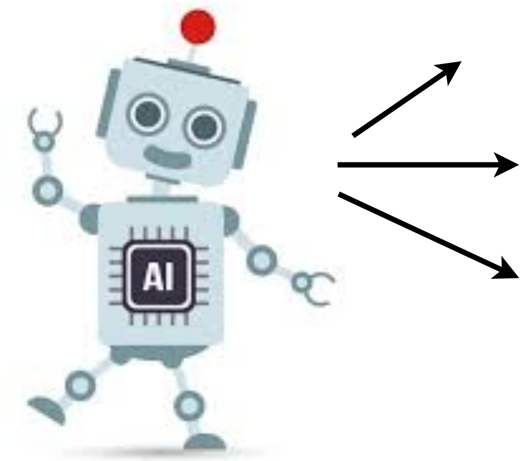

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Also see

Reframing Human-AI for Generating Free-Text Explanations
[Wiegreffe, Hessel, **Swayamdipta**, Riedel & Choi, NAACL 2022]

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nearest neighbors to seed example

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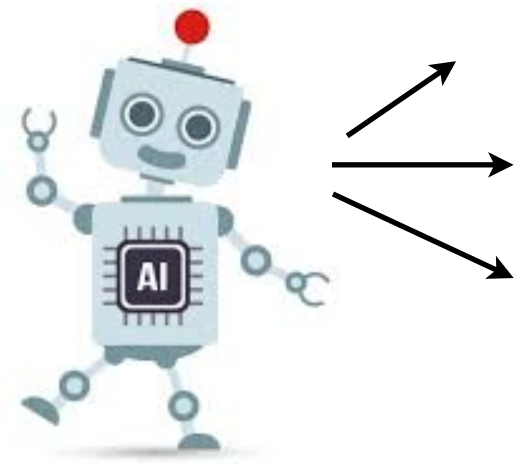

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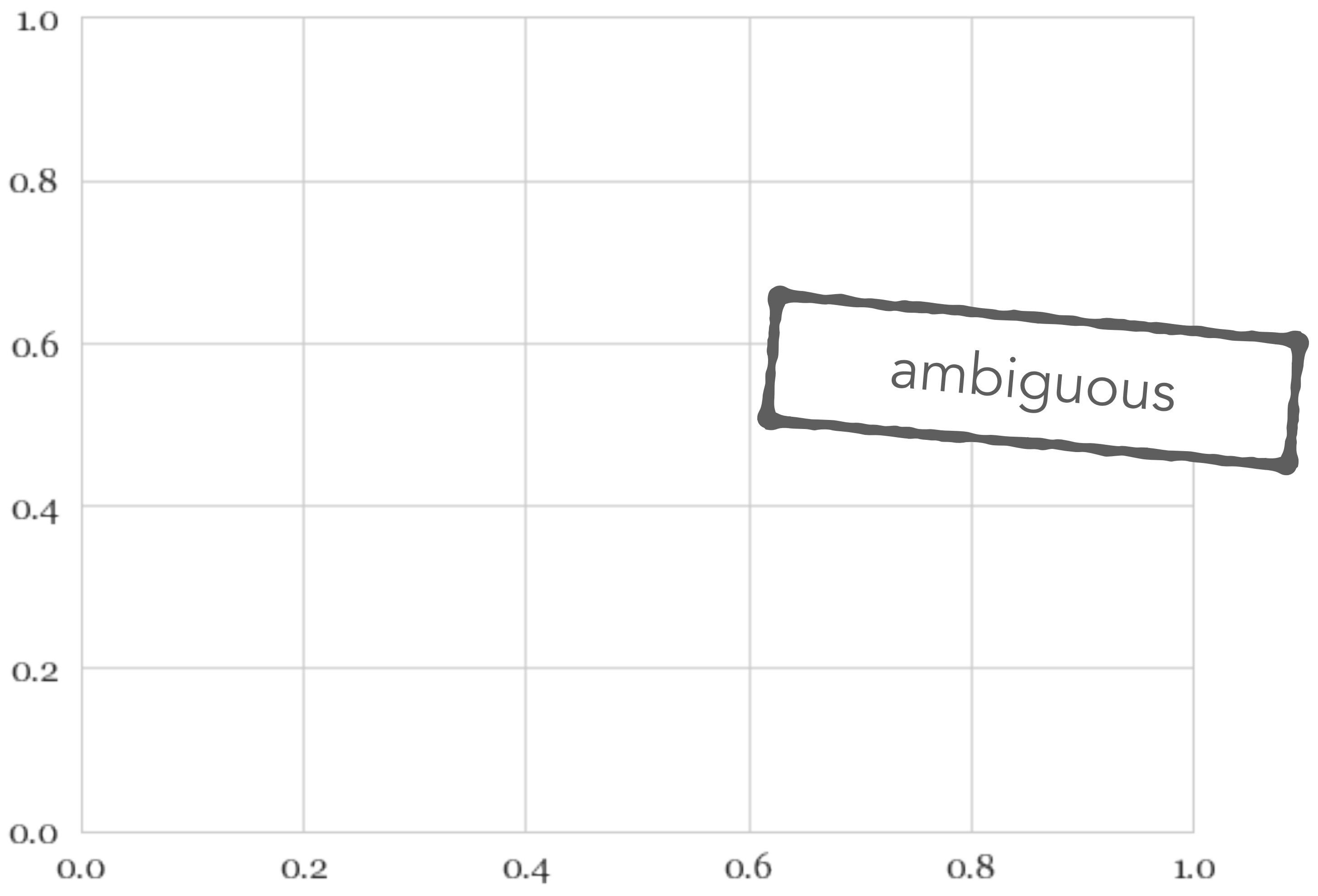

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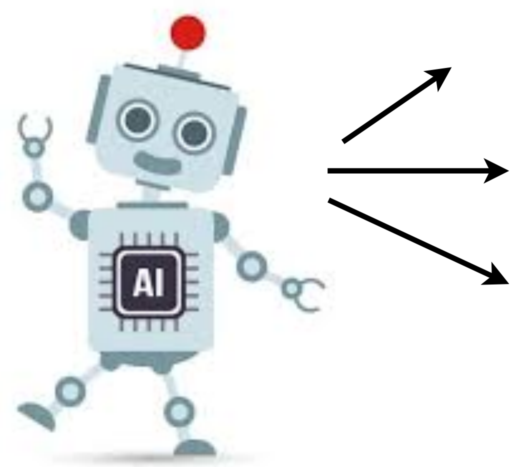

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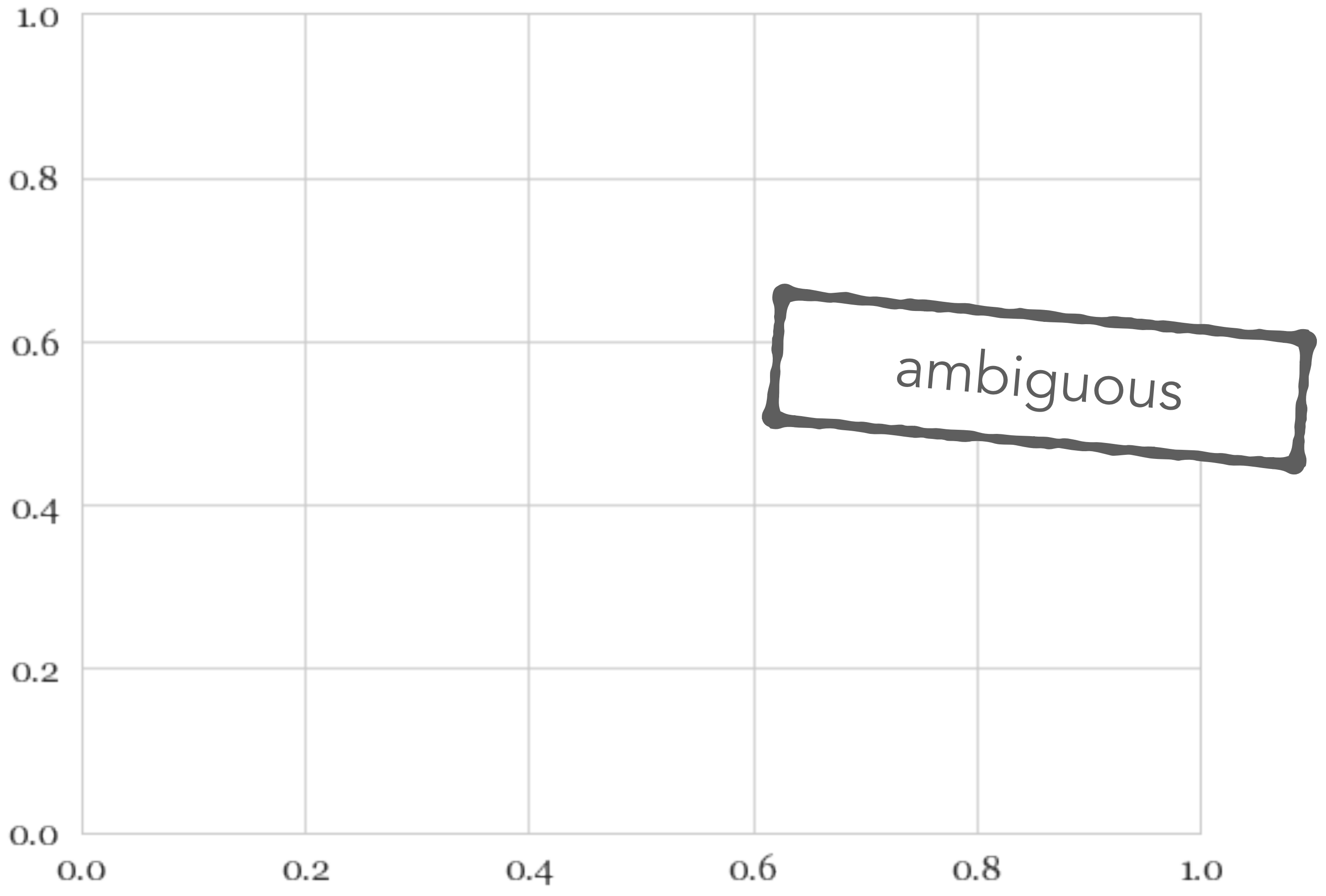

variability

Standard deviation of the **true class** probability

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

instruction

nearest neighbors to seed example

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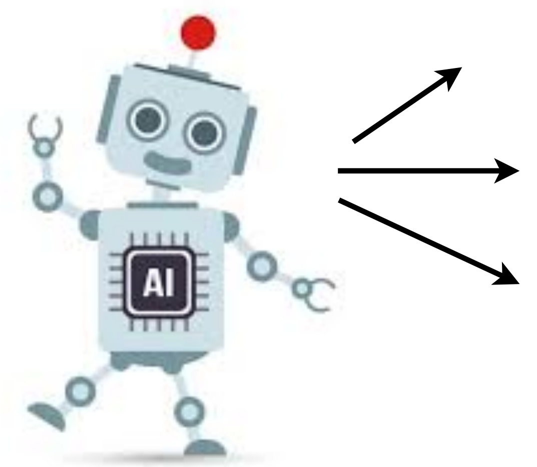

