

the duolingo CEFR checker:

a multilingual tool for adapting learning content

Bill McDowell
December 2021



disclaimer

- **Outdated** — All results are from 3 years ago
 - My memory is fuzzy about many details
 - There is relevant recent work on large language models and contextual embeddings

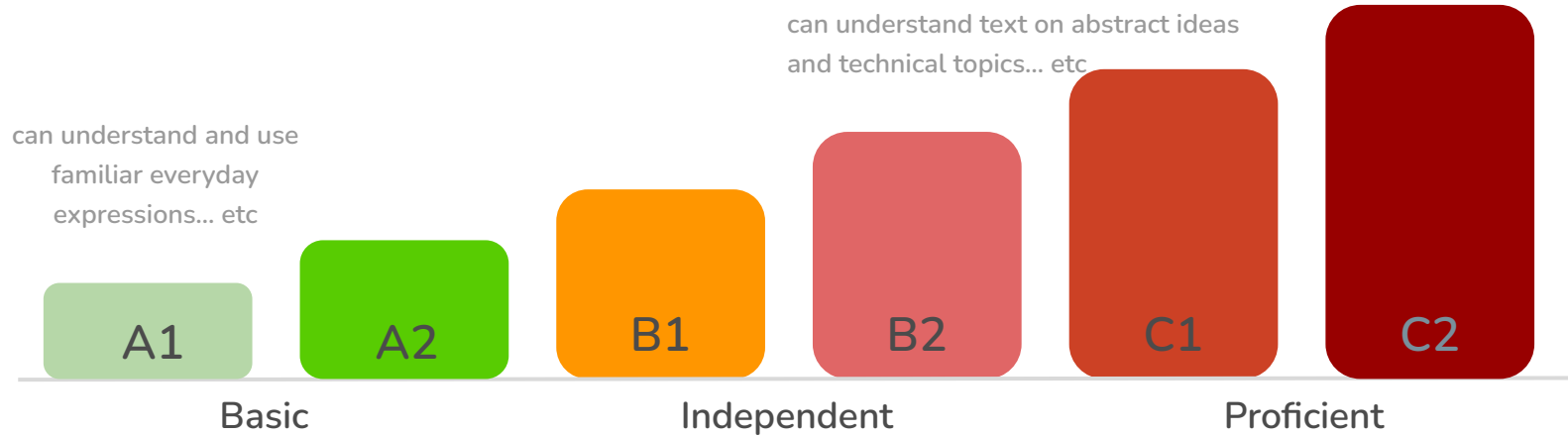
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 - Some obvious experiments are missing
 - Some relevant result breakdowns are scattered across old spreadsheets, so I only report those which were readily available

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- **Unreviewed and unpublished** — Don't take anything here too seriously

CEFR



CEFR checker

- **Check appropriate proficiency levels for content** — Automatically determine whether text is appropriate for language learners at various CEFR levels
- **Multilingual** — Work across multiple languages to adapt content for many Duolingo courses
 - English, French, Spanish, German, Italian, Portuguese

CEFR checker



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CEFR checker

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Eng ▼ Wor ▼ Pre ▼ CEF ▼

4 tokens | 4 types

LEVEL
A1

She has a dog.

English Words Predicted CEFR

<div style="width: 100%;"></div>	A1 100% (4)
<div style="width: 0%;"></div>	A2 0% (0)
<div style="width: 0%;"></div>	B1 0% (0)
<div style="width: 0%;"></div>	B2 0% (0)
<div style="width: 0%;"></div>	C 0% (0)
<div style="width: 0%;"></div>	? 0% (0)

Hover to isolate a level, click to lock isolation, shift + click to select multiple.

CEFR checker



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Eng ▼ Wor ▼ Prei ▼ CEF ▼ 17 tokens | 16 types **LEVEL B2**

The furlough scheme will be extended across the trans-Atlantic region until the final days of March.

English Words Predicted CEFR

	A1 56% (9)
	A2 13% (2)
	B1 19% (3)
	B2 13% (2)
	C 0% (0)
	? 0% (0)

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Eng ▼ Wor ▼ Pre ▼ CEF ▼ 126 tokens | 85 types **LEVEL C**

The **Common European Framework of Reference for Languages: Learning, Teaching, Assessment**, abbreviated in English as **CEFR** or **CEF** or **CEFR/L**, is a guideline used to describe achievements of learners of foreign languages across Europe and, increasingly, in other countries. It was put together by the Council of Europe as the main part of the project "Language Learning for European Citizenship" between 1989 and 1996. Its main aim is to provide a method of learning, teaching and assessing which applies to all languages in Europe. In November 2001, a European Union Council Resolution recommended using the CEFR to set up systems of validation of language ability. The six reference levels (A1, A2, B1, B2, C1, C2) are becoming widely accepted as the European standard for grading an individual's language proficiency.

English Words Predicted CEFR

<div><div style="width: 39%;"></div></div>	A1 39% (33)
<div><div style="width: 22%;"></div></div>	A2 22% (19)
<div><div style="width: 15%;"></div></div>	B1 15% (13)
<div><div style="width: 11%;"></div></div>	B2 11% (9)
<div><div style="width: 11%;"></div></div>	C 11% (9)
<div><div style="width: 2%;"></div></div>	? 2% (2)

Hover to isolate a level, click to lock isolation, shift + click to select multiple.

CEFR checker



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Spa ▼ Wor ▼ Pre ▼ CEF ▼ 144 tokens | 98 types **LEVEL C**

El Marco Común Europeo de Referencia para las lenguas: aprendizaje, enseñanza, evaluación (MCER, o CEFR en inglés) es un estándar europeo, utilizado también en otros países, que sirve para medir el nivel de comprensión y expresión oral y escrita en una determinada lengua. El MCERL adopta un enfoque orientado a la acción que, según Carlos César Jiménez de la Universidad Nacional Autónoma de México, se remonta a las propuestas teóricas de los filósofos del lenguaje, tales como Ludwig Wittgenstein en las décadas de 1950 y sociolingüistas como Dell Hymes. Entre los conceptos teóricos clave utilizados en el MCER, se encuentran el conocimiento declarativo, el conocimiento **procedimental** y la competencia, entendida como el conocimiento mínimo suficiente que suponemos se requiere para ejecutar un tipo de tareas específicas. Estos conceptos se complementan con la competencia existencial (habilidades sociales), la habilidad para aprender y la competencia lingüístico-comunicativa.

Spanish Words Predicted CEFR

	A1 35% (34)
	A2 9% (9)
	B1 16% (16)
	B2 23% (23)
	C 12% (12)
	? 4% (4)

Hover to isolate a level, click to lock isolation, shift + click to select multiple.

how we've used this at
duolingo

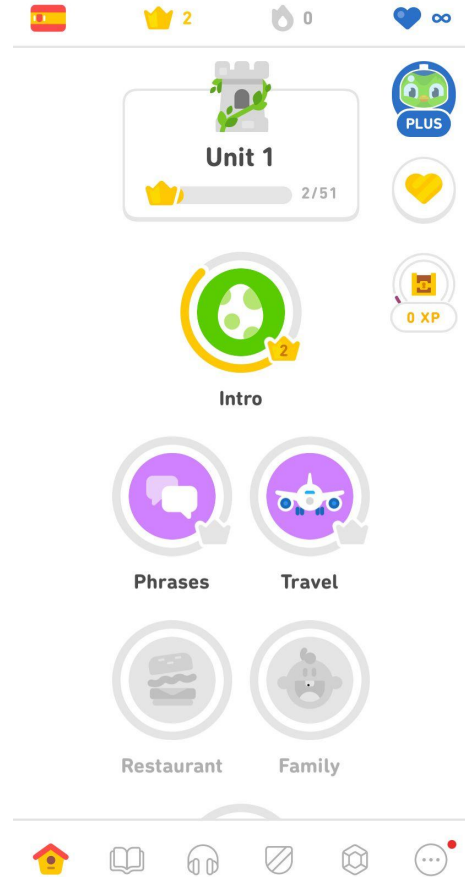
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- **Mission**— We aim to develop the best education in the world and make it universally available

