Unfoldings

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Photograph by Traci Daniels, 1991

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Unfoldings by Caryn L. Johnson

Submitted to the Department of Architecture on May 8, 1992,
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Abstract

Unfoldings examines connections between play, visual art, and mathematics.

Huizinga's analysis of play, described in his text *Homo Ludens*, is compared to the creative process in art-making and to the creative response of the viewer. The play process is examined through questionnaire responses and observations made during an evening of experimental play.

Huizinga's assertion that play is not a factor in the plastic arts is challenged. Refutations and counterexamples drawn from the history of art since the Renaissance show that play is indeed a factor. The artistic movements cited are those which provide examples of works having either particularly playful or particularly mathematical content, or both, including Anamorphic painting; Dada; Bauhaus; Neo-Plasticism; Concrete Art; Op Art; Fluxus; and Kinetic Art. Special attention is given to the works of Alexander Calder, George Rickey, and Yaacov Agam.

The author describes a personal iconography, and introduces the geometric foundation of her sculptural works, which derive from the geometry of R. Buckminster Fuller's "vector-equilibrium jitterbug." Descriptions, photographs, and drawings are included for the author's Thesis Project, comprising several kinetic, manipulatable jitterbug sculptures.

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Introduction

My artistic work centers around the meeting point of mathematics, visual art, and play. The blurring of dividing lines among these modes is my inspiration, prompting me to consider such questions as:

- When does a sculpture become a toy? Particularly, when does a geometric kinetic sculpture become a mathematical toy, and what is the power of that toy/ sculpture to prompt discovery, to become a tool for understanding space?
- What is the role of play in the creative process, and in the viewers' response to artistic works, particularly to works with strong mathematical content?
- Do artists inform and teach through play? Do spectators learn through play?
- How do artists whose work is fundamentally geometric, or who employ geometric symbolism, analyze and discuss the geometric content and concepts of their work?
- Are there deeper meanings to other artists' geometric icons as there are in my own work?

Most people do not see mathematics and art as having any connection. I view mathematics as a collection of specialized languages for discussing, in the abstract and as precisely as possible, characteristics of the observed world, and characteristics of "logically possible" worlds. Algebra is a language for describing quantities and their combinations, geometry is a language for describing the attributes of space and dimension, the calculus is a language for discussing the characteristics of change, and so on. These languages have their origin and foundation in observations of relationships in the real world on the one hand, and in the development of logic and discursive reasoning on the other hand. The visual arts have their foundation in the process of representation of worldly objects and phenomena on the one hand, and in intuitive, purely conceptual creative actions on the other hand. Anything that shifts between these modes must merge the rational with the intuitive, the logical with the extra-logical.

I posit that play is one such bridge, that it is a fundamental activity permeating all cultural forms, and an essential element of the creative process in the visual arts. I also posit that, when an artistic work provokes a playful response in the viewer, the viewer's experience of that work changes. I test this thesis against the opinions of a number of artists whose work is related to or has inspired my own, as well as comparing it to the responses of a group of test subjects.

My sculptures—hinged geometric sculptures in wood, plastic, metal, and glass—are human-scale, some intended to be held in the hands, some to be moved using the whole body. They continually shift across the line dividing sculpture from toy, sculpture from mathematical model.

The elements of my sculptures derive from branches of mathematics that deal with form and dimension: geometry and group theory (the branch of mathematics that categorizes spatial symmetries). Other mathematical disciplines dealing with space—topology and relativity, for example—have greatly influenced the field of visual arts, for investigations in these disciplines complement artistic explorations of figurative representation and perspective, of distortion and twist, of time as an artistic dimension, of symmetry and asymmetry in decorative pattern and in composition, and of the visual power of pure form. I posit connections between play and the artistic expression of these influences.

This thesis results from an on-going inquiry into these questions. The territory I am exploring is rich, and what follows is a record of the results of my prospecting in a favorite lode.

Acknowledgments

I owe an enormous debt of thanks to a great many people who have helped me along the path that has led to this exploration and this thesis. Some have guided, some have accompanied me, and some have gotten behind me and pushed when I didn't think I could go any further. To all of those people, I offer my heartfelt gratitude. Were I to list all of their names, the list would be nearly as long as the thesis itself, but I must express my written thanks to a crucial few:

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>
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Characteristics of Play

In examining the meeting point of art, geometric mathematics, and play, I investigated play first. I find play very closely related to creativity both in character and in action, and sought substantiation of that view. I wanted to understand what play means to the participants in a game, to examine the aspects of play that come into the creation of a game, a toy, or anything else to which people respond in a playful manner, and then to consider the aspects of geometry that connect to art/play.

The seminal work in this field is *Homo Ludens: A study of the play element of culture*, by Johan Huizinga. I find most of Huizinga's account accurate, succinct, and compelling in its descriptions of the fundamental characteristics of play in its many forms and aspects. Huizinga exposes the play characteristics of myth, ritual, language, law, philosophy, and war. He demonstrates ties between play and poetry, play and music, play and dance. In all of these pursuits he shows that the power of play to introduce order, to make the mysterious in some way comprehensible and to move the players outside the ordinary into the mystical, is an essential feature separating out particular subsets of these social forms. Huizinga's analysis is not flawless, however.

"Haiti, 1950"

Huizinga's Analysis of Play

Huizinga sets out to show that "genuine, pure play is one of the main bases of civilization" and that play falls among human pursuits as a "special form of activity:"

> existing before culture itself existed, accompanying it and pervading it from the earliest beginnings right up to the phase of civilization we are now living in. [1]

Huizinga examines the characteristics of play, the aspects of play that make it significant for the players, that separate it as an activity from the rest of life, while trying to, as he puts it, "avoid the philosophical short-circuit that would assert all human action to be play."[2] Unlike researchers in biology and psychology, who seek a physiological or a psychological basis for play, Huizinga seeks to discover what it is about play that makes it "fun," just as I have. In play's diverse forms, he finds the following four essential characteristics:

- play is voluntary
- play takes the participants outside of "ordinary" or "real" life
- play is separated from ordinary life in space and time, taking place in its own "magic circle"
- play creates order.

I summarize Huizinga's justifications for these propositions and add comparisons to the creative process in the sections below.

Play and Volition

Regarding the assertion that play is voluntary, Huizinga claims:

> Play to order is no longer play: it could at best be but a forcible imitation of it. By this quality of freedom alone, play marks itself off from the course of the natural process. . . . It is never a task. It is done at leisure, during "free time." Only when play is a recognized cultural function—a rite, a ceremony—is it bound up with notions of obligation and duty. [3]

Thus one cannot be compelled to either create or join the magic circle of normal play—being coerced into playing takes the fun out of it. In ritual, there are other elements 'coming into play,' so to speak, as the community gathers for the purpose of commemorating or anticipating some real or mythic event, participating in that event through the special means of re-presentation or symbolic foretelling. Participation in such ritual is an extension of participation in society as a whole: members of the society are expected to share in rituals in the same way they are expected to share in the other tasks of community life.

Though Huizinga does not discuss the perspective of the outsider, one cannot demand entrance to the magic circle either, as that is tantamount to demanding that those involved in the game "play to order" for the one who wishes to join.

It is possible, however, to invite or entice someone into play, to join the game, and it is possible for an outsider to request to join. The invitation or the request, and the response on either side, must be done delicately, or else the spell of play is broken. Entering the game means both accepting, and being accepted into, a special, temporary society created by the players. This invitation and acceptance have a special bearing on the role of play in the visual arts, as the material in the following chapter demonstrates.

Play and "Real Life"

The separation of play activity from "ordinary" life is, in Huizinga's terms, a distancing in both thought and action:

> [it is] a stepping out of "real" life into a temporary sphere of activity with a disposition all of its own. . . . It stands outside the immediate satisfaction of wants and appetites, indeed it interrupts the appetitive process. [It is] an intermezzo, an interlude in our daily lives. [4])

The word *interlude* is curiously self-referential here, the Latin meaning being "in the midst of play." In a way, this statement presents play as a subtext of life-as-play, which robs the magic circle of its specialness, threatening to create the short-circuit Huizinga was trying to avoid. But the sense of the passage is clear. In play, one forgets, for a while, life's headaches and obligations, and allows imagination to redefine aspects of self, shape, and situation.

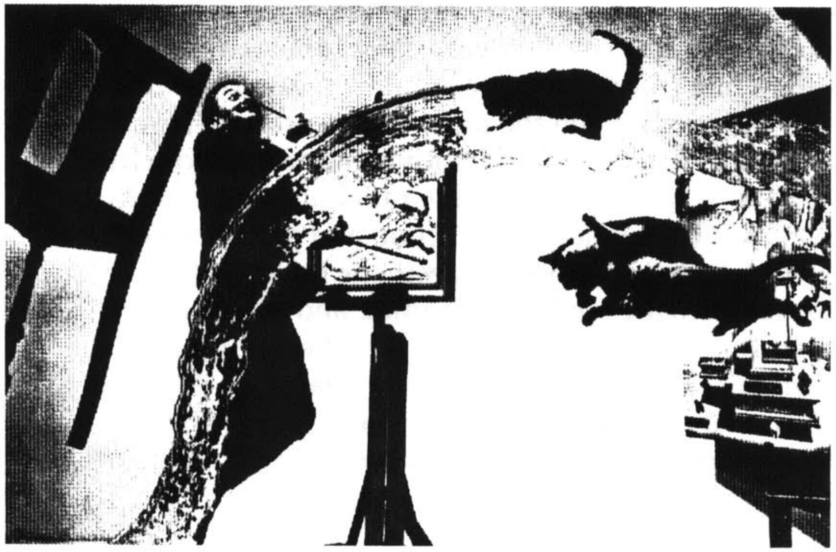
In this sense, play is transportive, leading the player out of the realm of normal thought and behavior, permitting the participants in the game to act in ways that are not necessarily dependent on either instinct or logic, but are instead based on imagination and intuition. Huizinga comments:

> Nevertheless, . . . the consciousness of play being "only a pretend" does not by any means prevent it from proceeding with the utmost seriousness, with an absorption, a devotion that passes into rapture and, temporarily at least, completely abolishes that troublesome "only" feeling. Any game can at any time wholly run away with the players. [5]

This is an aspect that play has in common with the creative process, with the products of intuition. Art is inherently intuitive, and cannot be reduced to the purely rational; even when the artist apparently starts with the ordinary stuff of life, and with ideas grounded in the everyday, the logical, and the rational, it is actually the process of invention, of selection and juxtaposition according to intuition and aesthetic judgment, of imbuing the forms with symbolic meaning and divesting them of their functional character that lifts the result out of the realm of the ordinary, beyond the realms of illustration, craft, and design, and into the realm of art. Théo van Doesburg recognized that this is not a logical, theoretic-discursive process:

> One of the most serious of the many reproaches leveled against modern artists is that they address themselves to the public not only through their works, but through their words as well. . . .
>
> This is the source of the misconception that the modern artist is too much of a theoretician and that his work springs from *a priori* theories. In fact, precisely the opposite is the case. The theory came into being as the necessary consequence of creative activity. Artists do not write *about* art, they write *from within art*. [6]
>
> The artist, and particularly the modern artist, sees nature creatively in that he gives form to his experience through pure artistic means, not arbitrarily, but according to the logical laws of his branch of art (these laws are the means of controlling creative intuition). [7]

Art-making is therefore either a form of play, or is closely related in character—another activity that can wholly run away with the participant, as perhaps it has in the following image:



"Dali Atomicus"

Huizinga continues:

> Play is distinct from "ordinary" life both as to locality and duration. It is "played out" within certain limits of time and place.
>
> Play begins, and then at a certain moment it is "over."... While it is in progress all is movement, change, alternation, succession, association, separation.
>
> More striking even than the limitation as to time is the limitation as to space. All play moves and has its being within a playground marked off beforehand either materially or ideally, ... forbidden spots, isolated, hedged round, hallowed, within which special rules obtain, ... temporary worlds within the ordinary world, dedicated to the performance of an act apart. [8]

Huizinga presents this aspect of play as the physical analogue of the spiritual distancing described above. As the psychic character of play is special, extra-ordinary, so the physical aspects, space and time, are invested with special status.

However, though the physical space of play is special, I disagree that the playspace actually needs to be that physically distant from areas of normal activity. In fact, play in the open takes on a special atmosphere—it is bold, it is adventurous, it challenges those nearby folk who are engaged in normal pursuits to dare to step out of the mundane.

Huizinga comments on the importance of boldness, of risk in play:

> To dare, to take risks, to bear uncertainty, to endure tension—these are the essence of the play spirit. Tension adds to the importance of the game and, as it increases, enables the player to forget that he is only playing. [9]

Playing in public may, in fact, change the attitude of the players. They may think not "we are only playing," but "everyone else is only going about their business," turning play into celebration, as in the two images below by Dolf Kruger and Alexander Calder.

"Rapenburgerstraat"

Is the physical distance Huizinga describes also an element of the creative process in the visual arts? Does the artist separate himself or herself from the ordinary world, entering a "temporary world within the ordinary world, dedicated to the performance of an act apart"?

Traditionally, until the past century or so, the answer has been yes. The artist worked within a studio, or a salon, in order to create without distractions, to set up models and lighting where they would not be disturbed, and to keep from contaminating art materials with everyday materials and vice versa.