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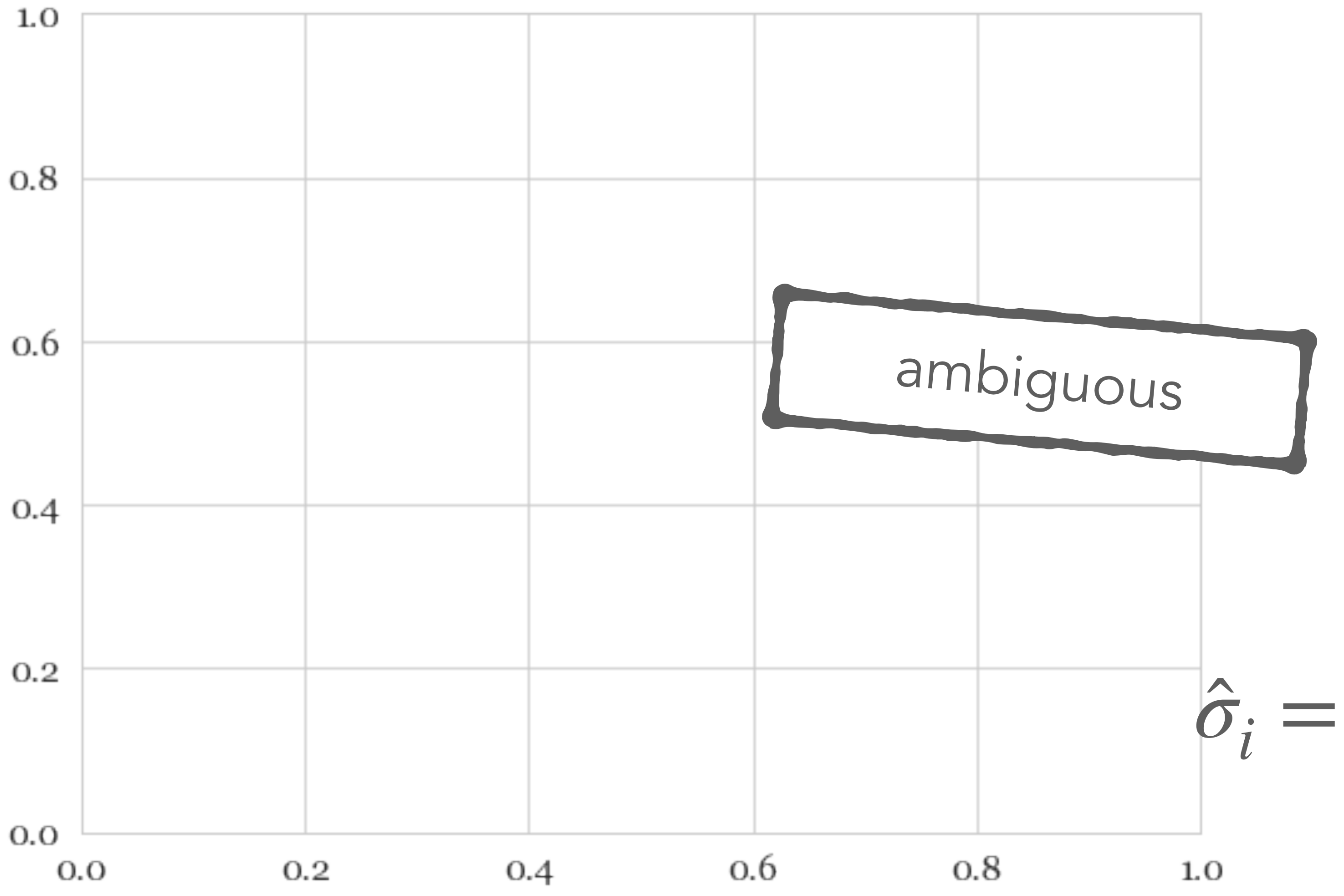


variability

$$\hat{\sigma}_i = \max_{y\in\mathcal{Y}} \sqrt{\frac{\sum_{e=1}^{E}\left(p_{\boldsymbol{\theta}^{(e)}}(y \mid x_i) - \hat{\mu}_{i,y}\right)^2}{E}}$$

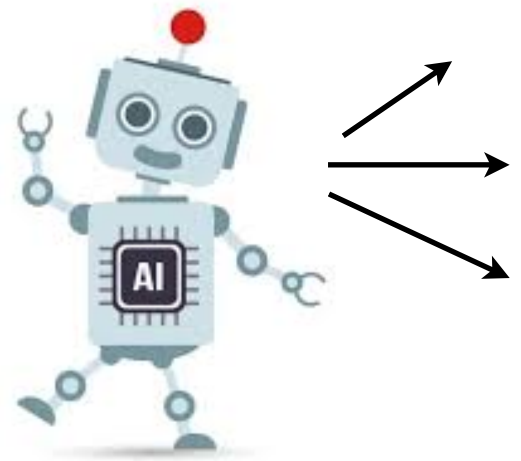
Standard deviation of the **max** ~~**true**~~ **class** probability

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

instruction

nearest neighbors to seed example

seed ambiguous example from MultiNLI - RoBERTa



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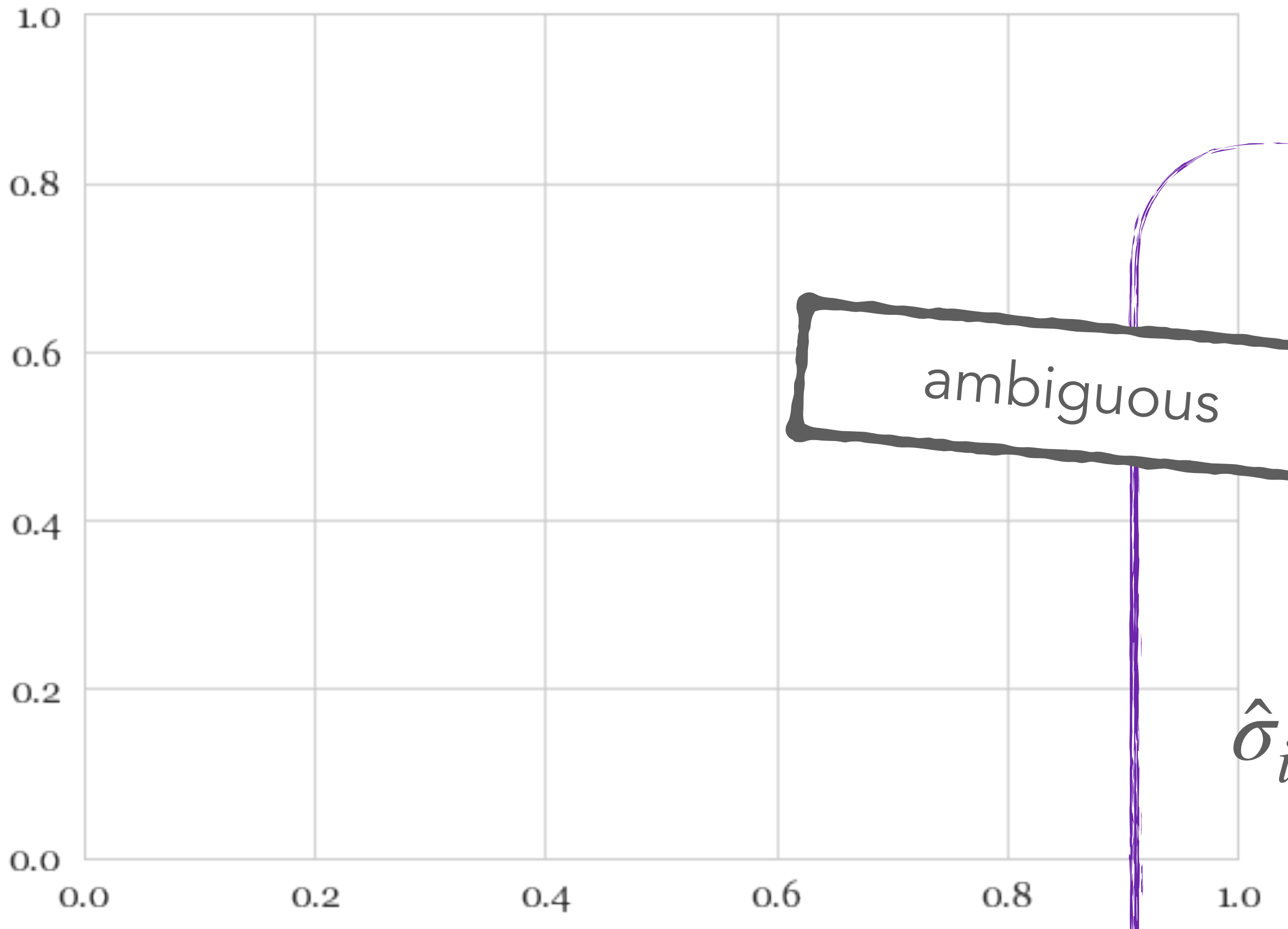

expected worst-case ambiguity

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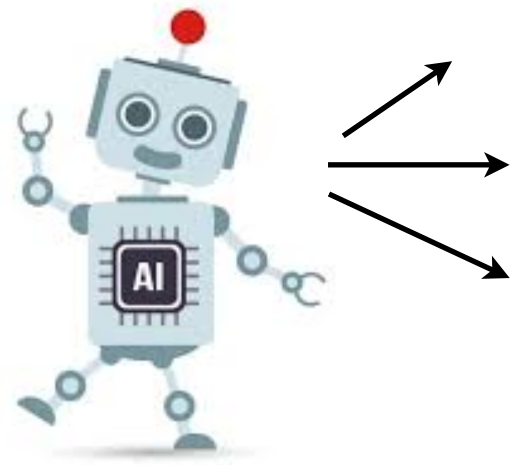
instruction

