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4th INTERNATIONAL MEETING ON ART-SCIENCE
2015: THE INTERNATIONAL YEAR OF LIGHT
22, 23 e 24 Setembro de 2015

READING SPEECH[1]

THE SYNOPTIC EXPERIENCE

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This text is about the *synopter* and its relation to art. In 1907, a patent was filed by Moritz von Rohr (figure 1), an optical scientist at Carl Zeiss in Jena, Germany. During his life he made various significant contributions to optical science and also worked together with nobel prize winner Allvar Gullstrand. Many of inventions were commercialized by the Carl Zeiss company but strangely, the synopter not.

The basic idea of the synopter was to ‘annul the perception of depth’ that arises from binocular vision. As you may probably know, the two eyes receive slightly different images because they are separated by 6.5 cm laterally. You can check this yourself by holding you finger in 30 cm in front of your nose. Now, look only with your left eye, and now with your right eye. (People can do it in de audience). What you will see is that the background is shifted with respect to the finger position.

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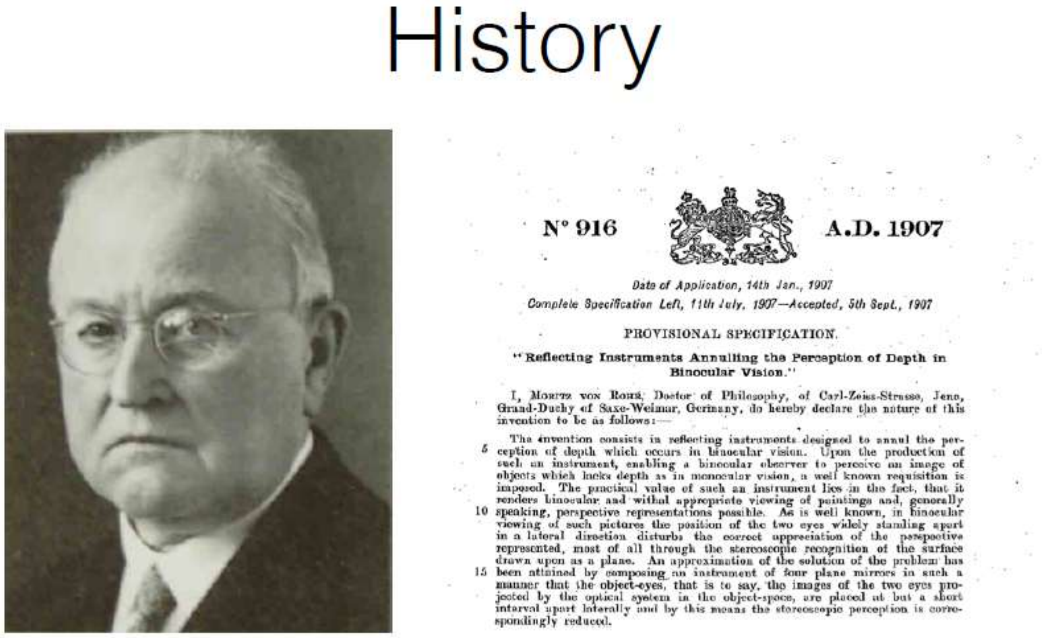
[1] Palestra encaminhada pelo autor e apresentada no decorrer do evento. Formatação diferenciada dos resumos expandidos.



History

N° 916 A.D. 1907

Date of Application, 14th Jan., 1907
Complete Specification Left, 11th July, 1907—Accepted, 5th Sept., 1907

PROVISIONAL SPECIFICATION.

"Reflecting Instruments Annulling the Perception of Depth in Binocular Vision."