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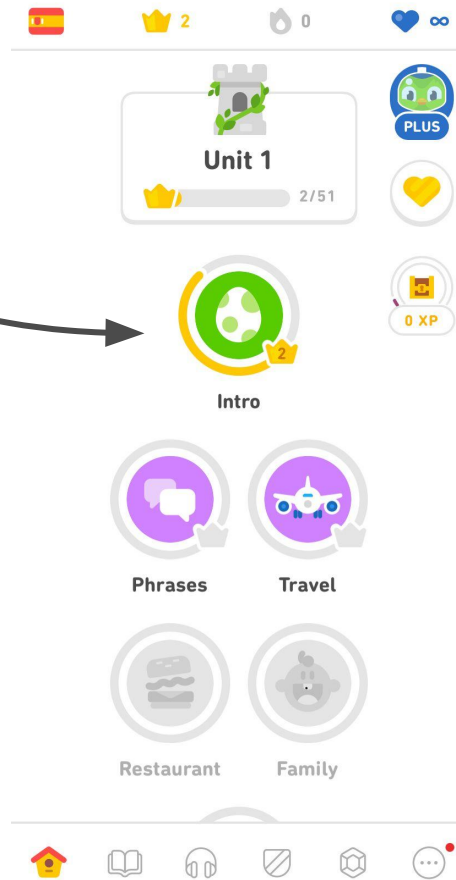
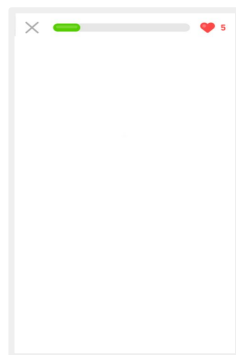
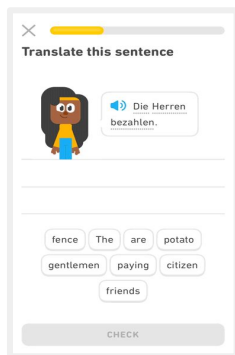
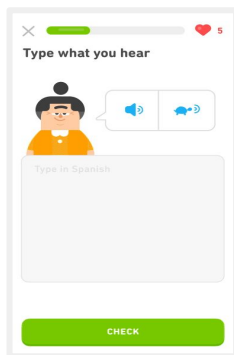
- **Mission**— We aim to develop the best education in the world and make it universally available
- **Current language learning app**
 - Started in 2012
 - More than 500 million users globally
 - Currently language learning 90+ courses (including Irish and Esperanto)
 - Expanding to 100+ courses (including Māori and Yiddish)
 - All learning content is FREE

duolingo



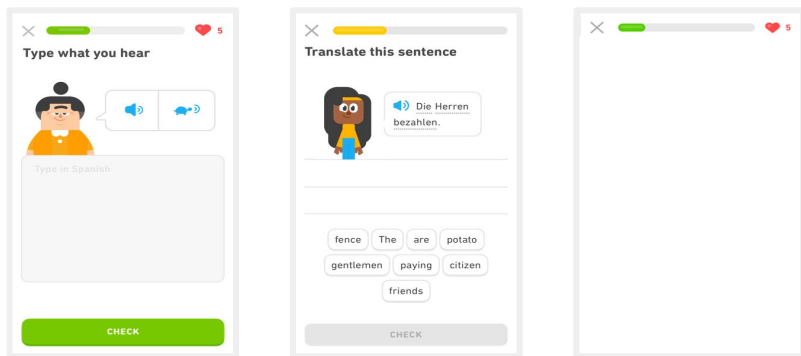
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game-like lessons grouped into skills by topic

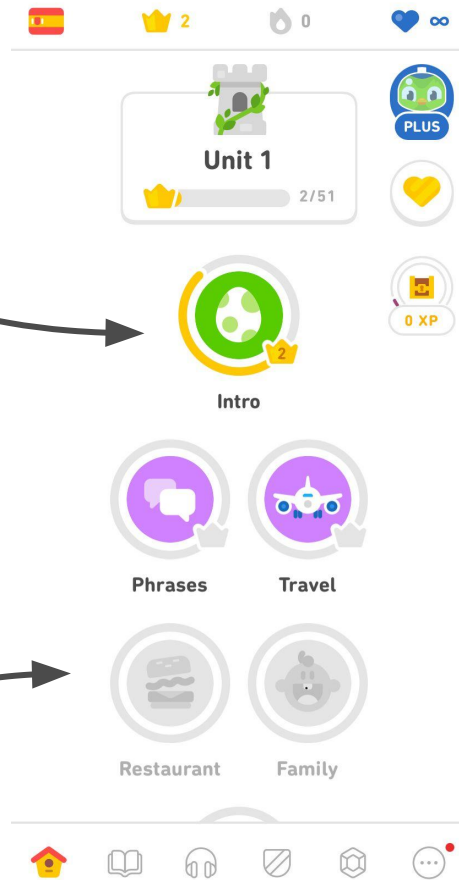


duolingo

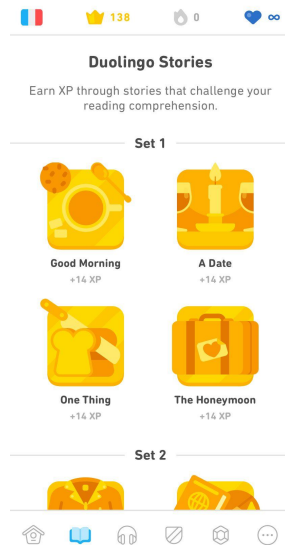
game-like lessons grouped into skills by topic



learners complete skills to unlock more rows



duolingo



French flag icon, 138 XP, 0 hearts, infinity hearts icon

Duolingo Stories

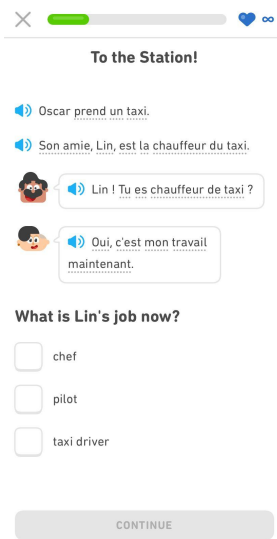
Earn XP through stories that challenge your reading comprehension.

Set 1

- Good Morning (+14 XP)
- A Date (+14 XP)
- One Thing (+14 XP)
- The Honeymoon (+14 XP)

Set 2

Home, Book, Headphones, Shield, Gem, More icons



Close icon, progress bar, infinity hearts icon

To the Station!

Oscar prend un taxi.

Son amie, Lin, est la chauffeur du taxi.

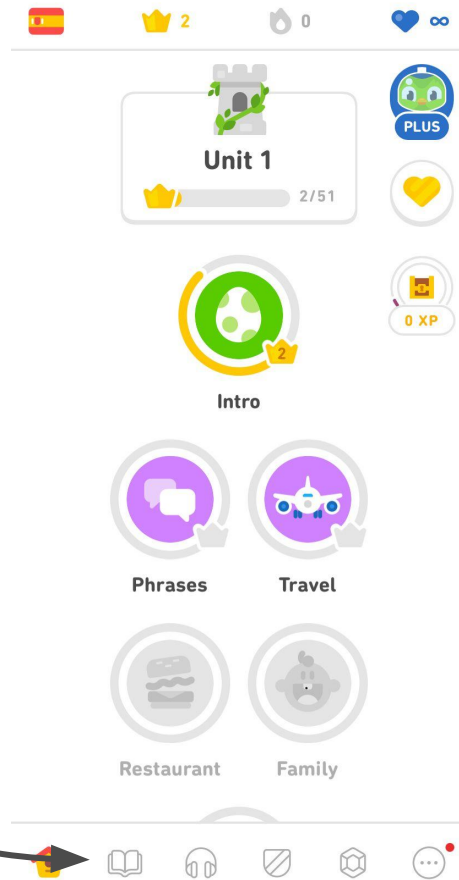
Lin ! Tu es chauffeur de taxi ?