nearest neighbors to seed example

seed ambiguous example from MultiNLI - RoBERTa



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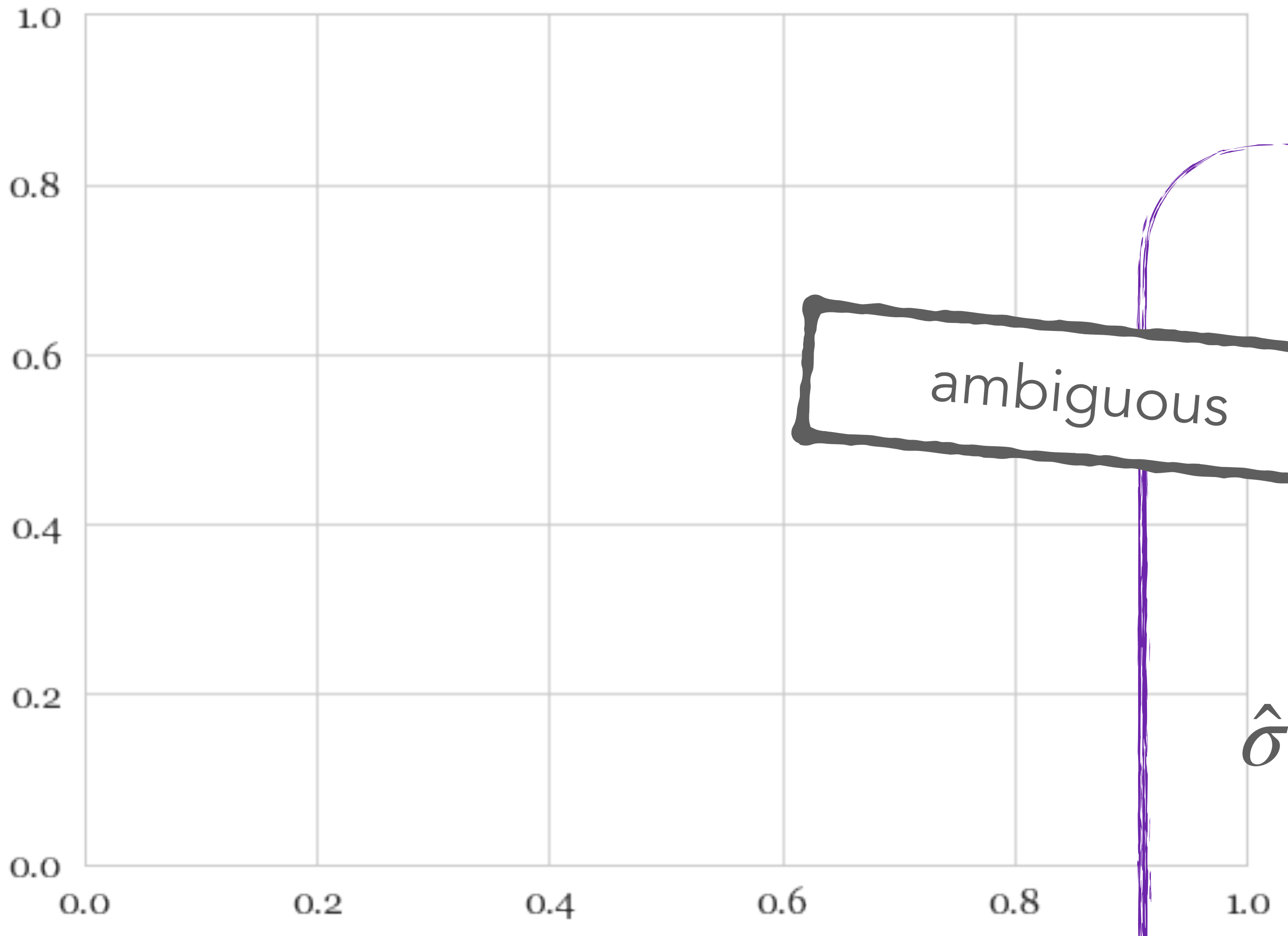

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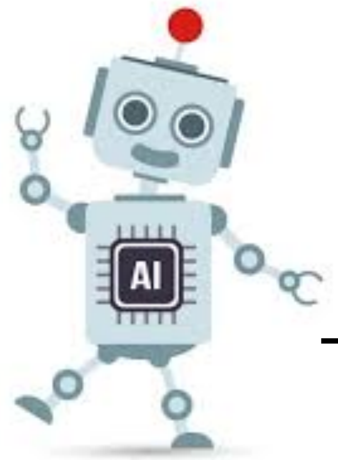
nearest neighbors to seed example

seed ambiguous example from MultiNLI - RoBERTa



GPT-3

1 percent of the seats were vacant.
Implication: **99 percent** of the seats were occupied.

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

instruction

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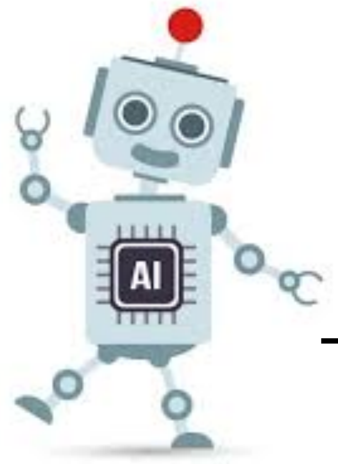

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Labels?

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

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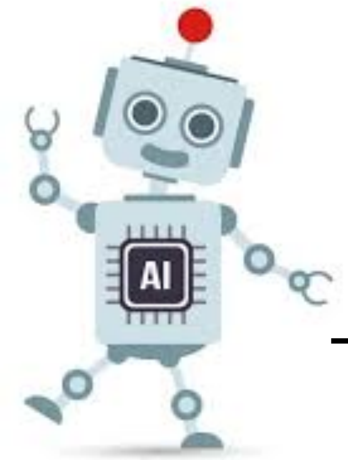

GPT-3

1 percent of the seats were vacant.
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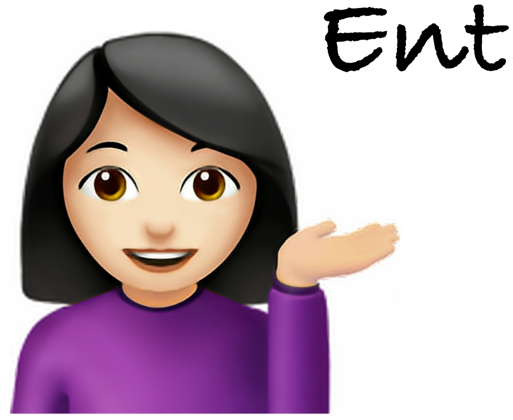
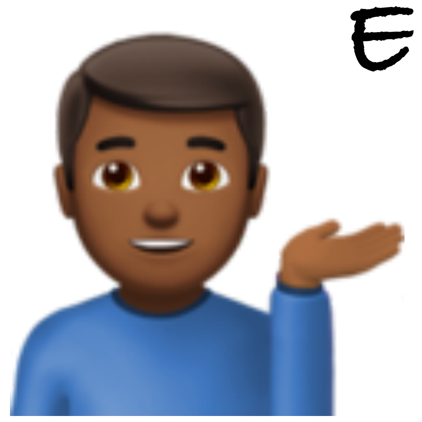
Labels?

Reliable and trustworthy!



Entailment



Entailment

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

Worker-AI Collaborative NLI: WANLI

万理 Ten thousand reasoning

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

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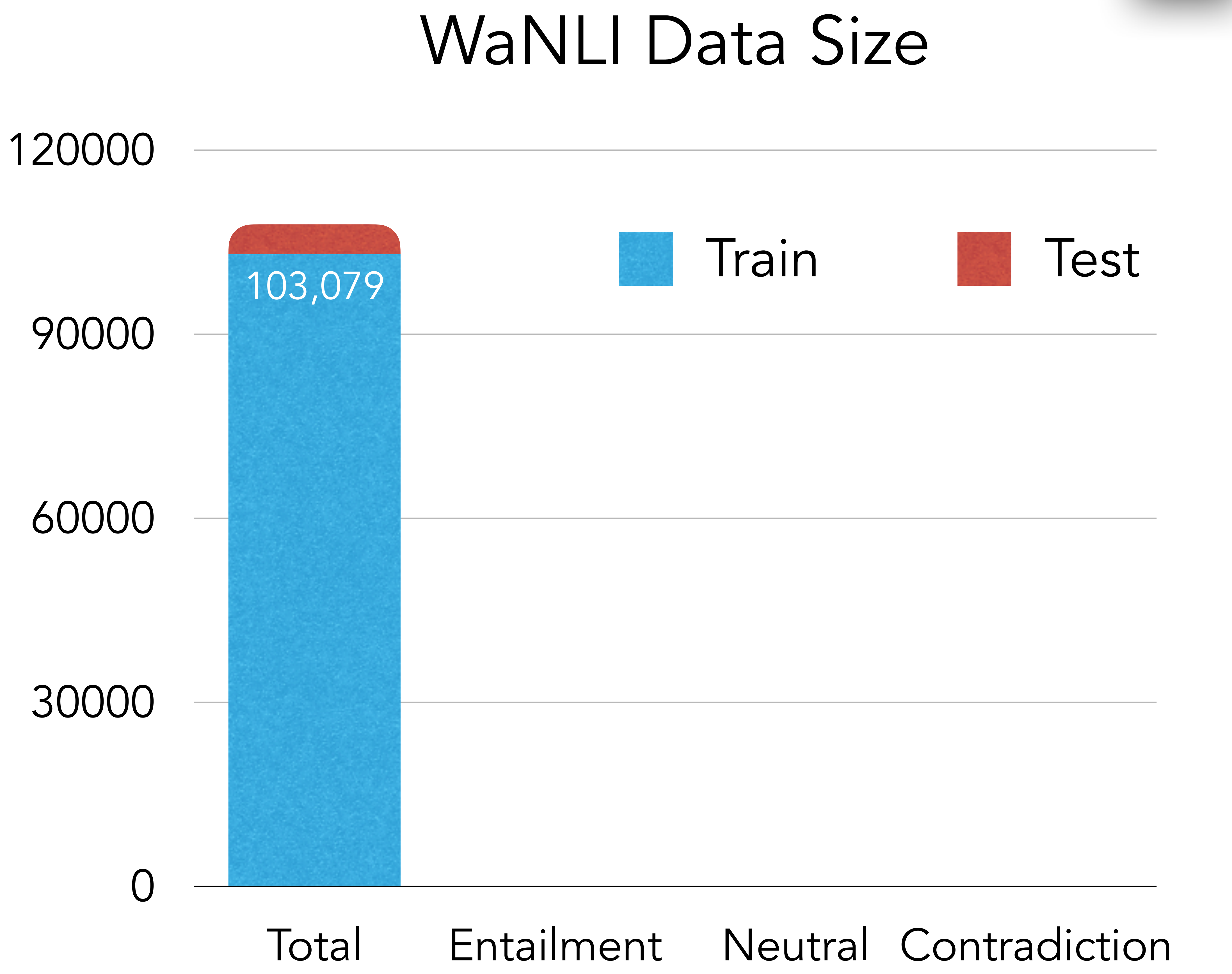

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Worker-AI Collaborative NLI: WANLI

