Art and Mathematics in the Thought of El Lissitzky: His Relationship to Suprematism and Constructivism

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ABSTRACT

Lissitzky's analogies between art and mathematics pertain to two aspects of modernity—namely, non-objectivity and the negation of perspectival space. According to Lissitzky, non-objectivity in art was analogous to the modern concept of number, and the structure of a work of art corresponded to mathematical concepts such as functions and systems. These theories demonstrate Lissitzky's divergence from both Suprematism and Russian Constructivism. Furthermore, the analogies elucidate the artist's insistence on order, his notion of the art-game and the relationship between intuition and intellect in the creative act. An analysis of pictorial space by analogy with real and imaginary numbers and a comparison of art with set theory help clarify the system of the Proun paintings and the theoretical base of Lissitzky's exhibition spaces. They also expand our understanding of Lissitzky's relationship to Malevich's Suprematism. In conclusion, the analogies provide an alternative theoretical base to non-objective art, different from the other 'isms' of art in the 1920s.

Lissitzky's writings on art contain many references to mathematics, connoting a tight relationship between the two disciplines. This relationship pertains especially to pictorial form and space and involves some of the central issues of modern art: the ideas of game, order and objectivity; the relative importance of intuition and intellect in the creative process; and the concept of indeterminateness.

These and other issues, such as 'becoming' in opposition to 'being', as well as terms like 'systems' or 'dematerialization', occurred often in the discussions and writings of Russian avant-garde artists and theoreticians. However, Lissitzky's use of these terms was idiosyncratic in that it involved a mathematical sense. He elaborated a consistent theory of art by analogy with mathematics [1].

Underlying his analogies was his belief that the modern era had abolished the barriers between the different spheres of knowledge and activity, for example, between technology, art and physics. In support of this thesis, Lissitzky evoked Minkowski's space-time continuum, the theoretical interchangeability of the dimensions of space and time [2]. In using the Communist Revolution as a social example, Lissitzky observed that it had discredited old concepts that had set up barriers in society: the notions of classes, nations, patriotism and imperialism. In this vein, he argued that towns would be rebuilt in such a way as to abolish the separation between their different elements, since houses, streets, squares, bridges and the like were now linked by "underground metro, underground monorail, electricity transmitted under the ground and above the ground" [3].

Similarly, Lissitzky rejected as invalid the contradiction between spirit and matter, or 'soul and body', and hence objected to the division between an artistic and a scientific understanding of space. "The discoveries of new spatial perceptions," he held, "went hand in hand in painting and in mechanics" [4]. Aware, though, of the dangers of superficial comparisons, Lissitzky stated that "the parallels between A.[rt] and mathematics must be drawn very carefully, for every time they overlap, it is fatal for A.[rt]" [5]. Thus, at the beginning of his lecture on the Prouns, given at the Moscow Institute of Artistic Culture (INKhUK), Lissitzky declared: "We will examine the movements of mathematics and art as two sets of graphs not always advancing in parallel planes but always active in the same ambience: the culture of their time." He further explained that he was taking the analogies in their "essential sense" [6].

My aim in the present paper is to clarify Lissitzky's interpretation of this 'essential' relationship between mathematics and art. I will show that the analogies Lissitzky drew between the two disciplines in the 1920s reveal an alternative theoretical base for non-objective art—a theory that differs from both Suprematism and Russian Constructivism [7].

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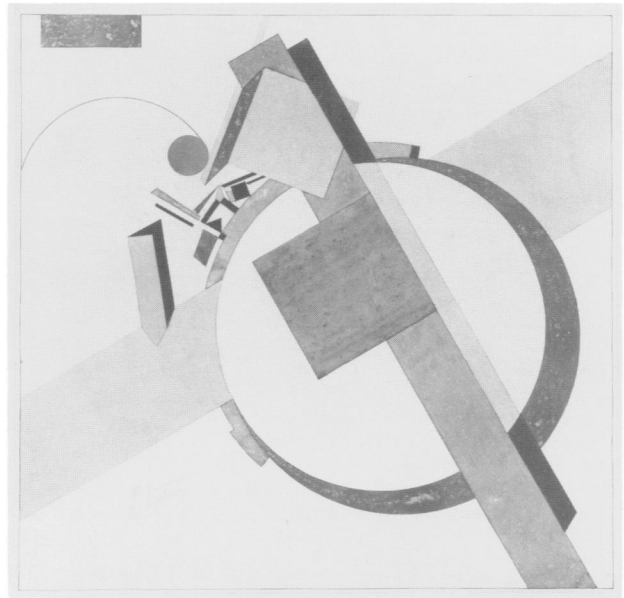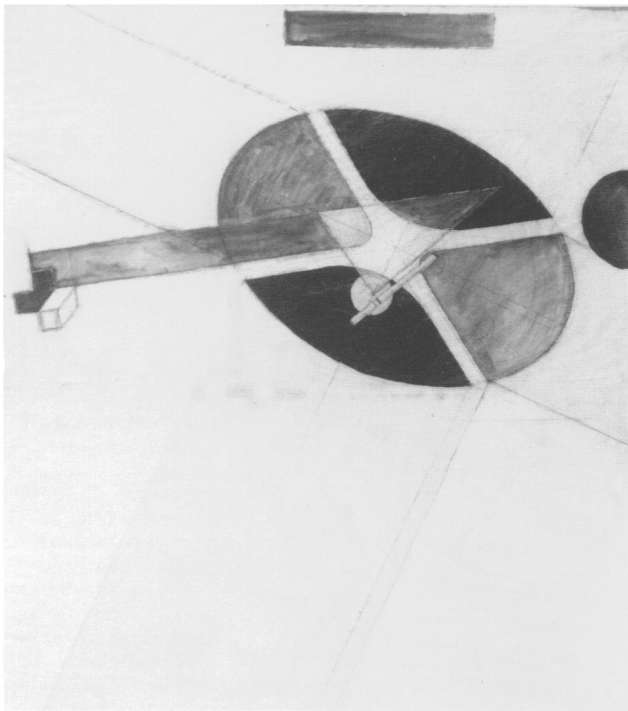
Fig. 1. *Proun (Untitled)*, gouache and watercolor on paper, 38.8 × 40.5 cm, ca. 1920. (Indiana University Art Museum, Bloomington, Jane and Roger Wolcott Memorial. Photo: Michael Cavanagh and Kevin Montague.) The reading of a Proun painting varies according to shifting attentions and alternating analyses of the relationship between forms and colors.

Fig. 2. *Study for Proun G 7*, pencil and watercolor, 78.4 × 62.7 cm, 1922. (Stedelijk van Abbemuseum, Eindhoven) The theme of change and multiple readings pervades all of Lissitzky's works. *Proun G 7*, for instance, represents the idea of the 'artist engineer', a human configuration accompanied by geometrical instruments, which Lissitzky repeated in other paintings with either minor or major modifications.

THEORY OF NON-OBJECTIVE ART

The term 'non-objective' connotes two interrelated characteristics of modernism: the work of art as an autonomous, non-referential object [8] and the specific 'non-objective' forms that make up a painting or a sculpture. Lissitzky believed that both characteristics applied equally well to modern mathematical thought. He observed that mathematics was the "purest product of man's creativity: a creativity which does not repeat (reproduce), but creates (produces)" [9], and that it was unconcerned with concrete magnitudes and quantities but dealt with the relationship between abstract concepts. As he described it:

The number in antiquity was always *concrete,* only concrete; the number of modern times is *abstract,* non-objective. For a Greek '3' always meant 3 columns, 3 sheep, 3 ribs; beyond the object there was no number. In the new mathematics of x, y, z there is no definition of the quantity. They are signs of the connection between an infinite number of possible positions within one and the same character; taken as a whole, they equal a number. . . . x, y, z are numbers only inasmuch as the signs + or = are [10].

