README

Analysis part

Qualitative and quantitative analysis for each text + interpretation

1. **Data Availability Statement**

In accordance with data-protection guidelines, raw eye-movement recordings are not publicly available. The publication includes a set of derived visual representations of the data (scan-path diagrams, fixation density maps, and temporal gaze plots), which are archived in this document. These visualizations capture all features relevant to the analyses presented in the paper. Researchers interested in further data access may contact the authors for a restricted, anonymized dataset.

1. **README: Eye-Tracking Visualization**

**2.1. Overview**

This document contains derived visualizations from the eye-tracking experiment reported in the paper *Visual Reading of Digital Texts: A Semiotic Perspective*. The document includes fixation maps, beeswarm plots, heatmaps, aggregated temporal gaze plots, and our suggested interpretation of some results. These visualizations illustrate the main empirical patterns discussed in the manuscript.

Raw eye-movement data (e.g., EDF/CSV/ASC files) are not included to ensure participant anonymity. Researchers needing further access may contact the authors.

### **Methods Summary**

Eye-tracking data were recorded using *Tobii Pro Spectrum* 300 eye-tracker at **300 Hz**. Participants viewed multimodal **texts**, and fixations and saccades were detected using the manufacturer’s default algorithm. All visualizations were generated using **Python.**

# TEXTS PRESENTED TO THE RESPONDENTS

1. Plain text without emojis (90 tokens) -> Aoi words only
2. Emojis as determiners (105 tokens with emojis) -> Aoi words and emoji
3. Mixed functions emojis -> Aoi words and emoji
4. Emotions correct -> Aoi words and emoji
5. Emotions wrong -> Aoi words and emoji
6. Emojis wrong mixed functions -> Aoi emoji only
7. Emojis with replacing function -> Aoi words and emoj

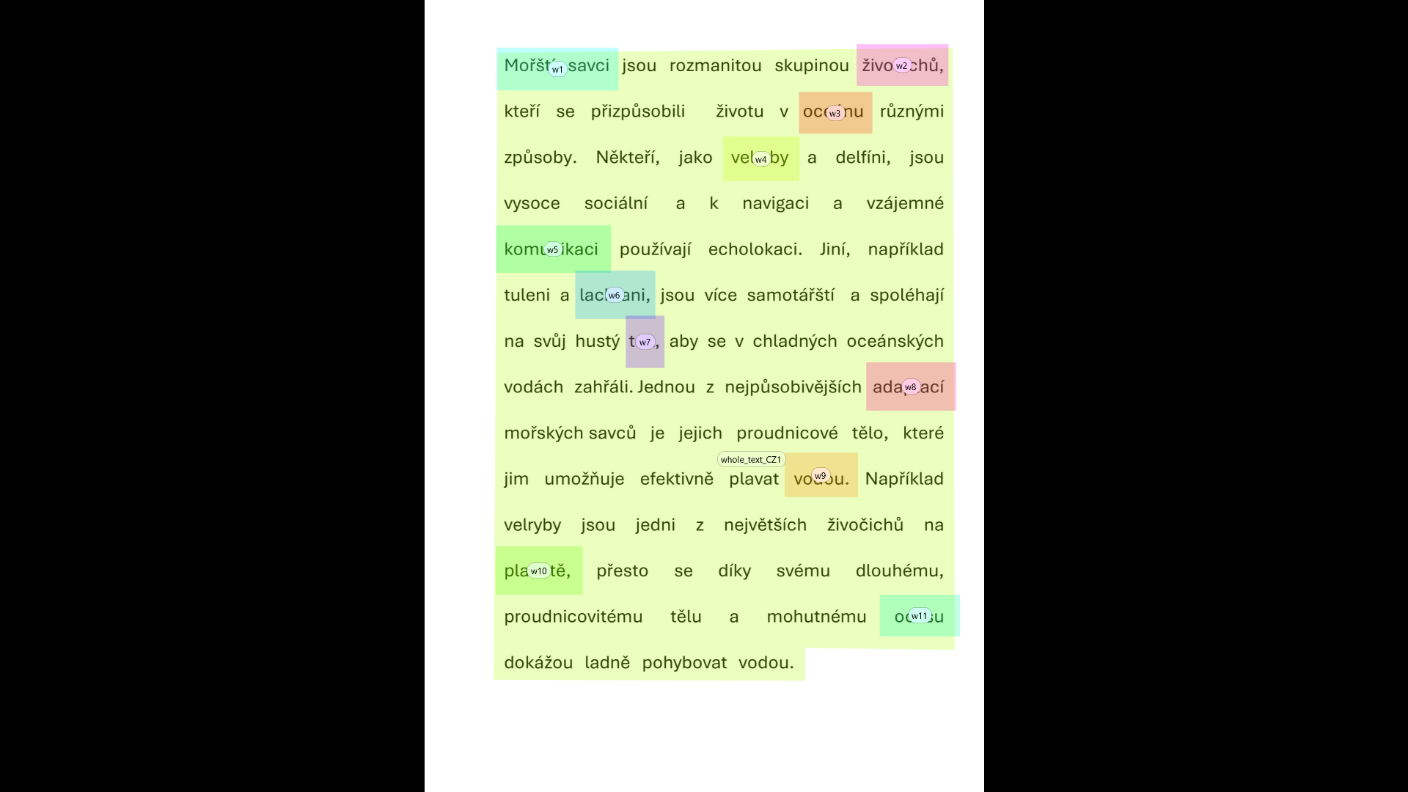
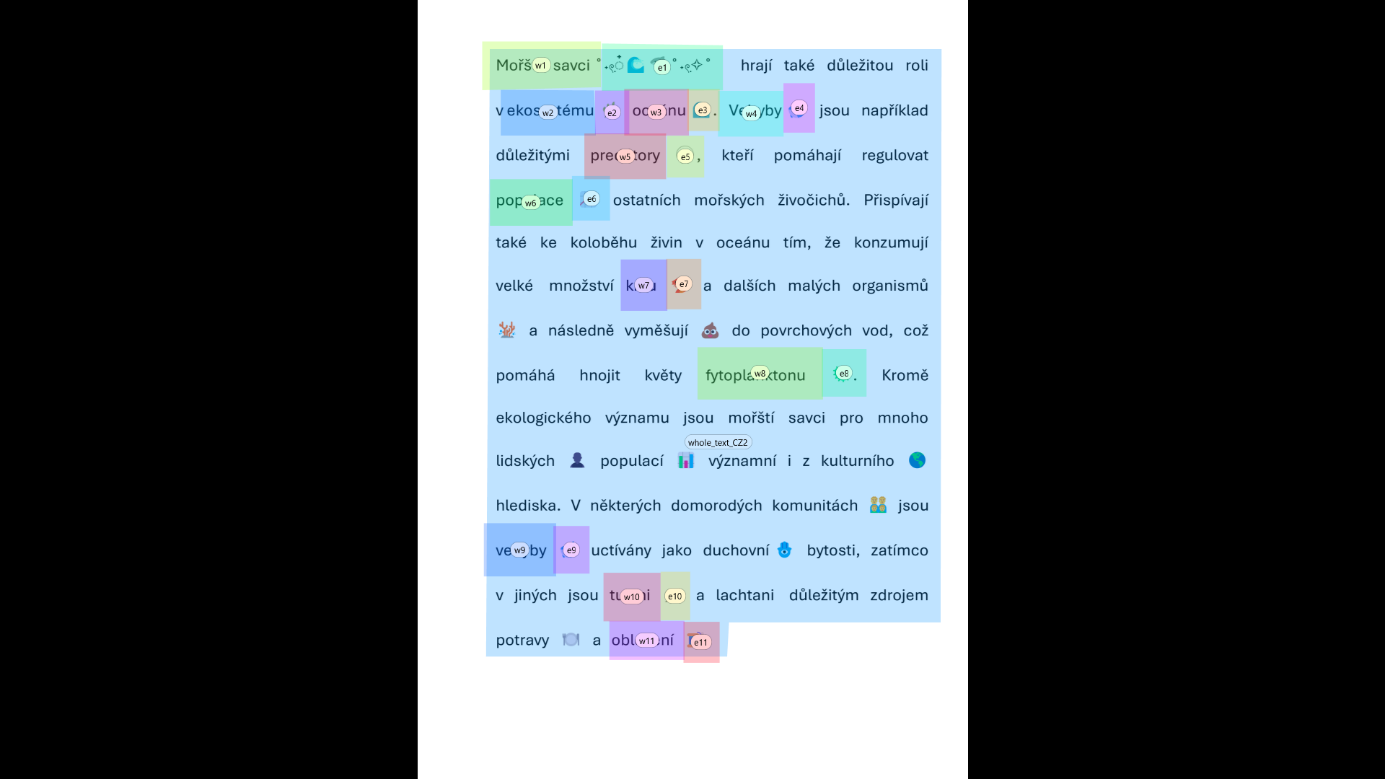
CHOOSING AOI (AREAS OF INTEREST)

List of Aois created:

-> for each text (CZ, EN): *whole\_text*

-> for TextCZ1 (text without emoji), random nouns were chosen, tagged *w1 – w11*

-> for TextCZ2, both words and emojis were strategically chosen: *w1 – w11, e1 – e11* (Consult images below for more detail)

*Figure 1 TextCZ1\_media\_aoi Figure 2 TextCZ2\_media\_aoi*

=> For each AOI the following metrics were exported:

CHOSING METRICS

I exported 2 versions of our data. First -> "emoji\_metrics.tsv" contains 27 metrics for each AOI (I filtered some for easier first approach) Shape: 974x33. Second -> "emoji\_metrics\_all.tsv" contains 47 (all available) metrics for each AOI (for each of the 26 participants).

