

A Computational Approach to Language Learning: Examining the Efficacy of Spaced Repetition in Duolingo and Anki



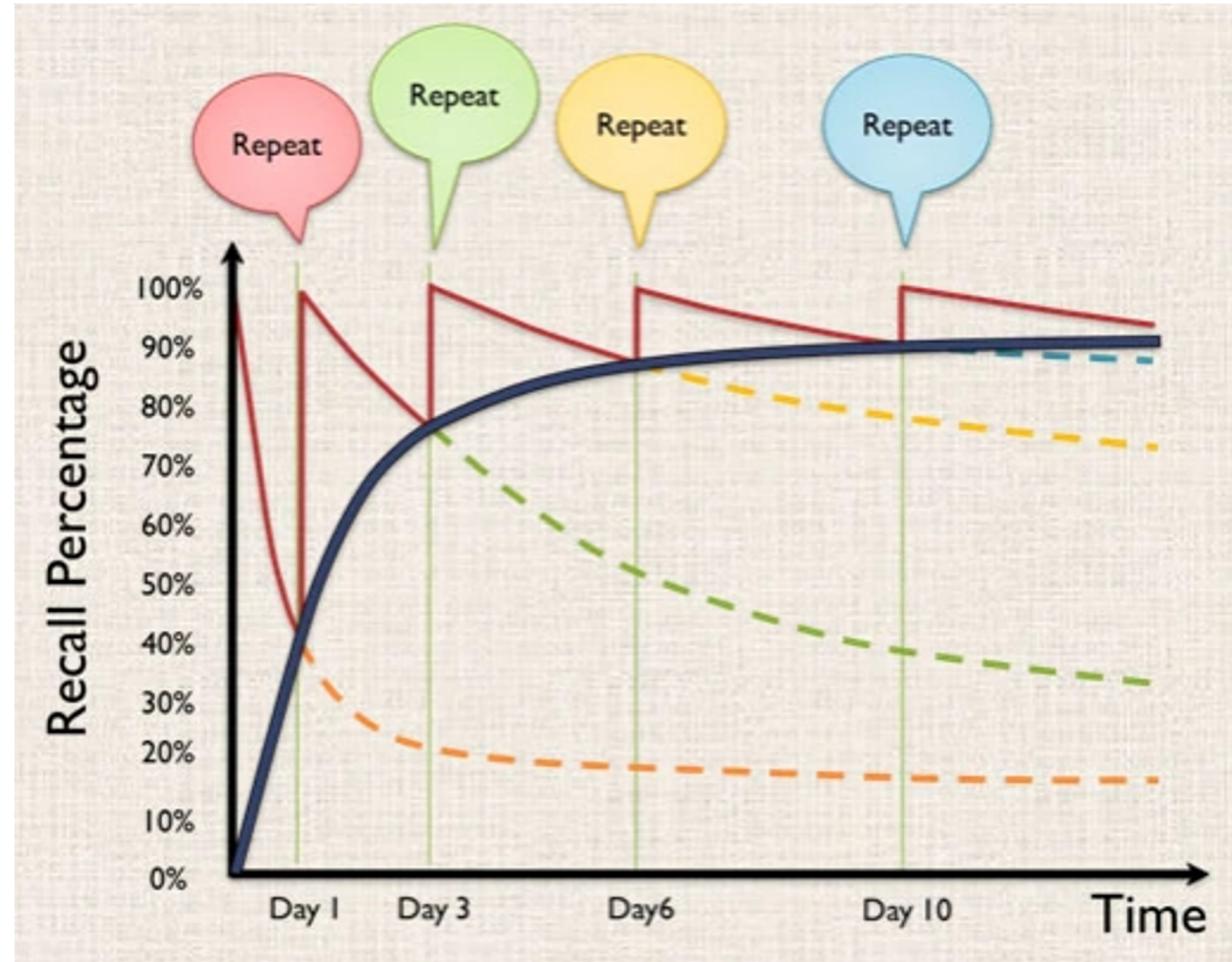
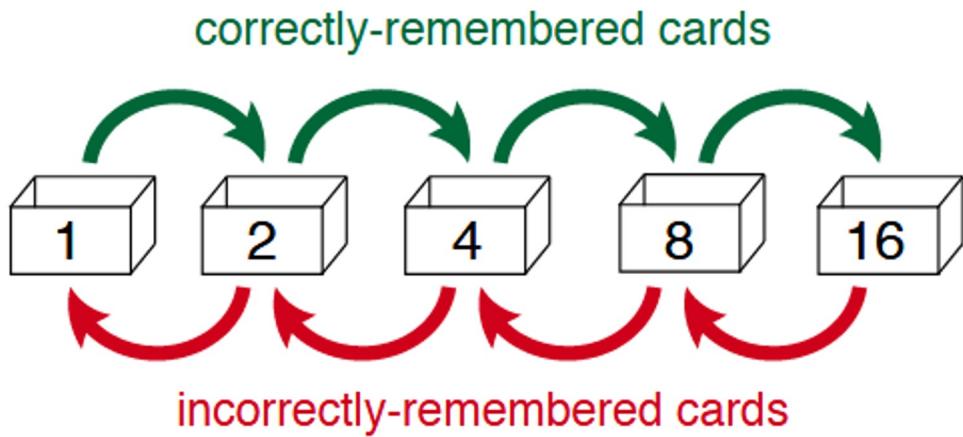
duolingo