The same changes occurred in the concepts of line and space. In ancient Greece, Lissitzky explained, the line was considered the measurable edge of a body, and space was defined by the object and its delimiting planes. In

modern times, on the other hand, a line is considered an unlimited complex of points, and space is conceived as abstract: "no point in it can be seen or measured, it is merely a relative center" [11]. Hence, in antiquity, one knew only what one saw and felt. In modern times, by contrast, abstract notions prevail; in analytic geometry, for example, points in space can be identified by sets of numbers, and space can be n-dimensional.

According to Lissitzky, the decisive transformations in art were analogous to the new concept of number—that is, art became totally divorced from material phenomena and free of the physical object. This fundamental change occurred, in Lissitzky's view, with Malevich's Suprematist *Black Square* (ca. 1913). Prior to Suprematism, artists depicted objects from nature, and all new movements—e.g. Cubism, Futurism and Expressionism—were nothing more than attempts to endow the object with a new life [12]. The Suprematist canvas, on the other hand, existed independently of anything outside it [13]. In terms of the analogy with mathematics, "Suprematism transposed painting from the condition of the ancient objective and concrete number to that of the modern number abstracted from the object. This number occupies its own, independent place in nature alongside all objects" [14].

Malevich, therefore, was the first artist to start in a completely new direction.

Moreover, Lissitzky claimed that geometric forms were pure inventions of the mind [15], comparable to the abstract terms of functional equations and the notations x, y, z, which imply a universally valid system of relationships [16]. In the same way, the artist had to find a system of relationships that would be valid for all artists. This, Lissitzky argued, happened in Suprematism:

The moment the square and the circle are dissected and distributed over the flat surface . . . a relationship is formed between the individual parts. . . . The result is not a personal affair concerning one individual artist, but a *system* of universal validity [emphasis added] [17].

Thus art, like mathematics, constituted a system of relationships.

In his lecture on the Prouns, Lissitzky used the analogy of mathematical systems to define Suprematism. He distinguished between proportions—that is, an equality of ratios between two quantities—and the concept of functions in set theory. The latter has to do with the idea of dependence between any two sets of elements, independent of quantities; as the artist defined them: "The ratio of quantities is PROPORTION; DEPENDENCE is the essence of function" (Lissitzky's emphasis) [18]. In 1921, when Lissitzky developed his theory of art, he felt that Suprematism epitomized a funda-
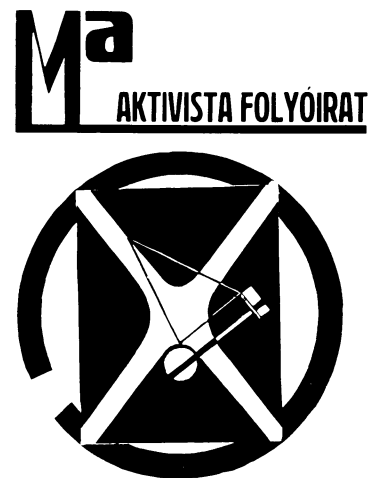
Fig. 3. Cover for *MA*, No. 8 (August 1922). This cover for the Hungarian avant-garde art journal *MA* presents one variation on the theme of the 'artist engineer', which Lissitzky started in early 1922 with *Study for Proun G 7*.

mental change in the concept of rela-
tionships, for this art form was built,
not on the idea of proportions, but on
the notion of dependence:

> From the canvas Suprematism dis-
> carded all depiction and represen-
> tation of objects and colors. It left be-
> hind pure color within pure form.
> From these elements it began to com-
> pose whole classes, groups and equa-
> tions of formal possibilities according
> to their functional interdependence
> [19].

The definition of Suprematism in
terms of functional dependencies re-
ferred to the basic difference that the
First Working Group of Constructiv-
ists had established between composi-
tion and construction [20]. Lissitzky
agreed with the Group's definitions,
and using mathematical terminology,
he explained that

> ratios can be increased or decreased.
> But functions can only be trans-
> formed. Therein lies the essential
> contrast between the old and the new
> world, between old and new plastic
> forms. Any proportion presupposes a
> constancy of each element (the
> CLASSICAL ORDERS), but any
> transformation presupposes a varia-
> bility (SUPREMATISM). An old work
> of art can be increased or decreased,
> whereas a modern work of art has to
> be transformed [Lissitzky's empha-
> sis] [21].

If one variable in a ratio changes,
the other variables have to be changed
accordingly, but the ratio will remain
the same. In artistic terms, following
the Constructivists and Lissitzky, ratio
denotes composition, that is, if parts
of a composition are removed or col-
ors changed, the rest of the composi-
tion would require some rearrange-
ment, but in essence it remains the
same. If one element of a function is
changed, the whole function has to be
transformed. Hence functions define
construction; the term construction
came to denote the functional neces-
sity of each part as in any mechanical
construction. "In adding new ele-
ments and transposing them", Lis-
sitzky said, "we transformed the can-
vas" [22].

The First Working Group of Con-
structivists devoted one of its early ses-
sions to a discussion of two paintings
by Malevich, one Cubist and the other
Suprematist. Their consensus was that
Malevich's Suprematist canvas fol-
lowed the laws of composition. Ac-
cording to Rodchenko, for example,
"Malevich makes no color resolutions.
His form is strong, but if you were to
paint it a different color with the same

Fig. 4. *Proun
(Construction)*,
plate 5 from
*Erste Kestner-
mappe* (First
Kestner port-
folio), litho-
graph, printed in
color, 60.4 × 44.2
cm, 1923. (Col-
lection, The Mu-
seum of Modern
Art, New York)
Lissitzky wished
to incorporate
time into his
work. He initially
attempted to do
so by trying to
capture different
moments of
movement
through the repe-
tition of lines
and forms in
such a way that
these seem to
change their posi-
tion in space.
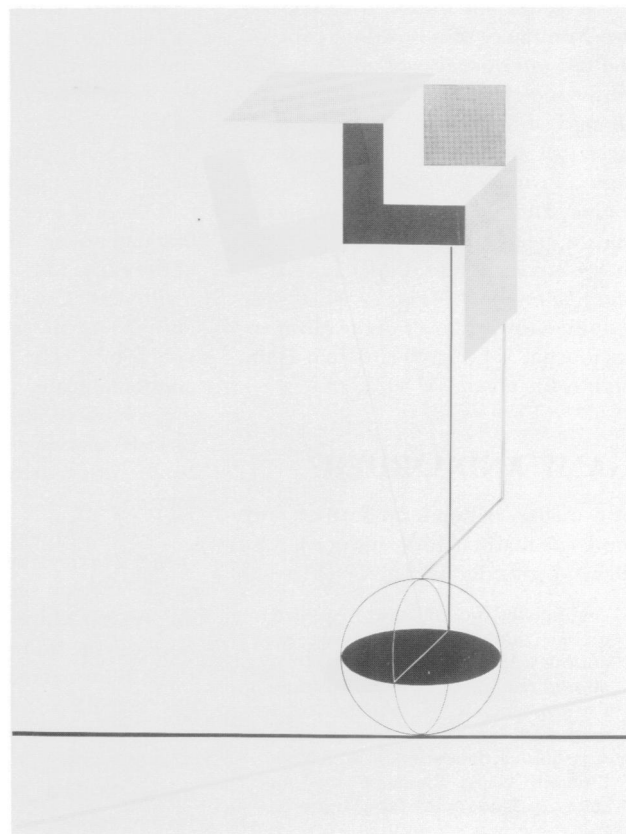
intensity, nothing in the work would
be changed" [23]. The Group's com-
position verdict against Malevich
stood in blatant contradiction to Lis-
sitzky, who argued that the term ap-
plied equally, even primarily, to Supre-
matism.

This difference between Lissitzky
and the Constructivists was more than
a disagreement over terminology. For
Lissitzky, a Suprematist painting was,
by definition, constructive art [24].
Thus he repudiated the final decision
taken by the First Working Group of
Constructivists—namely, that a utili-
tarian element had to be immediately
present in the idea of construction
[25]. Lissitzky distinguished between
the necessity to create new forms and
the question of direct utility. For him,
a new artistic form generated utilitar-
ian forms, which, consequently, en-
riched and modified art and caused
further developments in both art and
production [26].

