Animated Backgrounds on the Web Reduce Reading Speed: Some Empirical Evidence from a Remote Experiment

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Abstract. It is generally considered a bad practice to place animations as backgrounds to text. There are many convincing arguments against using animated backgrounds, yet there are few empirical studies that have assessed effects of animated backgrounds in the context of the web. This study therefore set out to collect empirical evidence to support the recommendation of avoiding animated backgrounds. A remote web-based controlled reading experiment was conducted. The results showed that an animated background led to a significant slower reading speed and lower preference scores. Hence, the empirical evidence supports the established practices.

Keywords: readability, luminance contrast, animation, web, accessibility, augmented reality.

1 Introduction

In the early days of the web, it was not uncommon to find websites with animated background behind body text. As the web has matured over the last decades such cases have become increasingly rare. It is generally considered bad practice to place animations behind text. Advice on the use of animations on the web has been proposed, for example Weir and Heeps [1] who argued that animations should not distract and not cause cluttering.

There are several obvious arguments for not using animated backgrounds. First, animated backgrounds may temporarily result in too little contrast between the text and the background. For instance, if the text is white on a black background, while the animation for some seconds is white in the neighborhood of a specific text the text will obviously be unreadable (white on white). This is because visual perception is based on detecting differences also known as luminance contrast [2, 3, 4]. This is why closed captions in videos often are presented on a solid or semi-transparent background, or with a clear contrasting outline [5]. Similar issues hold for transparent menus [6].

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Second, animations usually involve motions, and motions within the visual field of view are known to attract the attention of the visual system, thereby heightening the risk of drawing the attention away from the text reading process. For example, Hong et al. [7] demonstrated that flash animations on websites attract users' attention.

The problems associated with animated text backgrounds may seem obvious and trivial. This problem has gained renewed relevance in contexts of see-through augmented reality and heads-up displays [8] where text information is mixed with images of the world [9, 10, 11]. This is especially critical for low-vision users [12] that relies on visual cues as opposed to tactile or auditory cues [13, 14] or alternative strategies [15]. We therefore designed a simple controlled reading experiment to measure the impact of animations on the reading process, measured both objectively and subjectively.

The rest of this paper is organized as follows. The next section presents related work. Section 3 outlines the methodology used. The results are presented in Section 4 with a discussion in Section 5. The paper is closed with concluding remarks in Section 6.

2 Related work

There is a vast body of literature on aspects that may improve usability and accessibility on the web (see for instance [16, 17]) and interactive elements that may affect web use (see for instance [18, 19]). Some of the literature has focused luminance contrast between text and background on the web [2, 3, 4]. There has recently also been interest in effects of so-called interface dark mode [20]. Several studies have focused on the process of selecting colors [21] and others have suggested tools that help designers select color pairs for text and background that has sufficient contrast [22].

To the best of our knowledge there are few studies of readability of text with animated background on the web. However, there are several related studies that have addressed readability of text superimposed on 3D visualizations [23] and the readability of text in see-through displays [9, 10, 24] where text is mixed with the image of the background.

Scharff et al. [9] measured readability using search times. They explored several factors, including type text contrast level, level of transparency (additive and multiplicative transparency) and background type (wave and plain). Their results indicated that all these factors affected readability. They claimed that an adjusted global masking index could be used to predict the readability of text.

In a similar study [10] Scharff et al. varied the text contrast and four spatial frequency filtered textures. They found that background texture only affected readability when the text contrast was low.

Rzayev et al. [24] explored the readability of text presented in smart see-through glasses where text is mixed with the background. Their results showed that text positioned in the top-right region of the field of view led to a higher perceived workload and lower comprehension. Moreover, they found that text presented sequentially in a serial manner was the most effective when participants were sitting, while scrolling text was more effective when participants were walking.

In a study of text overlays on three-dimensional (3D) visualizations and video [23] showed that that reading performance was unaffected by whether the type of background consisted of videos or 3D visualizations. They found that negative polarity resulted in a higher reading performance than positive polarity. They also found that participants preferred billboard drawing styles.

There has been some interest in the effects of webpage backgrounds in the context of advertising. For instance, Stevenson et al. [25] found that simple backgrounds were perceived as more positively, while Noiwan [26] found that users ignore animated ads. Benway [27] confirmed banner blindness in a controlled experiment, while Lee and Ahn [28] used eye-tracking to find that animations in banner ads had a negative effect on attention. Zhang [29] found that animation as a secondary cue reduces reading comprehension, while this disturbance diminishes with the complexity of the reading task. They also noticed that irrelevant animations and strong colors had negative effects on reading. Hong et al. [30] observed that flash animations helped information seeking, while Zhu and Grabowski [31] found no significant effects of animated versus still images.