CSC-475: Seminar in Computer Science
Jace Rettig

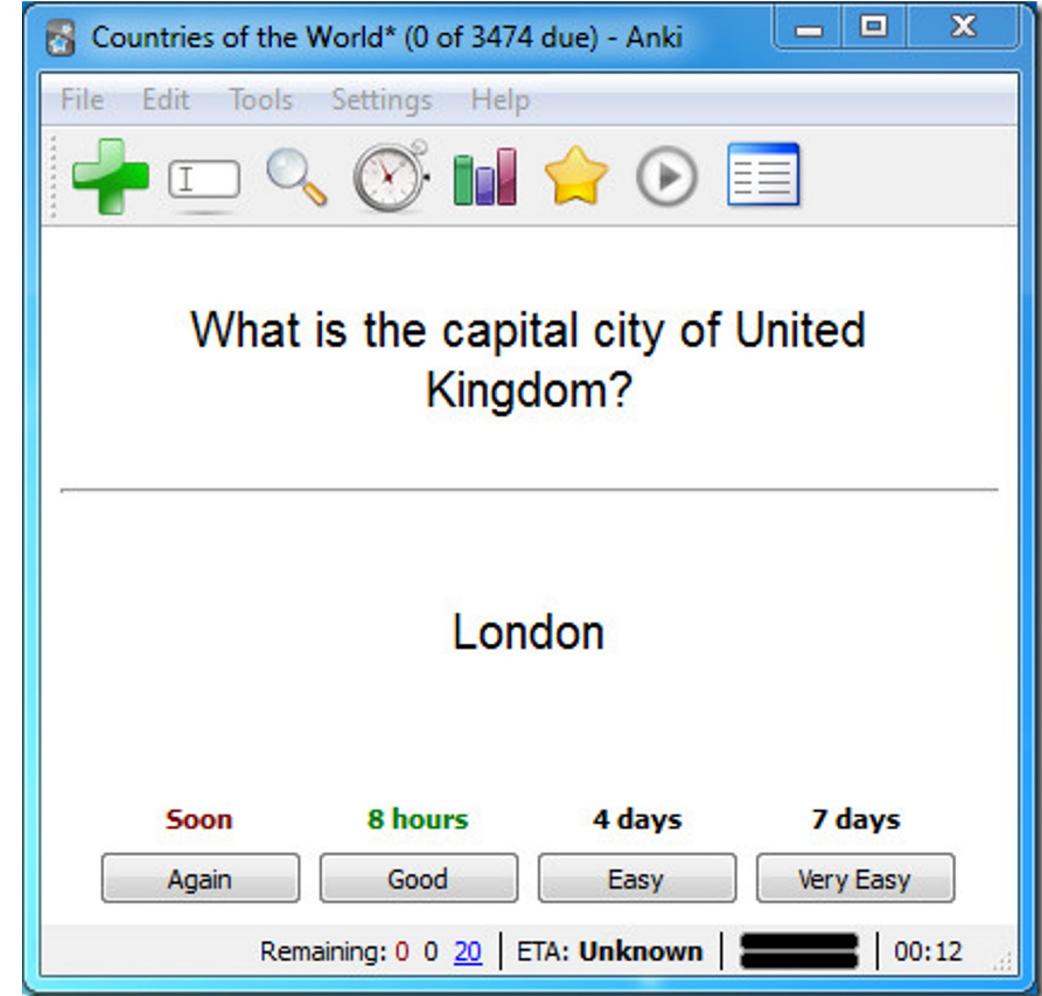
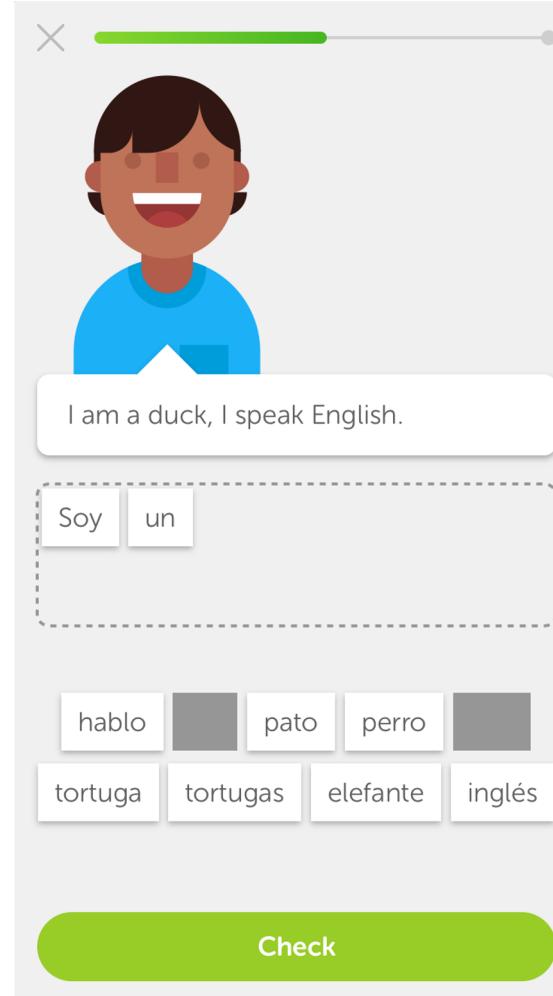


Spaced Repetition

- **Spaced repetition:** method for language learning where the learner reviews a piece of information *just before they are about to forget it.*
 - With each review, the length of time between reviews gets larger.



Duolingo and Anki



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User 1 - Anki

File Edit Tools Migaku Help

Decks Add Browse Stats Sync

靈

1 2 3 4
5 6 7 8
9 10 11 12
13 14 15

Spirits

After raining 雨 for two 二 days in a row 並, you plead with the 灵 for some relief.