Firemen's dinner for Brancusi[1]

However, within the past century, various trends have, in some measure, dissolved the walls around the artist. The whole of 20th century art is filled with movements whose stated aim was to take art out of the museum and salon, out of the studio, to intentionally contaminate art materials with everyday materials—to make everyday materials themselves into art materials. Art schools and circles of artists strove to take access to art out of the province of the elite, to connect the artist to the common citizen, to show that, in fact, the common citizen could be a maker of art, to apply the methods and intuitions of art to the creation of everyday things, and to make everyday activities into art activities, into "acts apart." Consider these descriptions of the foundations of Dada, the Bauhaus, and Fluxus:

---

[1] In a Greenwich Village restaurant decorated with a papier-maché horse's head, murals and a firemen's pole, Calder and a group of Whitney Studio Club members cavorted in honor of Brancusi's exhibition at the Joseph Brummer Galler, New York City, November 1926. Clockwise around the table are seen Alexander Brook, Yasuo Kuniyoshi, an orating Louis Bouché, a leaping Calder, Niles Spencer, Walt Kuhn, an unidentified figure, Donald Greason, another unidentified figure, Edmund Duffy, Art Young, and, on the pole, the athletic artist-brothers Robert and Charles Howard [10]

> **Dada:**
>
> It is hardly surprising that the mechanized mass killing of the First World War should have driven [Marcel] Duchamp to despair. Together with a number of others who shared his attitude, he launched in protest a movement called Dada. . . .
>
> Dada has often been called nihilistic, and its declared purpose was indeed to make clear to the public at large that all established values, moral or aesthetic, had been rendered meaningless by the catastrophe of the great war. During its short life, . . . Dada preached non-sense and anti-art with a vengeance.
>
> Yet Dada was not a completely negative movement. In its calculated irrationality there was also liberation, a voyage into unknown provinces of the creative mind. The only law respected by the Dadaists was that of chance, and the only reality that of their own imaginations. . . . Playfulness and spontaneity are . . . the impulses behind Duchamp's Ready-Mades, which the artist created simply by shifting their context from the utilitarian to the aesthetic. . . That artistic creation depends neither on established rules nor on manual craftsmanship . . . is an important discovery. [11]
>
> **Bauhaus:**
>
> Although the Bauhaus changed direction several times during its short life, it initially pursued three main aims. . . .
>
> The school's first aim was to rescue all the arts from the isolation in which each then (allegedly) found itself, and to train the craftsmen, painter and sculptors of the future to embark on cooperative projects in which all their skills would be combined.
>
> The second aim was to elevate the status of the crafts to that which the 'fine arts' then enjoyed. 'There is no essential difference between the artist and the craftsman' the Manifesto proclaims. 'The artist is an exalted craftsman. . . Let us then create a new guild of craftsmen without the class-distinctions that raise an arrogant barrier between craftsman and artist!'
>
> The third aim. . . was to establish 'constant contact with the leaders of crafts and the industries of the country.' [12]
>
> **The Fluxus Manifesto:**
>
> PURGE the world of bourgeois sickness, 'intellectual,' professional & commercialized culture, PURGE the world of dead art, imitation, artificial art, abstract art, illusionistic art, mathematical art—PURGE THE WORLD OF 'EUROPANISM'!
>
> PROMOTE A REVOLUTIONARY FLOOD AND TIDE IN ART. Promote living art, anti-art, promote NON ART REALITY to be grasped by all peoples, not only critics, dilettantes and professionals.
>
> FUSE the cadres of cultural, social & political revolutionaries into united front & action. [13]

Fluxus artists in particular pursued the goal of making not only works of art but the creative tools for making art available to the masses through their FLUXKITs and

FLUXYEAR boxes, described more fully in the next chapter.

Various 20th century artists have felt the need to go out into the world to make art, to capture the essence of things as they happen, as Walker Evans did when he photographed passengers on the New York subways. Alexander Calder went out into the world to create both out of desire and out of necessity:

> he had no studio, he lived and worked out of doors; already he sought action, light and movement. He was enthralled by the circus, the zoo, sporting events (Six-day Bike Race), and parties (Firemen's Dinner for Brancusi and The San Regis Restaurant). [14]

Like Evans, Calder made the daily commuter into one of his models:

> You folded a sheet of [a certain wrapping paper] into eight rectangles and it would fit in your pocket. With this we used to pass our time drawing people in the subway on our way to and fro. [15]

But he also felt the need for a workspace set apart from daily concerns, beginning with the workshops his family provided him throughout his childhood and young adulthood, and later his studios and workshops in France and the United States.

Hence art-making, like play, can be an intermezzo pursued in the special atmosphere of the studio but can also be 'an act apart' performed in the midst of worldly bustle.

Play and Order

Huizinga states:

> Inside the play-ground an absolute and peculiar order reigns. . . . Into an imperfect world and into the confusion of life it brings a temporary, a limited perfection[2]. Play demands order absolute and supreme. The least deviation from it 'spoils the game,' robs it of its character and makes it worthless. [16]

I agree with the proposition stated here, but I have a slight criticism of this passage—Huizinga has written it such that he has avoided discussing who or what imparts the order to the game. My hypothesis is that it is the game's inventor and its participants (who may themselves be the inventors) who mutually create and maintain the order Huizinga describes for the duration of the game. 'Order' here means two things: first, the existence of a set of rules for the behavior of players and the manipulation of objects (or, in the case of some games, Twenty Questions, for example, the "manipulation" of concepts), which I think of as the "structural order" of the play-circle, and second, the actual conformance of the players to the rules, which I think of as the "social order" of the play-circle. In other words, play succeeds only when the players know what they are to do and are doing it.

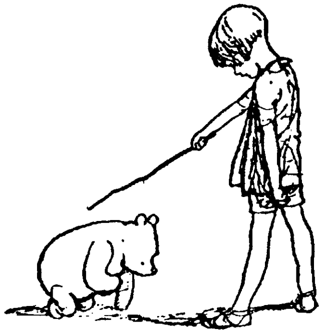
This touches upon my definition of the difference between a game and a toy, which has to do with both the physical qualities of the elements of the game or toy, and with the player's interpretation of the rules associated with those elements. In a game, the inventor has provided a specific set of rules that go beyond the pure formal possibilities of the game pieces, or in which there are no physical pieces at all, and the player or players try to follow those rules. In the case of a toy, the original inventor has provided an object, sometimes with a set of rules, or with suggestions for the method for play, but the player or players feel free to create new ways of playing with the object, or to create toys from objects not intended as toys (in which case they are themselves the inventor of the toy). The new ways of playing with the object are based on any or all of the following:

---

[2] By perfection and order Huizinga does not mean "predictability." He makes it clear that a game one can always win is no longer fun.

- the shape(s) of the pieces of the toy, or things that the shape suggests to the players

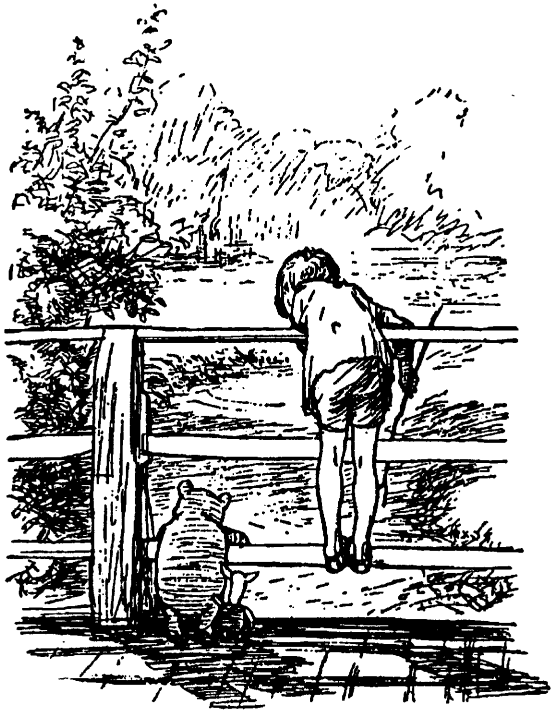
  This is the case when a player uses a stick as a wand; a sceptre; a conductor's baton; a twirler's baton; a sword; a strut for a kite; a stylus for drawing shapes in the sand or in the snow; and so on.



Christopher Robin knighting Pooh

- an idea a player comes up with that has little or nothing to do with the formal aspects of the object, but for which that object will serve because it is either related conceptually to the player's idea, or, simply, because the object happens to be at hand

  In this case, a player might use a stick as an object to tease a cat with, or as an object to throw for a dog to retrieve. Another example would be to use any object as a playing piece for something else, such as the shoe and hat pieces in Monopoly—the fact that they are shaped as they are has nothing to do with their meaning in the game, and any two small objects with distinct shapes would serve just as well. The object is, in a sense, a toy within a game. Here is an example:



A game of Poohsticks

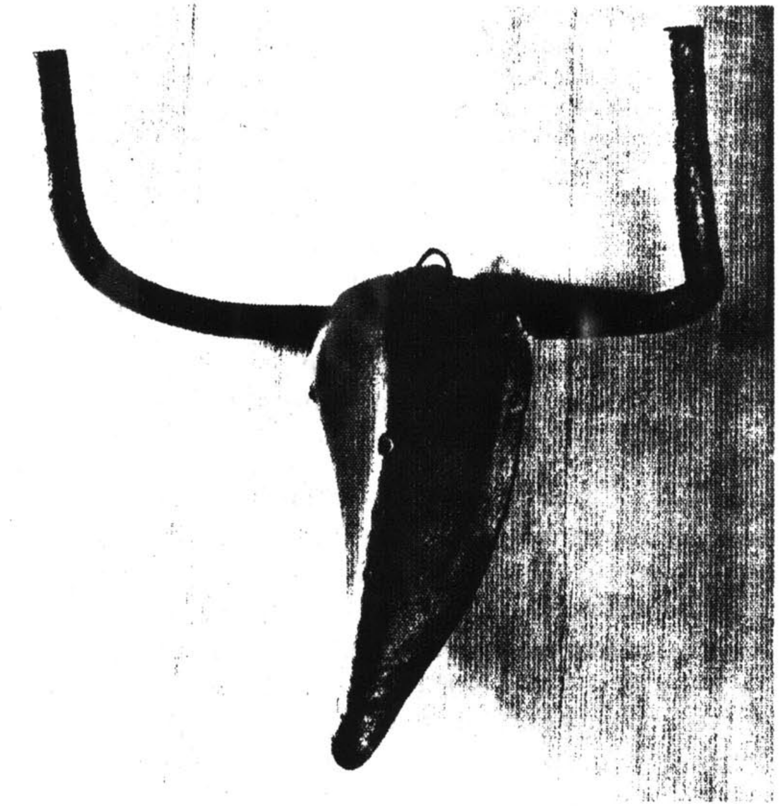
> [Pooh] had just come to the bridge; and not looking where he was going, he tripped over something and the fir-cone jerked out of his paw into the river.
>
> "Bother," said Pooh, as it floated slowly under the bridge, and he went back to get another fir-cone. . . . But then he thought that he would just look at the river instead, . . . so he lay down and looked at it, and it slipped slowly away beneath him . . . and suddenly, there was his fir-cone slipping away too.
>
> "That's funny," said Pooh. "I dropped it on the other side," said Pooh, "and it came out on this side! I wonder if it would do it again?"
>
> It did. It kept on doing it . . . and when he went home for tea, he had won thirty-six and lost twenty-eight, which meant that he was—that he had—well, you take twenty-eight from thirty-six, and *that's* what he was. Instead of the other way around.
>
> And that was the beginning of the game called Poohsticks, which Pooh invented, and which he and his friends used to play on the edge of the Forest. But they played with sticks instead of fir-cones, because they were easier to mark. [17]

Though A. A. Milne described this in the context of fiction, this is the process one goes through in real life of discovering a principle, and deciding to use it.

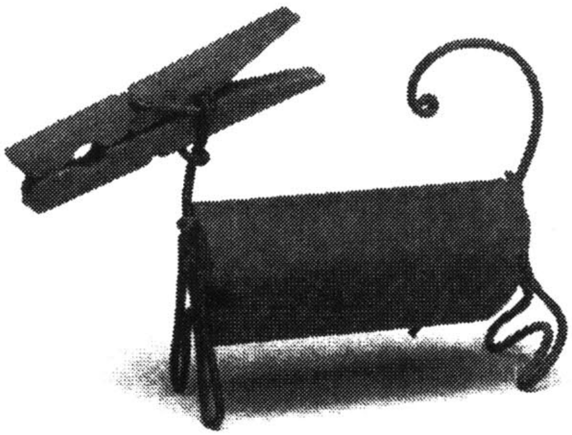
These two aspects of invention—shaping objects according to a concept on the one hand and creating a concept according to the suggestive power of a shape on the other—are the essence of the creative act, the process underlying image-making and sculpting. The artist either finds a suggestive form within an existing image, a block of wood or stone, a collection of objects, and builds upon that form (as in Picasso's "Bull's Head," Duchamp's "Ready-mades," or Calder's "Dog"), or begins with an idea and molds materials chosen to match that concept into a visual manifestation of the idea. The latter case is the more common one, but, as an example of the former case, Marchesseau notes:

> Calder's early [carved] wood sculptures show that he began by seeking in the shape of a stump the outlines that were best suited to the individual sculpture. This concern led him to rough out various caryatids and the curious figure of *Saint George Slaying the Dragon.* [18]

Thus, a person inventing ways of playing with a toy is an artist of a kind, though the object thus produced, the toy, serves a purpose different from the sculptor's creation.



Bull's Head by Picasso



Dog, by Alexander Calder, 1940

The idea that playing with a toy could be an expression of an inner artistic impulse was at the foundation of Baudelaire's 1853 article in Le Monde Litteraire, titled "La morale du joujou" (The moral significance of playthings) in which he commented,

> "a plaything is a child's first introduction to art, or rather, its first manifestation, and once he reaches adulthood, no other manifestation of art will fill his heart with the same warmth, the same enthusiasm, the same confidence." [19]

Playful Response

Having investigated creativity in art-making, I began to research playful responses to artwork, for the work serves as the invitation to join the magic circle, and, as mentioned earlier, the invitation must be carefully made and freely accepted.

