

CHAPTER 10

Blindsight, unilateral-neglect and the bakery facade illusion

Introductory

This chapter delves a little deeper into the subject of visual mechanisms and systems. It is one of the most important in the book because it provides information concerning the central problem as to how preconscious, bottom-up processes enable top-down control of the skilled use of eye/hand coordination. The first part takes the form of a detective story. The key to unlocking the mystery lies hidden in two experiments, relating to two visual impairment syndromes, each resulting from damage to a different part of the brain. Though other syndromes can be legitimately given the same names,¹ they will be referred to as “blindsight” and “unilateral-neglect”. The second part of the chapter describes a powerful visual illusion, first noticed in relation to the facade of a building in Castelnau de Montmiral, S.W. France. This is shown to have general implications both for artists trying to depict scenes containing rectangular surfaces and for psychologists of perception, trying to understand the mechanisms underlying analytic-looking.

Together the two parts provide powerful evidence concerning the way in which the eye-brain prepares, preconsciously for focusing attention on objects it is targeting. One of its strategies is to place an axis of symmetry upon them and then to adjust this to fit into a purpose-specific framework within the brain. The unilateral neglect experiments establish the use of a vertical axis and the bakery facade illusion demonstrates an horizontal one. The latter also makes clear that the process of imposing these axes influences the perceived orientation of the borders of objects in conscious visual perception.

BLIND SIGHT AND UNILATERAL NEGLECT

Figure 1 diagrams the idea that there is a visual pathway that allows information from the eyes to bypass the main route, via the optic nerve and the *lateral geniculate nucleus* (LGN) to *Area 1* in the *visual cortex*. This goes, via the *supe-*

1 Weiskrantz, 1980, *Unilateral Neglect*

rior colliculus (SC), on its ways to parts of the brain that control visually guided actions, including *direction of gaze*, whether determined involuntarily or voluntarily. *Involuntary* eye movements can be a response to either visual or nonvisual modalities of input (such as a sudden movement or a sudden noise). *Voluntary* ones require the use of pathways to and from the frontal eye fields (situated about as far away from *Visual Area 1* as possible), via midbrain systems, including the *hippocampus*, with its store of information relating spatial location.

Significantly for what follows, *Figure 1* also shows that, as well as enabling the eyes to look at unexpected events, the route to and from the *frontal eye fields* via the *superior colliculus* is also used to mediate the process of *pointing* at objects. This seems intuitively right, since it is possible to point in the direction of sounds, heard when the eyes are shut.

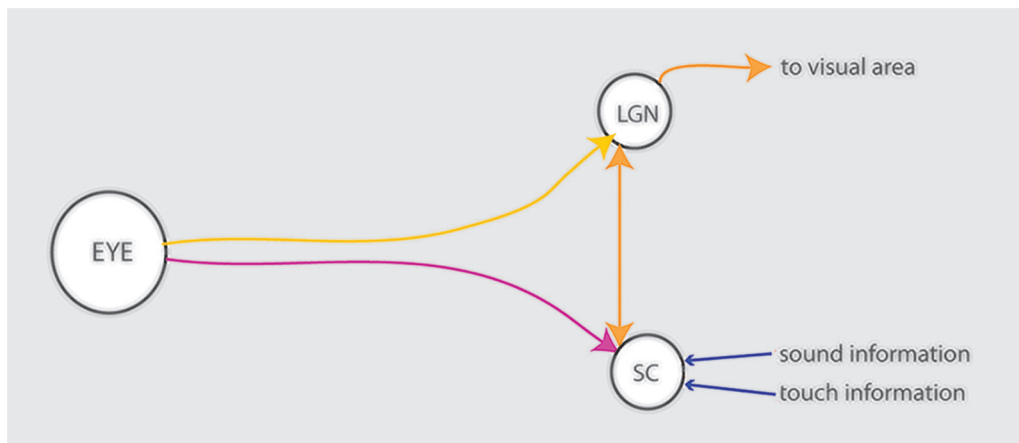


Figure 1 : The superior colliculus route

Blindsight

Anyone silly enough to look directly at the sun for more than an instant, can cause permanent damage to his or her retina. A patch of it may well be burnt out and, as the cells involved will never regenerate, the part of the eye concerned will never again be able to mediate vision. In other words, it will be blind. One method of finding out just where the damage has occurred, is to use the equipment illustrated in *Figure 2*. The circles represent light bulbs, each of which can be switched on and off independently. The little cross in the middle is a fixation

