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## Can perceiving letters cause spatial shifts of attention?

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### Abstract

There is an association between number or letter perception and response preference with faster left-hand responses for small numbers and faster right-hand responses for large numbers. Involuntary shifts of attention to the left or right visual field were shown to occur when stimuli with a strong meaning appear in the visual field. We investigated whether perceiving letters of the alphabet can induce such a shift of attention. The results suggest that the spatial component of letters might not be as strong as that of the numbers, and it probably takes longer for letter perception to induce shifts of attention.

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**Keywords:** Spatial attention; mental alphabet line; attentional shift

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### 1. Introduction

Involuntary shifts of attention have been shown to occur when stimuli with a strong meaning (e.g., direction arrows, numbers, etc.) abruptly appear in the visual field, even when the observers know these stimuli are irrelevant to their task and should be ignored. Visuospatial attention orienting has been investigated by presenting such informative cues or uninformative abrupt onsets. The association between numbers and space has been widely investigated and there is mounting evidence that perception of numbers involves a spatial component. Low numbers are associated with left-side space and higher numbers with right-side space, suggesting the existence of a metaphorical “mental number line”.

Dehaene, Bossini, & Giraux (1993) in a study investigating parity judgment task found that odd or even judgments for low digits (namely 1 or 2) are faster when responses are made with a left button-press rather than a right button-press. The reverse was true for the higher digits (namely 8 or 9). So the relative magnitude of numbers would be encoded analogically in terms of left-right spatial numerical associations, along a mental number line (Dehaene, 1992; Restle, 1970) they called it SNARC effect (Spatial Numerical Association of Response Codes). Based on the finding that the representation of digits is closely associated with space, Fischer, Castel, Dodd, and Pratt (2003) investigating whether number perception can induce a shift of attention to the left or right visual field,

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suggested that the mere observation of numbers activates the spatial representations associated with number meaning and causes involuntary shifts of attention to the right or left visual field.

Because numbers convey not only real or integer meaning but also ordinal meaning, we wondered whether non-numerical ordinal information (i.e., letters of the alphabet) is spatially coded. Only few studies have investigated the association between letters of the alphabet and space (e.g., Gevers, Reynvoet, & Fias, 2003). Although initially the SNARC effect was found exclusively with numbers, further studies showed that non-numerical information is also spatially coded. Gevers et al. (2003) showed that the SNARC effect is also present when elements from other ordinal sequences, such as letters of the alphabet have to be classified. They concluded that the mental representation of letters is spatially defined and can affect performance automatically. Other studies have also showed that letters have a left-to-right mental representation and confirmed the existence of a “mental alphabet line” (e.g., Gobel, Calabria, Farnè, & Rossetti, 2006; Nicholls & Loftus 2007) with early letters on the left and later letters on the right (i.e., A-Z)

Based on the finding that the perception of letters is closely associated with space, in the present study we investigate whether letter perception can induce a shift of attention to the left or right visual field.

## 2. Method

The participants ( $n = 23$ ) were psychology students of the University of Padova who volunteered to participate in the experiment. All had normal or corrected-to-normal vision. They were naïve to the purpose of the experiment.

The participants were seated in front of a computer monitor. Their sagittal middle corresponded to the midsection of the monitor. Participants were asked to keep their eyes approximately 60 cm from the screen and hold their head and body orientation fixed for the duration of the experiment.

Our experimental setting was very similar to those of Galfano, Rusconi, and Umiltà (2006) and Fischer, Castel, Dodd, and Pratt (2003) with some modifications. The stimuli appeared in white against a black background. The sequence of events was as follows. The participants fixated a white cross, which centered between two placeholder boxes. Then the cue appeared that replaced the fixation cross and could either be: the first letter of the Italian alphabet, A, the last letter of the Italian alphabet, Z, or a diamond  $\diamond$  (non-alphabetical neutral cue). The cue was displayed for a random SOA (500, 800, or 1000 ms). It was followed by the presentation of the target that was a small filled square in the center of the boxes while the fixation cross, replaced the cue. This display remained visible until a response was made or 1000 ms had elapsed. The participants had to do a simple detection task by pressing the space bar with their dominant hand as soon as they saw the target in either of the left or right boxes (in 80% of the trials). Catch trials where there was a small filled circle instead of a square occurred in 20% of the trials to prevent anticipatory responses. There was an equal number of trials for each cue (A, Z,  $\diamond$ ), for each target (right or left), and each SOA. The trials appeared in a randomized manner. The participants knew that the cue did not provide any information about the target location. They were instructed to keep their eyes on the fixation point during the experiment.

Before the experimental sequence began, a set of written instructions was presented on the screen. The experimenter also explained the instructions verbally. Then 10 practice trials preceded the experimental trials. The trials were divided into 2 blocks to provide an interblock interval for the subjects. The experiment took about 25 minutes. The presentation of the stimuli and registration of reaction time (RT) were controlled with the E-prime software.

## 3. Results

Incorrect responses, anticipations, and reaction times out of  $\pm 2$  standard deviations from the individual mean were cancelled and not analyzed. A  $3 \times 2 \times 3$  ANOVA (A, Z,  $\diamond \times$  target left or right  $\times$  SOAs 500, 800, 1000 ms) showed main effect of the SOA and of the stimulus type but no reliable interactions. *t*-test (with Bonferroni correction) showed significant effect of the right vs. left presentation only for the letter Z at 1000 ms ( $p < 0.001$ ), and for the neutral cue at 800 ms ( $p < 0.032$ ). The participants were significantly faster when Z preceded a right-sided target.

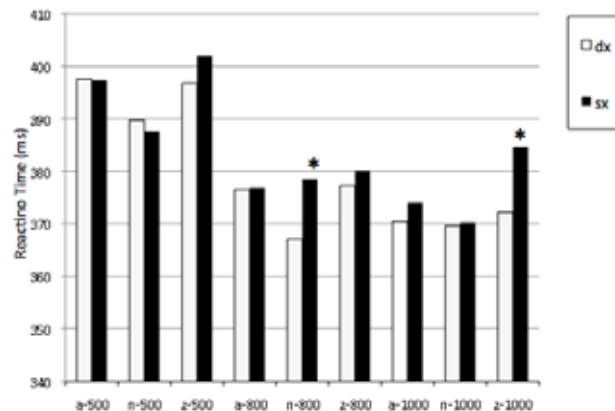


Figure1. Means of reaction times for different conditions. An asterisk indicates conditions that are significant.

#### 4. Discussion

Spatial corresponding effects for the letters of the alphabet did not appear for SOAs shorter than 1000 ms. At 1000 ms the effect of spatial congruency is significant for Z but not for A. This does not reflect a polarity effect (beginning vs. end of a list) because it would have predicted similar effects for A and Z. One possibility is that more time is needed to let the effect surface for A as well. The SOA effect in fact suggests that time is needed for an attentional bias to develop, consistently with what was found by Stoianov, Kramer, Umiltà, and Zorzi (2008), and by Gevers, Reynvoet, and Fias (2003) who had an even longer SOA (1200 ms) and by Nicholls, Loftus, and Gevers (2008). Further experiments will clarify this issue.

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