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Typeface comparison – Does the x-height of lower-case letters increased to the size of upper-case letters speed up recognition?

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ABSTRACT

Daily contents presented on television screen are in most cases equipped with titles, for example the names and surnames of presented people, data about the location, subtitles or different advertisements. It is widely believed that upper-case letters are more useful (compared to lower-case letters) for placing short titles. The aim of the research was to determine the differences in recognition and reproduction times of short titles in various experimental conditions (especially the difference between lower- and upper-case letters when the x-height of lower-case letters is increased to the main size of upper-case letters). We were interested in how lower-case letters are comparable to upper-case letters in recognition and information processing. Five typefaces were included in the experiment, i.e. Calibri, Georgia, Swiss 721, Trebuchet and Verdana. Three-letter words were presented in lower- and upper-case, covering a comparable area in four different positions on the screen. The analysis of variance showed that the Calibri typeface was recognized and processed faster. The Georgia, Trebuchet and Verdana typefaces showed comparable processing times regardless their letter case.

1. Introduction

Our visual attention is drawn to different static and moving objects. While watching television, the main aspect is the moving picture, which gives us the larger part of the information. Apart from the moving picture, static elements can be significant as well. The purpose of these elements, called *titles* in this paper, is to upgrade the video content while providing extra information that can be useful in the holistic view of the situation (data about the presented person, event venue, election- or sports results, subtitles). Static elements, which are presented for a short time, can attract viewers' attention. The question is how to incorporate these elements onto the screen, for them not to be overly disturbing for the viewer, yet still serving as supplementary information to the video.

When titles are presented on the screen for a short period of time, the recognition of letters and words is of great importance. It is not entirely clear yet how different parameters, e.g. size, use of upper- and lower-case letters, position and limited showing time, can affect the attention to and recognition of titles. These can be presented in two different letter cases, i.e. lower- and upper-case. Lower-case letters include different x-height sizes, ascenders and/or descenders, and form clusters of letters, often a whole word (e.g. cat, dog, pig), or the so-called Bouma shape (Larson, 2004). Upper-case letters do not form word shapes since each word written in upper-case letters forms the shape of a horizontal rectangle (e.g. CAT, DOG, PIG). Some researchers (Woodworth, 1938; Smith, 1969; Fisher, 1975; Larson, 2004) have pointed out that the recognition of lower-case letters is easier due to the formation of shapes. Sequences of letters form shapes which can be recognized more quickly and can be remembered better since people tend to remember alternating shapes better than square shapes. Nevertheless, the statement that a word shape has the strongest influence on reading and recalling the text has no solid ground (Hohenstein and Kliegl, 2014). Larson (2004) claims that the word shape is important for word recognition. On the other hand, some researchers (Garrod and Daneman, 2003; Arditi and Cho, 2007) suggest that word shapes do not have the strongest influence on recognition. Some believe that for the recognition of short (three-letter) words, the use of upper-case letters is much more effective (Garrod and Daneman, 2003; Pušnik et al., 2016). The shape of words is less important when determining the recognition of short

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titles (Pelli et al., 2006). Schiepers (1978) and Bock et al. (1993) claim that a series of letters has a stronger impact on the recognition than the word shape. For the recognition of three-letter words, the shape of an individual letter is more important than the shape of the entire word (Bouwhuis and Bouma, 1979).

Research (Lawry, 1980; Nazir et al., 1998) has shown that the design features of letters affect word recognition. In consequence, the research on serif and sans-serif typefaces is important (Lund, 1999; Bernard et al., 2003; Arditi and Cho, 2005) as is the research on the legibility of different groups of typefaces (Sheedy et al., 2005; Moret-Tatay and Perea, 2011). The main characteristics of legible typefaces are increased x-height and stressed counter shape (Weisenmiller, 1999; Wheildon, 2005; Možina et al., 2010). Furthermore, important factors include the form of letters, the thickness of strokes and white spaces (Tinker, 1966; Reynolds, 1988; Lund, 1999; Shaikh et al., 2006).

Legibility is defined as the detection of text with respect to its relative typographic value (Pastoor, 1990) and is measured with the reading speed at which a content can be processed. Typefaces differ according to their usage. Some are more appropriate for printing, others for on-screen use; in both cases, problems can occur if the presented letters are too small in size. This can affect visibility and consequently, recognition and legibility (Weisenmiller, 1999; Nazir et al., 1998; Legge and Bigelow, 2011). At small sizes, the specifics of typefaces which define visibility, recognition and legibility and which are important for reading can be lost (Bouma, 1971; Cosky, 1976). The processing of small upper-case letters is faster than the processing of lower-case letters of the same size since the former cover a wider area. When the x-height of lower-case letters is increased to the main size of upper-case letters, the two cases become more comparable as they are of the same height (Rudnicky and Kolers, 1984; Sanocki, 1991; Bringhurst, 2004). The sizes in the vertical direction become equal, whereas differences appear in the horizontal direction. The rise in letter size increases the white space in lower-case words. A wider word covers a wider visual angle. Consequently, separate letters in the word are more visible (Stevens and Grainger, 2003), which can affect the speed of reading (Yu et al., 2007).

