Rhythmic subvocalization in silent poetry reading

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Implicit prosody has been demonstrated to influence sentence processing in various ways (Fodor, 1998, Bader 1998). Only recently has psycholinguistics focused on rhythm processing in stress patterns (Breen & Clifton, 2013, Breen et al. 2019) and poetry (Scheepers 2013, Blohm 2020). Scheepers had shown pupillary reactions to rhyme violations in spoken Limerick processing. Our study on silent reading of *metrically-regular, rhymed language* (MRRL), as instantiated e.g. in conventional poetry, aims at *i.* establishing to what extent the effects are based on *rhythmic subvocalization*, and *ii*. how rhythm perception and induction is influenced by a formal visual presentation as poetry (Blohm & Menninghaus 2020, Xue et al. 2019).

Thirty-eight participants read eight German MRRL texts - 7 newly created, 1 original. Four items were presented in regular *poem* layout with seven 4-line stanzas each. The other half was presented in a visually more irregular prose layout, where line endings often appeared mid-line (within participant factor *layout*). As a second within participants factor, we manipulated whether or not items contained anomalies (version *inconsistent*). Inconsistent versions included three types of anomalies: 1. metrical anomalies, adding one or two stressed or unstressed syllables to the rhyme word to break regular meter, 2. rhyme anomalies, or 3. combinations of both (within item factor *anomaly type*; see example). Most anomalies closed stanzas to ensure that the beat could be extracted and induced by the metrical grid.

Participants were instructed to read silently in their own pace, and no comprehension task was given. Each stimuli was presented on two to three successive screenpages. No backward page-turning was allowed. Participant's eye-movements were recorded.

We predicted that the silent reading of MRRL would result in building up auditive expectations based on a rhythmic "audible gestalt", induced by subvocalization of rhythmic patterns. Hence participants were expected to be disturbed by rhythmic anomalies, and potentially more so in poem layout.

We fitted two linear mixed effects models, each focusing on different interest areas:

1. For the main model, residual log reading times for *critical interest areas* (i.e. position of the anomaly) were fitted with factors *layout* (*prose* vs. *poem*), *version* (*inconsistent* vs. *consistent*), and *anomaly type* (*metrical*, *rhyme*, or *both*); RT-measures used were *single fixation duration*, *gaze duration*, *regression path duration* and *total reading times*. These were residualized beforehand in a base model - across all words of each text-stimuli - for a variety of predictors known to affect reading times, e.g. word frequency, word length.

Results show a fairly robust pattern over all RT-measures, indicating that readers were sensitive to rhythmic-gestalt-anomalies, but differently so in poem and prose layouts (see plot selection, figure 1, 2). Metrical anomalies in particular resulted in increased fixation and RTs in the poem layout, amounting to a significant three-way interaction (factors *layout*, *version*, *anomaly_type metric* for GAZE: $p=.041$, RPD: $p=.021$, TRT: $p=.042$, SFD marginally: $p=.066$). Rhyme anomalies elicited stronger effects in prose layout. The analysis of re-reading times (load contributions) additionally revealed systematic re-reading of rhyme primes (see figure 4).

2. For the complete model, we analyzed the (log) reading times *on all other words* of the stimuli (i.e except CIAs). We established a clear effect of number of *syllables* (residualized by *word length,* see figure 3) on word reading times, for all RT-measures $p<.001$.

Syllables are the units of speech and usually show little effect on RTs on top of word length in "normal" sentence processing (Fitzsimmons & Drieghe, 2011). Hence, the effect of *syllables* is an indicator of subvocalization in reading MRRL and suggests a close eye-to-(inner)-voice span. The syllable effect was stronger in item versions containing anomalies, suggesting an even more cautious and more vocal reading style. What is more, the presence of anomalies had differential effects in the two layouts: participants initially read slower in poem layout when anomalies were present, but adapted to them in later trials, which they did not in prose layout.

In general, the overall pattern of results suggests that eye-movements reflect, and are closely aligned with, the *rhythmic subvocalization* of MRRL.

Stimulus example

poem layout

Wir hatten keine Kerzen bei
und auch die Taschenlampen nicht
es war ja auch ganz einerlei
wir liefen gut auf freie Sicht

Die Taschen waren voll bepackt
mit allem was die Welt begehrt
wir gingen Gleichschritt, fast im Takt
doch schnell war's meiste aufgezehrt $_1$ | **aufgebraucht** $_2$

Der Hunger dennoch war vorbei
was andres war viel lockender…
Bald Nacht vom Tage ganz entzwei
und Füße trabten stockender

Die Bäume jäh schon trennten sich
und vor uns liegend Wassers Gang
Das Ufer drüben nur ein Strich
er ging am untern Himmel lang $_1$ | **entlang** $_3$

