ング要因であるといわれる (Nakayama, He & Shimojo, *Frontiers in Cognitive Neuroscience*, '95) 。また最近の事例として、 中心視野から周辺視野への輝度エッジを飛び越える色拡散が報告されたが、この効果においても、知覚される面ごとに拡散が独立に生じる (Shimojo, et al., ECVP '02; Wu et al., VSS '03; Kanai et al., *in prep,*. '03)。類似の現象は、色と運動の組み合わせにおいても見られた(Wu, Kanai & Shimojo, *Nature*, '04)。この最後の事例はまた、特徴の御結合(feature misbinding)が持続的、安定的に観察される稀な例とも目される。

6. 面知覚の神経メカニズムは脳内の広汎な神経回路に担われている

最近の fMRI による研究から、課題や注意などの条件によって、多重面の三次元知覚のためにさまざまな脳内部位／機能がダイナミックにリンクされる。たとえばスリット視現象では、わずかなスリット幅越しの見えから、背後を側方に動く対象の二次元輪郭が中枢レベルで統合され、知覚される。このとき、輪郭の統合の程度に相関する神経活動は、初期視覚皮質ではなく、 頭頂の視覚運動領域と側頭の対象認知領域でみつかった(Yin et. al., *Cur. Biol,*. '02) 。

7. 面や輪郭の意識的な知覚経験について、新たな知見がある

その例として、TMS(脳磁気刺激)による人工盲点とその色充填 (Kamitani & Shimojo, *Nature Neurosci.*, '99) 、TMS による「再現」現象(Wu & Shimojo, *VSS* '03)、輪郭順応による消失現象 (Shimojo & Kamitani, *VSS* '01, '02; Moradi & Shimojo, *Vis. Res.*, '03)などを挙げることができる。ここでは詳細を省くが、知覚のアウェアネスには一定時間の皮質情報処理が必要であることや、輪郭検出の重要性などが示唆された。

以上の諸知見のまとめとして、 まず第一に、心理物理的アプローチの神経科学コミュニティにおける役割が例示された。すなわち心理物理学は神経科学に本質的な問いを発するだけではなく、その答えの範囲を一気に狭める働きもする。第二に、(視覚の中間レベルとしての)多重面表現の存在とその機能的重要性が示された。第三に、視覚／認知神経科学の今後の方向として、明確な理論的検証のため TMS や fMRI などの新手法と心理物理パラダイムのを巧妙に組み合わせることが要求されるだろう。

Anomalous motion illusion and stereopsis

Akiyoshi Kitaoka

Department of Psychology

Ritsumeikan University, Kyoto 603-8577, Japan

akitaoka@lt.ritsumei.ac.jp

Abstract

A strong resemblance in stimulus configuration among the optimized Fraser-Wilcox illusion Type IIa, reversed phi movement, phi movement, positional illusion, and related 3D effects, is discussed. Although these phenomena cannot be explained by a single mechanism, a limited number of shared mechanisms are thought to underlie them.

Key Words: Optimized Fraser-Wilcox illusion, reversed phi movement, phi movement, positional illusion, binocular stereopsis

1. Anomalous motion illusion

The Fraser-Wilcox illusion [1,2] is a typical one of anomalous motion illusions, those characterized by apparent motion in a stationary image. We optimized this illusion [3], in which the direction of apparent motion was thought to be "black to dark-gray" or "white to light gray".

Here I classify the optimized Fraser-Wilcox illusion into four categories: Type I, Type IIa, Type IIb, and Type III. Type I is characterized by luminance gradients being the critical configuration. Type II refers to a three-field configuration in that the center field is a narrow band flanked by two broad fields of different luminances. Moreover, Type II is classified into two subtypes. Type IIa is the "line" type where the narrow band is brighter or darker than both flankers. Type IIb is the "edge" type where the narrow band is the intermediate luminance between those of the flankers. Type III consists of two fields of different luminances. These characteristics are shown in Figure 1.

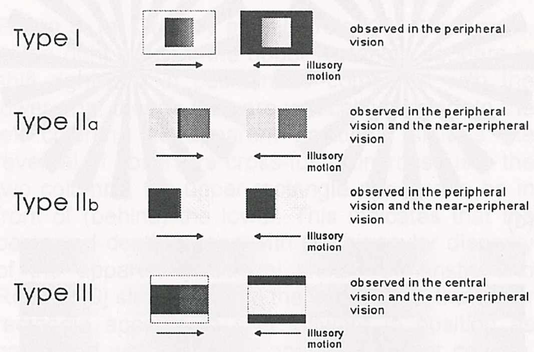


Figure 1. Temporary classification of the optimized Fraser-Wilcox illusion.

