CHAPTER 7

SEEING AND SHOWING TIME

The objects of the previous chapter were graphics aimed at showing things that cannot be seen. I argued that such graphics are based on rules that are largely shared and accepted, even though they have never been formalized or imposed. The same fact is true of the graphics that are the subject of chapter 7—those created to represent time. Representations of time form a vast and varied body of graphic productions. But despite its diversity, the theme of time posseses an underlying unity and a strong structural homogeneity. As in the preceding chapter, I claim that such unity stems not only from our own cultural history, but also from constraints that are cognitive and perceptual in nature.

FOUR WAYS TO THINK ABOUT TIME

First and foremost time is a philosophical, scientific, and existential problem. This is not surprising because time, in practice, coincides with our individual and collective life. The whole history of philosophy is rich in theories attempting to understand time both as a subjective experience and as the measure of all things concrete and abstract. Nonetheless, philosophical speculation is rarely conveyed through graphics. Therefore, it would be difficult to find pictures of time among typical philosophical mediations. One can, instead, start from ways to ***think*** about time and then try to envision how such conceptions may produce different ways of showing the concept. I divide conceptions of time into four main kinds. Each involves conceiving time as a feature of sensory experience, and each is profoundly different from all the others. Yet all four are largely shared by most of us.

Time as persecutor. Time chases us, spurs us, causes things to mature and rot. Time soothes our pains, but it also brings in new worries. In the end, time kills us. In this view, time takes on the role of a persecutor that only rarely blandishes us with welcome change.

Time as necessity. Time is a necessary dimension for all events. Any event necessarily entails a transformation that must happen in time.

Time as cause. From a naïve thinking perspective, far from any current epistemology, time as "before" and "after", "past" and "future" reflects causality. In this conception, time is an order parameter because causes must precede effects. Einstein drew on this idea, which was originally Kant's, when he stated that "the order of time, the order of before and after, can be reduced to the order of causality." (1)

Time as a problem in psychology and graphics. Some graphic elements are perceived and interpreted as information about temporal positions. Typically, we see them added to elements that represent objects spatially, in the attempt to convey the time dimension. So far, I have not considered this feature of graphics, but its nature is psychological and perceptual and in many ways deeply interesting. Temporal features of graphics have to do with our ability to decide, from looking at pictures, that entities are new, old, young, antique, decaying, second-hand, refurbished, restored, and so on. From the point of view of those who study cognition, our ability to decypher clues about temporal positions of things has to do with the activation of mechanisms that are capable of picking up and processing specific sources of information. We could think of these sources as being visual cues to temporal positions. Identifying and understanding these cues is a perceptual problem that will be the object of the final part of this chapter. I will not deal in this chapter with time perception as it is usually presented in introductory texts of psychology, however. In the typical introduction to psychology, temporal perception deals mostly with acoustic phenomena, such as the perception of musical intervals and rhythms. But my problem here is that of understanding that vast graphic production that aims at conveying the ineffable feature of temporal flow, usually by means of graphic devices that are part of a single, observable image. In the study of graphics, interest in the problem of temporal perception has been twofold, including both the issue of the representation of motion, the oldest and most widespread (2), and the issue of the allegorical meanings and the contents of images portraying time. The latter are especially worth consideration, given that structurally different graphic solutions are apparent, depending on the notion of time that is being communicated. Time flows, and it flows in many different way depending on how one thinks about it. And depending on how one thinks about it, different graphic solutions become more apt.

TIME AS PERSECUTOR: TEMPORAL ALLEGORIES

For a long period in our history, time has been represented by means of several different allegories. Typical of these are the snake that bites its own tail, signifying both the eternal cycle of years and the infinite cycle of existence; the monster with three heads, wolf (the past), lion (the present), and dog (the future); the poplar tree, the leaves of which are white on one side and brown on the other and are in continuous motion, as in the continuous alternation of day and night. But the most common allegory of time is that of an old man, skinny and almost naked, with a long white beard and white hair. He has wings to represent the speed of time's flow, and he carries a sickle or hourglass, the first signifying the destructive power of time, the second signifying the continuous flowing of the years (Figure 7.1).

7.1. A representation of time as an old man with wings. Note. From Handbook of Early advertising Art, 1947, by C. P. Hornung (Ed), New York: Dover.

The allegory of Old Man Time seems to fit naturally with the conception of time as persecutor—so much so that one finds natural to think of the allegory as the embodiment of that conception. Nonetheless, (3)the historical development of the image followed drastically different routes. In fact, it is the product of a long, subterranean interplay of meanings at different strata of our culture. The pessimistic intepretation that we hold today is only the final product of this process.

Panofsky noted that classical art represented time in one of two ways. The first was a young man, naked and bearing wings at the shoulders or feet, which represented the fugitive character of time and its potential to provide a decisive moment in people's lives. The second was an imaginary winged animal with the head and paws of a lion. This second image desceded from the Eastern cult of Mithras and is believed to represent eternity as a creative force. Thus, the ancient images of time were symbols of flow and precarious balance, on one hand, and of universal power and fertility, on the other. Never in antiquity was time represented by symbols of decline and destruction.

How could such as radical shift in meaning take place? It seems that it was a chance occurrence. Panofsky noted that the Greek word for time was chronos, which is extremely similar to the name of the eldest of gods, Kronos. In the Roman Olympus, Kronos was called Saturn, and being the eldest of gods, he was represented as an old man. He was also, however, the god of agriculture, and for this reason he often was depticted carrying a sickle. During the centuries, the images of Kronos and Saturn gradually supplanted those of Chronos until they came to signify time proper. For instance, artist of the middle ages repeatedly produced images of Saturn as the old man with a sickle. These images were recycled by astrologists and then reinterpreted by Neo-Platonists in Florence during the 15th century. Thus, the image came to possess the meaning that is familiar to us:

> Half classical and half Medieval, half Western and half Eastern, this figure brings to life, purely by chance, the grandeur of an abstract philosophical principle and the evil voracity of a demon of destruction; only the richness and complexity of this new imagine could account for the frequent appearance and diverse significance of Old Man Time in Renaissance and Baroque art. (4)

The winged old man carrying a sickle intepreted many different roles in art. He cut the wings of love (Figure 7.2), revealed truth (Figure 7.3), prized innocence, triumphed over earthly concerns, and sought victims for death. As the moral rigor of the austere art of the Renaissance began to give way to irony and sarcasm, Old Man Time began to be scripted as a comic figure. Thus, on the front page of a 1638 book, Cento Statue *Romane* Risparmiate *all'Invidioso* Dente del Tempo (One Hundred Roman Statues Preserved From the Envious Teeth of Time), we see the old man biting a statue, the famous Torso del Belvedere (Figure 7.4). In 1761, we see the old man brutally cutting across a canvas with his sickle, sitting on the torso of a destroyed statue, or smoking the surface of a painting (Figure 7.5). The artist of these images, William Hogarth, was criticizing the fashionable enthusiasm of his era for the so-called "dark-masters," the great painters of the past, whose canvases were considered more precious because they bore the signs of passing time. Here, the image of the winged old man is no longer just a symbol of time. It has became an ironic social character,

7.2. O. Venius, 1567, Time cuts the wings from Love. In Studies in iconology, 1939, by E. Panofsky, New York: Harper Torchbook, 1962.

involved in producing the opacity and the imperfections that are perceived as the hallmarks of the genuine antique, the features that determine value in the antique market, the true selling of time.

Figure 7.6 reproduces one of the last great performances of Old Man Time. Directed again by Hogarth, the character is playing a dramatic as well assatyrical role. A pessimistic statement about the political and social context of his time, this is the last of Hogarths' etchings, completed only a few months before his death. In the image, all objects are either broken or collapsing. It is the end of time, which entails the end of the world and therefore the end of mankind. But the causal sequence could also be interpreted in the other direction: the end of each person is, for that person, the end of the world and the end of time. In this way, time as a weak old man becomes the representation of a person at the time of death. But the strength lost by the character is transferred to the image, which is still rich with arguments against a world

7.3. G. L. Bernini, Time reveals truth. In Studies in iconology, 1939, by E. Panofsky, New York: Harper Torchbook, 1962.

7.4. F. Perier, 1638, Time the destroyer. In Studies in iconology, 1939, by E. Panofsky, New York: Harper Torchbook, 1962.

7.5. W. Hogarth, Time aging a painting by smoke. Note. From Engravings by Hogarth, 1973 Dover by S. Shesgreen. (Reprinted with permission)

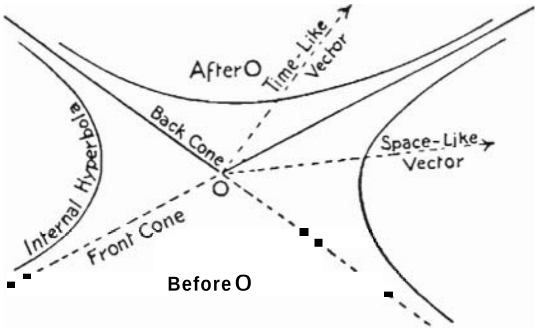
7.6. W. Hogarth, The end of time, the end of the world. In Shesgreen S., Engravings by Hogarth, Dover 1973. (Reprinted with permission)

that cherishes the dark painters. And so the pipe, time's companion object in Hogarth's staging, breaks. The sun's cart, a theme dear to the painters of the establishment, skids frighteningly at the curves of its celestial route, and its driver is thrown out of its course, inebriated by the feel of death. Other objects, of no symbolic value, are sapiently mixed with objects rich in symbolic value. The irony of chaos overcomes the order of comformism.

Time has had many lifes, and in part he has lived them in parallel. William Hogarth died in 1764, after accomplishing the death of metaphorical time. Isaac Newton, who died in 1727, had already given birth to mathematical time. For Newton the problem of time as a physical dimension stemmed from the theoretical difficulties of describing motion (5). A description of motion requires spatial measurement as well as temporal variations simultaneously. But what are measures of time, if not meaures of some kind of movement? Therefore, Newton drew a bold inference: "He took all the functions that could be used to describe mathematically possible motions in space, chose one at random, hypothesized that the function involved constant velocity, and dubbed it time" (6). Time, which continued to be one of the objects of philosophical speculation, also became an open problem of physics. It continued to have this status in the long period that began with Galileo and ended with Einstein.

The theory of relativity achieved a new unity of space and time, thanks to the glue provided by the universal constant of the speed of light. Quoting hiinkowski, Bellone noted that also the objects of our perception require an integration of space and time: "No place can be perceived if not at a certain time, and no time can be perceived if not at a certain place" (7). Therefore, "the destiny of time and space, taken by themselves, is to disappear as pure shadows, for only some kind of union of the two can possess independent reality" (8). These conclusions ring true. At the same time, however, in our phenomenal experience, space and time can be easily separated. Not surprisingly, we can talk a bout space independently of time and vice versa. And one

7.7. H. Minkowski, 1908, Space-time diagram.



domain in which the separation of space and time is especially apparent is that of images.

Each image, abstract or representational, is a way of presenting a spatial array in a given point in time. But an image is also evidence of a small catastrophic event: the separation of space from time. Once created, an image becomes and remains independent of time. This separation is necessary to produce and process the image. Perhaps for this reason, physics has doubted the utility of visualization in the analysis of physical concepts (chapter 6). The separation of space and time is wholly unacceptable to modern physics. Even to depict events that happen in multidimensional space, hypothetigraphy tends to use abstract schemes in two dimensions. Far from locking the events in a two-dimensional framework, the two dimensions of the drawing sheet work well as an abstract support for multidimensional conception. This is what can be seen in Minkowsy's drawing of a light impulse propagating equally in all spatial directions, which corresponds to a cone in space-time (Figure 7.7). The two-dimensional compression of a cone into a single line works better, as a representation of the four dimensions of the event, than a three-dimensional image attempting to convey the shape of a real cone. Time, inextricably united with space, becomes an intrinsic component of events that can no longer be shown as an external entity capable of influencing events while staying independent of them.