Frank Popper writes, in his beautiful monograph on Yaacov Agam,

> In the postwar world, the cultivation of the play instinct was stimulated by the activity of the early 1950s. At the same time as the German progenitor of Concrete poetry, Eugen Gomringer, was putting forward his idea of the poem as *Spielraum* (area for play), Agam was developing a highly original attitude toward play in connection with the plastic arts: he was inviting the spectator to abolish the traditional antinomy between contemplation and action.
>
> His work . . . may be considered a stimulus to that specifically human creativity that the spectator possesses as well as the artist. For Agam, every human being is equal before the work, and there is no sense in which the highly cultivated or the highly intelligent should be regarded as privileged with respect to it. But at the same time each human being who participates in the work is engaging in the highest possible human activity, that of creation. [20]

Agam is by no means the first artist to express the idea that the creativity of the spectator is as fundamental to the success of a work as the creativity of the artist. In 1917 van Doesburg wrote

> the observer himself shares inwardly in the creation and to this extent the process may be described as a new re-creation in the consciousness of the observer. This, the *creative* way, is the only true way of looking at visual art. There is none other, either for classical or for modern art.[21]

In other words, the viewer cannot simply look at a piece passively, but must literally re-act toward the work, exploring and discovering the same visual territory as the artist who made the work in the first place.

Salvador Dali describes his sudden awakening to the magic of paintings through this same creative response:

> I was eating . . . all by myself, when I suddenly saw the pictures. They were the work of Ramón Pichot, who at the time was painting in Paris and much involved with Impressionism. I gazed in fascination at the spots of paint, apparently put on without any order, in thick layers, that suddenly shaped up magnificently, in one got the right distance away, into a dazzling vision of colors that communicated a deep, sun-soaked image of a stream, a landscape, or a face. I think my eyes were popping out of my head. Never had I experienced such a sensation of enchantment and magic. That, then was art! (Unspeakable p. 42*)

Endgame

"Play begins, and then at a certain moment it is over" (see quote on page 16). Huizinga doesn't spend much time discussing how one returns to 'real life' from the play world. From my observations, I conclude that the process of play ends under one of several circumstances:

1. both inventor and participants agree the game ends

   In this case, the inventor of the game provides a rule that defines the end of the game, and the participants agree that this concludes the process, the other options being to start the same game over or to shift to a new game, in which case the participants remain within the "magic circle."

2. the participants decide the game has ended

   This can happen three ways:

   i. the participants may select a stopping point not dictated by the rules provided by the inventor

   ii. in the case of a game which the players have redefined, they may mutually define an endpoint

   iii. the players' sense of involvement and excitement in the game may fade.

3. the discovery of an error or inconsistency in the rules or the lack of an endpoint defined by the game's inventor may "spoil the game"

   Here play dissolves into confusion—and, due to the extra-logical character of play, there is usually little recourse in the rational assessment of the situation. The magic of the game is usually preserved only if some one of the participants steps in to provide a new rule, and other participants accept both that person's authority and the rule itself.

4. a participant may change or break a rule

   Whether by error or by design, one participant's deviation from the rules of the game may produce the same dissolution as when the inventor's rubric fails.

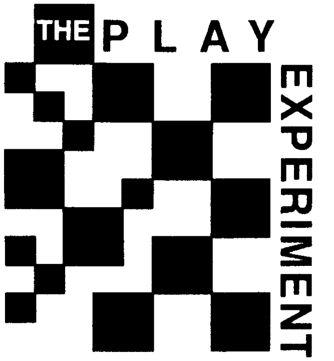
Huizinga does not explictly treat the first three of these outcomes, but he discusses this final case in some detail:

> . . . as soon as the rules are transgressed the whole play-world collapses. The game is over. The umpire's whistle breaks the spell and sets "real" life going again.
>
> The player who transgresses against the rules or ignores them is a "spoil-sport". The spoil-sport is not the same as the false player, the cheat; for the latter pretends to be playing the game, and, on the face of it, still acknowledges the magic circle. It is curious to note how much more lenient society is to the cheat than to the spoil-sport. This is because the spoil-sport shatters the play world itself. . . . He robs play of its illusion, . . . he is a coward and must be ejected. In the world of high seriousness, too, the cheat and the hypocrite have always had an easier time of it than the spoil-sports, here called apostates, heretics, innovators, prophets, conscientious objectors, etc. [22]

Huizinga's observations provide a fairly complete picture of play 'in the abstract,' but I felt that the only way to fill in missing elements and actually get a sense of the real human process and dynamic of play was to actually observe and engage in play. I needed both to see if Huizinga's analyses of the characteristics of play were borne out in action, and to test my comparisons of the dynamic of play with that of intuition and creativity, so I invented an observation game: The Play Experiment.

The Play Experiment

In order to obtain a better understanding of the actual interactions of game players and their responses to rules (particularly to shifting rules) and in order to collect a sampling of opinions about the play/art/math questions that interest me, I held an event called The Play Experiment on the evening of February 12, 1992. Approximately 35 people attended, mostly adults in their 20's and 30's, with two young participants (one age 2 and one age 9), and with a few participants in the 40 to 65 age range.



The event lasted from 6:30 to a little after 9:30 in the evening, and consisted of three sessions: 1 hour and 15 minutes of "Unstructured Play," about an hour of "Structured Play," and a little less than an hour of discussion. Participants filled out questionnaires during the Unstructured Play session describing:

- what characteristics attracted players to the first object they played with
- what physical characteristics they remembered about one of the first two or three objects they played with (the physical qualities that relate playthings to art-objects)
- how players responded to rules during the unstructured play session
- how players responded to changing rules

The Experiment was not meant to be a carefully controlled sociological or psychological research, but was more a way to find out whether my ideas about the responses of players to rules had any basis, and to discuss the process of play with people who had just been in the middle of it. The results are more anecdotal than conclusive.

Session 1: Unstructured Play

The purpose of the Unstructured Play session was to allow the participants to select freely one or more objects to play with. I wanted to see whether they were influenced by, and later remembered, the physical characteristics of the first object they played with or whether familiarity was a stronger enticement than a toy or game's physical attributes.

I set up the Experiment in the Exhibition Room of CAVS, and provided a large number of toys and games—more, in fact, than the number of Experiment participants. A number of friends (see References at the end of this chapter for acknowledgments) and I provided several types of games and toys, almost all of which were the sorts of things children or young adults would play with indoors.

A hopscotch pattern made by two friends and a play sculpture that I designed called frameWORK greeted participants as they followed the hallway leading to the Exhibition Room. Inside the room the selection of toys was arranged on about a dozen tables and on the floor such that the more "physical" games and toys were close to the door (where there would be a lot of activity and movement anyway) and games or toys requiring concentration or a lot of open space were toward the far walls. Participants had to go to one of the farthest walls to put down their coats and then backtrack to return to the door.

Among the games and toys were:

- several "classic" games and toys, some version of which would be known to most Western children of the "Baby Boom" era:

  balloons, bubbles, building blocks, cards, checkers, chess, dice, two or three dozen geometric "take-apart" puzzles, jacks, jigsaw puzzles, juggling balls, kaleidoscopes, marbles, two kinds of 3-D mazes to roll marbles through (one a transparent plastic cube about 4 inches on a side, and the other a construction toy), an electric model train, pick-up sticks, 3-D tic-tac-toe, a half-dozen wire (or "tavern") puzzles, tangrams, a stuffed teddy bear, tiddly-winks, yo-yos

- a number of variations of classic games that introduced unfamiliar visual or tactile elements:

  a battery-powered bubble gun that uses a mini-fan to blow lots of bubbles out of the barrel when the player dips the barrel into soap solution and pulls the trigger

  a chess set with a soft, fuzzy playing board about 3 feet across and plastic, sand-weighted pieces up to about 1 foot tall

  a kaleidoscope with clear plastic shapes suspended between polarized film layers and a cylindrical mirror surface replacing the traditional angled flat mirrors

  wooden building blocks marked with symbols to indicate that either the block is empty, contains a weight fixed at one end, or contains a weight that can slide within the block

- a number of store-bought games and toys that either my friends and I played with as children or that are currently popular, and would be likely to be familiar to my American middle-class contemporaries. A partial list appears below (these names are trademarked, and the owners of the trademarks appear in the References at the end of this chapter):

  Boggle, Chutes and Ladders, Clue, an Erector set, Etch-a-Sketch, Lego blocks, Liar's Dice, Mastermind, Memory, Mille Bournes, Monopoly, Mousetrap, Othello, Pachisi, Perquacky, Pictionary, Risk, Rubik's Cube, Scrabble, Slinky, Soma Cube, Sorry, Spirograph, Stratego, Trivial Pursuit

- several rather obscure store-bought games from my childhood

  Autobridge, Booby Trap, Continuo, Lunar Probe, Reckon, and geometric and logic games called Cornered and Matchwitz

- several non-American games:

  Owari and Mancala from Africa, Go from Japan, and Husker-Du from Holland

- two or three store-bought American and European games and toys that have been produced within the past several years, but would likely not be familiar to the majority of the participants. A partial list (with simplified rules) appears below:

Abalone: a two-player game in which the players take turns pushing groups of one, two, or three marbles across a board and try to push the opponent's marbles off the board. The first player to eject six of the opponent's marbles is the winner.

Gravity Graph: a drawing toy consisting of a felt-tip pen fixed vertically above a drawing surface mounted on a swinging pendulum.

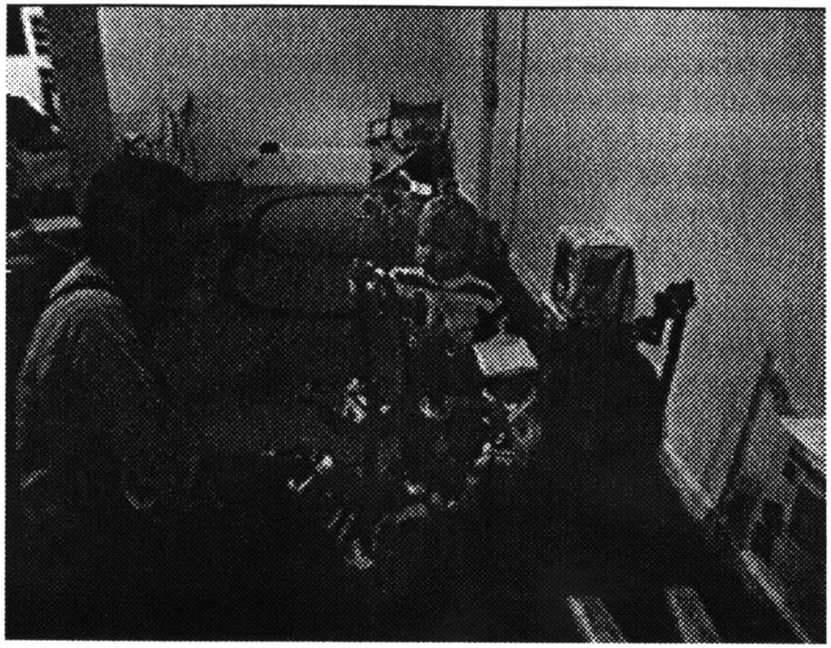
Hoomdorms: a pair of pneumatic 'robots.' The player pumps air into the robot using a small hand pump, then removes the pump and turns a switch. The robot jumps or flexes its way across the floor for about 15 feet before its air supply runs out.

Jenga (or Ta-Ka-Radi): a two-or-more-player game in which small rectangular blocks are stacked in layers. Each layer contains three blocks, all oriented the same way, separated by a slight space. Each layer is oriented at right angles to the layer below. Players take turns using one hand to pull out a single piece from some layer other than the top one and then add that piece to the top layer (keeping the same stacking rule). The player who knocks the stack over while pulling out a piece loses, and must re-stack the pieces for the next game.

Novi: a one-, two-, or several-player game in which the players take turns laying down tiles that have black-and-white patterns (the pattern on each tile is based on a 3x3 square grid) and try to create pathways and patterns.

Stack Challenge: a one-player hand-held electronic game modelled on the arcade and computer game "Tetris." Pieces composed of four squares in all possible edge-connected configurations drop from the top of the screen, and the player tries to rotate and move them in order to completely fill the rows they fall into at the bottom of the screen. Completed rows disappear, leaving room for more pieces to drop from the top. The game ends when there is no more room for pieces to drop because every row is incompletely filled.

Wabbit Wampage: a several-player role-playing game in which players act out the part of rabbits on a farm. The rabbit characters may decide to help out the farmer, or they may decide to be as destructive as possible to ruin the farm.



Still from the Play Experiment videotape shot by Dan Spikol

In the discussion at the end of the evening, a number of people observed that almost no one was willing to start a game that they knew would either take a lot of time or a lot of concentration, or that seemed more "serious" than playful. The best example of this was that no one played chess during the entire evening, people agreed in the discussion that chess has connotations of something more complicated and confrontational than most games (someone said "chess isn't a game, it's an obsession").

However, several people played other games on the chessboard—but *only* on the fuzzy chessboard. The hand-carved wooden chessboard and chess pieces from Poland were never touched. The physical aspects of the fuzzy board and its pieces drew participants in—it was inviting as an object, and so people treated the elements of the chess game as toys, learning or inventing ways of playing with them that did not have the negative connotations of the game of chess.

The games and toys that were in use nearly continuously throughout the evening were the marble raceway construction toy, the bubble gun, the juggling balls, the teddy bear, the geometric wooden puzzles Stu Coffin designed, model train, and the Booby Trap game. Other games and toys that were played with a lot were Abalone game, the "tavern" wire puzzles, the Gravity Graph and the Spirograph, the fuzzy chessboard (on which Marta taught a Slovenian game and Pam Rockwell and I invented a game based on checkers), the Boggle game, and the weighted blocks. The following games and toys were played with at least once: the backgammon set, the go set, the balloons, the jacks, the Hoomdorms, the Jenga game, Stack Challenge, Tiddly Winks, Lunar Probe, Chutes and Ladders, Mastermind, the 3-D tic-tac-toe, the Etch-a-Sketch, and the hopscotch (which, curiously enough, was "played" a lot by people who came into the Center in the week or two following the Experiment).