Figure 2 shows images giving global motion. Figure 2a shows Type I, Figures 2b and 2c demonstrate Type IIa and Type IIb, respectively. Figure 2d is based on Type III.

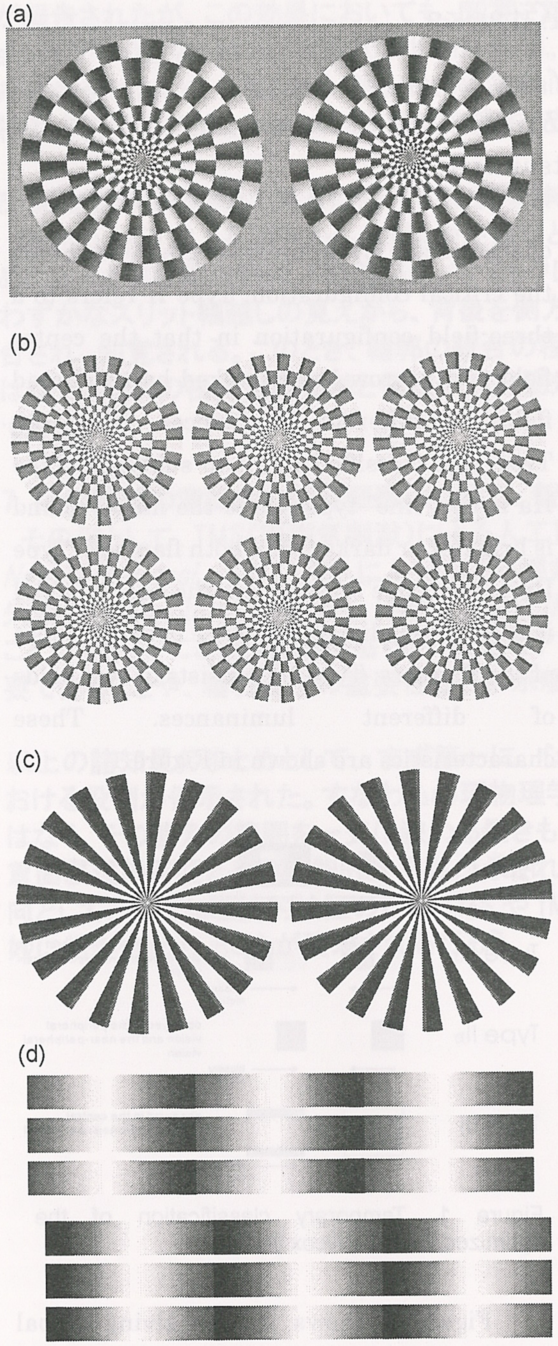


Figure 2. (a)-(c) Apparent rotation is observed in each disk. (d) Apparent slides in the horizontal direction are observed.

In addition, the apparent motion of the "Rotating snakes" illusion (Figure 3) [4], which has recently drawn attention [5-7], can be regarded as Type IIa.

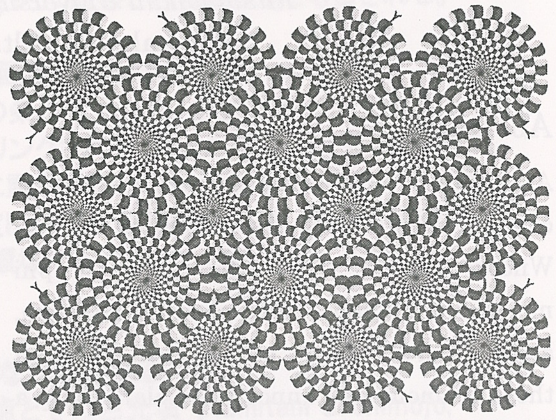


Figure 3. "Rotating snakes". Apparent rotation is observed in each disk.

2. Reversed phi, phi, positional illusion and stereopsis

Reversed phi movement refers to an illusory motion in the direction opposite to the positional shift of an object [8,9]. Figure 4a shows an example, in which the right flank of the inset is always bright and the left flank is constantly dark while the luminances of the inset and surround are dynamically changing. When the luminance of the inset increases and that of the surround decreases, the inset shifts rightward in position accompanied by a negative-to-positive change while the perceived motion is leftward.