Another concept involved in the
theory of systems was that of change.
Ernst Cassirer had noted that the
mathematician was concerned with
the idea of 'becoming' rather than the
idea of 'being' [27]. The opposition of
becoming to being was a recurring
theme in Russian Constructivist dis-
cussions. Thus, for N. Tarabukin,

rhythm in art was an element of 'life';
it was that which "Bergson, Rikkert
and Spengler name 'becoming' in op-
position to the frozen. . . . Rhythm is
always movement, élan, surge" [28].
This nature-derived significance of be-
coming is also present in Lissitzky's
writing; however, for him the similar-
ity to mathematics was equally impor-
tant. In his opinion, the work of art was
analogous to mathematical systems,
and like them, it evolved during its ex-
ecution [29].

Furthermore, even when the work
had been completed, the process con-
tinued, since the spatial relations be-
tween the forms and colors were
changeable, depending on the specta-
tor's choice. Indeed, the reading of a
Proun painting varies according to
shifting attentions and alternating
analyses of the relationship between
forms and colors and their relation-
ship to the picture plane. For instance,
in *Proun (Untitled)* (Fig. 1), a square is
painted on a form that, because of the
black contour shown in perspective on
its lower right-hand side, is either a
circle or a cylinder. On the upper edge
of the 'circle', to the left, Lissitzky
placed a stereometric open cube—a
recurring theme in the Prouns. Its
black face on the left-hand side may be
read as either advancing or receding.

Thus, we see the outer envelope, the two front faces of a receding cube or the two interior faces of an open and advancing cube. In fact, the theme of change and multiple readings pervades all of Lissitzky's work, since many Prouns are variations on a theme, and the same configurations may appear with either minor or major modifications. One example is *Study for Proun G 7* (Fig. 2), which was modified for the cover of the Hungarian journal *MA* (Fig. 3) and then again slightly for *Proun 43* [30].

GAME AND ORDER

The analogy between modern art and modern mathematics induced Lissitzky to consider art a game [31]:

> Archimedes would have regarded modern mathematics as a clever, but curious GAME (because its aim is not an end result like three buns, forty-five kopecks, etc. . . . but the actual operation, combination and construction of dependences which we find with Gauss, Riemann and Einstein). . . . The result of the Suprematist 'game' was a canvas which bore within it a kind of symbol [Lissitzky's emphasis] [32].

Modern mathematics was a game, for, like games, it was an autonomous, rule-governed activity [33]. Indeed, the modern formalist mathematicians of Lissitzky's time considered mathematics mere play with symbols. For these mathematicians, mathematics had become an endless game of chess that had no meaning beyond the rules of the game [34]. The aim of modern mathematics, including geometry, lay only inside the actual mathematical operations. The real object of the mathematicians' investigations was the relational structure as such, the various species of dependency that could subsist between numbers and forms [35].

As Lissitzky saw it, art, too, had become a formal language of signs—a game between forms and colors; and the relationships between the signs were as rule-bound as those between x, y, z in formal mathematics [36]. Unlike formal mathematics, however, art-games had both a social and an ideological significance: one could change the world through art. The Suprematist revolution, accordingly, was equal to the Communist Revolution. It was, in fact, Suprematism that would revolutionize the world, for when its aim and significance were fully grasped and integrated, "we shall give a new face to this globe, we shall reshape it so thoroughly that the sun will no longer recognize its satellite". Art, then, was a supreme vehicle of world transformation, superseding even the social revolution; in the final analysis, the future would be shaped, not by Communism, but by Suprematism:

> In the further stages of development, it is communism which will have to remain behind because suprematism . . . will attract everyone away from the domination of work. . . . After the old testament there came the new—after the new the communist—and after the communist there follows finally the testament of suprematism [37].

The concept of art as game and its analogy with mathematics elucidate Lissitzky's insistence on order and objectivity. His 'call to order', like that of other artists of the avant-garde, undoubtedly was motivated in part by the example provided by modern technology and machines. But it was further sustained by his adherence to the idea of necessary connections between art and mathematics [38]. The very comparison of art with abstract mathematics and the definition of art as a system of relationships imply an idea of order, of which Lissitzky was surely conscious [39].

The foregoing analysis of Lissitzky's theory of art, as paralleling changes in mathematics, demonstrates that he was not a Suprematist. Like Malevich, Lissitzky believed that forms and colors were autonomous creations of pure thought, totally unrelated to exterior objects. The two artists, though, differed completely on the conceptual foundation of the rejection of natural objects. Malevich refused representation on the basis of his idealist, transcendental philosophy, according to which "in reality form does not exist [and] nature . . . does not reveal itself in things" [40]. Lissitzky, on the other hand, held that objects did exist, but in a sphere that was of no interest to the artist, just as it was of no interest to the modern mathematician. Both art and mathematics were concerned with abstract relationships governing the universe independently of concrete objects and magnitudes. Moreover, the very emphasis on relationships contradicted Malevich's philosophy of art, in which "each form is free and individual. Each form is a

Fig. 5. *Proun (8 Positions)*, metal foil, oil and gouache on canvas, 98.6 × 98.6 cm, 1924. (The National Gallery of Canada, Ottawa) Another way to incorporate time into a work of art was to make the canvas rotatable, that is, equally legible from any of its four sides.
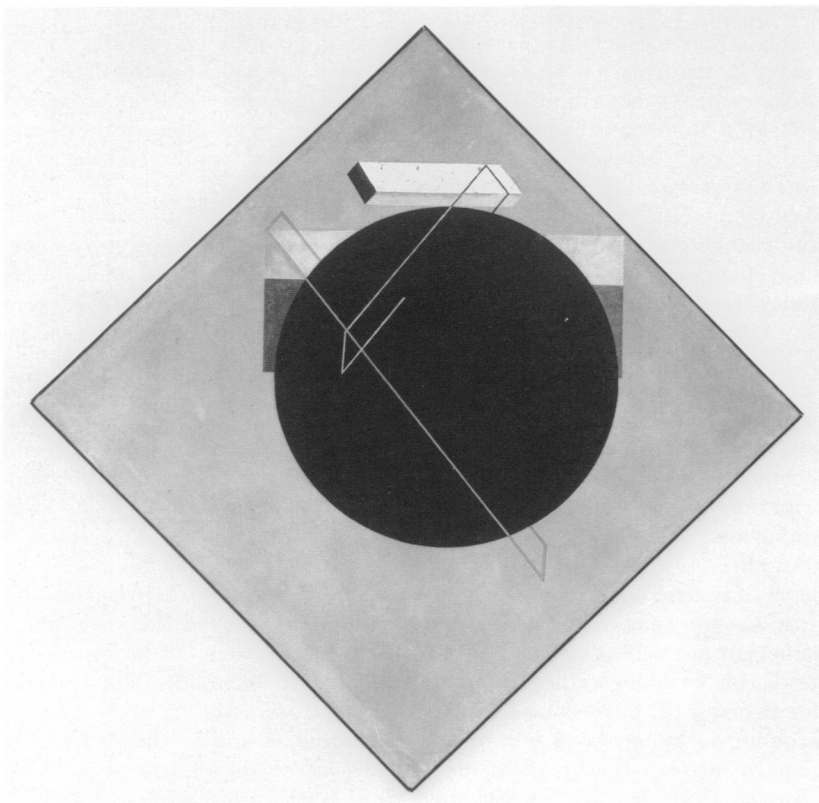
world" [41]. In Lissitzky's Prouns, on the contrary, relationships were important; the meaning of a Proun depended on the relationships between the forms.

INTUITION, INTELLECT AND INDETERMINATENESS

Another problem elucidated by the comparison of art with mathematics is Lissitzky's supposed Romanticism and vacillation between rationality and mysticism [42]. Alan C. Birnholz claimed that, despite Lissitzky's rationality, the artist remained an idealist and a romantic. To prove his point, Birnholz quoted from the essay "A. and Pangeometry", in which Lissitzky wrote: "A.[rt] is an invention of our spirit, a complex whole, combining the rational with the imaginary, the physical with the mathematical, $\sqrt{1}$ with $\sqrt{-1}$" [43]. Birnholz concluded that for Lissitzky art had an "inexplicable aura about it"; that by the use of 'A.' for Art and 'F.' for Form, Lissitzky wished to connote that art was "something mysterious, undefinable" [44].

