#NLP4CALL2019

Predicting learner's knowledge of single words using machine learning

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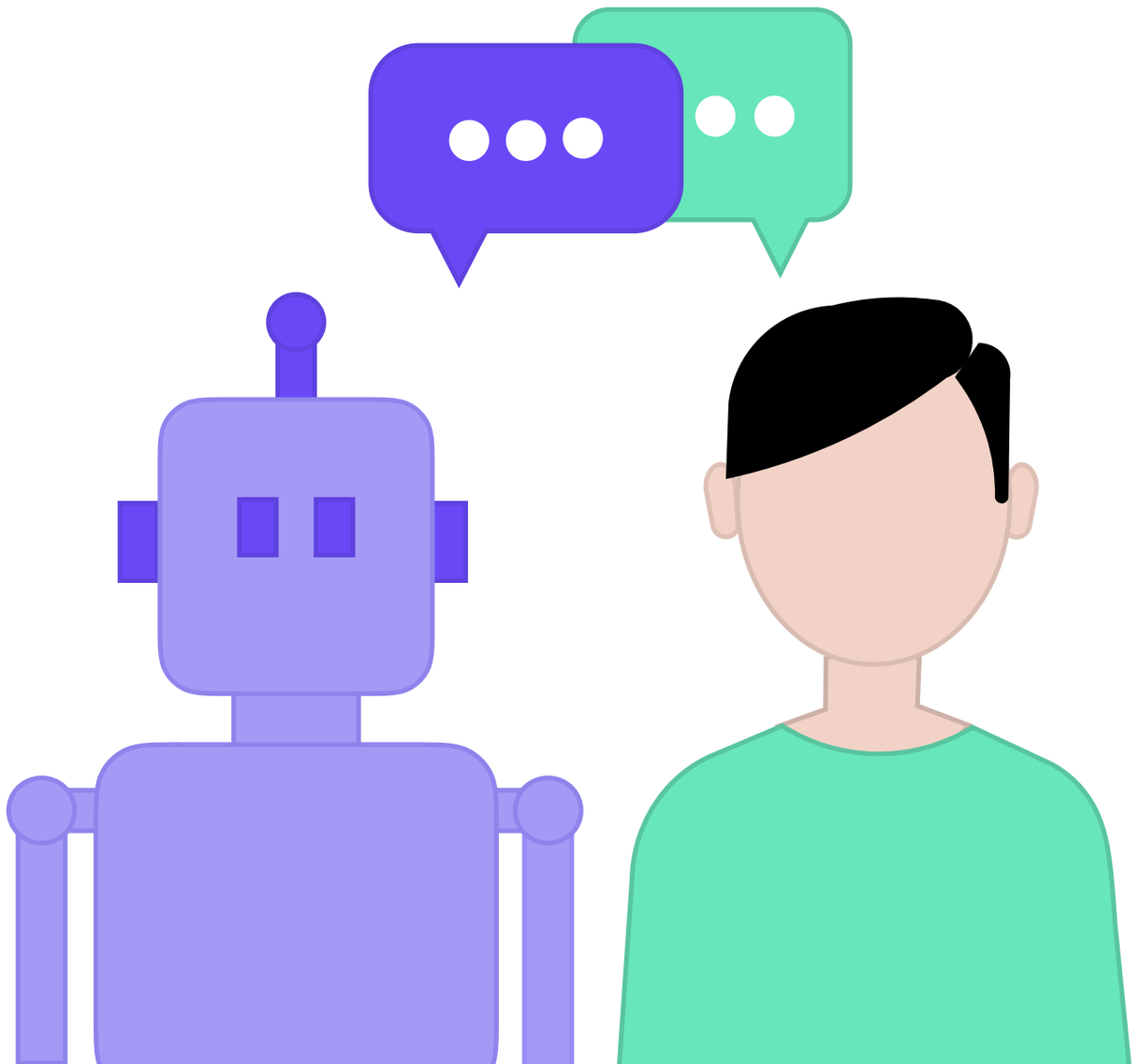
MOTIVATION

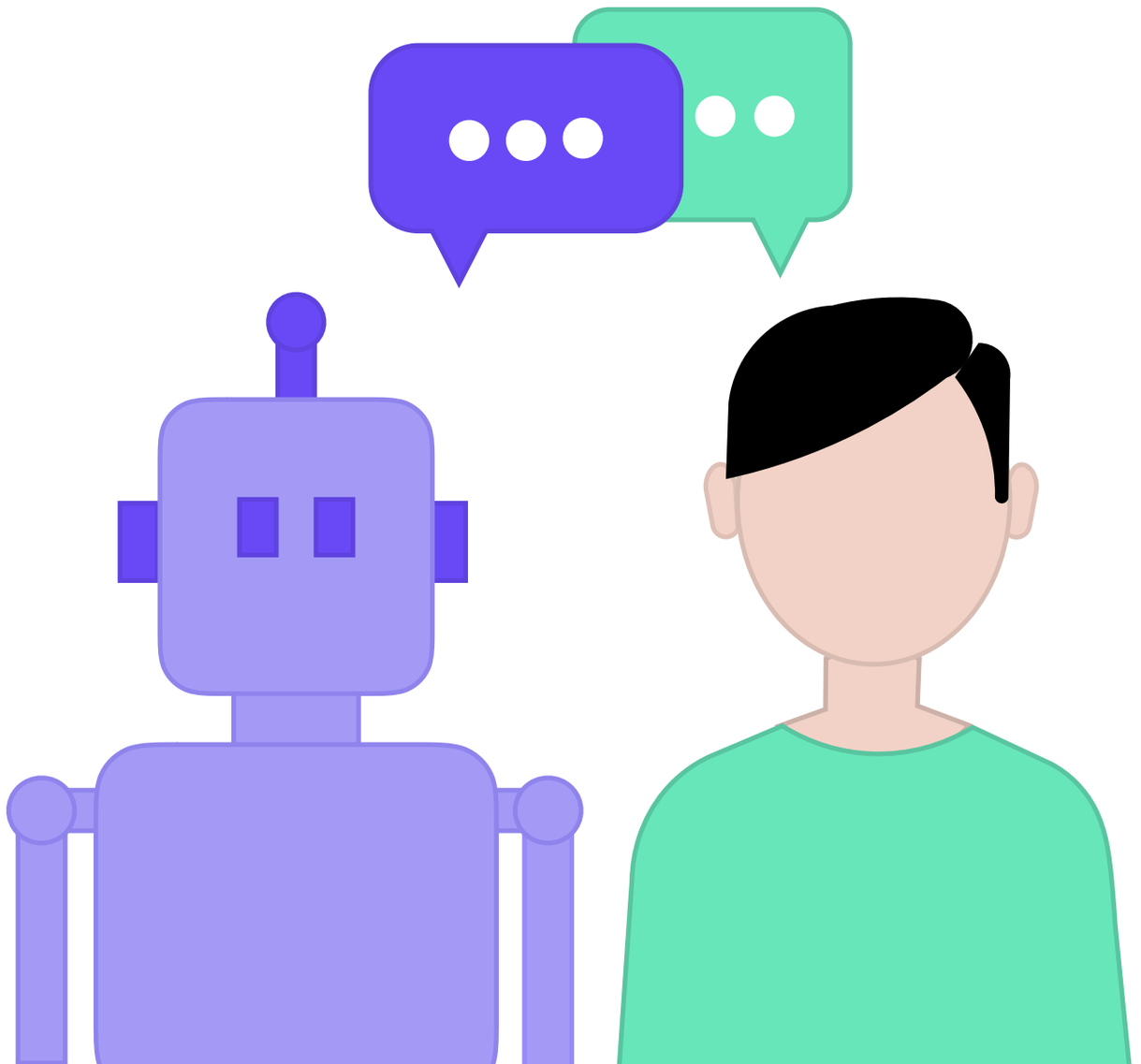
MOTIVATION

for personalized interaction
of intelligent tutoring systems
with language learners



MOTIVATION

for personalized interaction
of the intelligent tutoring system **Elia**
with language learners