Gregory and Heard [10] found that the dynamic change of only the surround is sufficient to generate such a motion illusion. Figure 4b shows an example, in which the lumimance of the inset is constant while that of the surround dynamically changes.

In this paper, I regard the Gregory-Heard motion illusion as sharing the same mechanism as the reversed phi movement, and call them "luminance-change-dependent motion illusion".

There is another luminance-change-dependent motion illusion. It was called "phi movement" by Anstis and Rogers [9]. Figure 4c shows an example, in which the luminance of the inset is always dark and that of the surround is constantly bright while the luminances of both flanks are changing. When the luminance of the right flank decreases and that of the left flank increases, the inset appears to shift rightward in position as well as in motion

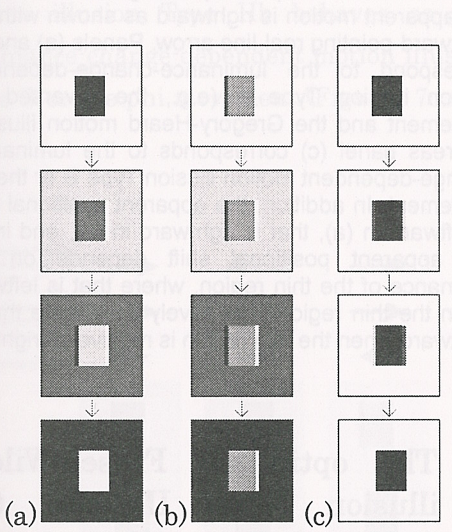


Figure 4. (a) Reversed phi movement proposed by Anstis and Rogers [8,9]. The thin flanks of the inset are constant in luminance (dark or bright) while the inset changes from dark to bright and the background simultaneously changes from bright to dark. In this sequence, the perceived motion of the inset is leftward whereas the positional shift is rightward. (b) The illusory motion investigated by Gregory and Heard [10]. The only configurational difference from the reversed phi movement is that the inset is constant in luminance. In this sequence, the perceived motion is leftward while the positional shift is rightward. (c) Phi movement demonstrated by Anstis and Rogers [9]. The inset and surround are constant in luminance while the right flank changes from bright to dark and the left one changes from dark to bright. In this sequence, the perceived motion as well as the apparent positional shift of the figure is rightward.

In these situations, there are two types of positional illusions and two types of binocular stereopsis. These are described in the legend of Figure 5.

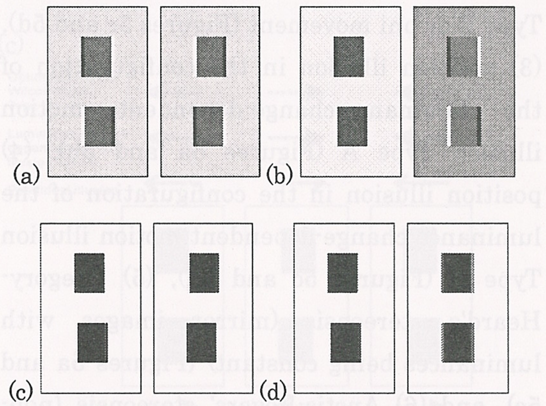


Figure 5. (a) Gregory and Heard's [10] stereogram. In the right column, the upper rectangle appears to shift rightward in position as compared with the lower one, though they are vertically aligned. In the left column, the apparent positional shift is the reversal. If observers cross-fuse (uncross-fuse) the two columns, the upper rectangle appears to be in front of (behind) the lower. This indicates that the perceived depth agrees with the binocular disparity of the apparent positional shifts. (b) Anstis and Rogers' [9] stereogram. In the left column, the upper rectangle appears to shift leftward in position as compared with the lower one. In the right column, the apparent positional shift is small. If observers cross-fuse (uncross-fuse) the two columns, the upper rectangle appears to be behind (in front of) the lower. This indicates that the perceived depth disagrees with the binocular disparity of the apparent positional shifts. (c) A stereogram made up of the stimuli of Anstis and Rogers' [9] phi movement. The apparent positional shift as well as the binocular depth perception are similar to those in panel (a). (d) An unmentioned stereogram of the stimuli of the phi movement. The configuration is

similar to panel (b), but the perceived depth agrees with the binocular disparity of the apparent positional shifts. That is, the upper rectangle in the left column appears to shift leftward in position as compared with the lower one while the upper rectangle in the right column do not appear to shift so much, and the cross-fused (uncross-fused) upper rectangle appears to be in front of (behind) the lower.