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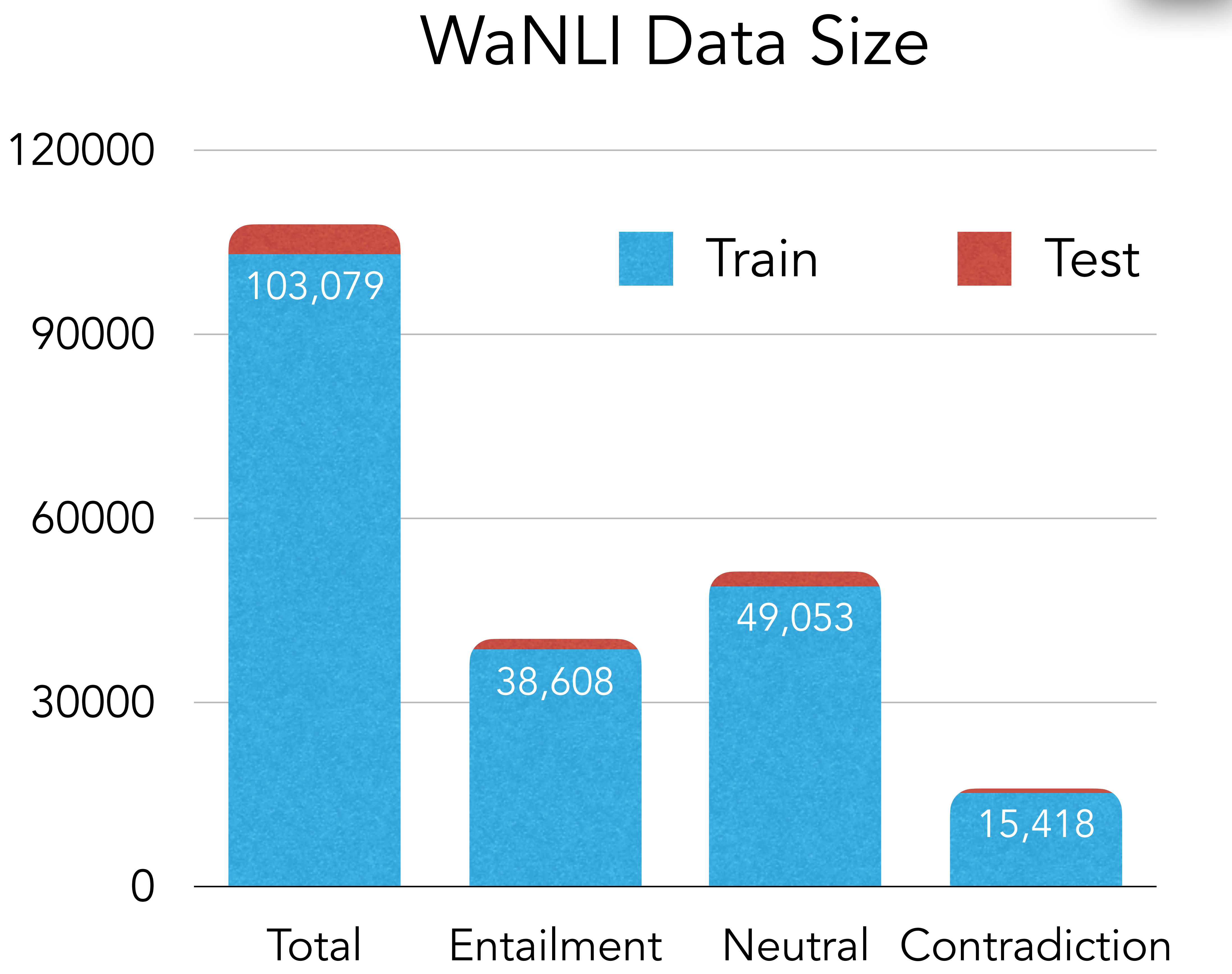
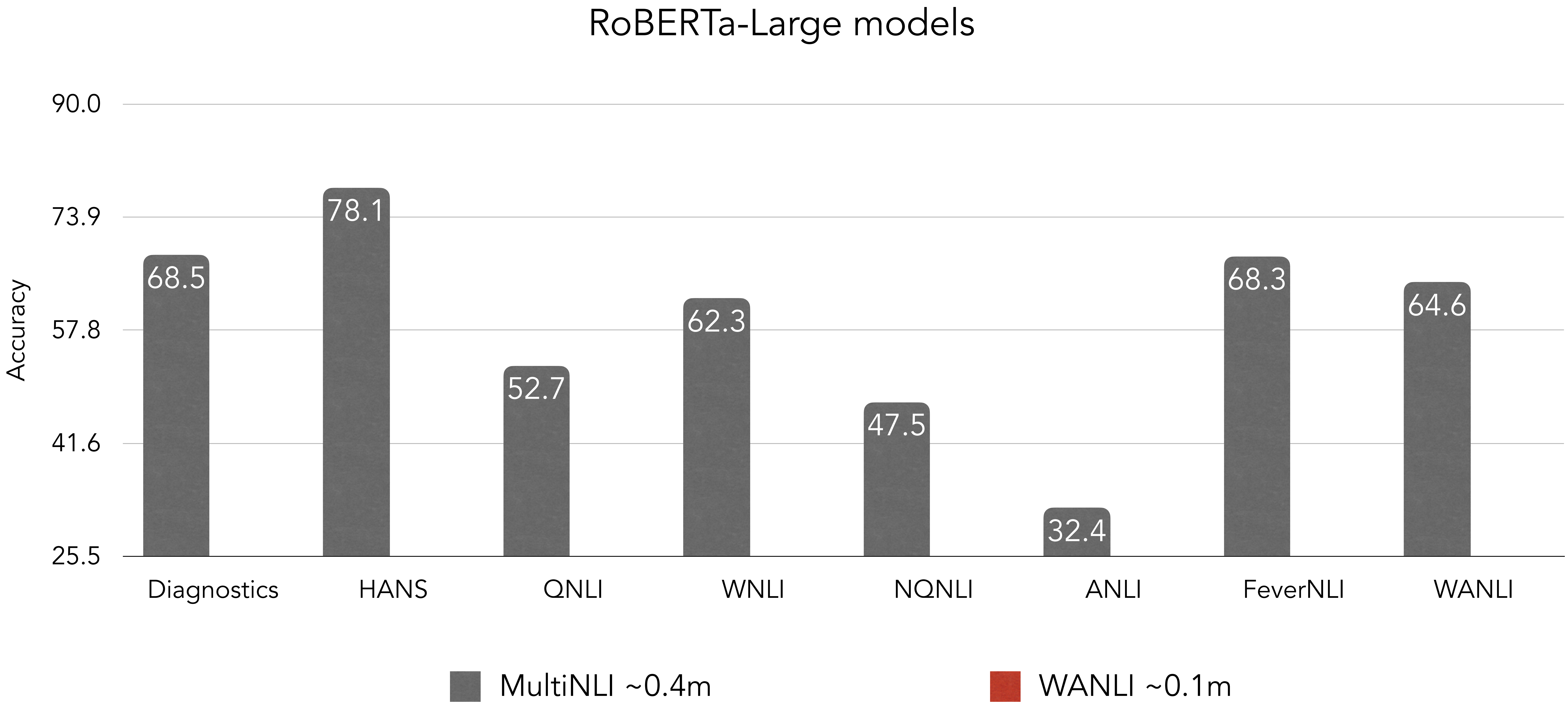


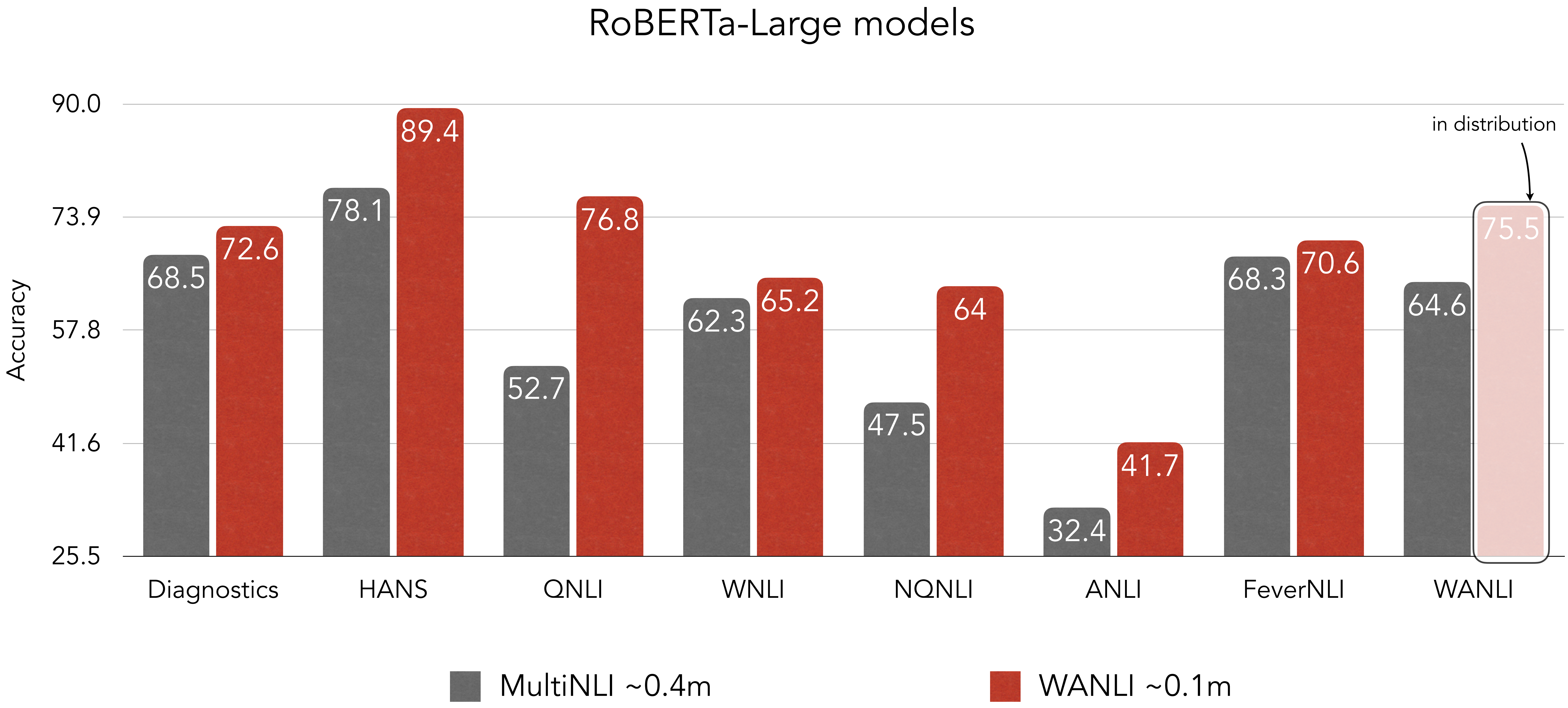
WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