I, MORITZ VON ROHR, Doctor of Philosophy, of Carl-Zeiss-Strasse, Jena, Grand-Duchy of Saxe-Weimar, Germany, do hereby declare the nature of this invention to be as follows:—

The invention consists in reflecting instruments designed to annul the perception of depth which occurs in binocular vision. Upon the production of such an instrument, enabling a binocular observer to perceive an image of objects which lacks depth as in monocular vision, a well known requisition is imposed. The practical value of such an instrument lies in the fact, that it renders binocular and withal appropriate viewing of paintings and, generally speaking, perspective representations possible. As is well known, in binocular viewing of such pictures the position of the two eyes widely standing apart in a lateral direction disturbs the correct appreciation of the perspective represented, most of all through the stereoscopic recognition of the surface drawn upon as a plane. An approximation of the solution of the problem has been attained by composing an instrument of four plane mirrors in such a manner that the object-eyes, that is to say, the images of the two eyes projected by the optical system in the object-space, are placed at but a short interval apart laterally and by this means the stereoscopic perception is correspondingly reduced.

Moritz von Rohr

Synopter patent

Figure 1

The 3D-cinema is based on this principle. By offering two different images in each eye, that are recorded with a dual lens 3D camera, your brain receives extra depth information from these binocular disparities.

Binocular disparity

Now coming back to the synopter patent. The idea of von Rohr was *to get rid* of the binocular disparities. He made 3 designs that could all achieve this goal. The most intuitive version is shown here. First identify the two eyes. They are at letter ‘l’ and ‘r’: the left and right eye. Furthermore, there are four mirrors. Three of them are normal mirrors: at letters ‘i’, ‘h’ and ‘g’. The fourth mirros is half translucent, and it is at position ‘a’. What is happening with the light, is that it comes first at mirror ‘a’. At that special mirror, half the light is transmitted to ‘h’, but the other half is reflected to mirror ‘g’. After ‘g’, the right comes into the right eye. And after ‘h’, the light is first reflected by ‘i’, and then enters the left eye.

What is important now, is that if we optically reconstruct where the ‘virtual eyes’ are positioned, we find that it is at the bottom position, denoted by r1l1, the dashed illustration of an eye. This means that both eyes have exactly the same viewpoint.

History

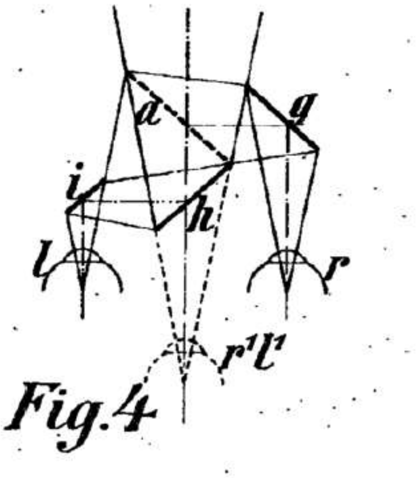
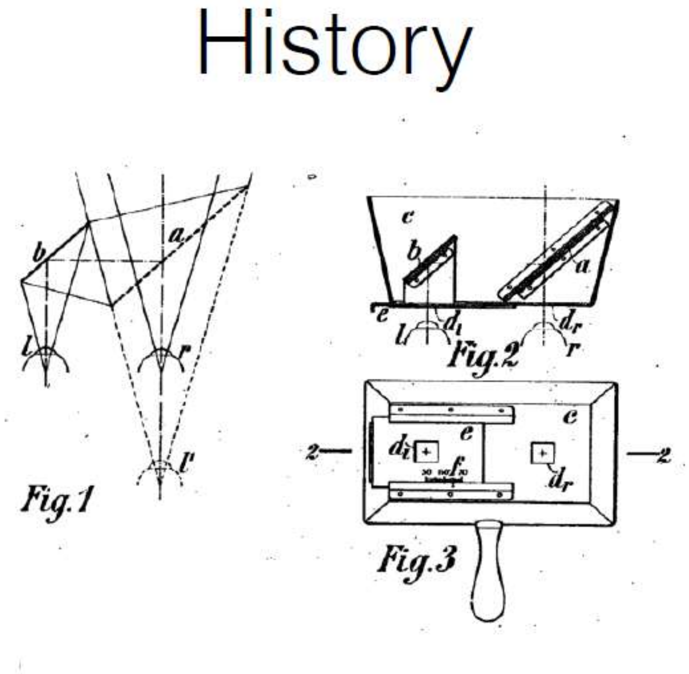