In sum, there are six different illusions or effects [11]: (1) luminance-change-dependent motion illusion Type A or reversed phi movement (Figures 5a and 5b), (2) luminance-change-dependent motion illusion Type B or phi movement (Figures 5c and 5d), (3) position illusion in the configuration of the luminance-change-dependent motion illusion Type A (Figures 5a and 5b), (4) position illusion in the configuration of the luminance-change-dependent motion illusion Type B (Figures 5c and 5d), (5) Gregory-Heard's stereopsis (mirror images with luminances being constant) (Figures 5a and 5c), and (6) Anstis-Rogers' stereopsis (non-mirror images with different luminances) (Figures 5b and 5d).

These phenomena can be grouped into three types: the first group (Anstis-Rogers' stereopsis-compatible group) includes (1) and (6) (under the condition of the luminance-change-dependent motion illusion Type A), the second group (Gregory-Heard-stereopsis-compatible group) contains (3) and (5) (under the condition of the luminance-change-dependent motion illusion Type A), and the third group (phi movement-compatible group) covers (2), (4), (5) and (6) (under the condition of the luminance-change-dependent motion illusion Type B).

Furthermore, the elemental motion in the reversed phi movement or the phi movement is summarized in Figure 6 [11,12], where luminance changes in three fields of different luminances are critical. Moreover, the central field should be narrow.

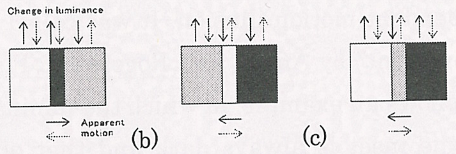
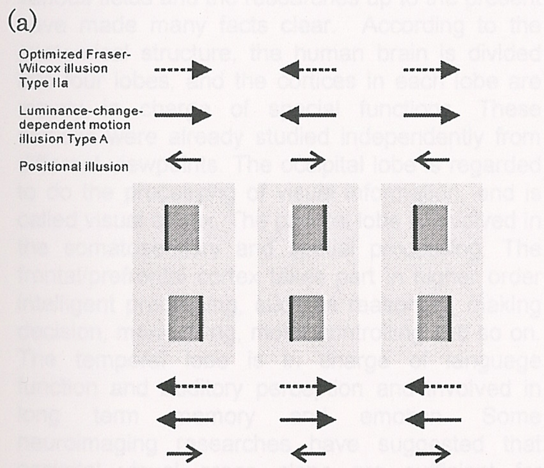


Figure 6. Perceived motion in the three elemental spatio-temporal configurations. Upward-pointing arrows show the increase in luminance in each region while downward-pointing arrows mean the decrease in luminance in each region. Right-pointing or left-pointing arrows indicate the direction of the apparent motion. For example, when the bright region in (a) increases in luminance as indicated with the upward-pointing real-line arrow, the apparent motion is rightward as shown with the rightward-pointing real-line arrow. Panels (a) and (b) correspond to the luminance-change-dependent motion illusion Type A (*e.g.*, the reversed phi movement and the Gregory-Heard motion illusion) whereas panel (c) corresponds to the luminance-change-dependent motion illusion Type B or the phi movement. In addition, the apparent positional shift is leftward in (a), that is rightward in (b), and in (c) the apparent positional shift depends on the luminance of the thin region, where that is leftward when the thin region is relatively dark while that is rightward when the thin region is relatively bright.

3. The optimized Fraser-Wilcox illusion Type II and the luminance-change-dependent motion illusion (reversed phi and phi)

Here I point out two pieces of similarity in stimulus configuration. One is the similarity between the optimized Fraser-Wilcox illusion Type IIa and the luminance-change-dependent motion illusion Type A, while the other is the similarity between the optimized Fraser-Wilcox illusion Type IIb and the luminance-change-dependent motion illusion Type B. The former share the same configuration of line appearance (Figures 6a and 6b), while the latter do the same configuration of edge appearance (Figure 6c). Both consist of three fields of different luminances where the central field is narrow.