Session 2: Structured Play

After participants had been playing for a little over an hour, I went around the room to the various groups of players who were involved in games, and to one group playing with a toy, and imposed a change. I gave each group a choice: either they could make up a new rule for the game they were playing (or for whatever game they played with thereafter), or I would create a new rule for them. The major groups responded as follows:

- the group of five people playing Boggle allowed me to impose a rule, which was that they were allowed to select one letter cube to skip over in word, so long as they could get to it with the usual connection rules (adjacent to the previous and next letters in the word either vertically, horizontally, or diagonally)
- the group playing Stratego allowed me to impose a rule, which was that a player could move one of the opponent's pieces, but then had to make at least five normal moves before doing so again.
- the group playing with the marble raceway construction toy allowed me to impose a rule, which was that they had to find a way to make a three-way path for a marble to follow at some position in the structure
- the group playing Booby Trap decided to make up their own new rule, which was that each player had to simultaneously remove two pieces, one with each hand

My intent here was to find out how the groups responded to the entire Experiment as a kind of meta-game, and whether they accepted my invitation to play by the rules I invented for the meta-game, or whether I was taken as a 'spoil-sport.'

What was most interesting was what happened after I walked away from each of these groups. The Boggle players decided that they were not happy with the new rule I had created, and asked my permission to abolish that rule and make up a new rule of their own. The Stratego players did not use the rule for a long time, then one of the players finally used it "when it would cause the most damage." The group playing with the marble raceway decided to reinterpret the rule, playing with the semantics of the rule statement to change its meaning. The Booby Trap players discovered that their new rule made the game more interesting, and used it consistently thereafter.

The responses reminded me of the various ways that religious sects interpret the words of the gods. There are those who don't like what the gods have ordained who try to bargain with the gods to change the commandments. There are those who don't like the commandments but do not petition or pray for a change of the laws, and who live within the letter of the law, but transform its meaning to suit their preferences. There are those who accept the commandment only when it suits their purposes, and there are those who accept the commandments as the guide for their behavior. Interestingly, no one in the group admitted to simply ignoring the 'commandments' altogether.

Session 3: Discussing Play

After about an hour of structured (or perhaps I should have called it "re-structured") play, everyone gathered around the central table in the Exhibition Room, and we talked about several topics:

- the difference between a toy and a game
- players' responses to the physical and to the conceptual characteristics of the games and toys
- the difference between a toy and a sculpture
- players' responses to the initial rules of the games, and to the imposition of the rule change—both their response to me instituting the change, and how they actually played thereafter (I described this above)
- Huizinga's quote regarding the difference between the spoil-sport and the cheat, and the difference in society's response to these two archetypes
- whether I, as the Master Gamer for the evening, took on either the role of spoil-sport or cheat by changing the rules

Toy vs. game:

The Players' definitions of these were fairly similar to my own.Players defined a game as: goal-oriented; something you can win; having a path, meaning a definite end-state and a well-defined way to try to reach that state (it may not always happen that you reach it); having some evaluation system, such as scoring and points.

A point that several players stressed is that the rules ARE the game—if you change the rules, you're no longer playing the same game.

Players defined a toy as: something you can fantasize about rather than having to play by the rules; an object with socially defined (rather than written or codified) rules; anything where, when you reach an apparent end, as when you've used up all the blocks you're building with, you feel free to decide what to do next: "you get to knock it down" and start again, "so you're not really done, you get to do it some more."

Response to physical aspects of games and toys

Participants thought that they were generally quite aware of the physical characteristics of the games, though I found that most people's list of physical characteristics of toys were quite incomplete. What was quite clear is that the physical characteristics are a strong influence, even where players don't remember them clearly.

One participant mentioned that he prefers playing solitaire with real cards to playing in on a computer because he likes the way real cards feel.

One player took exception to the statement by another player that "the rules *are* the game, and the stuff that you play with is just the stuff that you use to make the rules work properly." He pointed out that the rules and the "stuff" of the game do have to match, or at least should not conflict with each other in order to make the game fun. He explained:

> In Tiddly-Winks, you have a big 'tiddly' and a little 'wink.' Well, we switched it: we winked the tiddles and boinked the big things. Well, you were saying the stuff was arbitrary, but it dictated what worked and what didn't work very well.

This same player said he is usually very much affected by both the conceptual aspects of a game, i.e. rules, strategy, symbolism, and the physical aspects, i.e. the way the game looks the way the pieces feel, the way they move, the patterns they make. He is generally aware of the physical qualities as sculptural rather than toy-like: he is aware of the physical characteristics but does not become distracted by the possibilities those suggest.

On the videotape I watched one player get very absorbed in experimenting with the physical qualities of one of the pneumatic Hoomdorm toys. She exclaimed "I love this! I love this pump!" (the pump went with the toys); she carefully tested the feel of the moving legs against her hand; she compared the way the toy responded on the rug to the way it responded on the linoleum hallway floor; she experimented with the amount of air it took to get the toy to move and how it responded when it was running out of air, and whether the switch on the side changed the response. All of these are ways of figuring out the intrinsic rules of the object, of responding to it, as opposed to trying to impose rules, trying to make the object respond. This player happened to report on this toy in the "Physical Aspects" section of the questionnaire, and her memory of the colors, shapes, sounds, and materials was one of the two or three most complete lists compared to all the respondents.

Toy vs. Sculpture

The majority of the players' comments here were pretty straightforward: they said it's a sculpture if you only get to look at it and a toy if you get to play with it. Thus toys displayed in museum cases are sculptures (though that was not their original nature).

One player mentioned the aspect of time in the difference, saying "statues are static." Thus, like Huizinga, this player associates action with play, and denies "toy-ness" to still objects.

Another participant stated that a given object can be either a sculpture or a toy (or puzzle) depending on how the viewer responds. If they "appreciate" the shape and the aesthetics, and if they "leave it alone," then it's a sculpture.

Someone else countered, using the magnetized Rhomblocks as an example, that it can still be a sculpture and be moved around and rearranged. They said it's more toy-like when "you're rearranging it for the point of rearranging it—I can stick this piece against that piece and the magnets make it stick—I would call that experimentation versus 'directed' building."

One very interesting comment was one player's assertion that finding the rules of a shape is the equivalent of toying, and building according to rules and strategy is sculpting. This differs markedly from my own definitions, and has a curious implication (which the speaker may not have thought about) that it makes sculpting into a logical activity rather than an intuitive one—you should, by this definition, be able to program a computer to do it if you can state the rules and the strategy completely enough.

Spoil-Sports

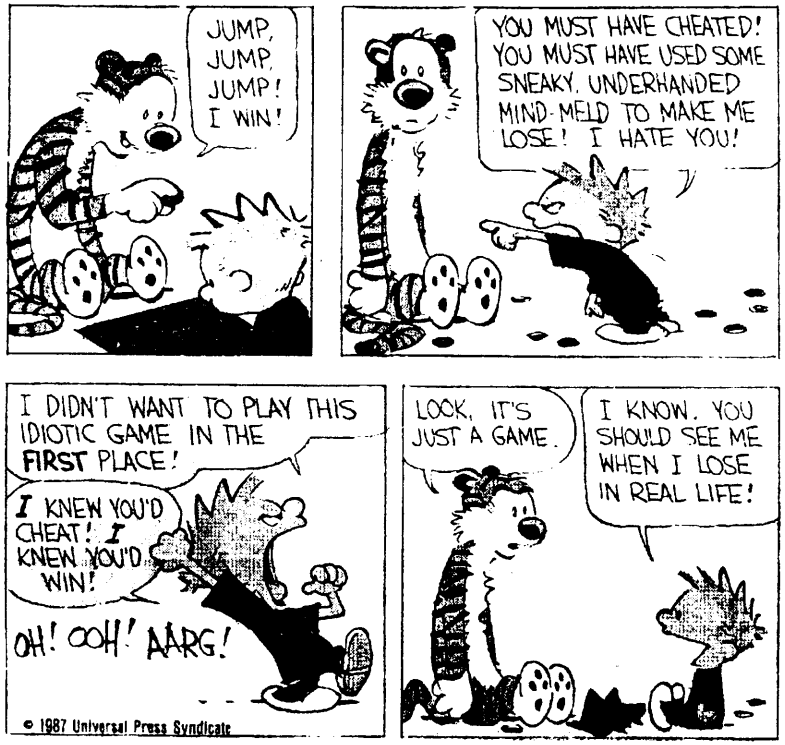
In at least one situation, a player who looked at Booby Trap as a game objected when another player treated it as a toy. The first player wanted to know what the rules were "so he could play." The second player treated the objects as a toy: she felt free to invent her own rules for playing with the object, which, in this case, meant experimenting with and enjoying one of the physical characteristics of the object—the rapid, jerky motion of the spring-loaded bar.

Neither Huizinga nor I had considered the fine points of the interaction of player's whose concept of the object of play differed. For the player who expects the object to be a game, especially a game whose rules the player is just learning, the toy-player is an irritant, a usurper of authority, clearly not a collaborator in the establishment of order. The toy-player does not intend to destroy the magic circle, merely to adjust its boundaries, However, beyond a certain point, those who want the boundaries to be narrower will label the irritant a spoil-sport.

What interested me is the leeway the toy-player has for experimentation.This may be one of the factors that causes experimenters and inventors in the plastic arts to find their works greeted with the response "That's NOT ART." One of the "rules" in art, simplistically put, is that part of the point is to achieve certain effects through application of a set of visual media and methods to be experienced by a viewer. Another of the rules is that one *must* invent: repeating one's own work too many times is frowned upon within the artistic community as banal, and repeating someone else's work without modification is termed forgery. The acceptable effects, applications, and media are all historically and socially defined within the art-world. The result is that an artist who "invents" a new effect, application, medium, or method, or appropriates one from some other discipline, has an oddly narrow boundary within which to innovate. If that artist steps too far outside the standards within the art-world, the result is expulsion, excommunication by those still within the tradition. The paradox of the art world is the unspoken credo "Create, but don't get too creative about it."

Cheaters

The definitions the players gave for cheating were: "deciding the rules don't apply to me," "changing the rules without telling the other person," "not telling a new player all of the rules, especially telling them only when it's to your advantage and not to theirs."


JUMP, JUMP, JUMP! I WIN!
YOU MUST HAVE CHEATED! YOU MUST HAVE USED SOME SNEAKY, UNDERHANDED MIND-MELD TO MAKE ME LOSE! I HATE YOU!
I DIDN'T WANT TO PLAY THIS IDIOTIC GAME IN THE FIRST PLACE!
I KNEW YOU'D CHEAT! I KNEW YOU'D WIN!
OH! OOH! AARG!
© 1987 Universal Press Syndicate
LOOK, IT'S JUST A GAME.
I KNOW. YOU SHOULD SEE ME WHEN I LOSE IN REAL LIFE!

Calvin and Hobbes, by Bill Watterson

Responses to the Spoil-Sport and the Cheat

A player pointed out that the severity of treatment of the spoil-sport and the cheat depends somewhat on the context. In tournament play, the spoil-sport is just ignored, and it's the cheat who receives harsher treatment.

Rule-Changing

Interestingly, none of the players saw my role in the evening as that of a spoil-sport or cheat. They did describe me as a meddler, a capricious higher authority (but one that they *did* try to appease), and as the inventor of a kind of meta-game the rules of which they had accepted by coming to the event in the first place.

The complete description of the results of the rule changes appear on page 28.

Contests and Tests of Skill

Though I did not explicitly ask the players about goals and about the relationship between play and the sense of achievement, the subject came up once or twice, as mentioned above. The videotape captured several short competitions and a couple of tests of skill that the players created.

In one vignette, the 2-year-old (whose vocabulary still consisted of single words only his parents could understand) created a test of skill for himself. He was trying to place one of the marble raceway sections at the top of a tower nearly as high as his shoulders. Since he was holding the piece upside down, it wouldn't fit. His father gently repositioned the piece in his hand, and another player steadied the tower. The child ignored everything around him, including encouragement from the person steadying the tower until the piece dropped in, and stayed where it was when he took a step back and paused. Upon seeing that the tower stayed up, the child exclaimed "Yay!" and clapped his hands and reached for another piece. I found this an interesting demonstration of the idea that play is truly fundamental, that the desire to test oneself is ingrained by the age of two (a still image from this sequence appears on page 27).

Another episode on the video shows a group of four people all playing with small wire and geometric puzzles. They are gathered in a loose circle, and none of them are talking, but they occasionally look over at each other's progress. One player gets his puzzle apart, and silently holds up the pieces: the obvious implication is that he has won. The others all look over, without pausing in their own tinkering, and one of them nods. They all go back to working on the puzzles. The group has, without any discussion, established their activity as a being both individual and social.

Analysis of Questionnaire Responses

Of the 35 or so participants, seven or eight did not stay for the whole event, and, of the ones who stayed, 22 filled out questionnaires.

The most common reason people chose a particular game or toy at the beginning of the evening was familiarity. Nine participants gave this as one of their reasons for selecting the first toy, and many of those mentioned that their first response was nostalgia for the times they played with the toy or game in the past. One player mentioned selecting a first toy because it reminded her of a different, more goal-oriented puzzle (Rubik's Cube), but that the less goal-oriented version (colored cubes connected by elastics that let you twist the whole toy out of the cube shape) left the player with the option of ignoring the goal—this player immediately recognized both the contest or goal-potential of the object-as-game, which Huizinga describes in some detail, as well as the creative potential of the object-as-toy that I had posited.

There were several things I noticed about the group's response to the physical characteristics of the games. The first was that, where I had provided two versions of a toy that differed in tactile quality, the softer one was used and the harder one was untouched, for example, the two chessboards and the two stuffed animals. However, during the discussion period, no one seemed able to talk about why that was so. From observing the participants, I conclude that the softer game or toy provided more possibilities to the player, made them feel a little freer to focus on the potential of the object rather than on the rules associated with it.

