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プルフリッヒ効果およびベクションを用いた映像表現を通して Demonstrative な心理学を考える

Through visual representations using the Pulfrich effect and vection.
Considering Demonstrative Psychology

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概要：プルフリッヒ効果とベクションを利用した 8K 映像を大画面提示した作品”L∞P”および、その手法に物語性を加えることでアニメーション作品化した"人生は振り子である"を紹介する。「心の科学は可能か」という議題については積年問われ続けてきたが、個人的には不可能だと感じている。そこで、科学という概念を芸術や表現に広め、より大きいものとしてそれを「ベクション」と呼ぶことを提唱したい。その足掛かりとして作品を紹介する。

キーワード：プルフリッヒ効果，ベクション，3D 映像，心理学

1. Plüflich effect

The brain's interpretation of binocular disparity enables the perception of 3D structure (3D stereoscopic presentation of 2D images has been, in principle, based on this binocular disparity, and there are also some deceptive pictures using monocular depth perception of pictorial cues; "3D" in the current contents means this physical disparity jump-out). The Plüflich effect is a term used to refer to the effect of neutrality. The Pulfrich effect is the perception of depth when viewing a horizontally moving object with one eye covered by a neutral density filter. German physicist Carl Pulfrich observed a pendulum swinging from side to side on a frontal parallel plane, with an ND filter in front of one eye, and reported that its trajectory was elliptical (Pulfrich 1922). When an object moves vertically, the depth effect is weak (Kolehmainen and Keskinen 1974) and not strong enough to produce a sense of depth, since vertical motion produces only a pseudo-vertical parallax.

Early psychological studies, like Brauner & Lit (1976), reported mainly on the stimulus parameters effective in eliciting this effect; Kirkwood et al. (1969) found this effect in both conjunctive and detached eye movements; Morgan & Thompson (1975) reported a Pulfrich effect even with intermittent target presentation. The magnitude of the effect is comparable to that of continuous presentation if the intermittency is not too great. Although the Pulfrich effect was defined mainly only for horizontal stimuli, the same effect has also been found for vertical stimuli, although the intensity is reduced by approximately 60% (Yoshika & Nakamizo. 2001). Ito (2003) reported that the Pulfrich effect is mainly determined by objective physical motion parameters, not subjective speed or direction. Nickalls (1986) proposed a model of this effect and showed its validity using behavioral data.

The former effect, proposed by Pulfrich (1922) and extended by Lit (1949) and Alpern (1968), is explained by the theory of variations in the delay between retinal correspondence points and information transfer in the visual pathway. Placing a filter in front of one eye decreases retinal illumination and increases visual latency. Thus, when corresponding retinal points in an unequally illuminated retina are excited simultaneously, impulses from disparate retinal regions converge simultaneously at one central analyzer, and this disparity is interpreted as a depth displacement of the moving object.

It is known that the filter reduces the transmission rate of neural signals in the filtered eye, causing interocular differences in signal latency (Cynader et al. 1978; Lit, 1949; Wilson & Anstis, 1969; Nickalls, 1986; Julesz and White 1969).

Anzai et al. (2001) found that most neurons exhibit spatiotemporally oriented response profiles in both monocular and binocular regions. This indicates that these neurons jointly encode motion and depth and explains phenomena such as the Pulfrich effect (Read & Cumming, 1995, 2005). They hypothesized that the temporal properties of disparity-sensitive

neurons place important temporal constraints on stereo matching and that the effect of interocular delay on disparity-selective V1 neurons is related to stereopsis and the Pulfrich effect OnCarney et al. (1989) found that disparity-sensitive cells in cat V1 activated by Pulfrich stimulation. However, only a few neurons (5/72) had their preferential disparity altered by interocular delay, and the majority of neurons showed no disparity-delay profile relationship.

2. 3D effects in Multimedia

An example of a common application of the Pulfrich effect is NTV's "Three-Dimensional Animation Ienakako". In this work, the picture is composed of multiple layers, and the sense of depth is emphasized by the fact that the background and elements surrounding the subject are constantly moving in a certain direction.

The movie "Avatar," released in 2009, was a huge hit for its use of a 3D digital camera to depict more subtle visual textures and an overwhelmingly immersive viewing experience unmatched by any other movie at the time. In 2010, there was the craze for 3D TVs, including the "VIERA VT2"; in 2011, Nintendo released the "Nintendo 3DS", which came standard with stereoscopic capabilities; in 2020, the Sony Group commercialized the "ELF-SR1" spatial reproduction display; and in 2011, the "VIERA VT2" was released as a standard feature in the "Nintendo 3DS", which came standard with stereoscopic capabilities. LCD monitors that enable naked-eye stereoscopic viewing and the practical application of holograms are also gaining traction.