The relationship between them is depicted in Figure 7. As a result, the optimized Fraser-Wilcox illusion Type IIa just behaves as the luminance-change-dependent motion illusion Type A or the reversed phi movement (Figures 7a and 7b). On the other hand, the optimized Fraser-Wilcox illusion Type IIb behaves as the luminance-change-dependent motion illusion Type B or the phi movement (Figures 7c and 7d).



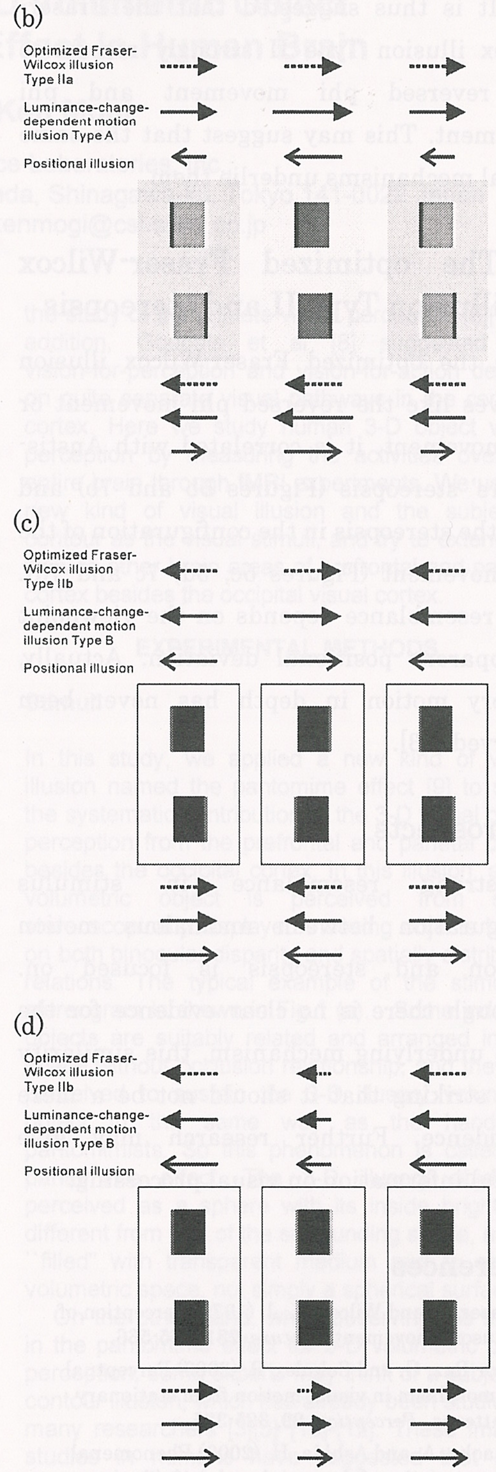


Figure 7. Comparison between the optimized Fraser-Wilcox illusion Type II and the luminance-change-dependent motion illusion. Panels (a)-(d) correspond to those in Figure 5, respectively. These images are stereograms, too.

It is thus suggested that the Fraser-Wilcox illusion Type II strongly resembles the reversed phi movement and phi movement. This may suggest that the same neural mechanisms underlie them.

4. The optimized Fraser-Wilcox illusion Type II and stereopsis

Since the optimized Fraser-Wilcox illusion behaves like the reversed phi movement or phi movement, it is correlated with Anstis-Rogers' stereopsis (Figures 5b and 7b) and with the stereopsis in the configuration of the phi movement (Figures 5c, 5d, 7c and 7d). This resemblance depends on the viewpoint of apparent positional deviation. Actually, illusory motion in depth has never been observed [13].

5. Prospects

A strong resemblance in stimulus configuration between anomalous motion illusion and stereopsis is focused on. Although there is no clear evidence for the same underlying mechanism, this similarity is so striking that it should not be a mere coincidence. Further research may give fruitful information on visual processing.

References

[1] Fraser, A. and Wilcox, K. J. (1979) Perception of illusory movement. *Nature,* 281, 565-566.

[2] Naor-Raz, G. and Sekuler, R. (2000) Perceptual dimorphism in visual motion from stationary patterns. *Perception,* 29, 325-335.

[3] Kitaoka, A. and Ashida, H. (2003) Phenomenal characteristics of the peripheral drift illusion. *VISION (Journal of the Vision Society of Japan),* 15, 261-262.