In fact, the title of Lissitzky's essay referred to Lobachevsky's treatise on non-Euclidean geometry, *Pangeometry*, published in Kazan in 1855 [45]. Lobachevsky believed that the true mathematics of space was Euclidean and that his own non-Euclidean geometry was a totally imaginary construct of the mind; nevertheless, he considered 'pangeometry' a rational, even rigorous, theory of parallels [46]. Thus Lissitzky, through this reference to Lobachevsky, apparently was suggesting that art was a rigorous, logical construction just like Lobachevsky's pan-geometry, although imagination and the imaginary were necessarily an integral part of this construct. Moreover, 'A.' and 'F.' allude to the abstract, formal nature of relationships between the elements of the painting, comparable to x, y, z in mathematical functions. The square root of 1 and the square root of −1 referred to Lissitzky's theory of space, developed further in his essay; therefore, as will be seen later, no mystification was intended and none should be inferred.

The recognition that art, like mathematics, combined logic with imagination reflects Lissitzky's belief in the necessary interdependence of intuition and intellect in the creative process. Indeed, Lissitzky affirmed the important role played by intuition in the first phase of creation: the "path into the future . . . is a path leading from creative intuition" [47]. He linked creativity with the moment all conscious control was abandoned: "There was only one way out—the artist had to fling himself into the abyss in the belief that when he reached the bottom he would not be dead, but would be newly born" [48]. A painting thus grows out of the artist "as organically as a flower from the soil" [49]. At the same time, art reflected our capacity as human beings to create, that is, to order voluntarily the range of our sensations. Thus, the formal elements of a painting had to be organized consciously, for without control over the arrangement of forms and colors, the result was a "rubbish heap" [50]. Lissitzky praised the young Russian artists who recognized order as the base of all art, and he preferred the clear geometry of László Moholy-Nagy to other non-objective painting, which he termed "jellyfish-like" [51].

Non-Euclidean geometry occupied an important place in Lissitzky's thought in different contexts. It corroborated the notion of non-objective art, since it declared mathematics to be a free creation of the mind, independent of our capacity to visualize [52]. It also negated the idea of 'absolute truth', or 'undeniable truth', through the coexistence of several non-Euclidean geometries [53], thus nullifying old beliefs and proving that humans could doubt everything [54]. Discussing Lobachevsky, Lissitzky remarked that the mathematician "exploded the absoluteness of Euclidean space", and added that Lobachevsky, Gauss and Riemann had proved that Euclidean geometry was only one instance among many other equally correct possibilities [55]. Referring to the theory of relativity, he observed: "Modern science . . . has destroyed many absolutes. The absolute of all measures and standards has been destroyed. . . . The new mathematical thought has destroyed many assertions" [56].

Both ideas, the suspension of old beliefs and the denial of absolutes—and consequently the inherent possibility of doubt—were of primary importance to Lissitzky. Doubt as such became the subject of the Prouns. It is reflected in the ambiguous spatial relationships that Lissitzky established between the forms in his paintings, such as overlapping transparent fields of color, equivocal tangencies, apparent symmetries and play with fore-, mid-, and back-planes [57]. All these serve to arouse incertitude. Thus the relationships between forms are indeterminate, and the spectator cannot exhaust all the possible readings of a Proun.

The 'essential sense' of mathematics to which Lissitzky referred in his lecture, and which initiated his study of correspondences between art and mathematics, is closely allied with the denial of absolutes. Both mathematics and art were "symbols of the new concept of the world" [58] in that they abandoned old formulas and stated that humans forever had to consider new possibilities and new solutions. The artist's and the mathematician's revolutionary act concerned not only their separate domains but also life and revolution. If it was possible to reject Euclid and Newton, if it was possible to reject the natural concrete object and Albertian perspective, it was, perhaps, also possible to install a new social order. The way to the new social

Table 1. Lissitzky's equations refer to the general theory of relativity and, through the theory, to the artist's concept of 'imaginary' space, that is, a space created through the rapid rotation and vibration of a body. In the 1921 INKhUK lecture, the equations referred more directly to the possibility provided by the axonometric mode of representation of rotating a Proun painting [88].

Proun Space

FORM OUTSIDE SPACE = 0

FORM OUTSIDE MATERIAL = 0

THE RELATIONSHIP OF FORM TO MATERIAL IS THE RELATIONSHIP OF MASS TO FORM

Fig. 6. Reconstruction of Lissitzky's Second Exhibition Room in Hanover Provinzialmuseum, 1927–1928. (Niedersachsische Landesgalerie, Hanover, 1968. Photo: Foto-Hoerner, Hanover.) Left-hand wall, seen from the entrance. Placed perpendicular to the walls were steel strips 3 cm wide and spaced at 2-cm intervals. The strips were painted black on one side, white on the other, with the wall itself painted gray. The black side of the strips faced the door; seen thus from the entrance, the wall looked all black.
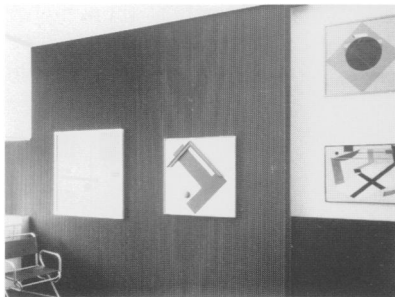
Fig. 7. Reconstruction of Lissitzky's Second Exhibition Room in Hanover Provinzialmuseum, 1927–1928. (Niedersachsische Landesgalerie, Hanover, 1968. Photo: Foto-Hoerner, Hanover.) Left-hand wall, seen from the front. The wall itself was painted gray; therefore, from the front, the wall seemed an almost uniform gray.

order—which, for Lissitzky, was the ultimate aim—passed through art. "Life", he wrote, "is now building a new, reinforced concrete, Communist foundation for the peoples of the earth. Through the Proun we will come to build upon this universal foundation for a single world city—for all the people of the earthly globe" [59].

THEORY OF SPACE

Lissitzky developed his definition of pictorial space through analogy with set theory, postulating that art was a 'universal set' and that each spatial system constituted a subset. He distinguished three successive systems in the history of art: the planimetric, the perspectival and the 'irrational'. Artistic space was at first planimetric; the 'set of art' was later enriched by perspective. Thus the set of art became composed of two members: planimetric and perspectival space [60]. Lissitzky compared each of these artistic systems to a set of real numbers. In planimetric space, the relation between forms was organized according to the arithmetic progression of ordinal numbers (1, 2, 3, . . .). In perspectival space, the relation was arranged according to geometric progression (1, 2, 4, 8, 16, 32, . . .), that is to say, an equality of ratios between two pairs of quantities (1 : 2 = 2 : 4), or proportions—hence, composition [61].

What Lissitzky called 'irrational' artistic space corresponded to the concept of irrational numbers. The set of positive integers, called natural numbers, was first extended into a class of integers by the adjuncts of zero, negative integers (−1, −2, −3, . . .) and rational numbers, that is, fractions of integers. The next step was the inclusion of irrationals, or numbers that cannot be expressed as the quotient of two integers (such as $\sqrt{2}$), to obtain the set of real numbers, which is made up precisely of rational and irrational numbers [62].

According to Lissitzky, Suprematist space was 'irrational' in the sense of irrational numbers—that is, the distance between forms could not be represented as a determinate ratio of two integers. This meant that Suprematist space was the first extension of the 'set of art' after Renaissance perspective. However, since the extension of the set of numbers to include irrational numbers did not eliminate naturals, integers and rationals, Lissitzky employed all three spatial systems—planimetric, perspectival and irrational—sometimes in the same painting.

