

Introduction

Typography is concerned with the legibility, scale and formatting of text and considers the arrangement of textual units including font, letter spacing, kerning, word spacing, and inter-sentence spacing (ISS – the horizontal space between sentences).

The effect of intra-word spacing, inter-word spacing and visual crowding on reading speed and eye movements has been thoroughly investigated.

However, the effect of ISS and visual crowding and the effect of the size of the ISS on eye movements has not been studied. The era of typewriters saw the emergence of the 'double space' as the standard for the ISS due to the lack of flexibility of the typewriter striker compared with a printing press. In the 1950s the commercial printing press, and later the computer, saw the introduction of 'single space' ISS. Studies on reading rate have been inconclusive as to whether single- or double- ISS leads to smoother reading with improved comprehension.

This study therefore aimed to examine if the size of ISS has an effect on eye movements, reading performance and comprehension.

Method

Ethics approval was obtained to recruit subjects aged 18+ years who mostly spoke English, had completed senior secondary education, who also had best corrected distance acuities of 20/20 or better and N5 at near binocularly, no reading addition, no dyslexia and no diplopia.

Four level-6 passages from the standardised Neale Analysis of Reading Ability Test were varied for ISS in MATLAB so that text with 0.5x, 1x and 2x spaces between sentences could be randomly presented to participants. Inter-word, intra-word, inter-letter, and inter-line spacing were kept constant across all passages. Eye movements were monitored using an Arrington View Point Eye Tracker and the time taken to read measured. After reading each passage, participants had to undertake the set comprehension questions, without being timed.

Multiple ANOVA was used to determine if there was a significant relationship between ISS and eye movements or reading speed. Non-parametric analysis was used to examine the correlation between ISS and comprehension scores.

Results

51 subjects aged 23.0±6.0 years (23 males, 28 females) participated in the complete set of tasks.

Comprehension

There was no significant difference between comprehension scores obtained amongst the three varied ISS conditions ($p=0.1261$, Friedman test, Figure 1).

Reading speed

A significant effect ($p=0.0458$, MANOVA) was found between time taken to read half and single inter-sentence spaced passages (Figure 2). Half-spaced passages were read faster than single-spaced passages, with half-ISS averaging 40.944 seconds to be read compared to single-ISS which averaged 44.167 seconds to be read. There was no significant difference between time taken to read half and double inter-sentence spaced passages (average 42.080 seconds) nor any significant difference between time taken to read single and double inter-sentence spaced passages (Figure 2).

Eye movements

There was no significant difference in the number of fixations made ($p=0.4643$, MANOVA) nor any difference in the mean duration of fixations made ($p=0.4086$, MANOVA) amongst the three ISS conditions (Figures 3 and 4).

There were no significant differences in the number of forward saccades ($p=0.5163$, MANOVA) and number of regressions ($p=0.5647$, MANOVA) amongst the different ISS groups (Figures 5 and 6). There was also no significant differences in the mean duration of forward saccades ($p=0.3493$, MANOVA) and mean duration of regressions ($p=0.3836$, MANOVA) amongst the different ISS groups (Figures 7 and 8).

Conclusion

The hypothesis that individuals would exhibit slower reading performance and lower comprehension scores in the 0.5x and 1x ISS conditions compared to 2x ISS was not the case. Therefore it may be concluded that visual crowding through intrinsic ISS was not present. Indeed, reading was faster with 0.5x ISS where crowding is increased.

One possible explanation why participants took significantly less time to read 0.5x ISS passages compared to 1x ISS passages is the concept of 'inter-sentential pausing'. Inter-sentential pausing occurs during reading where one pauses between sentences. If there is a distinctive gap between sentences, as in the case of 1x and 2x ISS conditions, it is natural for a reader to pause before continuing. Pauses are an important feature of intonational phrase boundaries and vary depending on the individual. Since the gap is reduced in 0.5x ISS conditions, it may be that readers continue reading with less pause than in the other spacing conditions.

The phenomenon of the perceptual visual span may also contribute to this significant result between time taken to read 0.5x and 1x ISS conditions. 'Visual span' refers to the number of letters that can be reliably recognised at a glance without moving the eyes. The extent of the visual span during reading is approximately 14-15 letter spaces to the right of fixation and is otherwise known as the 'perceptual span'. It follows that the size of the visual span is an important factor when it comes to reading as a limited visual span will result in a greater number of fixations being required thus limiting reading speed. Hence, potentially the 0.5x ISS condition could attribute to greater individual perceptual spans, and reduced overall reading time required.

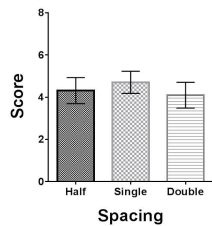


Fig 1. ISS and comprehension score (95% CI)

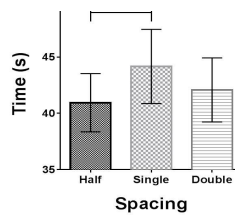


Fig 2. ISS and time taken to read (95% CI)

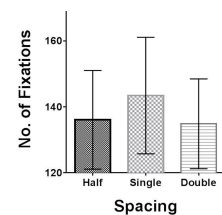


Fig 3. ISS and fixations (95% CI)

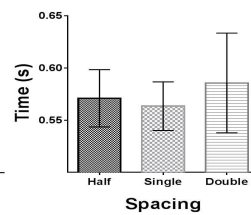


Fig 4. ISS and mean duration of fixation (95% CI)

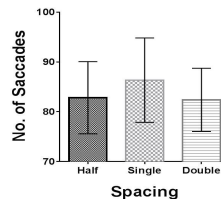


Fig 5. ISS and forward saccades (95% CI)

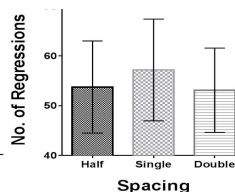


Fig 6. ISS and regressions (95% CI)

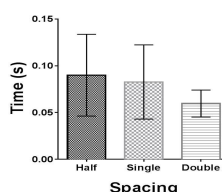


Fig 7. ISS and mean duration of forward saccades (95% CI)

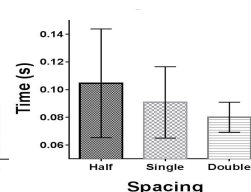


Fig 8. ISS and mean duration of regressions (95% CI)