List (of the 26) metrics + participant variables:

['Recording', 'Participant', 'Age', 'Chinese\_symbols', 'Mother\_tongue',

'Sex', 'Social\_networks', 'TOI', 'Interval', 'Media', 'AOI',

'Duration\_of\_interval', 'Total\_duration\_of\_fixations',

'Average\_duration\_of\_fixations', 'Minimum\_duration\_of\_fixations',

'Maximum\_duration\_of\_fixations', 'Number\_of\_fixations',

'Duration\_of\_first\_fixation', 'Total\_duration\_of\_Visit',

'Average\_duration\_of\_Visit', 'Number\_of\_Visits',

'Duration\_of\_first\_Visit', 'Total\_duration\_of\_Glances',

'Average\_duration\_of\_Glances', 'Number\_of\_Glances',

'Duration\_of\_first\_Glance', 'Number\_of\_saccades\_in\_AOI',

'Time\_to\_entry\_saccade', 'Time\_to\_exit\_saccade',

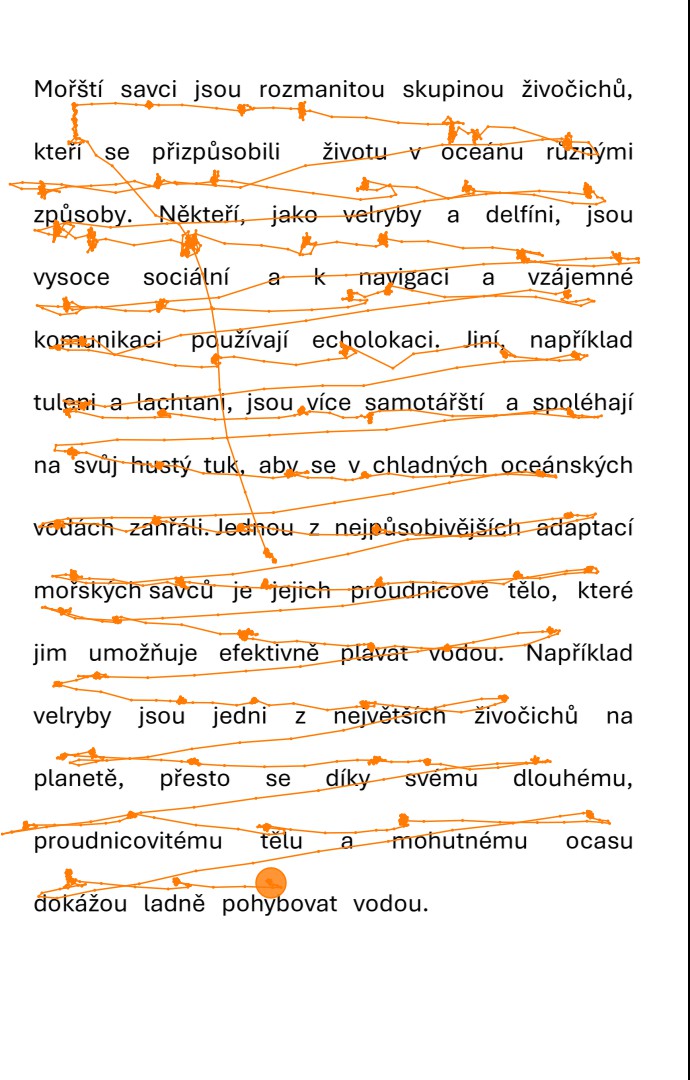
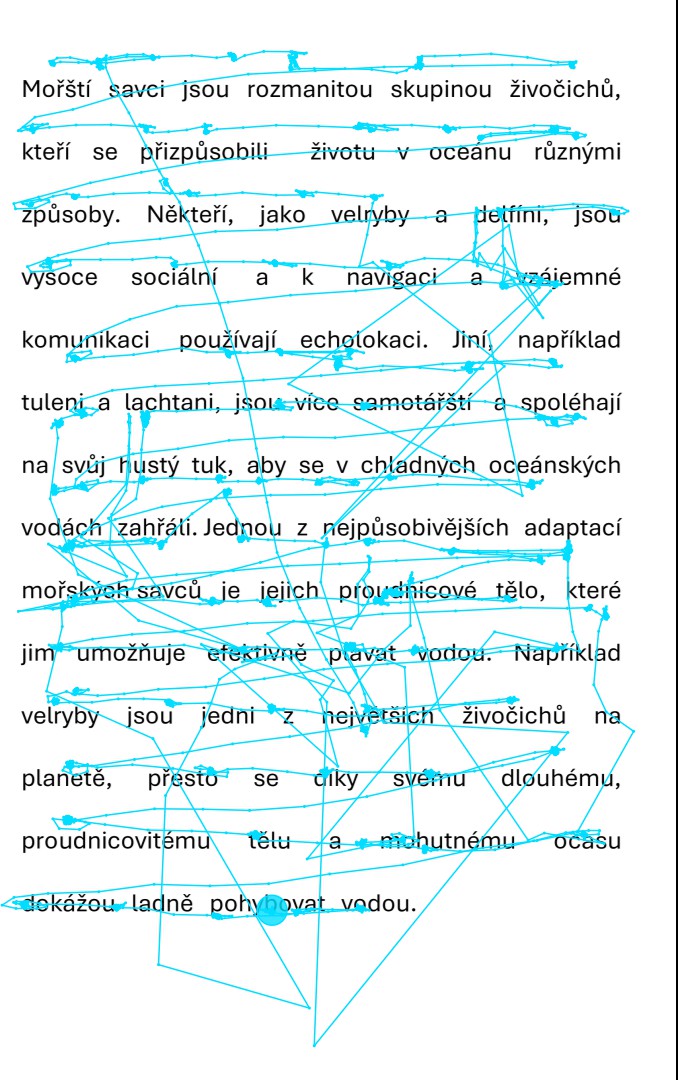
'Peak\_velocity\_of\_entry\_saccade', 'Peak\_velocity\_of\_exit\_saccade',

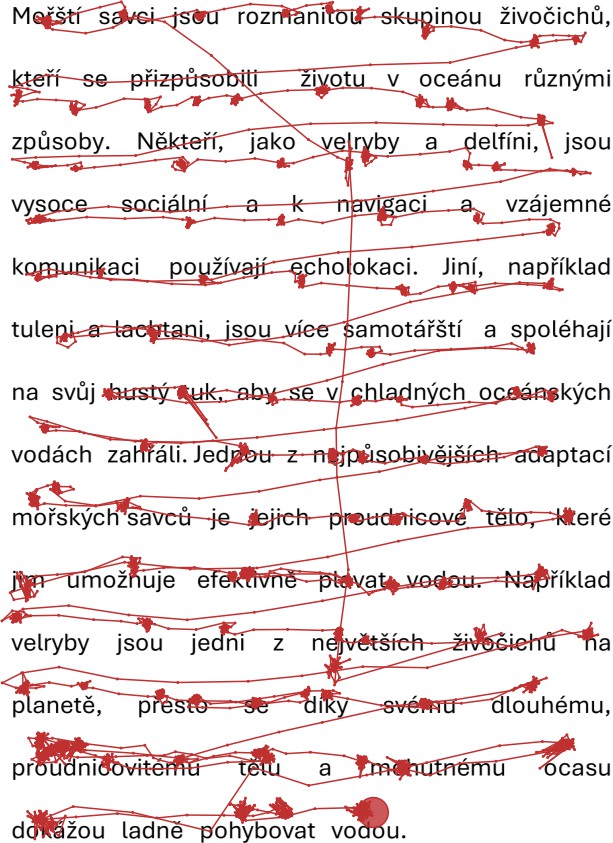
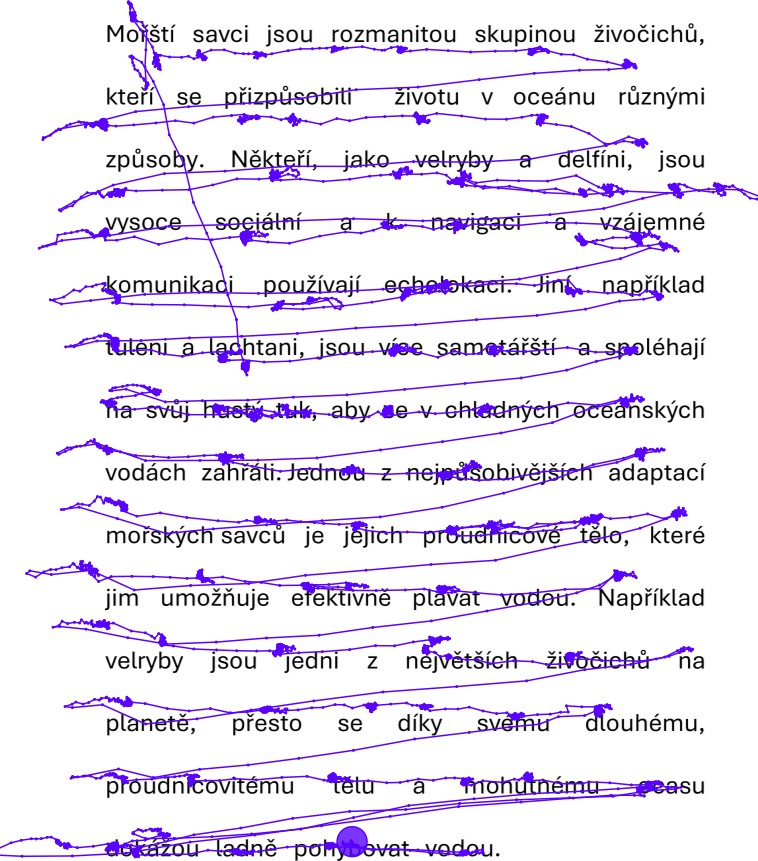
'AOI\_Type', 'Sex\_Label']

