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Half and half is less than one-eighth and seven-eighths: Asymmetry affects judgment of numerosity

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Abstract

Our visual perception is not perfect. It is prone to interference of configuration of elements and irrelevant dimensions. In this study, we aimed to investigate whether combinations of white and black dots can interfere with the perception of numerosity. Participants were asked to judge numerosity of two serially presented sets of dots, while the ratio of black and white dots in the second set changed. Our results showed that the interference follows a 4th order effect. Further studies needs to be done to investigate underlying mechanisms.

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Keywords: Magnitude; Numerosity; Symmetry; Interference

1. Introduction

It has been repeatedly shown that our perception is prone to interference of configuration of elements and irrelevant dimensions. Despite all the sophistication of our vision, visual perception is not perfect. For instance, Oppel (1855) and Kundt (1863) showed that the distance between two dots is perceived shorter or longer depending on the number of distracting dots in between them. Similar illusions are shown in line-length comparison tasks: while the length of a pair of lines in the configuration of an L is judged correctly, their length in a T-configuration is

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miss-judged (Coren & Girgus, 1978; Künnapas, 1955). Charras and Lupiáñez (2009) showed that the amount of bias in perception depends on the symmetry of presentation. They showed that length is underestimated when the two lines, in a cross-configuration, are bisected into two equal-size parts and overestimated when the two lines are bisected into two different-sized parts. Effects of symmetry and asymmetry, i.e., equal- and unequal-size bisections, have also been shown in numerical comparison domain. Charras, Brod, and Lupiáñez (2012) asked participants to compare a standard number with sums of two numbers. The two numbers could either be repetitive, e.g., 26+26, or different, e.g., 24+28. Their results showed that sums with repeated values are underestimated and sums with different values are overestimated. In all these studies the modulating parameter, i.e., location of bisection and equality of values, was the same dimension as the dimension in question, i.e., length and magnitude. We aimed to investigate whether similar effect holds when the modulating parameter is irrelevant to the task. We used a numerosity judgment task in which participants' task was to compare two sets of black and white dots, while the ratio of black and white dots was variable. In-line with Charras et al. (2012), we hypothesized that numerosity of a set of dots with equal number of black and white dots will be underestimated while the numerosity of a set of dots with different number of black and white dots will be overestimated.

2. Methods

Thirty participants (19 female, age mean = 23.23, SD = 4.78) judged which one of two serially presented sets of dots contained more dots. The first set was composed of either completely black or completely white dots, while the second set was composed of different ratios of black and white dots (see Fig. 1). This *ratio* ranged from completely black (0% white) to completely white (100% white) according to the method of constant stimuli. Participants were asked to respond as accurately and as fast as possible. A repeated measures ANOVA was run with ratio of black and white dots as an independent factor and performance, percentage of selection of the 2nd set, as the dependent factor. In order to investigate the mechanism of effect of ratio, we ran within-subject different orders of contrast analysis.

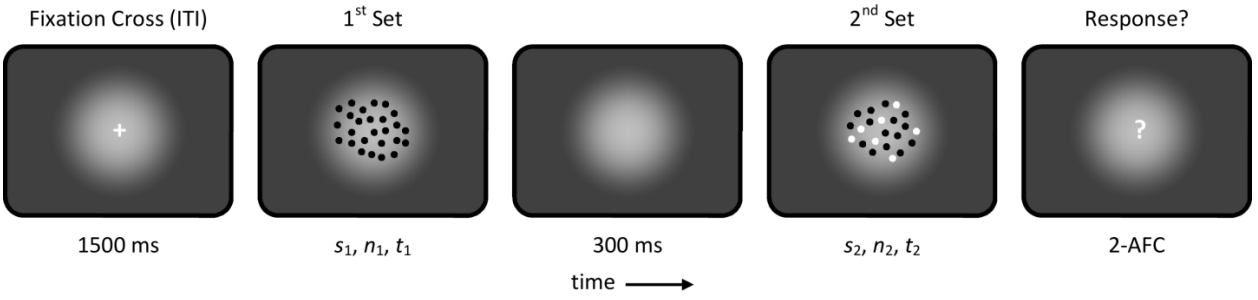

Fig. 1. Procedure of the experiment. Two factors of numerosity (n) and symmetry (s) were manipulated in between the sets. n_1 = {26} and n_2 = {18, 22, 26, 30, 34}. s_1 (%) = {0, 100} and s_2 (%) = {0, 12.5, 25, 37.5, 50, 62.5, 75, 87.5, 100}. t_1 & t_2 (ms) = {100, 350, 600}. t_1 & t_2 were equal in all the trials. 2-AFC stands for 2 alternative forced choice.

3. Results

The ANOVA showed a significant main effect of ratio [$F(8, 232) = 2.452$, $p = 0.014$, partial Eta squared (η_p^2) = 0.078]. Contrast analysis showed a very high significant 4th order effect [$F(1, 29) = 30.139$, $p < 0.001$, $\eta_p^2 = 0.510$]. Contrast in no other order became significant ($p>0.204$). This implies that the interference follows an M-shape effect (see Fig. 2).

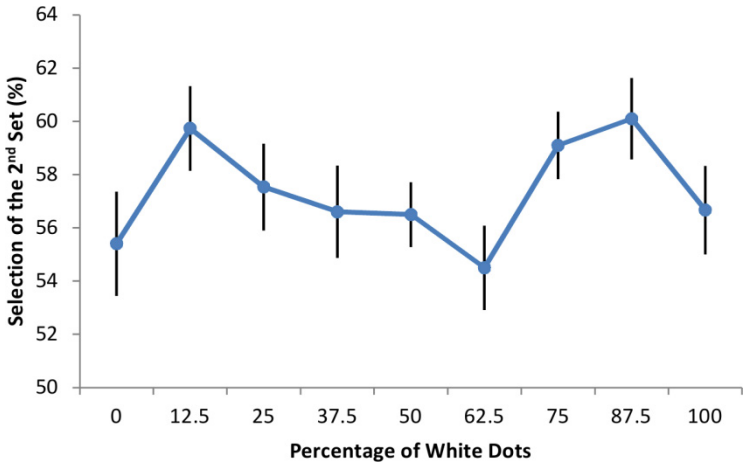

Fig. 2. Effects of interference of symmetry on numerosity judgment task. Error bars represent one standard error of mean.

4. Discussion

Interference of symmetry followed a 4th order effect leading to an M-shape result. This shows that the dynamics of interference involve complicated mechanism(s). Further studies must be done in order to identify underlying mechanism of this action.

Acknowledgements

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