Fig.4

Design by Von Rohr

Here is another versions of the synopter. You see it is much simplified. Here, the virtual eyes no no have the exact same position, but are located behind each other: the virtual left eye is located behind the right eye. This design is also the only design for which von Rohr drew an explicit implementation, as can be seen on the right. He was even so clever to use a sliding aperture to correct for variations in interocular distance.

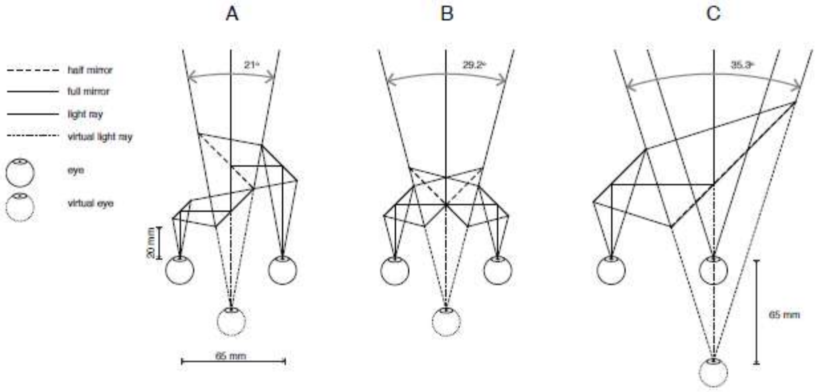


History

When we started our study, we first measured which of the three designs by Von Rohr has the largest viewing angle. This is important because when you are viewing artwork, you would like to enjoy as large a viewing angle as possible.

Design A and C are similar to the ones you just saw in the previous slides. As you can see, there are substantial differences between the designs, and clearly design C offers the largest viewing angle. So we continued with this design.

Our design



We wanted to make something that is easily produced with a laser cutter, and uses affordable materials. The biggest challenge was the half translucent mirror.

If you want a mirror that really reflects and transmits half of the light equally, you will end up with a super expensive beam splitter. Therefore, we simply tried out a so called ‘spy mirror’. It is made from perspex and relatively cheap. To our surprise, this mirror worked quite well.

Our design

Here you see some photographs that we made through the eye apertures.

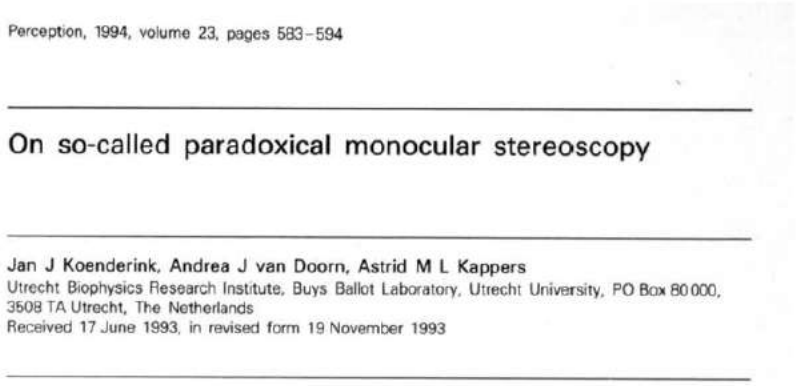
The setup is shown on the left hand side. On the right side you see the pictures we took through the right and left eye holes. At 'A' you see that there are some color differences. This is due to the perplex mirror not being of optimal optical quality.

Next, we put a 3D object in between the image and the camera. At 'B' you can see that there is no parallax between the giraffe and the image, this is the essence of the synopter. In figure 'C' we removed the synopter, and here it is clearly visible that the left and right eye image have parallax: the giraffe is displaced with respect to the background.