Strokes: 15

#1930

Edit Again Hard Good Easy More ▾

← Immersion Vocabulary Review

成年

多くの国で、18才以下は未成年とみなされ、投票することはできない。

SHOW ANSWER

0 0 147

成年

多くの国で、18才以下は未成年とみなされ、投票することはできない。

せいねん ►

adult age | majority

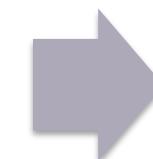
< 10 min AGAIN	5.1 mo HARD	1.4 yr GOOD	3.3 yr EASY
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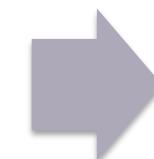
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Why is this important?

Analyze the effectiveness of Spaced Repetition in Duolingo and Anki



Promote research and data collection to identify the best model for language learning



Model can be generalized to make learning more efficient and effective overall



Duolingo Data

Interface Language	Learning Language	Lexeme String	History Seen	History Correct	Session Seen	Session Correct	P_Recall
English	Portuguese	come/comer <vblex>	21	20	1	1	1.0
Italian	English	newspaper/ newspaper<n>	42	39	4	3	0.75
English	German	frau/frau <n><f>	6	5	2	1	0.5
English	Italian	mie/mio<det> <f><pl>	7	7	3	2	0.67
English	Spanish	hermana/hermano <n><f>	12	10	1	1	1.0
English	French	et/et <cnjcoo>	38	27	2	1	0.5

Table 1: Example Table of Learning Traces (Simplified)

- Contains 12.9 million learning traces that were collected over 2 weeks
 - Used for a 2016 study on the Half-Life Regression Model that is implemented in Duolingo's mobile app.