In addition, Lissitzky compared Suprematist space to the extended line of real numbers, which comprises integers, rational and irrational numbers and also infinites. In this representation, the Suprematist picture plane functioned like the zero on the number line: like numbers, Suprematist space could be projected not only forward from the plane but also backward into depth. In other words, it possessed an infinite extensibility into the foreground and the background. On the other hand, the *Black Square* also corresponded to zero, in accordance with Malevich's idea that with the

Black Square he had arrived at "the zero of form" [63]. In Lissitzky's interpretation, the Suprematist *Black Square* functioned like the zero on the number line, since it marked a turning point between negative and positive. More precisely, it separated the old "painterly culture" (negative) from the new "material culture" (positive), that is, it presented the possibility of creating both new artistic and everyday objects [64].

The second stage in Suprematism was the disintegration of the *Black Square* into colorful forms, the organization of which required a new concept of space. Suprematism arrived at the white plane, which is infinity. The infinite Suprematist space had "broken through the blue lampshade of the firmament" [65]. This conclusion accorded with Lissitzky's comparison of art to set theory.

Georg Cantor's set theory presented a method of dealing with infinites, namely, the paradox of a finite dimension composed of an infinite number of points devoid of any dimension. It was a problem that preoccupied mathematicians, as well as philosophers, from the time of the ancient Greeks (Zeno's paradox) [66]. Cantor solved the problem of the infinite set—the set of all integers, the set of points on a line—by pairing, i.e. by a one-to-one correspondence between the objects of two sets. In set theory, then, the infinite can be defined mathematically [67]. According to Lissitzky, Suprematism, like Cantor's set theory, symbolically transgressed the theological injunction against the representation of the infinite.

The foregoing analysis clarifies Lissitzky's special interpretation of Suprematism. He stripped Malevich's philosophy of art from its transcendental idealism and presented it as a logical system in accord with modern mathematics—hence, as acceptable to the international community of avant-garde artists in Germany and in central and eastern Europe [68].

IMAGINARY SPACE

Movement played an important role in Lissitzky's art, as it did in the art of other avant-garde artists. Speed, dynamics and energy were associated with technological progress and thus characterized the modern era; by depicting movement, artists believed

that they were participating in the new world of technology. For Lissitzky, however, as for Tarabukin, the inclusion of time-movement in art demonstrated its connection with modern mathematics [69]. "The mathematics of the ancients is stereometry. It apprehends objects as *quantities*, outside time. It's a kind of mathematical statics" (Lissitzky's emphasis). Modern mathematics, on the other hand, was dynamic; it took time into prime consideration. In Einstein's physics, space and time were inseparable. "Modern science", Lissitzky said, "has seen that the world lives in time and it has introduced time as the fourth coordinate. It has become dynamic and has destroyed many absolutes" [70].

Accordingly, Lissitzky wished to incorporate time into his work. At first, he did so by capturing different moments of movement through the repetition of lines and forms (Fig. 4) and through a rotatable canvas, that is, making the canvas equally legible from any side, as in *Proun (8 Positions)* (Fig. 5) [71]. However, wanting to make real time and real movement a component part of art, Lissitzky therefore added a fourth spatial system to the three described above and named it 'imaginary'. The mathematical analogy was imaginary numbers— like the square root of −1, designated by i for 'imaginary' ($\sqrt{-1} = i$) [72]. Since the square of any number, positive or negative, must, by definition, be positive, there is no possible square root for a negative number on the real line [73]. Thus, by terming the new space 'imaginary', Lissitzky reinstated his former analogy of planimetric, perspectival and irrational spaces with real numbers. It was as though the three had completed the real line of the 'set of art', and hence any new space had to be termed 'imaginary'. Furthermore, the exceptionality of the number i is that it is not greater than, less than or equal to zero and cannot be represented on the real line [74]. Similarly, Lissitzky intended to abandon 'irrational' space, which was still on the real line, and to move on to abstract space [75]. The imaginary number was also involved in time as the fourth dimension; $\sqrt{-1}$ was used by Minkowski in his formulation of the space-time continuum to make the time dimension imaginary [76].

The first realization of abstract 'imaginary' space was, for Lissitzky, Vicking Eggeling's filmic space, in which the forms projected on the screen had

no existence without movement. Space unfolded in time and did not exist without it, "like the notes of music" [77]. However, he considered the film insufficient, since "it was only a dematerialized projection of the plane" and exploited only the fact "that disconnected movements, separated by periods shorter than 1/30, seem to create the illusion of continuous movement" [78]. Instead, Lissitzky suggested rapid rotation and body vibration:

> When it [this body] is motionless it forms a unit in our three dimensional space, and when set in motion it generates an entirely new object, ... a new expression of space which is there as long as the movement lasts and is therefore imaginary [79].

The space thus created was imaginary, since it was ephemeral and immaterial, and abstract, since it coincided with the mathematical definition of space: a set of points together with a set of relations. At the same time, imaginary space referred to time as the fourth dimension—the three-dimensional concrete object together with the fourth dimension, time. Furthermore, imaginary space related to the concept of matter and space in the general theory of relativity. In his lecture on the Prouns, Lissitzky explained the theory with his own group of equations (see Table 1).

In Lissitzky's imaginary space, as in the general theory of relativity, space was not an absolute; it was generated by matter, without which it would not have existed. The image created space, and space in its turn created the illusory image. Lissitzky himself had never constructed a kinetic sculpture, but he was familiar with the works of both Naum Gabo and Moholy-Nagy. It is possible that he was also familiar with Marcel Duchamp's experiments with the perception of the passage from one dimension to the other, as in *Rotary Glass Plates (Precision Optics)* [80].

Lissitzky realized the passage from the real number line to imaginary space in his Exhibition Rooms. In the *Berlin Proun Room* (1922), the space was still 'linear', although time-movement was an integral part of both the conception and the realization of the room. Visitors were induced to follow a predetermined linear itinerary, as was stipulated by Lissitzky himself: "The first form, which 'leads in' someone coming from the large hall, is placed diagonally and 'leads' him to the broad horizontals of the front wall and from there to the third wall with the verticals" [81]. No such itineraries

Fig. 8. Reconstruction of Lissitzky's Second Exhibition Room in Hanover Provinzialmuseum, 1927–1928. (Niedersächsische Landesgalerie, Hanover, 1968. Photo: Foto-Hoerner, Hanover.) Left-hand wall, seen from the window. The white side of the strips faced the source of light; therefore, from the window, the wall looked all white.
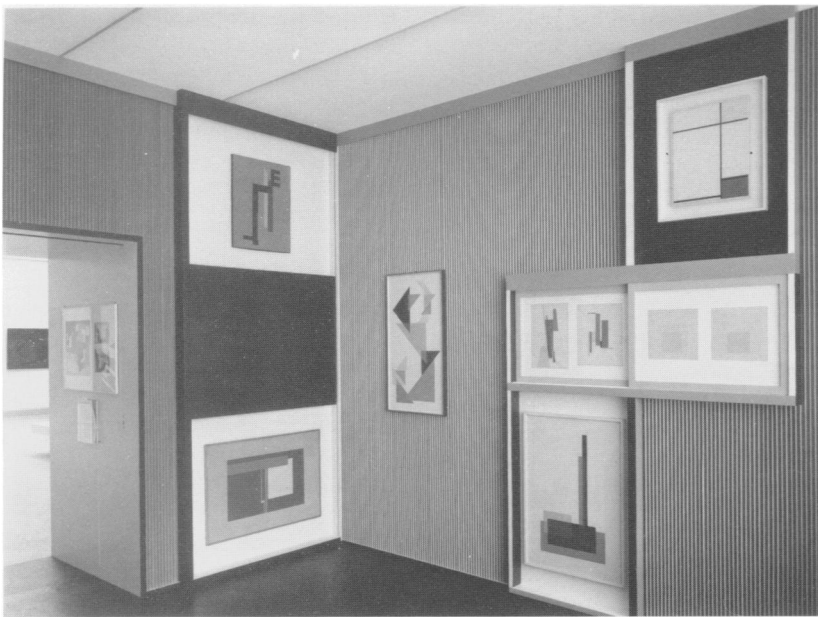
Fig. 9. Reconstruction of Lissitzky's Second Exhibition Room in Hanover Provinzial-museum, 1927–1928. (Niedersachsische Landesgalerie, Hanover, 1968. Photo: Foto-Hoerner, Hanover.) Right-hand wall, seen from the window. Next to the door, Lissitzky placed a vertical frame containing a plate that could be moved to cover one of three paintings inside the frame, so that only two paintings were visible at any time. Another such vertical frame was installed on the left-hand wall (see Figs 7 and 8).
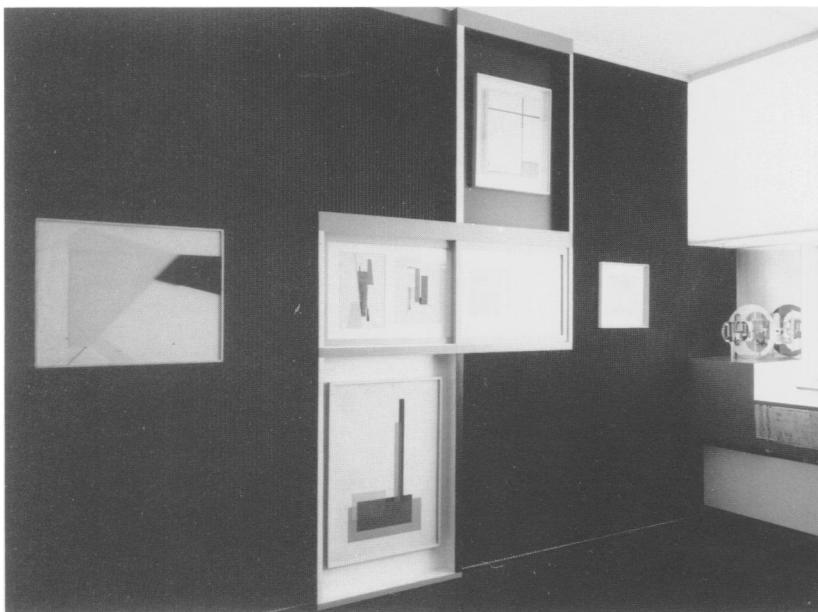

