If any monument of art be an invitation to the past, an interior like the intarsia study of Federigo da Montefeltro, installed in the Museum in 1941, has this appeal in an eminent degree. Sculptures have pedestals, paintings frames, leading from our everyday world to that of illusion; but here the illusion is complete, the visitor wholly enters the past. When we have accustomed ourselves to the spell of the warm, golden-brown dusk, the walls begin to speak. A graceful architectural setting becomes visible, its pillars framing cupboards with benches projecting beneath, all filled with books, musical and scientific instruments, armory, and library tools in pleasant order and variety. The illusion of depth is so great that we must make an effort to convince ourselves that we face two-dimensional pictures in inlay.

Was this little room a real study, a workroom for the learned Duke? Fill it in your imagination with the customary appliances of a private library of that time and you will see how the charm of the imagery upon the walls would be destroyed by any competition with
Fig. 1. Cittern with a pair of dividers and an hourglass. In the cupboard in Section 9 of the study.

Fig. 2. Cittern in inlay by Fra Giovanni da Verona. From the choir stalls in Monte Oliveto in Siena.

Fig. 3. Detail of a Madonna and Child by Cosimo Tura in the National Gallery in London.

Fig. 4. Angels playing citterns, detail from the pulpit by Lucca della Robbia in the Cathedral of Florence.
actual objects. The Duke, we must suppose, had better taste. Besides, the balance of the decorative display, unbroken as it is, would only be disturbed by any outside intrusion. What then is the idea of this room? It is a witty play with the exciting new technique of strict linear perspective. It is also a homage to the Duke, with his various interests and activities. Finally, it is a mirror of the rich intellectual life at the court of which he was not merely the illustrious head but also the stirring heart.

Libraries have been written on Federigo da Montefeltro. His contemporaries called him the light of Italy. Statesman, warrior, scholar, and connoisseur in the arts, he stands out even against the background of his most versatile time as the embodiment of the practical, theoretical, and aesthetic gifts. In short, he approximated the ancient Greek ideal of harmony, well known to him from his beloved Aristotle. There was one trait of character, however, which distinguished this humanist condottiere from most of his fellows. This was his sense of justice and responsibility. That he, unlike most princes of the day, could dare to stroll unarmed among his subjects, be heartily greeted with “Dio ti mantenga, Signore!” he owed above all to his celebrated system of taxation.

There is no image in the little study which does not celebrate the many interests of this universal man. The books, no less than fourteen, remind us of the library he built up in his main residence, Urbino. It was the greatest library of its time, containing in its wealth of items the catalogues of such libraries as the Vatican, San Marco, Florence, and Oxford. He preferred written to printed books and for many years employed thirty or forty writers, with an output of sometimes as many as two hundred books in twenty-two months.

Besides these compendia of the learned mind, we find the tools of the searching mind: a pair of dividers, a quadrant, a lever, a celestial globe. The latter particularly reminds us of the Netherlander, Paul von Middelburg, who was Federigo’s court astrologist and mathematician.

The many arms depicted appear to be symbols of the art of war, in which the Duke was a learned and successful master. His authority in the rules of “correct,” scientific warfare was undisputed, his victories famous, his new techniques, such as the use of heavy field artillery, epoch-making. He was a patron of all the sports of chivalry and loved to lead the evening contests of his young courtiers.

We next observe an amazing number and variety of musical instruments, no less than fourteen, witnesses of the exquisite musical taste at Federigo’s court. Besides percussion instruments, such as a tambourine and a tabor, we find plucked string instruments: two lutes, a cittern, a harp; bowed instruments: a rebec and a fiddle; wind instruments: two cornettos, a hunting horn, a pipe, and finally a magnificent portative organ. The cittern (fig. 1), similar to that of Fra Giovanni da Verona (fig. 2), shows some features lost afterwards, when the cittern became the fashionable instrument in the barbershops of Elizabethan England, namely the characteristic hook at the neck and the sharp detachment of the neck from the body, which also occur in some fiddles of the same time (fig. 3). The pear-shaped rebec (fig. 6), leaning beside its bow, is clearly recognizable through the latticework of the cupboard door by its sickle-shaped pegbox. The almond-shaped fiddle (fig. 7) unfortunately does not
Fig. 6. Rebec and bow. The sickle-shaped peg-box is partly visible. In Section 6

