The Recognition Rate of Handwritten Words in Tachistoscopic Display

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1 Introduction

This paper describes an experiment that looks at the relationship between exposure time and the recognition rate of handwritten words displayed tachistoscopically on a computer screen.

The experiment is one of a number of experiments looking at the effect of rendering techniques on the legibility of digital ink. The recognition rate during tachistoscopic display has been chosen as one measure for the legibility of digital ink.

To run tachistoscopic experiments that highlight differences in legibility, we need to be assured that our results are not obscured by any thresholding effect in the recognition rate. To this end, our experiment has been designed to investigate the existence, and location of such an effect. The results of this experiment will inform the design of latter experiments so that measurements can be made at, or below, any threshold.

2 Hypothesis

There is a threshold in the recognition rate of tachistoscopically displayed handwritten words, after which increasing exposure time does not lead to a significant increase in the recognition rate.

3 Related Work

Tachistoscopic display is an established method for measuring the relative legibility of different printed symbols. Tinker [6] notes that it “is useful for measuring the relative legibility of letters and digits, specific letters in
different typefaces, and the effect of variation in brightness contrast between print and paper”. He does however caution that it is not suitable as an overall measure of legibility for continuous text as the task in no way reflects the process of ordinary reading.

Maddox et al. [4], used tachistoscopic display for comparing the legibility of three dot matrix fonts. More recently Kingery and Furuta [3] used the technique for investigating the effect of a number of typographic factors on legibility when skimming electronic newspaper headlines.

No work has been found describing the tachistoscopic presentation of handwritten words. There is a small amount of work concerning human identification of handwritten words displayed on a computer screen[1, 5], which has been used to inform the development of handwriting recognition algorithms.

Human recognition of words is affected by a number of different factors: script size; handwriting style; distance from the display; screen contrast; and rendering method may all have an influence. When conducting an experiment such as this, it is important to be aware of these factors.

4 Method

4.1 Handwritten Material

To reduce variability in script style, 199 individual words were collected from a single author. The words were drawn from the most common six and seven letter words in the English language as listed in the LOB corpus[2]. Each word was copied from a typed list and written on paper with a Wacom Intuos Inking Pen. The writing paper was attached to a Wacom Intuos digitizer tablet which sampled the pen movement at around 94 Hz. Each word contains 300–900 samples. The information sampled includes:

- Movement data, at 100 points per millimetre.
- Pressure data, at 1024 arbitrary levels.
- A time stamp, with microsecond precision.
- Pen tilt data.

The pen data were rendered into anti-aliased word images using a pen model which uses the pen speed and pressure to calculate the intensity of the pen trace. This algorithm mimics the characteristics of real pens. One such word can be seen in figure 1.
4.2 Subjects

Eight volunteers from the University of Hertfordshire administration staff were used in this experiment. One male and seven female. Administration staff were chosen for this experiment as they are more likely to work with other people’s handwriting than any other type of staff or student.

4.3 Equipment

The tachistoscopic display program ran on an 800 Mhz Intel Celeron PC running RedHat Linux. The experiment was conducted in a closed room with no natural light to control for illumination. Subjects were seated so that their heads were approximately 180 cm away from a Tatung 17” monitor (dot-pitch of 0.27 mm) with the display resolution set at 1024×768. Subjects were asked to keep their backs straight against the back of the chair so as too keep the distance between their eyes and the screen constant. The words were displayed at the size they were originally written at. The x-height of the words displayed on the screen was around 2.5 mm.

4.4 Experiment procedure

The subjects were split into two groups which each saw one of two sets of 90 words drawn at random from the corpus of 199. The images were shown in sequence at different exposure times: 200–40 ms descending in 20 ms steps. Each subject saw ten sequences, showing words at each of the different exposure times.

Upon entering the room, subjects were asked to sit on the chair in front of the computer. They were given written instructions and allowed to ask any questions. They were given a keyboard to rest in their lap and asked to start when they were ready.

Upon pressing the space-bar on the keyboard, after a small random delay between 0.5–1.5 s the target word was displayed in the place of a pre/post
exposure focus point. The subject then spoke the word they thought they had seen. Before the subject could proceed to the next word, their response was marked by the experimenter using a mouse click. Button 1 marked a correct response, button 3 an incorrect response.

The results of each experiment were logged to a text file recording: the word; the target exposure time; the actual exposure time; the delay before exposure; and the mark recorded by the experimenter. 97% of the exposures were within 1% of the target exposure time.

The whole experiment took between 5 and 10 minutes for each subject to complete.

5 Results

The results of two participants were dropped because they fell below a 60% recognition rate at the 200 ms exposure time. It was deemed that their poor visual acuity would confuse the results.

The correct responses from the remaining six participants were summed and plotted, this is shown in figure 2.

The graph in figure 2 shows, as expected, a threshold recognition rate of 40% for a 40 ms exposure time, falling to 50% for a 80 ms exposure time, then rising to 90% for a 200 ms exposure time.
about 80% which is reached between an exposure time of 100–120 ms. The recognition rate tails off rapidly as the exposure time decreases from this threshold.

6 Discussion

The result of the experiment presented here is very limited, especially as only six subjects were used. However as only a rough indication is required for future work, no further subjects were run.

The two values determined from this experiment: an 80% human recognition rate of context free handwritten words; and an exposure threshold between 100–120 ms, are both dependent on a number of factors and so are probably not generally applicable.

The results of this experiment are likely to be dependent on three major factors. These are:

**Visual acuity:** Differing visual acuity is possibly the greatest influence on recognition rates.

**Visual angle:** The ratio between the viewing distance and the x-height of the script, 72:1 in our case, will dictate the perceived size of the script.

**Familiarity:** The subject’s familiarity with the task, and reading that particular style of handwriting will also influence the recognition rate.

Other smaller factors may include: the contrast of the words against the screen; and the resolution the words are rendered at.

7 Conclusion

No previous work has been discovered involving the tachistoscopic display of handwritten words on a computer.

This work confirms the existence of a recognition rate threshold for tachistoscopically displayed handwritten words. Under this particular experimental setup, the threshold recognition rate was around 80% and occurred at an exposure time between 100–120 ms.

Future experiments employing the tachistoscopic display of handwritten words will employ a similar setup, and use an exposure time of 120 ms or less.

This experiment has also drawn attention to the importance of controlling for visual acuity in this type of experiment.
References