TIME AS NECESSITY

Space and Time

Greek historiography reported that the ancient Mesopotamic religion postulated an early union of space and time. Believers held that a dramatic event broke the union, and after that space and time could never again be whole. In the introduction to his rich and eloquent book about representations of time in art, science, and technology, Pierantoni said: "because time is neither tangible nor visible, the only way to represent it in one's own mind is as motion in space" (9). Although it is true that motion takes place in space over time, the visual representation of time cannot be reduced completely to the representation of movement. In our phenomenal experience, time and space are interconnected in many different ways, but the weight and their salience is seldom the same. Most often, one of the two components is more salient, and this has profound implications for the representation of both phenomena. Time can be especially difficult to translate into visual patterns, and this often produces a shift of balance in favor of spatial features.

What are the implications of this loss of balance in the salience of space and time? To answer this question, we must consider all aspects of phenomenal experience that are not fixed or stable. Thus, anything that can be modified is the object of our analysis. Among this vast class of phenomena, we can draw a first distinction between two subsets of modifications: transformations and movements. Transformations, or metamorphoses, imply a change in form over time, independent of spatial position. An object can change its configuration without necessarily changing its position. Movements, or displacements, imply a change in position over time, while preserving three-dimensional shape. Although both classes of phenomenal change include both temporal and spatial dimensions, I argue here that in the first case, that of shape transformations, the weight of the spatial dimension is reduced while that of time grows. The opposite happens in the second case. The expansion of the salience of time emerges suggestively in Ovid's treatment of the Metamorphoses (10). Ovid's narration of the story of Apollo and Daphne, which is one of the most frequently illustrated portions of the book, serves well as an example of my claim.

Apollo, guilty of offending the cruel and vindicative Cupid, is punished in a fashion typical of the god of love. He is made to fall desperately in love with Daphne. The beautiful Daphne refutes all admirers, and especially the most obstinate, Apollo, whom she particularly disliked. Daphne's features are rich in hints of controlled movement; even her undisciplined hair is barely kept at bay by a head band (coercebat positos sine lege *capillos*). She will escape rather than accept Apollo's courtship. The chase begins. She runs faster than the wind, but "pushed by the wings of love, the chaser is faster, he denies himself any rest" (*Qui tamen* insequitur, pennis *adiutus Amoris, ocior* est *requiemque* negat). Daphne turns to the heavens, asking to be freed of the physical appearance that makes her so attractive to Apollo. Her prayer is heard, and suddenly the transformation begins: "a heavy torpor invades her limbs, ... and her feet, which were previously so fast, turn into fixed, unmovable roots" (Pes *modo* tam *velox,* pigris *radicibus* haeret). At this point, the motion of the chase ends, and space becomes frozen. From this point forward, all events will pertain to time only.

Consider now pictures inspired by the story of Apollo and Daphne. The speed and the tension of the chase are often summarized by a single image full of movement: A scantily dressed young woman, beautiful and scared at the same time, is shown leaning slightly forward, her weight on one foot, with the other foot raised in a running gait. Her veils are suspended in midair to suggest her motion cutting through space. A young man, also running, pursues her with his arms raised and aimed in her direction; he is clearly the pursuer. The position of both bodies is definitely unstable, such that a stationary body could preserve it without losing its balance. In front of them is the space they are about to enter violently; behind them, the space through which they have just passed. Time is thus conveyed by the awareness that the frozen instant is one of instability that could not continue, of a transition toward some other state. Thus, the "before" and the "after" of the instant are somehow present in the image.

When Daphne is caught and the metamorphosis begins, time begins to predominate over space. The transformation is a different kind of change of state, where the instability of bodily position cannot work to convey it. In his attempt to represent Daphne's transformation, Bernini chose to sculpt a figure that is part young woman and part laurel tree. He tried to capture one instant of the temporal sequence of the transformation, but the result fails to suggest the before and after of the event, just as a centaur or mermaid is not usually seen as part of a sequential transformation from a human to beastlike. And this makes sense, for how could one decide if this is the transformation of a woman into a fish or of a fish into a woman? There is no suggestion of the direction of the transformation, no arrow of time. To represent a metamorphosis, a single image cannot suffice. To highlight the temporal dimension, one needs a sequence of ordered images. This artifice allows depiction of the different forms taken by the subject over time, while anchoring it in a spatial position. Note that this sequential technique also can be used to represent movement, but movement also can be depicted by other means in a single image, as I have discussed above. A metamorphosis, on the other hand, can only be represented by the sequential technique.

Events

To discuss facts of our experience possessing a temporal dimension, it is useful to agree on a psychological unit of time. Physical time, as a continuous and homogeneous dimension, can be divided in infinite different units, all equally arbitrary and legitimate. Psychological time, however, is definitely discontinuous and inhomogeneous. In our experience—and perhaps even more notably in our memory of experience—temporal segments are regrouped and reorganized around actions or scenes. These become discrete and self-contained entities that are linked to each other in complex ways. Imagine that you wanted to tell the story of your life. Your narration will consist of a series of episodes, each with a beginning, a plot, and an end, and each connected by the common thread of your identity.

Thus, we need some way of parsing time into psychologically meaningful elements. The notion of an event, as an entitity possessing a definite temporal beginning and end, is best suited to deal with the inherent discontinuity of psychological time. An event is the minimum unit of time, the elemental transformation that one can cognitively detect. As the nucleus of a single transformation that is phenomenally self-contained, an event can therefore be part of a larger happening, and it may be concluded while the overall happening is still taking place. In other words, an event can always be considered as one part of a higher chain of events; yet it also can be considered a larger whole made of many lower events. A chemical reaction can be an event or a chain of events. Examples of chains of events are a biological process, a soccer game, a story, a life, the history of humankind.

In terms of physical time, there are no gaps and not units. Yet when I observe things as they take place and recall the corresponding memories, I have no awareness of a continuous flow. Instead, I experience and recall chunks or units of transformations. These are the events. Events are created by a process similar to the segregation of figure and ground in a picture. Once the segregation has taken place, the degree of the figure's psychological reality takes over that of the ground. The figure becomes strongly salient; the ground remains only weakly present. In the same fashion, an event condenses the meaning of the happening in the logic of its temporal transformation. The physical transformations that are left out of the event dissolve in a temporal background. Thus, every event can be thought of as a catastrophe, a dynamic process that maps all the infinite ways of organizing segments of time into a single organization, the event we have witnessed. We experience and remember events to achieve economy of representation. It allows us to discard irrelevant information and to organize important information into units.

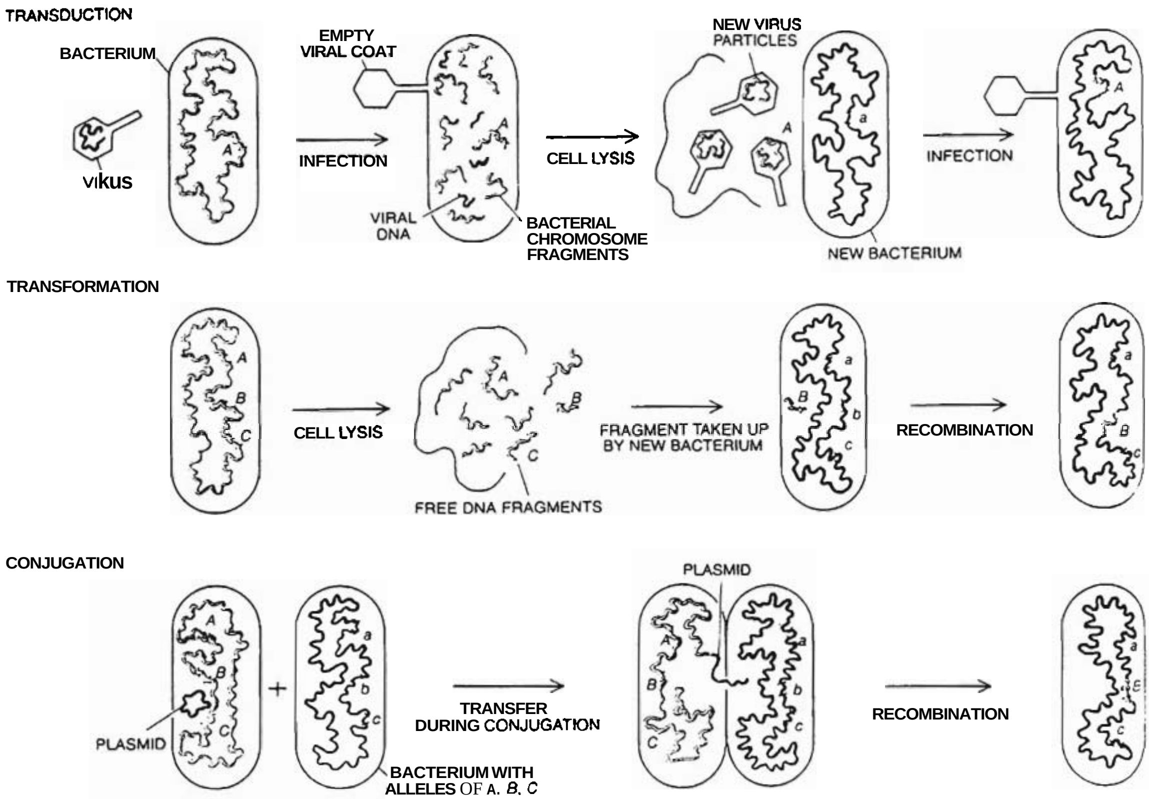
Art and the Representation of Events

For thousands of years, still pictures were the only medium for preserving and communicating visual information, even if the information was about transformation and movement. Thus, the visual arts have devised a number of different strategies aimed at coding and transmitting the dynamic content of events. These strategies are largely based on an intuitive understanding of the cognitive constraints involved in perceiving images and in linking them cognitively as successive representations of the same event evolving over time. Later I will examine the specific features of these types of images. To produce linkable images, one must provide visual information to specify their temporal distance. This information will thus define the temporal dimension of the narrative by connecting each pair of static images more or less strongly.

The outcome can be either an ***illustrated story*** or a ***story told through images***. The first kind of narration is essentially verbal, with images added to translate selected episodes into a visual form. The second kind of narration is a sequence of strongly linked images, which actually show the sequence of episodes that constitute the overall story. In this second kind of narration, verbal material is used only to report dialogue (words) or to suggest environmental sounds (onomatopoeic nonwords). Both kinds of narration can be used for literature but also for scientific narration and even for technological narration. In the latter forms, the protagonists are not human beings (or humanized things or animals), but natural forces and artificial machines.

Critical to creating a link between successive images is the presence of permanent features common to all of them. Such image permanences are similar to the notion of geometric invariants, discussed in the preceding chapters, although they are defined less rigorously. Permanences must be combined with meaningful variations. Permanences group images into a single sequence. Variations provide information about temporal ordering and highlight differences in temporal position. The perceived temporal evolution of a sequence of images is thus based on a trade-off between permanence and variation.

Examples of such trade-offs are easy to find. Even today, despite many sophisticated techniques for animation and temporal sequencing, the presentation of sequential graphics is still used daily for its ease of use and presentation. One example is Figure 7.8, which presents a sequence of three interdependent events: the transduction, transformation, and conjugation in bacterial recombination. The arrows pointing right indicate the temporal progression of the processes. A second example is provided in Figure 7.9, a table by Italian cartoonist Hugo Pratt (11). The table is read from left to right and from top to bottom, in the natural sequence of reading. As one scans the image in this order, a link is established between the images, generating an experience of continuity. Although each image shows the same character, each image is different. The variations are synchronized with the temporal sense of the observer, so that they are experienced as the unfolding of an event. Thus, the figure in the second image is immediately recognized as the same character as that of the first image, shown at a later point in time, the two figures in the fourth image are the same characters depicted



7.8. Small variations and large permanences in the sequence of the phases of an event. Note. From Transposable genetic elements, by Cohen S. N., Shapiro S. A. In Scientific American, February 1980.

in the second image, and so on. The successive presentation of permanences and variations is critical. If the first image on the top left had been followed directly by the last image on the bottom right, there is little doubt that readers would not naturally establish the connection. Note that the sequence represented in Figure 7.8 is more tolerant of potential rearrangements. For instance, if the first part had been followed directly by the third one, then the temporal relationship would have been weakened but not destroyed. This image is rich in permanence and contains only small variations. Pratt's table is more balanced in this respect. From a theoretical point of view, an interesting problem is to understand the proper balance between persistence and variation for a given depicted event. The adequate balance should favor linking the successive images while at the same time suggesting their interpretation as parts of the same event evolving over time.