MOTIVATION

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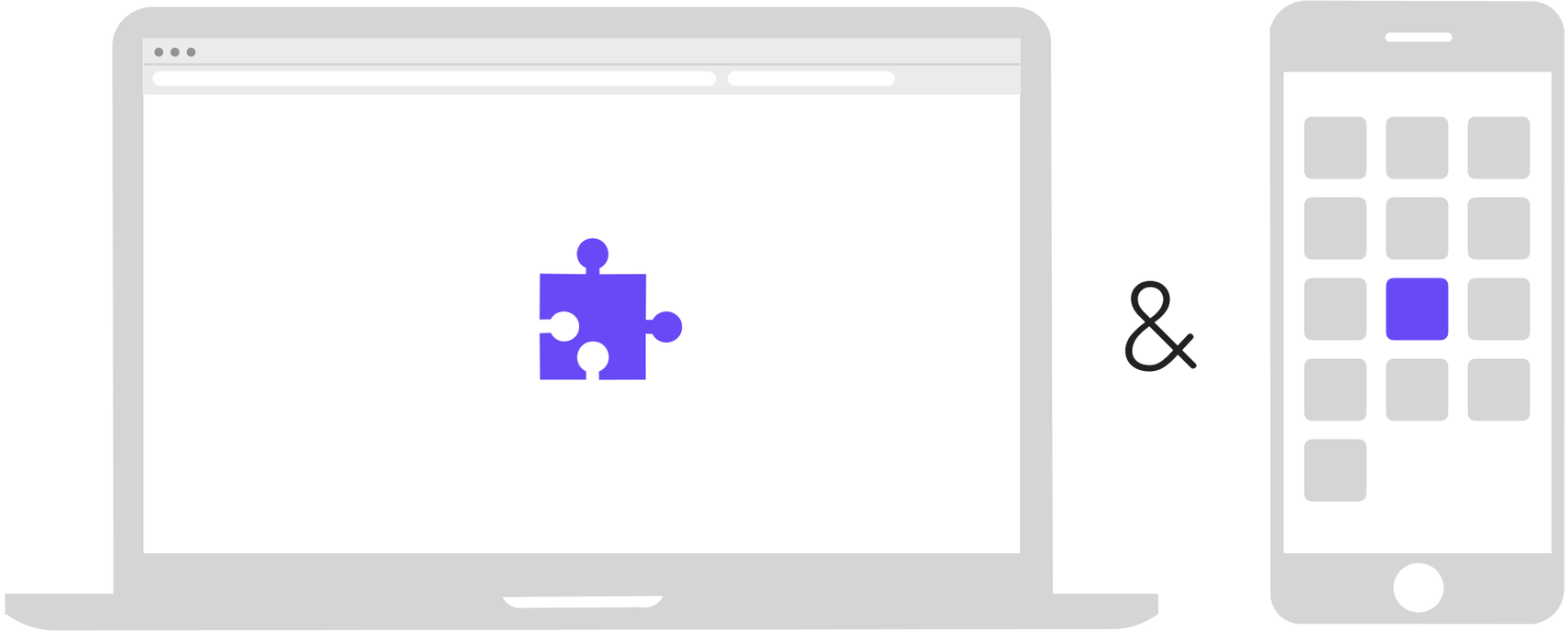
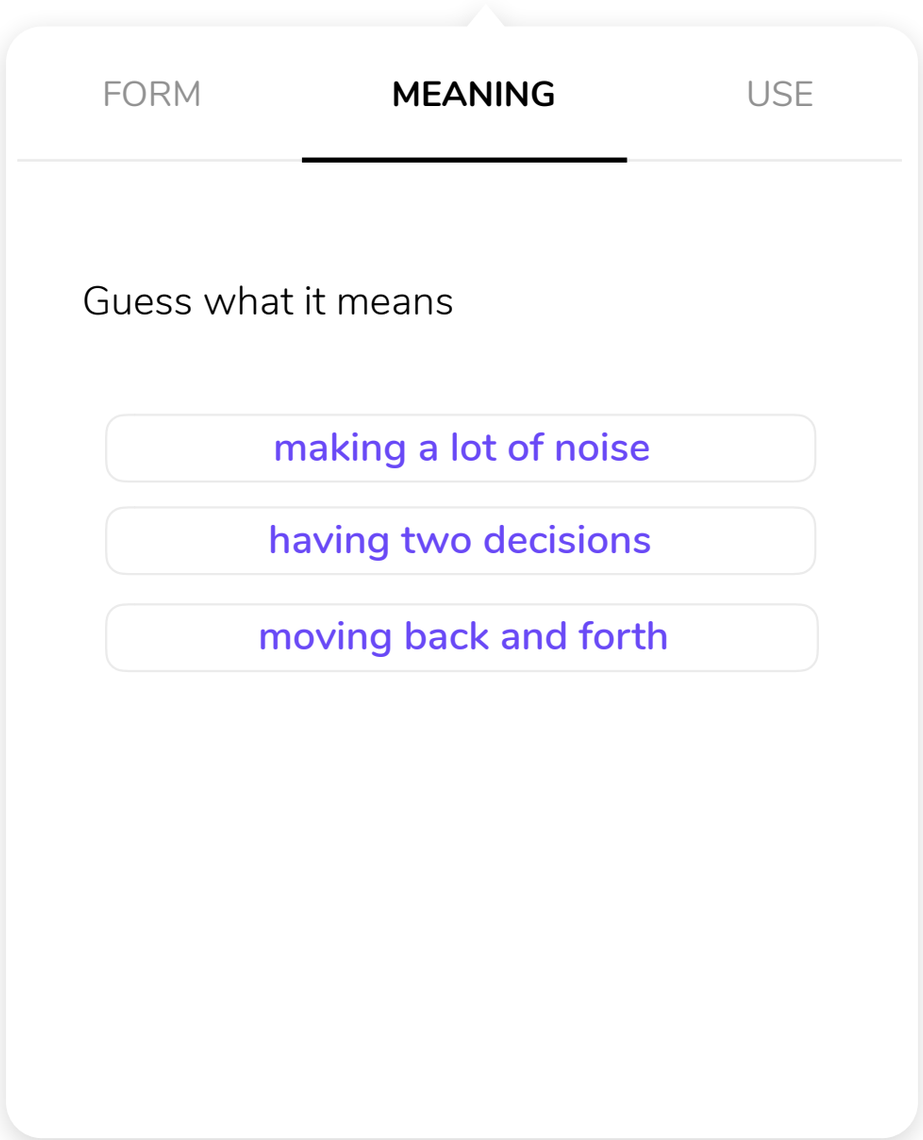


MOTIVATION


FORM
MEANING
USE
Guess what it means
making a lot of noise
having two decisions
moving back and forth

MOTIVATION

FORM | **MEANING** | USE

You might know this word!

It comes from the same word family as:

attend VERB

NEXT

MOTIVATION

FORM | **MEANING** | USE

You have seen this word before in these sentence(s)!

This was a nice a nice evening.
They gave me a very nice present.

NEXT

MOTIVATION

Fill the gap with a correct word!

The plan gained rapid media

shortly afterwards.

NEXT

MOTIVATION

Choose the closest synonym of
the word **-attention**!