Oui, c'est mon travail maintenant.

What is Lin's job now?

- chef
- pilot
- taxi driver

CONTINUE



Spanish flag icon, 2 crowns, 0 hearts, infinity hearts icon

Unit 1 2/51

PLUS

0 XP

Intro

Phrases Travel

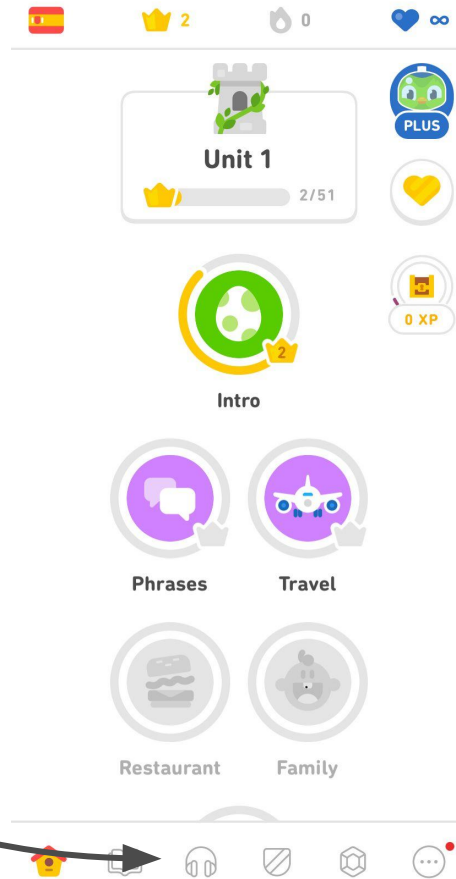
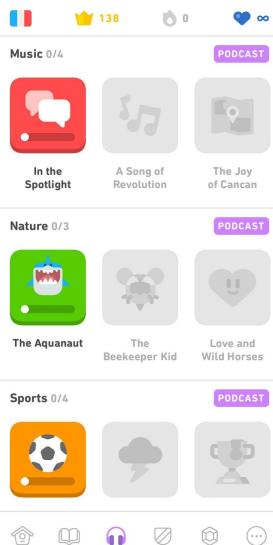
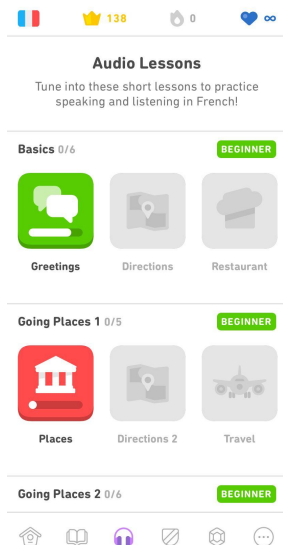
Restaurant Family

Home, Headphones, Shield, Gem, More icons

learners can also read interactive stories



duolingo

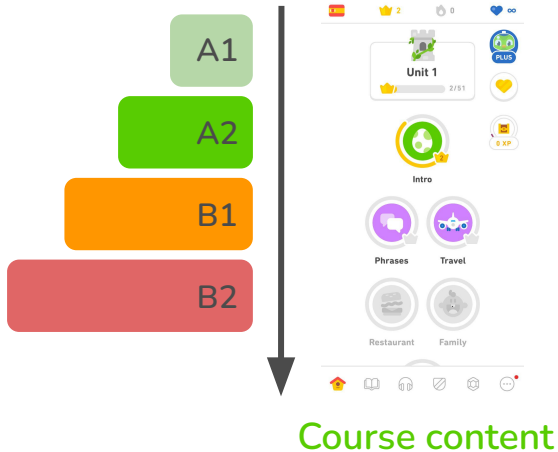


there are also audio lessons and podcasts



CEFR at duolingo

- **Course content** — Courses are aligned the CEFR, such that skills are taught in order by targeted proficiency level



CEFR at duolingo

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- **Podcasts and Stories** — Podcast and story content has been adapted to target particular CEFR levels using the CEFR checker