On the other hand, these 3D devices have not fundamentally penetrated households. At least in Japan, almost no one watches 3D images every day at home. As for content, the three-dimensionality increases the amount of information, yet it has not led to an overwhelming spread. The discomfort of wearing glasses has been pointed out as a reason for this, but the authors would like to cite "the feeling that the original image is degraded" as a new reason.

With the LCD shutter method, it is possible to express twice the time resolution (number of frames) by presenting the same image on both sides, and the overall brightness and saturation are also reduced. Therefore, creators must take this into account from the beginning when creating images. In the case of the anaglyph method, the original colors are lost. In the case of lenticular lenses (e.g., Looking Glass), spatial resolution must be physically reduced. The inability to present the best 2D image that can be produced with the device as it is as a 3D image was the reason why creators did not take the initiative in choosing 3D presentation. I believe the same mood existed among viewers who were aware of this.

3. Plüflich effect as a new method in this era

Concurrently with 3D imaging technology, the resolution of images continues to improve. 8K is composed of 7680 horizontal pixels and 4320 vertical pixels, and Australia has an 8k theater space called DEEP SPACE 8K. In Japan, 4K8K satellite broadcasting began in December 2018. In the private sector, 8K Cultural Heritage Viewing Solution/8K Interactive Museum is operated by Sharp Corporation. With the unprecedented advancements in image quality and resolution, is there any way to translate this overwhelming power of expression directly into 3D? We have found a possibility in the Pulfrich effect.

No matter how advanced video technology becomes in the future (16K, 128K, etc.), there will always be a method that is not limited by devices. A method that allows creators to create what they want to create without any restrictions and apply a monocular filter only when they want to do so. This is the method of creating 3D image contents using the Pulfrich effect. Efficient stereoscopic viewing requires ingenuity in the speed and direction of movement. The creators and the viewers should learn from each other as they accumulate the know-how to achieve this.

Another advantage of Pulfrich is the right to choose 2D. With conventional 3D images, the viewer does not have the right to not pop out. If you take off your glasses in a movie theater, the image is blurred. Conversely, if you wear glasses, you cannot escape the filter's reduction in brightness.

With Pulfrich imagery, the presented image is always perfect as 2D, and the viewer can choose to enjoy the stereoscopic effect of his or her own volition, without losing the right to enjoy it as 2D. It is also a methodology to realize an inclusive expression that can be enjoyed by people who can enjoy stereoscopic images as well as those who cannot, regardless of their individuality, such as ship's eyes or strabismus.

Currently, video content can be produced based on the assumption that it will be viewed repeatedly. Therefore, by attaching and removing filters, people can enjoy different experiences over and over again. Because you can actively create your own unique video experience, you can expect to have a one-of-a-kind experience and memory. Furthermore, it is extremely simple and inexpensive.

The Pulfrich effect (depth illusion) requires motion stimuli that move uniformly and mainly horizontally on a large screen. This stimulus, if the screen itself is large, induces an illusory sense of movement of the self-body, or vection, in many observers (Brandt et al., 1973; Palmisano et al., 2015; Seno et al., 2019). Vection has been used extensively in films in the past at the beginning of the film with the intention of increasing immersion in the image, as Tokunaga et al.

Vection works well with Pulfrich and matches the era of large-screen images. In addition, the improved resolution of the screen increased the sense of realism, and a synergistic effect with the

three-dimensional effect could be expected. Aoki et al. have summarized the history of vection as content, and it has been widely explored from the early days to the present, including movies, Cinerama, large-scale video exhibitions, 4DX, and so on. In recent years, it has also been used in picture books and content for rehabilitation. Since movement in the metaverse space is vection, the use of vection will become even more valuable in the future. For this reason, in this video work, we also kept in mind the effective use of vection as well as Pulfrich.

4.　Demonstrative Psychology

I mentioned earlier that the use of the Pulfrich effect has an inclusive element. At the same time, there are individual differences in optical illusions. This makes it possible to realize a unique experience for each viewer, with different images that cannot be anticipated by each viewer. Conversely, it is possible to convey one of the essential elements of art, that there is no right answer, and if there is one, we can create it ourselves. This is one of the reasons why adding psychological elements such as optical illusions, in addition to the splendor of the screen, can create a more appealing form of expression.

