STEREOSCOPIC THERAPY: FUN OR REMEDY?

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Abstract

Once the material of playful gatherings, stereoscopic photographs of cities, the moon, landscapes and fashion scenes are now cherished collectors' items that keep on inspiring new generations of enthusiasts. Nevertheless, for a stereoblind observer, a stereoscopic photograph will merely be two similar images placed side by side. The perspective created by stereoscopic fusion can only be experienced by those who have binocular vision, or stereopsis. There are several causes of a lack of stereopsis. They include eye disorders such as strabismus with double vision. Interestingly, stereoscopy can be used as a therapy for that condition. This paper approaches this kind of therapy through the exploration of North American collections of stereoscopic charts that were used for diagnosis and training purposes until recently.

Keywords. *binocular vision; strabismus; amblyopia; stereoscopic therapy; optometry.*

1. Binocular vision and stereopsis

Vision and the process of forming images, is an issue that has challenged the most curious minds from the time of Aristotle and Euclid to the present day. Merging the two images processed by each eye in the brain and its relationship to the notion of depth perception generated by parallax, allows the concept of stereoscopic or binocular vision to be addressed. Its complexity is mirrored in the vast history of arguments that try to explain it, as well as the scientific and artistic interest that it has aroused. The study of the laws of perspective and the physiology of vision made by Wheatstone (1802-1875), which "seem to have escaped the attention of every philosopher and artist" allowed the invention of a "simple instrument" (Wheatstone, 1838): the stereoscope. Using pictures as a tool for his study (*Figure 1*) and inspired by the Trattato della Pittura of Leonardo da Vinci[1], he stated "that the mind perceives an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinæ" (Wheatstone, 1838). He applied the two primary theories of binocular stereopsis: fusion and suppression. "According to fusion theory of binocular combination, dissimilar images engage in alternating suppression but similar images falling on corresponding retinal locations gain access to the visual system at the same time and form a unitary visual impression. According to the suppression theory, both similar and dissimilar images from the two eyes engage in alternating suppression at a low level of visual processing" (Howard & Rogers, 1995). Wheatstone's experiments included regarding the pictures with one eye, both eyes, from different distances and angles, forms and magnitudes, as well as in different colours. According to Wade (1987), "he actually carried out most of his experiments with free fusion (...) He made the stereoscope so that others, who did not share his ability to dissociate accommodation from convergence, could experience the phenomenon. It is likely that stereoscopic depth perception was added to the body of binocular phenomena not simply because it could be seen in the stereoscope, but also because the disparities could be exaggerated or reversed in the stereoscope". In the twentieth century, optometrists and ophthalmologists saw the stereoscope as a tool for the diagnosis of visual dysfunctions (Guibor, 1930) and as training for fusion sense (Hutchison et al., 1913).

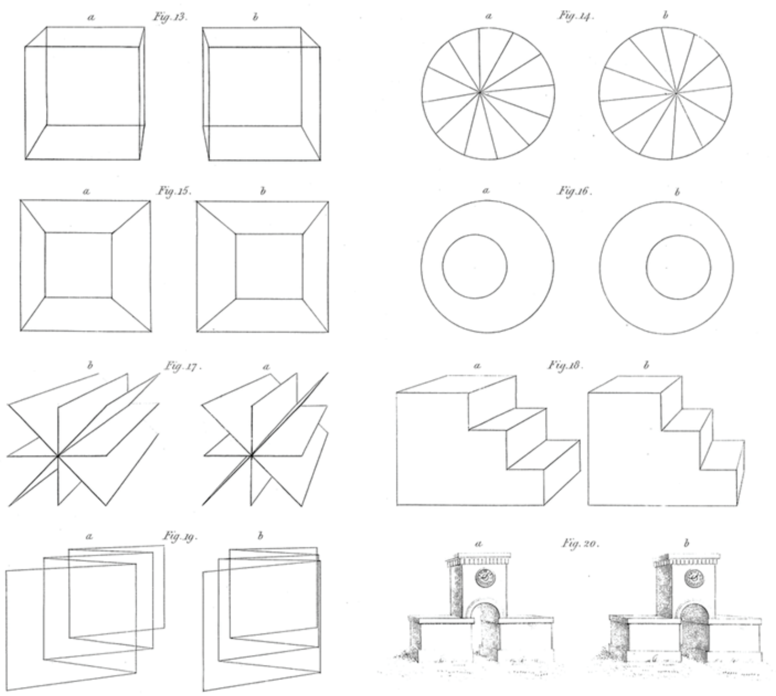


Figure 1. Pictures studied by Wheatsone (1838).