A1
A2
B1
B2

Course content

B
1
B
2
B
2

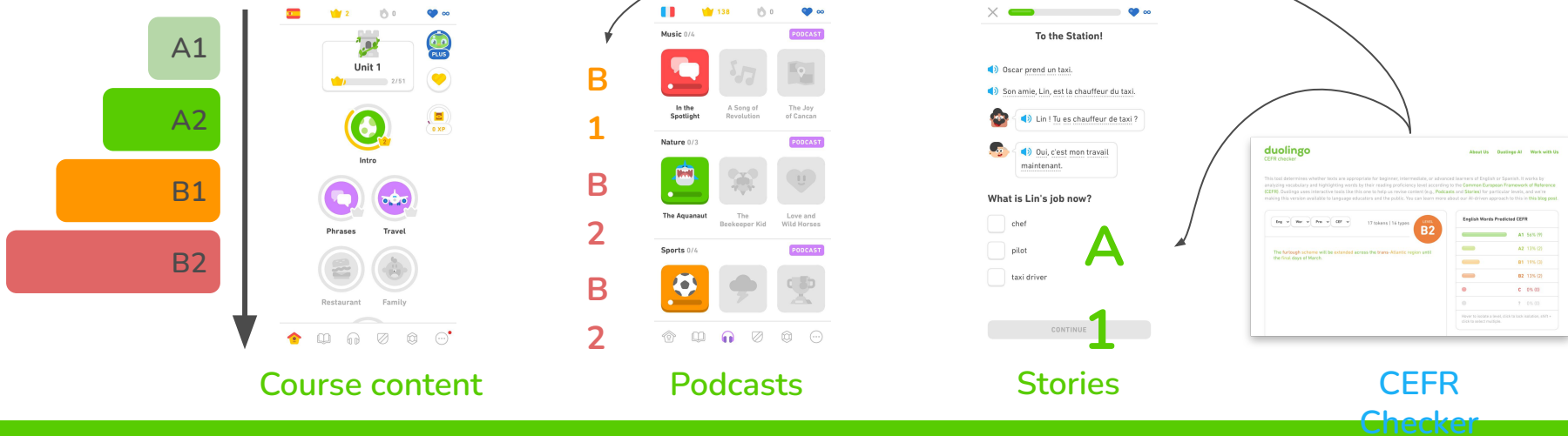
Podcasts

A
1

Stories

CEFR at duolingo

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CEFR checker problem setup

CEFR checker problem setup

- **Want a mapping** — from text to required CEFR proficiency level

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CEFR checker

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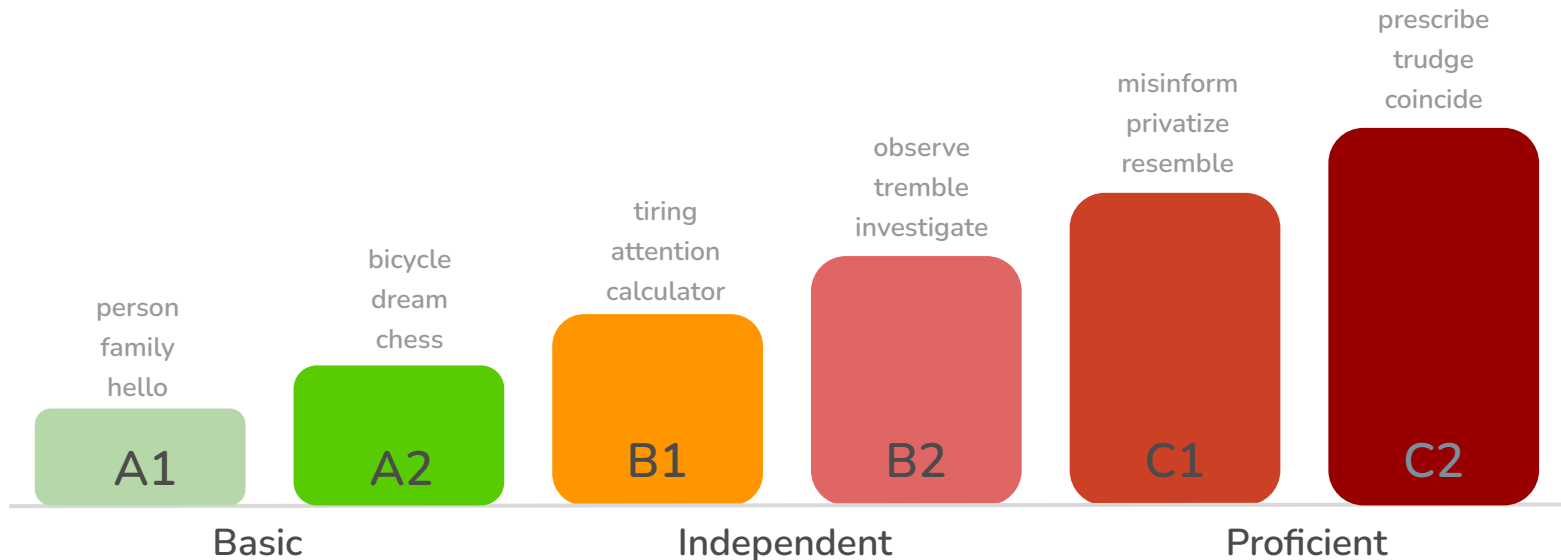
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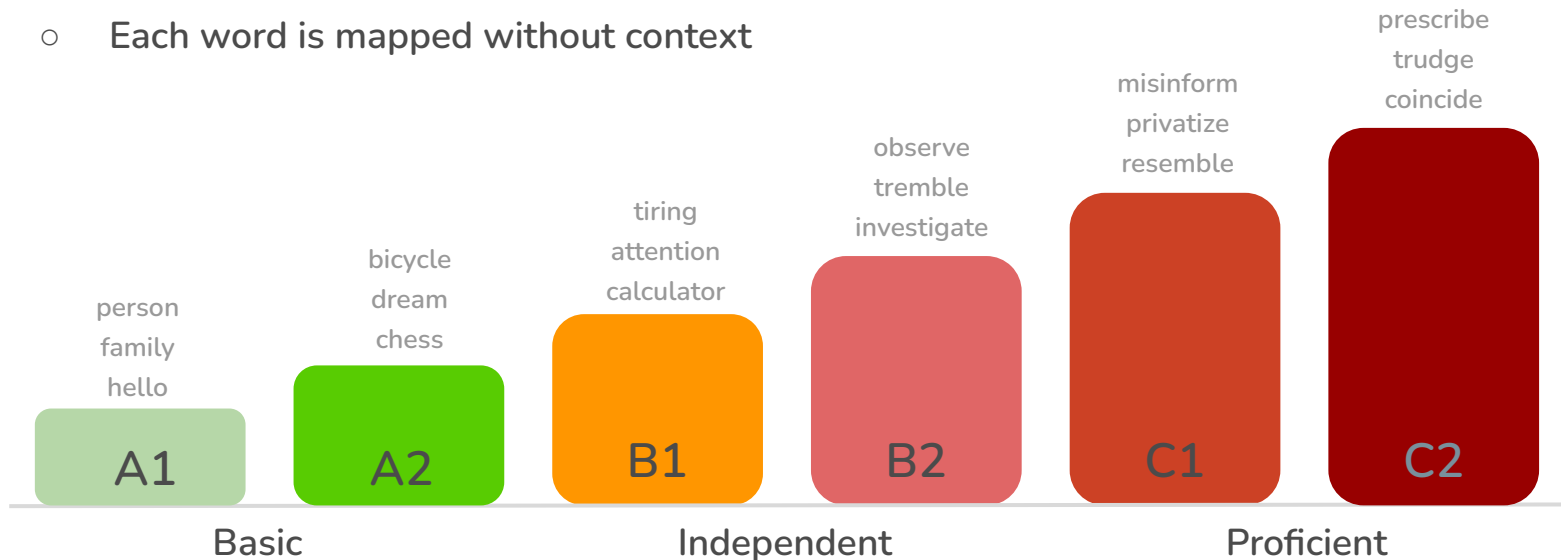
CEFR checker problem setup

- **Want a mapping** — from text to required CEFR proficiency level
- **Simplifications**
 - Map words to CEFR levels



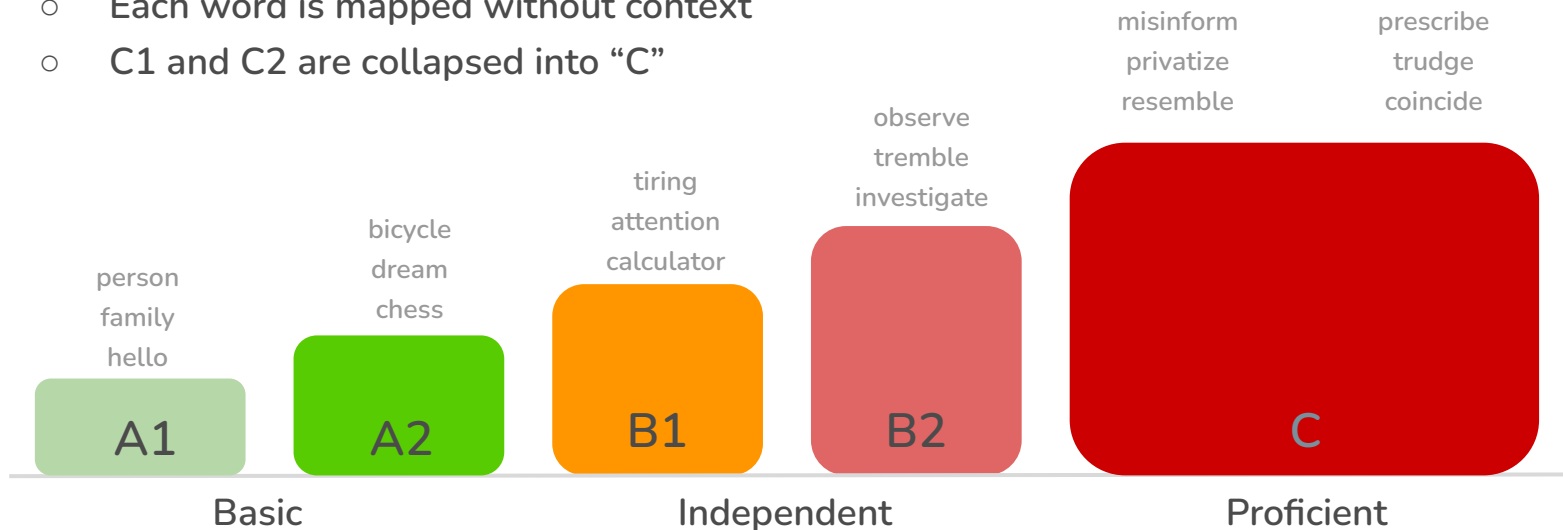
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 - Each word is mapped without context



CEFR checker problem setup

- **Want a mapping** — from text to required CEFR proficiency level
- **Simplifications**
 - Map words to CEFR levels
 - Each word is mapped without context
 - C1 and C2 are collapsed into “C”



basic solution

CEFR for words

- **Initial data** — 8800 English words hand-labeled with CEFR levels
 - Initially labeled based on frequencies across essays from learners at various levels
 - Also further curated internally by Duolingo's curriculum experts
 - Further extended to **5218 Spanish** and **5645 French** words labeled from **A1 up to B1**