Our design

Although the synopter was invented in 1907, it was never taken into production and also largely unknown, at least to the vision science community. That changed when Jan Koenderink and colleagues published a paper about its effect on pictorial depth perception.

Previous research



Perception, 1994, volume 23, pages 583-594

On so-called paradoxical monocular stereoscopy

Jan J Koenderink, Andrea J van Doorn, Astrid M L Kappers
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Received 17 June 1993, in revised form 19 November 1993

Using an experimental paradigm with which they could quantitatively measure the surface of a depicted 3D object, they found that more depth was perceived when viewing with the synopter.

Previous research

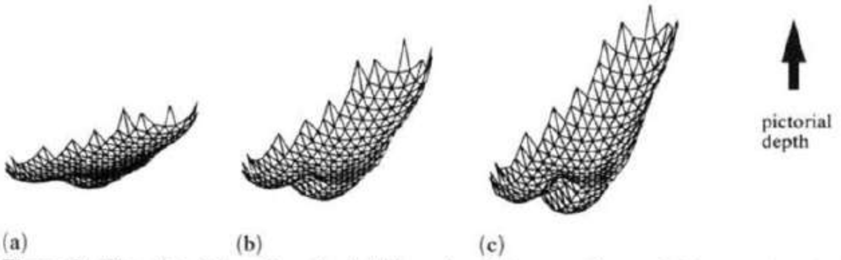


Figure 5. The pictorial surface for (a) binocular, (b) monocular, and (c) synoptic viewing conditions for subject JK and the torso stimulus. The depth is scaled in picture coordinates (pixels), thus the depth range is similar to the frontoparallel size in the synoptic condition. The projection is also shown on the ground plane of the box in figure 4. Synoptic depth is 2.7 times binocular depth. The relation is a perfect linear scaling within the experimental spread.

Previous research

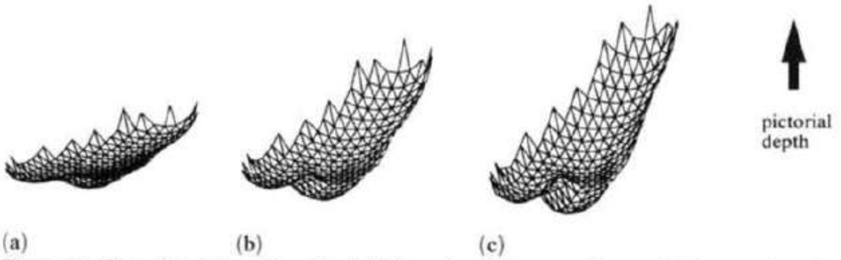


Figure 5. The pictorial surface for (a) binocular, (b) monocular, and (c) synoptic viewing conditions for subject JK and the torso stimulus. The depth is scaled in picture coordinates (pixels), thus the depth range is similar to the frontoparallel size in the synoptic condition. The projection is also shown on the ground plane of the box in figure 4. Synoptic depth is 2.7 times binocular depth. The relation is a perfect linear scaling within the experimental spread.

So why does the synopter increases your perception of depth when you view a picture. Let’s look at a painting. What you see here, the projected onto a projection screen. The projection screen is flat. Also the painting, if you would look at it in real life in a museum would be flat. We all know that. However, there is clearly pictorial depth. We can see *into* the painting. We see vegetables lying in the bottom right corner. We can perceive their shape and we can also see that the old man is further away than the vegetables. All this depth is available to our brain through so-called ‘monocular cues’, or ‘pictorial cues’.