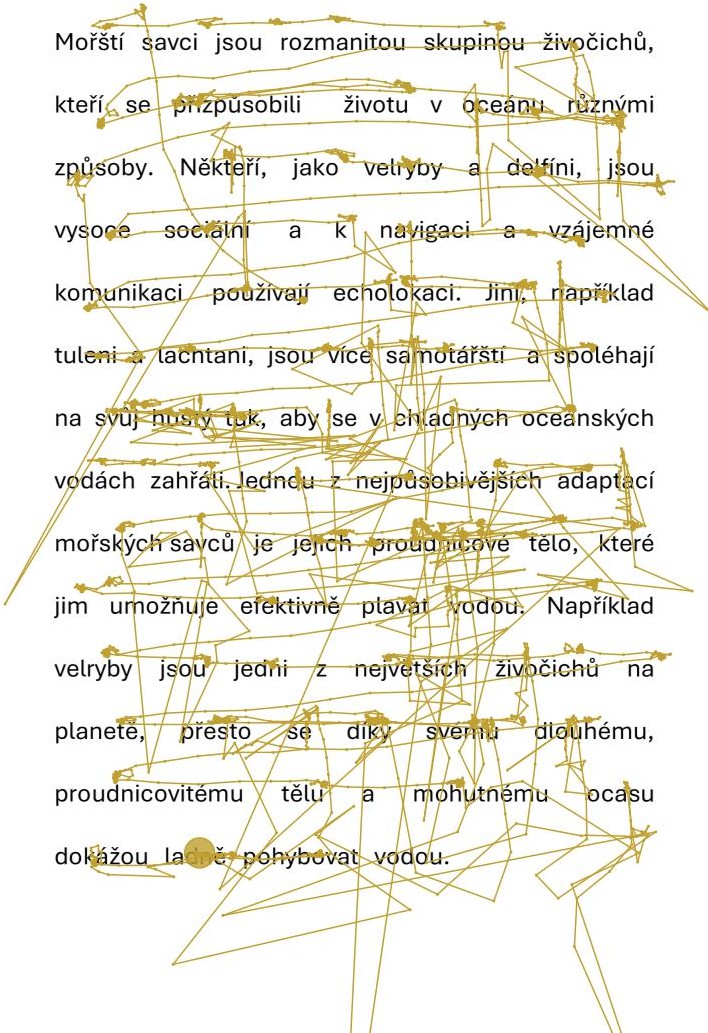
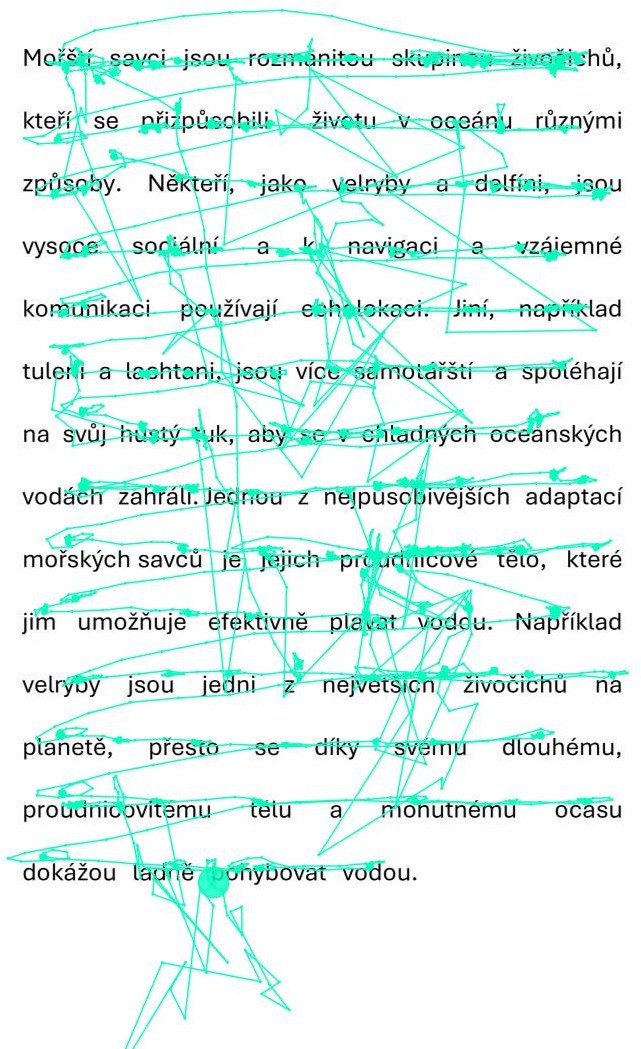
Aoi metrics were exported for Times of interest (Toi), which in our case were manually marked in each video recording. Our Toi is the interval of the first reading (Some participants read the text multiple times).

1. **BEESWARM plots examples of single reading patterns**

Text1CZ (plain text, only word Aois)



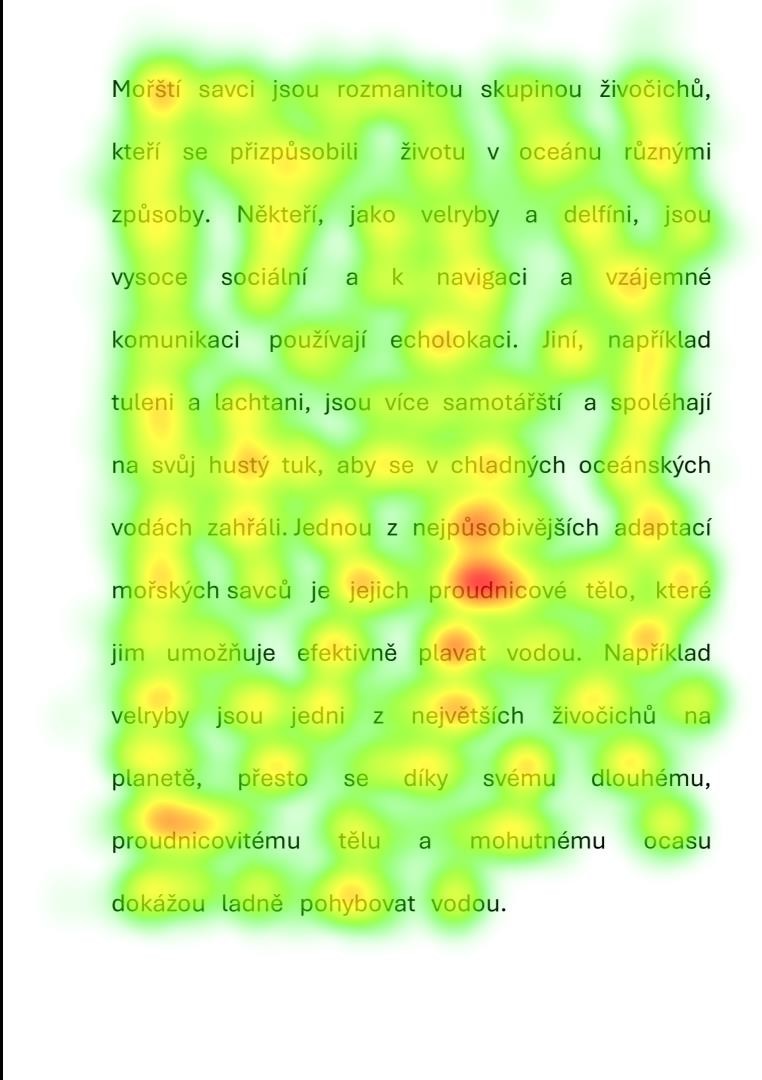
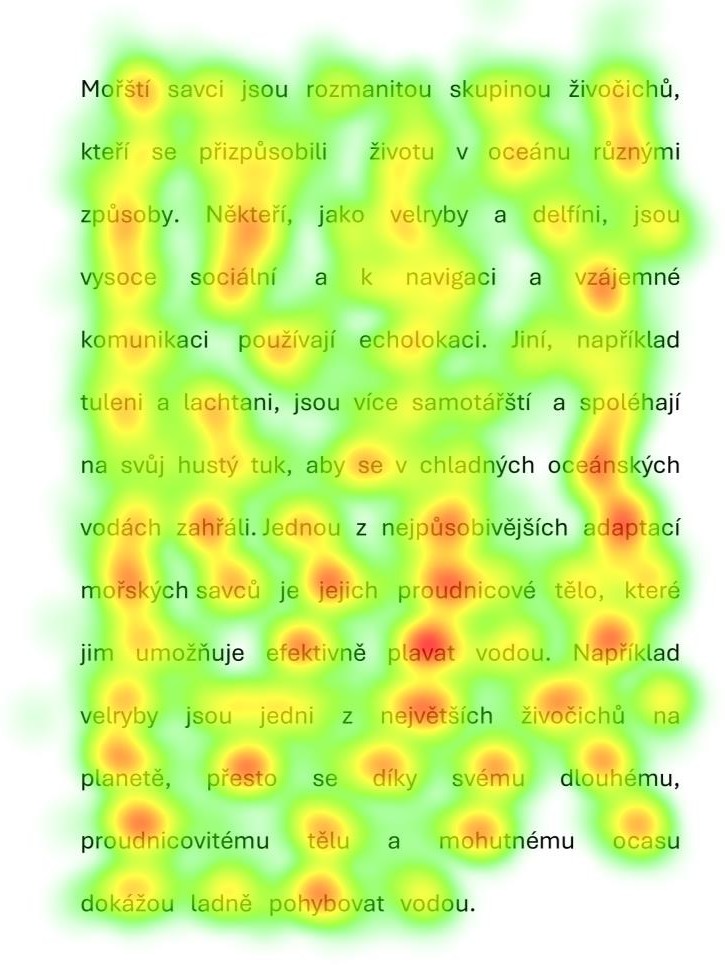