CEFR for words

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 - Initially labeled based on frequencies across essays from learners at various levels
 - Also further curated internally by Duolingo's curriculum experts
 - Further extended to **5218 Spanish** and **5645 French** words labeled from **A1 up to B1**
- **Generalized to other text**— The CEFR tool generalizes from this initial labeled data
 - A wider vocabulary of hundreds of thousands of English, Spanish, and French words
 - Other languages, including German and Italian
 - But these were not available in the public tool

CEFR for words

- **How to generalize?** — Learn a model from the hand-labeled data that maps language agnostic word representations to CEFR labels

CEFR for words

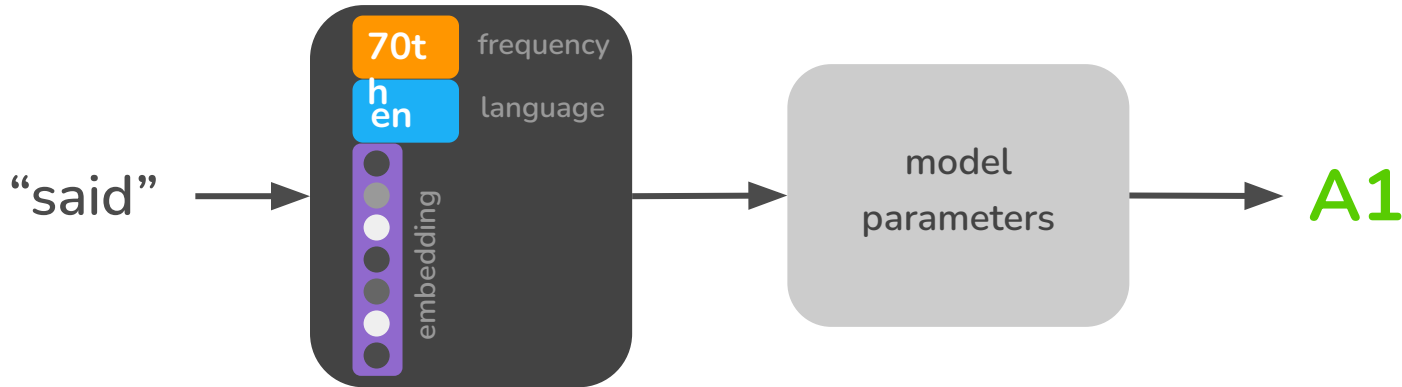
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- **Model** — Logistic regression with some minor tweaks

CEFR for words

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CEFR for words

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model

- **Multinomial Logistic Regression** — Treat CEFR labels as unordered labels

model

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- **Ordinal Logistic Regression** — Rennie, Jason DM, and Nathan Srebro. "Loss functions for preference levels: Regression with discrete ordered labels." Proceedings of the IJCAI multidisciplinary workshop on advances in preference handling. Vol. 1. Kluwer Norwell, MA, 2005.
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 - Treat CEFR labels as **ordered** labels
 - Gives a marginal improvement over multinomial logistic regression
 - We generally use this for the results presented here

corpus word frequency estimates

- **OpenSubtitles** — Tiedemann, Jörg. "Parallel data, tools and interfaces in OPUS." Lrec. Vol. 2012. 2012.
 - Word [frequencies](#) computed across a large corpus of movie subtitles
 - Over 60 languages and millions of documents

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 - Word [frequencies](#) computed across a large corpus of movie subtitles
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- **Features** — We compute several features to allow non-linear relationships to CEFR labels
 - Log raw frequencies
 - Log frequency ranks
 - Bucketed log frequency ranks
 - For several bucketed frequency ranges:
 - 1 if log rank below the range
 - 0 if log rank above the range
 - Between 0 and 1 if log rank in the range

multilingual word embeddings

- **Distributional hypothesis** — Words that share similar contexts share similar meanings

multilingual word embeddings

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- **Word vectors** — Use the distributional hypothesis to embed words in a vector space such that words with similar meanings (i.e. contexts) are close in the space

multilingual word embeddings

- **Distributional hypothesis** — Words that share similar contexts share similar meanings
- **Word vectors** — Use the distributional hypothesis to embed words in a vector space such that words with similar meanings (i.e. contexts) are close in the space
- **Multilingual embeddings** — Allow words across languages to share the same space, such that words with similar meanings (e.g. translations) are close in the space

multilingual word embeddings

- **MUSE embeddings** — Conneau, Alexis, et al. “Word translation without parallel data.” arXiv preprint arXiv:1710.04087 (2017)

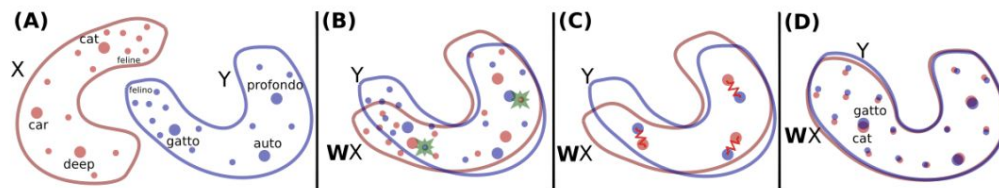


Figure 1: Toy illustration of the method. (A) There are two distributions of word embeddings, English words in red denoted by X and Italian words in blue denoted by Y , which we want to align/translate. Each dot represents a word in that space. The size of the dot is proportional to the frequency of the words in the training corpus of that language. (B) Using adversarial learning, we learn a rotation matrix W which roughly aligns the two distributions. The green stars are randomly selected words that are fed to the discriminator to determine whether the two word embeddings come from the same distribution. (C) The mapping W is further refined via Procrustes. This method uses frequent words aligned by the previous step as anchor points, and minimizes an energy function that corresponds to a spring system between anchor points. The refined mapping is then used to map all words in the dictionary. (D) Finally, we translate by using the mapping W and a distance metric, dubbed CSLS, that expands the space where there is high density of points (like the area around the word “cat”), so that “hubs” (like the word “cat”) become less close to other word vectors than they would otherwise (compare to the same region in panel (A)).