point. To map the damage, the patient is asked to stare at the cross (to stop his or her gaze wandering) while individual lights are separately switched on and off at random. The task required is to respond with a “yes” whenever a bulb is perceived to come on. Accordingly, when the light illuminates a burnt-out region of the retina there will be no response, whereas if it strikes a healthy one, there will be a “yes”. Once the response or lack of it to all the bulbs are has been tested, a map of the damaged region will have emerged.

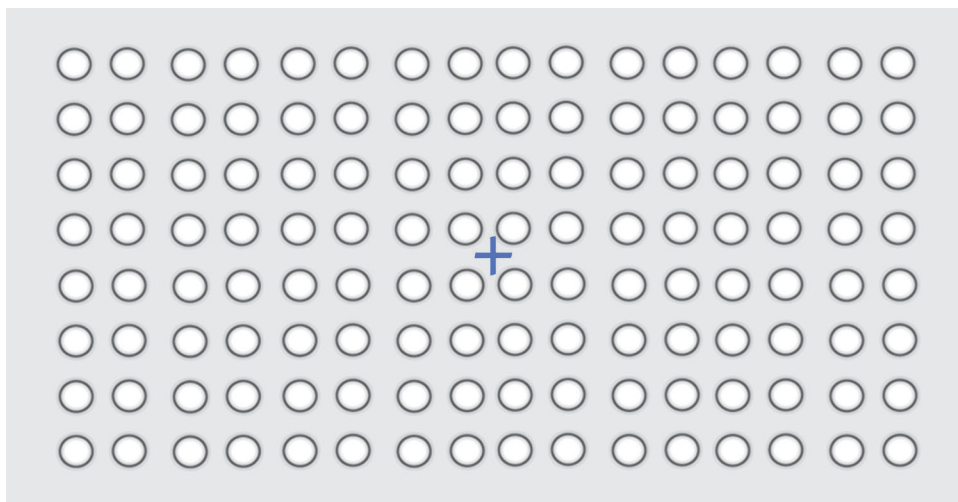


Figure 2 : an array of independently switched light bulbs

Blindsight is a phenomenon that is experientially the same as if a part of the retina had been burnt out. The difference is that, on this occasion, the cell damage which causes it (possibly consequent upon a stroke or a tumour) is not in the retina but further up the system in *visual-area one* of the neocortex. However, because this area is *retinotopically mapped*, exactly the same diagnostic technique, using the array of light bulbs, can be used to find out just where the damage lies.

A scientist who was aware, not only of the existence of the superior colliculus but also of the alternative pathways illustrated in *Fig 1*, had an insight. It was that there is no logical reason why this part of the brain should not be capable of mediating responses to regions of the visual world made invisible to consciousness due to damage in the visual cortex. Furthermore, he argued that, since the superior colliculus mediates pointing, patients with such damage should be able to point at things that they are unable to see. Following this idea, a patient with

the appropriate brain damage was set the task just described, except that the instructions were slightly different. Instead of being asked to respond verbally, he was alerted each time a bulb was switched on and told to point at it.

At first, when the illuminated bulb shone in a blind spot, he was at a loss to know what to do. This was hardly surprising since he was being required to point at something of which he was having no conscious experience. It was necessary to cajole him into guessing the location of the light. The astonishing thing was that, once he had got over his scepticism, he found that he kept guessing correctly. Indeed, his guesses were correct virtually every time, which is another way of saying he wasn't guessing all. Seemingly miraculously, he was evincing the capacity to make appropriate use of visual information in the absence of the experience of seeing. In other words, he was using *blindsight*.