1. **HEAT MAPS examples**

-> Here we used a fixation filter on all the recordings. The visualization thus offers averaged trend for all participants, not a single reading.

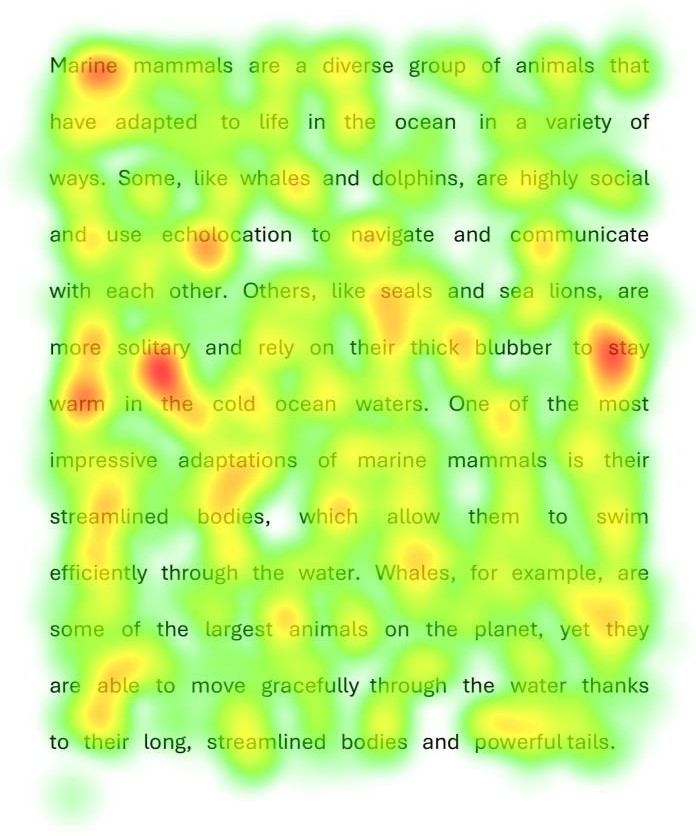
! Difference btw attention (left) and fixation filter (right): The **fixation filter** detects only **stable fixations** where the eye remains focused on a point for a minimum duration, while the **attention filter** includes both fixations and **brief glances**, capturing a broader range of visual awareness. In our case, fixations are much more effective, but we lose the information of participants “seeing” or “perceiving” parts of the text on which they are not fixated. This is a feature not much needed in our study, but it needed to be mentioned.

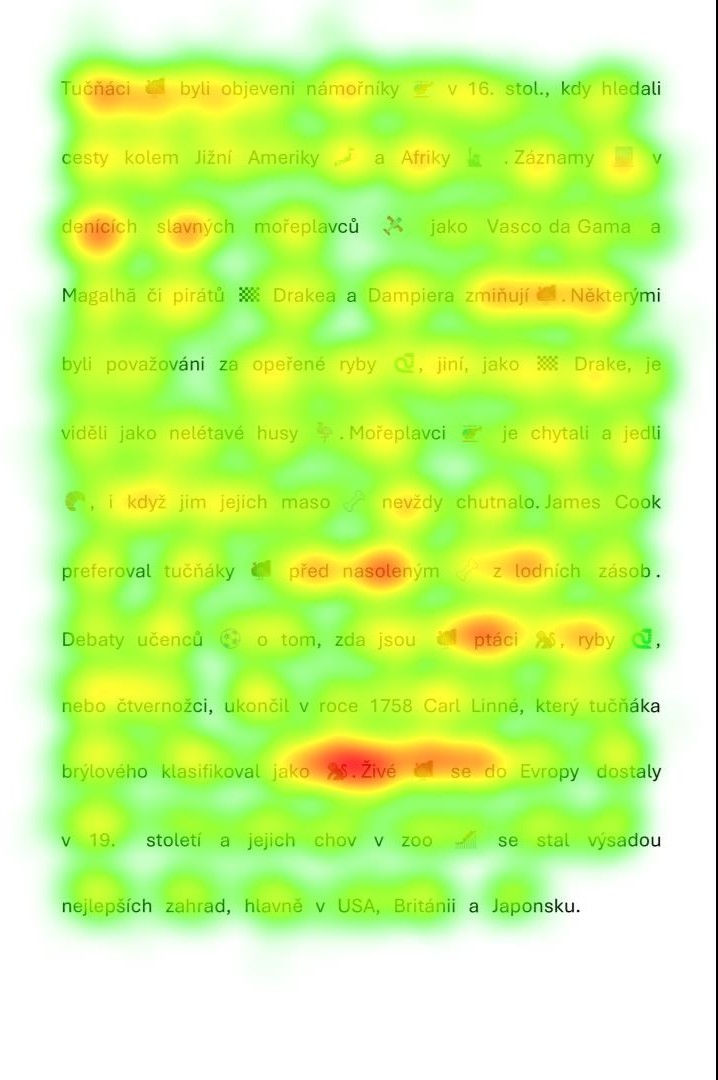
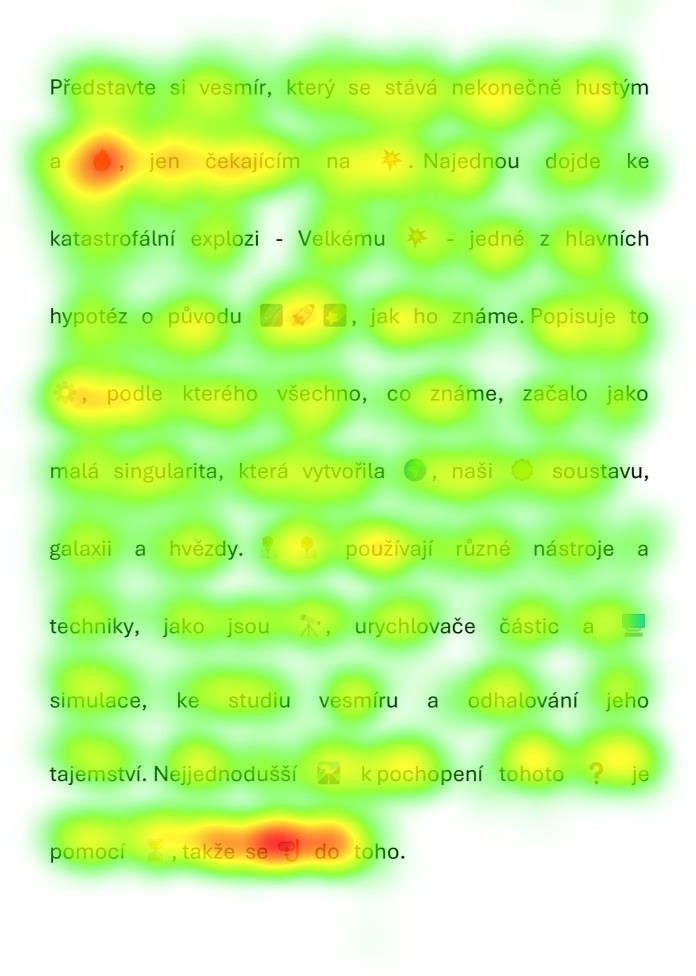
-> Here we show both filters to understand the difference:



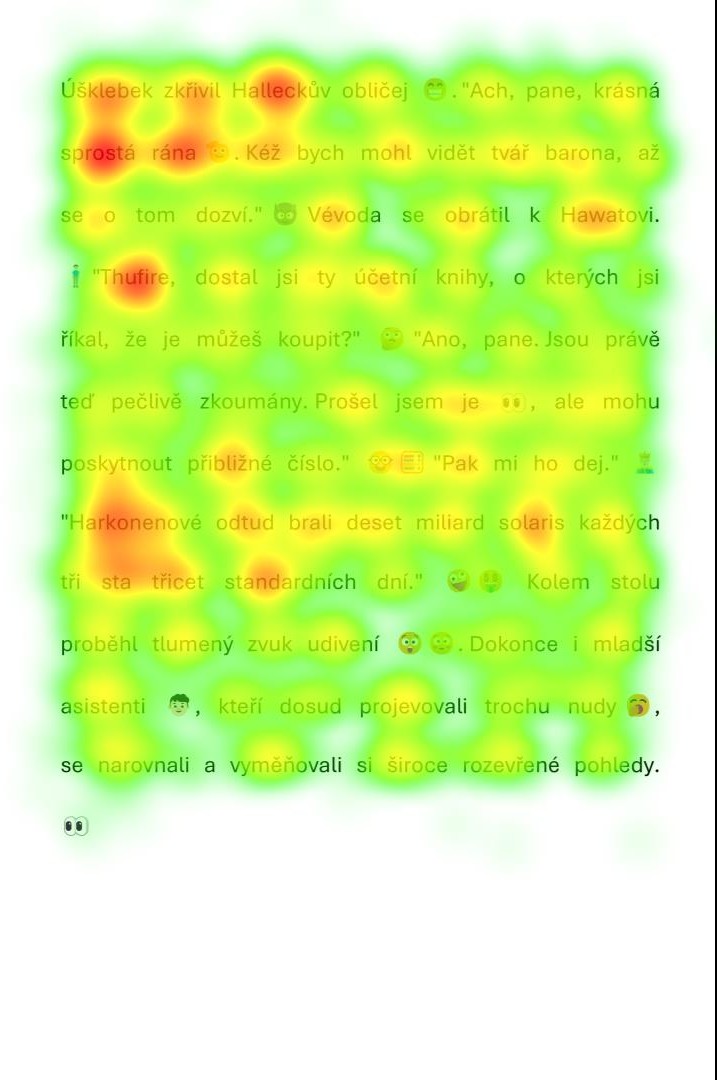
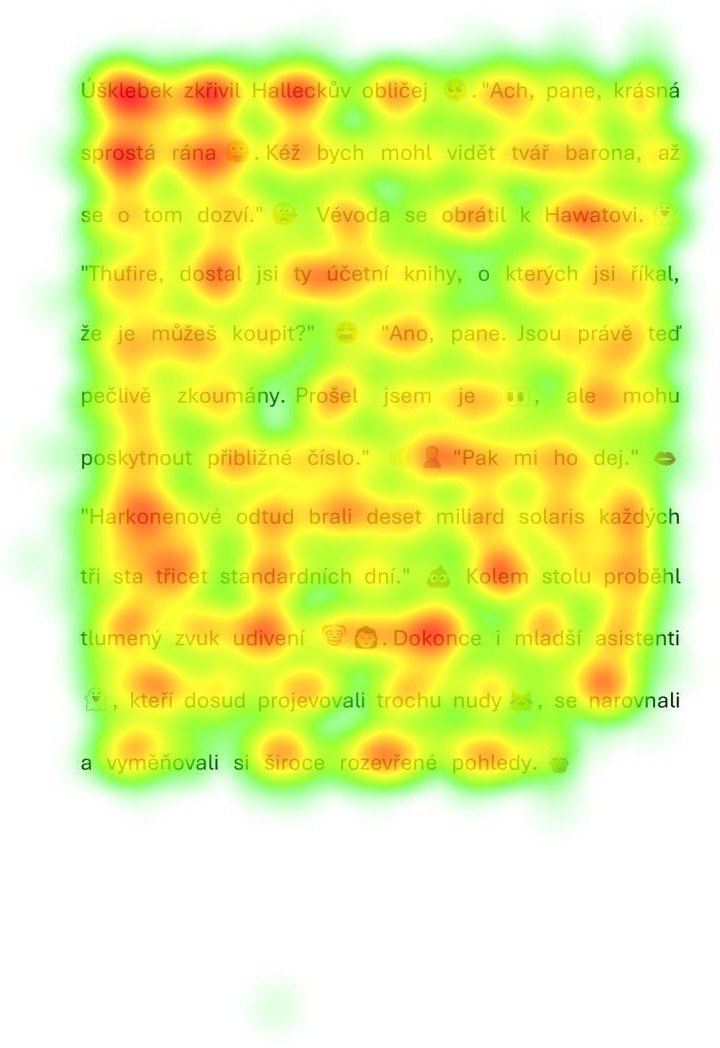
We can observe that the **attention filter** has a **lower threshold**. While reading, we don’t need to pay attention to **every word** (or whole words) to understand the text. Interestingly, this reveals the **redundancy of language**—we don’t actually need to process **entire words**. Instead, we **jump to the center of words**, where we fixate for a certain amount of time. The duration of this pause determines whether it is a **fixation, a brief glance, or just a visit**, while the surrounding of the word is **perceived peripherally**, requiring **no fixation**.

On the other hand, the **image on the right** represents **fixations**, or more precisely, **points of interest that require higher cognitive effort to process**. In the case of the **plain text**, there were roughly **two key fixation points** where the readers’ eyes remained relatively stable: **"nejpůsobivějších"** and **"proudnicové"**. These are **easy to interpret in this context** since they are **long and relatively infrequent.**

-> Text1EN shows a similar tendency:



-> Text 4 CZ had CORRECT face emojis accompanying the words as determiners, and we can see that the most attention went to difficult words, neglecting the emojis. Text 5 CZ was the same as text 4 BUT with WRONG emojis. We can see that this clearly increased the difficulty of reading. The words needed more fixations, since the emojis were confusing the readers.

There would be the question of whether correct emojis speed up or slow down the reading. Text 1 about marine life without emojis and the continuation of this text with emojis have incredibly similar mean duration of fixations with text1 = 0,224s and text 2 = 0,228s (seconds)

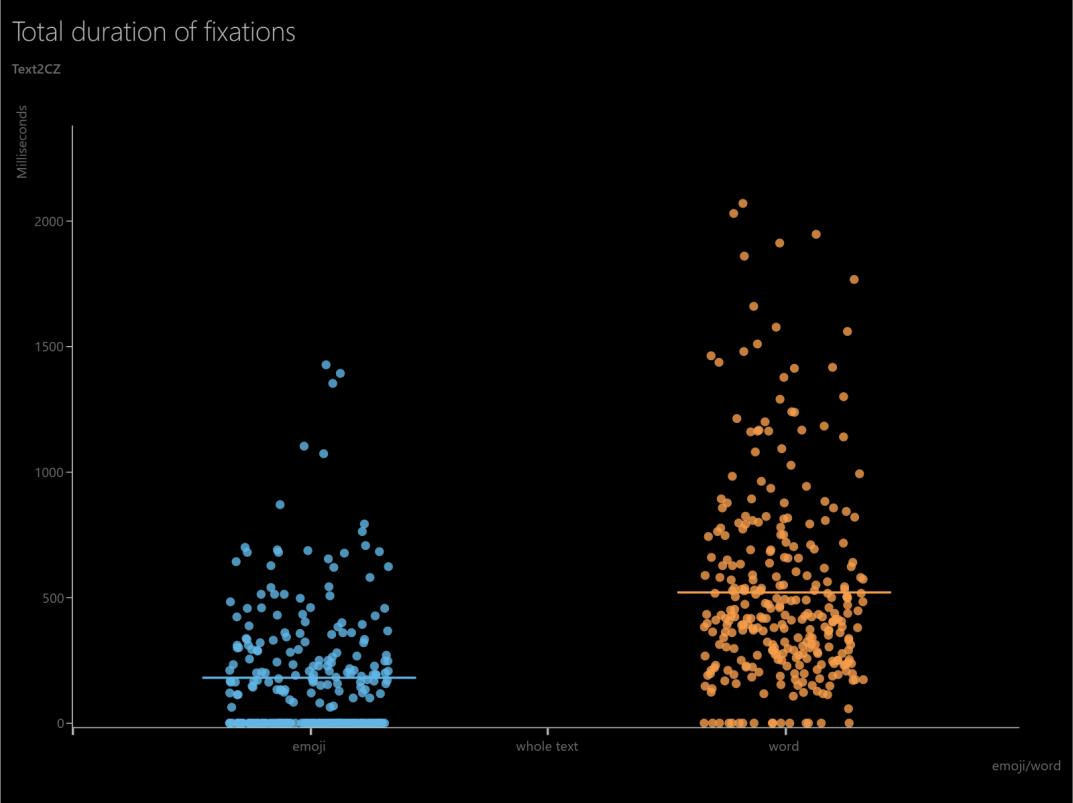
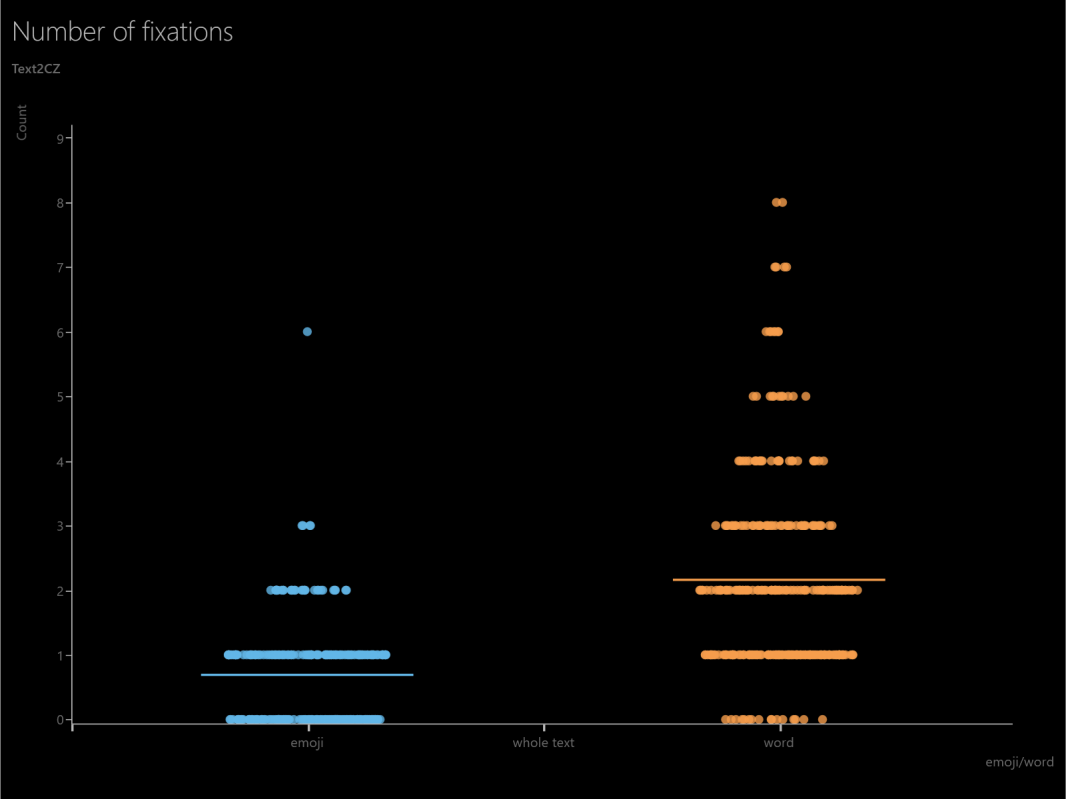
1. **Analysis with Tobii Pro Lab METRICS VISUALIZATION**