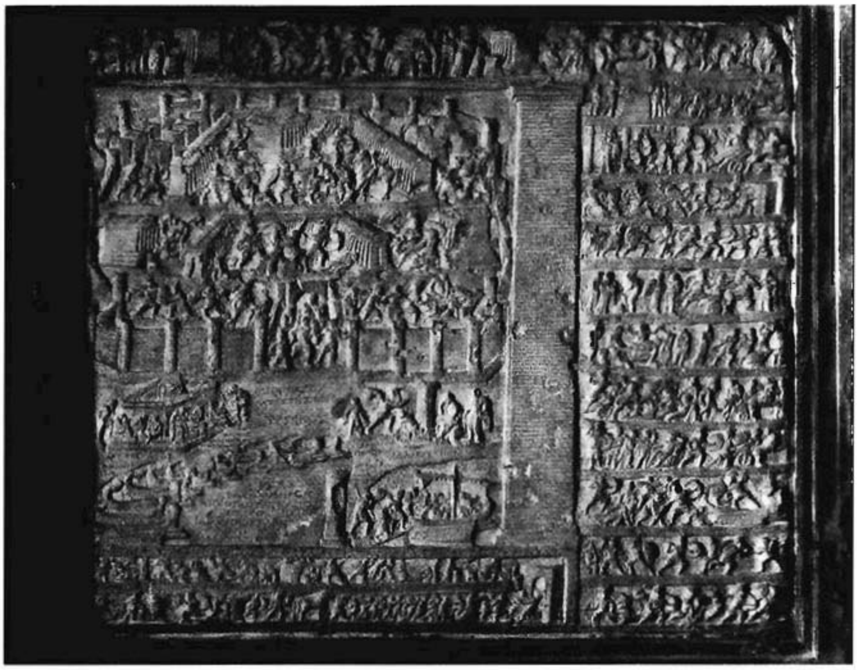
Temporal distances possess specific features in comic strips compared with other narrations through images. McCloud (12), in his entertaining and intelligent structural analysis of comics (told using comics), suggested that the grandfather of comics is sequential visual art, including all kinds of sequential graphics from Egyptian hieroglyphics to the arras of Bayeux, to the Aztec codes found by Cortez, to the moral tales of Hogarth. In my view, comics must instead be considered as structurally different from other narrations conveyed through images because of their specific use of temporal rhythm in different images. Comics were born in a cultural climate that had "magic" devices to create stroboscopic motion. It was an environment that witnessed the development of the chronophotography of Muybridge and Marey and the invention of moving pictures. In his relationships to these

7.9. Hugo Pratt, a sequence from *L'uomo del* Certao, 1978, *Milano:* Edizioni CEPIM.

new media, time as represented in a comic strip is different from other narrations both qualitatively and quantitatively. From a historical point of view, narrations conveyed through images have a distant origin and have evolved gradually through a series of modifications and adaptations. Nonetheless, there has never been a single, commonly accepted way of representing temporal positions in one image or a series of images. If we consider some of the ways that have been most popular, we can appreciate that constraints have been followed only approximately. Most likely, there were attempts to represent sequences of events in prehistoric cave etchings. We find obvious (if not immediately interpretable) traces of this intention in Egyptian and Assyrian bas-reliefs. A good choice for a historical example of early narration through image is the Tabula Iliaca Capitolina from the age of Augustus at the end of the 1st century BCE (see Figure 7.10a). Brillant chose this table as a classic paradigm of "continuous narration"(13). The table is essentially a summary, through images, of Homer's Iliad, created by a sculptor known as Thedorus. The panel shows three episodes of the fugue of Eneas from Troy. Each episode is set in the same scenario in which Eneas appears three times.

> The first time, Eneas, the black figure on the left of Figure 7.10b, is depicted inside the perimeter of the city walls, the second time while he is passing through the doors of the city wirh his father and his little son, and finally, in rhe lower right corner, while he is boarding a ship (14).

7.10. (a) Tabula iliaca capitolina, 1st century, "Eneas escaping from Troy." Photo Alinari. (Reprinted with permission); (b) scheme of the same "tabula" in R. Brillant (1984), Visual narratives story telling in Etruscan and Roman art, New York: Cornell University Press. (Reprinted with permission)



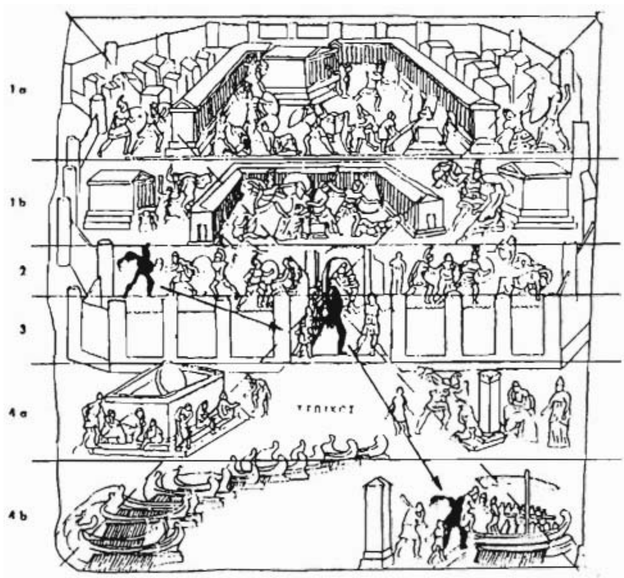


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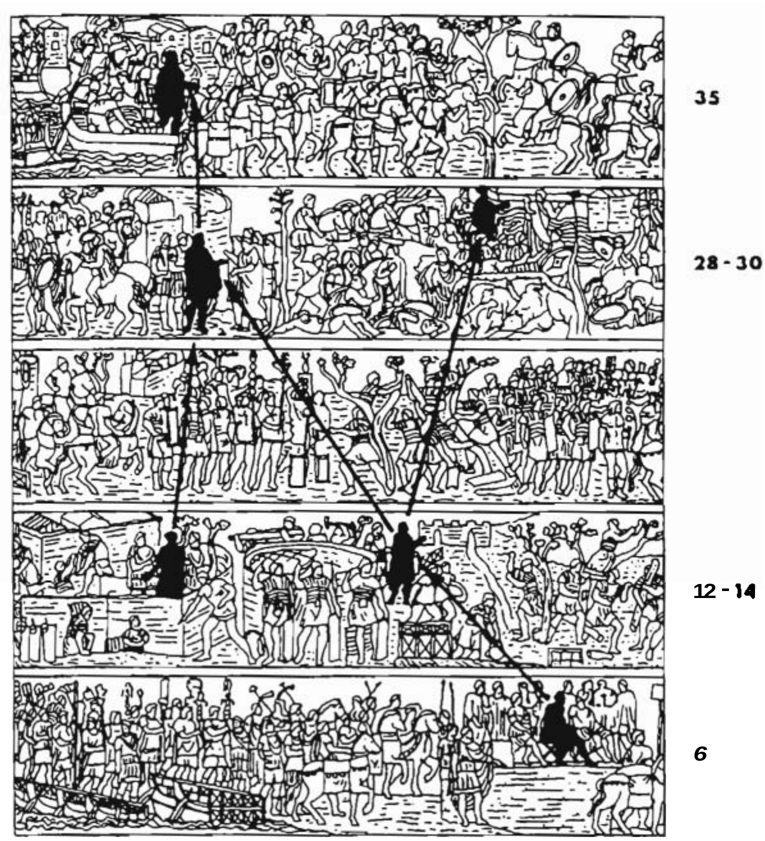
Figure 7.10 outlines the subdivision of the panel in six horizontal registers. Of these, 1a e 1b represent the destruction of the city; 4a e 4b show the escape of the hero. Between these two, are the two central registers, 2, in which Eneas receives the statues of the Penates from Anchises; and 3, in which Eneas — shown enlarged to enhance the drama — exits the doomed city under the guidance of Hermes. Brillant noted that

> the figure of Eneas, repeated three times, defines the course of the action. As the principal actor, he plays a central role in the entire composition of

the panel. Despite the relatively small size of this work and the descending direction of its motion, the composition reminds us of the the organization in different sections of the ***Colonna Traiana*** (Figure *7.1*1) not only in the suggestion of sequences by loops of images cutting across the work, but also in the great weight of the principal actor, the key element of the narration. (15)

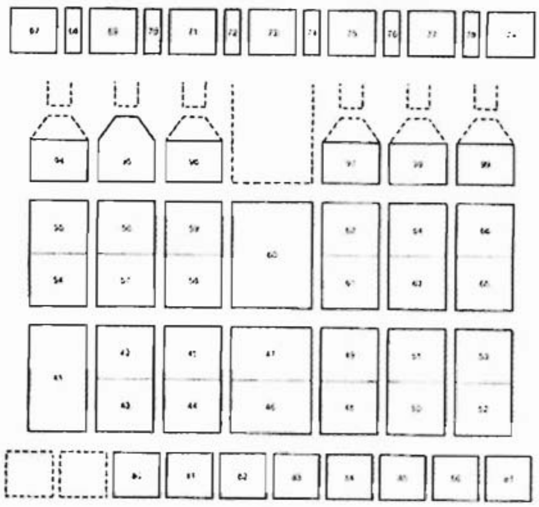
Works such as these were not simply aimed at telling a story, they also served the purpose of glorifying the powerful and creating legends. For this reason, the temporal sequence is preserved in the macrostructure of the whole, but not in the microstructure of the various components. Different positions in time can be switched and temporal paths can cross, so that the story is at places atemporal despite a general chronology governing the whole. A work such as the Colonna Traiana could be enjoyed and understood by it viewers primarily because they already had knowledge of the episodes that were described. These Roman observers were looking at an illustration of a story with a predefined temporal order in their memories. The figure of the emperor acts as the pivotal character. The different scenes revolve around his figure, which also serves the function of temporal unit of measurement. The presence of the emperor determines the "historical" succession of the episodes, which does not necesseraly agree with the true succession in natural time. In this sense, the rhythm of time on the Colonna ***Traiana*** agrees with the rhythm of time of the Roman society, which revolved around the feats of the emperor, his campaigns and military conquests, and his political decisions.



7.11. ***Scheme** of **the eastern side of the Traian column: repetition** of **the figure of the emperor. In R. Brillant (1984). Visual narratives story telling in Etruscan and Roman art, Cornell University Press, New York. (Reprinted with permission)***

The treatment of the temporal dimension does not change in the great pictorial cycles of the Christian tradition. In these works, the figure of the hero or of the emperor is simply substituted by that of Christ or a saint. The Western Christian tradition promoted images in large part as teaching devices to be offered to the illiterate masses that were conforming in increasing numbers to Christianity. By looking at the images, one could learn about the episodes of the Sacred History and recognize in them the symbolic meaning defining the "right way" toward eternal life. Cycles devoted the Old and New Testaments, to the life of Mary, to the passion of Christ, and to the saints and the martyrs of the Christian tradition enjoyed widespread diffusion and success for several centuries.