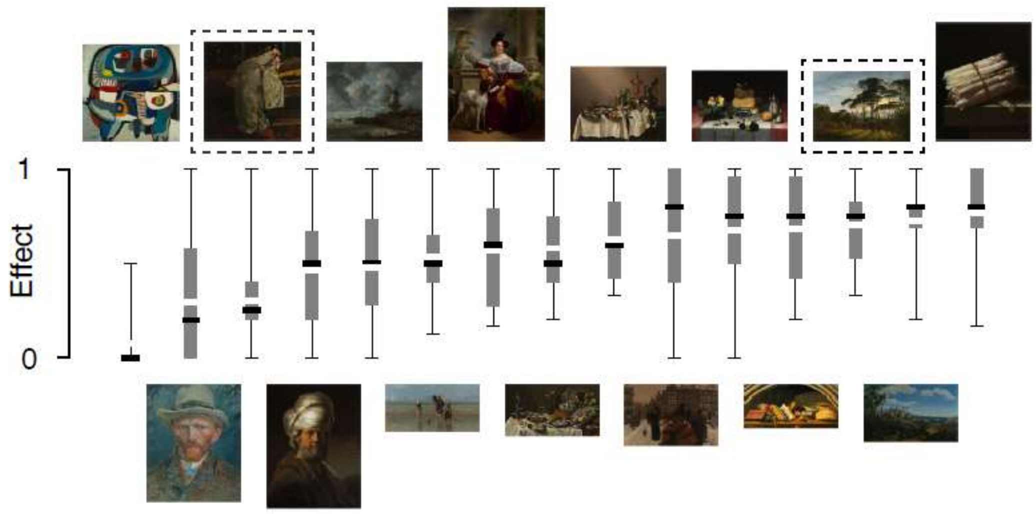
These cues include shading and chiaroscuro, but also perspective and interposition. So we see something threedimensional while at the same time it is physically flat. This would not be a problem if we did not know that the painting was flat. But yet, we do! Because the binocular disparities that our brain receives tell us that it is flat. So looking at any flat image with two eyes is a conflicting situation for our brain: we see depth and flatness at thesame time.

This is why the synopter works: it removes the knowledge that the painting is flat. By removing the binocular disparities, the information that the painting is flat is not available anymore to the brain. And this results in a relatively increased perception of depth, because we can fully enjoy the pictorial cues while not being hindered by the binocular information.

Previous research

Besides a new design of the synopter, we also investigate the role of the monocular cues on the synoptic effect. We simply showed a lot of different paintings and asked observers about the strength of the effect. We found that observers agree quite well on this task, implying that these paintings use different pictorial cues.

Our research



In a subsequent experiment we tested a some hypotheses concerning these monocular cues. Here you see the a beach scene painted by Israels. In the first experiment, we found that the synopter did not have much effect for this painting. We hypothesized that this could possibly be due to foreground-background segregation. Therefore, we added photographic blur [skip to slide 15, back and forth]. And indeed, we found that the synopter had a larger effect on the manipulated version. Therefore, we concluded that for the synopter to have effect, there most be a clear contrast between foreground an background, in these case articulated by blur.

Here you see a Breitner, a Dutch painter who is quite famous here. In the original, the synoptic effect was found very strong.

We hypothesised that this is due to the depth composition: there are many layers of depth because of the complex scene and the number of people inhabiting theAmsterdam bridge. Therefore, we removed all the others except the front woman

Again, we found that indeed, the synoptic effect was altered, although this time, as hypothesised, it became weaker. We tested a few other hypotheses, than can be read in the paper we published.

Lastly, I wanted to show some pictures of the synopter in action. For our paper, we only performed lab experiments, but did not test in museums. However, we did quite a lot of informal testing and to our surprise, the synopter works much better in a museum context than in the lab. We also got some media attention and while doing the interview, we found than many visitors of the museum really liked looking through the synopter.

Synopter in action

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Een moment *in* de Nachtwacht doorbrengen

We also made a new design, and tested on on hundreds of visitors at a pop festival.

Synopter in action

And that is the version I shipped to brazil. We also did some new experiments, in which we tested a novel idea, but that these findings I will have to keep for another time.

Synopter in action