-> Tobii offers some basic means to visualize the metrics, but there is not much customization.

# TEXT 2

On average, **emojis don’t even receive a single fixation**, meaning many of them are completely ignored. **Words, on the other hand, receive slightly more than two fixations on average**, with only a few instances where they were skipped entirely.

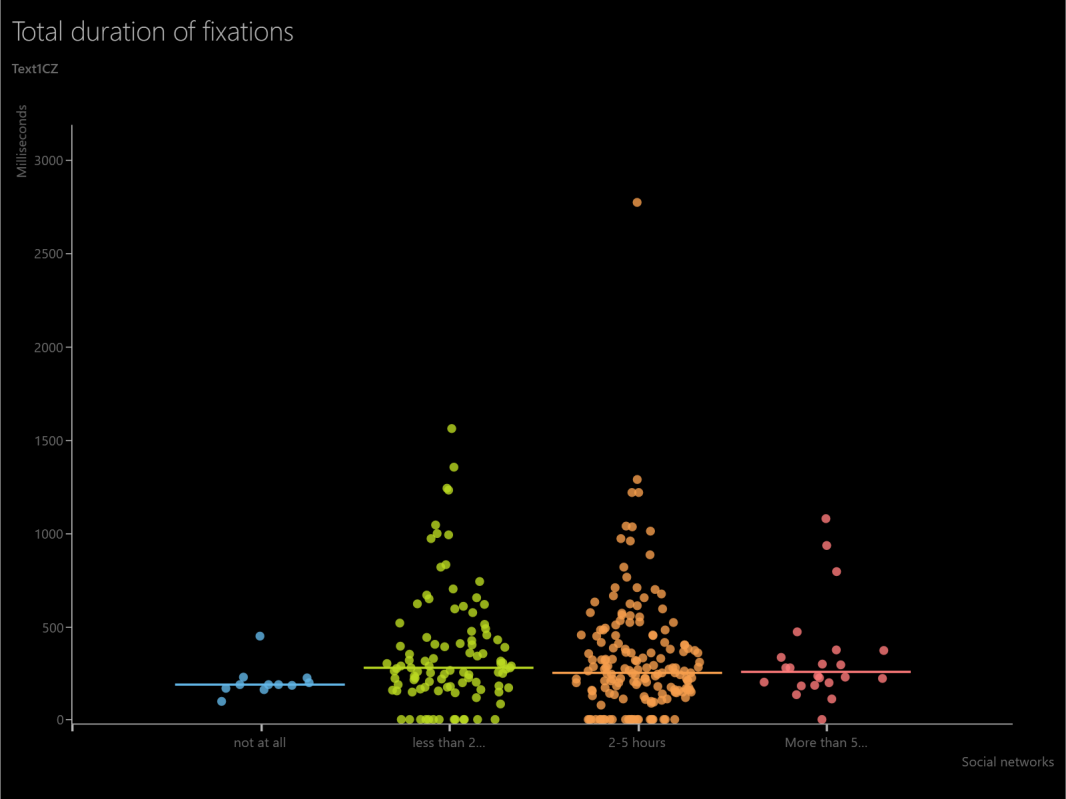
However, in **Text 2**, emojis function as **determiners**, meaning they **do not play a crucial role in conveying meaning**. We will compare this with cases where **emojis replace entire words** to see whether they receive as many fixations as regular words.



# **Comparison based on metadata: social media exposure**

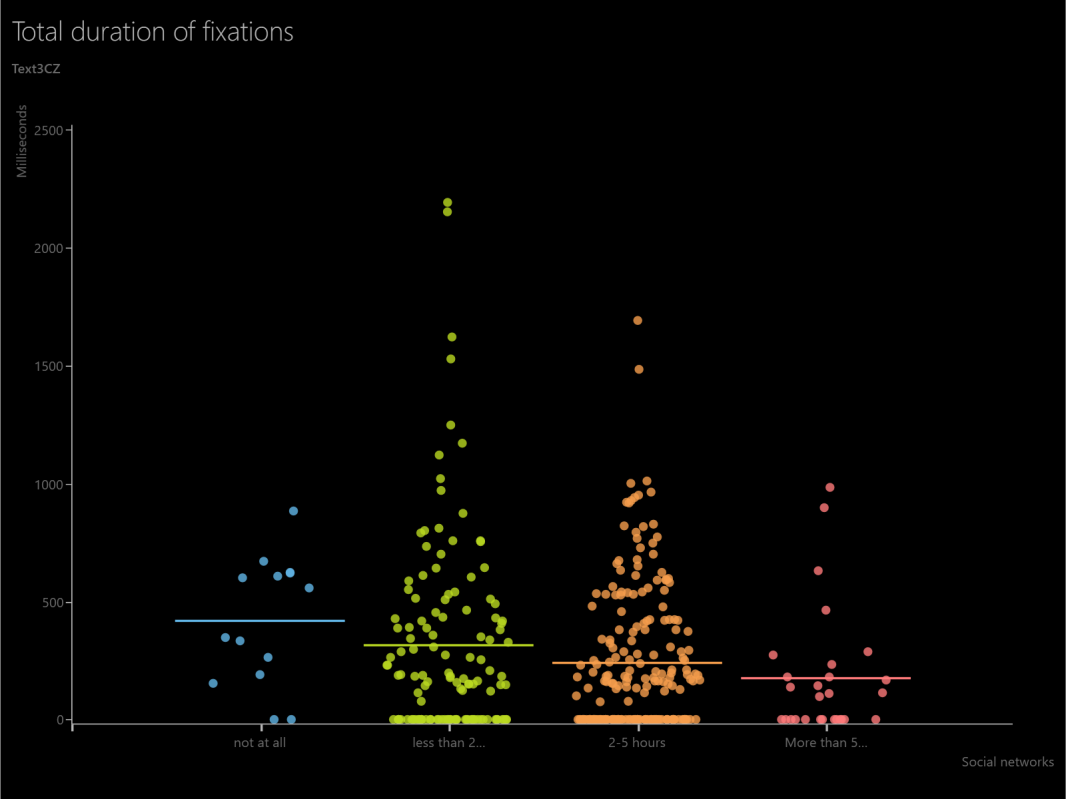
# TEXT 1

# Total duration of fixation based on social media usage -> almost the same, even though we have less data in the 2 categories. So it looks like social media doesn’t have an effect, but it is important to remember that all the data points in Text 1 are WORDS Aois, no emoji Aois yet.