Especially precious for its high artistic quality is the example provided by the cycle of the passion of Christ, painted on the back side of the table of the Maesta in the Duomo of Siena by Duccio di Buoninsegna (1308–1311, see Figure 7.12b). The cycle is a collection of scenes telling a story of great significance to the Christian world, with strong symbolic value. In the statute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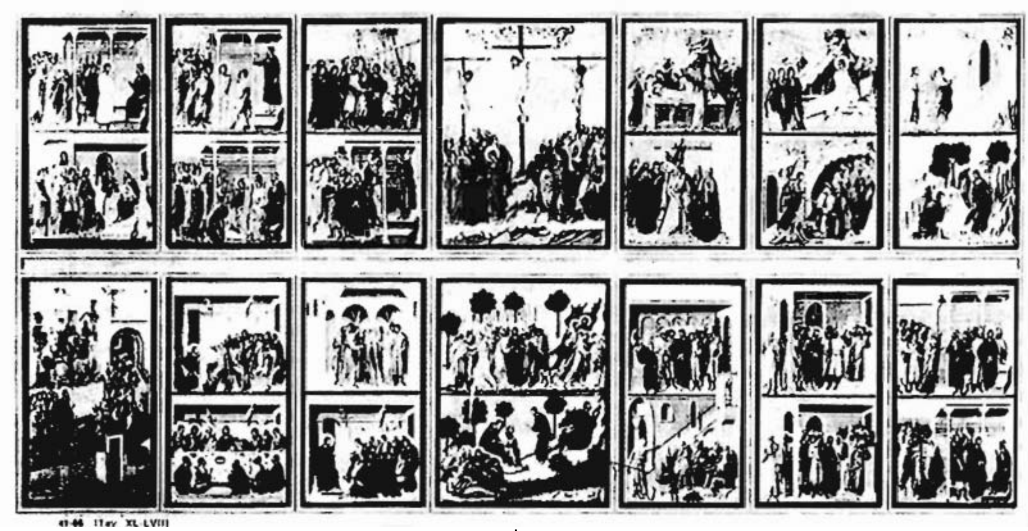

b

7.12. ***Maestri by Duccio di Boninsegna, 14th century, "Ciclo della Passione di Cristo." In (a) the scenes are numbered according to the temporal order. From G. Cattaneo (Ed), L'opera completa di Duccio (Milano, Rizzoli 1973).***

of Senese painters (1335), we read: "We are, through God's grace, those who illustrate to the low, illiterate people the miracles performed by the virtues of the sacred faith" (16). The tables are meant to be read from bottom to top and from left to right, but with two inversions: the temporal sequence of panels 42-43 and 56–57 is form top to bottom (see Figure 7.12a).

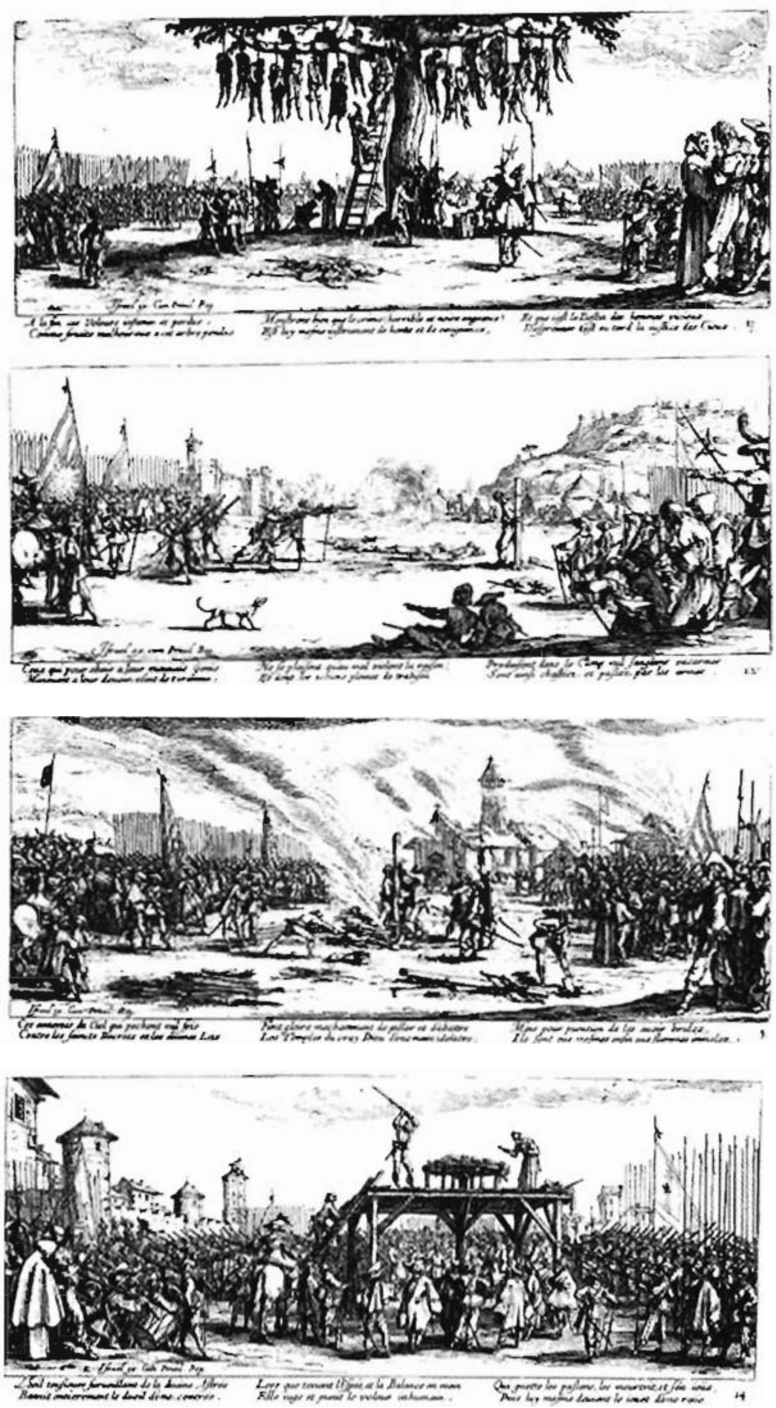
Although the figure of Christ connects and links all the images, one would not be able to reconstruct their temporal order or their meaning. The presence of Christ in all the scenes guarantees that even those who do not know the story would guess that the episodes are connnected, but the critical events of the episodes are intellegible only to those who already know the story. Different scenes do not have the strong links provided by the combination of persistence and variation that one finds in the tables by Pratt (Figure 7.9). Duccio's work is not a true narration through images, but simply a set of images meant to illustrate a narration.

Interestingly, the rule for mounting the images on the panel does not follow the convention that we follow today. We read text and images from left to right and from the top to the bottom. With the passage of time, this cultural convention has become a rule not to be disregarded.

After the Renaissance, and especially in the 17th and 18th centuries, scenes of secular life began to be become more and more usual. The culture of the Enlightenment attempted to transfer education and morals from the powers of the church and the monarchy to those of nature and society. In this cultural climate, the principles of nature and society are conceived as intrinsically good and just. Those who go against them were, and are, destined to be punished with methods that are intrinsic to nature and society. This idea, which sometimes generated a moralistic stance, in other cases spurred art that was inspired by great sincerity and moral rigor. Two interesting examples are Callot's series titled The Misery and Disasters of War and Hogarth's illustrated stories, A Harlot's Progress and A Rake's Progress. I find them to be of great interest not only for their high artistic level, but also for their original treatment of the temporal dimension. In the work of Callot, there is only one time; the present, and this present is dramatic in that it cannot go away. In that of Hogarth, instead, time is continuously, inexorably moving toward a final catastrophe. Hogart's time is dramatic because it annihilates permanence, and therefore any temporary impression of happiness.

In 1633, Callot produced 18 etchings depicting different episodes of the Thirty Years War (four are reproduced in Figure 7.13). All of them present episodes that are far from glorious. Despite the poems written under each of them, which glorify military valor, and despite the fact that the brutality is attributed to the enemy, Callot's images are a dramatic denounciation of the violence and the drama of war. There is no protagonist or plot to link the scene in a temporal sequence. Except for the first and last etchings, which act as an introduction and conclusion by presenting a frontispice and an image of the general prizing virtue and banishing vice, all the other images can be put in any sequence or conceived as happening simultaneously. This is a time without time, a depiction of present events that could happen anywhere. This is the endless present of all wars.

In the six tables of A Harlot's Progress, Hogarth illustrated the story of a prostitute that eventually dies because of venereal disease. In the eight tables of A Rake's Progress, he set forth the adventures and misfortunes of a libertine that eventually becomes mad and dies (Figure 7.14). Hogarth's



***7.13.** Callot, four scenes from The Miseries of War. In Daniel H., Callot's Etchings, Dover 1974. (Reprinted with permission)*

morals are more secular than religious. Thus, his punishments come from society and nature, not from the heavens (17).In opposition to Callot's use of time, the temporal sequence of Hogarth's table is necessary and anchored to the presence of recognizable protagonist. The central figure here is no longer the measure of the temporal grouping of events as in the Roman series, however; instead, the protagonist is the victim of time, the

7.14. ***Hogarth, two tables from A Rake's Progress. Shesgreen S., Engravings by Hogarth, Dover 1973. (Reprinted with permission)***

object of events that happen in time. In the cycles of Hogarth, time is catastrophic, accelarating as if it followed a parabolic law, and doomed to end in tragedy.

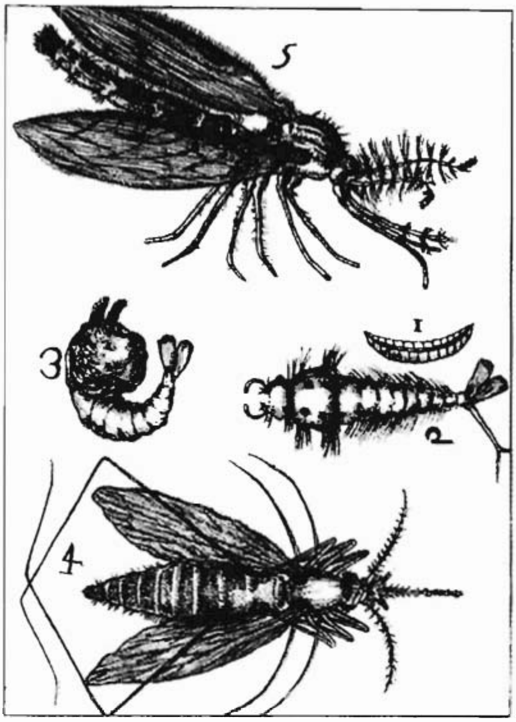
In the work of both Callot and Hogarth, lines of text accompany each table. These words have the function of providing additional information about the connections between the episodes in each image. The authors are forced to include this nonpictorial information because the images, even if stylistically connected, illustrate only the most important episodes of a larger narration. If the narration were omitted, the connection between the images would be weakened or lost. Hogarth and Callot were not aware of the perceptual constraints governing the linking of successive images. To see the sequence as interconnected and consequential, the temporal interval between successive images must be small. In the 1870–1890s, the revolutionary experiences of the chronophotographers Muybridge and Marey made illustrators aware of this, and after this discovery, words were no longer necessary to fill temporal gaps between consecutive images.

Representing Scientific Events

The invention of the microscope brought about new curiousity and enforced a new way of looking at nature. The Aristotelian view, based on the assumption of a perfect harmony between nature and perception, disegregated gradually, and scientists began to attend to all aspects of nature analytically and selectively. A good example of the process is provided by the old theory of spontaneous germination for insects. Nobody could rightly claim that insects are born from parents because nobody had seen eggs inside a mother insect. With the microscope, awestruck 17th-century naturalists discovered an unexpected world, full of metamorphic beings that could alter their aspect in radical ways, sometimes even under observation, and often more than once before they reached maturity. The surprise of these naturalists is well expressed by Henry Baker (1753), who first observed an amoeba under a microscope. He described his discovery with the following passionate words: "None of the many different Animalcules I have yet examined by the Microscope, has ever afforded me half the Pleasure, Perplexity, and Surprise, as that I am going to describe at present." Baker could not believe that the same animal could take on so many different shapes. "Whose Ability of assuming different Shapes, and those so little resembling one another, that nobody (without actually seeing its Transformation performed under the Eye) would believe it to be the same Creature" (18).