experiment:
generalizing within
languages

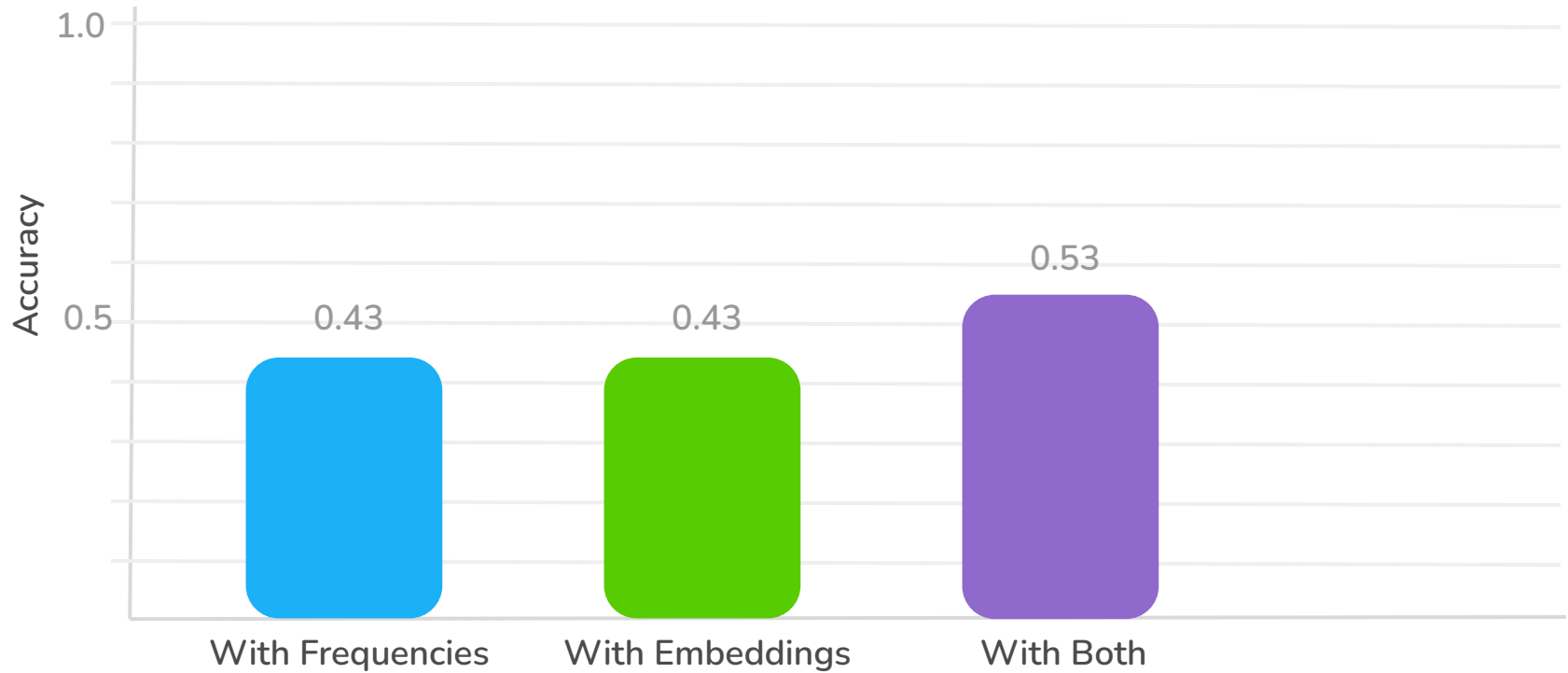
training and evaluation

- **Data** — 7226 English, 3764 Spanish, and 3903 French words hand-labeled with CEFR levels
 - Subset of the full labeled data that had MUSE embeddings and OpenSubtitle frequencies
 - French and Spanish only up through B1

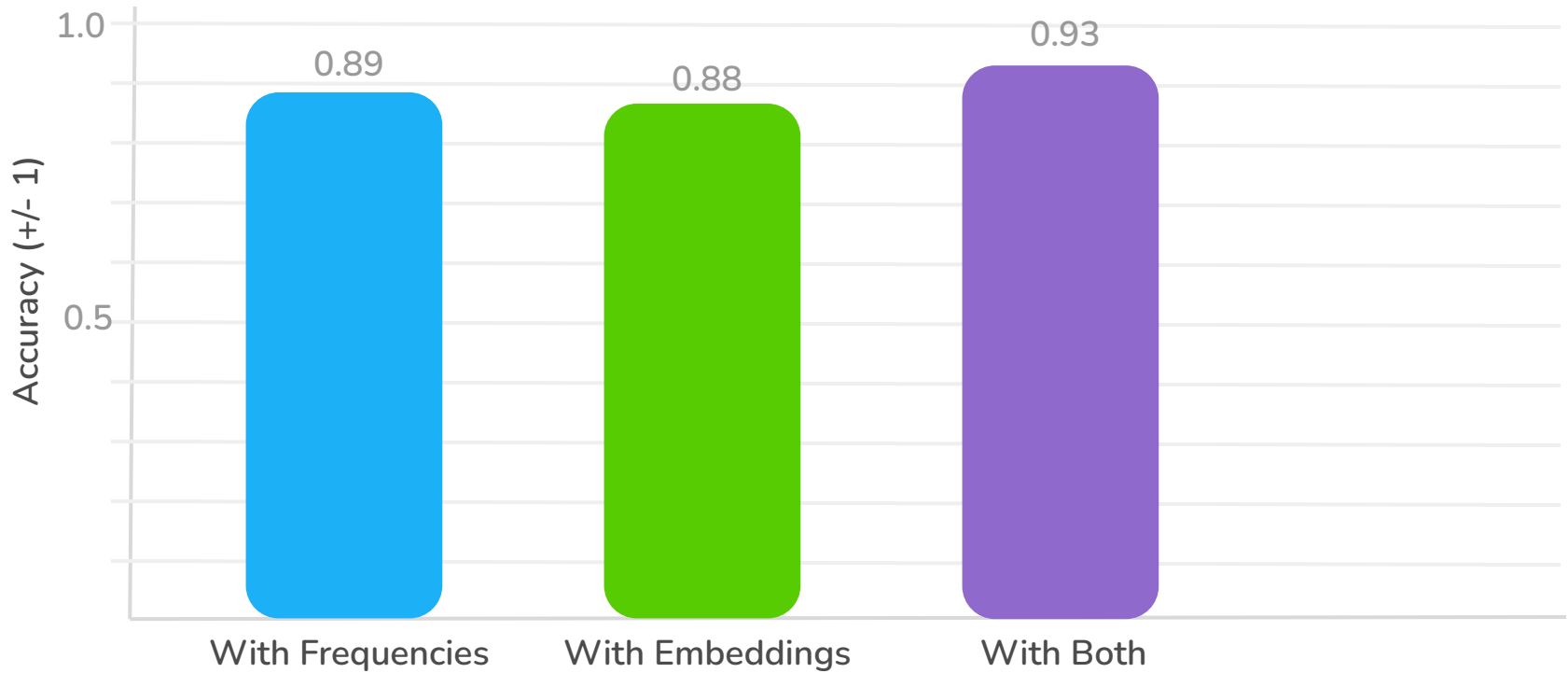
training and evaluation

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 - Subset of the full labeled data that had MUSE embeddings and OpenSubtitle frequencies
 - French and Spanish only up through B1
- **Evaluation** — 4-fold cross-validation on English, French, and Spanish
 - Can we generalize within these languages?
 - Many evaluations (accuracy, F1, Pearson correlation, Spearman rank correlation, etc)
 - We give accuracies here for simplicity, but all tended to hang together, in general

within language generalization



within language generalization



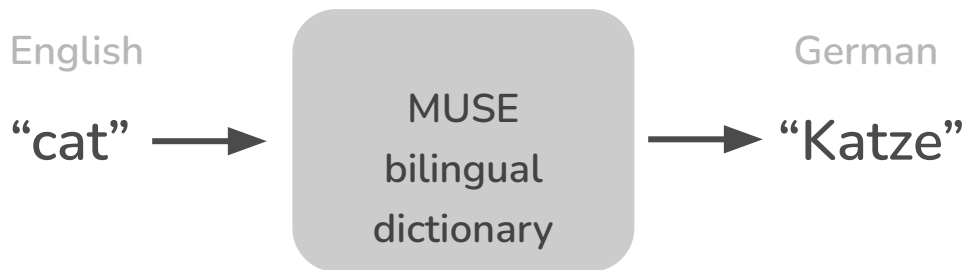
experiment:
generalizing to new
languages

translating data across languages

- **Labeled data** — CEFR labeled English, French (up to B1), and Spanish (up to B1) words

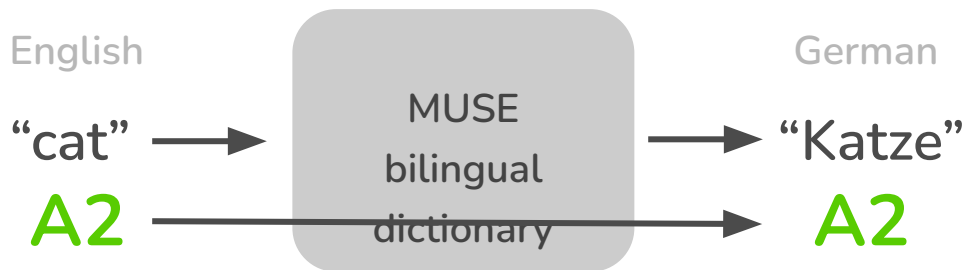
translating data across languages

- **Labeled data** — CEFR labeled English, French (up to B1), and Spanish (up to B1) words
- **Translated data** — Labeled data translated into new languages using bilingual dictionaries
 - Bilingual dictionaries automatically constructed from MUSE embeddings
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 - Translating from English CEFR labeled words, we construct:
 - 8469 Italian CEFR labeled words
 - 8755 German CEFR labeled words
 - 4153 Spanish B2 and C level CEFR labeled words
 - 4161 French B2 and C level CEFR labeled words

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- **Can we generalize from labeled to translated data?** — Evidence for several hypotheses:
 - Does translating using bilingual dictionaries consistently transfer CEFR labels?
 - Can our models generalize across languages?

