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Increasing the default interletter spacing of words can help drivers to read traffic signs at longer distances

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ABSTRACT

Would an increase in the default interletter spacing improve the legibility of words in traffic signs? Previous evidence on traffic sign design and recent studies on the cognitive processes involved in visual word recognition have provided conflicting results. The present work examined whether an increase in the default interletter spacing would improve the search of a word in direction traffic signs. To achieve this objective, twenty-two drivers participated in a driving simulation experiment. They followed a highway route and indicated whether a target place name was present among a set of distractors shown on direction traffic signs along the route. We compared the default interletter spacing of the Spanish "CC Rige" font (which is based on the internationally-used Transport font) and a 2.5-times expanded interletter spacing. The results revealed that the drivers were able to give a correct response at a distance to the traffic sign that was on average longer in the expanded than in the default spacing condition. This advantage in the legibility distance was observed in the absence of significant differences in reading accuracy, gaze behavior, or driving performance measures. Therefore, the evidence provided supports that drivers can benefit from a slight increase in interletter spacing relative to the standard spacing. Some of the design factors influencing this effect are discussed.

1. Introduction

Words displayed on traffic signs must be designed so that drivers can accurately read them at an adequate distance within a limited time. Among the multiple factors that can influence how fast and easy it is to read a word on a traffic sign while driving (for reviews, see for example, Garvey and Kuhn, 2004; or Lay, 2004), the present paper will focus on the interletter spacing, i.e. the size of the blank space between the letters in a word. Overall, a basic principle is that there would be an optimal value, or range of values, of interletter spacing for reading, below which the word letters cannot be easily segregated from each other, and beyond which it is hard to group the letters to create a word. For traffic signs, in general, Lay (2004, p. 36) proposed that 'an inter-letter spacing of about 0.30 times the letter height appears optimal for legibility'. For the particular case of variable message signs (VMS), Dudek (1991) suggested that the best inter-character spacing is 2/7th of the letter height (0.29 times), Garvey and Mace (1996) recommended a minimum spacing of 3/7th (0.43 times) of the letter height, and Sørensen (2011) defended that the spacing should be approximately 25% of the letter height (0.25 times). Considering that either an excessive or a restricted interletter spacing will hinder legibility, a critical question is whether the fonts currently used in traffic signs have been optimally designed or there is still room for improvement by modifying the default interletter spacing of words. For example, recent research on the cognitive processes involved in visual word recognition, outside the field of the traffic research, supports the idea that slight increases of the default interletter spacing for a given font can facilitate the processing of the word (e.g., Perea et al., 2011; Perea and Gomez, 2012; Perea et al., 2012; or Slattery et al., 2016). However, this issue has been quite controversial, considering the inconsistencies reported in the previous literature, but Slattery et al. (2016) -see also van den Boer and Hakvoort (2015)- recently provided a revision of the studies, putting forward some relevant modulatory factors that might be critical to find such effect. For example, a critical regulatory factor would be whether the letter font is monospaced –i.e., the width is fixed for all the letters of the alphabet- or proportional –i.e., the letters vary in width-. Indeed, they provided some evidence that the recognition of isolated words could even benefit from a slight reduction in the default inter-letter spacing when using monospaced fonts, whereas recognition is better if the default spacing slightly increases when using proportional

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fonts (Slattery et al., 2016, Experiment 2). These differences were attributed to the fact that the default interletter spacing for monospaced fonts is overall larger and less uniform than for proportional fonts. Then, it was estimated that the optimal value of interletter space, at least for isolated word recognition, is about 30% of the average letter width (as calculated from the formula Percent space = 100 * Mean space width/Mean letter width). This percentage appeared to be valid for the six fonts tested –four of them were proportional, and the other two were monospaced-.

Regarding the traffic research, the effect of an increase in the default interletter spacing had been examined in the field of traffic sign design some decades earlier, also providing conflicting results (Anderton et al., 1974; Garvey and Mace, 1996; see also Holick et al., 2006; or Sørensen, 2011). First, Anderton et al. (1974) assessed the legibility distance for place names in a laboratory experiment, using static images presented in four interletter spacing conditions: the space used at that time on direction and information signs in Australia (standard space), a wider space (1.33 times the standard), and two narrower spaces (0.75 and 0.50 times the standard), according to a within-subjects factorial design. The worst performance (i.e., shortest legibility distance) was obtained for the narrowest space, but no differences were reported between the other space conditions. Therefore, these results did not support the idea that an increase of the default interletter spacing would produce an effect in word processing.