A viewer's surprise is even bigger when wholly unpredictable and unexpected worlds are found in a reality close to us, part of our daily routines and far from any exotic destination. New optical instruments revealed a new world that awaited exploration and description. In opposition to the New World recently discovered on the other side of the ocean, the world discovered through the microscope was not far than one's home and body. The transformation and the marvellous chain of events that one witnessed through the microscope required a tool suitable to communicate them to the larger public. The many medieval collections of animal figures, the *Bestiari* (19), did not fit the bill. As classifications, they lacked systematicness; as natural descriptions, they mixed known animals with mythological beasts and monsters based on tales from the distant lands across the ocean. Their depictions consisted of prototypes with little attention to their ontogenesis or locomotion. The new discoveries on the birth and development of insects and parasites highlighted the critical role of the temporal dimension in the study of life forms. The fact that the same organism could change the shape of its body several times before reaching adulthood required a new graphic solution. The same image needed to represent the identity of the depicted organism while representing the diversity of its manifestations. The early solution was to draw on the same page the different images of the organism, without separations between them, and adding numerical labels (Figure *5.35).*

The drawing thus became a place where the same entity was shown at different times of its existence, creating a diachronic synchronicity. Because the temporal sequence was represented by the numbers rather than an ordered spatial arrangement, viewers had to reconstruct the sequence at



7.15. ***Pietro Paolo da Sangallo, 1675, The Developmental Cycle*** of ***the Mosquito. In G. Penso,*** La conquista del mondo invisibile, ***1973, Milano, Feltrinelli.***

a cognitive level. The idea of mapping time onto a spatial ordering of the images came much later.

Thus, the true connection between the images was the text, even more so than in the moralistic tales of Hogarth. Among the many produced in the period, a nice example is a letter dated 1675 and written by Pietro Paolo da Sangallo to describe to his teacher, the naturalist Redi, the developmental cycle of the mosquito. The letter contains an illustration of great naturalistic precision (Figure 7.15), used as evidence for the claims set forth in the text. As a scientist, Sangallo lacked a specialistic terminology to describe the new facts he was observing. He had to come to terms with the approximations of common language, and he did so by referrring to the illustrations that thus became the necessary condition for clear and accurate communication.

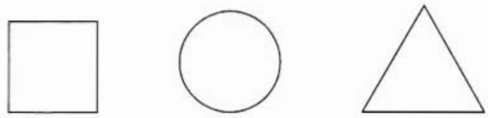
In concluding this section, I would like to describe one example that represents the anticipation of later developments. Between 1773 and 1774, Miiller worked at the first systematic classification of infusoria. Among them was the amoeba, which had elicited so much suprise and awe in Baker. Miiller devoted an illustration to Proteus *mutabilis*, as he called the amoeba, and it is especially interesting from the standpoint of this discussion (see Figure 7.16). Morphological transformations happening at a very fast pace and in a seemingly random order are not frequent in nature. The amoeba is indeed a unique case, and to describe it, Miiller created a sequence of images that is almost cinematographic in character, juxtaposing states very close to each other in time and arranging them from left to right and top to bottom. The sequence is one of the early examples of a narration through images, a story entirely told by visual means and understandable without any verbal "glue" to connect its various moments.

7.16. F. Miller, 1786, Proteus mutabilis (amoeba). In La conquista del mondo invisibile, by G. Penso, 1973. Milano: Feltrinelli.

The Distance Between Images in a Sequence:

As described in the previous section, in several early works the text that accompanied the sequence of images played an important role in organizing them in time. This was true of the Colonna *Traiana*, of the passion of Christ by Duccio, and in Sangallo's illustration of the developmental stages of the mosquito. Pratt's comic strip sequence of Figure 7.9, on the other hand, is readily organized in time without the help of verbal material. What makes the difference? The first factor is the width of the temporal range of the events. The passion of Christ takes several days. The deeds of Hogart's libertine begin when the protagonist is a young man and continue until his death. The developmental cycle of an insect takes several days, sometimes even months. The action depicted by Hugo Pratt, in contrast, takes only a few minutes, or perhaps even less. The information Pratt provided in those images allows us to perceive an action spanning a very short temporal interval. As all readers of comic strips know, our perceptual system readily understands if two sequential images are temporally separated views of the same event, or if they are simply two different, unconnected events.

Perhaps we possess a cognitive ability to represent the properties of the actions people can perform and of the transformations that objects can undergo. If these schemes include information about duration, some top-down process could provide temporal coordinates when activated by the expressive or the semantic properties of the images. In this top-down process, information present in memory integrates the information provided by the



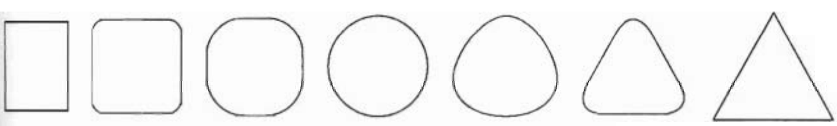
7.17. ***Three independent figures.***

pictures. Therefore, a crucial role in this hypothesis is played by the semantic components of the figures. In other words, the process requires that the images represent things, people, animals, or objects that we know.

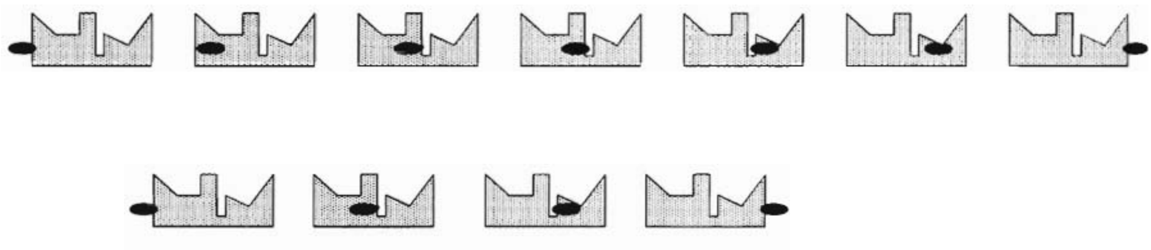
There is also another possibility, however. Perhaps the process takes place at a lower level and without a contribution from previous experience. In this alternative process, the critical role is played by the structure of the images, and therefore from the trade-off of permanences and variations between successive images, independently from their possible meanings. In support of this latter hypothesis, I will discuss here two lines of evidence. The first is that it is relatively simple to create sequences of abstract, meaningless images and yet produce the impression of temporal sequencing; the second is that people agree on how to order a sequence of abstract images even if these are presented in a random order.

Consider first the three patterns of Figure 7.17. No observer would experience a formal connection between them, at least not in the sense of experiencing the second as a derivation of the first, and the third as a derivation of the second. Nonetheless, it suffices to add two more figures between the square and the circle to induce the experience of a square transforming into a circle. I have done this in Figure 7.18. Note that the two additional figures progressively reduce the square character of the figure and increase the circle character. When we look at the left side of Figure 7.18, we see a square. In the next shape, we can still see a square, presumably the same square as before, but we also see some change at the corners that have become slightly rounded. Further to the right we see a compromise between a square and circle. Finally, circularity is the main characteristic at the center of Figure 7.18. In the same way, at the right side of the figure, I have created the experience of a metamorphosis from a circle into a triangle.

The trade-off between persistence and transformation seems to stimulate a process that may be called cognitive ***drag.*** Information acquired during the observation of the first image is dragged onto the second and integrated with it. If there is a sufficient amount of persistence, then the second image is not seen as a new object, but as a representation of the first one after some transformation. Cognitive drag provides an economic mode of processing information, presumably based on the capacity and the mechanisms of working memory (20). An immediate consequence of the cognitive drag hypothesis is that if one enriched the sequence by adding even more intermediate figures, then the experience of a continuous transformation would be even stronger and coercive. The more minimal the interimage transformation, the more continuous the sequence. It is as if our cognitive system were forced to assume that in a short interval, only minimal transformations can occur. Thus, the amount of change between two successive images is



7.18. A square turning into a circle and then turning into a triangle.



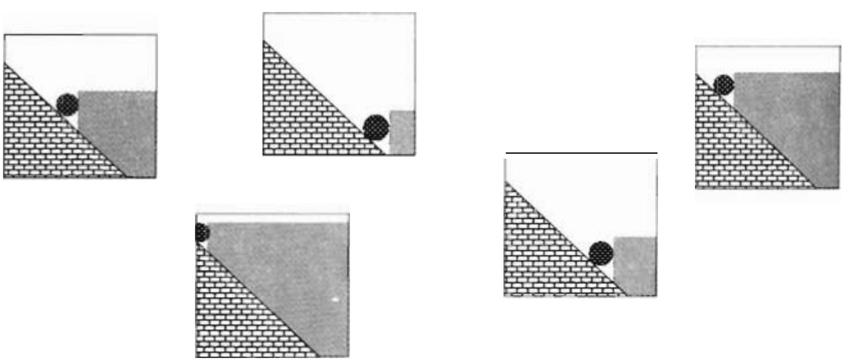
7.19. The changes depicted in the sequence of seven figures (top) are the same as those depicted in the sequence of four figures (bottom).

interpreted as information about the temporal distance between the depicted scenes.

In an unpublished experiment, I presented viewers with sequences of figures containing transformations or displacements of simple geometric shapes. The same amount of change was presented either in seven or in four-image strips (see Figure 7.19). The task of participants was to estimate, on a nine-step scale, the velocity of the event. In principle, there are two assumptions that one could make to reach a judgment of velocity with these materials. The first is to assume that the temporal distance between the images remains constant, independent of what is shown in the images. Under this assumption, one would have to report that the two transformations take different amounts of time. But the two sequences depict the same amount of spatial change. Therefore, one would have to perceive the longer sequence as a slower event. The second possibility is to assume that the overall duration of the sequences remains constant. Under this second assumption, the temporal distance between the images should change between the sequences. The results of the experiment unequivocally favor the first assumption. The transformations presented in seven-image sequences appeared slower to participants (lasting 34.54 seconds) than those presented in four-image sequences (23.46 seconds). The difference was statistically significant. Therefore, it seems that the perceptual system assumes constant temporal distances between images. Metaphorically, one could say that we have an internal movie camera that records a fixed number of images per unit of time.

Suppose now that I gave you a set of images such as those of Figure 7.20, randomly laid out on a table. Can you order them so that they form a temporal sequence? The task directly addresses the problem of the visual perception of time. Seeing time is, in a nutshell, the ability to pick up the potential temporal ordering of a series of still pictures. For images such as those in Figure 7.20, the task is relatively easy. Once viewers order the images by scanning the sequence from left to right, they readily achieve the impression of an event evolving over time. It matters little what order

7.20. A random ordering of five figures in a sequence.



has been chosen; for instance, in Figure 7.21, one could choose to view the sequence from right to left or left to right. The necessary condition for reliable ordering is that the set of images contain a phenomenally continuous modification of the same structural characteristic. This modification must be neither too small nor too large. If the difference between the images is too small to be appreciated, as in Figure 7.22, we cannot establish a criterion for ordering them, and the flow of time cannot be perceived. If the difference is too large, as in Figure 7.23, we cannot find a criterion for linking the images, and therefore a temporal link also becomes impossible. The only solution in this case is to add verbal material to fill in the gaps between the images and to suggest connections explicitly.

Practical Exercises

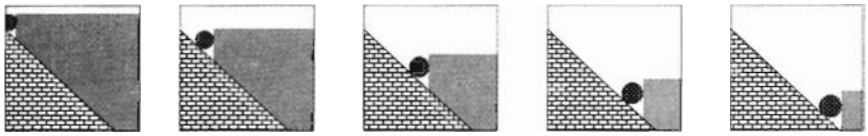
I now present two examples of image sequences that provide temporal information as practical exercises. These exercises can be solved in many different ways. I will offer some and leave the task of finding alternatives to the reader. My intention is to provide additional empirical foundations to my claim by appealing to the reader's direct experience.