Number of Learning Traces for Each Language

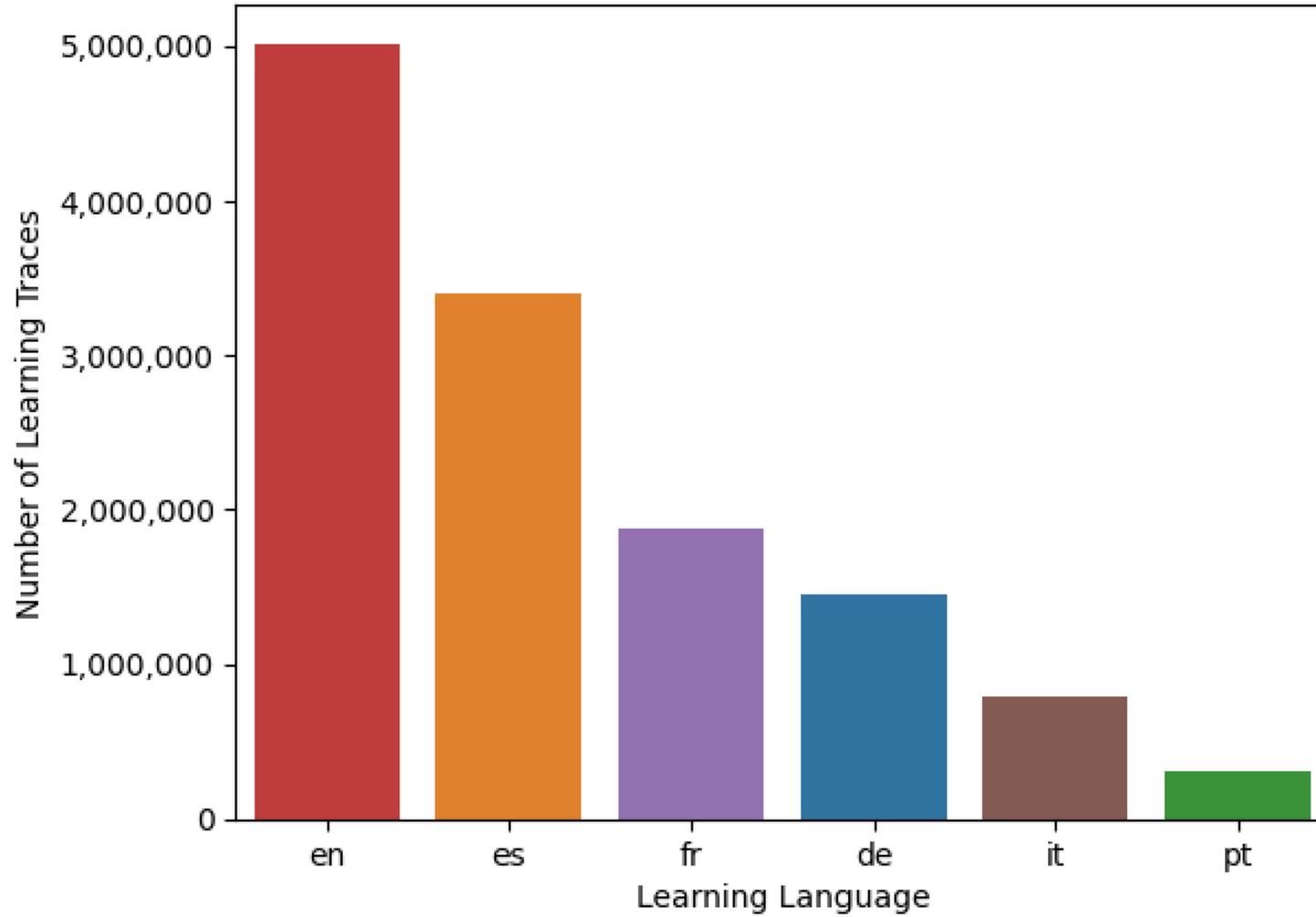


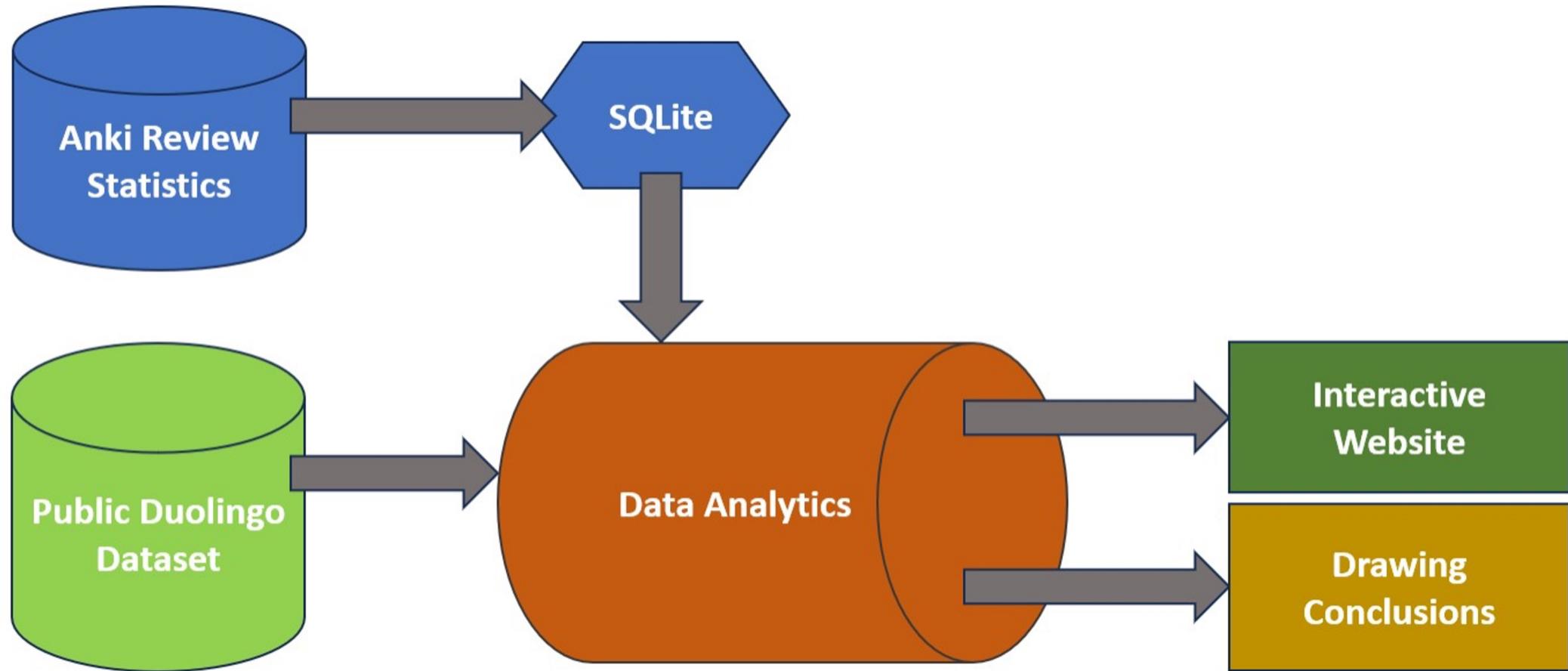
Figure 1: Distribution of languages being studied through Duolingo. There is a heavy bias towards English and Spanish traces.

Anki Data

Time of Review	Card ID	Ease of Recall	Interval for Next Review
1566452085029	1528564711188	2	1
1566452447881	1528565827041	2	2
1566626988674	1528564661613	3	5
1596122830309	1444182700694	3	62
1626313041376	1603083802365	4	108

- Contains over 92,000 reviews performed on 5,000 cards from the author's personal use of the app
 - Card ID and Time of Review are stored as UNIX epoch timestamps
 - Flaws in data?