The strongest secondary reasons for selecting the first game were visual:

Reason	# of times checked
The game was unfamiliar, but looked interesting	7
Liked the shapes	6
Played with the first thing you saw	6
Liked the textures or materials	4
Liked the colors	3

The social aspects were, somewhat to my surprise, down at the very bottom of the list:

Reason	# of times checked
A friend asked you to play	2
A stranger asked you to play	1
Watching someone else play with the game got you interested	1
You had heard of the game	1

The responses to the section of the questionnaire that dealt with rules were somewhat curious in that no one admitted to cheating or to having anyone else cheat:

Reason	# of times checked
The players of the game added or invented a new rule	8
Players knew different versions of a game	6
Players disagreed about game rules	5
Rules provided with the game were incomplete or unclear	4
Players of the game decided to get rid of or ignore a rule	4
You or someone else "cheated"	0

There was one instance caught on videotape where one player accused another of cheating at backgammon by not explaining all the rules, and allowing the novice player to make mistakes.

Conclusions

In the main, I found that my hypotheses were borne out by the events in the Experiment. There were a number of issues that I found myself still curious about, and I would have liked to hold additional experiments, particularly one focused on creative play and on responses to changes of visual and physical rules (I had planned to call that one The Illusion Experiment).

Among the issues raised but not answered were:

- ways of testing the proposition that building intuitively is toying and building according to rules is sculpting
- what factors affect the leeway a player has to be inventive without being labelled a spoil-sport, and how that relates to the 'outsider' in art
- how to manipulate an image or object to cause viewers to see it first as toylike and second as sculptural, or vice versa

All of these are interesting questions, but they will have to be deferred for now.

Chapter References

(Please see the Bibliography for complete publication information for book citations.)

[1] *Homo Ludens: A study of the play element in culture* by Johan Huizinga, p. 4.

[2] Ibid, p. 211

[3] Ibid, pp. 7-8

[4] Ibid, pp. 8-9.

[5] Ibid, pp. 8.

[6] *Principles of Neo-Plastic Art* by Théo van Doesburg, p. 5.

[7] Ibid, p. 29.

[8] *Homo Ludens*, pp. 9-10.

[9] Ibid, p. 51.

[10] *The Intimate World of Alexander Calder* by Marchesseau, p. 29.

[11] *History of Art* by Janson, pp. 660-61.

[12] *Bauhaus* by Frank Whitford, p. 12.

[13] *Fluxus*, by Phillpot &Hendriks, frontspiece.

[14] *The Intimate World of Alexander Calder* by Marchesseau, p. 31.

[15] *Calder's Universe* by Lipman, p. 81.

[16] *Homo Ludens*, p. 10.

[17] *The House at Pooh Corner* by A. A. Milne, pp. 94-5.

[18] *The Intimate World of Alexander Calder* by Marchesseau, p. 152.

[19] *The Intimate World of Alexander Calder* by Marchesseau, pp. 24-5.

[20] *Agam* by Frank Popper, pp. 139-140.

[21] *Principles of Neo-Plastic Art*, by van Doesburg, p. 39.

[22] *Homo Ludens*. pp. 11-12.

[23] I wish to thank the following people who graciously lent toys and/or taught games for the Play Experiment: Jeff Carter, Dr. Willard Johnson and Dr. Vivian Johnson (my parents), Peter Atlas, Pam and Dennis Rockwell, Jennifer Sawin and Jim Herndon, Beth Kevles, Stewart Coffin, Josh Boughey, Chaya and Hillel Shahan-Bromberg, Otto Piene and Elizabeth Goldring, Gregory Haun, Joe Gaudreau, and Zora Jones Rizzi and Diane Willow, who made the terrific hopscotch in the front hallway for me. Many thanks to Dan Spikol for videotaping the event.

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Page 17: Firemen's dinner for Brancusi, from *The Intimate World of Alexander Calder*, p. 29.

Page 20: Christopher Robin knighting Pooh, and Page 21: A game of Poohsticks, from Ernest H. Shepard's drawings for *The House at Pooh Corner* by A. A. Milne.

Page 22: Dog, by Alexander Calder, 1940, page 85 of *The Intimate World of Alexander Calder* by Marchesseau.

Page 22: Bull's Head by Picasso, 1943, page 9 of *History of Art* by Janson.

Page 32: Calvin and Hobbes, by Bill Watterson from the Bostion Sunday Globe, Jan 5, 1992.

The Role of Play in the Visual Arts

There is a major point where I disagree with Huizinga's treatise. When he comes to the question of the relationship between play and art, he claims that:

> Turning from poetry, music and dancing to the plastic arts we find the connections with play becoming less obvious. . . . The very fact of their being bound to matter and to the limitations of form inherent in it, is enough to forbid them absolutely free play and deny them that flight into the ethereal spaces open to music and poetry. [1]

Huizinga bases this view on three observations. First, he claims that, even if the inspiration of a work involved play, the labor required to make the work is just that: labor, not play, and thus "the play-element is to all appearances lacking in the execution of a work of plastic art." [2]

Second, he looks upon the plastic arts as static, lacking what he calls "visible action" within the works themselves, and lacking the quality of unfolding in time before the observer, as in dance and music, so that:

> The absence of any public action within which the work of plastic art comes to life and is enjoyed would seem to leave no room for the play-factor. [3]

Huizinga's third claim is that, in a work of plastic art:

> the very nature of the thing. . . is determined to a large extent by its practical purpose—and this is in no way dependent on aesthetic impulse. The man who is commissioned to make something is faced with a serious and responsible task: any idea of play is out of place. [4]

The only areas where Huizinga will grant the infiltration of play into art are the cases where art serves the purposes of ritual, and where the creation of artwork is made into a form of contest.

I take exception to all three of Huizinga's arguments against the existence of a play-element in art, and offer the following observations and references.

Regarding Huizinga's notion of the nature of plastic artworks, I strongly disagree that there is or should be a "practical purpose" for most works that can be called fine art: the fine artist does not take brush in hand merely to relieve the starkness of a blank wall. I also disagree that the nature of the work is entirely dictated by such purpose even where it does exist: even when the artist is commissioned by someone whose goal is merely to cover the wall, the artist must still come up with an image. This is a creative rather than a practical endeavor. Where practical purpose does dictate the character of the work, I believe that is the major factor that transforms the work into an example of design, craft, or illustration rather than art.

Regarding the making of an artwork, I demonstrated in the previous chapter the strong similarity between the creative process and play by drawing parallels to Huizinga's four characteristics of play. I showed that:

- intuitive and creative actions are voluntary and cannot be forced
- creative labor often distances the artist psychically from the concerns of daily life for a while
- artists have traditionally worked in studios physically removed from living and working space, but creative work in public has a similar character to play in public
- the discovery of order within form and the imposition of order on form are the essence of the creative process in the visual arts.

True, making art is not always playful—some of it is exactly as Huizinga describes: it is physical labor. But the artist must keep gauging the progress of the piece against intuition and aesthetic judgement, so the play-element is most certainly apparent again and again in the midst of the work.

Play Sculptures

Re-examining the claim that an artistic object's nature derives from its practical purpose (ignoring, for the moment, whether or not that *actually* dictates the nature of the work), if the object's purpose is to be a toy, a simple connection can be made between the plastic arts and play.

Among toys designed by artists, perhaps the most famous example is Calder's Circus (a toy that ended up occupying more than five trunks). Before he began the famous Circus itself, Calder made several others, including a small circus he made for himself at the age of seven. In addition to making animals and figures from bits of wire, wood, and whatever, Calder drew sketches of the animals at New York's Bronx and Central Park Zoos, and of the performers and trained animals at circuses during the early 1920s. Rather than being an object designed for a purpose, the circus was an extension of Calder's observation of and love of animal and human forms and actions.

Calder made numerous toys and "amusements" for his family and friends: "nose masks," fantasy eyeglasses, pull-toys, doll houses, and a seemingly endless collection of animals and figures. Though he received a couple of commissions to make toys and circuses, he didn't find the majority of toy companies receptive to his efforts:

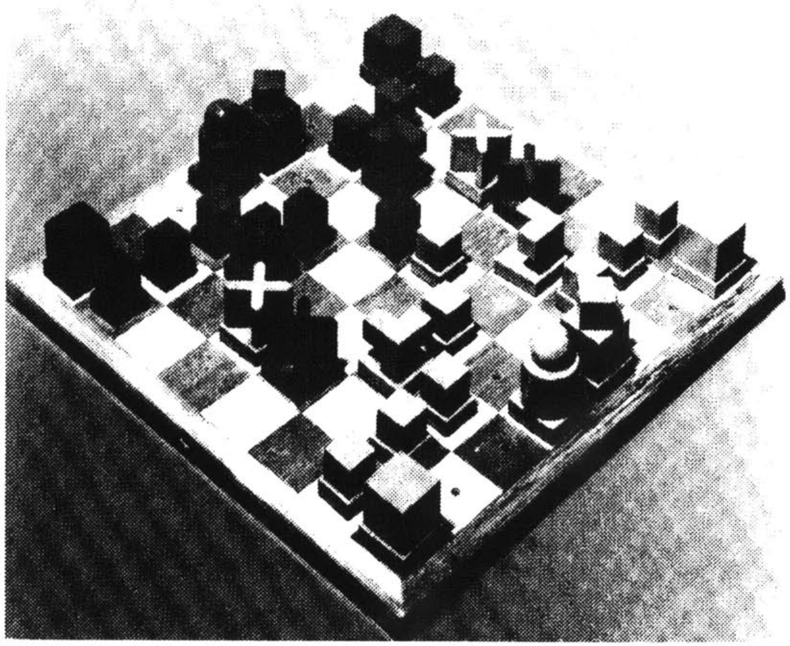
> William Hayter recalled, "This was when Sandy began making toys (1927). I can still remember how naively astonished he was when the toy manufacturers were not interested in his ingenious toys: they amused the children and ourselves so much! I guess he didn't realize that toys are manufactured by people who claim to understand what the parents (who pay) think their children will like." [5]

Some would argue that these aren't artworks. Certainly many of Calder's creations were objects that would, by many definitions, be called craftworks—his jewelry and kitchen utensils, for example. However, the object's utility wasn't usually the main reason for making it, nor for making it in a particular way: they were made in a spirit of aesthetic play, creativity and invention. Calder himself recognized that naming his creations could cause controversy:

> Calder deliberately uses the word 'work' instead of 'art,' and he usually calls individual pieces 'objects' because "then a guy can't come along and say, no, those aren't sculptures. It washes my hands of having to defend them." [6]

Calder roaring with the Circus lion, 1971

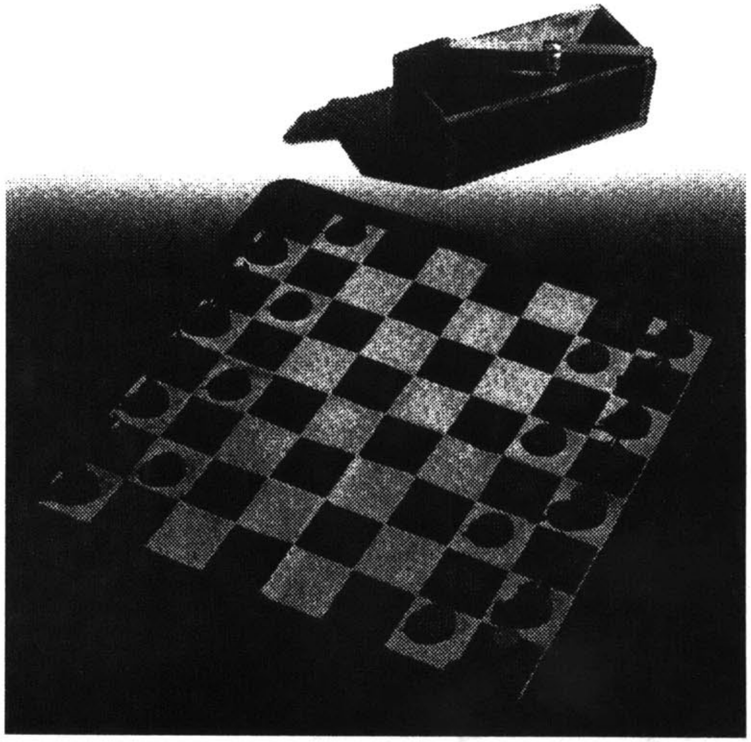
Calder commented about the toys he made, "They call me a 'playboy' you know. I want to make things that are fun to look at, that have no propaganda value whatsoever." [7] To his grandniece, Nanette, he wrote: "Above all, I feel art should be happy and not lugubrious."[8]



Chess Set designed by Bauhaus teacher Josef Hartwig, 1924

Calder is certainly not the only artist to make toys. The chess set has been a favorite art-toy, with examples produced by members of many different art movements. There is Josef Hartwig's Bauhaus chess set whose pieces' shapes indicate the way that they move, instead of resembling a royal retinue. Teeny and Marcel Duchamp made a chess board, for which Calder made the pawns (out of checkers and bolts) and the box, and on which Man Ray painted the text:

> Le Roi est à moi—la Reine est la tienne—
> la tour est un four—le jou est comme vous—
> le cavalier deraille—le Pion fait l'espion
> comme toutes canaille.
>
> Fait de toutes pieces pour Teeny et Marcel
> Man Ray 1964 [9]
>
> [My own loose translation:
> The King is mine, the Queen is yours,
> the Castle's gone and failed.
> The game's exactly like we are,
> the Knight has been derailed.
> The Pawns all play at spying
> like the rabble that we railed.]