First Exercise

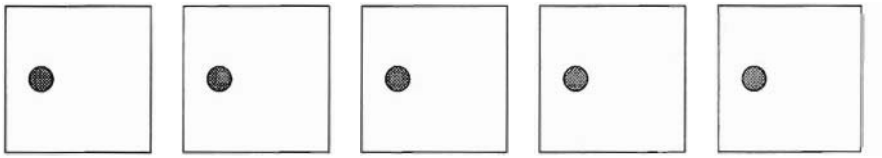
Take a simple form, arbitrarily drawn, and construct a sequence of five images, either showing a sequential transformation of the same form or showing different events. Some solutions, including possibilities already discussed, are the following:

1. Metamorphosis of a square into a circle (Figure 7.18)
2. Rotation during free fall (Figure 7.24)
3. Progressive opening of an angle (Figure 7.25)
4. Progressive increase in the size of a square (Figure 7.26)
5. Affine transformation of a square into a rhomboid (Figure 7.27)
6. Progressive erosion of a square (Figure 7.28)

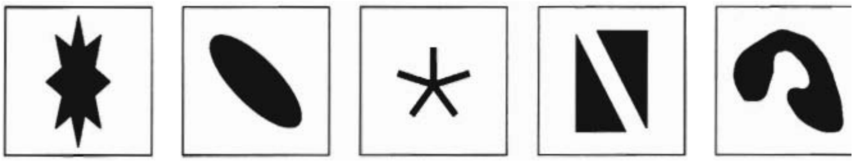
Each of the proposed solutions implies one of three possible cognitive outcomes. The first outcome is produced when the sequence contains local modifications of a shape that remains the same in some way. This is what happens in Figure 7.25, which is interpreted as an "opening" of an angle. The second outcome is produced when the transformation pertains to the whole shape. This is what happens in Figure 7.26, in which the modifications concern all the sides of the square. The perceptual interpretation is one of a progressive incremental increase in the size of the object, or of a looming event in which a square moves toward the observer without changing its dimensions. The third outcome is produced when a local transformation can be interpreted as involving an expressive component. In this case, the perception is not only of the "how much" and the "what" of the transformation, but also of the "how." In Figure 7.28, the sequence is interpreted as an erosion of the shape. Examples of this kind are consistent with the Gestalt notion of expressive qualities, mentioned in the previous chapter. According to the Gestaltists, perceptual objects do not possess only form, dimensions, and spatial position, but also expressive qualities, such has hardness or softness, sadness or joyfulness, attraction or repulsion. Arnheim (21) argued that these perceptual properties are conveyed by perceptual information, without the intervention of conscious thought or past experience.



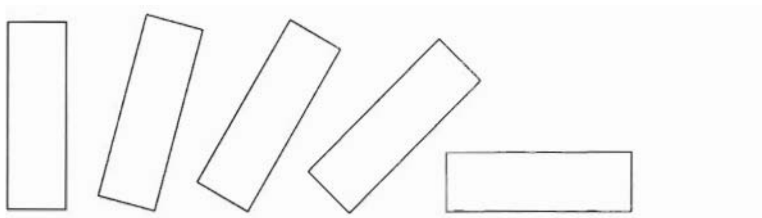
7.21. *The same figures as shown in 7.20 in the proper sequence.*



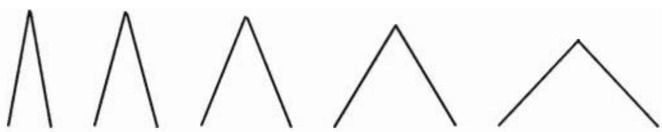
7.22. *A sequencein which the temporal flow cannot be seen.*



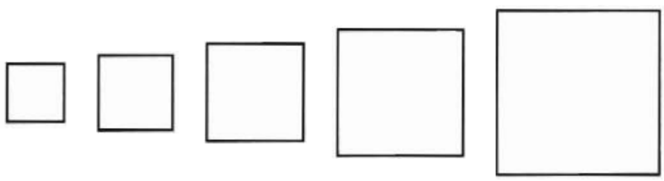
7.23. *Five figures that cannot be ordered in any specific way.*



7.24. **A** *sequence depicting a falling rectangle.*

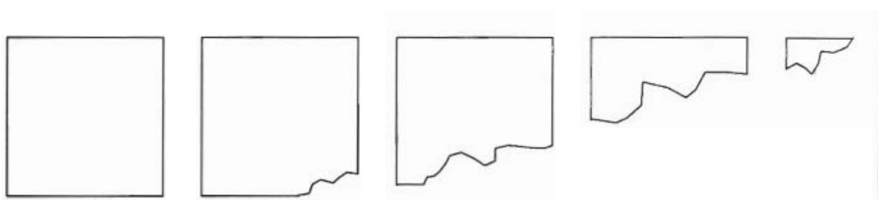


7.25. *Asequence depicting the progressive opening of an angle.*



7.26. *The progressive enlargement of a square.*

7.27. *Affine transformation of a square into a rhomboid.*



7.28. *Progressive erosion of a square.*

Second Exercise

Consider now a kind of event involving the relative linear displacement of two objects. The perceptual interpretation of the corresponding visual transformation is ambiguous, as I will exemplify below. Nonetheless, the corresponding perceptual interpretation is often unequivocal. This suggests that the intepretation is constrained by cognitive biases and assumptions. The effect of such biases is conditional on the presence of certain prerequisites, however, as the following exercise will clarify. Take two geometric patterns. Using these patterns, construct first some sequences that represent the displacement over time of one of them. Possible solutions may be divided based on the initial spatial relationship between the two patterns.

1. *Enclosure*

If the two figures have different dimensions and one contains or encloses the other (see Figure 7.29), one tends to see motion in the enclosed figure. This interpretation is only one of infinite possible alternatives, corresponding to different ways of partitioning the relative motion of the two figures. One could see motion of the enclosed figure relative to a stationary enclosing figure, or motion of the enclosing figure relative to a stationary enclosed one, or motion of both decomposed in any way one wishes. Yet the perceptual system is strongly biased toward an interpretation that assumes stability of the enclosing figure and motion of the enclosed one. This bias is strongly reminiscent of a phenomenon known as ***induced movement.*** Duncker (22) showed that if a small circle is presented inside a larger frame and both are showed in an otherwise featureless field, when the frame is moved at slow speeds, one sees motion of the surrounded circle while the frame appears stationary. In the absence of more information, the system takes the larger figure as a stationary frame of reference for the motion of the smaller figure.

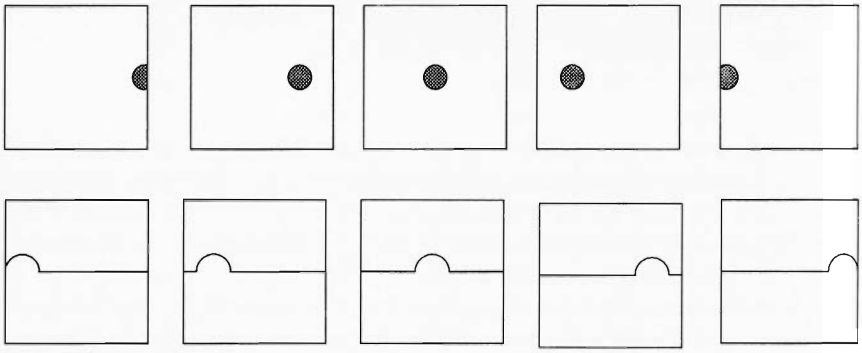
2. *Different positions without enclosure*

If two patterns having identical shape and size are displaced horizontally (Figure 7.30) or vertically (Figure 7.31) in opposite directions, two possible perceptual interpretations can take place: either one perceives one of the patterns as moving and the other as stationary, or one sees both moving in opposition. Contrary to the previous example, in this case there is no difference between the patterns that exchange positions. Therefore, neither tends to become a frame of reference for the other, and when scanning the sequences of Figures 7.30 and 7.31 from left to right, one can see either square moving or both moving.

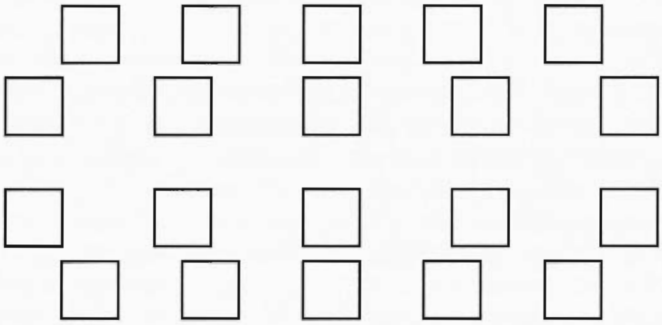
3. *Different structures without enclosure*

Suppose that two patterns are different in some structural property. Depending on the nature of this difference, one of the patterns may take the role of a stationary frame of reference for the motion of the other pattern. For instance, if the patterns have the same shape but different sizes, the larger one will typically be interpreted as the stationary one (Figure 7.32). I suspect also that, in general, patterns that are perceptually more stable in their expressive qualities (the square, for instance) tend to become the frame, whereas patterns that are less stable (the circle) tend to be interpreted as moving (Figure 7.33). The greater stability of the square may be explained by the fact that a square, when its sides are horizontal and vertical, appears as a structure that lies on the ground and therefore is more difficult to move.

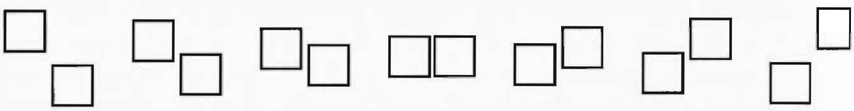
7.29. *The enclosed figure is interpreted as moving.*



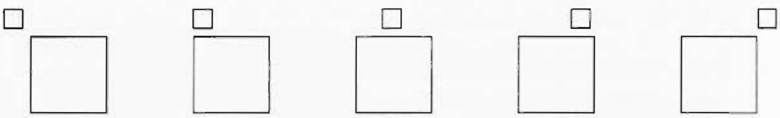
7.30. *A sequence of pairs of squares. In each, one square is displaced horizontally relative to the other.*



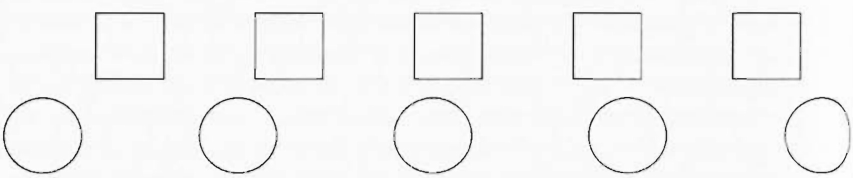
7.31. *The same sequence as in Figure 7.30 with vertical displacements.*

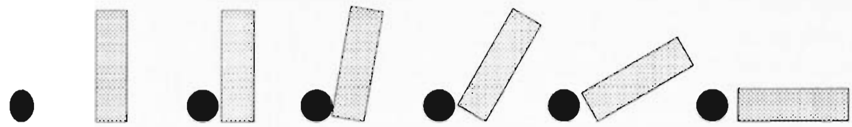


7.32. *In this sequence, the small square is interpreted as the moving element.*



7.33. *In this sequence, the circle is, interpreted as the moving element.*





7.34. *Pairs of shapes establishing causal relationships.*

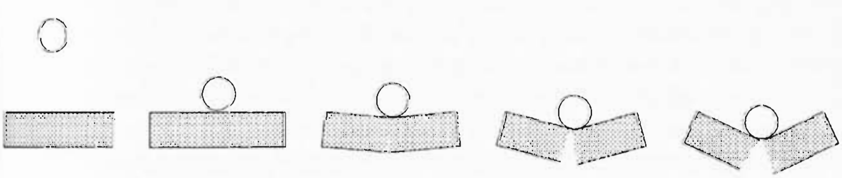
TIME AS CAUSE IN IMAGE SEQUENCES

Consider different versions shown in Figure 7.34. At far left, I have drawn a circle and a vertically oriented rectangle. Next to it, I have placed the circle much closer to the rectangle. In the next image, the circle and the rectangle are tangential to each other, and the rectangle has been subjected to a 5° rotation relative to the vertical. Next, the rectangle has been subjected to 15' rotation. When looking at this sequence of images, one spontaneously perceives a circular object that, rolling on the ground, comes close to a rectangle, hits it, alters its balance, and makes it topple. What one perceives is, in other words, a relationship of cause and effect that evolves over time. The two protagonists of the event take on different expressive roles, one active and the other passive.