Methods Pipeline



Duolingo Results



duolingo



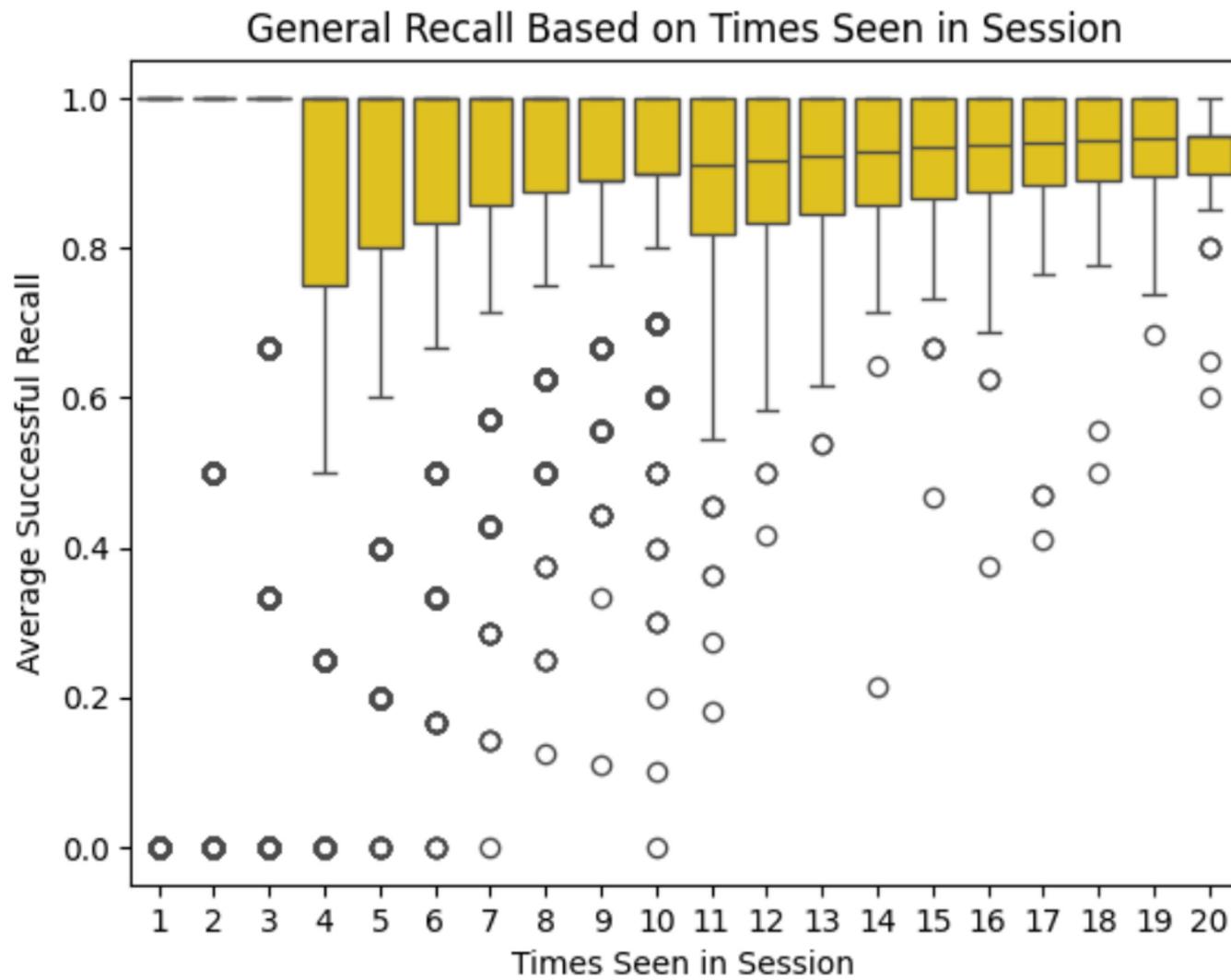


Figure 3: Correct recall based on times seen in the current session for all languages. The more times a word has been seen, the more likely the user will recall it correctly

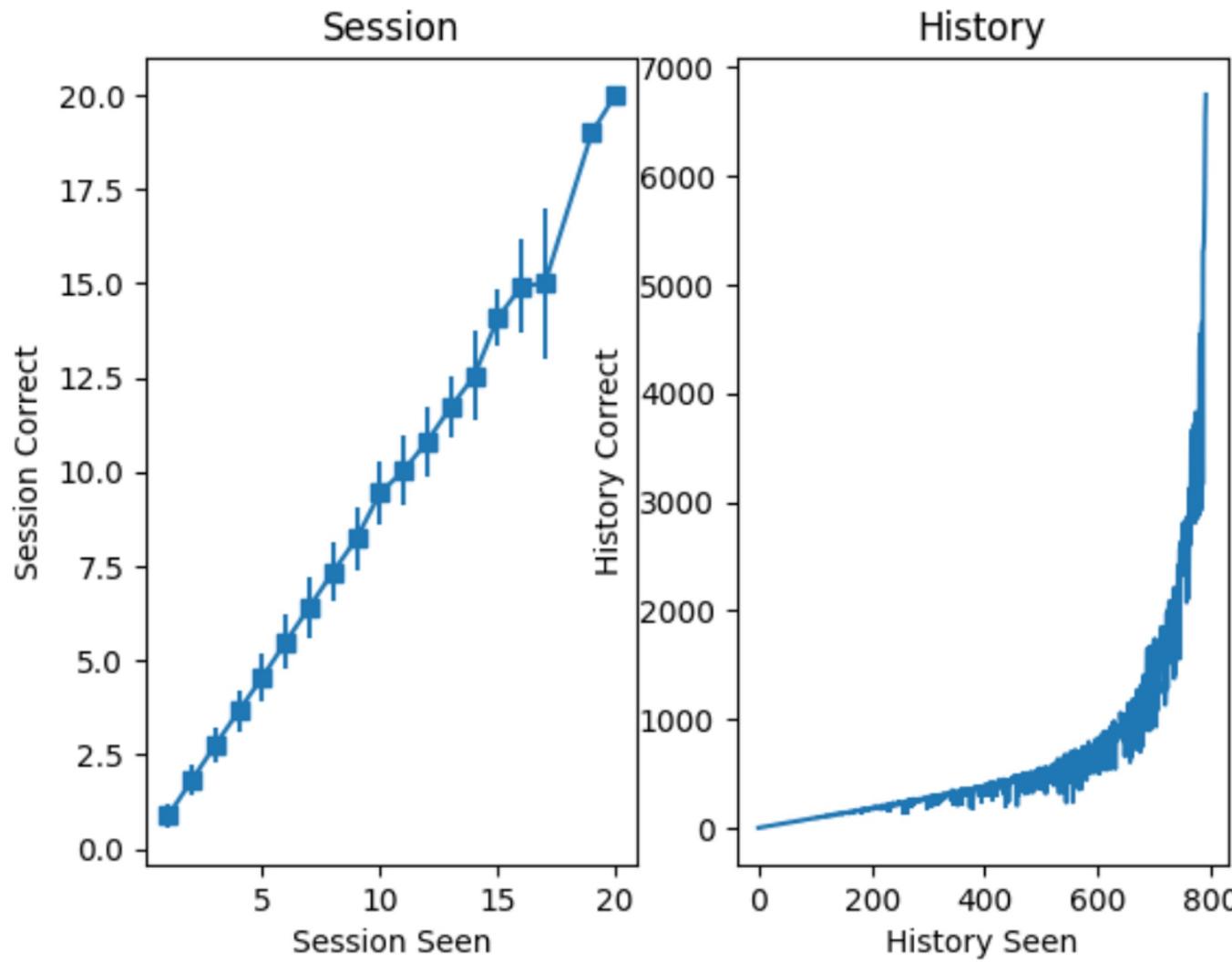


Figure 4: General trends for Duolingo learning with spaced repetition within and across sessions. History also shows a positive growth that is at a much larger scale