Since the first case of a blindsight patient, others have been studied with the same result, establishing that at least some people *can see without being able to see*. The explanation of this apparently paradoxical state of affairs, depending as it does on the existence of an unimpaired collicular route, advances our understanding in several ways:

1. It provides an example of a *visual-system operating completely independently of visual-area one* and, logically, by of other parts of the visual area of the neocortex. This is significant because, once the existence of one independent system has been established, it is easier to accept the possibility of others in both the old brain and the neocortex.
2. It shows that there is *at least one visual-system that does not depend on conscious visual awareness for operation*. As will be shown later, there are many others, including many that depend on information routed through the *optic nerve* and *visual-area one*.
3. It shows how looking at the situation from the perspective of known neural systems can suggest questions that would never occur to anyone relying solely on personal experience and introspection.

Unilateral-neglect

Figure 3 is a self-portrait by the well-known *German Expressionist* artist Lovis Corinth. It is the drawing of a man who, as a result of a stroke, had suffered irreversible damage within the *right side of his neocortex*, in the part of it known as the *parietal lobe*. As a result, he was a victim of a well-known and much-

studied brain damage syndrome which results in patients only being conscious of the right half their visual world. For them the left side is a blank. For obvious reasons, this syndrome has been called *unilateral-neglect*. It deserves particular attention because it provides new insights into the mechanisms that enable the knowledge-guided looking strategies, without which no visually-mediated skill, including drawing could be learnt. As with *blindsight*, the significance of *unilateral-neglect* can be extracted by considering psychological effects in the context of knowledge of brain structures and it is to some of these that we now turn.



Figure 3: a self-portrait by Lovis Corinth

Figure 4 illustrates the *optic chiasma*. This is where neural fibres from the right eye cross fibres coming from the left eye on their way to the contra-lateral side of the visual area of the *neocortex*. However, it also illustrates the fact that some of the fibres do not cross over to the other side. Thus, both eyes feed both sides of the brain. This is necessary to explain unilateral-neglect for, if the fibres from each eye simply went from one side to the other, parietal lobe damage in one side of the brain would simply mean blindness in it. However, this is not what happens. Instead, each eye is divided vertically into two hemifields and each of these sends information to both sides of the visual area allowing a complete image to straddle the division between the two halves of the brain. The fact that unilateral-neglect patients see only half their visual world shows that the parietal lobe in each hemisphere receives information from only one half of this composite image (though, of course, that half comes from both eyes).

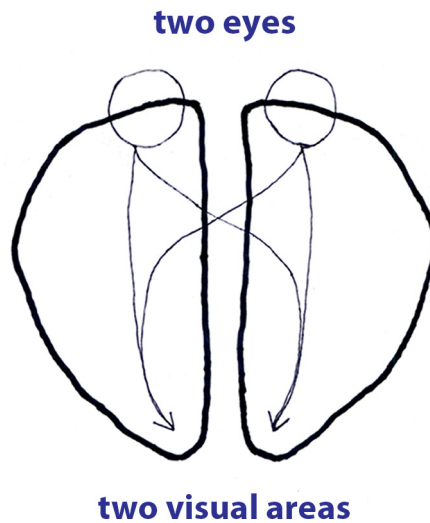


Fig 4 : The optic chiasma

An imagination experiment

Figure 5, is a highly schematic presentation of pathways within the brain demonstrated by the experiments described below (others possible pathways will be discussed separately). It shows how, after the information arrives at the visual

area (comprising several layers in which much processing of information takes place), it divides into two pathways.² One of these descends in the direction of the *temporal lobe*, while the other ascends into the *parietal lobe* whose function concerns the analysis of spatial relations. It also shows an arrow indicating a *connection between the memory stores and the parietal lobe* which plays a crucial role in what is to follow.