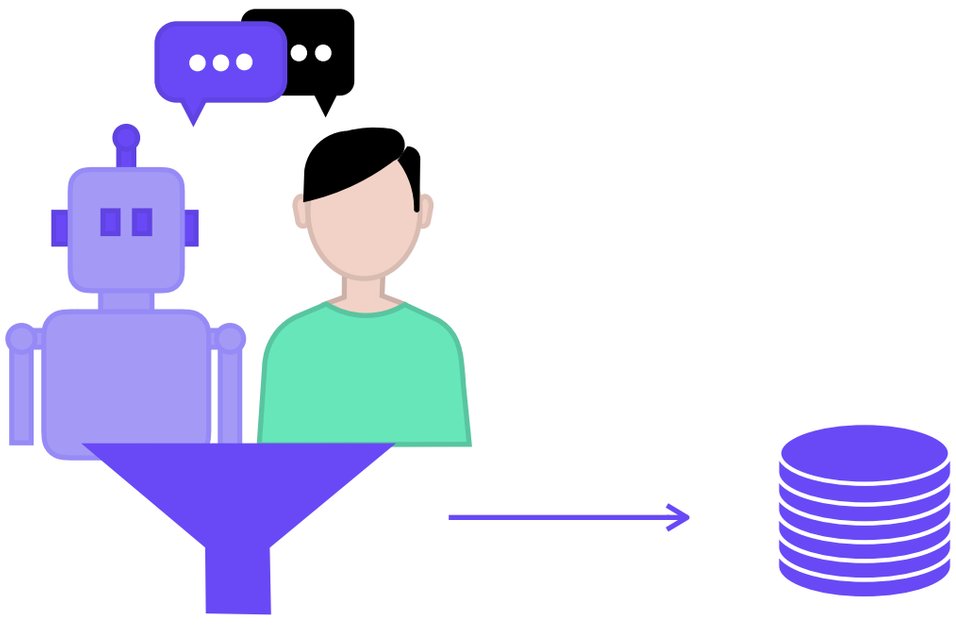
focus

characteristic

uniqueness

NEXT

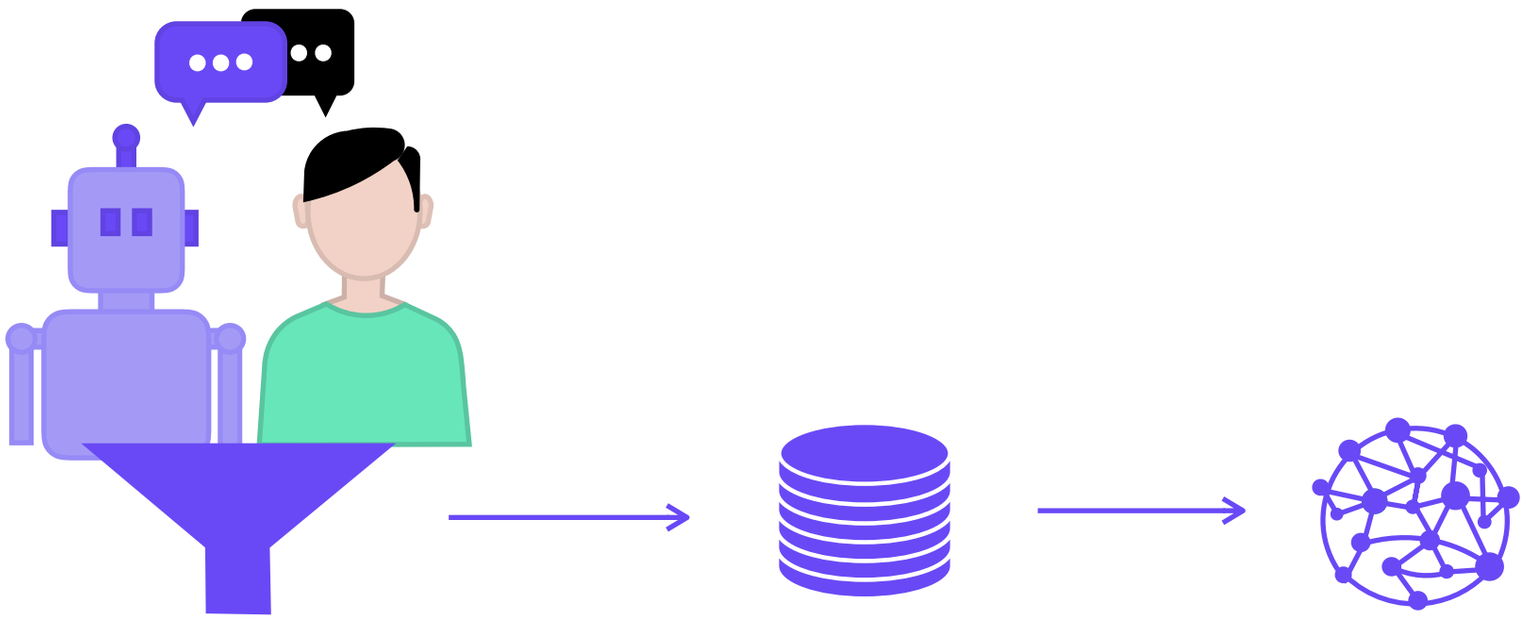
MOTIVATION



INTERACTION

DATA

MOTIVATION

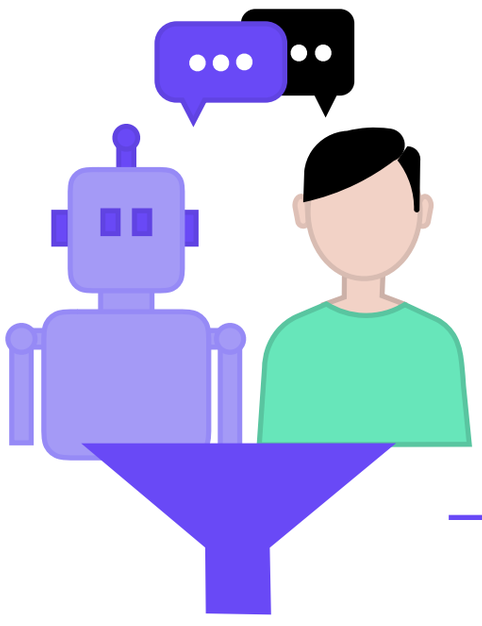


INTERACTION

DATA

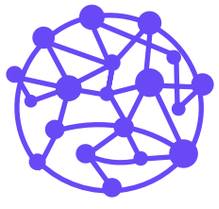
LEARNER MODEL

MOTIVATION

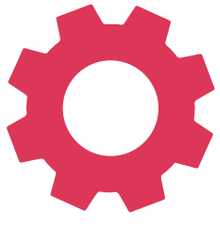


INTERACTION

DATA

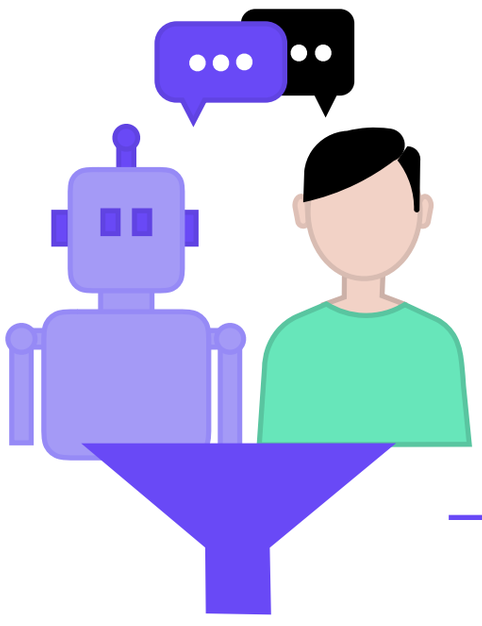


LEARNER MODEL



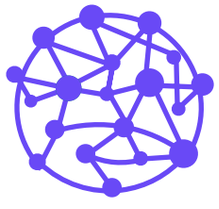
KNOWLEDGE PREDICTION MODEL

MOTIVATION

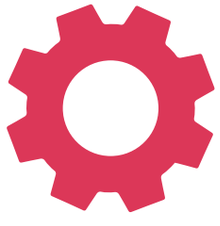


INTERACTION

DATA

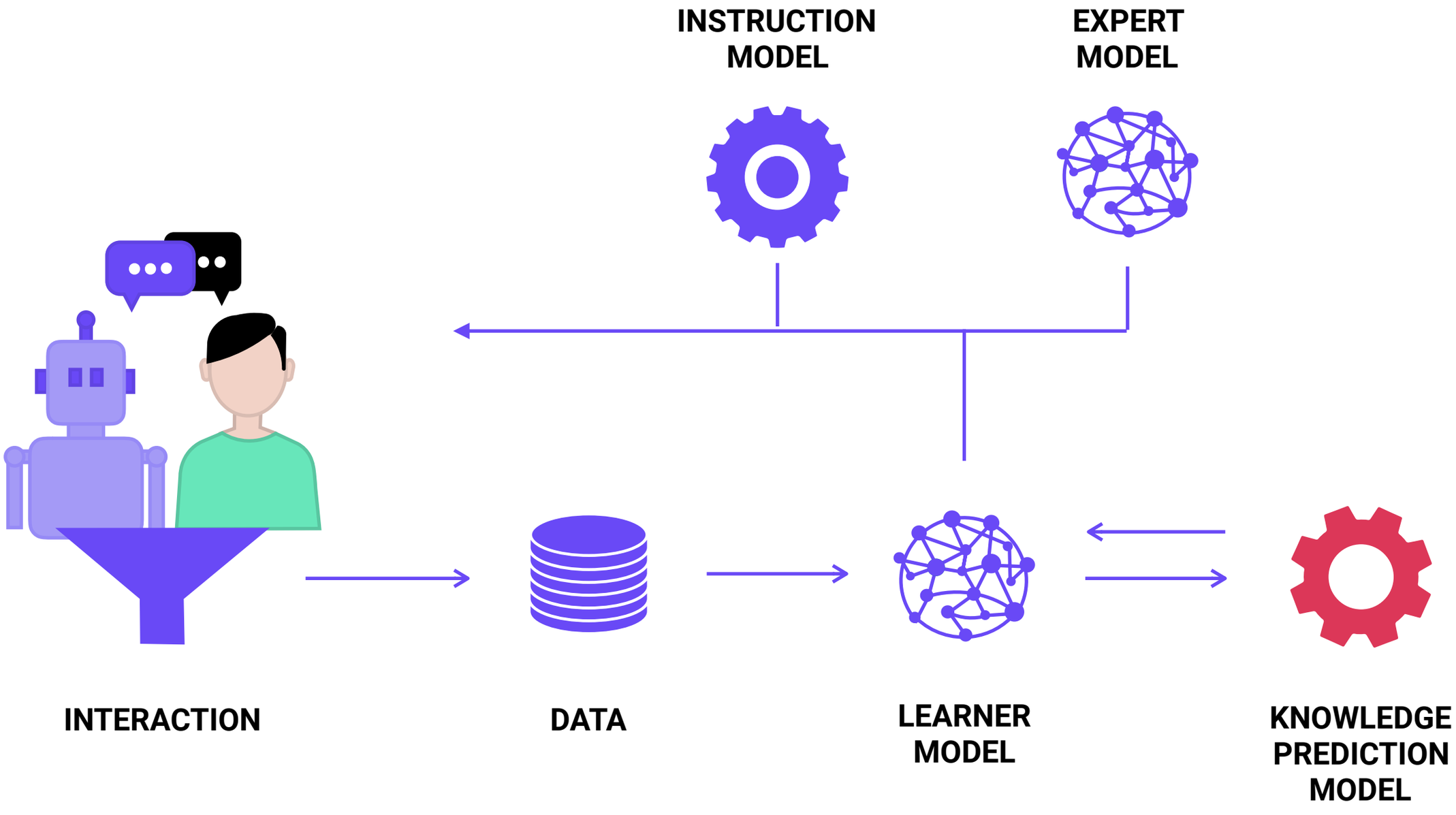


LEARNER MODEL



KNOWLEDGE PREDICTION MODEL

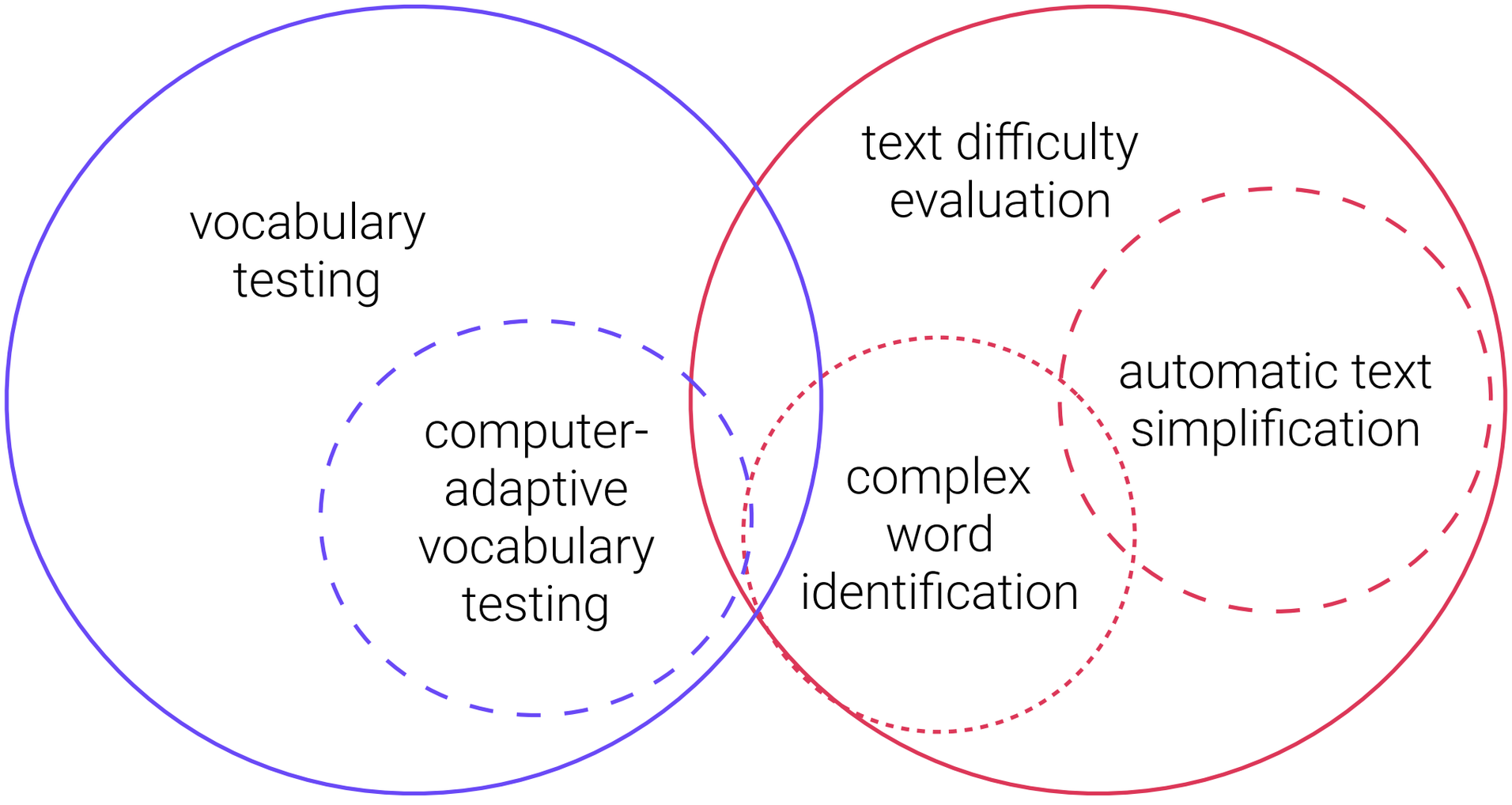
MOTIVATION


INSTRUCTION MODEL
EXPERT MODEL
INTERACTION
DATA
LEARNER MODEL
KNOWLEDGE PREDICTION MODEL

SINGLE-WORD KNOWLEDGE PREDICTION

	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1	???	KNOWN	UNKNOWN	???	UNKNOWN	KNOWN
Learner 2	UNKNOWN	???	???	KNOWN	KNOWN	KNOWN
Learner 3	KNOWN	KNOWN	UNKNOWN	UNKNOWN	???	KNOWN
Learner 4	???	KNOWN	???	KNOWN	???	UNKNOWN
Learner 5	UNKNOWN	???	???	???	UNKNOWN	???
Learner 6	KNOWN	???	KNOWN	UNKNOWN	KNOWN	KNOWN
Learner …	UNKNOWN	???	KNOWN	KNOWN	???	???

SINGLE-WORD KNOWLEDGE PREDICTION



RELATED STUDIES

Studies which tried to predict the knowledge of **single words** for **language learners**.

	Tack et al. (2016)	Alfter & Volodina (2018)	Lee & Yeung (2018)	Yancey & Lepage (2018)	Ehara et al. (2018)	This study (2019)

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application	text simplification /adaptation	exercise/ material generation	search for reading materials	text simplification	reading support	intelligent tutoring system