Fig. 10. Reconstruction of Lissitzky's Second Exhibition Room in Hanover Provinzial-museum, 1927–1928. (Niedersachsische Landesgalerie, Hanover, 1968. Photo: Foto-Hoerner, Hanover.) Right-hand wall, seen from the entrance. On the right-hand wall, Lissitzky placed a horizontally sliding plate that covered either of the two paintings placed inside the frame.

were given in Dresden (1926) or in Hanover (1927); on the contrary, in these spaces, visitors were expected to move about freely, retracing their steps or standing in front of a wall and moving their eyes, head and body to the left and to the right. It was only by moving that the spectator could experience and appreciate the changes in the colors of the wall—from black to gray to white (Figs 6, 7 and 8). Moreover, the sliding plates inside the horizontal and vertical frames encouraged the spectator to move the plates to and fro and thus to interrupt the straight continuity of the wall line (Figs 9 and 10). In so doing, the spectator was describing an imaginary space [82].

The very notion of an imaginary space in art distanced Lissitzky from Russian Constructivism, and also from Malevich. On the one hand, Lissitzky proposed a dematerialized object and an abstract, dematerialized space in place of the Constructivist culture of materials; on the other hand, imaginary space differed from Malevich's idealist transcendental space, since Lissitzky never wished to reveal to the viewer a transcendent reality, unless one considers Einsteinian four-dimensional space unreal [83]. For Lissitzky, dematerialized imaginary space was comparable to modern mathematics and physics. Just as modern mathematics transcended matter, monumental art, hewn in granite and cast in bronze, was replaced by a transitory art, an art deprived of its corporeality. He had arrived, in his own words, at "an a-material materiality" [84]. That is, although imaginary space transcended material experience, Lissitzky's ultimate interest was real space and real material life. He felt that the development of abstraction could be detected in modern technology, for instance, in the new communication systems [85]; and he foresaw the 'dematerialization' of books as well: "The printed sheet, the infinity of the book, must be transcended. THE ELECTRO LIBRARY" (Lissitzky's emphasis) [86].

The analogy between imaginary numbers and abstract space, on the one hand, and Lissitzky's project for imaginary space, on the other hand, elucidates the theoretical base of his exhibition spaces and provides a theoretical explanation of the kinetic art of his time. Furthermore, it adds yet another facet to his relationship with Malevich. Imaginary space, far from repudiating Suprematism, was indeed its logical continuation.

Art, for Lissitzky, was not limited to the representation of concrete, observable phenomena; rather, it was—like the modern notion of numbers, concepts and space—a pure construction of the mind. Aware that his theory of art with its analogy to mathematics might be misinterpreted, Lissitzky explained that he was neither a metaphysician nor a pseudo-mathematician. His concept of modern art, he argued, was indissociable from the modern understanding of the world and consistent with new developments in science and technology. It was, moreover, a battle against death, for stopping at concrete numbers and depicting objects meant death: the arrest

of the march of human thought and human creativity [87].

Although the formal vocabulary of Lissitzky's art was related to Suprematism and Constructivism, his theory of art, informed by his knowledge of the exact sciences, distinguished him from both these schools. Lissitzky's indifference to metaphysical problems, his concept of the necessary interdependence of the spiritual and the scientific, of intuition and intellect, and his refusal to sacrifice art on the altar of industrial production appealed to many eastern and central European artists. His subsequent stay in Germany (and in Switzerland) from 1922 to 1925, during the crucial years when International Constructivism was formed, made Lissitzky a central figure of the avant-garde.

References and Notes

1. Lissitzky's analogies between art and mathematics have been undervalued recently; Peter Nisbet claims that the artist's references to mathematics and to Einstein's physics were modern metaphors, mere substitutes for images from nature. I disagree with his opinion that "underlying most of these (references) is a predilection for invocations of natural growth and biological processes" (Peter Nisbet, "An Introduction to El Lissitzky", in *El Lissitzky 1890–1941* [Cambridge, MA: Harvard University Art Museums, Busch–Reisinger Museum, 1987] p. 28).

2. El Lissitzky, "Proun", trans. John E. Bowlt, in *El Lissitzky* (Cologne: Galerie Gmurzynska, 1976) p. 60. On Lissitzky's understanding of Minkowski, see Linda Dalrymple Henderson, *The Fourth Dimension and Non-Euclidean Geometry in Modern Art* (Princeton, NJ: Princeton University Press, 1983) pp. 294–299.

3. El Lissitzky, "Suprematism in World Reconstruction", in Sophie Lissitzky-Küppers, *El Lissitzky, Life, Letters, Texts*, 2nd Ed. (London: Thames and Hudson, 1980) p. 331.

4. Lissitzky [2] p. 67.

5. El Lissitzky, "A. and Pangeometry", in Lissitzky-Küppers [3] p. 355.

6. Lissitzky [2] p. 61. I agree with Alan C. Birnholz that this text must have been the lecture Lissitzky delivered at INKhUK on 23 September 1921, not, as suggested by John E. Bowlt, on 23 October 1924. To Birnholz's arguments should be added the simple fact that the latest possible meeting of INKhUK was at the end of March 1924. See Alan C. Birnholz, "Review of *El Lissitzky*", *The Structurist*, No. 15/16 (1975) p. 176. For the list of INKhUK lectures and their dates, see C. Lodder, *Russian Constructivism* (New Haven and London: Yale University Press, 1983) pp. 93–94 and p. 281 n. 85. There exist three different versions of "Proun". One is the text of the lecture translated into English and German and published in the Galerie Gmurzynska cataglogue (see Lissitzky [2]). Another, published by Lissitzky in *De Stijl* 5, No. 6 (June 1922), was translated into English and published in Lissitzky-Küppers [3] pp. 347–348. A third version, presumably the earliest, has not yet been translated from the Russian; it was published as "Tezisy k prounu" (Theses on the Proun [From Painting to Architecture]), in M. Barkhin et al., eds., *Mastera sovetskoi arkhitektury ob arkhitekture* (Soviet master architects on architecture), Vol. 2 (Moscow: Iskusstva, 1975) pp. 133–135.