Teeny and Marcel Duchamp's chess set

Several of the artists of the Fluxus movement of the 60's and 70's, founded by George Maciunas, produced games which Maciunas mailed out in art-for-the-masses Fluxus 'magazines.' These magazines were small wooden crates, stamped with the word 'FLUXUS' and containing a jumble of texts and objects.[1]

The artist Takako Saito seems to have been the Fluxus artist in charge of chess sets. She made at least nine FLUXCHESS sets between about 1965 and 1973. Many of them had the goal of making the players identify the pieces by some sense other than sight. They included:

- nut and bolt chess

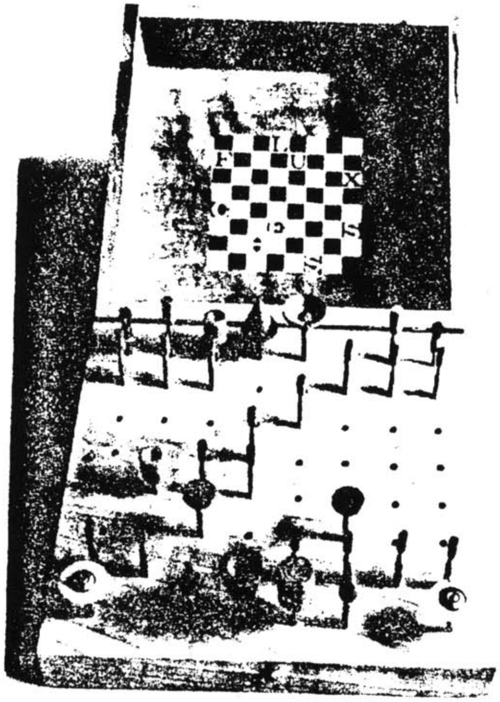
  A rather crude stepped wooden board and pieces made of painted bolts.

- jewel chess

  Pieces consisted of jewelry in small plastic boxes

- grinder chess

  This set had pieces made of machinist's grinding wheels and brushes (pictured below).



Saito's grinding-wheel chess set

- smell chess

  The pieces were clear vials containing the liquid essence of various perfumes. The pieces could only be told apart by their smell

- sound chess

  The pieces were small plastic boxes containing small objects which, which shook, made different sounds. The boxes were all identical, and could be opened to view the contents

---

1. It's interesting to note that the original meaning of the word 'magazine' is storehouse or a box of munitions, so Fluxus boxes are closer to being 'magazines' than the glossy paper objects we now call by that name. [10]

- weight chess

  The pieces were small plastic boxes of various weights
- spice chess

  The pieces were corked test tubes containing various spices. From the top all the corks were identical

Yoko Ono made a set that really did test the line between sculpture and toy: an all-white set on an all-white board which she titled *Play it by Trust.*

The Fluxus group produced lots of other toys as well, including George Brecht's games, puzzles, and decks of cards. These were games with a twist—for example, there was a deck of cards in which all 52 of them were the King of Spades, and there was a box containing a cup, a coil of wire, a pen, a chesspiece, an eggshell, various other small objects, and a card reading "Spell your name with these objects." These games couldn't be played without the active, inventive participation of the player, who was left to make most of the decisions about the rules to the games.

George Maciunas, the founder (or perhaps he would say the instigator) of Fluxus, felt that toys and games were at the heart of the Fluxus attitude, in contrast with the attitude of the established art world. He wrote the following text for the Fluxus Broadside Manifesto in 1965[2]:

> **Art:**
>
> To justify his professional status as an elite societal parasite, the artist must demonstrate that he is indispensable and exclusive, that his audience depends on him, that only artists can make art.
>
> In consequence, art must seem complex, pretentious, profound, serious, intellectual, inspired, adroit, theatrical, significant. It must seem to have commercial value in order to become, for the artist, a source of income. To increase its value (and therefore the income to the artist and the profit to the patrons), art must seem rare, available in limited quantities, and therefore accessible only to the elite and to large institutions.
>
> **The Art/Game of Fluxus:**
>
> To establish his non-professional status in society, the artist must demonstrate that he is neither indispensable nor exclusive, that his audience can be self-sufficient, that everything can be art, that anyone can make art.
>
> In consequence, the art/game must be simple, amusing, without pretention, preoccupied with insignificant things, neither demanding specific abilities nor uncountable repetitions, and having no commercial or institutional value. The value of the art/game will be reduced by being available in unlimited quantities, mass produced to be accessible to everyone and eventually produced by everyone. The art/game of Fluxus is an "arrière-garde" without either pretention or desire to challenge the "avant-garde" in the fight for supremacy. It contents itself with being monostructural, non-theatrical, with the character of natural, simple facts, of games, of gags. It's a mixture of vaudeville, gag, child's game, Spike Jones, and Duchamp. [11]

The Fluxus artists were aware that toys and games have a special power to engage, to change an observer into a participant, and that the game was therefore a tool that could be used in the context of art to change a viewer-of-art into a creator-of-art, by enticing the observer to join the art-maker's magic circle, and by sparking a creative response.

---

[2] I did not find an English-language copy of this text until May 7th. This quote is my own translation from the French.

Space-play

Going beyond art-toys , there exists a deeper connection between art and play. Huizinga claims that the plastic arts cannot incorporate play because they are tied to matter and its limitations, but it is precisely when artists make their works transcend these limitations that play enters the plastic arts.

It is here that mathematics begins to enter into the game as well, for, in working with the inherent limitations of space and form, artists often needed either to explore the existing abstract "languages" in which the laws of those limitations are formulated or to develop such abstract languages themselves. A number of artists were also influenced by developments in other disciplines that proposed connections among science, mathematics, and spirituality, and made visual references to these ideas.

The evasions of spatial limitations in the plastic arts take various forms:

- twisting spatial rules in both subtle and overt ways
- celebrating the 'limitations of form' by treating pure form as a subject
- making the eye see something more than the actual elements of the image
- creating an image that cannot be experienced in reality, defying everyday experience and physical laws

The rest of this chapter constitutes a brief treatment of a number of artistic movements that focused on the kind of spatial play that Huizinga claims doesn't exist.

Trompe l'Oeil and Anamorphosis

Many Renaissance painters sought to match their works to the eye's expectations, attempting to master the shaping of a form through light and shadow, and to understand and follow the rules of projective geometry, and thus create scenes that appeared to present objects as they would actually appear in space. The mathematics of perspective had been developed centuries early by Euclid, Ptolemy, Galen, and Alhazen. The beginning of success in the Renaissance endeavor came in the works of Brunelleschi and Masaccio around 1425, who were among the first painters of the modern era to accurately depict a scene with a single vanishing point. Brunelleschi succeeded in painting the Baptistry of Florence in accurate one-point perspective using a scheme in which, with his back to the building, he painted what he saw in a mirror aimed at the Baptistry.[12]

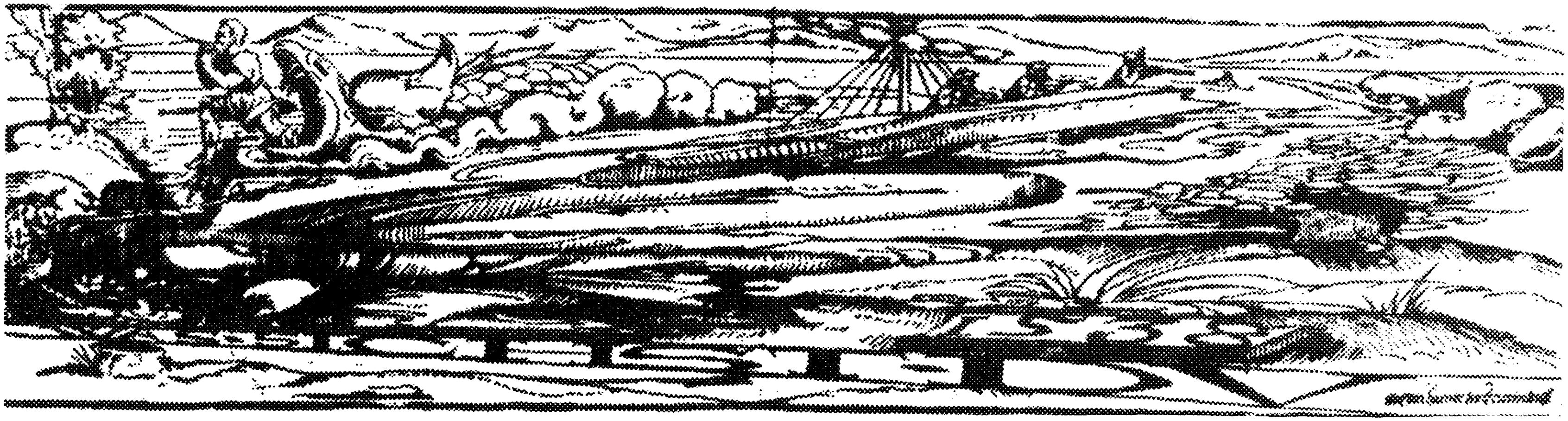
Painters of the 17th and 18th centuries revived investigation into geometric techniques, exploring two-point perspective to give their images greater realism. A small number of painters carried the exploration of projective technique to the extreme. 17th century painters of the School of Delft, one of the best known being Samuel van Hoogstraten, created perspective cabinets, painted on the inside with scenes that appeared in realistic proportion only when viewed through a special peep-hole. The cabinets were a kind of play on the tradition of the "perspective box" spatial division in painting, in which all scenes, including landscapes, were depicted as they would appear if built as a scene inside a box or stage. [13]

Some artists painted objects that came into view when the viewer looked at the wall or canvas obliquely and from a distance, as in Holbein the Younger's memento mori—the skull that appears when one looks obliquely at the canvass—in his painting *The Ambassadors*. A number of European artists even produced images that were, in essence, visual puns, simultaneously portraying a lush landscape when one looked at the canvas face-on and one or more portraits in the oblique view.

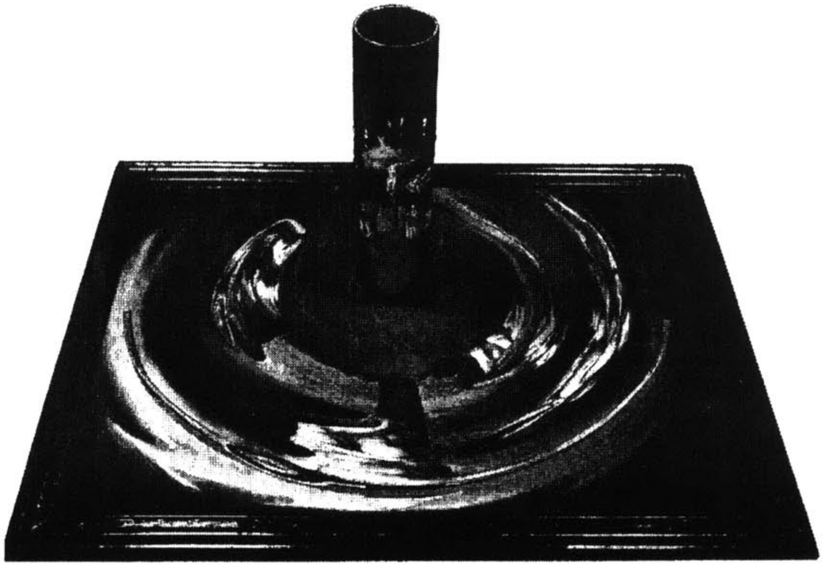
The images shown here and on the following page are from the catalog of a 1975 tour of anamorphic paintings and sculptures collected from around the world. The notes for Schön's "picture puzzle," shown below, state:

> This type of witty representation proves to be an ever-recurring one. The analogy between the man relieving himself and the whale that spat out Jonah is a truly original interpretation of this Biblical event. [14]

Erhard Schön. Picture Puzzle: What do you See? ("Was Siechst du?") 1538



In China, Turkey, and France, a few 17th artists produced another sort of anamorphic image that could be interpreted properly only when reflected in conical, cylindrical or pyramidal mirrors.



Crucifixion with Mary, John, and an Angel, c. 1640. Cylinder anamorphosis with reflecting cylinder

The catalog notes for the crucifixion painting shown above comment:

> In the northern Netherlands, there were, as we have learned from the perspective cabinets, many painters who were particularly interested in optical phenomena—clearly a congenial atmosphere in which anamorphoses could originate. [15]

Thus what had begun in the 1400's as a quest to conform to the exacting rules of projection became a kind of play on those very rules, demonstrating not only mastery in re-creating a scene as it would appear to the eye, but in manipulating the image and presenting scenes as they would appear if the eye itself were quite different than it is, able to see two views simultaneously or to see in all directions at once.

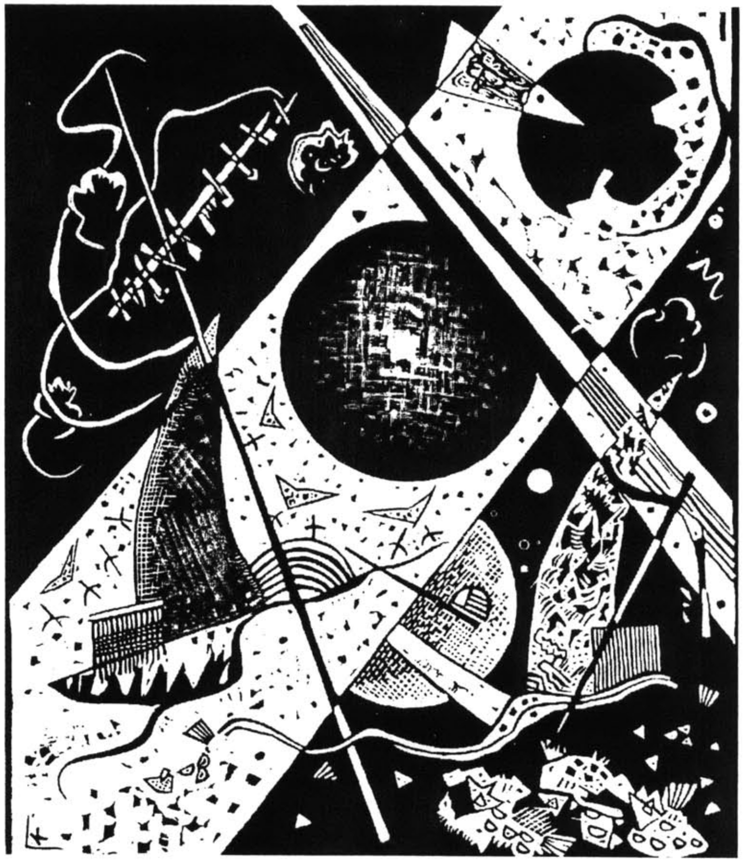
Non-Objective Art and Concrete Art

The second evasion of spatial limitation is not an evasion at all. It is the route taken by those who embrace the mysterious power of abstract and of geometric form itself, those who believe form and color alone to be potent enough to incite a creative response from viewers used to more figurative, representative images: artists such as Piet Mondrian and Wassily Kandinsky.