Michotte and the Phenomenal Causality

Historically, psychology provided a fundamental contribution to the study of causality perception through the contributions of Belgian psychologist Michotte (23). By investigating the stimulus conditions that give rise to causality intepretations, he cames to the conclusion that physical motion is a necessary condition for the perception of causality. However, the study of graphics may provide evidence that this conclusion is too restrictive. Causality can be perceived in sequences of static images, even if there is no actual movement. Sequences such as those in Figures 7.34 and 7.35 can be experienced as depicting causal events, just as they are experienced as depicting motion. Thus, to the extent that experienced causality seems to depend on the potentiality to engender a motion interpretation, we may hypothesize that the necessary condition for causality is not physical motion, but experienced or phenomenal motion. If this hypothesis is correct, then even a single image may engender a causality intepretation, as long as it contains clues to a transformation that can be taken as evidence of a past cause having produced the present image of the object.

Motion is a necessary condition for objects and animate beings to come in contact and interact with each other. Static objects cannot come in contact with each other and therefore cannot cause mutual modifications. Thus, such modifications are consequences of events that necessarily entail movement. Depending on the characteristics of object movements in a scene, we may see events of different kinds. To see an event does not always mean to be able to report the kinematic transformations of objects relative to spatial coordinates. Often, events are perceived as meaningful changes, rich



7.35. *In this sequence, the circle falls down and breaks the rectangle.*

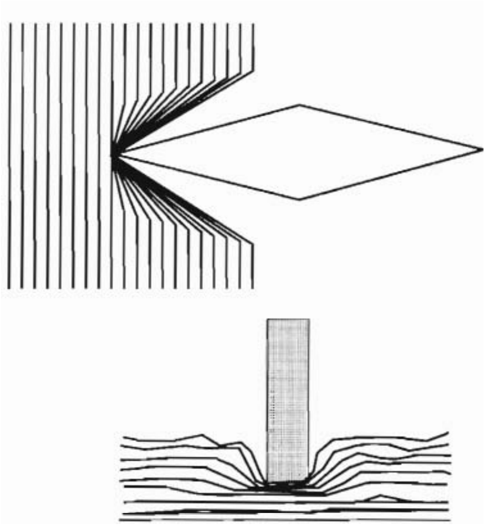
in expressive qualities that movements unveil. Michotte (24) demonstrated that coercive causal relationships can bc perceived even between abstract, unfamiliar forms. For instance, in a demonstration dubbed the "launching" effect, a black square and a red square were the protagonists of the following event. At the beginning, the black square approaches the red square, which does not move. As soon as the black square touches the red squarc, the latter begins to move, continuing along the same trajectory that the black square followed. The red square continues to move for some time and then stops. The event is spontaneously intepreted as a causal event, that is, the black square pushed or launched the red one. Michotte was impressed by the frequency of observer reports containing intentional and emotive descriptors, such as "the black squarc joins the red square, they have an argument, and the red square leaves on its own," "the black square chases the red square," or even "the black square visits the red square, and then they leave together. Reports such as these led Michotte to the conclusion that kinematic information is critical to the way we interpret the emotional states and the intentional actions of our conspecifics.

Whenever we witness movement, even consisting of interactions of simple geometric figures, we typically see the actors taking different and well-defined roles. These role include not only physical functions, such as active versus passive or subject versus object, but also their moral character, such as good versus evil, and their intentions, such as kind versus violent or submissive versus aggressive (2.5). The strong cognitive bias toward causal interpretations of events may be the reason early scientific explanations of causal relationships were often cast in terms of collisions, attractions, and pulls. These notions fundamentally influenced our understanding of causality (26). But we may also invert the chain of explanation and note that cognitive constraints on the perception of causality undermined early attempts at understanding physics. Early science worked under the assumption that reality coincided with its appearance, and its appearance, as demonstrated by psychologists, is spontaneously one of causal relationships. Not surprisingly, it took a long time to develop the physics of quantum mechanics, in which relationships of cause and effect are not respected.

Cause Without Motion

In the sequences discussed in the previous sections, the temporal dimension could be experienced through the series of images, but not in any of the single images. Instead, in a sequence depicting a causal exchange, even a single image may contain hints at its temporal position. Consider, for instance, the third image of the sequence in Figure 7.35. Most people readily interpret this scene as depicting a sphere that has broken an underlying surface. This interpretation entails seeing a broken surface, but also seeing that at a previous point in time, the surface was unbroken. Thus, the image shows not only the present state of affairs but also a previous situation. And this double awareness is doubly perceptual, not just a composite experience consisting of a visual experience coupled with a logical inference. The double percept of the "know" and the "before" necessarily implies time.

In collaboration with Paolo Bonaiuto (27), I have investigated a number of configurations that produce a spontaneous causality interpretation using abstract outline shapes. Additionally, we have been able to find a number of works by painters and drawers depicting causality relationships of different kinds. For instance, the two patterns of Figure 7.36 are perceived by most



7.36. ***Two representations of causal relationships: texture deformed by a diamond and texture deformed by a rectangle.***

observers as the outcome of a causal event that has taken place some time in the immediate past. In the upper figure, the rhomboid is seen as the agent responsible for deforming the texture of vertical lines. In the lower figure, the vertical rectangle weighs on the lines and squashes them.

Our analysis has demonstrated that it is not necessary to witness the full temporal unfolding of an event to have the impression of causality relationships, just as it is unnecessary to see a sequence of images to have an impression of temporal flow. In many cases, just by looking at the immediately visible, one can become aware of a "before" that consisted of a different state of affairs. In well-chosen conditions, it is sufficient to show effects (the consequences of an action) for observers to experience a causal event that those consequences have produced. For this to happen, it is not necessary that the causal event actually took place. We all know that the lines in Figure 7.36 have not been deformed by the other shape. They simply were drawn in that way by the illustrator. Nonetheless, the impression of causality is imposing, independent of what we know about the image. This is clearly one of the reasons why comic strips are so efficient and engaging in representing actions. In Figure 7.37, we immediately see that the Phantom is breaking through a door, but we know that the door simply was drawn in that way and that nobody has actually broken an object.

But what is the stimulus that determines the perception of causality in a static image? As I have noted in this chapter, the perception of causality in a single image seems rooted in a cognitive process that links the situation represented in an image to a previous state in a causal chain. Stated in this way, however, this is simply a redescription of the causal experience engendered by the image. Any state is part of a history that begins with some initial condition. Why should only some of these become integrated in the actual perception of the image as the "cause" for what one is witnessing? In our research, my colleagues and I have been able to demonstrate that the impression of causality tends to surface when a homogeneous structure contains some discontinuity in a limited part of the overall structure. Note that homogeneity does not imply regularity. One could see a discontinuity in an irregular part of an otherwise regular structure or in a regular part of an otherwise irregular structure. The discontinuity tends to be perceived as

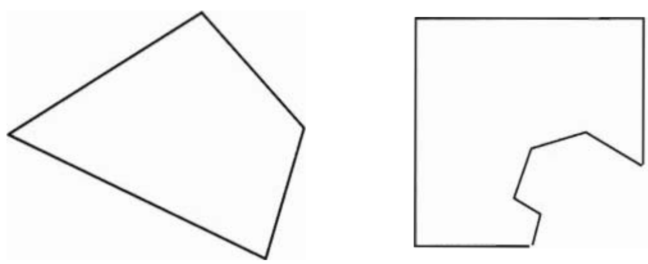
2.37. ***Another representation of causal relationships: "The Phantom" smashes a door.***

the consequence of a preceding event. This event has caused a permanent modification to the whole, but because the modification is partial, the whole is still recognizable.

Leyton's Theory

Leyton (28) observed that in many cases, part of the recent history of an object is visible in its shape. In these cases, perceivers see these shapes as the outcome of a process that has modified an initial state (usually more symmetrical and regular) to arrive at the present aspect of the object. The patterns depicted in Figure 7.38 serve as examples. Although I find Leyton's contribution original and fertile with theoretical and experimental implications, I also have the impression that his approach is limited by excessive rigidity. To substantiate my claim, I will first list the main components of Leyton's theory and then discuss some graphic counter-examples.

7.38. ***Two irregular shapes that are not consistent with Leyton's principles. (Author's modifications)***



Leyton's theory may be summarized by the following points:

The shape of an object tells us something about its history. The shape provides clues to the processes that caused it to appear the way it appears. "A shape is simply a single state, a frozen moment, a step outside the flow of time; and yet we are able to use this as a window into the past" (29).Shape is a source of information about time. Hence, "shape is time."

It is possible to recover the process that generated the shape only if this process leaves a "memory"; examples of such processes abound: scars on the surface of the moon, chips on vases, graffiti on subway trains, etc." **(30).**

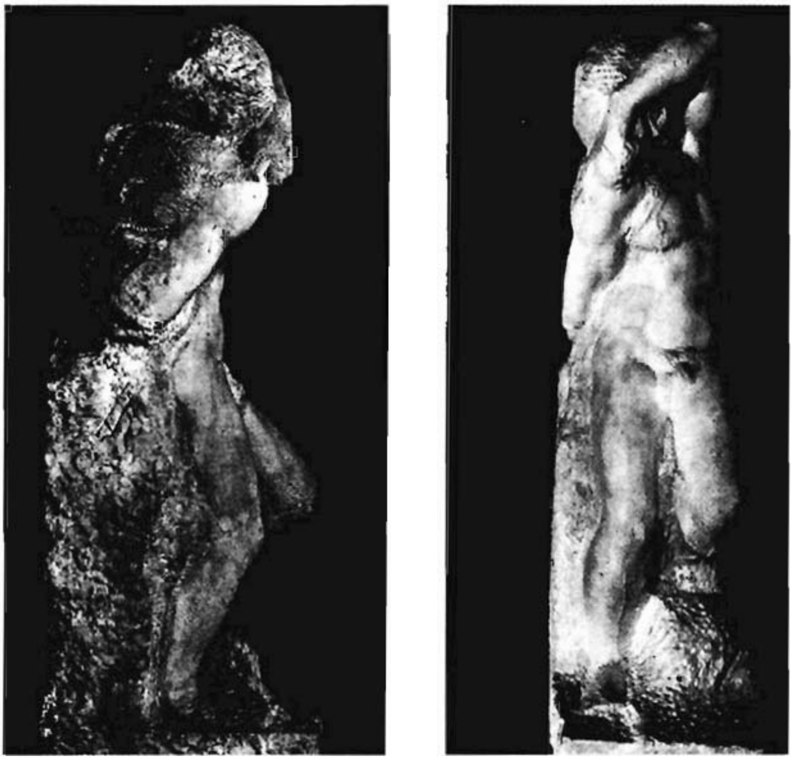
Most important, "a single ***abstract*** property characterizes ***all*** perceptual situations of memory: asymmetry is the memory that processes leave on objects." From this, it follows that: "symmetry is the absence of process-memory." Leyton calls these tenets the asymmetry and the symmetry principles **(31).**

"The asymmetry is a memory of the process that created the asymmetry.. **..** ***Asymmetry principle.*** An asymmetry in the present is understood as having originated from a past symmetry" (32)."A symmetry in the present is not a memory of anything other than itself." ***Symmetry principle.*** A symmetry in the present is understood as having always existed **(33).**

From the two principles, it follows that a "process moves from symmetry to asymmetry but not vice versa" (34).