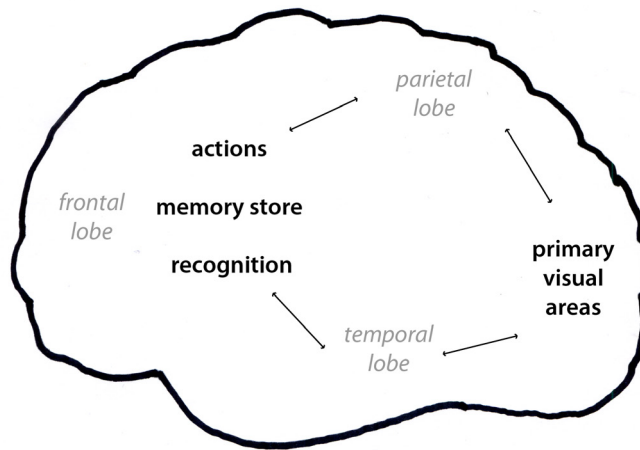


Figure 5 : Schematic presentation of the two visual pathways

As already indicated, *unilateral-neglect* has been much studied and many of these studies involved patients making copies of simple line drawings. However, before describing these, it is pertinent to say something about an experiment done by Bisiach and Luzzatti, working in Milan (in Italy) in the 1970s.³ This experiment followed the realisation that unilateral-neglect patients, in addition to being afflicted by a significant loss of visual awareness, also suffer impairment in their capacity to imagine.

The two researchers studied a male unilateral-neglect patient who had been an inhabitant of Milan all his life and was familiar with the *Piazza del Duomo* (cathedral square) in front of the city's famous cathedral. He was asked to picture

² Mishkin, M, Ungerleider, L. G. and Macko, K. A., 1983, Object vision and spatial vision: two cortical pathways. *TINS*

³ Bisiach, E. and Luzzatti, C., 1978, unilateral-neglect and the representation of space. *Cortex*. Vol. 14, pps. 129-133

himself looking across the square in the direction of the cathedral and, from this imaginary vantage point, to describe what he imagined he was seeing in as much detail as possible. He started off on his task impressively, showing an excellent memory for the buildings on the right-hand side of the square. However, when he got to the half-way point, he came to an abrupt halt. *He had absolutely no recall of the left-hand side of the square at all.*

This was what Bisiach and Luzzatti could have predicted on the basis of earlier experiments. Now they were ready to test for something new. The patient was now directed to *imagine* crossing the square to the other side and turning his back on the cathedral. The question was, what would be the result if he were asked to attempt a description from his new imaginary vantage point? Once again, he had no difficulty with the right-hand side of the square, but came to an abrupt halt at the midway point. This was a highly revealing result since what was now the right-hand side had formerly been the left-hand side. Imagining crossing the square and turning round had enabled their patient to remember the half of the square of which, a moment before, he had been totally unable to recall. In contrast, his memory for the half he had so recently described in detail had now completely blanked out. Clearly, though never simultaneously accessible, *knowledge of both sides of the square had remained somewhere in his memory.*

In these ways, the experiment of Bisiach and Luzzatti had succeeded in demonstrating that it was not the memory but the capacity to make use of it consciously (imagine) that had been compromised by the brain-damage. Clearly it was the damage in the right side of the parietal area that explained why the patient had been unable to recall more than half of the square at a time. In terms of brain structures, the experiment demonstrates that the brain damage was situated on the pathway from the memory to the parietal area as diagrammed in *Figure 5*.

Drawing experiments

We are now ready to progress to the drawing experiments mentioned earlier. As already indicated, from an experiential point of view, unilateral-neglect is like being blind in the left half of the visual world. Thus, it is not surprising that people suffering from this syndrome find difficulty in making a *drawing from observation of a clock face*. A typical result is a circle containing the numbers 12,1,2,3,4,5 and 6 placed on the right hand side of it. The emptiness of the left hand half indicates the lack of vision on that side. Bizarrely for people who have only experienced normal vision, in some cases, all the numbers from 1 to 12 are

included. If so, they are squashed into the same side of the circle. This squashing is significant because, as with the imagining experiment of Bisiach and Luzzatti, it indicates that a memory-trace of the numbers in the blanked out side has been made use of. All that is lacking is the ability to imagine them in the correct location. The production of a full circle is slightly puzzling, but can perhaps be explained by the hypothesis that motor (rather than visual) memory is being called upon to mediate the output instructions.