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L2 learners	**French**	**Swedish**	**Chinese**	**Korean**	**English**	**English**

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L2 learners	**French**	**Swedish**	**Chinese**	**Korean**	**English**	**English**
personalized	**NO**	**NO**	**YES**	**NO**	**YES**	**YES**

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L2 learners	**French**	**Swedish**	**Chinese**	**Korean**	**English**	**English**
personalized	**NO**	**NO**	**YES**	**NO**	**YES**	**YES**
machine learning	**NO**	**YES**	**YES**	**YES**	**NO**	**YES**

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application	Tack et al. (2016)	Alfter & Volodina (2018)	Lee & Yeung (2018)	Yancey & Lepage (2018)	Ehara et al. (2018)	This study (2019)
L2 learners	French	Swedish	Chinese	Korean	English	English
personalized	NO	NO	YES	NO	YES	YES
machine learning	NO	YES	YES	YES	NO	YES
unseen words	NO	NO	YES	YES	YES	YES

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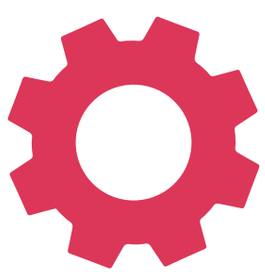
L2 learners	French	Swedish	Chinese	Korean	English	English
personalized	NO	NO	YES	NO	YES	YES
machine learning	NO	YES	YES	YES	NO	YES
unseen words	NO	NO	YES	YES	YES	YES
all-learner-together training	-	-	NO	-	-	YES

OUR STUDY

OUR STUDY

datatset

features



models

DATASET

Ehara (2012)

	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1						
Learner 2						
Learner 3						
Learner 4						
Learner 5						
Learner …						

DATASET

Ehara (2012)

16 Japanese learners x **12,000 words** from the SVL list

	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1						
Learner 2						
Learner 3						
Learner 4						
Learner 5						
Learner …						