Language Specific P_Recall in Duolingo Sessions

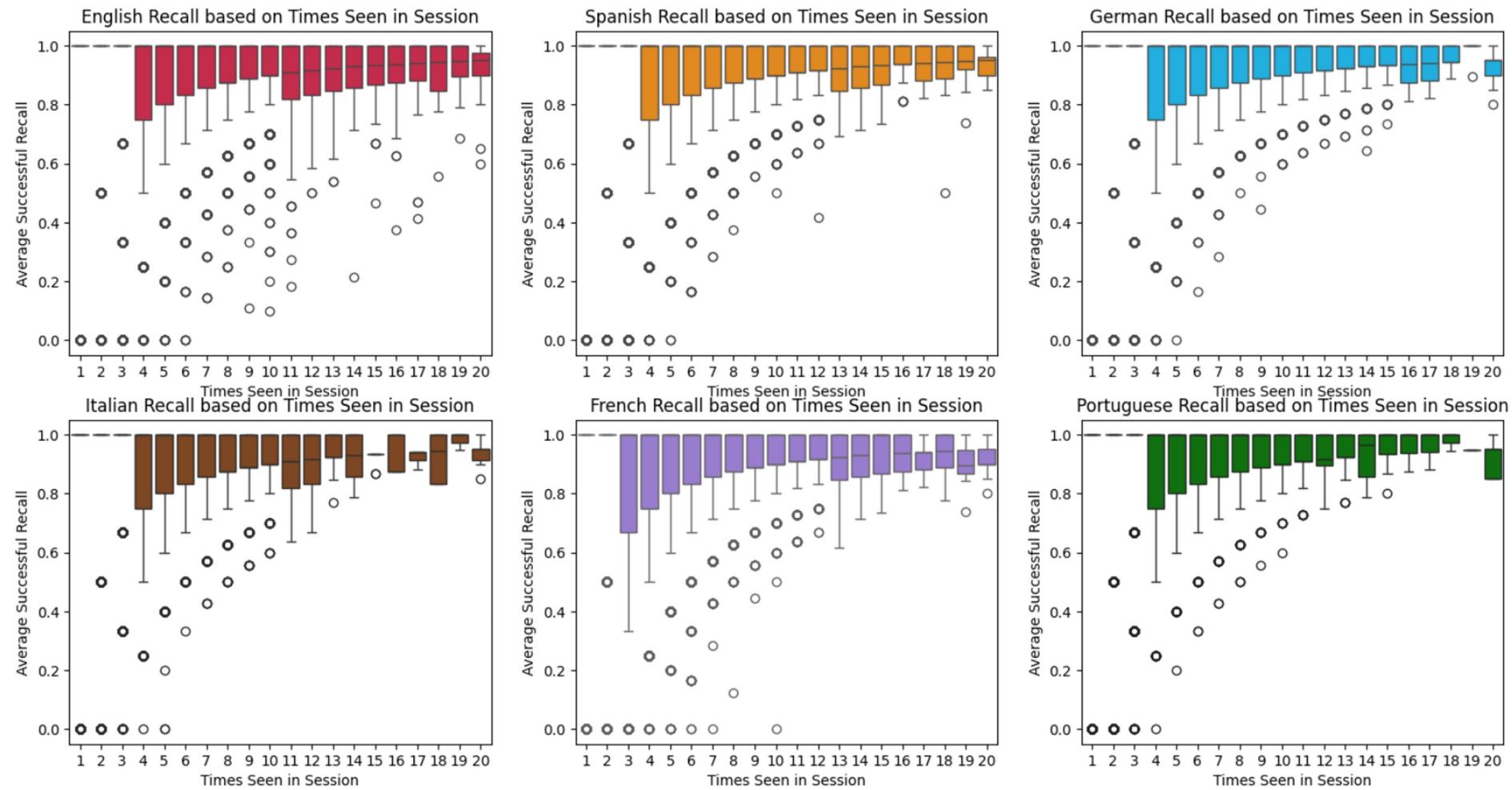


Figure 5: P_Recall trends across languages. The general trend of improved recall appears consistent regardless of the language

