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THE CONTRIBUTION OF ATTENTIONAL AND PRE-ATTENTIONAL MECHANISMS TO THE PERCEPTION OF TEMPORAL ORDER

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ABSTRACT

Conscious processing requires attentional mechanisms which filter the flow of sensory information. The perception of temporal order, as several other perceptual tasks, depends on attentional mechanisms as well as on purely sensorial, pre-attentional, processes. The purpose of the present work was to examine the effects of the allocation of visual attention, and also of stimulus size and location in the visual field, on the judgment of temporal order. Psychophysical experiments were carried out in which a pair of squares was briefly flashed in the visual field, one square being flashed close to the fixation point and the other square 9.5° away. The peripheral square had either a 0.12° side (the size of the central square) or a 0.54° side, and was presented either fixed or randomly on an isoecentric arc. The asynchrony between the onsets of the stimuli was randomly chosen and 6 volunteers had to report the order of appearance of the squares. In all experimental conditions the peripheral square had to be presented prior to the central one (negative intervals) in order to evoke the perception of simultaneity. A larger peripheral stimulus as well as a fixed location in the visual field yielded shorter but still negative intervals in order for the two stimuli to be perceived as simultaneous. Both attentional and sensorial mechanisms seem to have an important involvement in this task, but cannot account separately for the whole set of findings. These mechanisms should be further investigated and carefully discriminated from each other.

1. Introduction

The understanding of consciousness has become a central question in many scientific fields. This attempt must consider attentional mechanisms, which lead to selection of sensory information, as an important component of conscious processing (Posner, 1994). Attention is assumed to influence the speed at which information is transmitted through the sensory systems, and directed visual attention seems to affect, among other perceptual tasks, the perception of temporal order and simultaneity (Stelmach & Herdman, 1991). Several models of temporal order judgment have been proposed to account for its dynamics and underlying factors (Ulrich, 1987). Perceptual-latency models assume that temporal-order perception depends on the arrival time of sensory information to a central comparator (Allan, 1975). Consequently, basic features of the stimuli may also play an important role in temporal order judgments.

The purpose of the present work was to examine the contribution of visual attention and basic stimulus features, represented here by size and location in the visual field, as factors influencing the perception of temporal order.

2. Materials and Methods

Stimuli consisted of two small squares displayed on a CRT monitor (Figure 1). One square subtended a $0.12^\circ \times 0.12^\circ$ visual angle and was always flashed close to the fixation point, located in the center of the screen. The other square was presented 9.5° away from the fixation point. At each presentation the size of the peripheral stimulus was randomly chosen between two possibilities: either $0.12^\circ \times 0.12^\circ$ or $0.54^\circ \times 0.54^\circ$. In blocked experiments the position of the peripheral square was either fixed at one location or randomly chosen from eight possible locations spaced by 45° on an isoeccentric arc, therefore precluding previous shifts of attention. The asynchrony between the onsets of the squares was randomly chosen, at each trial, from 11 possibilities, ranging from -167 ms to 167 ms (negative intervals meaning that the peripheral stimulus was presented prior to the central one).

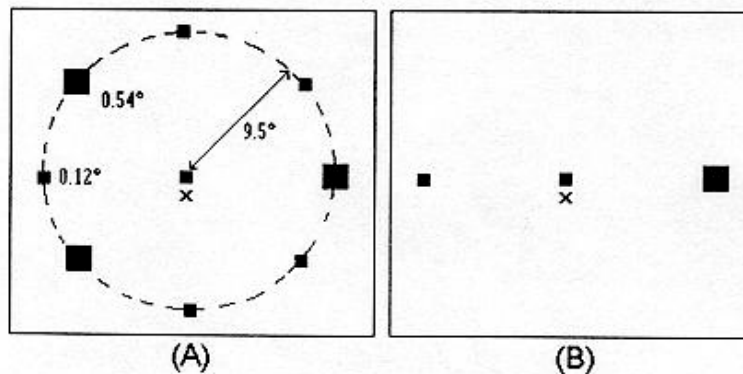


Figure 1- Schematic representation of the stimuli display. (A) represents the random situation in which the position of the peripheral square was chosen, at each trial, from 8 possible locations. In (B) the peripheral square was presented at a fixed position in the temporal hemifield, either on the right or left of the fixation point (x) depending on the eye used by the subject. In both situations the size of the peripheral stimulus was chosen, at each presentation, from two possibilities: $0.12^\circ \times 0.12^\circ$ or $0.54^\circ \times 0.54^\circ$.