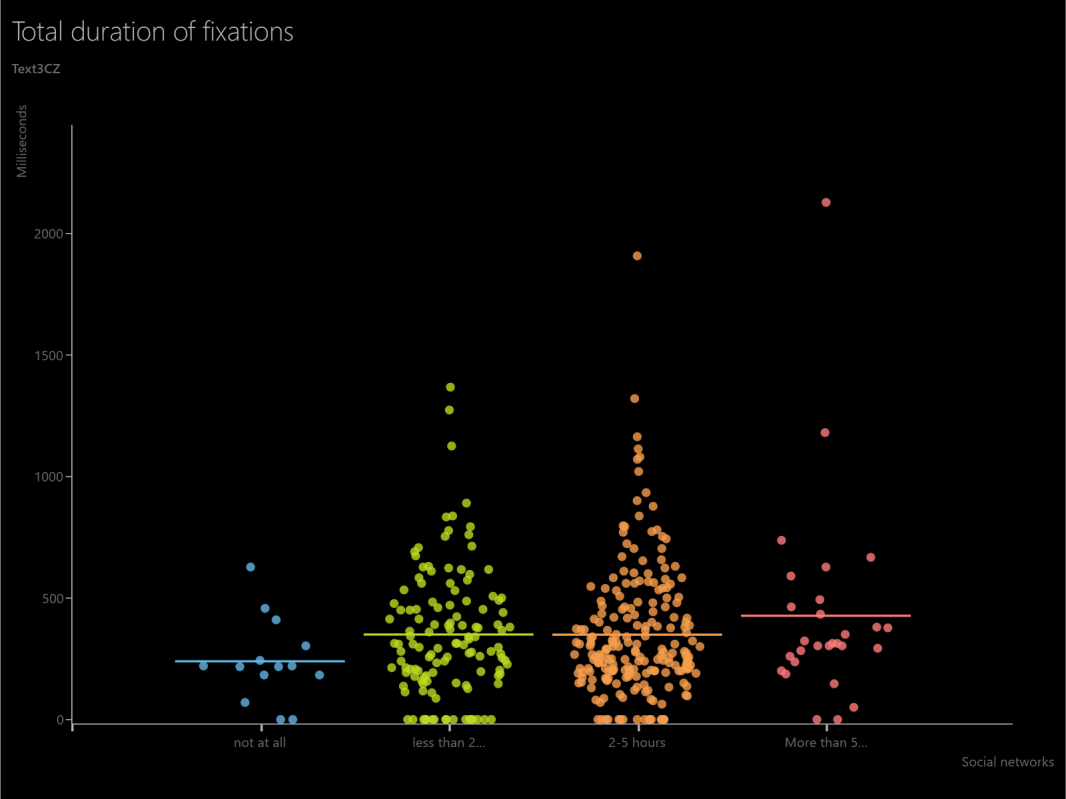


# TEXT 3

Duration of fixations on EMOJIS:



Duration of fixations on WORDS:



A **small but interesting trend** is emerging, though there is **too little data** to claim it as a general pattern. We observe that the **more time people spend on social media, the less time they fixate on emojis**. Conversely, with **words, the opposite is true**—the **less time people spend on social media, the shorter their fixations on words**.

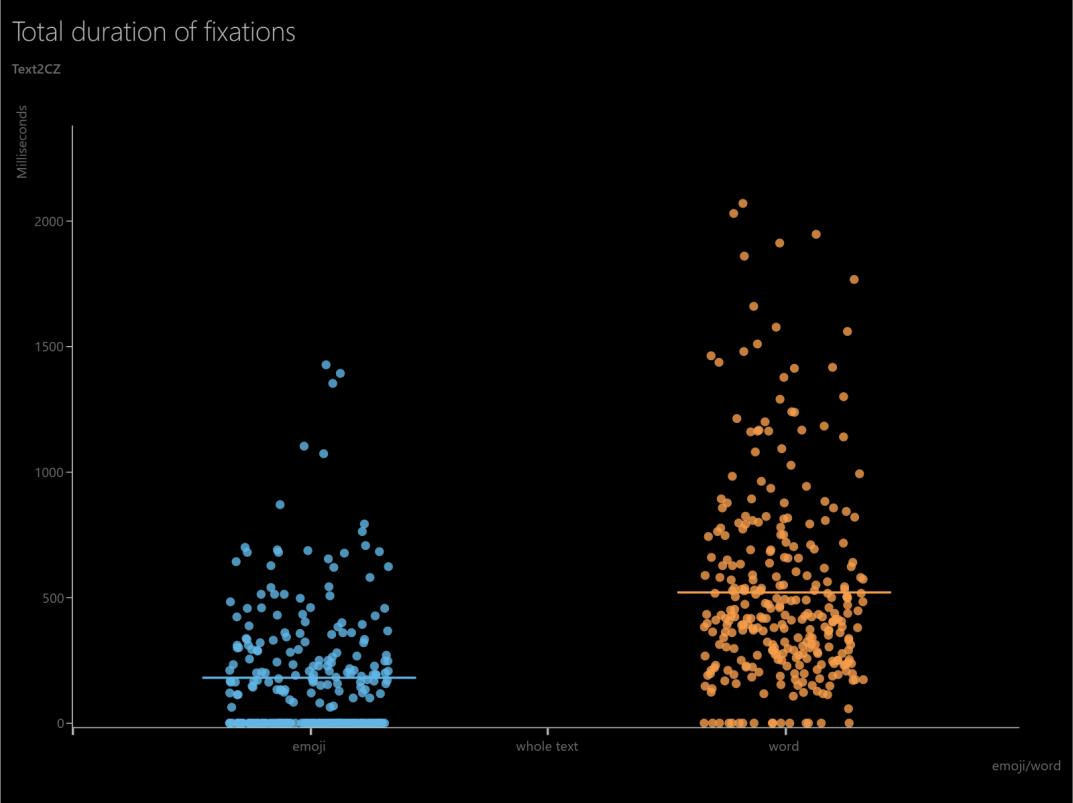
This suggests that people who **are not accustomed to emojis** may need **more time to decode them**, while at the same time, they **read words faster**. **Refer to the two plots above for visual confirmation.**

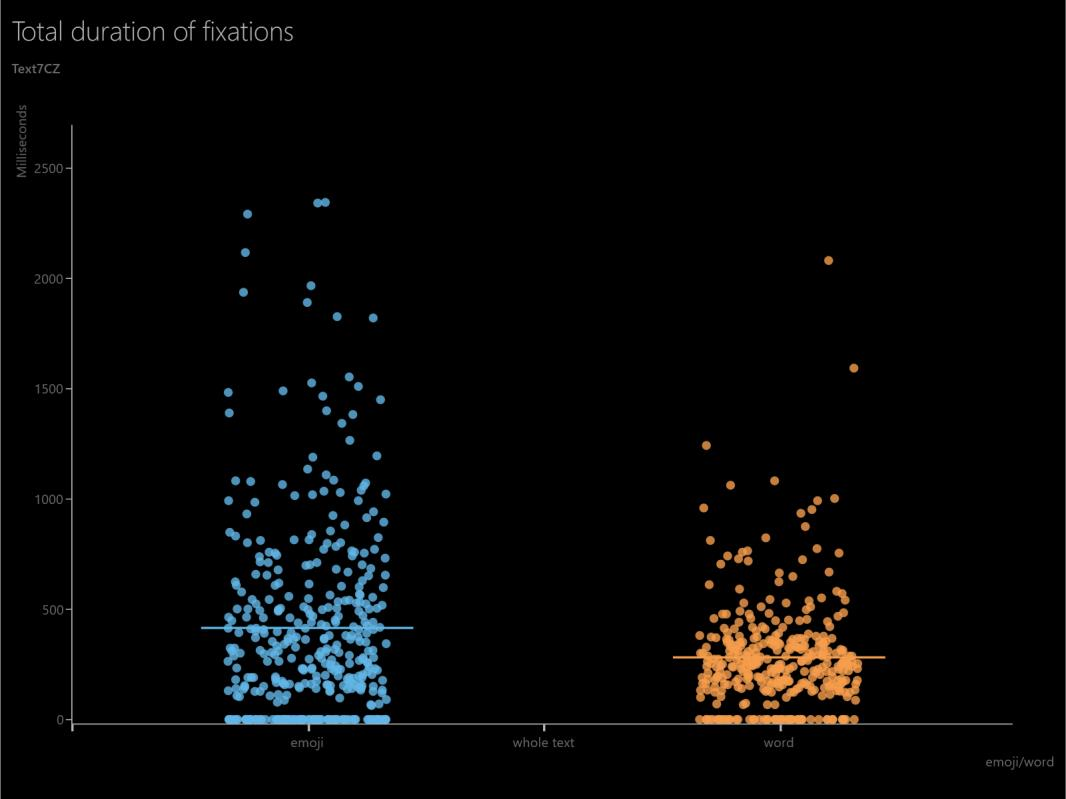
TEXT 2 – Determiners vs TEXT 7 – Replacement