Secondly, Garvey and Mace, 1996 carried out a series of studies to determine the best configurations for VMS in terms of the legibility distance. One of these studies (Garvey and Mace, 1996, Study 2) was based on a laboratory experiment, in which eighty-two participants were presented arrays of three words on a monitor, one per line. All words were selected from a list of preprogrammed VMS messages, but the three words on a given trial did not make a message (e.g., 'TWO DELAY STOPPED', or 'LOCAL ROADWAY FOR'). The stimuli were presented in four spacing conditions to all participants: the standard spacing in VMS in the United States at that time, a space equal to 125% of standard, another equal to 75% of standard, or a non-specified space equal to the minimum producible spacing in those VMS, narrower than the previous one. The narrowest spacing produced the worst (i.e., shortest) legibility distances, and the standard and the 75% of the standard spacing conditions produced similar thresholds. In addition, their results supported that the widest spacing produced better thresholds (i.e., longer legibility distances) than the standard condition, consistently with the idea that word processing can benefit from an increase of the default interletter spacing, unlike the results from Anderton et al. (1974). Finally, another study by Garvey and Mace (1996) (Study 5) was based on a field experiment in which the participants seated in the front passenger seat of a car, and had to read aloud three-word messages on VMS posted along a route. In this experiment, the interletter spacing of the words displayed on one of the VMS was equal to a single stroke width for 15 participants, and a double stroke for 9 different participants. The results from this experiment did not support significant differences in legibility distance between the two groups, unlike the results from their previous laboratory study (Study 2). Garvey and Mace (1996) argued that this null result suggested 'the need for even larger increases in interletter spacing to elicit improved performance.' (p. 112).

In short, according to the previous literature, it is still uncertain if an increase in the default interletter spacing would be beneficial to read traffic signs. There are recent studies on visual word recognition reporting a positive effect, whereas the earlier studies on traffic signs provided conflicting results. Regarding the literature on visual word recognition, there are different reasons to question the generalizability of such results to the legibility of traffic signs. Apart from potential differences in font design, the experimental tasks commonly used to study the cognitive processes of visual word recognition (such as lexical decision tasks) are rather rare in the context of the driving activity, and such tasks usually present the stimulus abruptly at fixation, with good visual quality, at a comfortable distance for reading, and words remain static on the screen until response. In contrast, while driving, the words in traffic signs expand as the driver approaches the sign and their visual quality can be relatively poor, at least during an initial period. Besides, participants in a lexical decision experiment can usually invest their full attention, whereas drivers must read traffic signs while performing other critical tasks, such as controlling the vehicle. In addition, regarding the earlier studies on traffic signs, the evidence is scarce (there are only a few published studies), and there are considerable differences in the methods used. For example, these studies diverge in the kind of traffic signs analyzed (static signs vs. VMS), or in the experimental setting (laboratory experiments vs. field studies in which the participant was seated in the passenger seat). Importantly, no previous study asked the participants to drive while reading the signs.

1.1. The present study

The main aim of the present study was to test whether an increase in the default interletter spacing would improve the legibility of words in direction traffic signs. In comparison to the previous literature, we required our participants to drive while reading the traffic signs. Thus, we used a driving simulator, manipulating the interletter spacing of the words displayed on a series of direction traffic signs embedded in the simulation. In addition, instead of a lexical decision or a reading aloud task, we asked the drivers to search for a target word among a set of distractors, similarly to when we search for the name of our destination on the traffic signs encountered along our route. We used two interletter spacing conditions: the one currently used for place names on direction traffic signs in Spanish motorways (default spacing), and another one that was 2.5 times the mean interletter space used on these signs (expanded spacing). In Spanish motorways, the current font used for place names on direction traffic signs is '*Carretera Convencional*', also known as 'CC Rige' (Dirección General de Carreteras, 2014). This font is based on the British font 'Transport', also used –either itself or a variation- in several other countries (e.g., Denmark, Greece, Iceland, Ireland, Italy, Portugal, or Hong Kong). The font CC Rige is a sans-serif, proportional font with an average default interletter spacing of only 0.14 times the letter height and 19.85% the letter width for lowercase letters. Therefore, increasing 2.5 times the mean default spacing would produce a spacing/letter height ratio more consistent with Lay's (2004) proposal of about 0.30 times. Thus, our expectation was that it is possible to facilitate the reading of the words displayed on these signs by applying such an increase of the default interletter spacing.

2. Method

2.1. Participants

The present study was approved by the research ethics committee of the University of Valencia. Twenty-two volunteers (13 women) participated in the study. Age ranged from 18 to 49 years (M = 27.7, SD = 10.1). Driving experience ranged from 2.5 months to 33.7 years (M = 9.2 years, SD = 10.7). Participants were recruited through a database of respondents to a questionnaire on reading skills and habits, which was available and could be completed via the university website. To participate in the study, respondents had to be native speakers of Spanish, hold at least a B category driving licence (which allows driving motor vehicles with a maximum authorised mass up to 3500 kg and transporting no more than eight passengers plus the driver), show normal reading performance in both the word and pseudoword reading tests of the PROLEC-SE-R (a battery of tests for assessing reading skills in Spanish, by Cuetos et al., 2016), and also normal or corrected-to-normal vision (a LogMAR value lower than 0.1 in an exam using an E chart was required).

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