RoBERTa-Large models

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

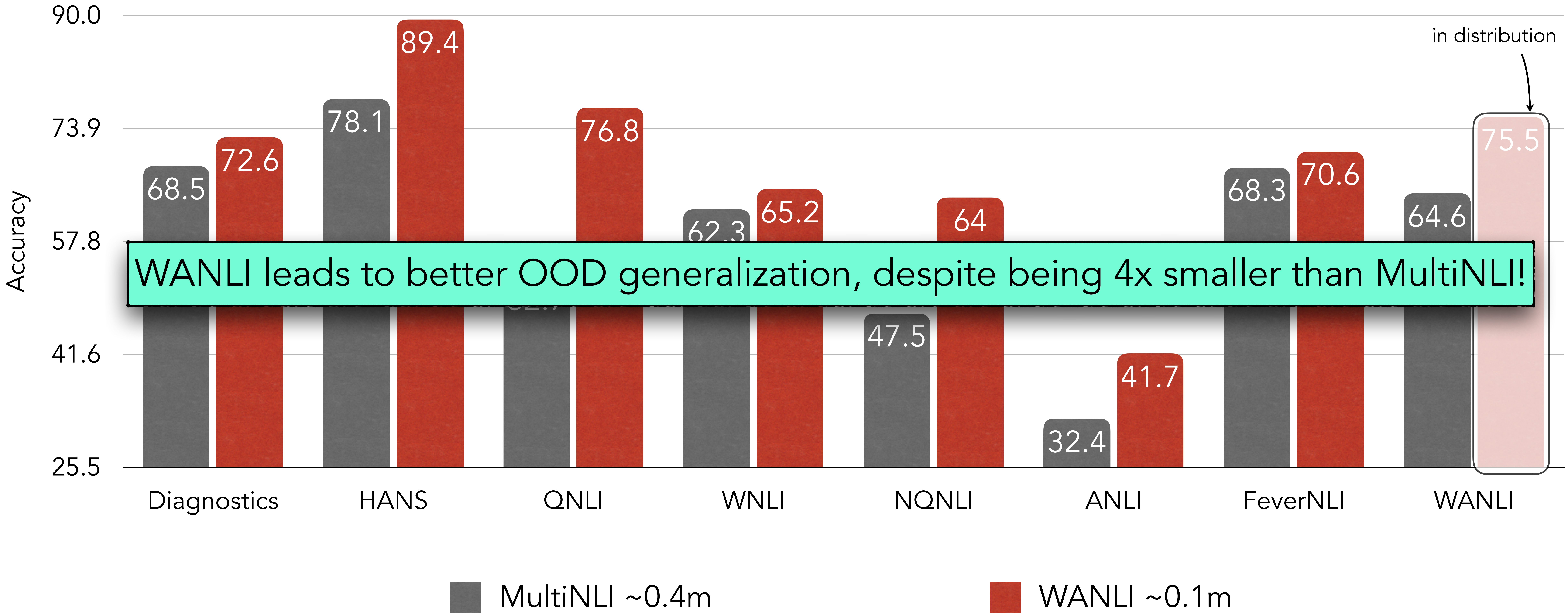


WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

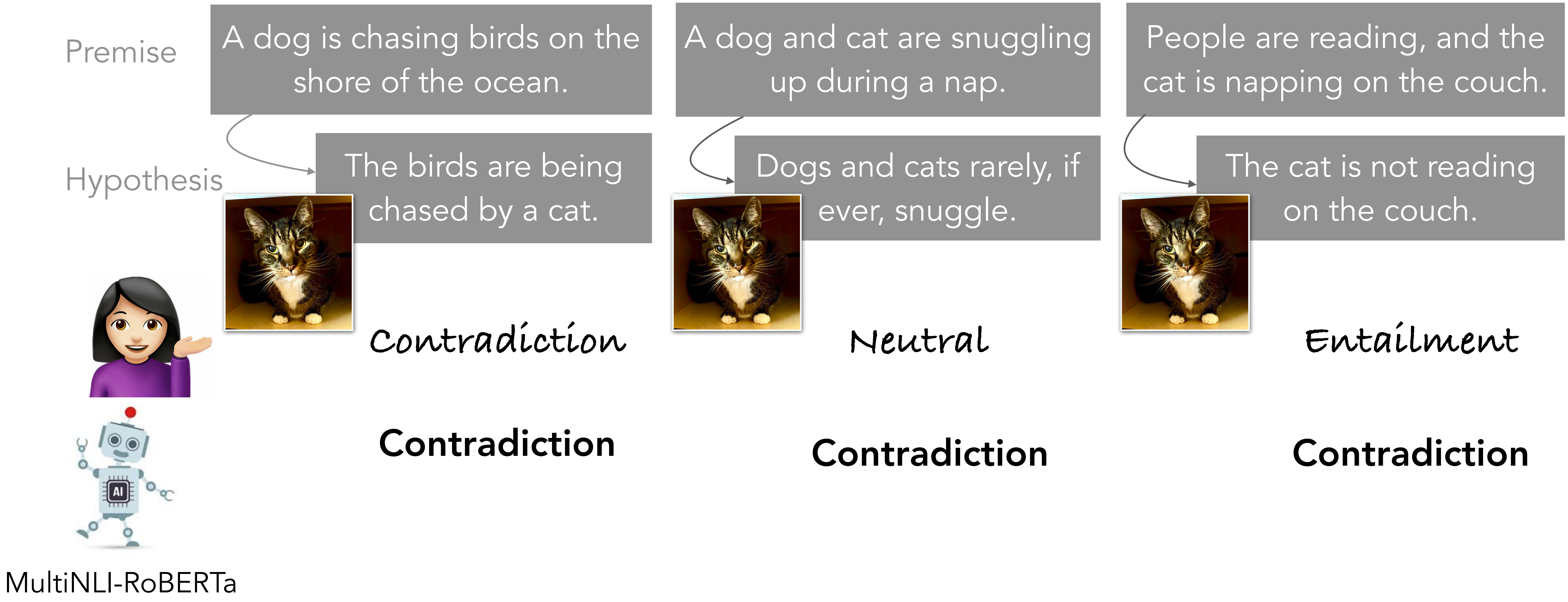
RoBERTa-Large models



WANLI leads to better OOD generalization, despite being 4x smaller than MultiNLI!

Please see paper for more comparisons

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



Premise	A dog is chasing birds on the shore of the ocean.	A dog and cat are snuggling up during a nap.	People are reading, and the cat is napping on the couch.
Hypothesis	The birds are being chased by a cat.	Dogs and cats rarely, if ever, snuggle.	The cat is not reading on the couch.
	Contradiction	Neutral	Entailment
MultiNLI-RoBERTa	**Contradiction**	**Contradiction**	**Contradiction**

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

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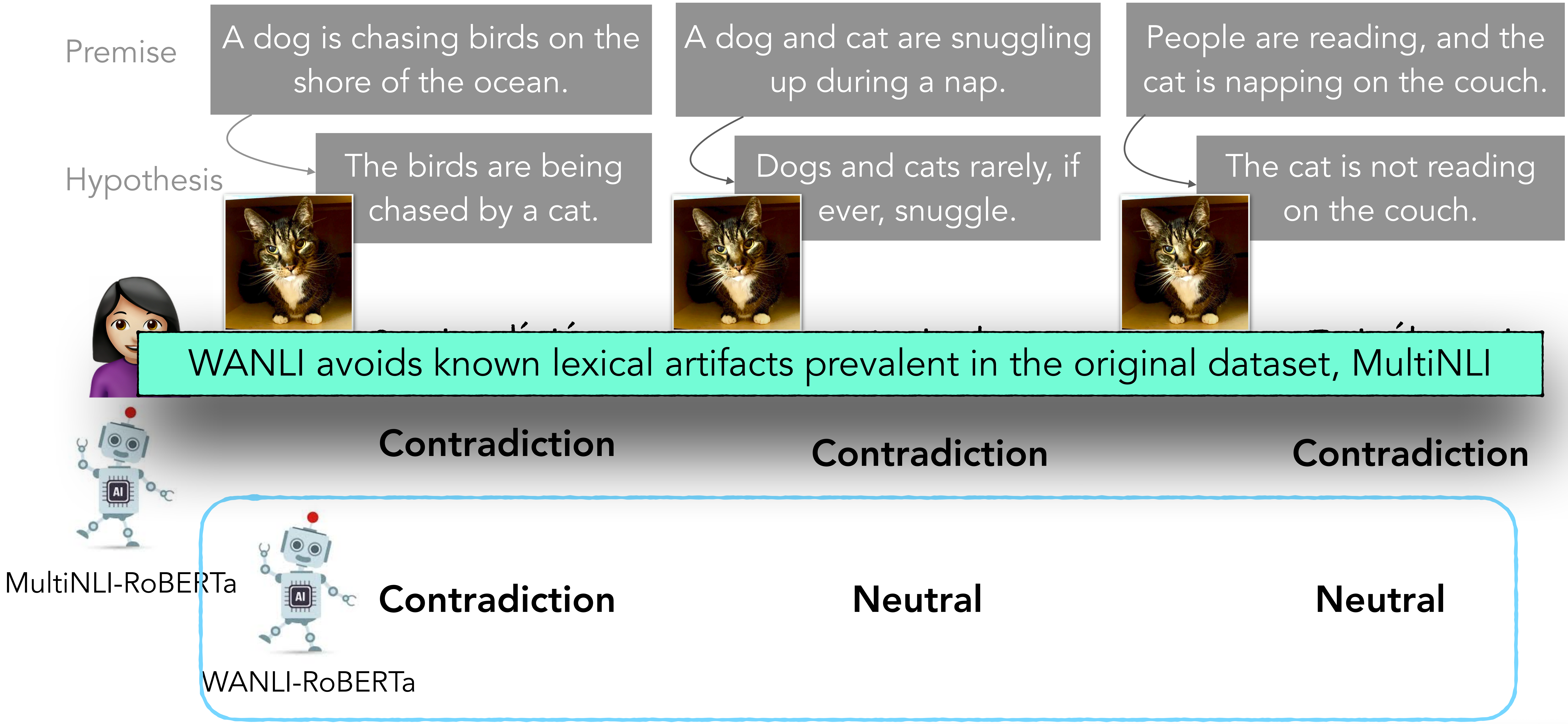
MultiNLI-RoBERTa	**Contradiction**	**Contradiction**	**Contradiction**
WANLI-RoBERTa	**Contradiction**	**Neutral**	**Neutral**

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



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MultiNLI-RoBERTa	Contradiction	Contradiction	Contradiction
WANLI-RoBERTa	Contradiction	Neutral	Neutral

WANLI avoids known lexical artifacts prevalent in the original dataset, MultiNLI

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

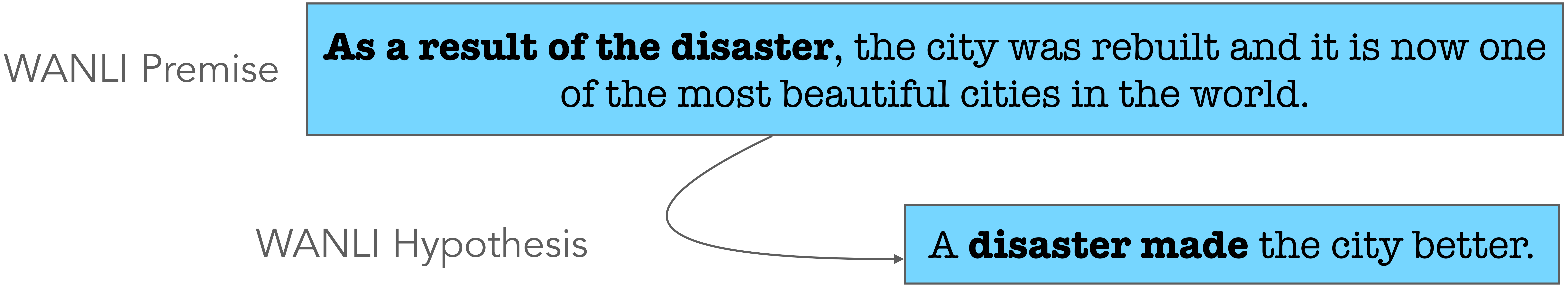
WANLI Premise

As a result of the disaster, the city was rebuilt and it is now one of the most beautiful cities in the world.