Thus, Leyton suggests that breaking symmetry is the fundamental vehicle lor conveying temporal information through images. This claim, however, appears to need revising. First, in Leyton's symmetry principle, all kinds of asymmetry are equally efficient as clues to the history of the object. This clearly is not the case. The pattern at left Figure 7.38, for instance, should appear as the deformation of a strongly symmetrical quadrilateral but does not, whereas it does appear so at right, which is equally asymmetrical but is easily perceived as a square with a part previously cut out. This suggests that asymmetry is not sufficient nor is it necessary for conveying the impression of an object's past. In my opinion, the weakness of Leyton's symmetry principle is its emphasis on symmetry as an absolute stimulus property. The phenomena under consideration are relational in nature. Most likely, we need a relational stimulus property to account for them. If I am correct, then the critical feature is not asymmetry per se, but the fact that the asymmetry is a discontinuity relative to an otherwise symmetrical structure. More generally, one could speak of a trade-off between regularity and irregularity in the comparison between local parts of a pattern and its global structure. This approach demands that our phenomenon should be possible also in a globally asymmetrical structure possessing a local symmetry. In this case, the discontinuity should be interpreted as due to a process that created order. Consider collecting pebbles on the beach. The shapes that are most attractive are the regular, well-formed ones. They are the discontinuity in a globally irregular set. Their regularity opens up a window on an irregular past. We have a similar experience when we perform the useful exercise that Leonardo Da Vinci recommended to all painters: looking at the clouds to discern in them shapes of actual objects. Lucretius, well before

7.39. *Michelangelo Buonarroti, Slaves. The bodies appear to emerge from amorphous matter. In F. Hartt, Michelangelo, la scultura, Garzanti 1972. By concession of N. Abrams, Inc., New York.*

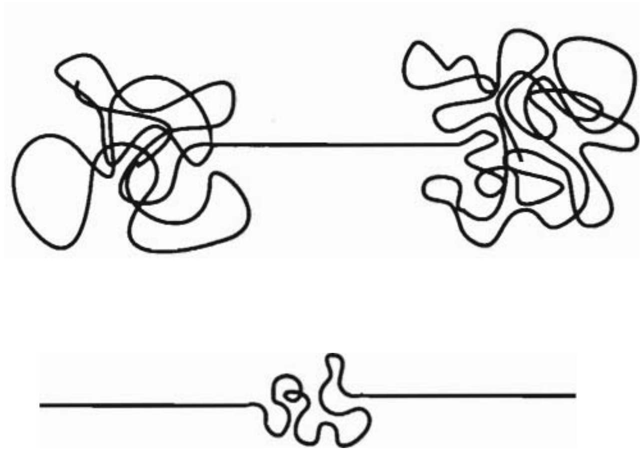


Leonardo, described the experience in this way (35):

ut nubes facile interdum concrescere in alto
cernimus et mundi speciem uiolare serenam,
aera mulcentes motu; nam saepe Gigantum
ora uolare videntur et umbram ducere late,
interdum magni montes avolsaque saxa
montibus anteire et solem succedere praeter,
inde alios trahere atque inducere belua nimbos,
nec speciem mutare suam liquentia cessant
et cuiusque modi formarum uertere in oras
(Lucretius, *De rerum natura*, IV, *vv. 131–140)*

The temporary regularity of the clouds bears signs of a process that began as an irregular one and evolved into regularity and symmetry over time. Yet another case of regularity informing the viewer about past irregularity are the sculptures that Michelangelo Buonarroti left unfinished, creating an effect of human shapes emerging from shapeless matter (Figure 7.39).

Our perceptual system is equipped to register events as they unfold, but also to detect the signs of past events through observation of the shapes of things. Our relationship with outside reality is ambivalent. On one hand, we have a clear experience of permanence; everything is out there and always has been. On the other hand, everything is also continuously mutable, in the sense that what we see here and now appears as the result of a long chains of causal events, which eventually led to the present observable state. Leyton claimed that the critical information in conveying the sense of past



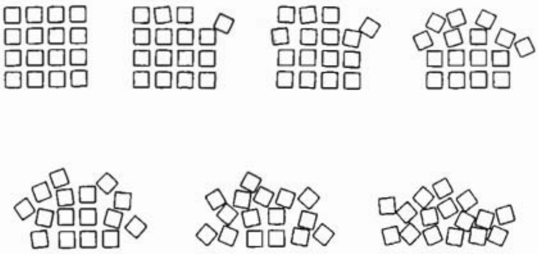
7.40. ***Two examples that are not consistent with Leyton's theory: top, an action has regularized a globally irregular structure; bottom, an action has caused a globally regular structure to become irregular.***

causes is the rupture of symmetry. In the position defended here, the critical information is more general and is conveyed by a dishomogeneity in the characteristics of a part relative to a whole. For instance, the top of Figure 7.40 is interpreted as depicting the consequence of an event that partially straightened a figure that was previously jumbled and asymmetrical and that therefore was previously even more asymmetrical than it is presently. The bottom of Figure 7.40, conversely, appears as the consequence of an event that has deformed a pattern that was previously symmetrical.

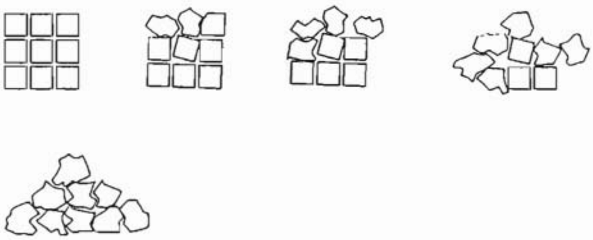
TIME IN PSYCHOLOGY AND GRAPHICS

When we want to define the temporal coordinates of the objects around us, we are capable of using a wide range of adjectives with a good degree of precision. What kind of information is used to decide which adjectives are appropriate? And how do we pick it up and process it? We do not possess a sensory organ specifically devoted to the perception of time, and there is no specific energetic medium that carries only temporal information. Yet time is so pervasive in human experience that almost any sensory stimulation inevitably conveys some kind of temporal information. Thus, when we say that something is young, old, new, ancient, recent, contemporary, past, secondhand, restored, transformed, renewed, redone, destroyed, decaying, refurbished, decrepit, and so on, we are in fact producing judgments that pertain to the temporal dimension of that thing. One could ask, therefore, what are the visual cues that form the basis for such judgments about the temporal position of things? Such users must be mediated by other sensory modalities, and in particular by vision. To isolate some potential visual cues for time, my colleagues and I **(36)** asked observers to order a set of randomly presented images temporally. The spatial structure of these images was varied under the hypothesis that the arrow of time proceeds from ordered to disordered states of matter (the physical concept of entropy).

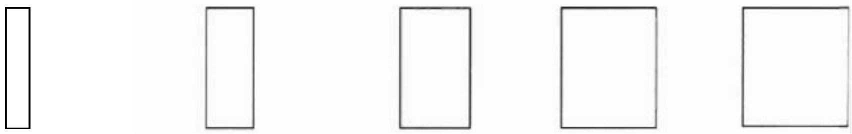
Positive entropy processes proceed always from order to disorder. For this reason, it is natural to hypothesize that the signs time leaves on objects should be intrinsically disordered and random. Preliminary observation of different patterns easily confirms that, when we notice disordered features in an otherwise regular structure, we tend to interpret the amount of disorder as a measure of time. The reason for the tendency to disorder stems directly from the overall structure of the universe: "To the extent that chance is operating,



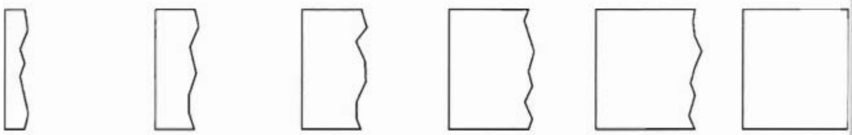
7.41. *A sequenceof the order–disorder polarity.*



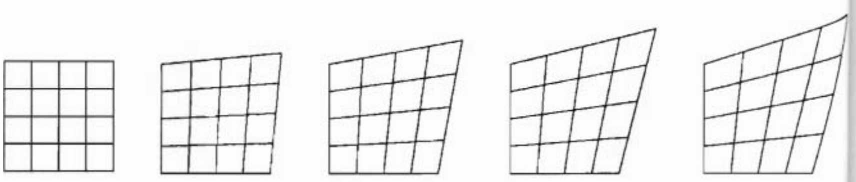
7.42. *A sequence of the regeneration–destruction polarity.*



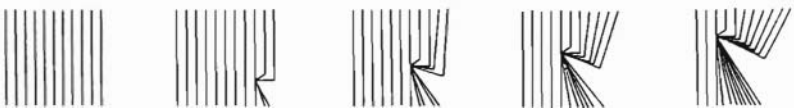
7.43. *A sequence of the growth–reduction polarity.*



7.44. *Regenerative growth-destructive reduction.*



7.45. *A sequence of the formation–deformation polarity.*



7.46. *A sequence of the action/reaction polarity.*

it is likely that a closed system that has some order will move toward disorder, which offers so many more possibilities" (37). Thus, there is a much higher chance for an older object to have been subjected to accidental interactions with other objects, leaving disordered signs on its parts. Perhaps it is not too daring to hypothesize that our cognitive system developed during our phylogenesis to use certain features of disorder as information concerning time.

According to these ideas, we conducted an experiment in which the stimulus materials consisted of several series of paper pictures, each representing progressive modifications of simple shapes such as a square. Sequences were divided in six different groups according to the type of modification applied. Modifications in turn were labeled in accordance with the direction of the possible ordering of the sequence, defined by pairs of polarities. The directions were the following: order ↔ disorder (Figure 7.41), regeneration ↔ destruction (Figure 7.42), growth ↔ reduction (Figure 7.43), regenerative growth ↔ destructive reduction (Figure 7.44), formation ↔ deformation (Figure 7.45), action ↔ reaction (Figure 7.46). The double arrow is meant to signify that the ordering of the sequence can be performed starting from either polarity. The subjects were presented with the pictures of any series in a random disposition. The subjects' task was to order in a sequence each series of pictures, taking into account the temporal sequence. Observers could fulfill the task by starting with the "grown" figure and step back to the "reduced" **figure** or vice versa.

From a purely logical viewpoint, all series of images could have been ordered sequentially in either direction. Our hypothesis, however, was that one of the directions would have been used more readily. If this were true,

***7.47.* Breugel the Eldest, Triumph of Time, 1574. In Vizi, virtù e follia nell'opera grafica di Breugel il Vecchio, by G. Vallesio (Ed.), 1979, Milano: Mazzotta Editore.**

7.48. De Vries, Rovina, 1600. In Brion ed. Quattro secoli di surrealismo, Milano Libri, 1973.

then the kind of direction that is preferred may provide clues to our biases in interpreting images as bearing the sign of a temporal transformation. Our results have demonstrated that for some sequences, statistically more observers chose a single ordering direction. This was toward disorder, destruction, or deformation for Figures 7.43, 7.45, and 7.46 and toward growth for Figures 7.43 and 7.44. A possible interpretation of these results is that temporal sequencing is in accord with entropy, but that we also assume that some processes can have negative entropy. Some negative entropy processes can indeed occur in nature; the birth and growth of animals and plants are an example. The stimulus feature that seems to be related to this choice are more localized breaks of order in the image and a stable rate of change along the sequence (see figures).

On the basis of the present evidence, the hypothesis that the interpretation of visual signs as temporal cues is based on an entropy assumption remains a speculation. In conclusion to my discussion, 1 want to go back an initial topic in this chapter, the allegorical representation of time. Old Man Time, in many of his depictions, is surrounded by representations of the destructive effects power (Figure 7.47, Figure 7.48). These effects include disorder, destruction, falls, and breakage of objects, even those that are dear and precious. Interestingly, these are the same figural aspects that have been examined by our experiment described above. In the history of art, a related finding can be mentioned in the domain of expressive choices. As is widely known, Romantic gardens were always peppered with false ruins. The Romantic soul, while recovering the heroism of its past, wanted also to mourn its loss. A ruin, even if fake or perhaps precisely because it was offered a perfect way to serve this double function—hence, the many Romantic representations of castles, temples, and cathedrals, wrecked and half destroyed, witnessing of their veritable antiquity. In short, even if the experimental evidence is still scant, we can find evidence to support our hypothesis in an additional set of data provided by Romantic architects and those who enjoyed their work.