

Plane-mirror inversion

Abstract. It has been suggested that the left-to-right inversion of mirror images is only apparent, that it is based on psychology rather than physics. Why then are mirror images reversed left-to-right for all people, rather than top-to-bottom for some and left-to-right for others? This inversion occurs because whenever we rotate objects we do so around a vertical axis—thus when we compare mirror images to rotate objects in our minds, we see a left-to-right inversion. A thought experiment is presented as support. We rotate around a vertical axis to preserve the vertical reference that gravity gives us.

Résumé. Il a été suggéré que l'inversion de gauche-à-droite des images de miroirs est seulement apparente, c'est-à-dire qu'elle repose sur la psychologie plutôt que la physique. Pourquoi donc les images de miroirs sont-elles inversées de gauche-à-droite pour la plupart des gens, au lieu de haut-en-bas pour certains et de gauche-à-droite pour d'autres? Cette inversion a lieu parce que lorsque nous effectuons la rotation des objets, nous le faisons autour d'un axe vertical—donc lorsque nous comparons les images de miroirs aux objets ayant subis la rotation dans notre tête, nous voyons une inversion de gauche-à-droite. Une expérience, basée seulement sur notre réflexion, est présentée en relation avec ce phénomène. Nous effectuons la rotation autour d'un axe vertical afin de préserver la référence à la verticale que nous impose la gravité terrestre.

Horsfield (1991) suggested that there is a misconception about mirror images, that mirrors invert images perpendicularly to the surface of the mirror, not laterally, and that the confusion is based on psychology rather than physics. Mirror images only appear to be inverted laterally, and this apparent inversion occurs because the observer subconsciously compares the mirror image to how the object would look if the observer were looking directly at it.

But the question still remains unanswered why mirror images appear to reverse left-to-right but not top-to-bottom, because although the inversion is only apparent, *all* people see mirror images reversed left-to-right instead to top-to-bottom. I suggest that the fact that mirror images appear inverted is grounded in psychology, but the direction of the apparent inversion is rooted in physics—specifically, gravity.

Maddox (1992) suggested that the mirror image is the same as viewing the surface of the object from behind. Let us start with an experiment to support this. Suppose we write on a sheet of transparency, and then hold it up to a mirror. In the mirror we see the lettering reversed left-to-right but not top-to-bottom. Looking through the back of the transparency at the same time, we see the same orientation as the mirror image—reversed left-to-right but not top-to-bottom.

Why is the lettering viewed through the back of the transparency not reversed top-to-bottom? When you turned over the transparency from facing you to facing the mirror, you rotated it around its vertical axis; that is, you turned it left-to-right, not top-to-

bottom. So of course, if you turned it left-to-right before viewing it through the back, the lettering would be reversed left-to-right and not top-to-bottom.

You can test a prediction of this. Now turn the transparency from front to back by rotating it around the horizontal axis, that is, turn it top-to-bottom. You will see the lettering reversed top-to-bottom, and not left-to-right; and the mirror image will look the same.

When you imagine that a mirror image is reversed left-to-right you compare that image to what the object would look like if you were to face it (Horsfield 1991)—but to face it, you typically turn the object left-to-right. Or, if you were located between the mirror and the object, then to face the object you would turn your head around; again, left-to-right. If we rotate the object or our head around the horizontal axis instead, then we would see the mirror image reversed top-to-bottom. By convention, when we turn our heads, our bodies, or other objects, we rotate them around a vertical axis.

Similarly, astronomers viewing photographs of the sky have East and West reversed (Maddox 1992). This is also convention; if astronomers would choose to view their photographs upside down from the way they traditionally view them, then North and South would be reversed, rather than East and West.

These conventions arise because gravity gives the world a vertical reference, whereas there is no common lateral reference. Thus when rotating objects we preserve the vertical orientation by rotating around the vertical axis, and when comparing mirror images to the object, we consider the object to have rotated vertically.

However, although the vertical reference of the world is initially caused by gravity, we view it relative to ourselves. Consider Horsfield's example of an observer lying horizontally on his right side and looking in a mirror. That observer still keeps his vertical reference intact by seeing the mirror image reversed left-to-right, even though the observer's 'left' is now the world's 'up'. We use our *own* vertical reference, even though it is no longer aligned with the world's vertical references.

References

- Horsfield E C 1991 Perception and a lateral inversion fallacy *Eur. J. Phys* 12 207–9
 Maddox H 1992 The semantics of plane-mirror inversion *Nature* 353 791

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Editor's note

Further thoughts on this topic should be kept for private discussion, and not submitted to the journal.