Mondrian's goal was to generate a sense of equilibrium, through what he perceived to be a lost connection to a cosmic unity, by visual representations of a kind of "holy mathematics:"

> A mathematical system was for him not a tool but an artistic solution to a formal problem—a solution that, however paradoxical this may sound, had an intuitive origin. . . . Like many other Dutch artists of the early twentieth century, he based his use of mathematics on a belief that there is a higher reality, with a systematic logical structure, behind the natural appearance of things. [16]

Kandinsky took as a guiding principle for his works the representation of tension and conflict, "making the spiritual visible in abstract forms and colors," and achieving "spiritual renewal . . . by turning to the abstract, the elemental." [17]



Small Worlds VI by Wassily Kandinsky

This category includes those who called themselves Concrete Artists as defined by Théo van Doesburg:

> concrete and not abstract painting, because nothing is more concrete, more real than a line, a color, a surface. Are a woman, a tree and a cow on a canvas concrete elements? No—a woman, a tree and a cow are concrete in the natural state, but in the state of painting they are more abstract, more illusory, more vague, more speculative than a plane or a line. [18]

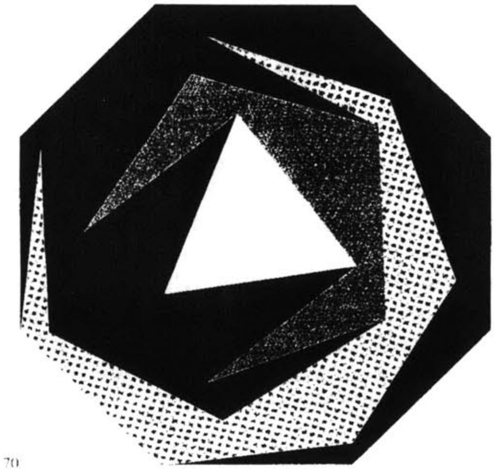
. . . and by Max Bill:

> We call "concrete art" works of art which are created according to a technique and laws which are entirely appropriate to them, without taking external support from experiential nature or from its transformation, that is to say, without the intervention of a process of abstraction.
>
> Concrete art is autonomous in its specificity, it is the expression of the human spirit, destined for the human spirit, and should possess that clarity and that perfection which one expects from works of the human spirit.
>
> It is by means of concrete painting and sculpture that those achievements which permit visual perception materialize.
>
> The instruments of this realization are color, space, light, movement. In giving form to these elements, one creates new realities. Abstract ideas which previously existed only in the mind are made visible in a concrete form.
>
> Concrete art, when it is true to itself, is the pure expression of harmonious measure and law. It organizes systems and is real and intellectual, anaturalist while being close to nature. It tends toward the universal and yet cultivates the unique, it rejects individuality, but for the benefit of the individual. [19]

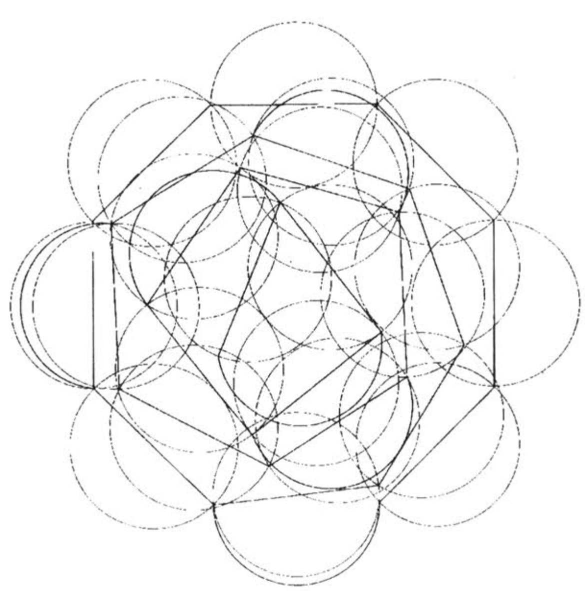
These artists were aware that the abstract elements they chose as their material must be used carefully, avoiding the creation of empty images. Kandinsky wrote:

> If we begin at once to break the bonds which bind us to nature, and devote ourselves purely to combinations of pure color and abstract form, we shall produce works which are mere decoration, which are suited to neckties or carpets. Beauty of Form and Color is no sufficient aim by itself. [20]

These artists sought a visual route to the spiritual, a means of sparking the creative response Huizinga ascribes to play situations: the sense of being transported, distanced from animal needs and logical thought, and participating, suddenly, in a transcendent order.



Variation 1 of "fifteen variations on a single theme" by Max Bill



Variation 2 of "fifteen variations on a single theme"

Op Art and Spatial Ambiguity

The third form of space-play, making the eye appear to see something more than the elements of an image, was the method of a number of 19th and 20th century artists. They explored the limitations of the eye's perception, developing another kind of visual pun—they painted images containing ambiguities that viewers saw as shifting images. They explored color perception, learning to make the beholders of their images see colors other than the ones in the artist's palette. Particularly in the 20th century, they also explored techniques for making the figure-ground relationship and the perspective clues of the image itself ambiguous, creating a sense of dynamic variation and movement in static images.

The early 20th century artists followed in the path of Josef Albers and Victor Vasarely, who established what would later be called Op Art. As with Mondrian and Kandinsky, these artists described as their ultimate goal the generation of a sense of transcendence and higher awareness.

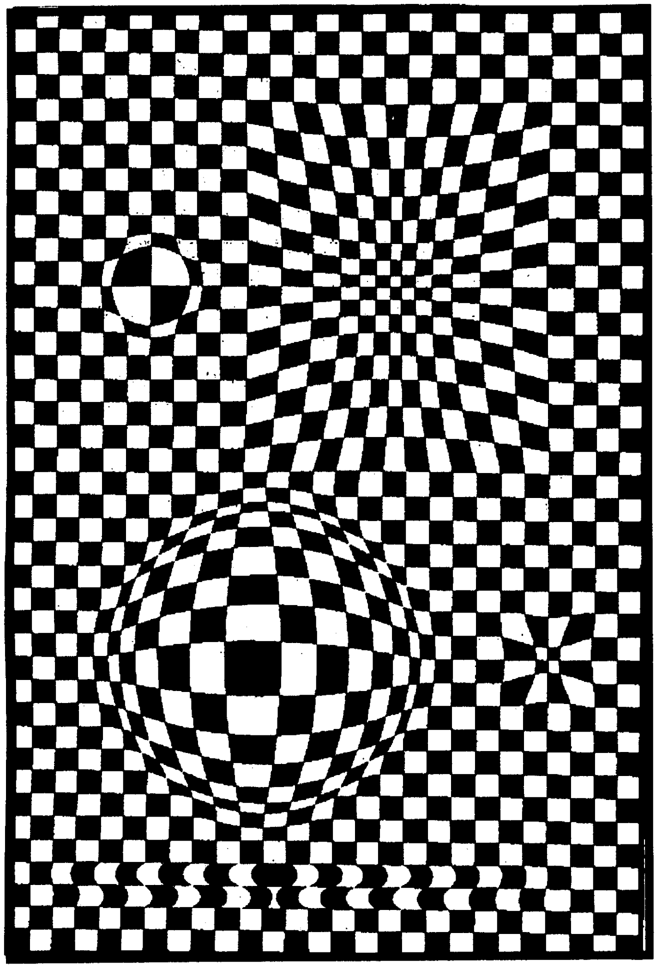
Describing a series of his black-and-white prints, Josef Albers wrote :

> These lithographs are built exclusively of horizontal and vertical lines which are the most two-dimensional and therefore the most non-spatial graphic elements.
>
> These abstract compositions perform space and volume illusions of multiple images, thereby inducing several interpretations.
>
> Receding directions are imaginary, appearing only through related junctions of horizontals and verticals.
>
> Movements are not confined to one direction only, but interchange. Thus solid volume shifts to open space and open space to volume. Masses moving at first to one side may suddenly appear to be moving to the opposite side, or in another direction.
>
> Likewise, upward acts as downward, forward as backward, and verticals function as horizontals. Parallels, horizontals or verticals, produce sloping planes, empty spaces become solid. Black lines produce gray tones, and, for sensitive eyes, color.
>
> Thus we cannot remain in a single viewpoint, we need more for the sake of free vision. [21]

Much of Albers' writing and poetry expresses, in one way or another, the idea that the possibility of ambiguity in two dimensional imagery represents the possibility of, and an incitement to, transcendent freedom of thought and spiritual vision.

Vasarely believed that this special, shifting perception of two-dimensional images could take the place of iconography in communicating to his audience, and would allow that communication to take place in the intuitive realm rather than in the more limited realm of perception. In his monograph on Vasarely, Werner Spies explains:

> [Vasarely's] world . . . might be designated the *iconography of optical aggressiveness*. This world lies between the *art of perception*, which makes a theme out of the visibility of an object, the intensity of its appearance in the field of perception, and the *art of apperception*, which aims at bringing about an understanding over and above pure perception. . . . Merleau-Ponty describes this reaction to an ambivalent perceptual figure and points out that it is impossible to apply learning or habit to such phenomena. [22]



Vega by Vasarely, 1857

Vasarely's ideas have been further developed by such artists as Bridget Riley, whose images, many of which are built up of simple manipulations of simple patterns, are completely baffling in their vertiginous effect.

All of the artistic movements I have just described playfully employ the rules of two-dimensional as compositional tools for increasing the power of plastic artworks to entice the viewer into an intuitive, creative response to the work and from there, in the 20th century movements, in any case, into a transcendent, spiritual response to the deeper issues beyond the limits of the image.

Time-play

In the midst of this exploration, a number of artists began to consider the possibilities of adding actual and spiritual dimension to their work, through visual exploration of discoveries in the fields of physics and mathematics. The very nature of space and time had been called into question, and a number of artists felt that the conceptual space and time of the elements of the plastic arts also required scrutiny. Of the artists already discussed, Van Doesburg in particular felt compelled to consider both time and the spiritual realm as possible fourth dimensions that must be expressed in art.

The consideration of a fourth dimension and of time in art is rather controversial, as attested to by Linda Dalrymple Henderson's monumental treatise on the subject (*The Fourth Dimension and Non-Euclidean Geometry in Modern Art*). Many artists, and many observers of art, believe that, even in what Huizinga would call a "static" painting or sculpture, time is an essential element if only because the viewer must experience the work through time, examining first one part of the piece and then another. Some take the more complex view that the viewer should be made to be aware of time, that the work should embody characteristics of time just as it embodies characteristics of space. Other artists do not accept this view, some feeling that even if time *can* be made an element of painting that it should not be allowed to enter—for example, Mondrian was quite disturbed at Van Doesburg's proposition that:

> an artist should take into consideration the new scientific discovery [new in 1922 at least -CJ] that perception is dependent on place and time: "As a result of the new scientific and technical widening of vision, a new and important problem has arisen in painting and sculpture beside the problem of space: the problem of time." [23]

Hoek explains Mondrian's concern thus:

> He was convinced that there existed one universal reality, which was the same in all places and at all times. Because things assume different aspects at different points in time, mankind was, according to him, no longer aware of the cosmic unity. Natural appearance, bound to place and time, disguised reality. In order to create a purely abstract image of the universal, it was necessary to do away with the aspect of time in the presentation. [24]

But for those artists who do believe that time is and should be an element of the plastic arts, time becomes another creative means, another tool for eliciting a creative response, and for achieving Huizinga's elusive flight into ethereal spaces. These artists, by the very nature of this incorporation of time, counter one of Huizinga's arguments about the static quality, the lack of "unfolding," he perceived in the plastic arts. Here, at last, the complaint that the play-factor cannot operate in the "absence of any public action within which the work of plastic art comes to life and is enjoyed" is directly countered (see page 39).

As Henderson shows, the element of time and theories of space-time had a profound influence on many of the art movements of the early 20th century, Dada, Cubism and Surrealism in particular. I shall not attempt the impossible and foolish task of distilling her excellent text into a few paragraphs, but shall instead consider the effect the incorporation of time had in one of the artistic trends I have already introduced, and will describe the time-based works of two artists whose work relates to my own.

Op Art and Temporal Ambiguity

One of the groups of artists to consider the time element were much inspired by Vasarely. This was a group of a half dozen young men, François Morellet and Vasarely's son Yvaral among them, who called themselves Groupe de Recherche d'Art Visuel (GRAV), and referred to themselves as researchers rather than as artists, thereby tying their activities in form as well as in subject to the scientific community whose theories served as one inspiration for their work.