Other studies have addressed the technical quality of different web animation techniques including animated gifs and flash [32]. More recent works have focused on CSS animations [33]. The effect of auditory distractions on reading [34] is another active area of research. Some claim that reading comprehension is negatively affected by fast and loud music [35]. Halin [36] explored an exciting connection between the visual and the auditory in that hard to read fonts requiring more concentration could help readers mask out disturbing speech from the environment.

One may suspect that animations used as carefully designed aesthetic elements on the web may be perceived positively by users. In fact, an interesting experiment conducted by Tractinsky, Katz, and Ikar [37] showed that users' perceptions of usability were more affected by the aesthetics of the interface than actual usability.

3 Method

3.1 Experimental design

A within groups experimental design with background type as independent variable and reading time and preference as dependent variables. The background type independent variable had two levels, namely uniform (no disturbance) and animated (disturbance).

3.2 Participants

A total of 14 participants were recruited for the experiment from 20 to 35 years of age.

3.3 Materials

Two different texts comprising 260 words were selected from the text Little Women by Louisa May Alcott. The two texts were considered to be at the same level of difficulty

since they were from the same work by the same author. The reading levels of the two texts were assessed using six well-known readability indices (using https://readabilityformulas.com/free-readability-formula-tests.php). The shown in Table 1 shows that both texts were at an average to difficult reading level. The indices also suggest that the text used with the animated background was somewhat less readable (23%-43% difference) than the text used with plain background and may thus be a source of bias in the experiment. However, the literature on readability indices suggests that such indices should be interpreted with caution as they only present a simplistic view on readability [38, 39, 40].

Table 1. Readability of the two texts according to six common readability indices.

	plain		animated		
Index type	score	interpretation	score	interpretation	diff.
Flesch Reading Ease sc.	62.7	average	47.3	difficult	24.5%
Gunning Fog	14.3	hard	18.4	difficult	28.6%
Flesch-Kincaid Grade L.	11.8	12th grade	14.8	college	25.4%
The Coleman-Liau Index	7.0	7th grade	10.0	10th grade	42.8%
The SMOG Index	8.5	9th grade	12.1	12th grade	42.3%
Auto. Readability Index	13.1	college level	17.1	college graduate	30.5%
Linsear Write Formula	16.8	college graduate	20.7	college graduate	23.2%

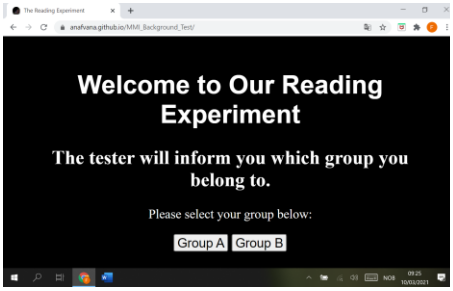
Both texts were presented in white foreground color on a black background (see Fig. 1 (f)). However, one of the texts had an additional cyclically repeating animated background with a multicolored wire-frame ball exploding in a fireworks-like manner covering the entire screen (see Fig. 1 (c-d)). The animation was achieved with an animated gif-file.

3.4 Procedure

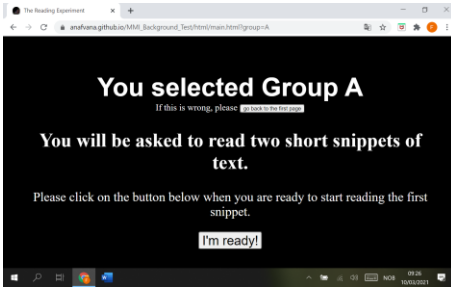
The experiment was conducted online and remotely due to the COVID-19 pandemic. A simple custom-made website was designed where participants first were given a start screen where they would select path A or path B (see Fig. 1 (a)). Path a would lead to the text with the plain background first, followed by the animated background second. Similarly, path B would show the text with the animated background first, followed by the text with plain background. The web instrument is available at (https://anafvana.github.io/MMI_Background_Test/)

The experiment was balanced by randomizing the presentation order. About half of the participants recruited were instructed to choose either path A, the other half were instructed to choose path B.

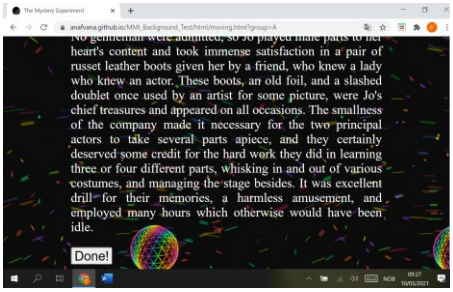
The participants were asked to read each of the texts and press next. The time the participants were on the text page was automatically recorded.