Part of Speech P_Recall in Duolingo Sessions

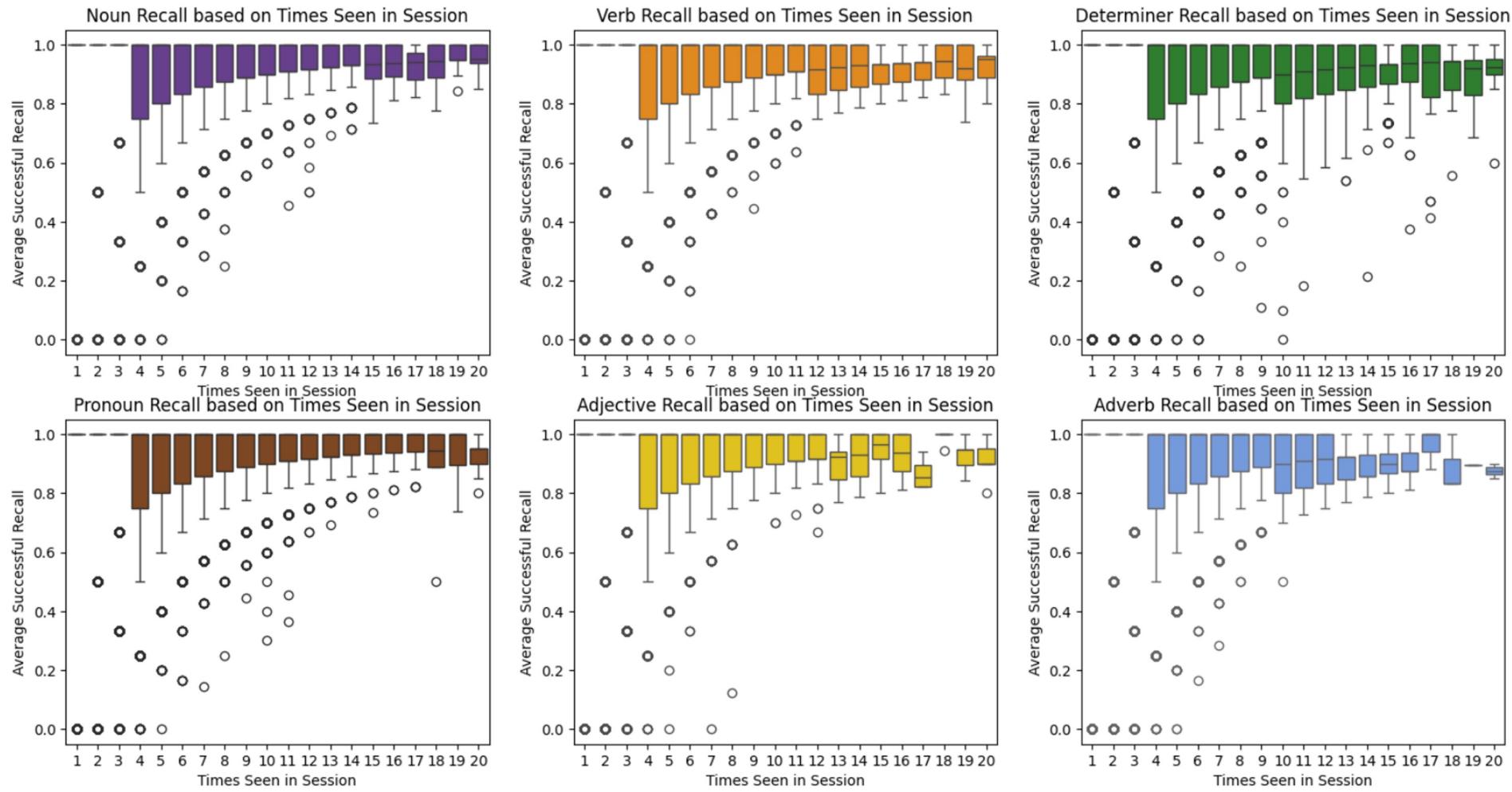


Figure 6: P_Recall trends across the most common parts of speech. The general trend of improved recall appears consistent regardless of the part of speech.