WANLI Hypothesis

A **disaster made** the city better.

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]



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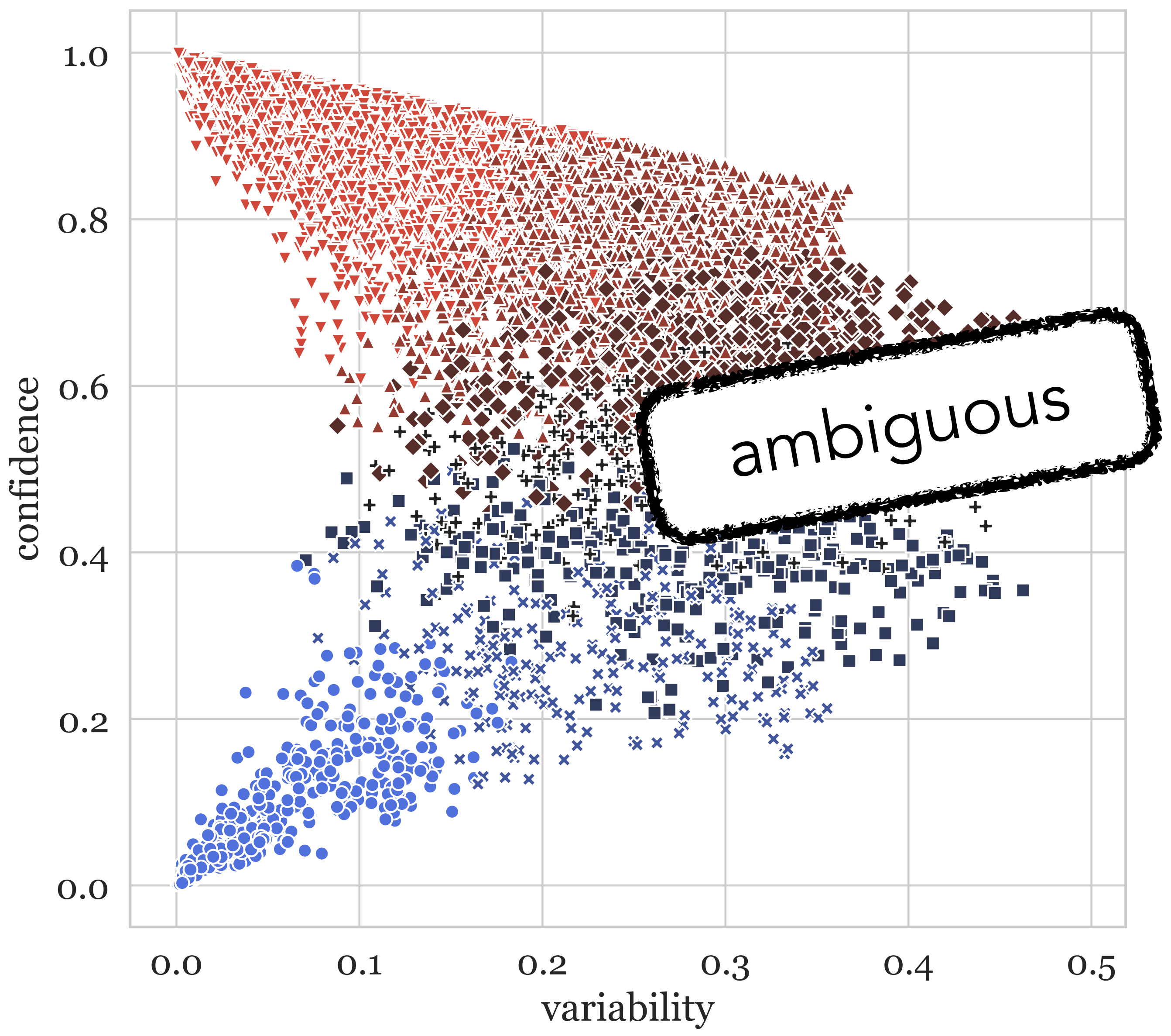
💁🏾‍♂️ Neutral 💁🏽‍♀️ Contradiction 💁🏼 Entailment

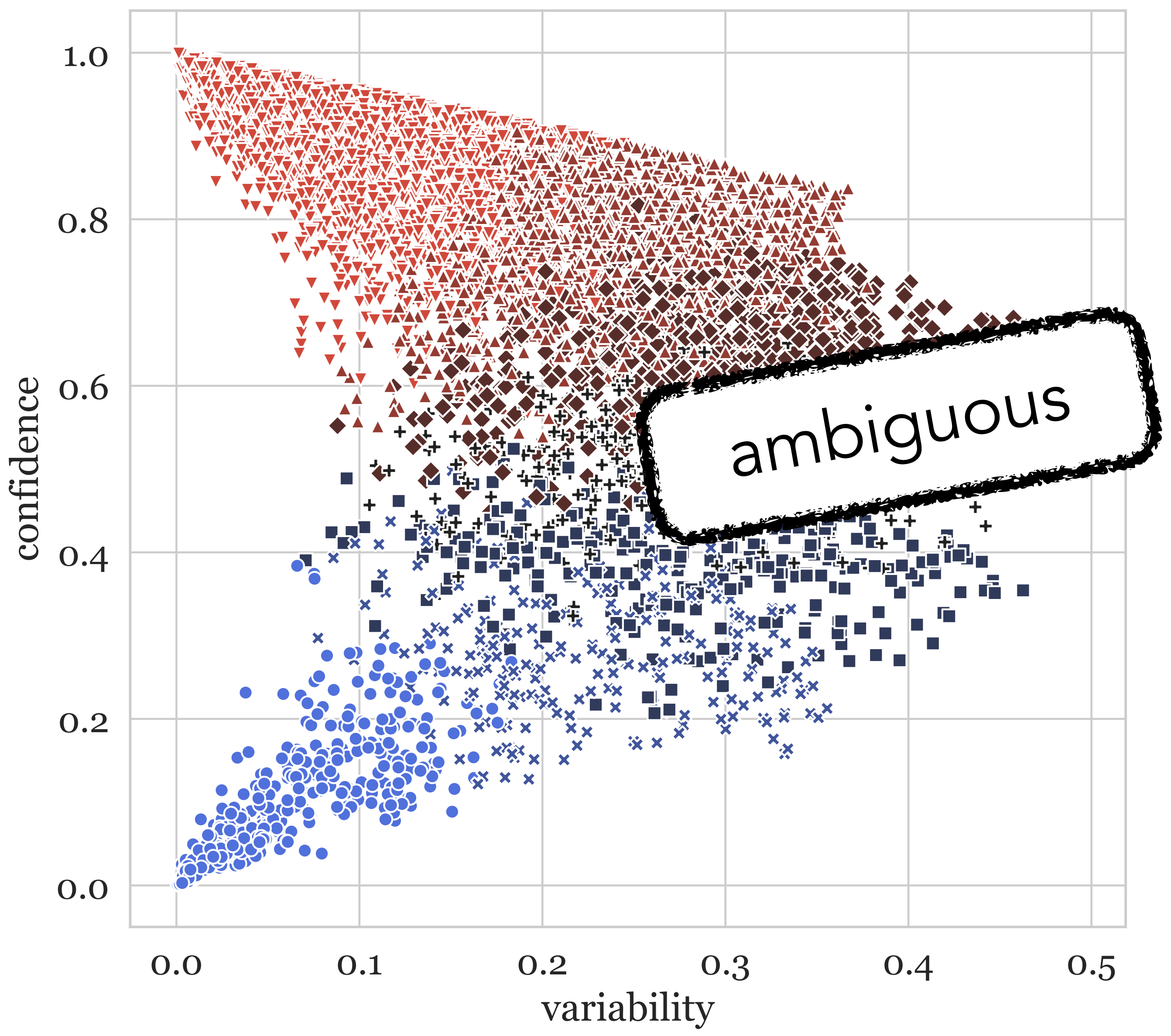
Also see

[Pavlick & Kwiatkowski, 2019; Chen et al., 2020; Zhou et al., 2022; Davani et al., 2021]

WANLI [Liu., **Swayamdipta**, Smith and Choi, ArXiV 2022]

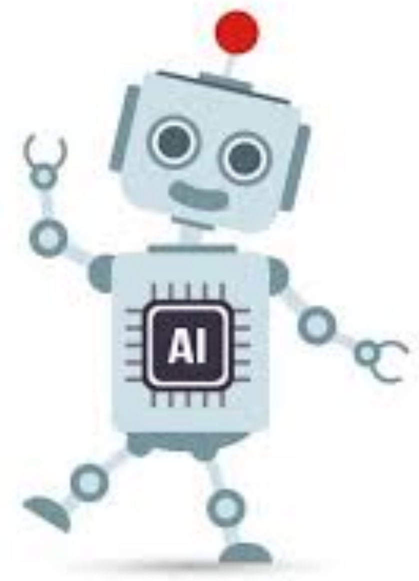


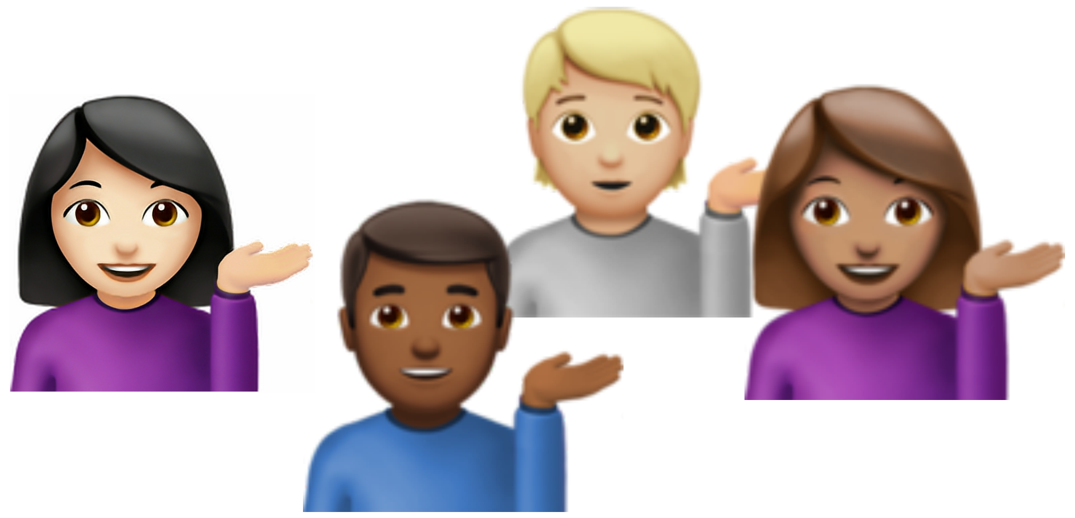
Mapping large datasets to discover regions which are **challenging** to models