Fig. 7. Fiddle with four melody strings and one drone. In Section 5

Fig. 8. Angel playing a rebec, detail of a fresco by Pintoricchio in the Church of Santa Maria in Aracoeli in Rome

Fig. 9. Angel playing a fiddle, detail of a painting by Signorelli in the Church of the Casa Santa at Loreto
show its pegbox, but it is easily recognized as a bowed instrument by its bridge, the form of its finger board, and the position and shape of the sound holes. Besides its four melody strings, a drone is visible, foreshadowing the later transition into the *lira da braccio*, played by so many Orpheus and angels and Apollos in renaissance painting. Characteristically, the string instruments, regarded as the nobler and favored by Pallas and Apollo, outnumber the winds, the playing of which distorts the face, as Plutarch says (quoted in Castiglione’s famous book on the courtier). What must have excited the inlay worker—the portrayal of wooden instruments in their natural substance but with their bulk reduced to two dimensions—is a sheer delight for the historian today. Old woodcuts of keyboard instruments caused many a headache to the connoisseurs before they discovered that the woodcuts had been reprinted in reverse. In our intarsias, the exact rendering of functional details, such as strings, frets, pegs, and so forth in their natural dimensions, surpasses in exactness most other modes of illustration.

The multitude of the objects depicted, however, is not merely a reflection of the versatile personality of the Duke. There is a deeper bond between them. They are symbolical of the intimate connection between the arts at that time and between the arts and the sciences, and it is only of secondary importance to what extent this symbolism was intended by the maker of the study; he was a creature of his time. Both art and science in the quattrocento drew their inspiration from one strong impulse: the tendency toward rationalization, sweeping through all branches of natural
Fig. 14. Celestial globe, books, and quadrant. In Section 2

Fig. 15. Shadow cast on moldings by the lectern. In Section 1

science, aiming at calculation and control of nature by establishing its laws. The basic structure of nature was to be found in simple numerical formulas. This conception of natural science swept the artists along with it, but they were themselves pioneers in its development; in portraying nature “correctly” they hoped to capture its secrets. Art was research into nature, the artist an experimental scientist, the canons of nature the canons or rules of “correct” artistic creation.1 Art was thus a sort of science, a body of knowledge dealing with the basic relations between phenomena, visible or audible. So, on the formula of the harmonic proportions were based, among other things, the standards for the human body and for architecture as well as the musical scale, and, as the most recent pearl on this string, the theory of linear perspective. The artist scientists around Duke Federigo were among the most influential standard-bearers in this new adventure of the mind, and our study, looked at from this angle, is a monument and showpiece of the new achievements.

The main key to this interpretation of the study is found not so much in the objects depicted as in the manner in which they are depicted: it is a triumph of linear perspective. Problems of the utmost complexity are mastered here with playful joy and accuracy; no intricacies are avoided. To begin with trifles: the border patterns consist of strings of geo-

1 Leonardo: “Those who are enamoured of practice without science are like a pilot who goes into a ship without rudder or compass and never has any certainty where he is going” (G. 8 r). “Perspective therefore is to be preferred to all the formularies and systems of the schoolman, for in its province the complex beam of light is made to show the stages of its development, wherein is found the glory not only of mathematical but also of physical science, adorned as it is with the flowers of both” (C.A. 203 r.a.).
metrical bodies, simulating three-dimensional forms (see figs. 10, 12). The turban ring (fig. 11) is only a slightly different version of one of the construction diagrams (fig. 13) described by Piero della Francesca in his famous treatise *De prospectiva pingendi*, dedicated in 1469 to Duke Federigo and most influential in the whole further development of theoretical and pictorial perspective, particularly on Luca Pacioli and Leonardo. The architectural details, such as the flutes of the pilasters and the moldings of the architrave (fig. 26), burst forth with plastic life. The cupboard doors are open at all possible angles. Only a master of projective geometry could have designed the shadow of the lectern shaft, running over the complex moldings of imaginary architecture (fig. 15). Particularly interesting is the border ornament around the cupboards which flank the window (shown on page 111). It consists of little disks threaded on a small stick, a common frame pattern in quattrocento woodcuts, where it appears in cruder versions (fig. 17). But here what accuracy! If we sweep our eye upward along this string, we progress gradually from a top view to a bottom view of the disks. One disk shows its rim only and thus appears at eye level—it might have been the Duke’s—and we remember Leonardo’s advice to painters to take as the vanishing point the eye level of an average man. If, however, we run our eye along the horizontal ledge below the cupboard, no disk shows us only its rim; though these disks also appear in successive positions, it is clear that they are adjusted for an eye placed somewhat farther to the right than the disk at the extreme right corner. This requires an observer placed not in the window niche but more to the center of the room. Thus the two rows of disks have a point of vision precisely determined as to its vertical and horizontal position.