2. Stereoscopic Therapy and Stereoblindness

The notion of perspective created by stereoscopic fusion can only be experienced by those who have binocular vision: stereopsis. There are several causes for the lack of stereopsis, also called stereoblindness. They include eye disorders such as strabismus with double vision. Interestingly, stereoscopy can be both diagnosis and therapy. For this purpose, together with several modifications made in the stereoscope, several researchers of stereopsis published sets of *stereoscopic pictures*. They included Javal (1896), Wells (1912) and Guibor (1930). These sets were prepared for use by the patient during consultation and as a home exercise in accordance with very exact instructions, together with a Holmes' stereoscope (*Figure 2*). Several authors (Javal, 1896; Wells, 1918) recommended this stereoscope in respect to strength, weight and cost (Javal, 1896).

When comparing the several sets of stereoscopic pictures it can be seen that some include charts from other authors, always identified. These pictures were used for several kinds of diagnoses: type of vision - monocular, binocular, or alternating – and to determine the presence or absence of suppression, stereopsis, fusion amplitude, size of retinal images, presence and degree of amblyopia, latent muscle anomalies and specific defects in stereoscopic ability.

Once diagnosis was made in a first examination, a therapy was suggested to the patient who was made aware that this could be a process of "some months", and told that, due to the specificity of each image, these charts were not to be used indiscriminately (Wells, 1918). The aims of the stereoscopic therapy were training the fusion sense, providing a perfect binocular fusion, and the stereoscopic treatment of strabismus[2] and amblyopia.

Fusion training was very important for stereoblind children, since it was believed that under five years of age the task of gaining stereovision through optometric vision therapy was "quickly and easily accomplished, and the results obtained most striking and gratifying. Between five and six the treatment is apt to take longer, and the results less perfect. After the age of six or, at the

Figure 2. Holmes' stereoscope (Javal, 1896).

Figure 3. Thaumatrope's advertisement.
Pollock's Toy Museum, London, 2015.
Photo ©S. Raposo

latest, seven years, the results are, from the patient's point of view, not worth the time and trouble which they cost" (Worth, 1906). This could be a tedious, frustrating process and in some cases without significant results[3]. A way to avoid the difficulty of the process was to create appealing images and invite children to a sort of play activity, using classic *Thaumatrope* imagery. This was a popular toy in the nineteenth century, invented by John Ayrton Paris (1785-1856) and consisting of a disk attached to two strings with two images printed on opposite sides of the disk. It was used as a toy to demonstrate the persistence of vision. Pulling the strings turned the disk, and the persistence of vision resulted in a mixed image (*Figure 3*).

Figure 4. *Kroll's Stereoscopic Pictures for the use of Squint-Eyed Children*. Collection S. Raposo.

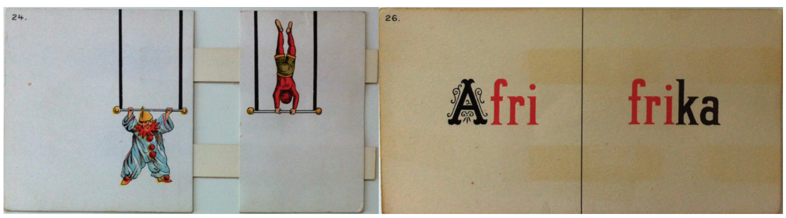


Figure 5. *Kroll's Stereoscopic Pictures* using moveable images and letters for fusion training. Collection S. Raposo.

Kroll's Stereoscopic Pictures for the use of Squint-Eyed Children[4], published and commercialised by F. A. Hardy & Co[5] in Chicago around 1900, was a set of 28 coloured illustrations using this principle. Beautiful images of birds and cages, similar to Paris' *Thaumotrope,* mice being trapped, bears, clowns and split words were used in therapy for strabismus (*Figure 4*). Some of the images were moveable, allowing the eye muscles to be trained for fusion (*Figure 5*).

Javal published a method for "measurement" of the strabismus with the stereoscope in his *Manuel du Strabisme* (1896). This method consisted of several series of charts for the fusion of letters, binocular reading and drawings to stimulate the convergence of images. The undercurrent of fun was totally absent from this method (*Figure 5*).

