Research Article

The Left-Right Plane Mirror Inversion: Was Feynman Wrong?

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Regarding the left-right inversion made by a plane mirror, many sources refer to Feynman's solution. According to him, the brain does the inversion to satisfy a sort of "good form". He does not pay much attention to ray trajectory or ocular physiology. But if we consider that the human eye has lateral sensors capable of detecting whether the light comes from the left or the right: we understand the phenomenon much better.

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I. Introduction

This article comes from a question asked as part of a university course. The professor gave a "psychological" answer, but the optometry school gave us a completely different answer. The phenomenon may seem simple, but there are several variable responses on the web [1][2][3][4][5]. Many of the most developed solutions refer to a video document of a famous physicist: Richard Feynman (1918-1988) [6]. According to Feynman and his disciples, humans want to see their right arm to the right of the mirror and vice versa for their left. It would be the brain which would cause the left-right inversion to satisfy a sort of "theory of good form". In Lectures on Physics, Feynman uses the virtual image to assert that the brain "arranges the image" [7]. In the exercises book, he asks to explain the inversion and refers to this passage for the solution [8]. We cannot extrapolate so much from a simple geometric technique. In the Feynman explanation, few consideration is given to the movement of the rays and especially to the structure of the eye. We will present here the phenomenon and the physiology of the eye: the conclusion will follow.

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II. Phenomena explanation

If we look at a person from the front, we identify their left arm with our right and vice versa (Figure 1-A). If the person's back is turned to us, their left arm is to our left and their right arm to our right (Figure 1-B). If we look at the image of a person facing the mirror (Figure 1-C), we see their right arm to our right and the left to our left. A person therefore does not have the impression of inversion when facing the mirror.

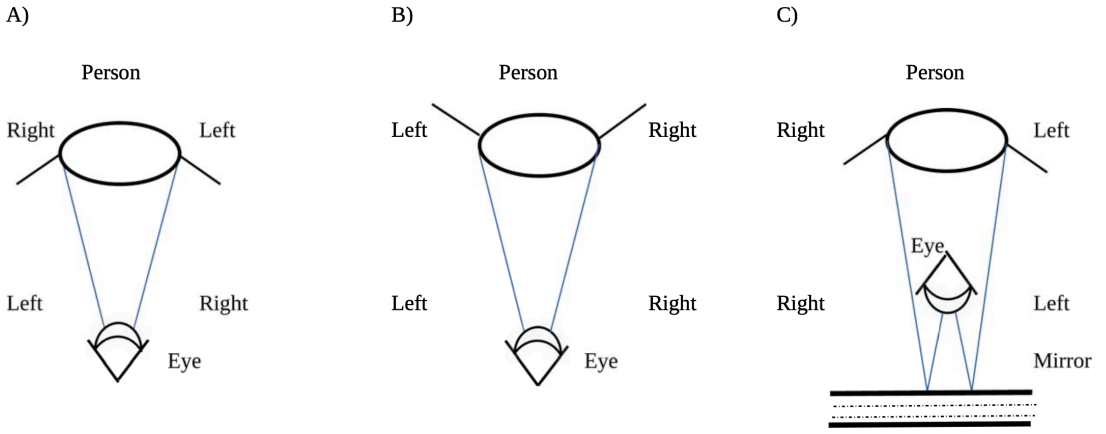

Fig. 1. Inversion of a natural person seen by another observer.

If we look at the word "**POLICE**" straight on, the "E" is to our right and the "P" to our left (Figure 2-A): this is normal. If we look at the image of "**POLICE**" in a plane mirror, the "P" is to our right and the "E" to our left: so it is reversed (Figure 2-B). This is unusual. It is therefore necessary to rectify. This is why we will write "**POLICE**" reversed (Figure 2-C). We will have the "P" on our left and the "E" on our right; we return to the normal situation. The car driver will see the word correctly written in his rearview mirror.

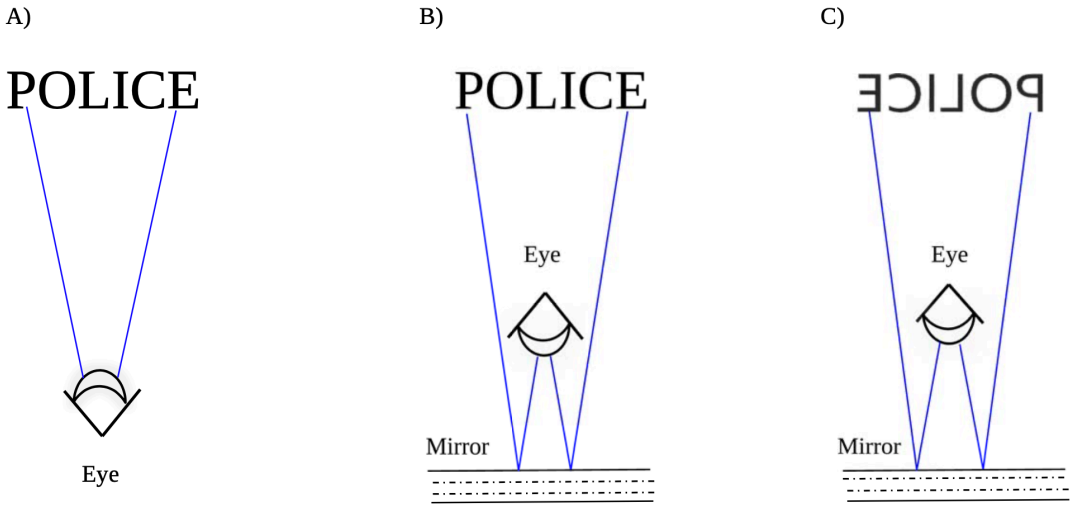

Fig. 2. Writing Inversion of the word “POLICE”.