Such a fixed position of the point of vision, as is possible for a single panel with its limited field, cannot be maintained for a whole interior: here the visitor turns around from wall to wall, continually shifting his point of vision. How complex this problem of a perspective interior is, may be shown by the following consideration: any three-dimensional object offers an infinite number of different two-dimensional aspects or images. 2 Only one of these images is chosen for a painting or any other two-dimensional representation, corresponding to one selected point of vision. Our intarsia room, however, is not a painting, or even a set of relatively independent images, but, like space itself, it continues and returns upon itself. Therefore, we might expect that, like any round object, it should offer to the ob-

2 Leonardo: “Each body alone of itself fills the whole surrounding air with its images” (C.A. 138 r.b.).
server, as he moves, a new aspect with every step, corresponding to his changing point of vision. But this it cannot do, being two-dimensional. Therefore, a sort of compromise is necessary to do justice to the observer in any possible position. How this compromise is approximated here without any loss in power of illusion constitutes an inexhaustible source of intellectual pleasure.

This problem of pictorial projection is made even more difficult by the further problem of the shadows. That the objects represented should throw shadows is obvious here where the highest degree of plastic illusion is aimed at. These shadows, particularly those of the balusters, are adjusted to two sources of light, the window and the door. Double shadows for one and the same object would have produced too confusing an effect. So in this too a compromise has been attempted. One has only to look at the corner formed by the small wall to the right of the door and the adjoining long wall to observe that the balusters at the small wall apparently receive their light and shadow from the window, while the long wall seems to be lighted through the door (fig. 16).

I am indebted to Cordray Simmons for an ingenious remark he made to me when I told him some observations made in the study. Being a painter and accustomed to constant shifting between one- and two-eye vision in his own painting, it occurred to him as he was helping to restore the study to wonder whether or not the one-eyedness of the Duke had anything to do with the particular character of the study as accomplished perspective illusion. The facts are that the Duke had lost his right eye in a jousting accident, and that the discrimination between a real object and its accurate portrait is much harder for one eye than for both. This defect in depth-sensation must have made the illusion even more perfect for the Duke.

The mastery of the visual reality by finding and formulating the numerical rules of space, that is, linear perspective, is only one aspect of the interfusion of creative art and science in the Renaissance. “Practice,” in Leonardo’s words, “should always be based upon a sound knowledge of theory, of which perspective is the guide and gateway, and without it nothing can be done well in any kind of painting” (G. 8 r). The first art to be founded on a grammar of this sort was not one of the visual arts but music. After the Pythagorean school discovered the precise dependence of the musical intervals upon certain arithmetical ratios of length of string, the search for a precise theoretical foundation of the arts and the conception of the scientist artist never died out. Behind subjective beauty, an objective, rational grammar took shape, teachable and learnable, that of harmonic proportions. How amazing and at the same time reassuring—the chaos of sensations.
Fig. 18. The Designer of the Vase, a woodcut by Albrecht Dürer

Fig. 19. Drawing by Francesco di Giorgio showing bombards and their sights from a manuscript in the Ducal Library at Turin