[4] Kitaoka, A. (2005) *Trick Eyes Graphics.* Tokyo: Kanzen.

[5] Conway, R. B., Kitaoka, A., Yazdanbakhsh, A., Pack, C. C., and Livingstone, M. S. (2005) Neural basis for a powerful static motion illusion. *Journal of Neuroscience,* 25, 5651-5656.

[6] Backus, B. T., & Oruç, İ. (2005) Illusory motion from change over time in the response to contrast and luminance. *Journal of Vision,* 5, 1055-1069.

[7] Murakami, I., Kitaoka, A. and Ashida, H. (2006) A positive correlation between fixation instability and the strength of illusory motion in a static display. *Vision Research,* 46, 2421-2431.

[8] Anstis, S. M. (1970) Phi movement as a subtraction process. *Vision Research,* 10, 1411-1430.

[9] Anstis, S. M. and Rogers, B. J. (1975) Illusory reversal of visual depth and movement during changes of contrast. *Vision Research,* 15, 957-961

[10] Gregory, R. L. and Heard, P. F. (1983) Visual dissociations of movement, position, and stereo depth. *Quarterly Journal of Experimental Psychology,* 35A, 217-237.

[11] Shapiro, A. G., Charles, J. P., and Shear-Heyman, M. (2005) Visual illusions based on single-field contrast asynchronies. *Journal of Vision,* 10, 764-782.

[12] Kitaoka, A. (2006) Configurational coincidence among six phenomena: A comment on van Lier and Csathó (2006). *Perception,* 35, 799-806.

[13] Kitaoka, A., Ashida, H., and Murakami, I. (2005) Does the peripheral drift illusion generate illusory motion in depth? *Journal of Three Dimensional Images (Tokyo),* 19, 6-8.

Representation of 3-D Volumetric Object from the Pantomime Effect in Human Brain

Qi Zhang, Ken Mogi

Sony Computer Science Laboratories, Inc.,
Takanawa Muse Bldg., 3-14-13 Higashigotanda, Shinagawa-ku, Tokyo 141-0022 Japan
zhangq@csl.sony.co.jp, kenmogi@csl.sony.co.jp

ABSTRACT

Human ability to process visual information of outside world is yet far away to approach for man-made devices and systems in high accuracy and speed. In particular, human beings can perceive 3-D object from various cues, such as binocular disparity and monocular shading cues. Understanding the mechanism of human visual system for perceiving 3-D object will lead to a breakthrough in creating human-like artificial visual systems and more comfortable 3-D display systems. In this paper, we study the 3-D volumetric object perception using a visual phenomenon named the pantomime effect.

INTRODUCTION

How does human brain process information from the outside world to attain perception? This question has attracted many researchers in various fields and the researches up to the present have made many facts clear. According to the anatomical structure, the human brain is divided into four lobes, and the cortices in each lobe are mainly in charge of special functions. These cortices were already studied independently from different viewpoints. The occipital lobe is regarded to do the processing of visual information, and is called visual cortex. The parietal lobe is involved in the somatosensory and spatial processing. The frontal/prefrontal cortex takes part in higher order intelligent processing, such as reasoning, making decision, memorizing, motor controlling and so on. The temporal lobe is in charge of language function and auditory perception and involved in long term memory and emotion. Some neuroimaging researches have suggested that occipital visual areas alone are sufficient for subserve visual perception [1][2] and most researches on visual perception were focused on the occipital cortex [3]-[5]. In contrast, Crick & Koch pointed out that prefrontal cortex also plays a central role in visual perception of stimuli based on the study of the primate visual perception [6][7]. In addition, Goodale et al [8] suggested that vision-for-perception and vision-for-action depend on quite separate visual pathways in the cerebral cortex. Here we study human 3-D object visual perception by measuring the activities over the entire brain through fMRI experiments. We used a new kind of visual illusion and the subjective contour as the visual stimuli, and try to extend our view to other brain areas of prefrontal and parietal cortex besides the occipital visual cortex.

