

縞パターンはターゲットの認知を促進するかそれとも妨害するか

畑 野 翔 太

要 約

何種類かの熱帯魚および何種類かの陸上動物は体に鮮やかな色の縞パターンを持っている。その理由の1つとしてそれらの縞パターンは非常に目立つので、彼らの体の輪郭線を隠し、結果的に敵に捕食される確率を下げると言われている。

一方カラーユニバーサルデザインにおいては、色覚障害者がパターンを認知しやすくする支援策として「ハッチング（地模様）」を入れることが推奨されている（野口，2014）。これらはお互いに相反する効果を前提としている。

本研究の目的は縞パターンはターゲットの認知を妨げるという仮説を実験的に検証することである。刺激の1系列は縞パターン（たてまたは横，3段階の空間周波数）を施された刺激と縞パターンのない刺激の組み合わせ（計100個）から成り，その中の1つの刺激をターゲット刺激として，ターゲット刺激の検出に必要な反応時間をPCタキストスコープを用いて測定した。刺激にはアルファベット，数字，ひらがなおよび図形を用いた。刺激はすべて無彩色であった。

結果は条件（ターゲット刺激の種類）によって異なったが，概して上記仮説に否定的であった。すなわち縞パターンのある刺激の方が，ない刺激よりもより短い反応時間で認知された。

キーワード：縞パターン，縞模様，認知，反応時間，色

Do the Zebra Stripes Facilitate or Interfere the Recognition of Targets ?^{*)}

HATANO Shota

(*Graduate School of Human Sciences, Kanagawa University*)

Keywords: zebra pattern, recognition, reaction time, stripe, color

INTRODUCTION

Some tropical fishes like *Amphiprion clarkii* (Kumanomi in Japanese) and some wild animals like zebras, after which the title of this paper is named, have strong stripe (zebra) patterns of vivid colors on their bodies. This is easy to confirm from the pictures in a book like Burnie (2004). The zebra patterns are so distinguished that they would divide the pattern of the body into several parts. This is why they are often called “dividing color”. They may make detection of the body by their predators difficult (Edmunds, 1974).

On the other hand, “hatching (textured line)” is recommended as a useful tool to aid for the people with anomalous color vision to recognize targets (Noguchi, 2014).

Pastoureau (1991) argued that zebra pattern may make human eye difficult to divide the plane between figure (focal plane) and ground (background plane) which is considered important to recognize the object (Metzger, 1953).

If the above logic can be applied to human recognition, it may be hypothesized that we have difficulty in reading characters with zebra patterns or take longer times to recognize them than

characters without zebra patterns.

In this study reaction times were obtained between the on-set when the stimulus was displayed and the on-set when the observer pushed the button recognizing the character.

METHOD

Apparatus and Stimuli:

A pc tachistoscope was used to present stimuli on the pc monitor and take measure reaction times. The refresh rate of the monitor was 120Hz. So the recorded reaction times should be estimated with errors of ± 8 ms.

Three kinds of stimuli , alphabets (W, X, Y, Z), digits (2, 4, 5, 8), and figures (○, □, △, ▽), and “Hiragana (Japanese letters)” with and without zebra stripes. The stripes were achromatic and of two orientations , vertical or horizontal, and of three spatial densities (0.27, 0.54, and 0.95 cpd) for each orientation. The average luminance of bright part of each stimulus was 42.9 cd/m^2 and that of the immediate grey background was 31.3 cd/m^2 (Fig. 1a).

A series of stimuli were composed of one hundred stimuli from each kind , half of which were with zebra stripes and half were without stripes. Therefore in the series of alphabets, 25 “W” were with zebra stripes and 25 “W” were without ones, 25 “X” were with stripe and 25 “X” were without ones and so on. A series of stimuli were presented one by one at random on the center of the monitor 100 ms after the cessation of fixation points lasting for 100 ms (Fig. 1b). The stimuli were observed at the distance of 72 cm forming the height of stimulus of 9.5° in visual angle.

The pc that the experimenter was operating and the monitor that the participant was observing were separated by curtain making ambient of the observer almost completely dark.

A session consisted of completion of a series of stimuli out of four kinds. In each session, a target stimulus, for instance “W”

with stripes, was fixed, and the observer was instructed to seek the target as soon as possible. Thus the candidates for targets were W, X, Y, Z, four “Hiragana (Japanese letters)”, four figures, ○, □, △, ▽ and four digits, 2, 4, 5, 8 with zebra stripes.

The participants used a chin rest to stabilize their fixation at rest. The stimuli were observed binocularly and naturally, with or without glasses in the semi-dark room.