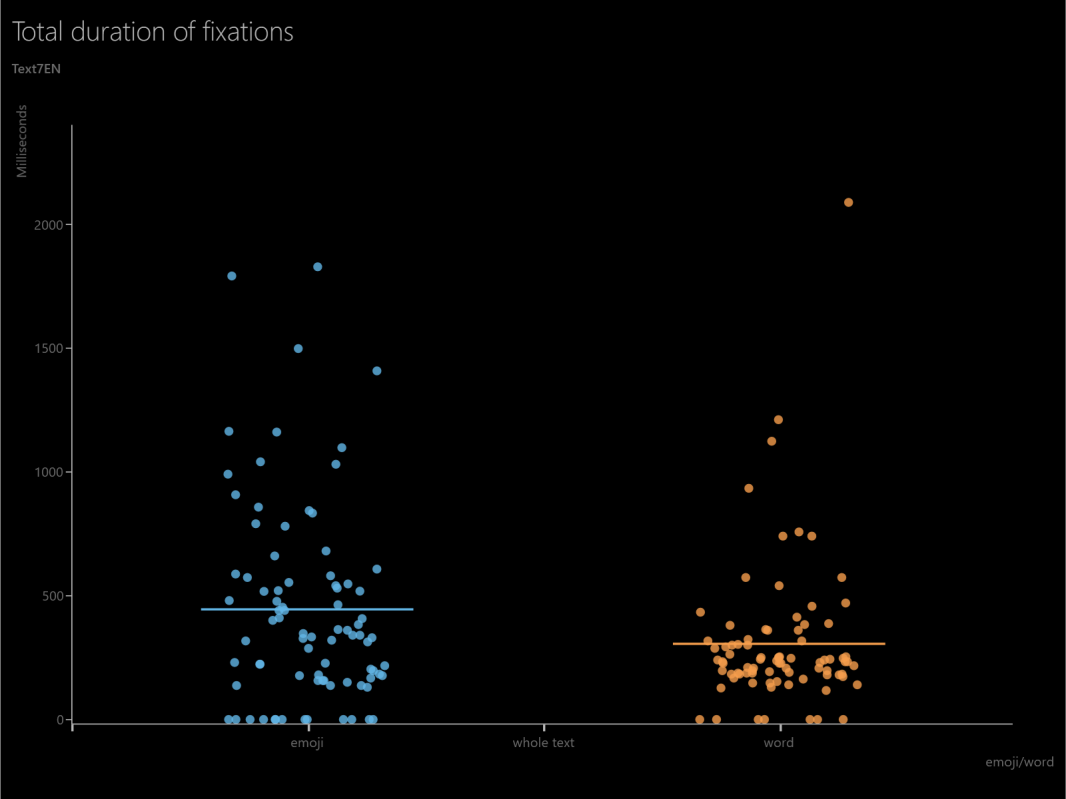
Every time emojis function as **determiners**, they receive **less attention than words**. Often, they have **zero fixations**, and they **always** have a lower average fixation time because they are not essential to the meaning. **Except in Text 7**, where emojis **replace entire words**, they show a **higher average fixation time than words**.

The same trend appears in the **English version**—**Text 7** was the only case where emojis had a

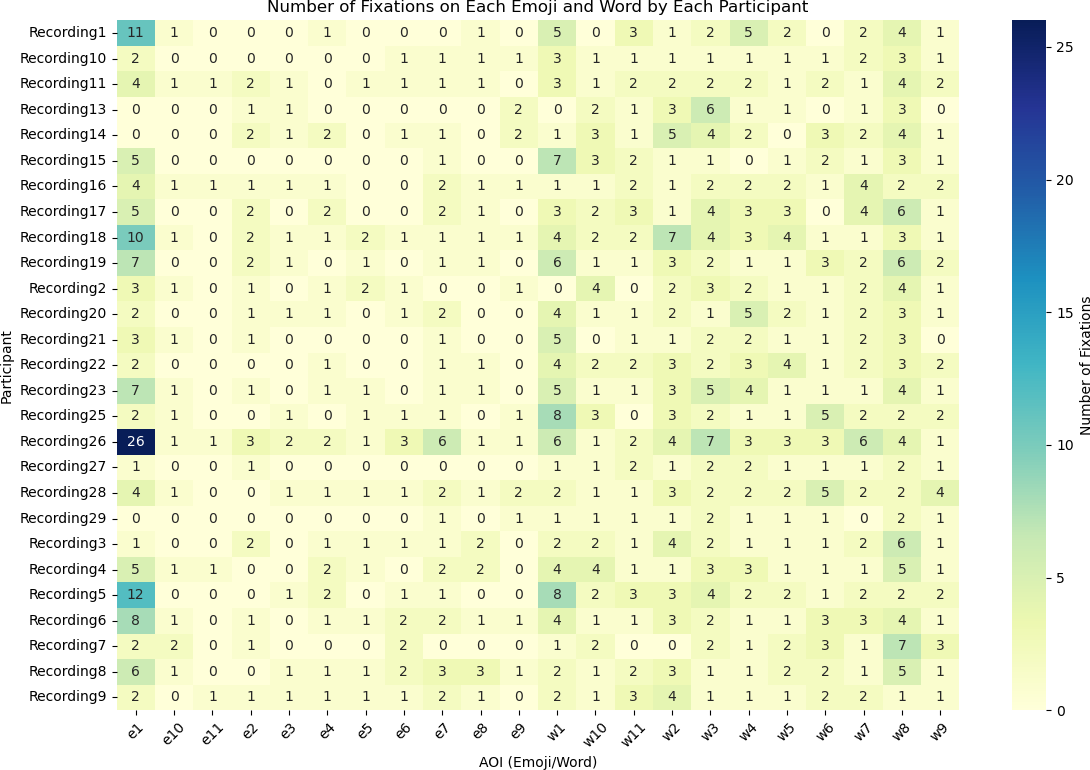
**higher average fixation time** than words.

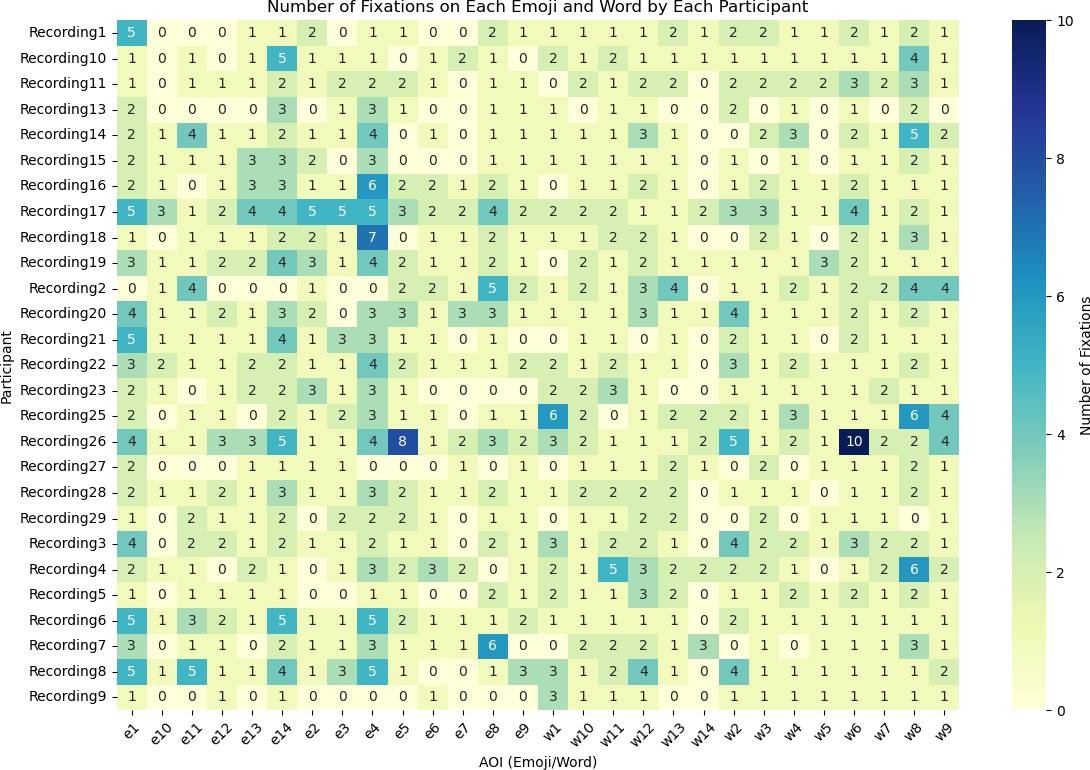






Here we can see the same comparison but in a different type of plot -> compare how many fixations got each emoji and word in Text 2 (determiners) vs Text 7 (replacing):





1. **Conclusions**

Comparison of English and Czech: After trying many metrics, both emojis and words are mostly processed in the same way by both Czech and English speakers. There is no difference in average pupil diameter, which would indicate a higher cognitive load. Even the number of fixations is very similar or sometimes even identical. The difference arises from the **function of the emoji**.

When used as **determiners**, emojis tend to be **neglected, ignored, or perceived peripherally**. However, when they serve a **replacing function**, they behave more like words. Their impact also depends on **the difficulty of the text and the complexity of each emoji**. If an emoji's meaning is less obvious, it may attract **more fixations**. At this point, a **qualitative analysis** is needed— carefully selecting **specific areas of interest** to extract more meaningful insights.