Similarly, when a unilateral neglect patient is given a line drawing of a house to copy, the result is an image of only half of it. And this simple fact poses a puzzle of far reaching significance: how can a copy of a half of something be made when the whole cannot be seen? Clearly such an outcome is logically impossible, since the concept of a half is meaningless without the concept of a whole to which to relate it. This being the case, we are faced with the realisation that, contrary to the evidence just sighted, the unilateral-neglect patients can, after all, in some sense of the word, perceive the whole.

At this point, the lesson coming from the blind-sight patients (and many other sources) that not all visual systems entail consciousness, suggests looking for a pathway which might mediate unconscious visual-processing. If such a route can be found, the behaviour of the unilateral-neglect patient becomes perfectly comprehensible and, as the perceptive reader will have already realised, such a pathway is indicated in *Figure 5*. It is the one that accesses memory via the temporal association-area.

So there it is. Access to memory does not necessarily depend on conscious vision. Here is proof that it can be achieved preconsciously. Put in terms of the know/see dichotomy, this means that people can know what they are looking at before they see it. For anyone to whom such a possibility has not occurred before, this can be quite a staggering thought. However, it is indubitably the case. Indeed, there is much evidence that memory is always accessed by subconscious route.

To sum up and clarify: It is now evident that the unilateral-neglect patients, having *recognised* the clock-face,⁴ placed it in the centre of their visual awareness, in the process imposing on it a *vertical axis of symmetry*. Since their very

4 Whether this stage is preconscious or conscious is debatable. Keith Williams, in a personal communication, described the experience of unilateral neglect patient with whom he was working. This man described a deeply frustrating two stage process which supports the existence of an ephemeral consciousness. Thus, at the very moment he became aware of the object he was looking at half of it disappeared.

ability to achieve this step shows that the visual systems concerned are in working order, we can deduce that it is a *prerequisite of all analytic procedures used in drawing from observation*. Indeed, we can suspect that the conscious visual analysis of spatial relations regularly depends on a preparatory imposition of axes of symmetry. It is also clear that the completed, two stage task requires the use of the parietal area in both halves of the neocortex. The unilateral-neglect patients' problem is that only one of these halves is operational.

One last question remains. Why don't the unilateral-neglect patients look a little to the left of the object they are trying to analyse? Surely, doing so would enable them to bring the whole of it within conscious vision? But this question misses the point. The evidence just cited shows, the axis of symmetry is imposed preconsciously. It follows that it will be in place before it is possible to be aware of any problem. This is not to say that the strategy of looking to the left would not work. Indeed, it is the basis of remedial treatment. However, overcoming an involuntary, preconscious habit is no easy matter and patients can take months to learn the new strategy. Even then, visual analysis entails the struggle so eloquently depicted in marvellous drawing of Lovis Corinth. It is a poignant and powerful example of the creative power of a shattered mind.

In everyday life, after an object is recognised, something has to be done with it. Skilled use of the eyes always depends on knowing what to look for and with which visual systems. This assertion applies as much to drawing and painting as to anything else.

THE BAKERY FACADE ILLUSION

Figure 6 shows a side on view of the bakery at Castelnau de Montmiral. *Figure 7* shows the same building from the front view and makes it clear that a peculiarity of this building is that the roof eaves slope up from left to right, with the result that the shape of its facade is not at all the usual rectangle of a house-front. Rather it is a trapezium. Returning to *Figure 6*, where the slope of the eaves seems even sharper, we see that the distortion is exaggerated by perspective.