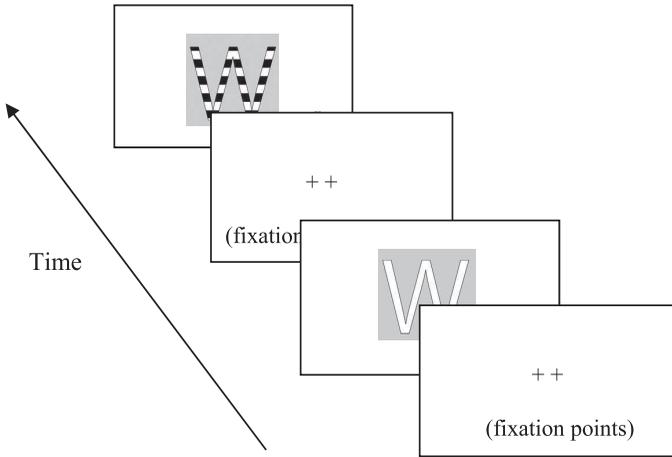


Fig. 1a The spatio-temporal configuration of stimuli

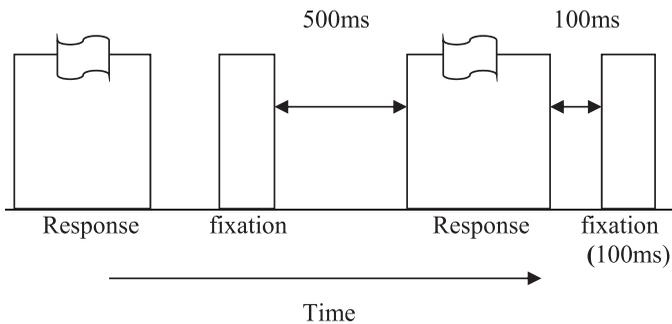


Fig. 1b Temporal configuration of stimuli

Participants:

Paid twenty-three participants were recruited in total. All of them were Kanagawa University's students at ages ranging from 19 to 21. All of them did not participate in all of 24 stimulus patterns. They were all naive to this kind of experiment.

Procedure

The observer was instructed to respond as soon as and as correct as possible by pressing one of two buttons when the stimulus he/she recognized was the target and by pressing other button when he/she recognized was whatever of non targets. Four sessions for four series of stimuli were conducted in a day and the session was repeated other day exchanging the buttons which the participant has to press for the target stimulus.

Prior the session, the participant was dark adapted for several minutes. Data in the first several trials were discarded for practice.

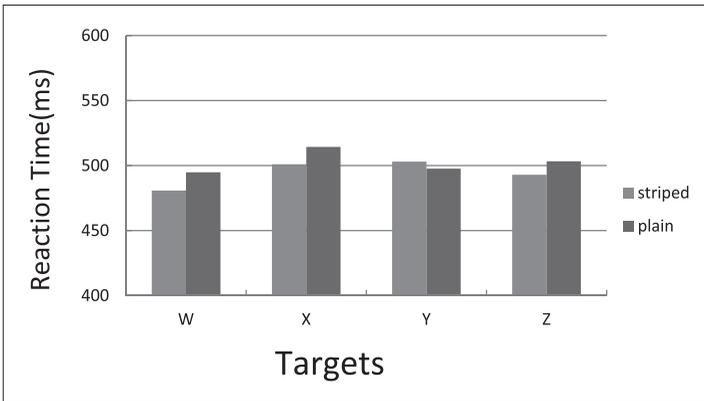


Fig. 2 Average reaction time (ms) for alphabets.

Fig. 2 shows the average reaction times for alphabets, with stripes of two orientations and of three spatial densities included all together. The reaction times were shorter for the stimuli with stripes than those without stripes except the target Y for which

the reverse result was obtained. But the analysis of variance (ANOVA 4) showed no significant effect on striped or non-striped (plain) stimuli (Effect A), on the effect of the kinds of alphabets (Effect B) and also no significant interactions for $A \times B$.

Fig. 3 shows the average reaction times for figures. ANOVA 4 showed no significant Effect A. The effect of the kinds of alphabets were significant ($p < .05$) between $\square - \nabla$, and $\circ - \nabla$. No significance was found in $A \times B$.

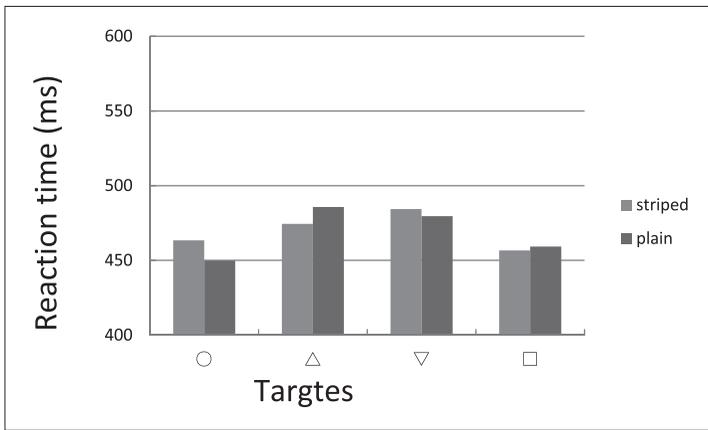


Fig. 3 Average reaction time (ms) for figures.