DATASET

Ehara (2012)

16 Japanese learners x **12,000 words** from the SVL list

Knowledge scale from “Never seen the word” to “Know the word’s meaning”

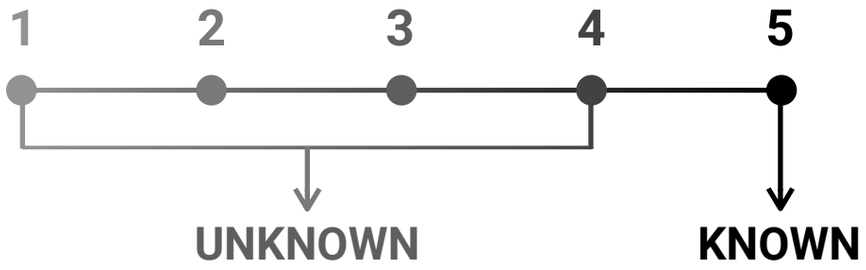
	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1	5	3	5	1	5	3
Learner 2	2	5	2	2	4	5
Learner 3	3	5	1	4	1	1
Learner 4	4	5	5	1	2	2
Learner 5	3	4	5	3	5	5
Learner …	2	4	2	4	2	5

DATASET

Ehara (2012)

16 Japanese learners x **12,000 words** from the SVL list

Knowledge scale from “Never seen the word” to “Know the word’s meaning”



	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1	5	3	5	1	5	3
Learner 2	2	5	2	2	4	5
Learner 3	3	5	1	4	1	1
Learner 4	4	5	5	1	2	2
Learner 5	3	4	5	3	5	5
Learner …	2	4	2	4	2	5

DATASET

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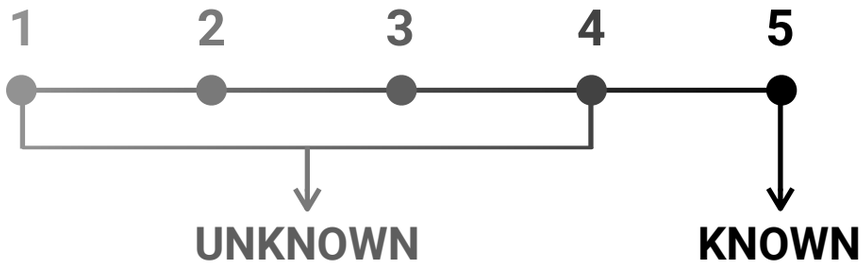
Knowledge scale from “Never seen the word” to “Know the word’s meaning”



	Word 1	Word 2	Word 3	Word 4	Word 5	Word …
Learner 1	KNOWN	UNKNOWN	KNOWN	UNKNOWN	KNOWN	UNKNOWN
Learner 2	UNKNOWN	KNOWN	UNKNOWN	UNKNOWN	UNKNOWN	KNOWN
Learner 3	UNKNOWN	KNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
Learner 4	UNKNOWN	KNOWN	KNOWN	UNKNOWN	UNKNOWN	UNKNOWN
Learner 5	UNKNOWN	UNKNOWN	KNOWN	UNKNOWN	KNOWN	KNOWN
Learner …	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	KNOWN

FEATURES

	Feature 1	Feature 2	...	Feature 23	Feature 24	Feature 25	...	Feature 78	Label
Learner 1 x **Word 1**									**KNOWN**
Learner 1 x **Word 2**									**KNOWN**
Learner 1 x **Word 3**									**UNKNOWN**
Learner 2 x **Word 1**									**KNOWN**
Learner 2 x **Word 2**									**UNKNOWN**
Learner 2 x **Word ...**									**UNKNOWN**

FEATURES

Word-specific

	Feature 1	Feature 2	...	Feature 23	Feature 24	Feature 25	...	Feature 78	Label
Learner 1 x **Word 1**									**KNOWN**
Learner 1 x **Word 2**									**KNOWN**
Learner 1 x **Word 3**									**UNKNOWN**
Learner 2 x **Word 1**									**KNOWN**
Learner 2 x **Word 2**									**UNKNOWN**
Learner 2 x **Word ...**									**UNKNOWN**

FEATURES

	Word-specific				Learner-specific				
	Feature 1	Feature 2	...	Feature 23	Feature 24	Feature 25	...	Feature 78	Label
Learner 1 x **Word 1**									KNOWN
Learner 1 x **Word 2**									KNOWN
Learner 1 x **Word 3**									UNKNOWN
Learner 2 x **Word 1**									KNOWN
Learner 2 x **Word 2**									UNKNOWN
Learner 2 x **Word ...**									UNKNOWN

FEATURES

Word-specific

	History	Movies	...	Feature 23	Feature 24	Feature 25	...	Feature 78	Label
Learner 1 x **Word 1**									**KNOWN**
Learner 1 x **Word 2**									**KNOWN**
Learner 1 x **Word 3**									**UNKNOWN**
Learner 2 x **Word 1**									**KNOWN**
Learner 2 x **Word 2**									**UNKNOWN**
Learner 2 x **Word ...**									**UNKNOWN**

FEATURES

normalized frequency of the target word in different genres

Word-specific

	History	Movies	...	Feature 23	Feature 24	Feature 25	...	Feature 78	Label
Learner 1 x **Word 1**	345261	568432							KNOWN
Learner 1 x **Word 2**	7432	6930							KNOWN
Learner 1 x **Word 3**	90234112	89996010							UNKNOWN
Learner 2 x **Word 1**	345261	568432							KNOWN
Learner 2 x **Word 2**	7432	6930							UNKNOWN
Learner 2 x **Word ...**	90234112	89996010							UNKNOWN

FEATURES

normalized frequency of the target word in different genres ⟶ COCA corpus (Davies, 2008)

Word-specific

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FEATURES

normalized frequency of the target word in different genres ⟶ COCA corpus (Davies, 2008)
psycholinguistic characteristics of the word

Word-specific

	History	Movies	…	Meaningful	Feature 24	Feature 25	…	Feature 78	Label
Learner 1 x **Word 1**	345261	568432	…	3					KNOWN
Learner 1 x **Word 2**	7432	6930	…	5					KNOWN
Learner 1 x **Word 3**	90234112	89996010	…	2					UNKNOWN
Learner 2 x **Word 1**	345261	568432	…	3					KNOWN
Learner 2 x **Word 2**	7432	6930	…	5					UNKNOWN
Learner 2 x **Word …**	90234112	89996010	…	2					UNKNOWN

FEATURES

normalized frequency of the target word in different genres ⟶ COCA corpus (Davies, 2008)
psycholinguistic characteristics of the word ⟶ MRC psycholinguistic database

Word-specific

	History	Movies	…	Meaningful	Feature 24	Feature 25	…	Feature 78	Label
Learner 1 x **Word 1**	345261	568432	…	3					KNOWN
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FEATURES

normalized frequency of the target word in different genres ⟶ COCA corpus (Davies, 2008)
psycholinguistic characteristics of the word ⟶ MRC psycholinguistic database

Word-specific

	History	Movies	…	Meaningful	Feature 24	Feature 25	…	Feature 78	Label
Learner 1 x **Word 1**	345261	568432	…	3					KNOWN
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Learner 2 x **Word …**	90234112	89996010	…	2					UNKNOWN

FEATURES

	Word-specific				Learner-specific				
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Learner 2 x **Word 1**	345261	568432	...	3					KNOWN
Learner 2 x **Word 2**	7432	6930	...	5					UNKNOWN
Learner 2 x **Word ...**	90234112	89996010	...	2					UNKNOWN

FEATURES

learner's knowledge of vocabulary in different genres

	Word-specific				Learner-specific				
	History	Movies	...	Meaningful	History	Movies	...	Sports	Label
Learner 1 x **Word 1**	345261	568432	...	3					KNOWN
Learner 1 x **Word 2**	7432	6930	...	5					KNOWN
Learner 1 x **Word 3**	90234112	89996010	...	2					UNKNOWN
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Learner 2 x **Word 2**	7432	6930	...	5					UNKNOWN
Learner 2 x **Word ...**	90234112	89996010	...	2					UNKNOWN

FEATURES

learner's knowledge of vocabulary in different genres and frequencies

	Word-specific				Learner-specific				
	History	Movies	...	Meaningful	History	Movies	...	Sports	Label
Learner 1 x **Word 1**	345261	568432	...	3					KNOWN
Learner 1 x **Word 2**	7432	6930	...	5					KNOWN
Learner 1 x **Word 3**	90234112	89996010	...	2					UNKNOWN
Learner 2 x **Word 1**	345261	568432	...	3					KNOWN
Learner 2 x **Word 2**	7432	6930	...	5					UNKNOWN
Learner 2 x **Word ...**	90234112	89996010	...	2					UNKNOWN