Later, David D. Wells made several studies of the use of the stereoscope in ophthalmology applied to strabismus and amblyopia, illustrating his books (1912; 1928) with several of the charts mentioned above, and produced a compilation of the best charts produced by Javal, Dahfeld, Kroll, Hale, Wells, Keystone and Bausch and Lomb, published by the American Optical Company. This set (*Figure 6*) consists of 50 black and white and 21 coloured charts and a chart for testing aviators in the service of the U.S. government. The charts are divided into *Series A* - adapted for patients with almost total suppression of one image (Kroll's charts), *Series B* – used to measure fusion amplitude (Javal, Wells' charts), *Series C* – consisting of half pictures to force fusion (Dahlfeld, Hale, Wells's charts), *Series E* – devoted to the cultivation of perspective (Hale, Shuman's charts), *Series F* and *G* – used to develop a refinement of fusion by a gradual progression from large to smaller characters (Javal's charts), *Series H* and *I* – for cultivating amplitude of the fusion faculty (Javal, Wells' charts) and *Series J* – used for increasing adduction with perspective (Wells's chart). By 1933, the Wells' set had been published in twenty-six editions.

In 1934, G. P. Guibor created and patented a set of 14 test charts for diagnosis and 66 split charts for vision training for adults and children, distributed by The House of Vision in Chicago. The split charts for training come together with a ruler to control the distance of the charts from a central point, and are arranged according to different degrees of difficulty. Guibor used three cards made by Hale, Sattler and Verhoeff in his set. The set was accompanied by a "detailed outline for the use of the Guibor Charts" (*Figure 7*).

None of the sets of stereoscopic charts included photographs, which is understandable because for a stereoblind observer, a stereoscopic photograph will simply be two similar images placed side by side, and fusion to obtain the 3D effect would be impossible. Nevertheless, Wells (1928) explains that Edmund Landolt (1846 – 1926) tried a consolidation therapy with patients who were ready to cease regular visits for consultation, using "ordinary stereoscopic pictures, putting two dots on one picture and a third dot on the other, so that the three will appear in a vertical line in the fused image." (*Figure 8*) "Two or three dozen of such photos, selected by him, are marked in this way, the dots being made as small as possible. He is thus taught to appreciate the absolute

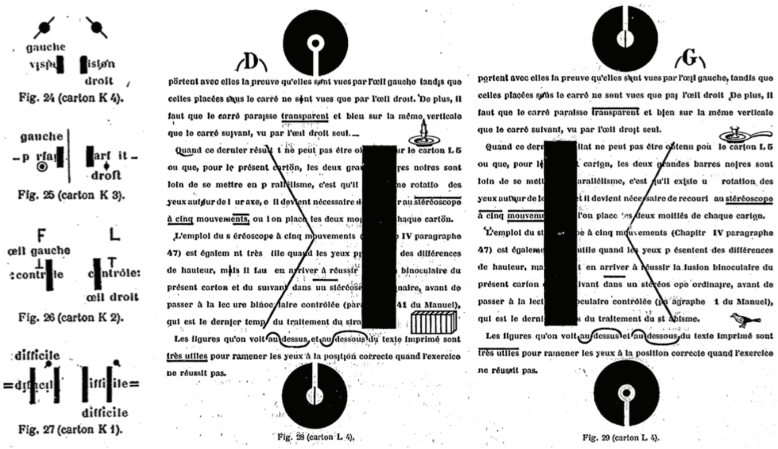


Figure 6. Javal's stereoscopic charts for fusion of letters (Javal, 1896).

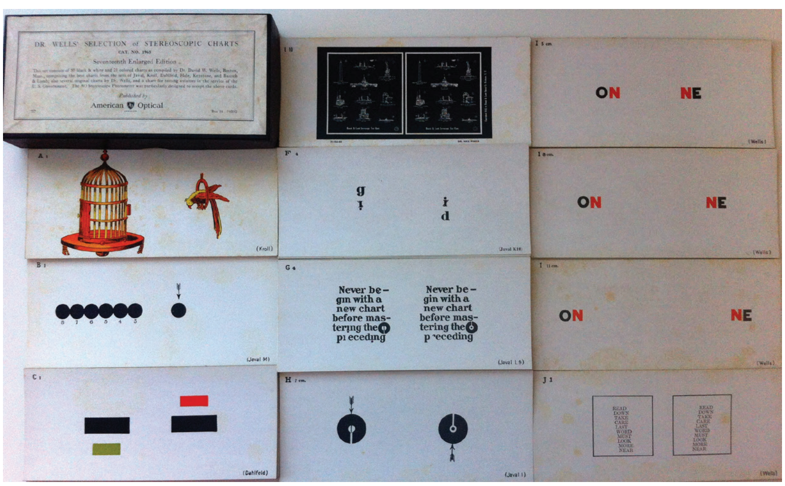


Figure 6. Dr Wells' Selection of Stereoscopic Charts and examples of each series used for different types of therapeutic purposes. Collection S. Raposo.