EXPERIMENTAL METHODS

Stimuli

In this study, we applied a new kind of visual illusion named the pantomime effect [9] to study the systematic contribution to the 3-D visual object perception from the prefrontal and parietal cortex besides the occipital cortex. In this illusion, a 3-D volumetric object is perceived from some stereoscopically displayed inducing objects based on both binocular disparity and spatially distributed relations. The typical example of the stimuli in stereogram is shown in Fig.1 (a). Some inducing objects are suitably related and arranged in 3-D space without occlusion relationship, and they are perceived to sustain the 3-D illusory volumetric object in the same way as the hands of pantomimists. So this phenomenon is called the pantomime effect. The 3-D illusory object is perceived as a sphere with its inside brightness different from that of the surrounding space, as if is ``filled'' with transparent medium and to occupy volumetric space, not simply a spherical surface.

On the other hand, when observing the stimuli in the pantomime effect for 3-D volumetric object perception, some experts may think of a subjective contour illusion, which has already been studied by many researchers [3][5] [10]-[12]. These imaging studies in humans have suggested that static illusory contours activate neuronal populations at the earliest levels (V1 and V2) of cortical

The University of Electro-Communications UEC 国立大学法人 電気通信大学 The University of Electro-Communications

3DFORUM

The Forum for Advancement of Three Dimensional Image Technology and Arts

三次元映像のフォーラム

（第77回研究会）

創立20周年記念国際シンポジウム

The 20th Anniversary of 3D Forum

INTERNATIONAL SYMPOSIUM on 3D Image Technology and Arts

3D Forum (the Forum for Advancement of Three Dimensional Image Technology and Arts) was established in 1987; the 20th anniversary of the Forum is coming and more than 1000 articles have been reported up to now. Nowadays, various kinds of 3D image technologies, their applications and contents have been developed, commercialized and progressed day by day. This Forum has been opened for wide fields of science, engineering, arts and culture relating to the three dimensional image including ideas, products, devices, contents and their applications. In this year, we will hold the INTERNATIONAL SYMPOSIUM on 3D Image Technology and Arts as the 20th anniversary of 3D Forum. The articles on researches and developments, products (hardware and software), contents relating to the three dimensional image technology and arts will be presented and demonstrated.

「三次元映像のフォーラム」は1987年に創設され、本年で20年目を迎えることになりました。その間に、1000件を越える論文が発表されてきました。

新しい三次元映像に関する技術、製品やコンテンツが開発され、商品化されてきました。そして今現在もその開発は続けられています。

本フォーラムでは、広く一般にも門戸を開き、多くの方々の参加、発表のできる場として活動を続けております。この度、改めて国内外から関連する調査研究を行っている方々からの発表を募り、"「三次元映像のフォーラム」創立20周年記念シンポジウム"を開催することとなりました。

本シンポジウムでは、三次元映像に係るあらゆる分野からの発表を致します。

~~~~~~

Date and Time： September 6-9, 2006 9：00-17：00
September 6-7, 2006 HC-2006 (Aizu Univ.) (English)
September 8-9, 2006 3D Forum (UEC) (English and Japanese)

Place： The University of Electro-Communications (UEC),
Graduate School of Information System Facilities (IS Bldg.) 2F

~~~~~~

日時：平成18年（2006年）9月6日（水）～9日（土）
9月6日（水）～7日（木） HC-2006（会津大学）（英語）
9月8日（金）～9日（土） 3D Forum（電気通信大学）（英語および日本語）
会場：電気通信大学 情報システム学研究科棟 IS棟 2F

プログラム PROGRAM

平成18年9月8日（金） Friday, September 8, 2006

10：00～14：00 HC-2006 (See http://terre.u-aizu.ac.jp/HC-2006/)

14：00～18：00 3D Forum Meeting
(In English) Chairman：Masanori Idesawa 座長：出澤 正徳（UEC）

【Invited Lecture 招待講演】

14：00～15：00 "Visual Surface Representation and Feature Binding"
『視覚の面表現と特徴統合』
Shinsuke Shimojyo (Prof., California Institute of Technology)
下條 信輔（カリフォルニア工科大学 教授）

15：00～15：50 "Anomalous Motion Illusion and Stereopsis"
『静止画が動いて見える錯視と立体視の関係について』
Akiyoshi Kitaoka (Prof., Ritumeikan Univ.)
北岡 明佳（立命館大学 教授）

15：50～16：00 Coffee Break and Demonstration コーヒーブレイク & デモ
Chairman：Hiroyuki Shimai 座長：島井 博行（UEC）

16：00～16：30 "Representation of 3-D Volumetric Object from the Pantomime Effect in Human Brain"
Qi Zhang, Ken Mogi (Sony Computer Science Laboratories)