Figs. 20 and 21. LEFT: Gaffurio teaching the theory of music. Woodcut from "Angelicum ac divinum opus musice" by Franchino Gaffurio (Milan, 1496). Compare the dividers and hourglass with those in Fig. 1. ABOVE: Woodcut from Gaffurio's "Theorica musice" (Milan, 1492)
Fig. 22. Title page of the first English edition of Euclid’s “Elements” (London, 1570) illustrating the Pythagorean union between the sciences. The Pythagorean atmosphere and the interest in the numerical foundations of nature and art, so vital at the Duke of Urbino’s court, lived on for centuries. It was an Urbanate, Federigo Comandino, who made one of the earliest translations of Euclid’s “Elements” into Latin (1572). In 1569 Urbino was visited by the English mathematician John Dee, who wrote the preface to the first English edition shown here.
ruled by a simple and rigorous formula! Here a bridge was found, no less amazing, between the realms of the eye and the ear. From Vitruvius up to the last stragglers of Palladio the theorists admonish the architects to borrow the rules of harmonic proportions from the musicians, who were the masters in this field. Leonardo, who, in his research on perspective, discovered the harmonic proportions in which a body withdrawing from the eye seems to diminish, regarded music as the “ sorella della pittura.”

It was for its strictly theoretical foundations that music was regarded as a science in antiquity and kept its place in the universitas literarum, beside rhetoric, geometry, arithmetic, dialectic, astronomy, and grammar, and that within the mediaeval classification of the arts into artes liberales and artes mechanicae it belonged to the first and nobler class, which imparted an elevated social position to its masters. This was by no means true of the visual artists; Plato ranked them with any other people exercising a skill, such as doctors, farmers, and sailors, and this was still the prevalent view in the quattrocento. No wonder the visual artists then, formulating the rules of their crafts, looked to music, where this formulation had been accomplished before. Besides, their social position could be improved by adding the same scientific rigor to their work as music enjoyed. Thus, after the model of music, the grammar of the visual arts was fashioned.

Viewed in this light the musical instruments in our study are of more than decorative importance; they are the tools of the most venerable “science art.” The cittern mentioned above is flanked by a pair of dividers and an hourglass (fig. 1), the instruments for measuring space and time. True, they belong to the common paraphernalia of a renaissance study, but the appearance of these metrical tools, side by side, and especially with a musical instrument, is perhaps more than accidental; and, indeed, these are the symbols by which, in the renaissance theory, the mathematical foundations of music are indicated. A woodcut in Franchino Gaffurio’s Angelicum ac divinum...
opus musice, Milan, 1496 (one of the standard musical treatises of that time), shows the author teaching, while to his left dividers and an hourglass remind us of the Pythagorean discovery that our scale, and hence harmony, is based on certain numerical relations, for instance, those of the lengths of strings or air columns producing sound (fig. 20). These lengths are illustrated also by lines with their measurements added and pipes with the same proportion numbers. In woodcuts from Gafurio’s Theorica musice, Milan, 1492, it is old Pythagoras himself who works on chimes and glasses, strings and flutes, all with their proportion numbers added (see fig. 21).

From here we do not have to pass far to other tools which we find in the cupboards, a celestial globe and a quadrant (fig. 14). There is no military leader from Alexander to Napoleon, and even beyond, who would not consult the stars. But the Pythagorean heritage, so vital in Federigo’s time, points rather to the nobler sister of astrology, astronomy. The Pythagoreans had found the harmony of tones in the proportions of the planets and their orbits. This leading motif sounds throughout the history of astronomy from ancient Greek speculation to the famous title of Kepler’s De harmonice mundi and the Harmonie universelle by the great musicologist and friend of Descartes, Father Mersenne. How unfortunate that we cannot open the books above which the celestial globe is hanging, perhaps among them a treatise of the court astronomer, Paul von Middelburg!