Figure 7. C. P. Guibor's Set of *Stereoscopic Charts for Adults and Children,* comprised of a "Detailed Outline" for its use and a ruler for the split charts for training. Collection S. Raposo.

Figure 8. Stereograph showing dots marked, used by Edmund Landolt.

reproduction of natural scenery, and is constantly able to verify his binocular perception by a glance at the dots. (…) It is advisable to insist upon good photographs properly mounted."

The many different types of stereoscopic chart sets used in diagnosis and training, and their numerous editions, reveal their success and acceptance by patients in addition to therapists. Despite this, the method, together with other alternative non-invasive therapies, such as the Bates[6] method for improving eyesight without glasses, were and still are controversial, but continue to have followers. Optometry and ophthalmology are accepted as different fields and the methods employed are different, but sometimes used together.

3. Stereoscope in Therapy

The stereoscope was improved through time and some modifications were introduced specifically to make its use in vision therapy more efficient and less time consuming. In 1896, Javal introduced the *Stéreoscope à cinq movements* (*Figure 9)* to be used as therapy for strabismus, which was prepared so as to use different types of lenses that could be moved, and adjustable rotation for the stereoscopic chart (Javal, 1896).

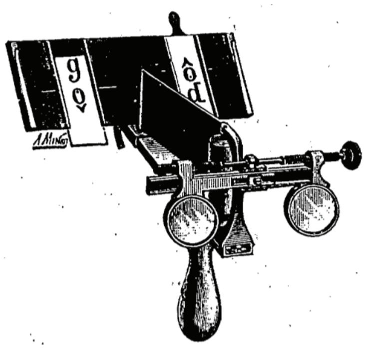


Figure 9. Stéreoscope à cinq movements devised by Javal (1896).

In 1899, Derby presented a "mechanical device that in its present form possesses advantages over other instruments (…). The object-card, made of metal, is placed on a firm shaft, and by a screw adjustment may be moved to any required distance from the eyes of the patient." (*Figure 10*).

Wells (1928) refers to an adaptation of the Holmes' stereoscope with a "cylinder with 14 facets", on which 13 different charts were mounted, "arranged with a ratchet, so that the patient can turn up one after the other of the cards, progressing in either direction." (*Figure 11*)

Although these new modifications of the stereoscope were important ones, the standard Holmes apparatus was the most common device, especially when used for home exercising. It could be easily purchased, together with the stereoscopic sets of charts, making this type of vision therapy very accessible. It was so popular in the early 1900s that the media started advertising it as a successful cure, describing the use of "attractive picture cards" (*Popular Science*, 1933).

Conclusion

This paper offers a different insight into the use of the stereoscope, exploring its application to science. 3-D has again become fashionable in entertainment, and stereoscopic vision is still a subject of study and application, in fields as diverse as computer science, cinema, game industry, engineering and others. Technologies using the tools of binocular vision

Figure 10. Derby's modification of the stereoscope (1899).

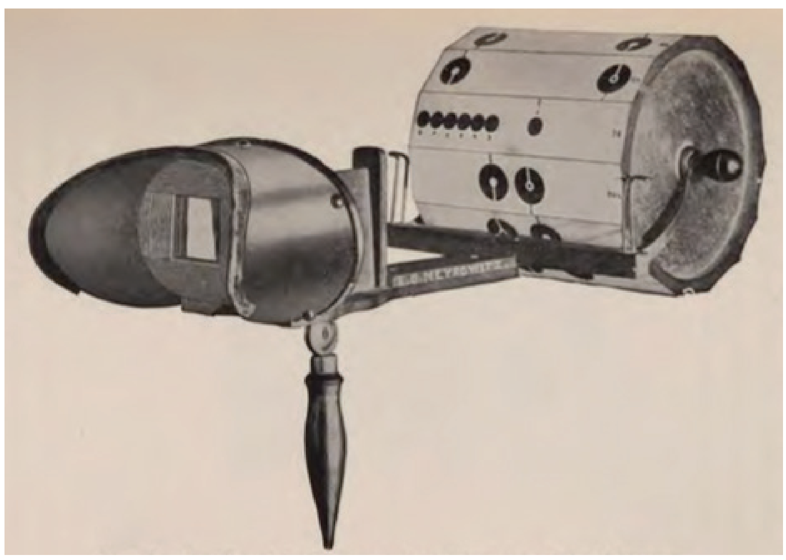
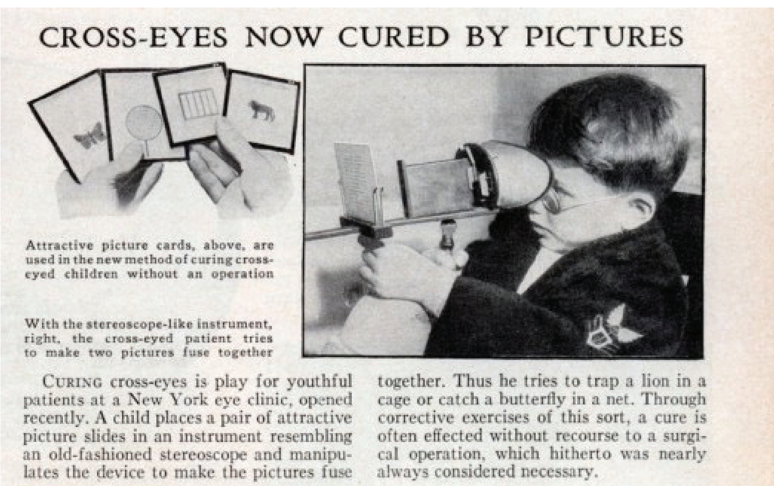