FEATURES

learner's knowledge of vocabulary in different genres and frequencies

⟶ COCA corpus (Davies, 2008)

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	History	Movies	...	Meaningful	History	Movies	...	Sports	Label
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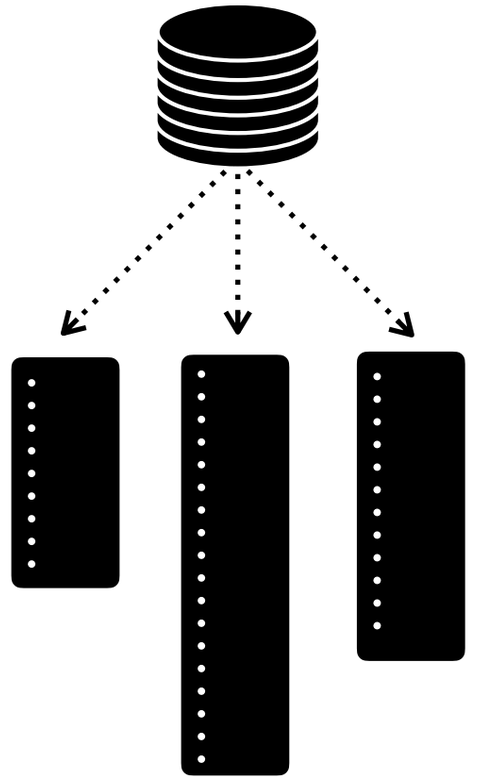
FEATURES

learner's knowledge of vocabulary in different genres and frequencies

⟶ COCA corpus (Davies, 2008)

1. *For each COCA subcorpus, keywordlist created*



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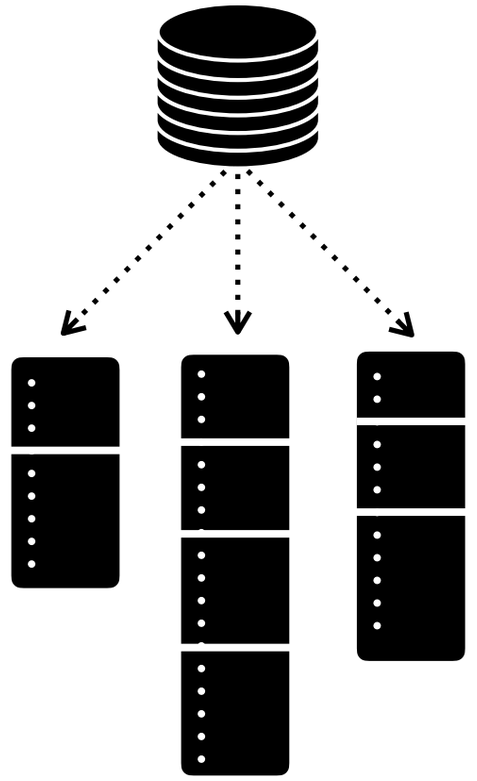
FEATURES

learner's knowledge of vocabulary in different genres and frequencies

⟶ COCA corpus (Davies, 2008)

1. *For each COCA subcorpus, keywordlist created*
2. *For each keywordlist, frequency bands created*



	Word-specific				Learner-specific				
	History	Movies	…	Meaningful	History	Movies	…	Sports	Label
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FEATURES

learner's knowledge of vocabulary in different genres and frequencies

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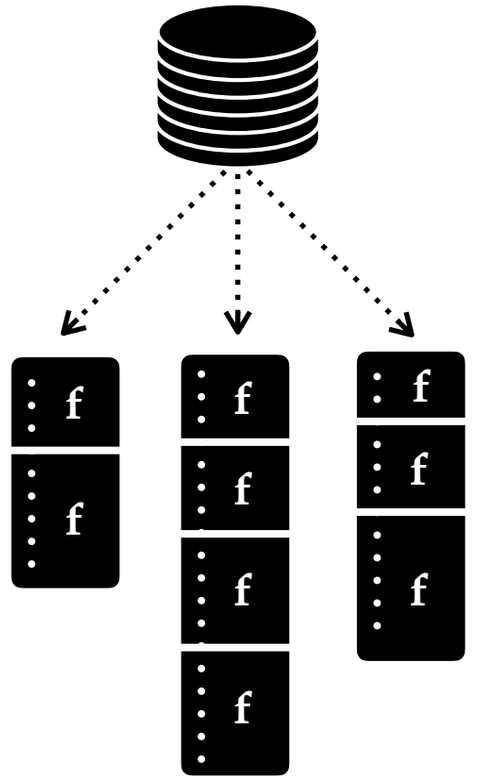

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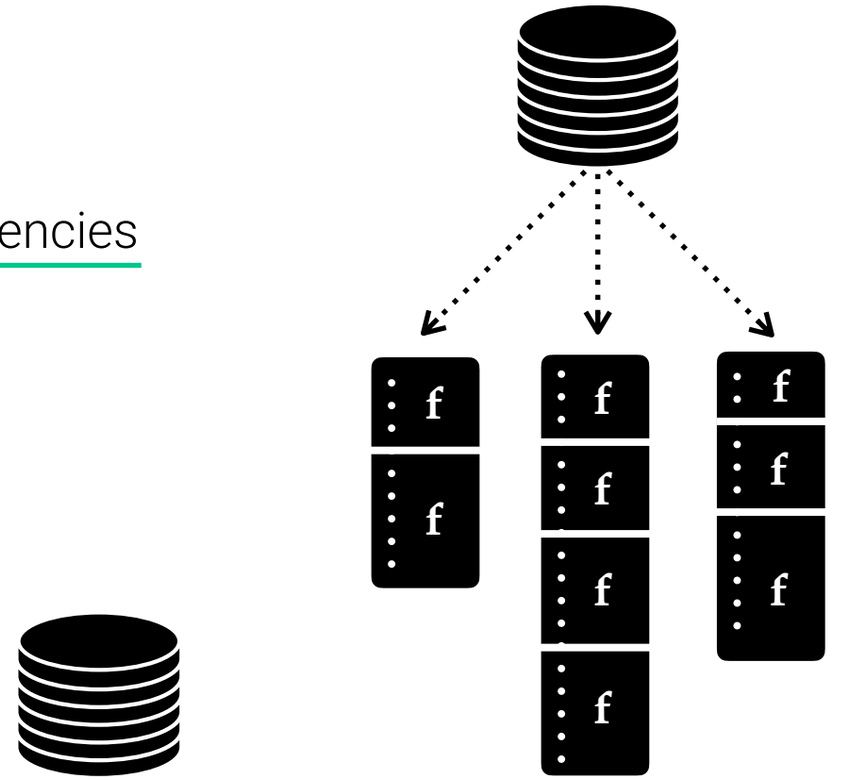

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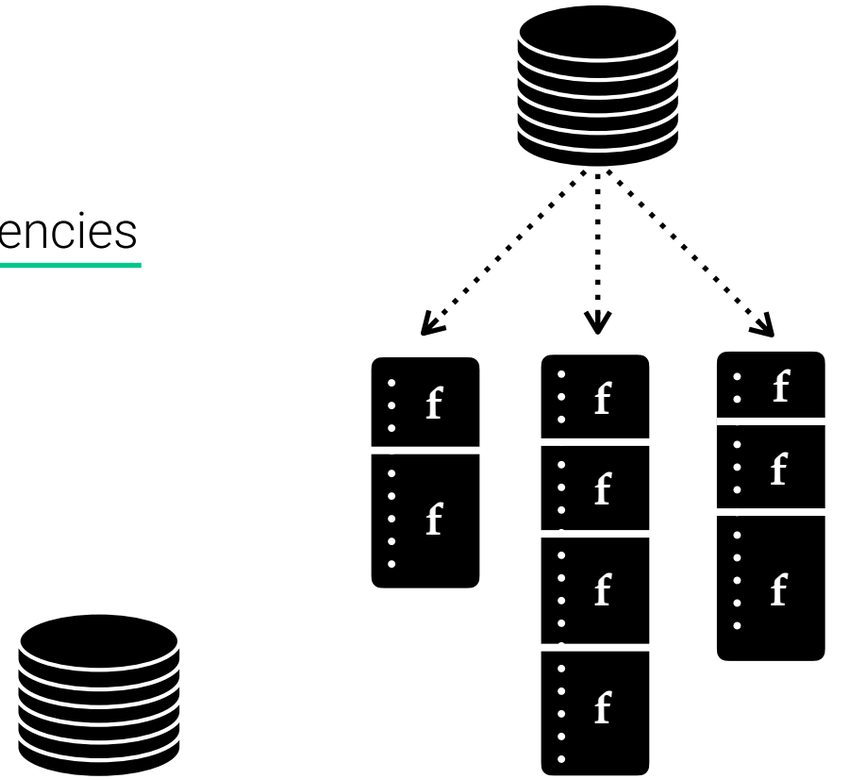