7. The literature on both Suprematism and Rus-

sian Constructivism is vast; however, the following two works are particularly helpful for assessing the essential differences between these movements and Lissitzky: E. Martineau, *Malévitch et la philosophie* (Lausanne: L'Age d'Homme, 1977); and Lodder [6].

8. "The meaning of the new art is not to represent, but to form something independent of any conditioning factor" (El Lissitzky, "From a Letter", in Lissitzky-Küppers [3] p. 358). Lissitzky refrained from using the term abstract, for "it is impossible to make a direct equation between mathematical, extra-material abstractions and that which in painting has acquired the unfortunate name of 'abstract'." Lissitzky [2] p. 61.

9. Lissitzky [2] p. 61.

10. Lissitzky [2] pp. 61–62. It should be noted, however, that even though classical Greek mathematics was concerned with concrete magnitudes, the importance of a book like Euclid's *Elements* lies in the fact that the concepts employed were totally abstract. Greek mathematicians were unconcerned with practical problems. See C. B. Boyer, *The History of Mathematics* (New York: John Wiley & Sons, 1968) p. 111.

11. Lissitzky [2] p. 62. Nisbet notes that Lissitzky's mathematical examples are repeated verbatim from Oswald Spengler's *The Decline of the West*. Indeed, the latter's theories of a fundamental relationship between art and mathematics were widely known in Moscovite Constructivist circles, and Nikolaï Tarabukin also referred to them more than once. It is nevertheless certain that Lissitzky used the knowledge gained through Spengler to elaborate a theory of non-objective art with analogies to mathematics totally independent of Spengler. See Nisbet [1] p. 29 and p. 49 n. 56. For Tarabukin, see N. Taraboukine, "Pour une théorie de la peinture", in *Le dernier tableau*, A. B. Nakov, ed., A. B. Nakov and M. Pétris, trans. (Paris: Editions Champ Libre, 1972).

12. Lissitzky's interpretation of Malevich's use of abstract geometric forms is only one possibility. For a study of the influence of P. D. Ouspensky and other related theories of the fourth dimension, see Henderson [2] pp. 274–294.

13. Lissitzky [2] pp. 63–64.

14. Lissitzky [2] p. 64.

15. Geometric forms are the creations of human beings; in a letter to J. J. P. Oud, Lissitzky wrote that he did not understand the Dutch point of view and that he disagreed with the equation "Universal = Straight Line + Vertical". In the universe, he wrote, "there are only curvatures and no straight lines" (*El Lissitzky* [2] p. 73).

16. Lissitzky [2] p. 62.

17. El Lissitzky, "New Russian Art", in Lissitzky-Küppers [3] p. 338.

18. Lissitzky [2] p. 62.

19. Lissitzky [2] p. 64. Since Lissitzky's intention in this sentence is clearly connected with the theory of sets, the mathematical term 'classes' seems more appropriate here than the term 'categories' used by John E. Bowlt in his translation. I wish to thank K. Rubinger of the Galerie Gmurzynska for providing me with the original Russian text.

20. For a detailed account of these debates and the differences between composition and construction, see Lodder [6] pp. 83–89; and M. Rowell and A. Zander Rudenstine, *Art of the Avant-Garde: Selections from the George Costakis Collection* (New York: The Guggenheim Museum, 1981) pp. 25–27, 226–227.

21. Lissitzky [2] pp. 62–63.

22. Lissitzky [2] p. 64.

23. On the debate on Malevich, see V. Rakitin, "Malevich and INKhUK", in *Malevich* (Cologne: Galerie Gmurzynska, 1978) pp. 288–294.

24. On Lissitzky's Constructivist interpretation of

Suprematism, with reference to other aspects of his thought, see M. Perniola, *L'aliénation artistique* (Paris: Union générale d'éditions, collection 10/18, 1977) pp. 294–295; and A. Turowski, *Existe-t-il un art de l'Europe de l'Est? Utopie et idéologie* (Paris: Les éditions de la Villette, 1986) pp. 117–119.

25. On the utilitarian idea that emerged from the composition and construction debates at INKhUK, see Lodder [6] pp. 94–98.

26. "New Russian Art" [17] p. 340.

27. E. Cassirer, *Substance and Function & Einstein's Theory of Relativity* (New York: Dover Publications, 1953) p. 90.

28. Taraboukine [11] p. 128.

29. "We acknowledge works which contain a system within themselves, a system which has not been evolved before the work started but has evolved in the course of it" (El Lissitzky, "Nacsi", in Lissitzky-Küppers [3] p. 351).

30. For a reproduction of *Proun 43* (1924), see Lissitzky-Küppers [3] Fig. 35.

31. Numerous other artists of the avant-garde were developing the notion of the game of art; however, since no other artist besides Lissitzky compared art-games with formalist mathematics, their theories are not relevant to the argument I present here.

32. Lissitzky [2] pp. 64–65.

33. For the definition of game as an autonomous rule-governed activity, see G. Boss, "Jeu et Philosophie", *Revue de Métaphysique et de Morale* 84, No. 4 (1979) p. 495. Boss's definition is based on Roger Caillois, *Man, Play, and Games* (New York: Free Press of Glencoe, 1961) pp. 9–10.

34. E. T. Bell, *The Development of Mathematics*, 2nd Ed. (New York: McGraw-Hill, 1945) p. 182.

35. Cassirer [27] pp. 83, 93.

36. On the element of game in Lissitzky's work, see my paper, "El Lissitzky's Art-Games", *Neohelicon* 14, No.1 (December 1987) pp. 177–191.

37. "Suprematism in World Reconstruction" [3] pp. 331–333.

38. At the Düsseldorf Congress of International Progressive Artists (1922), Lissitzky stated: "The new art is founded not on a subjective, but on an objective basis. This, like science, can be described with precision . . ." (S. Bann, *The Tradition of Constructivism* [London: Thames and Hudson, 1974] p. 63). At another time, he stated that "emptiness, chaos, the unnatural, become space, that is: order, certainty, plastic form" (El Lissitzky, "Proun", in Lissitzky-Küppers [3] p. 347).

39. In his *Principles of Mathematics*, Bertrand Russell explained that "quantity . . . does not occur in pure Mathematics. . . . The notion which does occupy the place traditionally assigned to quantity is *order*" (as quoted in Cassirer [27] p. 95).

40. K. Malevich, *Essays on Art, 1915–1928*, Vol. 1, T. Andersen, ed., Xenia Glowacki-Prus and Arnold McMillin, trans. (Copenhagen: Borgen, 1971) pp. 190, 192. For Malevich's idealist transcendental philosophy, see M. Lamach and J. Padrta, "The Idea of Suprematism", *Malevich* [23] pp. 134–180.

41. Malevich [40] p. 38.

42. According to Jean Leering, Lissitzky, despite his rationality, saw in art a creation beyond the rational. See Jean Leering, "Lissitzky's Importance Today", in *El Lissitzky* [2] p. 35. See also F. Pluchart, "Lissitzky, romantique et ingénieur de futur", *Art International* 10, No. 2, 16–18 (1966).

43. "A. and Pangeometry" [5] p. 352.

44. Alan C. Birnholz, "Time and Space in the Art and Thought of El Lissitzky", *The Structurist*, No. 15/16 (1975) p. 90.

45. N. I. Lobachevsky, *Pangeometry* (Kazan, 1855).

On Lobachevsky's fame and importance in Russia at the beginning of the twentieth century, see Henderson [2] pp. 241–245. See also R. Crone, "Malevich and Khlebnikov: Suprematism Reinterpreted", Artforum 17, No. 4, 38–48 (1978).

46. N. Bourbaki, *Eléments d'histoire des mathématiques* (Paris: Hermann, 1969) pp. 26–27.

47. "Suprematism in World Reconstruction" [3] p. 333.

48. "New Russian Art" [17] p. 337.

49. "New Russian Art" [17] p. 338.

50. "New Russian Art" [17] p. 339.