Figure 11. Stereoscopic attachment of the Holmes' stereoscope for home exercising.

to recreate realistic environments, for military training, teaching science and to make playful activities, have expanded dramatically in recent years. There is a vast potential in stereoscopes, but not everyone can benefit from them. Stereoblindness acquired as a result of disorders such as strabismus or amblyopia, is still a concern and the therapies employed to reverse it are controversial. Treating the lack of binocular vision and stereopsis using the principle of the stereoscopic fusion of images may seem a contradiction in terms, but when we take into account the use of eye muscles during therapy it becomes easier to understand. The ambiguity of its results may still be discussed and our lack of knowledge about neural networks, cell assemblies, impulse connections, and other complex factors, shouldn't be underestimated.

The creation of stereoscopic charts and their application for diagnosis and training was the result of careful research by renowned scientists, and put into practice in a wise manner, so as to draw more concrete conclusions about their effect. The collections studied and presented here allowed us to understand the evolution of the techniques used in stereoscopic vision therapy, and are a valuable tool for tracing its history. Trying to understand how the stereoscopic charts were employed made it possible to realise that the stereoscope went through several modifications in order to improve therapy. The history of the stereoscope and its adaptations to vision therapy cannot be told without studying the pictures that became the hallmark of the therapy.



CROSS-EYES NOW CURED BY PICTURES

Attractive picture cards, above, are used in the new method of curing cross-eyed children without an operation

With the stereoscope-like instrument, right, the cross-eyed patient tries to make two pictures fuse together

CURING cross-eyes is play for youthful patients at a New York eye clinic, opened recently. A child places a pair of attractive picture slides in an instrument resembling an old-fashioned stereoscope and manipulates the device to make the pictures fuse together. Thus he tries to trap a lion in a cage or catch a butterfly in a net. Through corrective exercises of this sort, a cure is often effected without recourse to a surgical operation, which hitherto was nearly always considered necessary.

Figure 12. Advertising stereoscopic therapy in the media. (*Popular Science*, 1933).

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Endnotes

1 Leonardo da Vinci was interested in eye morphology and studied the way vision was processed in the brain and its relation to perception (White, 2001).

2 Also known as cross-eyed, squint-eye or heterophoria (Worth, 1906; Wells, 1912).

3 Based on several descriptions made to the author from patients that tried this therapy during infancy and teenage period. This kind of therapy was still in use until the year 2000. For further details, see Barry, 2009 in which the author, Susan Barry, a neuroscientist, explores her stereoblindness and the visual therapies made with no result until her fifties. At this age, she finally recovers her stereopsis and starts to see the world in three dimensions. Susan was dubbed *Stereo Sue* by neurologist and author Oliver Sacks in a 2006 New Yorker article with that name.

4 An English edition of the original *Kroll's Stereoskopische Bilder für Schielende Verlag von Leopold Vass in Hamburg* (Derby, 1899).

5 F.A. Hardy & Co bought the firm of Chambers-Inskeep & Company in 1904, manufacturing opticians and wholesale dealers in optical goods (Lockley, 1928).

6 William Horatio Bates, M.D. (1860–1931) attributed nearly all sight problems to habitual strain of the eyes, and felt that glasses were harmful and never necessary. One of the most famous proponents of the Bates method was the British writer Aldous Huxley. *See* Huxley, 1942.