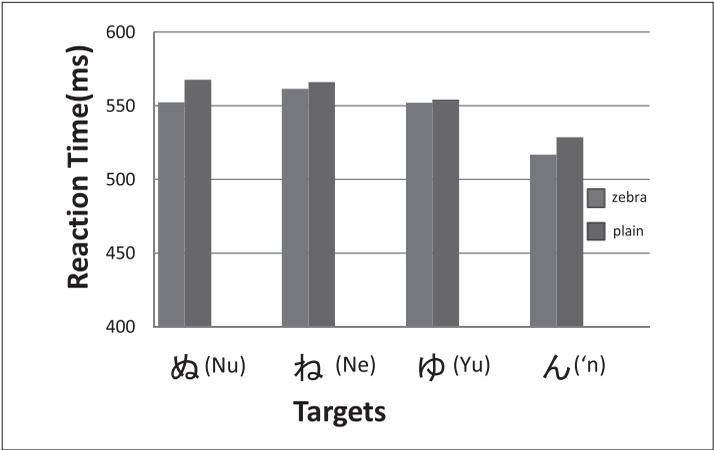


Fig. 4 Average reaction time (ms) for Japanese letters.

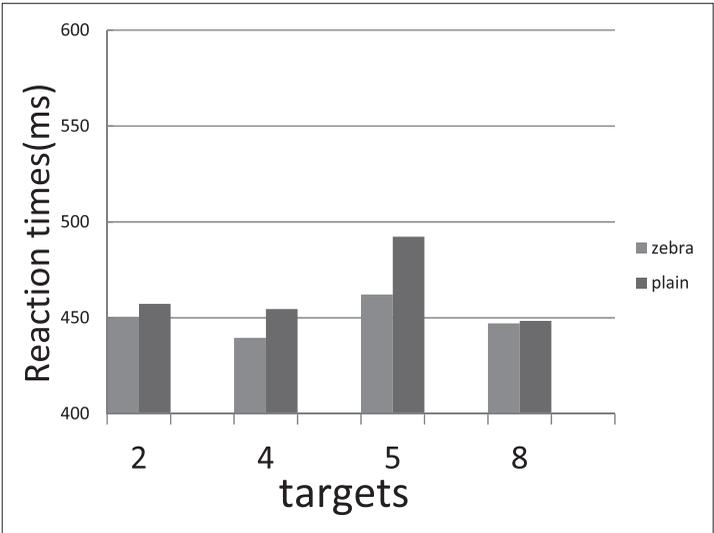


Fig. 5 Average reaction time (ms) for digits.

Figs. 4 and 5 show the results for Japanese letters and digits respectively. For these stimuli, reaction times were significantly ($p < 0.001$) shorter for the stimuli with stripes than plain ones.

For digits, there found were also significant effects not only among the kinds of digits ($p < 0.01$), but among spatial frequencies ($p < 0.005$) (See Fig. 6 and Table 1).

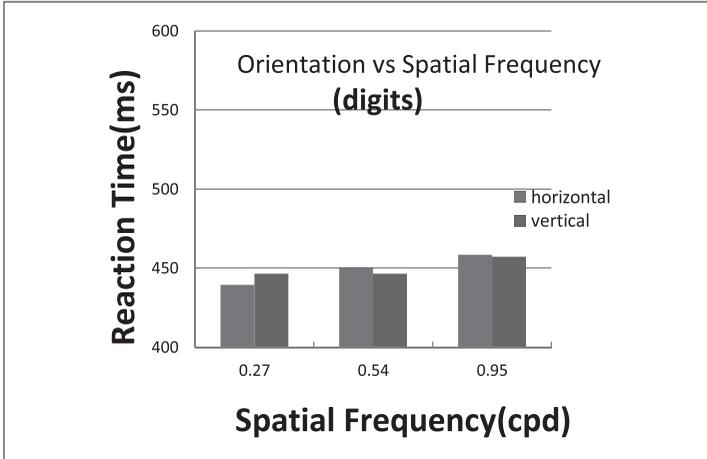


Fig. 6 The effects of spatial frequency the orientation of the stripes indigits.