Anki Results



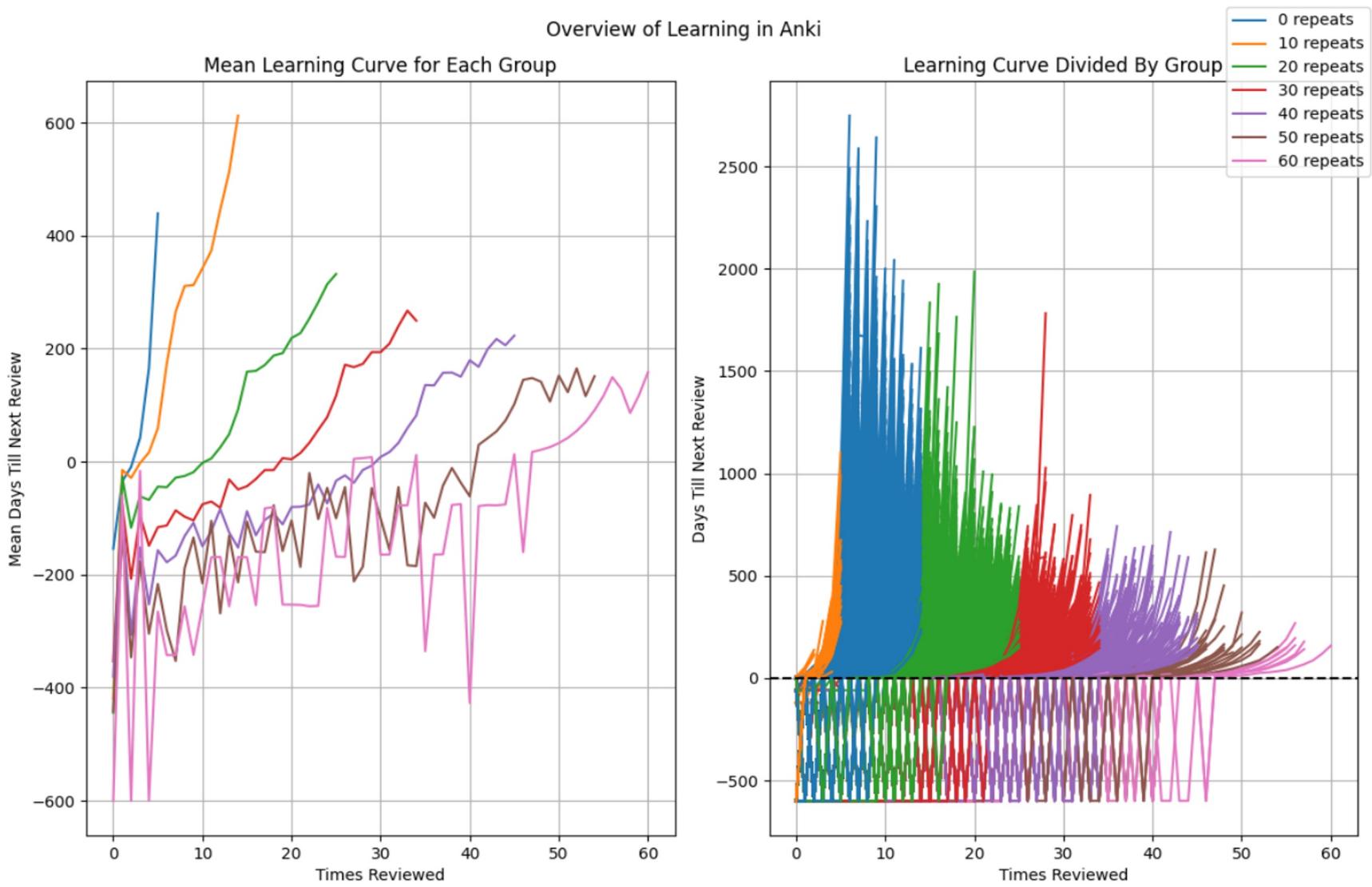


Figure 7: Anki learning progress for each card divided into seven groups. The average of each group can be seen on the left, with orange and red cards being easy to learn while brown and pink were very difficult to learn

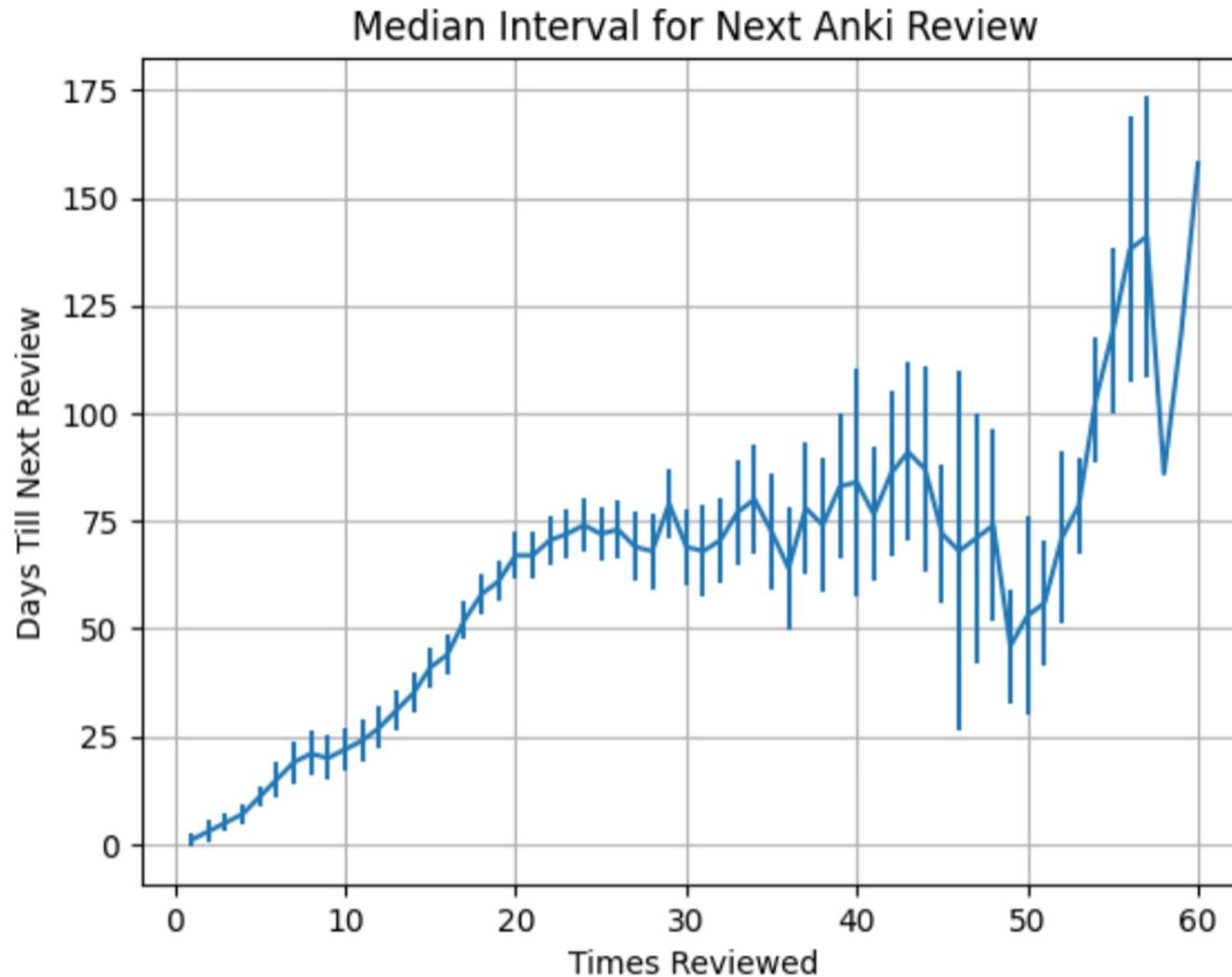
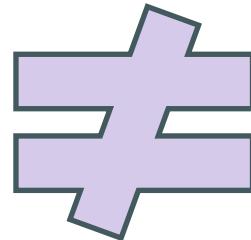


Figure 8: Median interval for next review with error bars. Spaced repetition is consistently effective for intervals less than 75 days or cards that have been reviewed less than 30 times

Discussion

Duolingo data suggests spaced repetition is working well



Anki data suggests there is a limit to spaced repetition's effectiveness

Does Duolingo's public data paint the full picture?

- Duolingo is a private company with their own objectives, likely don't want to publicly release data that shows faults with their application

Looking at only one person's Anki data is inherently biased, need more data to make more definitive conclusions

Future Work

This research serves as a light introduction to the efficacy of spaced repetition in language learning apps and should be used as a foundation for further research.

Future studies may consider analyzing more than one anki deck or getting more recent data from duolingo to draw stronger conclusions.



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