Recognition is not only influenced by the word size but also by its position (Dyson, 2004; Mills and Weldon, 1987; Dyson and Haselgrove, 2001). The titles can be placed in all four corners of the screen; however, in practice, they are mainly placed in the bottom positions of the screen. The positions at the bottom have become almost standard. Therefore, when titles are placed in the top positions, they can represent new, unexpected stimuli, which can attract attention and affect information processing (Nazir et al., 1992; Pušnik et al., 2016).

Other environmental factors, such as noise (Ljung et al., 2009) or vibration if the reading for example takes place in a vehicle (Kumar and Saran, 2014), can also affect the reading performance. In a noiseless environment, a person can focus more easily on reading, which may result in faster and better recognition of letters, higher reading rate and better understanding of the presented text.

The aim of our experiment was to examine how typeface, the size (height) of words, letter case and the positions of a word on the screen affect recognition in an environment free of distractors. We observed the effect of these factors on the recognition threshold, i.e. the minimum time required for the word to be processed to the level of recognition and reproduced correctly.

2. Method

The tested typefaces were Calibri, Georgia, Swiss 721, Trebuchet and Verdana. In television broadcasting, titles are often presented in these five typefaces. The typefaces are representatives of both serif and sans-serif typefaces (Josephson, 2003). Due to their characteristics (higher x-height, distinctive counter shape), they are suitable for on-screen use. The letters were presented in bold. Television broadcasts often use letters in bold for titles. According to Sheedy et al. (2005), a higher number of pixels covered by bold typefaces relates to higher visibility and legibility. The letters were presented on a grey screen, as suggested by White (1996) and Hunt (2004). The x-height of lower-case letters was increased, so that the visual angle in the vertical direction covered the same size as at upper-case letters. This provided a more adequate comparison of the reading performance with the one for upper-case letters since the area coverage (size of presented letters) could affect recognition times. On average, lower-case letters were increased by approx. 36 percent (Table 1). All typefaces were first measured in points (pt) and converted to pixels (px) for a suitable on-screen display.

Each observer participated in 40 experimental conditions – a combination of five typefaces, four positions and two letter cases ($5 \times 4 \times 2$). The high number of experimental conditions forced us to divide the measurements into two parts. The participants took part in 20 experimental conditions at a time (5 typefaces $\times$ 4 positions), first reading the words in lower-, then in upper-case letters, or vice versa. As four positions can be used to present titles on the television screen (bottom left and right or top left and right), we presented words in the four randomly alternating corners of the screen (De Bruijn et al., 1992; Hartley, 1999).

Fig. 1 shows the experimental setup and posture adopted by the participants. Words were presented in the corners of an imaginary square 1280 $\times$ 720 px in size, covering 16.6° of the visual angle vertically and 29.3° of the visual angle horizontally. A black spot with 4 mm in diameter, which represented the starting point (fixation) of each experiment, was placed in the centre of the screen. The distance between the fixation point and the presented word in one of four corners was constant, i.e. 195 mm. The height of the chair was adjusted to each participant so that the participant's eyes were at the height of the fixation point, which enabled them to sit comfortably in front of the screen, with the back supported by the chair backrest. The distance between the viewer and the screen was constant, i.e. 650 mm. TOBII X120 eye tracking device was used to ensure adequate distance from the observer to the screen. If the distance deviated substantially from 650 mm, the person was instructed to move less or not to move at all.

The visual angle of presented words was adjusted to a virtual rectangle (Fig. 2). The presented words (excluding ascenders and descenders) covered the same size in the vertical direction (i.e. the cap height in upper-case words equalled the x-height in lower-case words). The visual area in the horizontal direction was different for each typeface (the smallest with Calibri, followed by Trebuchet, Swiss721, Verdana and Georgia).

The presented words were in black (Hex #000000; RGB (0, 0, 0)) colour on a light grey (Hex #cccccc; RGB (204, 204, 204)) screen (LCD screen, HP ZR24w). The chromaticity of white colour on the monitor was set to D65. The resulting luminance of the LCD screen was between 80 cd/m^2 and 160 cd/m^2 (as suggested by Nooree et al., 2016). The surroundings of the room the experiment took part in were in neutral grey colour. The reflectivity was minimal and in line with the International standard, 2009. The reflectivity of the surroundings was smaller than that of the screen. The screen was calibrated according to the International standard, 2008. The chromaticity of white colour on the screen was set to D65.

Participants were given 10 min to accustom themselves to the lighting conditions of the experiment room. The procedure was explained orally to each participant; however, they also had the possibility to read the instructions. The experiment was divided into two parts to avoid participants' fatigue (separate sessions were carried out for each letter case). The duration of each session was