Six volunteers had to report the order of appearance of the squares on the screen by means of the computer's keyboard. The method of constant stimuli was employed and data points in the experimental psychometric function were approximated by a cumulative Gaussian function. The point of subjective equality (PSE) was defined as the temporal interval at which observers were equally likely to respond "central first" or "peripheral first".

3. Results

The mean values of the PSE were negative in all experimental conditions, meaning that the peripheral stimulus had to be presented prior to the central one in order for the subject to have the perception of simultaneity (Figure 2).

The random, unpredictable, location of the peripheral stimulus resulted in longer intervals as compared to the fixed situation. Also, a 4.5-fold increase in the linear size of the peripheral stimulus had the effect of shortening the PSE intervals in both situations, random and fixed, without, however, bringing them to zero. A two-way ANOVA indicated a significant effect ($p < 0.01$) for both factors (location and size) and absence of interaction between them ($p > 0.2$).

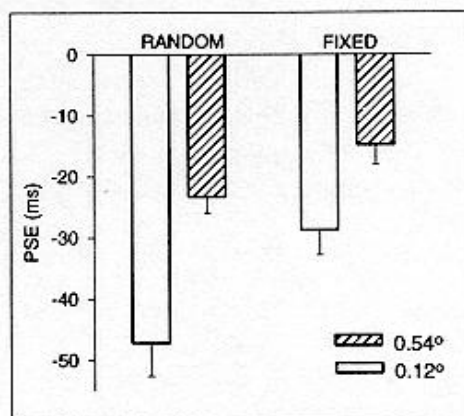


Figure 2- Mean PSE (in milliseconds) for each location and size condition of the peripheral stimulus.

4. Discussion

In all experimental combinations investigated here, the peripheral stimulus had to be presented prior to the central one in order to evoke maximum uncertainty in their order of appearance. This observation confirms previous findings showing the priority of foveal stimuli regarding the temporal order judgments of visual stimuli. The discrepancy observed between the responses to foveal and peripheral stimuli might be accounted for by purely sensorial, pre-attentive, mechanisms, and/or by assuming that attentional priority is facilitating the visual processing of the central stimulus. The presentation of the peripheral stimulus at randomly chosen locations has the effect of precluding the previous allocation of visual attention. Actually, the only difference between the fixed and random conditions is that in the former situation the observer knows the position where the peripheral stimulus is going to be presented, thus being able to allocate his or her attention to that region of the visual field, shortening the temporal interval expressing the PSE. Therefore, if we compare peripheral stimuli of same size in both situations, random and fixed, an

attentional mechanism seems to emerge as the best working hypothesis to explain the difference in the PSE observed between them.

Increasing the stimulus size also had the effect of shortening the mean temporal interval denoting the PSE. However, this effect cannot be fully explained simply by cortical magnification factors. Particularly, the M-scaling technique (Rovamo & Virsu, 1979) was not able to bring the PSE values close to zero. Although other sensory processes may still be called for to explain this size effect, an attentional mechanism is not excluded, since abrupt visual onsets can capture attention automatically (Yantis & Jonides, 1990). A larger peripheral stimulus could, therefore, require a shorter time to capture visual attention, reducing the temporal interval needed to yield the perception of simultaneity.

In conclusion, attentional mechanisms seem to play an important role concerning the temporal order perception of visual stimuli. Yet, basic sensorial processes might also be involved and neither of these two factors can alone explain our findings. Further experiments are being planned to manipulate the allocation of visual attention in a controlled way to discriminate more accurately between the attentional and pre-attentional components of this perceptual task.

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