Illusions have long been incorporated into works of art. The oldest is the trick painting, and the most famous is probably Escher. Surrealist master Dali's works are also frequently found to be deceptive. In Japan, Shigeo Fukuda used optical illusions as a motif, and the opening image of the anime "Lupin the Third" in 2016 is like an exhibition of optical illusions.

What is it that fascinates us about optical illusions? In my subjective experience, when I watched "The Lonely Child," I was intrigued by the strong optical illusion effect in the film. The three-dimensionality of the illusion, which did not seem to me to be a simulation, brought about a sense of immersion and a unique viewing experience that strongly moved me and left a lasting impression in my memory. It was a question, "What is reality?" or, to use Gabriel's words, "Is there a common ground? In Gabriel's words, "Is there a common ground? In other words, it is a qualia problem. The illusion is a clear indication of the "valley of despair where we cannot understand each other. However, this may be the starting point. Believe that the other person has an equal mind as you do. In doing so, we begin to believe in our own worth. You find a soul that is willing to go beyond that valley and join hands with you. This is art. In order to make the viewers realize this on their own and to make them walk away, it was necessary to incorporate illusion into the representation.

5.　Our Works

With the above objectives in mind, two video works were created. The video work "L∞P" by Koyama et al. and the animation "Life is like a pendulum" by Yuri Hata (see Figure 1 and 2).

In the work by Koyama et al., the visual beauty of the images themselves was pursued, and no story was included. The animation by Hata and others is based on Koyama's established technique, and a story is placed on top of it. This story is the artist's own message and is linked to Hata's own life.

There are three main significance that these productions can present. Firstly, from the creator's point of view, anyone can create stereoscopic contents without special knowledge, skills, environment or financial resources. This will help to develop new techniques in creative expression. Secondly, it can provide a unique visual experience. The individual differences in viewing created by the introduction of optical illusions become a kind of added value, creating a viewing experience that can only be obtained with this content. Third, it is compatible with 2D displays. This may provide an opportunity for people who are not comfortable with 3D to experience stereoscopic contents.

Although the idea of using the Pulfrich effect to create a pseudo-stereoscopic view itself has been utilised in the video and games fields since the 1970s, few examples of its use in the present day can be found anymore. However, even this classical method has a strong potential to create the above-mentioned value.Therefore, there may be new ways to utilise optical illusions in line with modern image technology. It is precisely because we live in the present age that optical illusions need to be given renewed attention as a method of expression.