But this is not all, for when we look at the photograph of the bakery facade from the side on view, even though it is a photograph and even with all the fore-warning implied by the word *illusion* in the section heading, the bottom edge of the trapezium (that is to say, the common edge with the wall top) will very likely be seen as sloping down from left to right. In the real world, the qualifying phrase

is unnecessary: The perception of a left to right downward slope is very powerful indeed. Although I have asked countless students and other people, I have never yet come across anyone who denies experiencing it.



Figure 6 : Bakery facade at Castelnau de Montmiral seen from an angle.

The reason why this outcome is so interesting is that what the students' see is an illusion. Actually, as in the photograph, the edge dividing the wall top from the bottom edge of the facade slopes slightly in the opposite direction.

Convincing people of this in the real-world context requires a change of mind-set. This can be supplied in two ways. The first relates to the rules of linear perspective. Having called people's attention to the fact that, as measured by a spirit level, the actual wall-top is horizontal, and having pointed out that they are looking down onto it, they can be referred to the rule which asserts that, in measured reality, from their viewing position, a horizontal wall top should be sloping upwards from left to right.

The second way of changing the students' mind-set is by calling their attention to the angles between the wall-top and the approximately vertical inner edges of the tree trunks in front of it. Everybody will see these as being near enough right angles, with a slight tendency to indicate a slope in the opposite direction to which they had perceived it earlier.



Figure 7: bakery facade, front view

Hard-nosed experimental psychologists might well make an objection to the nature of this evidence, for one of the cardinal sins of experimental design has been committed. The students have been told what they should be seeing before they being asked to describe it, and there is much evidence of the power of suggestion to distort perceptions. For this reason, it is appropriate to tell of an experience relating to a group of four *Painting School* students, consisting of one taller man and three shorter women, who decided to depict the view of the countryside, over the top of the esplanade wall. Somewhat to my surprise, while the women seemed to have no problem with the slope of the wall-top, the man could not seem to get it right. Despite agreeing that something looked wrong in his drawing and that the change in slope would make it look better, he could not be persuaded to change his view of what he was seeing. Eventually it transpired that reason he saw things differently was due to his being significantly taller than the women. This was why, when sitting at his easel, he could see over the wall to a trapezoid cornfield similar in shape to the bakery facade. I suggested that he lowered his head to the level of the women's. The effect on what he was seeing was immediate. As soon as the offending trapezoid field was obscured from view,

his perception of the wall top slope altered. Now he saw it as sloping in the same direction as the three women, whose perception had not been influenced by the trapezoid field because they were not tall enough to see it over the wall..

The explanation

The explanation for what I now call “*the bakery facade illusion*” becomes straightforward if we make two assumptions. These are that:

1. As a preparation for analytic-looking, the eye/brain imposes an axis of symmetry on the trapezium-shaped facade, analogous to the vertical axis imposed by the unilateral neglect patients. The top diagram in *Figure 8* illustrates this idea and shows the axis *sloping up* from left to right.
2. Orientation constancy is imposed upon this axis, so that it becomes horizontal (as illustrated in the bottom diagram in *Figure 8*).

If we now look at the bottom edge of the trapezium before it is rotated, we will see that it is approximately horizontal as is clear in *Figure 7*. However, if we now turn our attention to the same edge of the rotated trapezium, we will see that it is now sloping down from left to right. In other words, it is sloping in the direction as perceived in the *bakery facade illusion*.

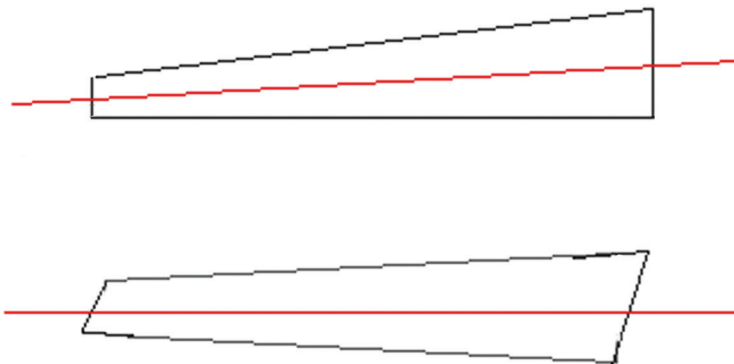


Figure 8: An axis of symmetry rotated such that it becomes horizontal

The lessons to be drawn from this illusion and its explanation are profound, both for artists and perceptual psychologists. Let us start with the artists.