16：30～16：55 "A Mask Scale Adjusting (MSA) Method for Stereo Matching"
Zheng Xu (UEC)

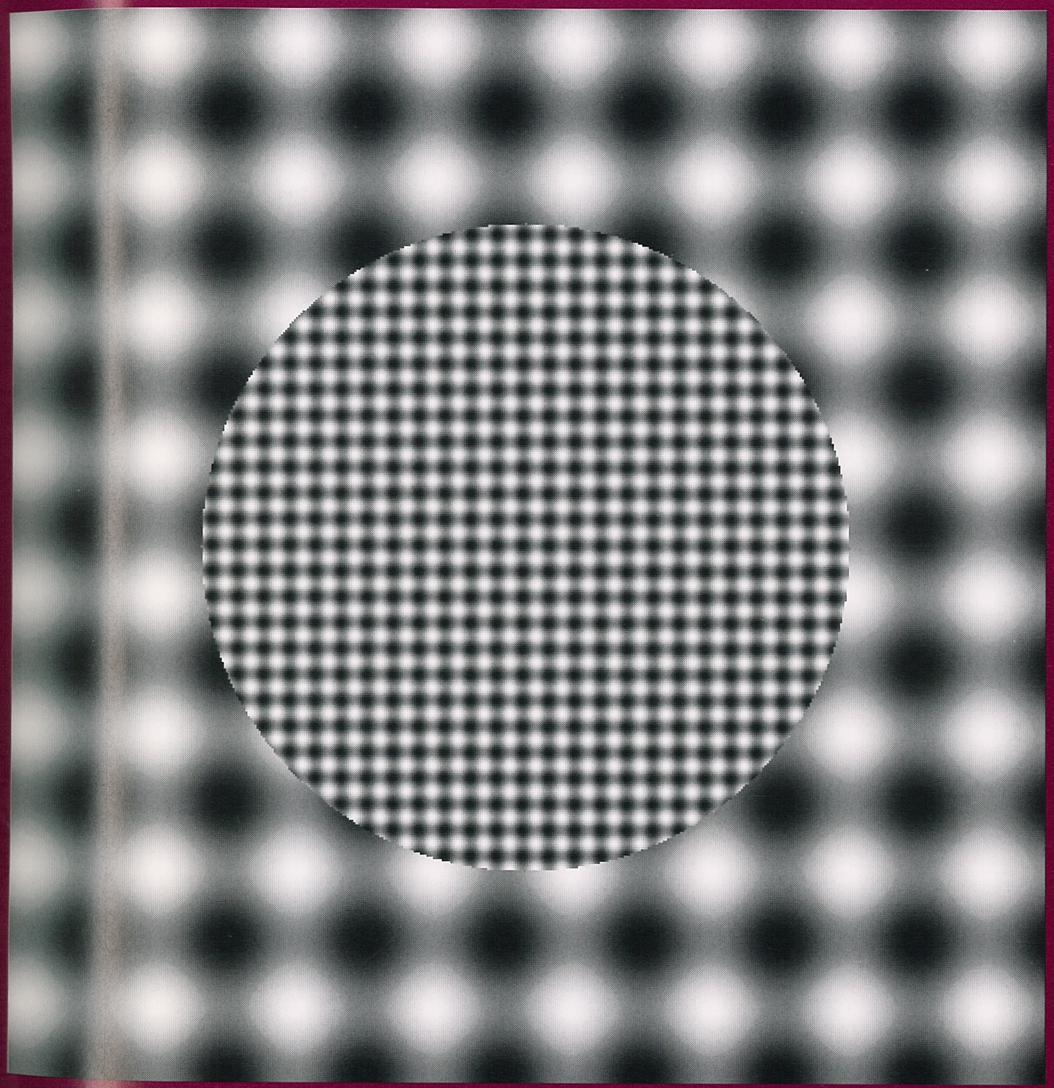
16：55～17：20 "Stereoscopy for Understanding Accessibility Issues"
Hiroyuki Nakamura (Shibaura Institute of Technology),
YAMADA Hajime (Toyo University)

平成8年1月16日 学術刊行物認可 ISSN 1342−2189

Vol.20 No.3　2006・9

The Journal of Three Dimensional Images

3D映像



三次元映像のフォーラム

THE FORUM FOR ADVANCEMENT OF THREE DIMENSIONAL IMAGE TECHNOLOGY AND ARTS