Da stoppten wir mit Atmung still

rhyme anomaly

metric anomaly

prose layout

Wir hatten keine Kerzen bei und auch die Taschenlampen nicht, es war ja auch ganz einerlei, wir liefen gut auf freie Sicht. Die Taschen waren voll bepackt mit allem was die Welt begehrt, wir gingen Gleichschritt, fast im Takt, doch schnell war's meiste aufgezehrt $_1$ | **aufgebraucht** $_2$

rhyme anomaly

Der Hunger dennoch war vorbei, was andres viel lockender… Bald Nacht vom Tage ganz entzwei und Füße trabten stockender. Die Bäume jäh schon trennten sich und vor uns liegend Wassers Gang. Das Ufer drüben nur ein Strich, er ging am untern Himmel lang $_1$ | **entlang** $_3$

metric anomaly

Da stoppten wir mit Atmung still und blickten in die Weite hin und hörten kurz noch Grillen Schrill, doch zügig war'n sie aus dem Sinn. Denn lichternd war's am dunklen See und wieder waren alle da. So manches knipste schnell noch Kle hell blinkend an, wir machten Ah! $_1$ | **Ohoh!** $_4$

m&r anomaly

Results

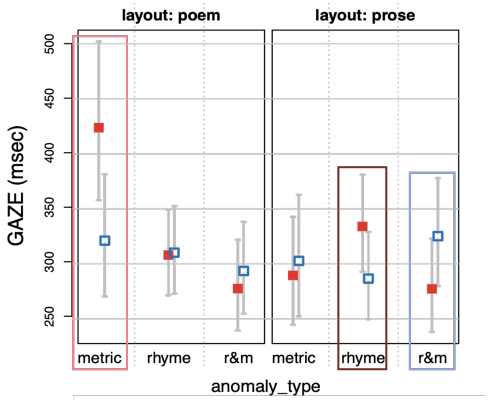

Figure 1. Gaze duration (GAZE) as a function of layout, MRRL_version and anomaly_type (main model).

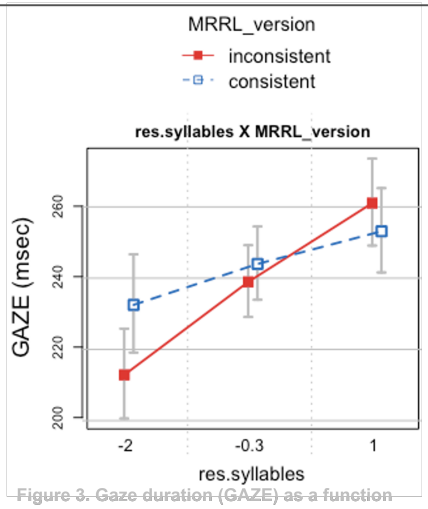

Figure 3. Gaze duration (GAZE) as a function of MRRL_version and residualized number of syllables (complete model).

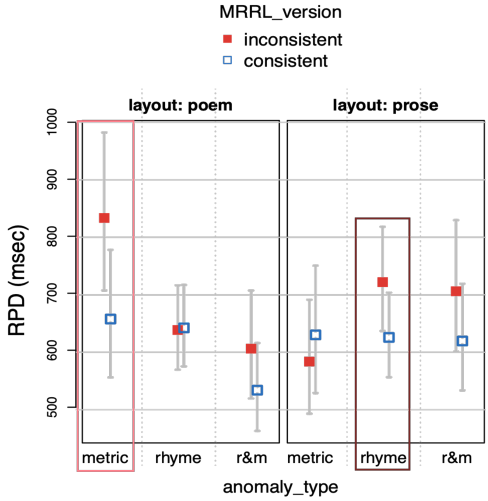

Figure 2: Regression path duration (RPD) as a function of layout, MRRL_version and anomaly_type (main model).

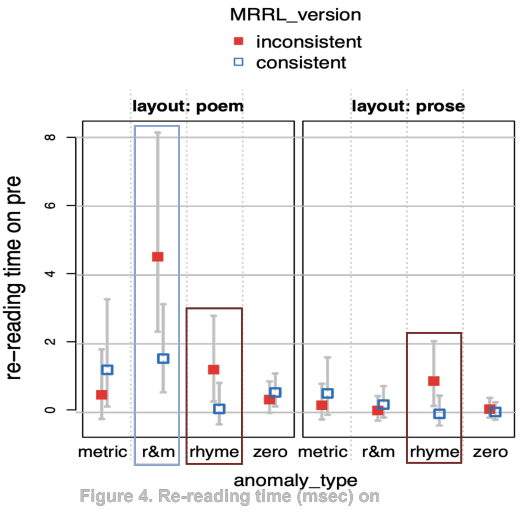

Figure 4. Re-reading time (msec) on prime for layout, version and anomaly (load contribution).

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