Several documents explain to us that the plane mirror undergoes an orthogonal transformation to the images of objects [9]. There is a formula using a transformation matrix applied to an image vector. This can be useful in modeling if you have several mirrors. But this model does not explain the why, that is to say the cause of the phenomenon.

In conclusion, we see from the diagrams (Figures 1 and 2) that the phenomena can be explained by two facts. The first is well known: it is the movement of the rays. The second is less known: the human eye can “perceive” from which side a ray comes. This is implied in the diagrams: the eye would have selective “sensors”. So, we have to look at physiology to understand better.

III. Physiological Explanations

In 1981, D. Hubel and T. Wiesel received the Nobel Prize in Medicine for explaining the biology of vision in cats, primates and humans [10][11]. It appears that the inside of our eye has several rods and cones, that is to say light “sensors”. These are located mainly in the center, but a few are located on the sides (15 percent) [11]. This gives “selective responses to the orientation” of the rays arriving at our eye, as mentioned in chapter 4 of J.F. Risse [11]. These “side” sensors have a particular network which puts them in contact with the cortex which produces the image [12]. In short, both humans and primates can know from which side the rays that strike their eyes come. In the phylogeny of hominids, we can assume that

this selectivity developed for the needs of hunting and protection. On the other hand, we do not have specialized light “sensors” to know whether the rays come from below or above: hence the absence of up-down inversion.

IV. Discussion and Conclusion

We can now fully understand the inversion phenomenon. The brain produces the image based on information coming from central and also lateral “sensors”. Humans know which side the rays come from. The phenomenon is both physical and biological: we do not need, like Feynman, to invoke a psychological justification. The principle of parsimony tells us that psychology is superfluous here[1].

So Feynman was wrong. A first reason comes from the fact that the work of Hubel and Wiesel was not very well known. Secondly, it must be considered that Professor Feynman was not a physiologist.

Acknowledgements

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Footnotes

[1] William of Ockham (1285-1347), philosopher, logician. The Principle of Parsimony is to use the minimum number of causes to explain a phenomenon.

References

1. ^*F. Stevens, “Pourquoi un miroir n’inverse-t-il pas le haut et le bas?”, Sciences Claires, 04/07/2013 (French), URL: http://www.vulgarisation-scientifique.com/wiki/Pages/Pourquoi_un_miroir_n_inverse-t-il_pas_le_haut_et_le_bas*
2. ^*Scientific Park Website, “Pourquoi le miroir inverse-t-il la gauche et la droite mais pas le haut et le bas?”, 19/04/2015 (French), URL: http://scientific-park.blogspot.com/2015/04/pourquoi-le-miroir-inverse-t-il-la.html*
3. ^*C.S. Baird, Why do mirrors flip left to right and not up to down?, 05/01/2013, URL: https://www.wtamu.edu/~cbaird/sq/2013/01/05/why-do-mirrors-flip-left-to-right-and-not-up-to-down*
4. ^*R. Allain, Why Do Mirrors Reverse Left and Right?, Website of Wired, 17/08/2011, URL: https://www.wired.com/2011/08/why-do-mirrors-reverse-left-and-right*

5. ^E. Schmidt, P. Gibbs, D. Richards, and S. Chase, Do Mirrors Reverse Left and Right?, Website of U. California Riverside, 2021, URL: https://math.ucr.edu/home/baez/physics/General/Mirrors/mirrors.html
6. ^R. P. Feynman, Richard Feynman Mirror, YouTube video of R.P. Feynman explanations, 15/04/2009, URL: https://www.youtube.com/watch?v=6tuxLY94LXw
7. ^R.P. Feynman, R.B. Leighton and M. Sands, The Feynman lectures on Physics, vol. 1 chap. 26, Addison-Wesley (1964) (with extended edition in 2005), Caltech University Website, URL: https://www.feynmanlectures.caltech.edu/I_26.html
8. ^R.P. Feynman, R.B. Leighton and M. Sands, Exercises for the Feynman Lectures on Physics, problem 20-1, The New Millenium Edition, URL: https://quizlet.com/explanations/textbook-solutions/exercises-for-the-feynman-lectures-on-physics-1st-edition-9780465060719/chapter-20-exercises-1-7440bcf6-f4cb-4161-8671-1028f3796ebf
9. ^MathPlanet Website, Transformation using matrices, 2021, URL: https://www.mathplanet.com/education/geometry/transformations/transformation-using-matrices
10. ^D.H. Hubel et T.N. Wiesel, Receptive fields and functional architecture of monkey striate cortex, The Journal of Physiology, 1968, 195 (1), PP. 215-243, URL: https://physoc.onlinelibrary.wiley.com/doi/10.1113/jphysiol.1968.sp008455
11. a, b, cJ.F. Risse, Société française d'ophtalmologie, Exploration de la fonction visuelle, Ed. L. Masson, 1999 (French).
12. ^TPE: Vision relief, Voies de traitement / Cortex visuel (French), URL: http://tpe-visionrelief.e-monsite.com/pages/aires-corticales-cortex-visuel.html

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