51. El Lissitzky, "Exhibitions in Berlin", in Lissitzky-Küppers [3] p. 345. It is interesting to note that Lissitzky's views are shared by researchers currently studying the psychology of artistic creativity. According to Anton Ehrenzweig, creativity involves a conflict between two kinds of sensibility: unconscious intuition and conscious intellect. Creation starts in the unconscious as an undifferentiated primary process, but a creative work is the result of the successful coordination of unconscious undifferentiation and conscious differentiation. See A. Ehrenzweig, *The Hidden Order of Art* (Berkeley and Los Angeles: University of California Press, 1971) p. 44.

52. Bell offers the following comments on the abstract nature of geometry: "The logical analysis of geometry ... made it plain to all ... that geometry is an abstract hypothetico-deductive system without intrinsic content other than that implied by arbitrarily prescribed sets of postulates" (Bell [34] p. 330). See also "A. and Pangeometry" [5] p. 355.

53. James W. Armstrong, *Elements of Mathematics* (London: Macmillan, 1970) p. 9.

54. According to Bell, "the deflation of older beliefs comprises the main contribution of non-Euclidean geometry to mathematical thought as a whole, and also perhaps, the principal contribution of mathematics to the progress of civilization" (Bell [34] p. 330).

55. "A. and Pangeometry" [5] p. 355. On the relationship between non-Euclidean geometries and the relativity of knowledge, and hence doubt, see Henderson [2] p. 17.

56. Lissitzky [2] p. 63.

57. On these traits in Lissitzky's work, see Alan C. Birnholz, "'For the New Art': El Lissitzky's Prouns", Artforum 8, No. 2, 65–67 (1969) and No. 3, 68–73 (1969). See also Birnholz, "Notes on the Chronology of El Lissitzky's Proun Compositions", Art Bulletin 55, No. 3, 437–439 (1973).

58. "Suprematism in World Reconstruction" [3] p. 331.

59. Lissitzky [2] p. 70.

60. "A. and Pangeometry" [5] p. 353.

61. "A. and Pangeometry" [5].

62. Bell [34] p. 220.

63. On zero in Malevich's thought, see Y. A. Bois, "Malévitch, le carré, le degré zéro", Macula, No. 1 (1978) pp. 28–48.

64. Lissitzky wrote that "it has been said that the centuries have brought painting right up to the square, so that here they can find their way down. We are saying that if on the one side the stone of the square has blocked the narrowing canal of painting, then on the other side it becomes the foundation-stone for the new spatial construction of reality" ("New Russian Art" [17] p. 338). The same idea is found in Lissitzky [2] p. 64.

65. "A. and Pangeometry" [5] p. 354. Here Lissitzky echoes Malevich: "The Suprematist system has conquered the blue of the firmament, heaven is pierced and has entered white as the true representation of infinite.... I have pierced the blue lampshade of coloured limitation, I have come out into the white ... " (quoted in *Le miroir suprématiste*, J. C. Marcadé, ed., V. and J. C. Marcadé, trans. [Lausanne: L'Age d'Homme, 1977] pp. 82–84).

66. Zeno's paradox is as follows: One cannot get to the end of a racecourse, for one must traverse half of any given distance before one traverses the whole, and half of that again, and so on, ad infinitum; hence, there is an infinite number of points on any given line, and one cannot touch an infinite number one by one within a finite time. See Bell [34] p. 64.

67. An infinite set is one that can be put into a one-to-one correspondence with a proper subset of itself; a finite set is one that cannot be put into one-to-one correspondence with any of its proper subsets. See Armstrong [54] pp. 98–100. See also G. Cantor, *Contributions to the Founding of the Theory of Transfinite Numbers*, Notes and Introduction by P. E. B. Jourdain (New York: Dover Publications, 1915). On the historical problem of infinites and Cantor's theory of sets, see Bourbaki [46] pp. 39–50.

68. On the difference between Malevich's concept of "an absolute 'receptacle' of infinite, white space" and Lissitzky's concept of infinite in the sense of Einstein's curved space-time continuum and the artist's use of the concept in the Prouns, see Henderson [2] pp. 294–295. See also Alan C. Birnholz, "El Lissitzky" (Ph.D. dissertation, Yale University, 1973) pp. 78–79. On axonometry and other aspects of Lissitzky's interpretation of Suprematist space, see Y. A. Bois, "Lissitzky, Malevich and the Question of Space", in *Suprématisme* (Paris: Galerie Jean Chauvelin, 1977) pp. 29–48.

69. According to Tarabukin, the problem of time in painting was evoked for the first time (in relationship with the introduction of a fourth dimension in mathematics) by Minkowski, Riemann and Lobachevsky. Tarabukin adds that Spengler had never mentioned this, since he "treated all manifestations of contemporary art with a contemptuous silence" (Taraboukine [11] p. 132).

70. Lissitzky [2] p. 63. For other interpretations of the importance of time in Lissitzky's work, see Birnholz [44].

71. The reversibility of the Prouns is explored by Birnholz in [68] pp. 97–98, and in [44] p. 92. For the theoretical importance of reversibility, see also Bois [68] p. 38.

72. "A. and Pangeometry" [5] p. 355.

73. On imaginary (complex) numbers, see B. W. Jones, *Elementary Concepts of Mathematics*, 3rd Ed. (London: Macmillan, 1970) pp. 136–138. On the introduction of imaginary numbers for the solution of equations, see Bourbaki [46] pp. 96–97.

74. On complex numbers in advanced calculus, see Boyer [10] pp. 562–564.

75. Abstract space has been defined as "a set of objects, usually called points, together with a set of relations in which these points are involved" (H. Eves, *An Introduction to the History of Mathematics*, 3rd Ed. [New York: Holt, Rinehart and Winston, 1969] p. 370).

76. On this subject, see Henderson [2] p. 297.

77. El Lissitzky, "Vicking Eggeling", *Izvestiya Asnova*, No. 1 (1926), in S. Lissitzky-Küppers and Jen Lissitzky, *El Lissitzky, Proun und Wolkenbügel, Schriften, Briefe, Dokumente* (Dresden: VEB Verlag der Kunst, 1977) p. 206.

78. "A. and Pangeometry" [5] p. 356.

79. "A. and Pangeometry" [5] p. 357.

80. Lissitzky never mentioned Duchamp, but he knew Man Ray's work well. Since Man Ray photographed Duchamp's *Rotary Glass Plates*, Lissitzky could have heard of it. On Lissitzky's acquaintance with Man Ray, see Lissitzky-Küppers [3] pp. 66–67.

81. El Lissitzky, "Proun Room, Great Berlin Art Exhibition", in Lissitzky-Küppers [3] p. 365.

82. For a detailed study of Lissitzky's exhibition spaces in Dresden and Hanover and of his later Soviet pavilions at international exhibitions, see Birnholz [69] pp. 378–393, 430–432.

83. For a different view of Lissitzky's abstract-dematerialized space, this time in connection with Gabo's and Moholy-Nagy's ideated spaces, see Rosalind E. Krauss, *Passages in Modern Sculpture* (Cambridge, MA, and London: MIT Press, 1981) pp. 55–67.

84. "What is particularly important for us, however, is that this A.F. [Art Form] should effect the destruction of the old idea of art, that of 'monumentality' ... for us monumental does not imply a work which will stand there for a year or a hundred years or a thousand years, but the perpetual expansion of human achievement" ("A. and Pangeometry" [5] p. 357).

85. El Lissitzky, "Our Book", in Lissitzky-Küppers [3] pp. 360–361.

86. El Lissitzky, "Topography of Typography", in Lissitzky-Küppers [3] p. 359. The notion of the dematerialization of contemporary culture was much discussed in the Constructivist circles in Moscow, especially in three lectures given by Boris Kushner at INKhUK in March 1922. Kushner and Tarabukin saw dematerialization as part of the new industrial production, as in, for example, electric energy, where the end product is not a material object but light, heat, etc. For Kushner's lectures, see Lodder [6] pp. 93, 100–101. For Tarabukin's views, see N. Taraboukine, "Du chevalet à la machine", in *Le dernier tableau* [11] p. 61.

87. Lissitzky [2] p. 71.

88. The equations are from Lissitzky [2] p. 67.