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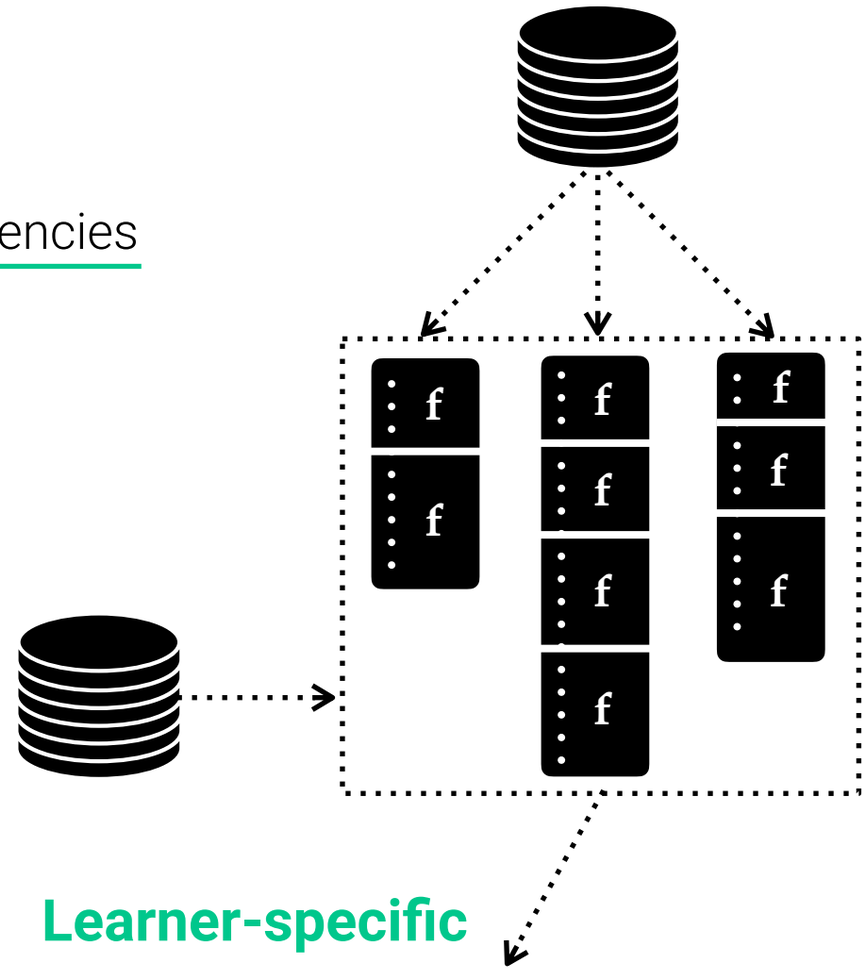

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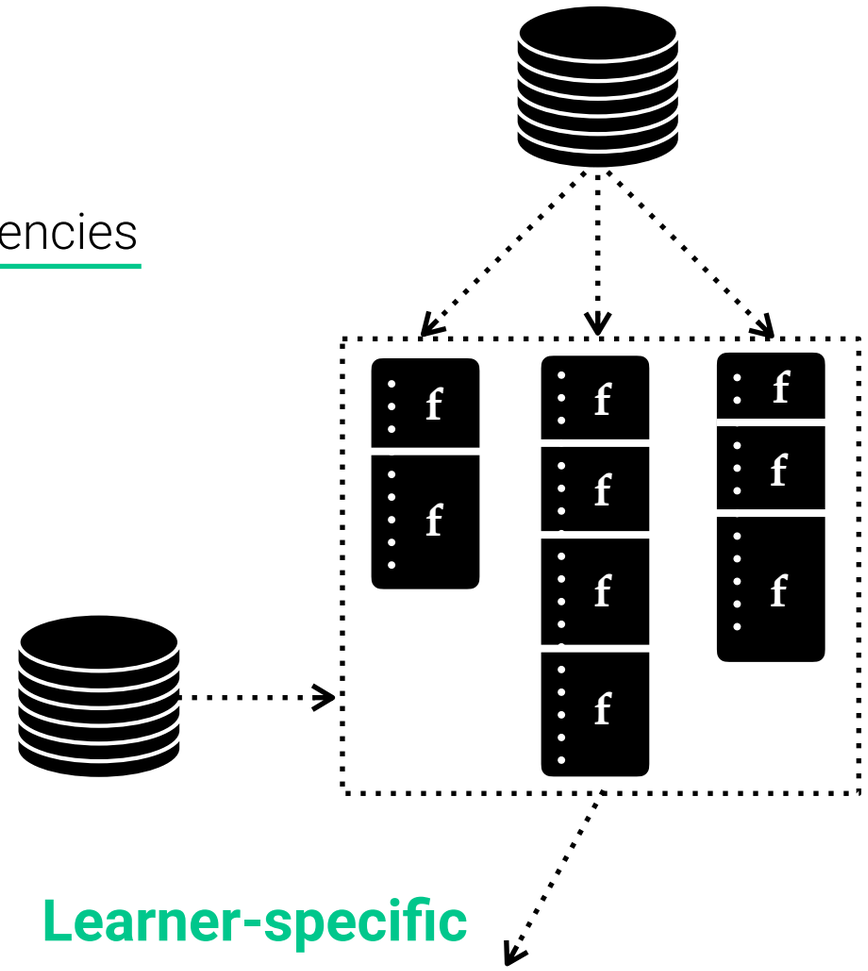

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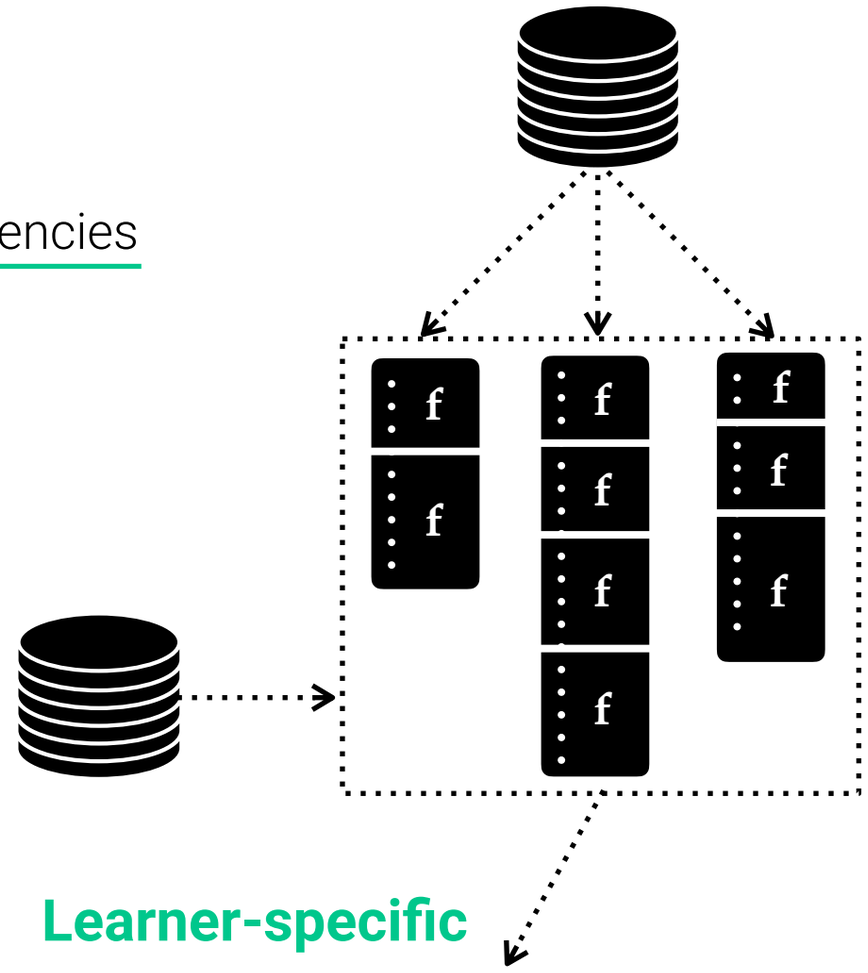