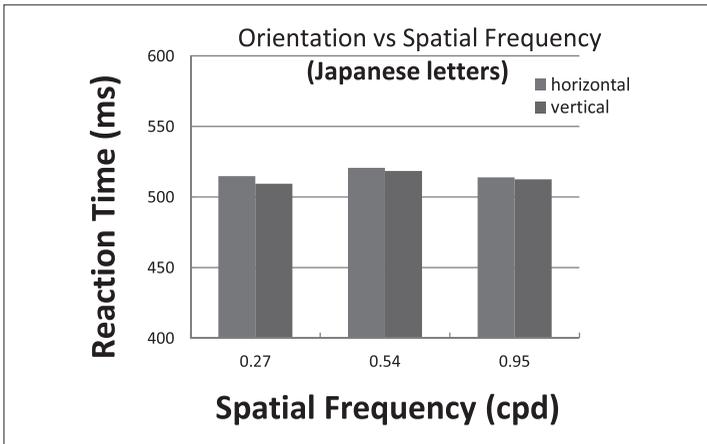


Fig. 7 The effects of orientation of stripe and spatial frequency in Japanese letters.

Figs. 6 and 7 show the relationship between stimulus orientation and spatial frequency. They both had significantly different effects for alphabets, and only spatial frequency had significant effect for digits (See Table 1).

Discussion

Table 1 shows the summary of the results. The effect which was central to the present study, i.e. the effect of the stripe, was significant for Japanese letters and digits. The reaction times were, on the contrary to the hypothesis, significantly shorter for the stimuli with stripes than those without ones. Those results indicate that the present hypothesis is rejected.

Table 1 The summary of the results.

targets / effect	A	B	C	D
alphabets	n.s.	n.s.	*	*
digits	****	**	***	n.s.
Japanese letters ('Hiragana')	****	n.s.	n.s.	n.s.
figures	n.s.	n.s.	n.s.	n.s.

A: targets with and without stripes, B: kind of targets (W, X, Y or Z and so on), C: spatial frequency of stripes, D: orientation of stripes.

* : $p < 0.05$, ** : $p < 0.01$, *** : $p < 0.005$, **** : $p < 0.001$ The effects of interactions were not shown.

How could the present results be compromised with what is happening in natural scene?. The author is still curious to know why some fish and land animals have such clear stripe patterns on their body.

One possible factor to explain the discrepancy may be color. Many tropical fishes are quite colorful. So it is worth to conduct experiments with chromatic stimuli.

Another factor could be the effect of the background against which they are seen. It could be that a zebra can be merged with background of the bush, but stand out in the plain. Further

studies should be needed with targets on striped backgrounds.

As a result the present results show the usefulness as a cue with which the color vision-deficient could recognize the visual information more easily.

The zebra stripes have an effect to shorten recognition time for digits and Japanese Hiragana letter. These stimuli have more complex shapes than others. It indicates a possibility that zebra stripe is effective to help recognizing complex shapes, but not for simple target, like circle.

The effects of orientation and spatial frequency of the stripes were controversial, depending on the kinds of target stimulus.

The spatial frequency used in the present study may be too low (Thomas, 1975) to test its effect.

Further study should be necessary using stimuli of higher spatial frequencies.

Acknowledgement

The author expresses his deepest gratitude to Mr. Akinobu Hatada, Kanagawa University and Ms. Kriston Norman, Harvey Lab Co. Ltd., Tokyo for revising and correcting the English manuscript.

*) A part of the study was presented in the 1st Meeting of the Asia Color Association (ACA), 2013, Thanyaburi, Thailand.

REFERENCES

- Burnie D. (2004) Animal (Japanese translation by Shirane T. et al.), Neko Publishing. (in Japanese)
- Edmunds M. (1974) Defence in Animals (Japanese translation by Obara Y. & Kato Y.), Baifukan Publishing Co. Ltd. (in Japanese)
- Metzger W. (1953) Gesetze des Sehens, Verlag von Waldemar Kramer, Frankfurt am Main (Japanese translation by S. Morinaga, 1968), Iwanami Publishing Co. Ltd. (in Japanese)
- Noguchi Y. (2013) The effect of hatching on the word recognition of the color vision-deficient using reaction times. The Bulletin of Human

Sciences of Kanagawa University 7, 5-17. (in Japanese)

- Pastoureau M. (1991) *L'Etouffe du diable. Une histoire des rayures et des tissus rayés*, Paris, Editions du Seuil (Japanese translation by T. Matsumura & E. Matsumura, 2004), Hakusuish Publishing Co. Ltd. (in Japanese)
- Thomas J. P. (1975) Spatial resolution and spatial interaction, In Carterette E. C. & Friedman M. P. (Eds) *Handbook of Perception Vol. X, Seeing*, Chap.7 , 233-299.