Lessons for artists

A little reflection will make it clear that very few views of rectangular shapes seen from side on so that the further vertical edge appears to be shorter than the nearer one, actually have precisely horizontal axes of symmetry. Indeed, assuming that the top and bottom edges of a rectangular shape are horizontal as measured by a spirit level, according to the rules of linear perspective their axis of symmetry will only be horizontal *if the eye level of the viewer is precisely half way up it*. The probability of this being the case is very low since would only occur if the viewer's height happened to be exactly half that of the rectangle. For example, if the rectangle being viewed were to be the receding wall of a house, it is unlikely that the viewer would measure exactly half its height, thus providing the unique case in which the horizontal axis of symmetry will exactly bisect the rectangle. Unless this were the case, the laws of linear perspective dictate that the axis of symmetry must slope in one direction or the other. If so the bakery facade illusion can be expected to come into operation. That this is what actually happens has received very strong support both from what students, professional artists and architects, claim they are seeing and errors that they regularly produce in the perspective drawings of the facades of buildings in recession.⁵

Lessons for psychologists of perception

The bakery facade illusion and other illusions that, for analogous reasons, lead artists to make mistakes when representing the angles of edges in drawings, give strong support for the four related propositions. These are:

1. That located within the parietal area of the neocortex there is a region, used as a regular preparation for conscious *analytic-looking*, that mediates the constancies of size, shape and orientation. One of its features is that it provides a stable neural analogue of vertical and horizontal axes with which, if appropriately rotated, stretched or squashed, the vertical and horizontal axes of symmetry of any visually targeted edge or shape can be brought into alignment.
2. That the computations that bring the real world axes of symmetry into alignment with the vertical and/or horizontal axes within the eye/brain region in question, provide useful information on the extent of the rotations and distortions required. Clearly this could be used for calculating

⁵ More about all this in "*Drawing with Knowledge*", which deals with practical issues relating to linear perspective..

actual distances and angles, when organising actions, including eye, head and body movements used in analytic looking).

3. That a key benefit of making all objects conform in terms of size, shape and orientation is that doing so makes possible (or, at least, enormously simplifies) the task of disambiguating classifications of objects and shapes that are never the same on different occasions.
4. That the resulting distortions are integrated into the visual world of our experience and, accordingly, influence the judgement of artists, boule players and all who attempt to make accurate visual measurements.

The first three of these propositions are of fundamental interest to students of eye/brain systems and the third is well worth consideration, not only by artist seeking accuracy in their drawings from observation, but also by psychologists that are interested in visual illusions.

Implications

The question as to how bottom up and top down processes are integrated by the brain has been much discussed by psychologists of perception. The studies of unilateral neglect and the bakery facade illusion contributes to these debates. If we combine the findings discussed in this chapter, three conclusions can be drawn. These are that:

1. *There is a sense in which we know what we are looking at before we become conscious of it.*
2. *Our preconscious knowledge enables us to place axes of vertical and horizontal symmetry upon whatever it is.*
3. *The placing of these axes precedes all visual analytic looking, which requires consciousness.*

All this leads naturally to another matter that, although not strictly relevant to the argument being presented, I feel it is important to make. For those who suffer from it, brain damage is no joke. In contrast, for researchers, it has, over and over again, proved to be a godsend, because the study of syndromes for which it is responsible has proved to be a particularly rich source of insights into brain function. The distressing condition that afflicted Lovis Corinth and the man from Milan provide cases in point. The aberrant behaviour of unilateral neglect patients has made it possible to establish not only the preconscious nature of recognition,

PART 2 - THE EVIDENCE

but also a neural circuit that mediates the top-down control of analytic behaviour. All those interested in analytic skills owe them a tremendous debt.