With Koyama's work, the two optical illusions, Pulfrich and Vection, enhance the physical beauty of the images, as well as their subjective enjoyment. This led to a sense of immersion in the experience itself, or "memory. One could say that Hata attempted to encourage the viewer by displaying his own life overlaid on top of it. Of course, the sadness and joy of the experience is not something that is conveyed to everyone. However, since what happened in the images was in the brain from the beginning, it is also certain that it will occur in the future. And there will surely be people who look at the work and want to create something of their own. In this way, that "something" will be connected. The answer to the question "What is real?
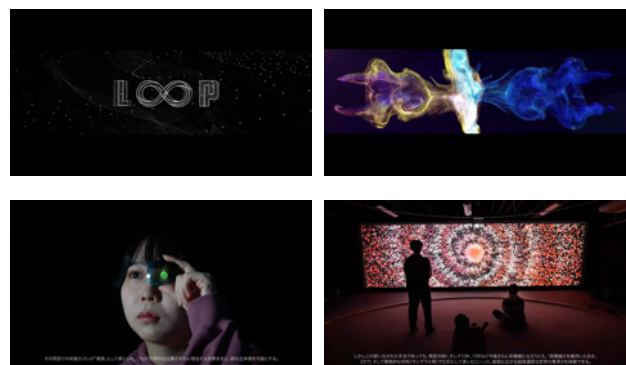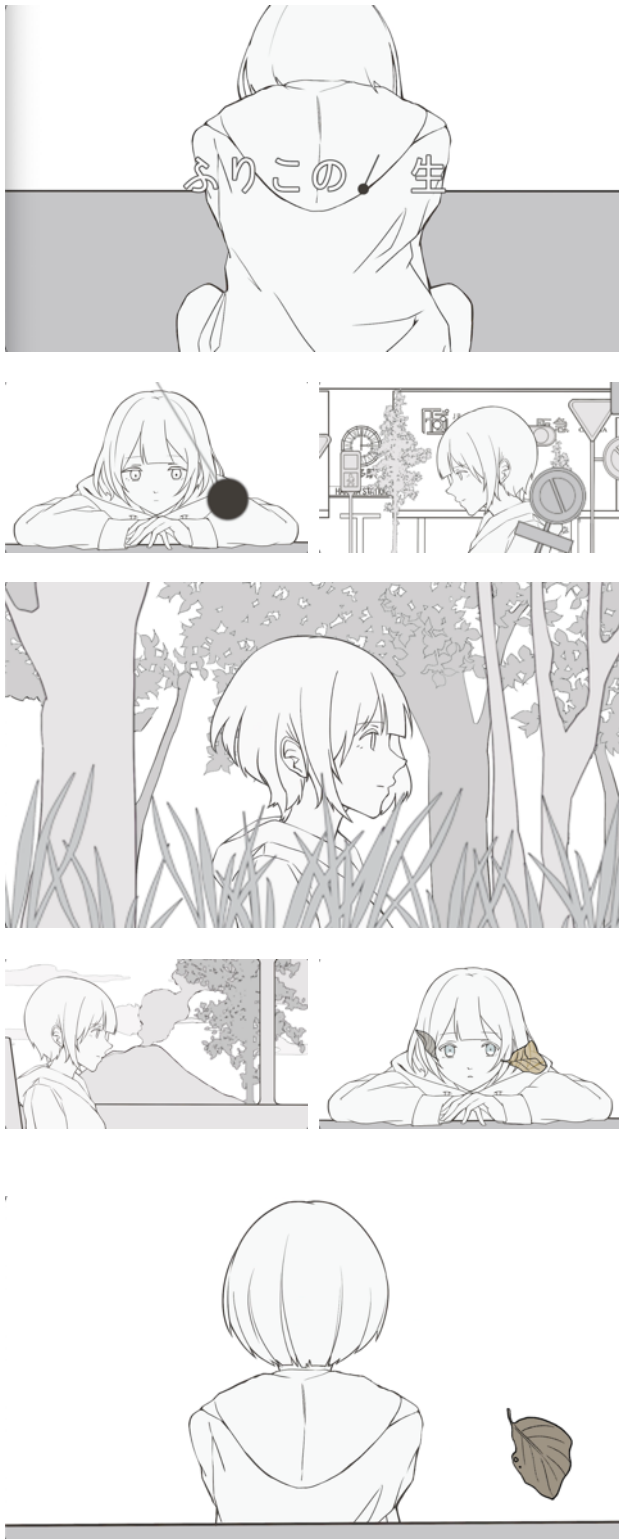

Figure 1. "L∞P" created by Koyama et al.

Figure 2. "振り子の人生" created by Yuri Hata.

付録

・「L∞P」小山理生

https://www.youtube.com/watch?v=qjLNJktAKOk&t=28s

・「振り子の人生」畑裕梨

https://youtu.be/gXwTd3skBho

参考文献

[1] Pulfrich,C(1922). Die Stereoskopie im Dienste der isochromen und hete-rochromen Photometrie. Naturwissenschaften 10, 553-564.

[2] 曽我有紀子・安田稔(1996). プルフリッヒ効果の解析, テレビジョン学会誌 Vol.50, No.9, 1277-1282.

[3] 中溝幸夫・吉賀宏美(2001). 垂直方向に運動する振り子でプルフリッヒ現象は起こるか？, VISION Vol.13, No.2, 115-118.

[4] P.Howard ・ B.J.Rogers(1995). Binocular vision and stereopsis, Oxford University Press, Oxford.

[5] K.Kolehmainen・E.Keskinen(1974). Evidence for the latency-time explanation of the Pulfrich phenomenon, Scandinavian Journal of Psychology, 15, 320-321.

[6] 金子寛彦(1996). 立体視における垂直視差の役割, VISION, 8, 161-168.

[7] 伊藤裕之(2003). The aperture problems in the Pulfrich effect.

[8] 小山理生(2022). 2022 年度九州大学芸術工学府卒業研究論文「超高精細映像における表現の多様性の追求~映像作品「L∞P」の制作~」.

[9] 妹尾武治(2021).「未来は決まっており、自分の意志など存在しない。心理学的決定論」光文社新書.

[10] 伊藤裕之(2021). 2021 年度九州大学芸術工学部開講「視覚心理学」授業資料.