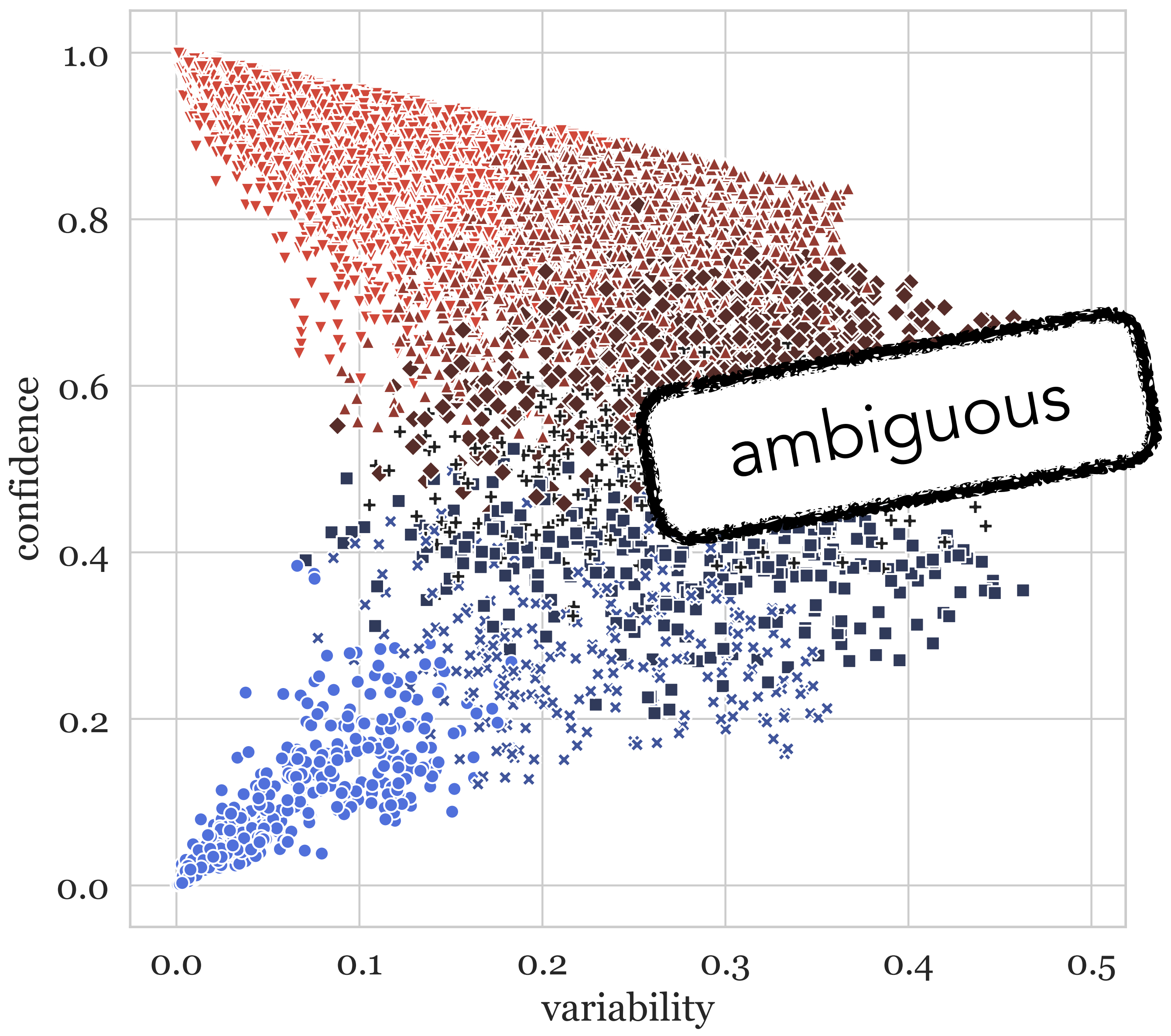
Mapping large datasets to discover regions which are **challenging** to models

GPT-3



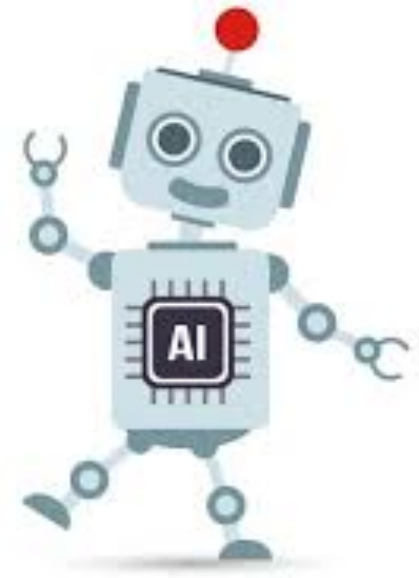


Generating new challenging instances via a collaboration of **humans and models**



+

GPT-3



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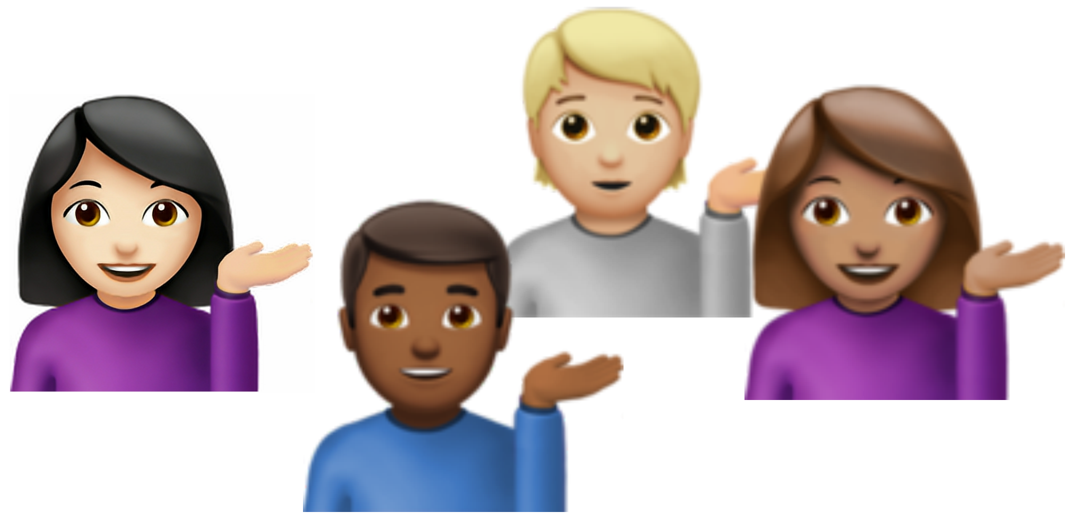
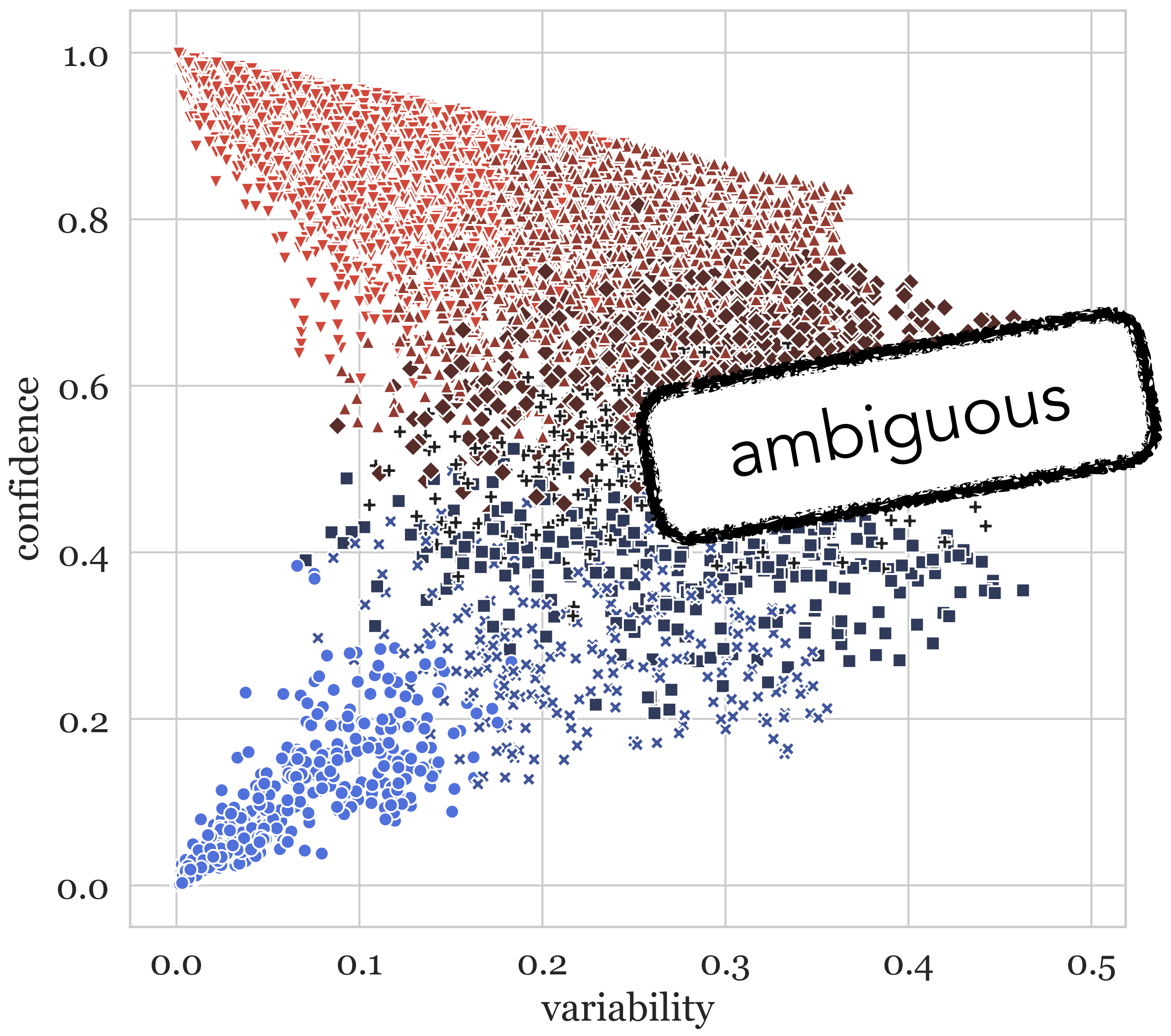


Generating new challenging instances via a collaboration of **humans and models**