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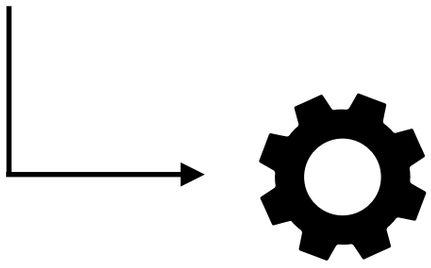

feature
importance
ranking

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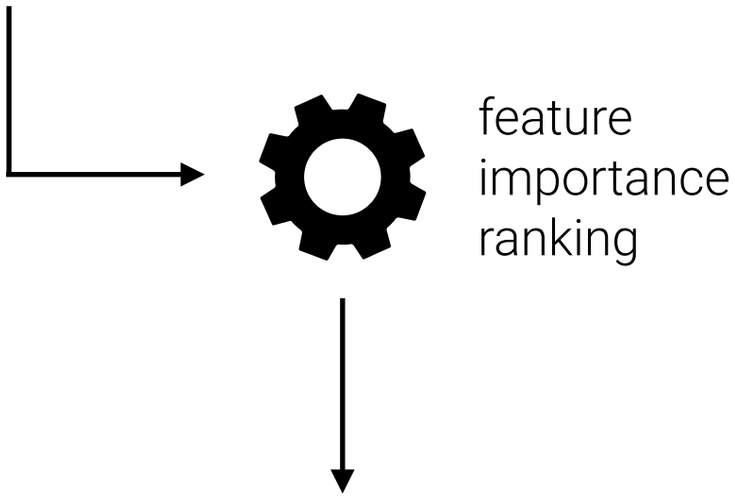

RANK	TYPE	NAME
1	**word**	total
2	**word**	spoken (national public radio)
3	**word**	academic
4	**word**	magazine (women/men)
5	**word**	fiction (journals)
...	...	...
101	**learner**	magazine (African American)
102	**learner**	magazine (home/health)
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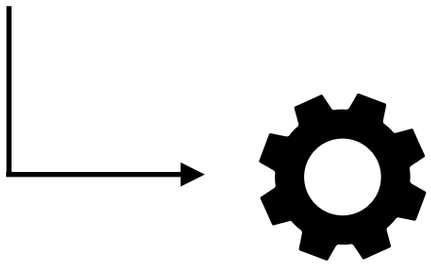

feature importance ranking

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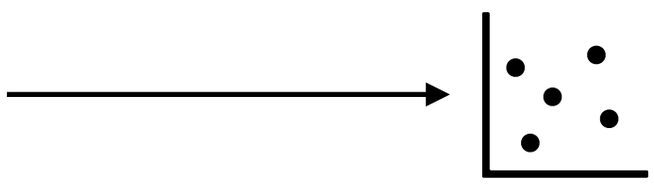

Pearson correlation
If >0.99, keep the top one

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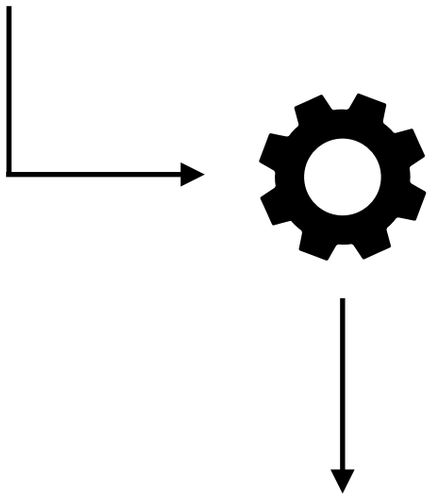

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39 features in total

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...	...	...
35	**learner**	news (local)
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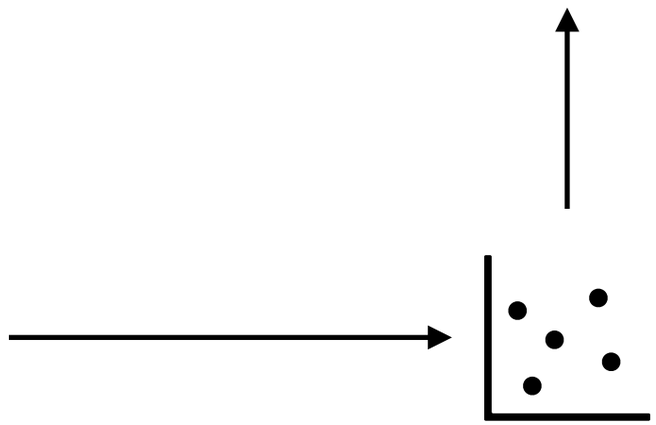
39	**learner**	spoken (national public radio)



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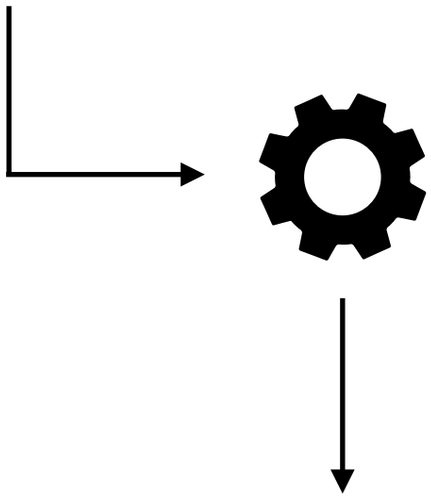

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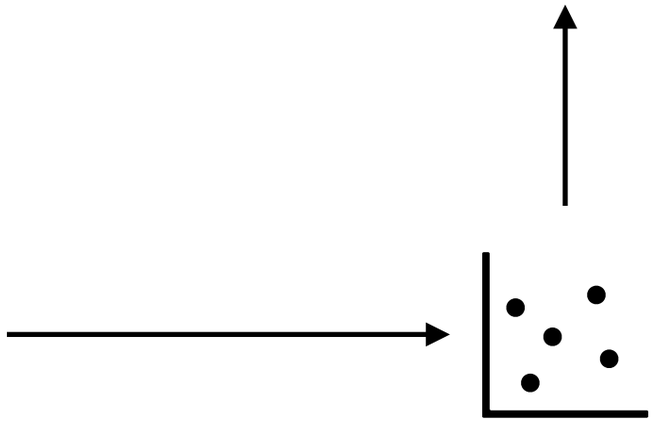

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MODEL

Complete Feature Space Dependent

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word-specific
learner-specific

MODEL

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learner-specific

Random Forest
Support Vector Machine
k Nearest Neighbors
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MODEL

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word-specific
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80% - 3% - 17%
training - validation - testing

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Neural Network Based

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Neural Network Based

word-specific

Fully Connected Neural Network
5 hidden layers

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word-specific
learner representation

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80% - 3% - 17%
training - validation - testing

79.89%

ACC

Neural Network Based

word-specific
learner representation

Fully Connected Neural Network
5 hidden layers

80% - 3% - 17%
training - validation - testing

79.18%

ACC

COMPARISON TO OTHER STUDIES

	Tack et al. (2016)	Alfter & Volodina (2018)	Lee & Yeung (2018)	Yancey & Lepage (2018)	Ehara et al. (2018)	This study
L2 learners	French	Swedish	Chinese	Korean	English	English
personalized	NO	NO	YES	NO	YES	YES
machine learning	NO	YES	YES	YES	NO	YES
for unseen words	NO	NO	YES	YES	YES	YES
all-learner-together training	-	-	NO	-	YES	YES
features						
models & results (accuracy)						

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for unseen words	**NO**	**NO**	**YES**	**YES**	**YES**	**YES**
all-learner-together training	**-**	**-**	**NO**	**-**	**YES**	**YES**
features	**-**	**count-based, morphological, semantic, context-based**	**difficulty level, frequency, count-based**	**frequency, count-based, proficiency level**	**frequency in 6 corpora, learner ability learnt**	**freq, genre, learner's knowledge in genres**
models & results (accuracy)	**FLELex 92.3%** (only for known words)	**SVM 48% MLPerc 53% ExtraTree 59%**	**SVM 78.0% Oracle 79.1%**	**SVM Linear 83.0% SVM RBF 84.3%**	**Rasch 66.3% Shared 77.7% Proposd 77.8%**	**RForest 79.89% NNet 79.18%**

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- adaptation & integration of this model to an intelligent system Elia

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- data size effect on the accuracy of the model

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- collection & creation of a new dataset for single-word knowledge prediction
  - more learnes
  - less words
  - different levels of knowledge
  - different aspects of knowledge

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    - more learnes
    - less words
    - different levels of knowledge
    - different aspects of knowledge
  - more studies
    - different features
    - different algorithms

THANK YOU

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Drilon Avdiu (drilon.avdiu@tum.de)
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