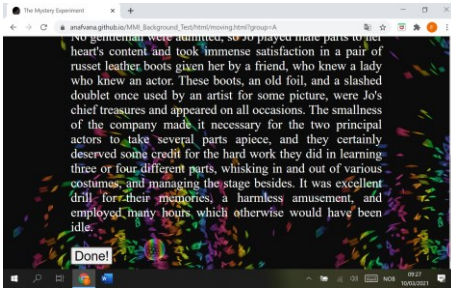
(a) Welcome screen, selecting path



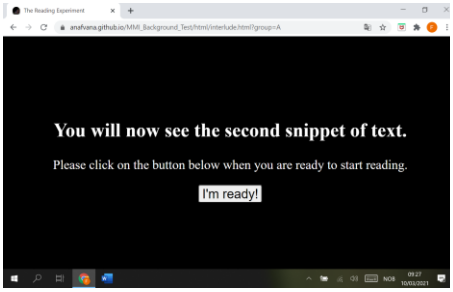
(b) Getting ready



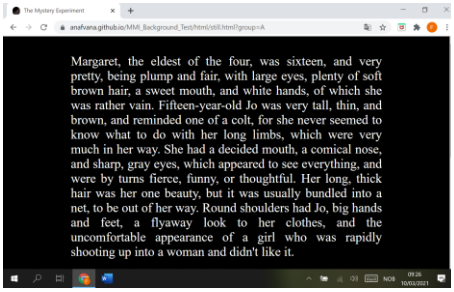
(c) Animated background



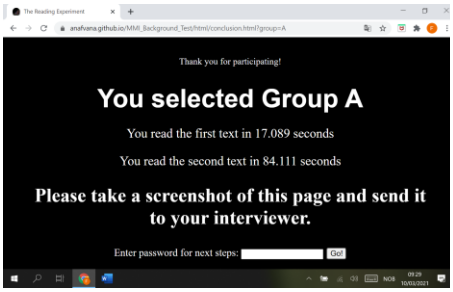
(d) Animated background (later)



(e) Getting ready for part 2



(f) Plain background



(g) Summary

Fig. 1. Reading experiment instrument.

At the end of the experiment a screen showing the recorded reading times for the two text were shown (see Fig. 1 (g)). The participants were asked to return these results to the experimenter via email.

Finally, the participants were redirected to a google form with questions about their perceptions on how much they learned from reading the two texts and how they found the reading experience using five-item Likert scales.

The experiment was anonymous, and no linking data was necessary as it was conducted in a single session [41].

3.5 Analysis

The reading speeds in words per minute (wpm) [42, 43] were calculated based on the observed time to read the 260 words using

$$Reading\ speed = \frac{60 \times words}{reading\ time}$$

The reading speed was checked for normality using a Shapiro Wilks test and analyzed using parametric procedures, while the Likert responses were analyzed using non-parametric procedures as the data were ordinal. Statistical analyses were performed using JASP version 0.16.1.0 [44].

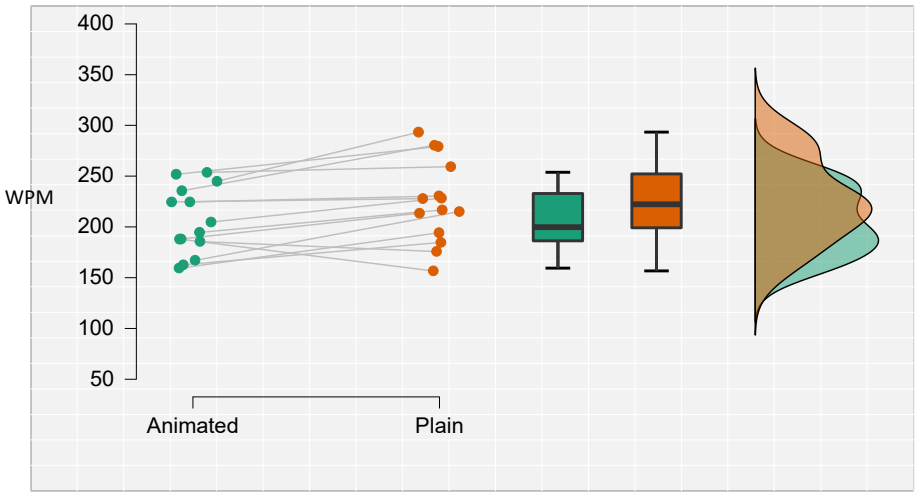


Fig. 2. Raincloud plot showing the distribution of reading speed observations with plain and animated backgrounds (words per minute).

4 Results

The observed mean reading speeds in words per minute (see Fig. 2) shows that the reading speed with the plain background ($M = 225.4$, $SD = 41.0$) was 9.2% higher than

the reading speed with the animated background (M = 206.1, SD = 33.1) and this difference was statistically significant ($t(13) = 3.172$, $p = .007$, Cohen's $d = 0.848$).