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note missing simpler
evaluation

cross language generalization

- **Generalize across languages?** — Can a model trained on original labeled data generalize to translated data?

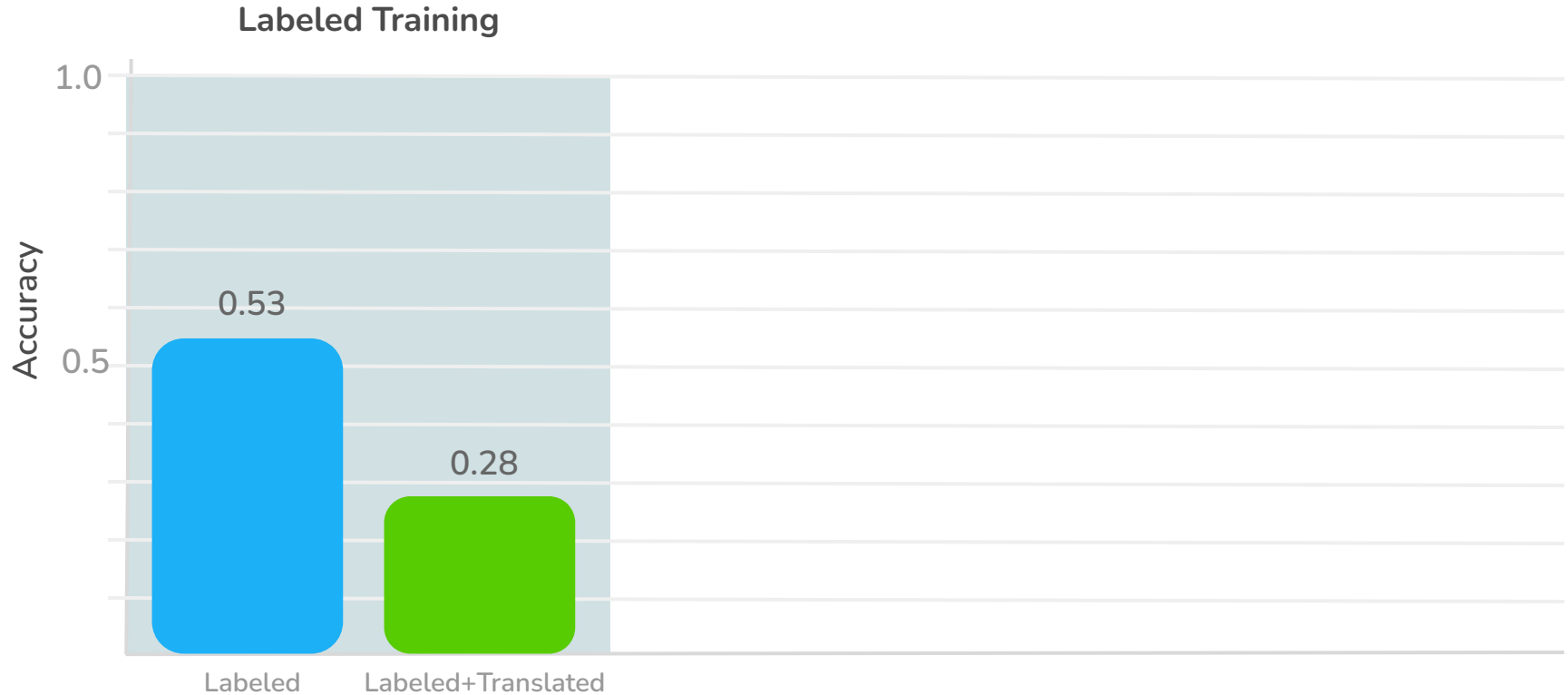
cross language generalization

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cross language generalization

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 - Features are language agnostic (corpus frequencies and MWEs)
 - Evaluate with 4-fold cross validation over translated data, similar to within language generalization experiments

cross language generalization



cross language generalization

- **Generalize across languages** — Can a model trained on labeled data generalize to translated data?
 - Features are language agnostic (corpus frequencies and MWEs)
 - Evaluate with 4-fold cross validation over translated data, similar to within language generalization experiments
 - Accuracy on translated data is lower, so something is wrong. Possibilities:

cross language generalization

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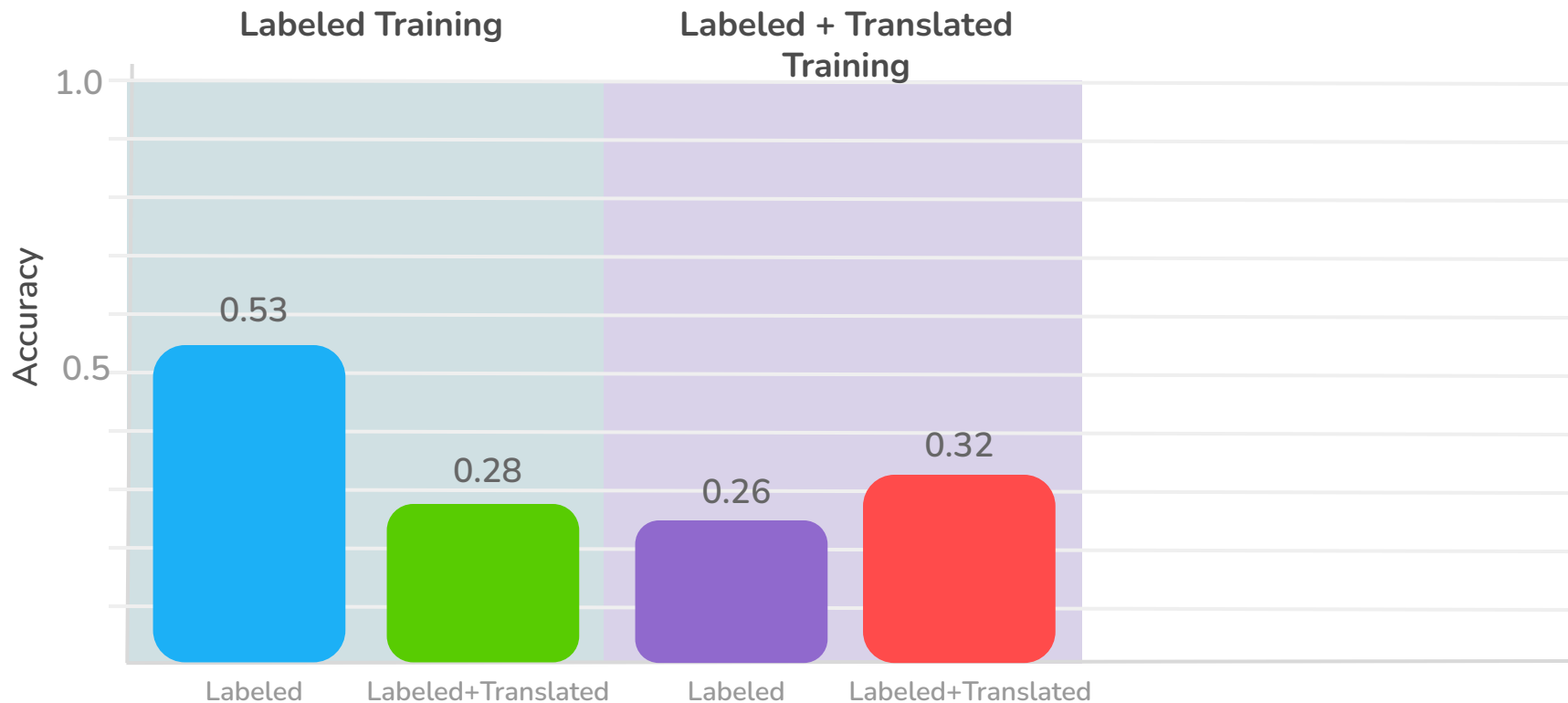
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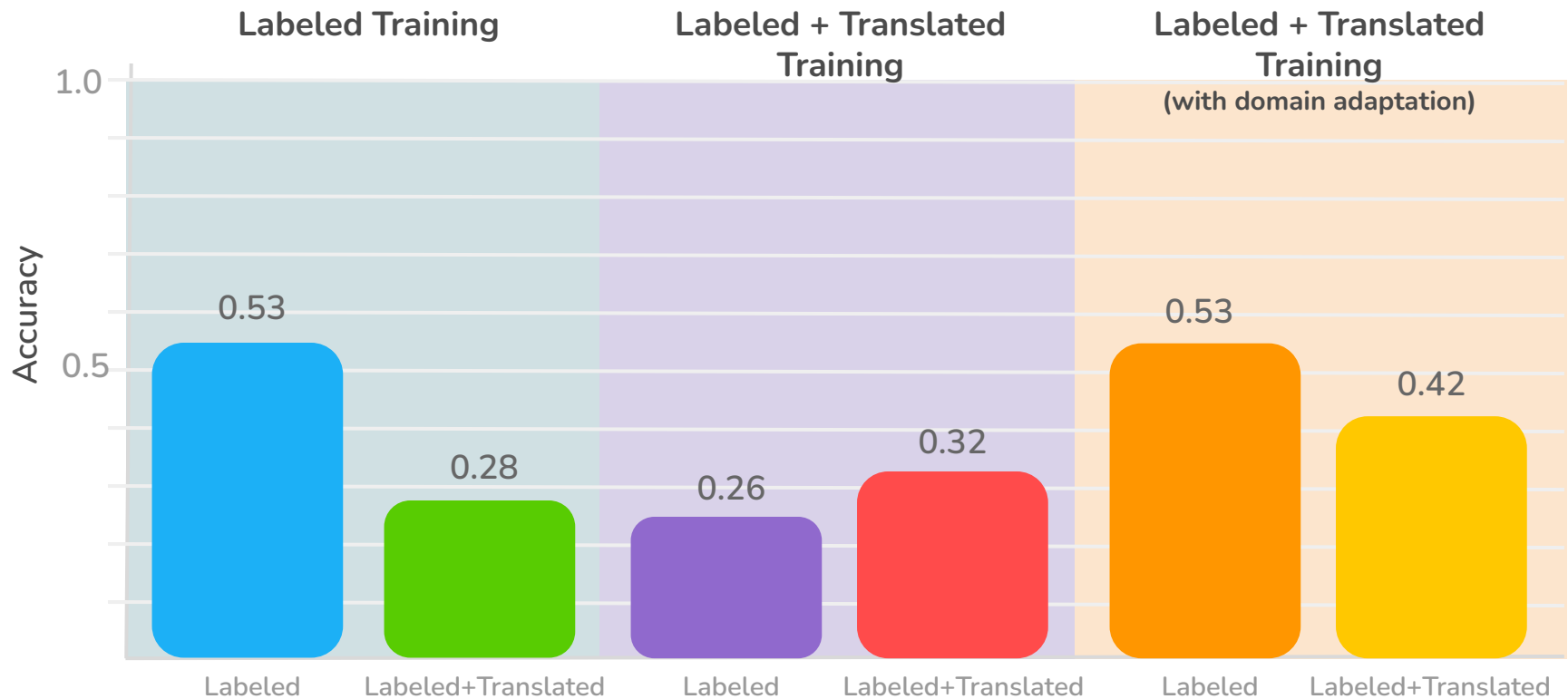
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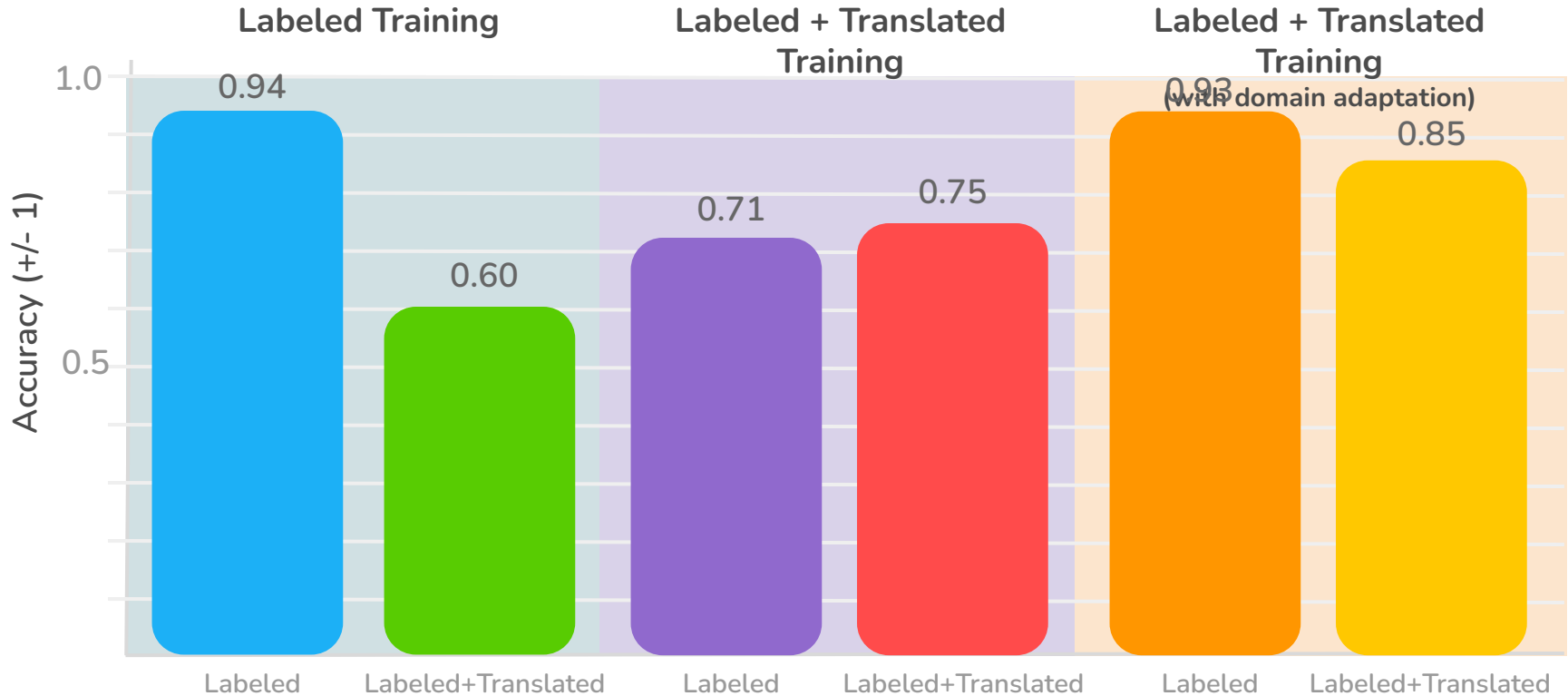
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cross language adaptation



cross language adaptation (+/- 1)



cross language adaptation

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other things we tried

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- **Googlebooks** — <https://books.google.com/ngrams>
 - We used Googlebook word frequency estimates in addition to OpenSubtitles
 - OpenSubtitles tended to produce better results

possible future work

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- **More languages** — Extend these methods to produce predictions across additional languages

questions?



thank you