There remains a last group of objects, the arms, evidence of a world apparently remote from the realm of science. But even warring, that exercise of sheer force, was carried on as an art in Federigo’s time, art meaning skill based on science. War became a topic of scientific speculation and was subjected to conventional and technical rules, the rules of correct warfare. Federigo, the Gonfaloniere of the Church, was a celebrated master of the “scienza militare.” His adviser in this matter, who built his castles and constructed his bombards and mortars, was the greatest military expert of the time, Francesco di Giorgio Martini, whose Trattato d’architettura civile e militare, written in Urbino and dedicated to the Duke, had its influence as late as the time of Prince Eugene of Savoy and even Napoleon. The revolution in the technique of war of that time is marked chiefly by the use of heavy artillery and the adaptation of fortification plans to this new weapon of attack. These arms, as well as the proper defenses against them, demanded a more systematic control of space. Shooting with heavy cannon actually means practical

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3 On the importance of Francesco di Giorgio Martini as theorist of military technique see L. Olschki’s very instructive Geschichte der neusprachlichen wissenschaftlichen Literatur, p. 119.
mastery of space; leveling a gun implies thinking in terms of levels of space; scientific gunnery, or ballistics, as well as the technique of fortification against artillery fire, is nothing else but applied perspective, and it may very well be that the practical needs of the new gunnery contributed more to the “rationalization of sight” than it is commonly supposed. Francesco di Giorgio, in a drawing for the treatise mentioned, illustrates one of his heavy guns leveled at a fortress by means of sights, which are also depicted in enlarged form (fig. 19). A glance at one of Dürer’s woodcuts (fig. 18) shows that the aiming device for the gunner is basically akin to that used by the artist working on linear perspective. Although both contrivances serve quite different practical ends, they both assist in that calculation of which the factors are object, distance, image, the gunner starting from the image given and searching for the distance, the draftsman defining the shape of the image with respect to a given distance. Both those operations are founded on the same mathematical principle, the precise proportions between the increasing distance of an object from the eye and its apparent diminution. Though the theoretical formulation of this principle is found first in Leonardo’s writings, there seems to be no doubt that it had been practiced before as a rule of thumb.

Thus, even the arms in the panels stand for a “science art,” the theoretical conquest of space, brought about by the geometers, the portraiters of nature, and the military geniuses. This rational conception of space is based on numerical rules, the same divine harmony of proportions that is realized by the musical instruments and observed by the planetary orbits (fig. 22). This is the great, the peremptory credo of the time: only by investigation into the blueprint of creation can one dare to portray it truly, to re-create it. In Leonardo’s words, “in Art we are grandsons unto God.” This belief, this search for the one in the many, the order in the chaos, the simple in the entangled is written not only in the treatises of the quattrocento, but with no minor eloquence on the walls of the study from Gubbio.

Francesco di Giorgio, like Leonardo, was not only a military engineer, but a celebrated civil architect, painter, and sculptor. The designs for our study are attributed to him. This assumption, which is based only on indirect evidence, might perhaps be strengthened by analysis of some peculiarities in his ornamental style: the alternation of round-leafed and catclaw-leafed palmettes characteristic of Francesco’s arabesques (figs. 24 and 25) occurs again in the border of the ceiling of the study (fig. 23); besides, both motives occur separately in many panels of the study. His predilection for the vine-leaf ribbon in combination with its inversion—differing, as it does, from the classical formula—is shown here, as elsewhere in his work, in the cornice (fig. 26); in the ceiling of the window niche, the upright and the inverted pattern touching each other; in the coffers of the main ceiling, with an intermediary ribbon between them. The decoration of the cornice (fig. 26) corresponds exactly to that of a fireplace in the Ducal Palace in Urbino (fig. 27), which is attributed to Francesco with good reasons. But aside from this or any piecemeal evidence, may we not find some inner logic in the supposition that the master of the bombards should also have designed the masterpiece of perspective which is our study?

Acknowledgments: figure 2, photograph by Brogi; figure 3, photograph by Hanfstaengl. The following illustrations have been reproduced from books: figures 5, 20, and 21 from La corte di Lodovico il Moro by F. Malaguzzi Valeri; figures 12 and 19 from Francesco di Giorgio Martini of Siena by Selwyn Brinton; figure 17 from Early Florentine Woodcuts by P. Kristeller; figures 24 and 25 from L’Architettura del quattrocento by A. Venturi.

Additional illustrations and information may be found in Preston Remington’s article on the Gubbio room in Section II of the Bulletin for January, 1941, which may be purchased for twenty-five cents.

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4 To quote the title of Mr. Ivins’ very original treatise on renaissance perspective (Metropolitan Museum Papers, No. 8).