Mapping large datasets to discover regions which are **challenging** to models

Rethinking data by **shifting the focus to data quality** over quantity



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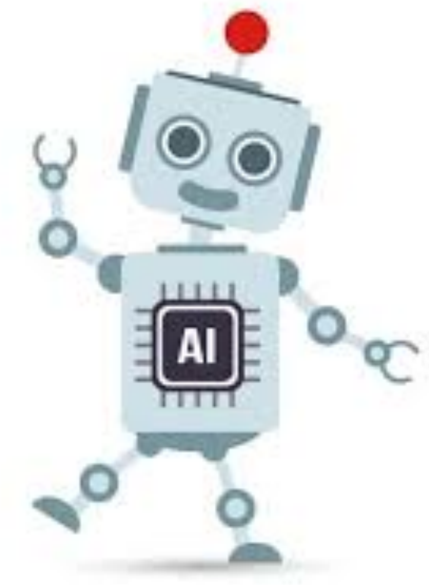

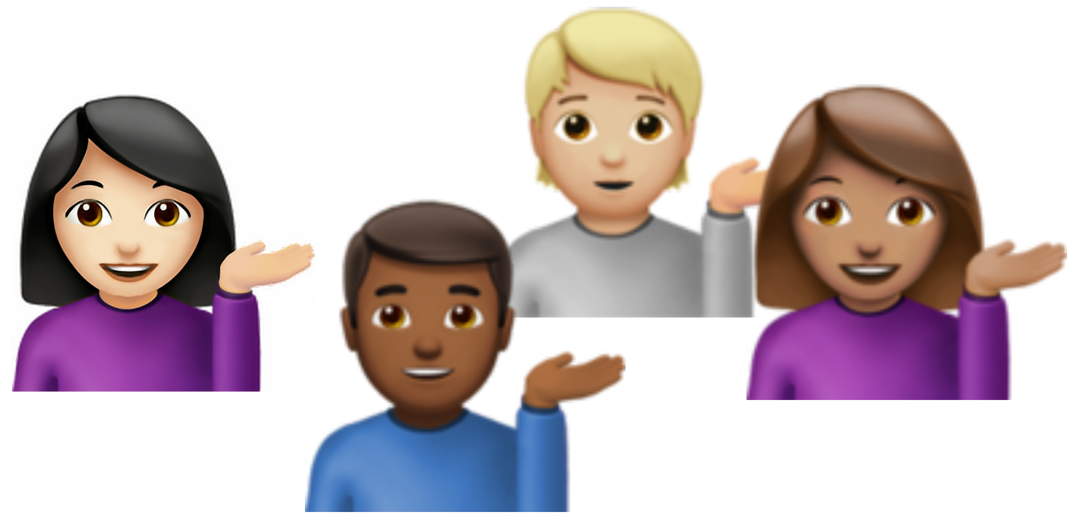

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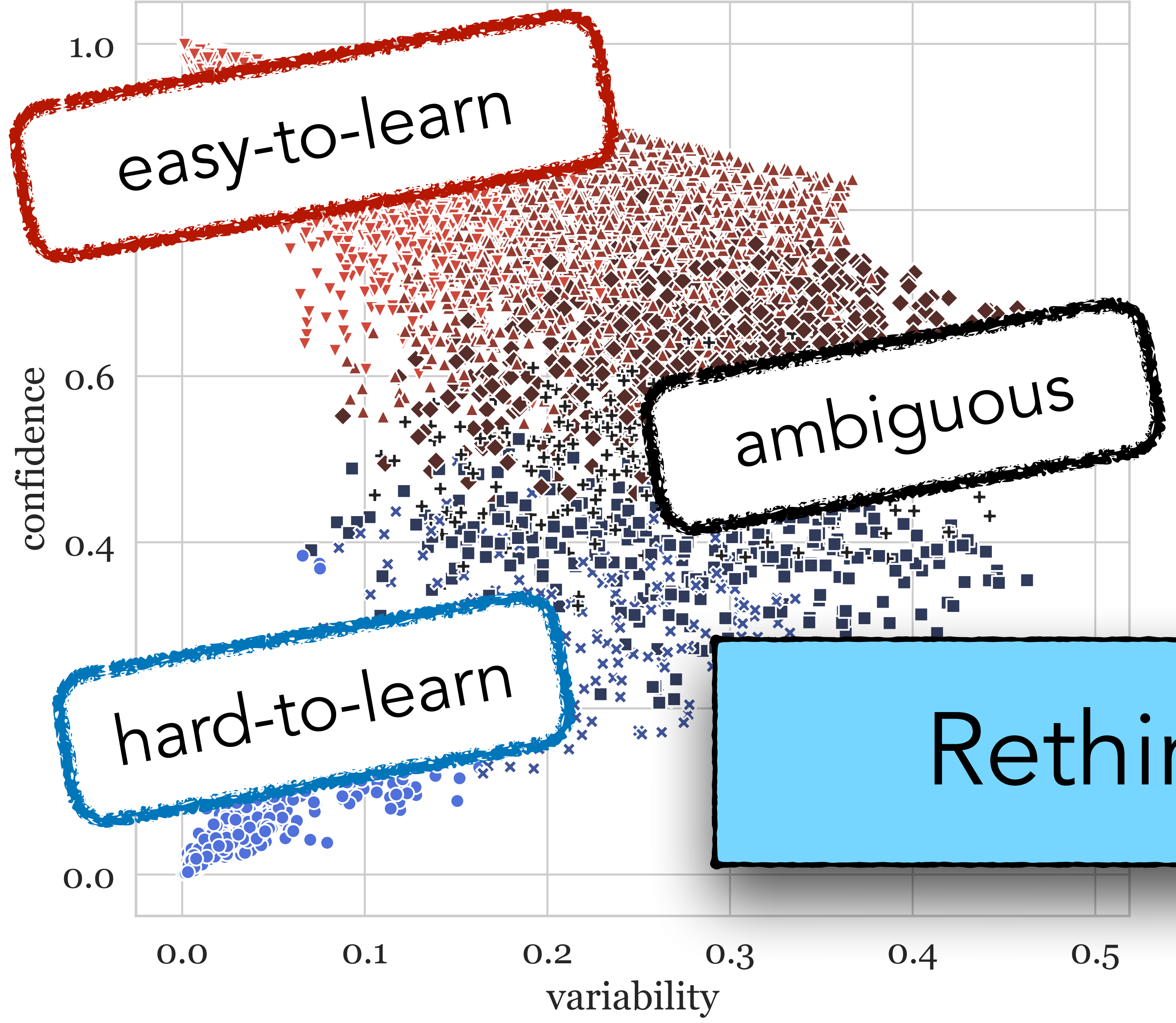
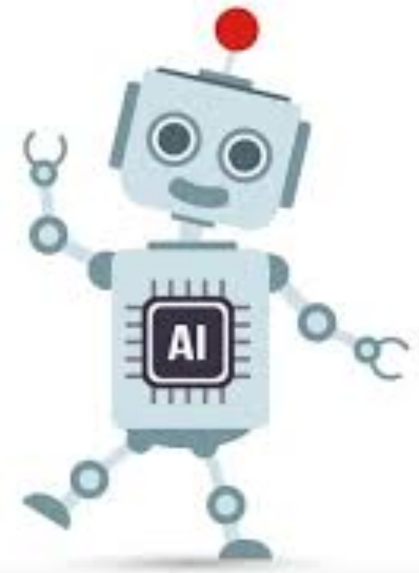
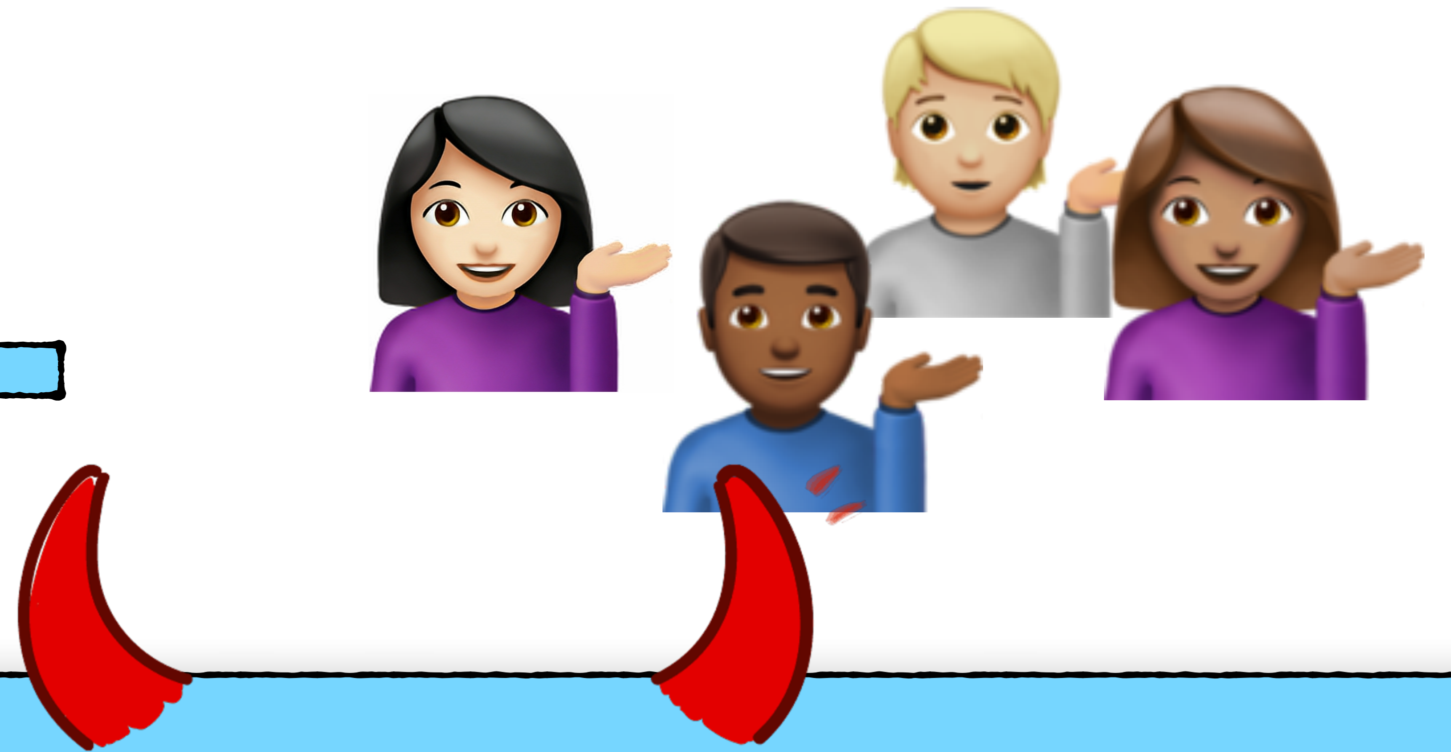


GPT-3





Rethinking data by **shifting the focus to data quality** over quantity

WANLI

Cartography

Alisa Liu

Roy Schwartz

Yizhong Wang

Nicholas Lourie

Hannaneh Hajishirzi

Noah A. Smith

Yejin Choi