The perception results from the five-item Likert questions (see Fig. 3) show that with plain background the reading experience (M = 3.3, SD = 0.7) and learning outcome (M = 3.3, SD = 0.7) where higher than the reading experience (M = 2.0, SD = 1.0) and learning outcome (M = 1.7, SD = 0.6) with the animated background. No 5 Likert scoring was given for any of the questions. A two-way analysis of variance using Durbin tests shows that the effect of background was significant ($\chi^2(1) = 17.8$, $p < .001$). Furthermore, a Durbin test shows that there was no significant difference in reading experience and reading outcome for each of the two types of background ($\chi^2(1) = 0.140$, $p = .708$).

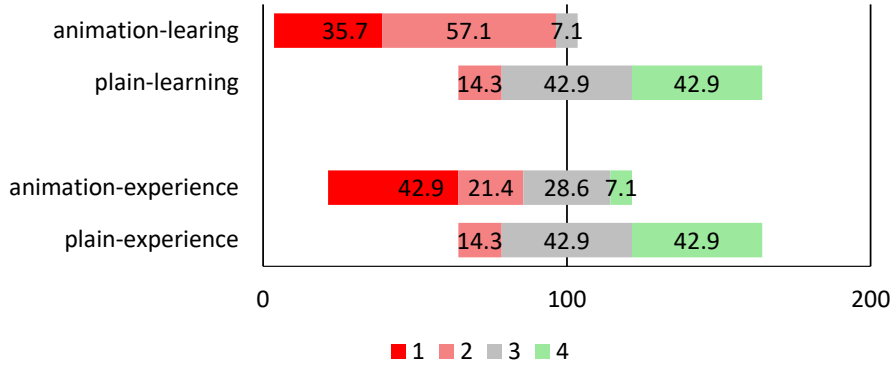


Fig. 3. Diverging stacked bar chart showing the percentage responses to perceived learning outcome from the reading activity and the perceived reading experience for the text with animated and plain background, respectively (five-item Likert scales).

5 Discussion

The results support the recommendation that animations should not be used as background for text. Background animations resulted in lower reading speeds (objective measure), and also lower perceptions (subjective measures). Although the difference was significant the difference was less than 10% which is lower than expected. The result agrees with previous work (see for instance [9,10]).

Moreover, the perceived learning and reading experience scores were also comparably low overall. With the animated background these were at the negative side of the scale though not at the lowest point. The mean scores for the text with plain background was just slightly above neutral on the positive side. This may be a result of the text used. Perhaps this text was too hard or not sufficiently engaging?

5.1 Limitations

One weakness of the current experiment is the possibility of bias due to the differences in reading level detected by the readability indices. Although such indices are especially sensitive to variations for such short texts, they do provide a neutral perspective. Moreover, the fact that all six totally different readability scores placed the readability of the text with plain background over the animated background suggests that there indeed may be an actual difference. Clearly, the results for the text with plain background were also the most beneficial and we can therefore not be completely certain that it is the text itself or the animated background, or a combination that is the cause of the slower reading speed and lower preference scores. In hindsight, the experiment should have been further balanced into four conditions where both texts were presented in both background conditions. This would have eliminated any text readability bias.

However, one may also defend the legitimacy of the experiment. If it is in fact so that the text with animated background was harder to read, it may also be that the harder reading task has helped mask out the potential disturbance of the background animation, in a similar manner as was observed in the experiments by Zhang [29] and Halin [36].

The search for text passages focused on getting equal length texts. In hindsight the focus should be on finding text passages with similar readability scores as the exact equal lengths are probably not as important as equal reading levels. Such a choice can be justified as the reading speed is analyzed and presented as a normalized measure that is independent of the actual text length.

Also, the experiment was based on simply measuring the time it took to read the text. We therefore could not control the way the text was read. Some may have read the text carefully, while others may have skimmed the text, although the spread suggests relatively consistent reading patterns across the participants. In other readability studies often search tasks are introduced to better control the way the text is read (see for instance [9, 10]).

According to Scharff et al. [9, 10] the effect of the visual background noise is related to the contrast level of the text. In this study we did not control contrast level and we must therefore assume that the contrast level was sufficiently low. However, it must also be noted that the type of experiment deployed herein were quite different from that of Sharff et al.

Another weakness of this experiment is the small number of participants, comprising a relatively narrow cohort. Although this was a pragmatic choice during the COVID-19 pandemic, a larger scale study with cohorts at different reading ability levels could give relevant insight into the effect of the background.

6 Conclusions

This study attempted to provide concrete empirical evidence in support of the recommendation that animations should not be used as text background on the web. A simple reading experiment was conducted. The results support the recommendation as the text with animated background resulted in a slower reading speed and lower responses in

terms of perceived learning and reading experience. These findings also give support to voices that argue for ensuring sufficient text contrast in see-through displays such as used for augmented reality. It must be noted that the results may be somewhat biased as readability indices indicate that the text used with the animated background was less readable than the text used with the plain background.

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