The sections of the 1961 GRAV statement of purpose describing the changes they desire to bring about in the relationship between the artist and society bear remarkable similarities to the Fluxus Art/Game statement by Maciunas—one may well have been influenced by the other. The section of the statement that is relevant here describes the GRAV propositions for changing the accepted relationship between the viewer's eye and the artwork, in which the eye is merely a filter, colored by non-visual preconceptions. GRAV desired to eliminate all the intrinsic and traditional associations of form, including those professed by classical art, naturalistic art, cubist art, abstract constructivist art, concrete art, and action painting, and to eliminate what they term arbitrary relationships among forms. The next step they proposed was:

> to shift the usual function of the eye (to gather knowledge through forms and their relationships) toward a new visual situation based only upon the limits of peripheral vision and visual instability. To create a time-awareness based on the relationship between the eye and the work transforming the usual quality of time. [25]

This is quite a dramatic step—the implication being that, in order to add the element of time to their works, it was necessary to throw away the precepts of all prior artistic movements, including precepts of movements that purported already to have tried to eliminate naturalistic and arbitrary formal relationships.

The paintings that the GRAV artists Stein, Sobrino, Morellet, and Rossi produced owed much to Vasarely's investigations of simultaneous contrast, moire-patterns, and the vibratory effect of making slight changes in angle and color in repetitions of simple forms. Le Parc's plexiglas works added slight physical movements and the resulting shimmer of reflected light to the collection of tools intended to produce the desired "new visual situation." Sobrino's plexiglas works sought to translate the unstable visual effect of painted color combinations into the realm of color combination in light, through the interaction of color and transparency of layers of geometric plexiglas shapes:

> Each level loses its individual color-form personality in combination with those on the other side of the work. The movement of the spectator around the piece equally alters and accentuates the play of these combinations. [26]

Yvaral's "plane-spaces" of criss-crossing cords of vinyl and rubber on plexiglas frames combined the effects of moire and relief, producing a sense of dizzying vibration in a viewer standing still in front of the work, and producing absolute vertigo as the viewer moves.

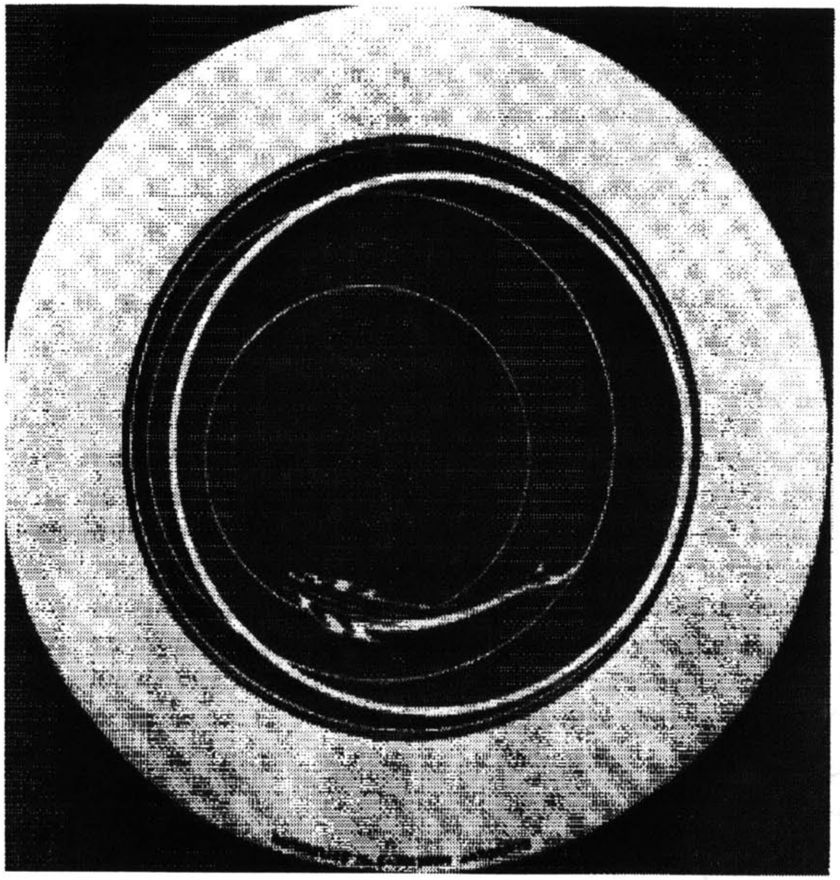
One important new factor here is the expectation that the spectator will observe the piece while walking back and forth, that the full effect of the work depends on the viewer's experience of movement and time in a different way than prior artworks. Yvaral's works, in particular, are carefully calculated to make the observer perceive the works as animated—but the trick is that what Yvaral has *actually* done is animate the observer.

Kinetic Art: Mobiles and Transformables

The next category to consider is a subset of the field of Kinetic Art. The meaning of the term 'kinetic' in relation to art is extremely broad: depending on whose definition one follows, it includes everything from the illusory movement-effects of Op Art to the physical motion of mechanical and motorized machine-sculptures by a large variety of artists, including Naum Gabo, Lazlo Moholy-Nagy, Man Ray, and Jean Tinguely.

Some artists have managed to combine different kinetic elements in a single work, as in Duchamp's 1925 *Rotary Demisphere* and 1935 *Rotoreliefs*, in which the interactions of patterns derived from concentric and eccentric circles mounted on spinning bases produced effects of three-dimensional spiraling. Duchamp even incorporated the derivation of the word 'kinetic' into his artwork—the term has the same root as 'cinematic'—with the creation of his 1926 film *Anemic Cinema*. The puns written on the

Rotoreliefs in the film parallel the puns expressed in the concepts of the work itself (note, for example, that 'anemic' is an anagram of 'cinema').



Rotorelief by Duchamp

The works I wish to consider in the final phase of this discussion are those in which the change in an artwork depends not on the eye's perception of two-dimensional illusion or on a clockwork-like or motorized mechanism, but depends instead on something outside itself to set it in motion.

Examples of kinetic art that I find particularly relevant to this discussion, combining kineticism, mathematics, physics, playfulness, and aesthetics, are the mobiles of Calder and the sculptures of George RIckey. One of the magic things about these works is that the movement originates outside the piece, from the touch of wind and the pull of gravity.

Calder credits Duchamp with the naming of his sculptures:

> I asked him [Marcel Duchamp] what sort of a name I could give these things and he at once produced 'mobile.' In addition to something that moves, in French it also means motive. [27]

Calder's mobiles have always seemed to me both otherworldly and organic, the disks of some of them evoking silhouetted schools of strange fish that might drift and circle in the turbid atmosphere of Venus, others of them seeming like trunks and leaves of trees that might grow on Mars. A Calder mobile about 15 feet high sat off to one side on a plaza that I crossed every day when I was an undergraduate in Connecticut. It always looked both graceful and silly, its tapering red base and black, yellow, and white plates gently swaying, a stark contrast to the concrete and granite around it and to the massiveness and solemn solidity of the enormous concert hall that served as its backdrop. It acted as a visual reminder that not everything had to be serious, fixed, and weighty. Calder made the marvelous comment:

> When everything goes right a mobile is a piece of poetry that dances with the joy of life and surprises. [28]

In Jean-Paul Sartre's preface to the Galerie Louis Carré catalog for a 1946 exhibition of Calder's mobiles, there appears the description:

> [The mobiles are] a pure play of movement in the sense that we speak of a pure play of light.... at once lyrical inventions, technical combinations of an almost mathematical quality and sensitive symbols of Nature. [29]

George Rickey mentions Calder's mobiles among the early influences for his own work:

> I had made some tentative and playful experiments with movement, in an Air Corps workshop. Late in 1949 I began working in three dimensions, or rather four. Calder, whose work I had known for a decade, had shown that an art of movement was possible, though I soon found that I could not accept his limits for myself. [30]

Rickey's sculptures remind me of the apparently precarious yet controlled balance of a gyroscope, or of a dancer on pointe: indeed, Rickey has described himself as a kind of choreographer. In the catalog notes for Rickey's installation at Boston's Institute of Contemporary Art in 1964, ICA director Sue Thurman described his sculptures' mesmerizing effect (emphasis hers):

> [Rickey] *sculpturally* projects into free space thinnish pieces of metal, usually steel, and he does so in such a way that the component parts *move*—indeed, that they *must* move, granted natural settings wherein air moves at random. He even sees that they move in ways which are really not *predictable* by the viewer, and virtually *not repetitive.*
>
> Children and cats—all of both groups—are captivated by the result. Rickey has noticed this. I think it can also be assumed that no adults, whatever their individual tastes for sculpture, are unappreciative of the process.... [T]he kinetic sculptures now on exhibition were hard to make, and ... are easy to watch. [31]

Rickey is himself captivated by the forces expressed in his work: the implications of energy-contained-in-mass provided by 20th century Physics, the expressive qualities of motion. He is also very much aware that artists can easily fall into the trap of incorporating these influences to produce works with novelty but no depth, his warnings recalling the admonishments written by Kandinsky a half century earlier (see page 48). He stresses that the kinetic artist should always be aware of nature's lessons:

> [Nature] is source book, example, competitor, analogy, tyrant, seducer, and also inexorable adversary. Nature has offered to the artist's eye landscape, figure, still life, and also geometry, light, intervening space (shallow or deep)—all well understood since the 15th century, and all fundamentally static. But nature is also 'natural laws:' gravity, Newton's laws of motion, the traffic laws of topology, or the laws permitting the motion of a ship or the trembling of the earth. Nature is rarely still. All the environment is moving at some pace or other, in some direction or other, under laws which are equally a manifestation of nature and a subject for art. [32]

The last artist I will mention is the one whose works combine practically all of the elements discussed above: Yaacov Agam. He is a pioneer of kinetic art of the sort both requiring and prompting movement from the spectator (his early works predate GRAV by a decade). Agam states his art to be "in perfect harmony with the spiritual, scientific and material Reality of the twentieth century"[33]: with the spiritual because of the element of irreversible time (and thus the consciousness of death) and the sense of living, rather than fixed, reality expressed in the work; with the scientific because of the implication of inseparability of space and time; and with the material because of his conception that any of the technologies of our century is a worthy tool for the making of art, whether for making light sculptures, sound sculptures, fire-and-water sculptures, or even bubble sculptures. In all of Agam's works, time is a fundamental element. Agam has said of his work:

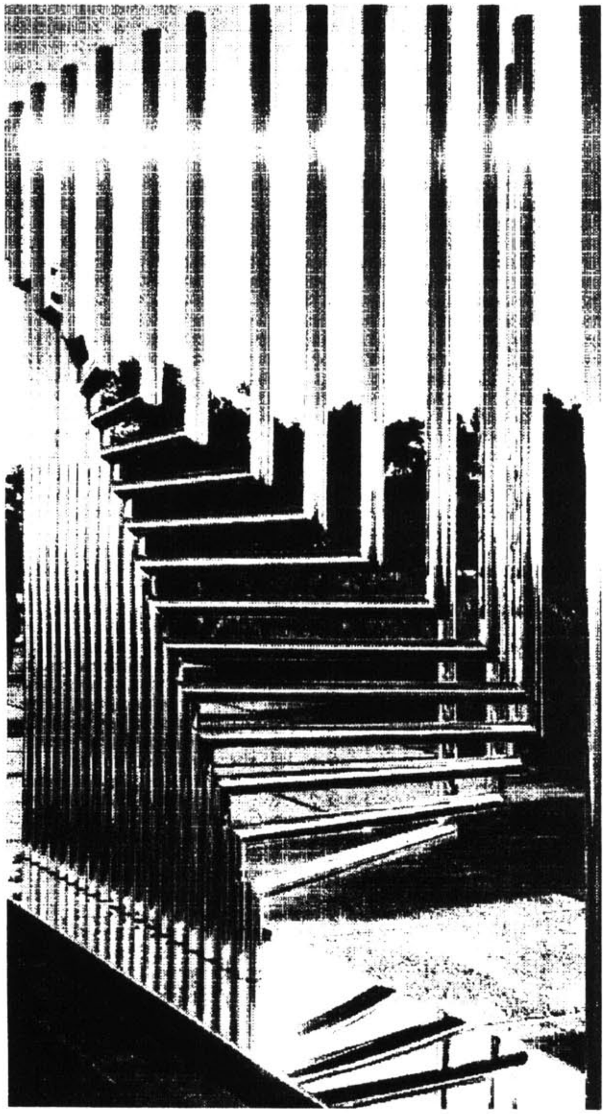
> The ordinary picture reveals itself to the spectator once only. The spectator sees everything. If someone listens to music, it takes place in time. One movement follows another. If someone reads a book, he cannot read it all at once. He reads it page by page, because there is duration implicit in it. That duration does not exist in painting. Some painters, such as Giotto, at Padua or Assisi, cover the whole side of a church, but that is only a matter of successive pictures. In my own work, every work of mine, the spectator can leaf through as if it were a book. He can listen as if it were music, because it unfolds in time. And, in contrast to books or music, in most of the work it is real time, irreversible time, because the work always reveals itself in an unexpected fashion. [34]

A sense of play is also at the heart of many of Agam's works:

> For Agam the notion of 'play' has never had the familiar connotations of winning or losing the 'game': it has been a question of man developing from his own internal resources an inner, unknown voice. From this perspective play becomes what he has called an "access to self-consciousness of freedom." [35]

Agam's work seems to be a pure distillation of much of the space- and time-play of the previous five centuries: his "accordion" paintings echo the oblique-view effects of perspective-anamorphic paintings; his use of geometric form and of color synthesizes and a harmonizes the precepts of the schools of abstract art of the early part of this century with Op Art pattern manipulation; his bubble sculptures seem to liberate the spirits of the disks of Calder's mobiles to perform a brief and complex dance.

His transformables, in particular, are all that Huizinga implied visual art could not be. They have a visual quality of play, but they add an element beyond all of the other works described thus far: they must be touched, handled, moved, so that the spectator is no longer spectator, no longer only a participant through the creative response van Doesburg described, but has now become, for the first time, physical participant, activator, player. The transformables are so varied in type and in size, from the wall-mounted peg-boards of graphic elements to the monumental transformable "linear" sculptures such as *The Hundred Gates*, *Star of David in Four Dimensions*, and *Beating Hearts*, and yet they are each in a certain way intimate, temporal, serious, and playful. They are clearly sculptures, they are clearly toys.

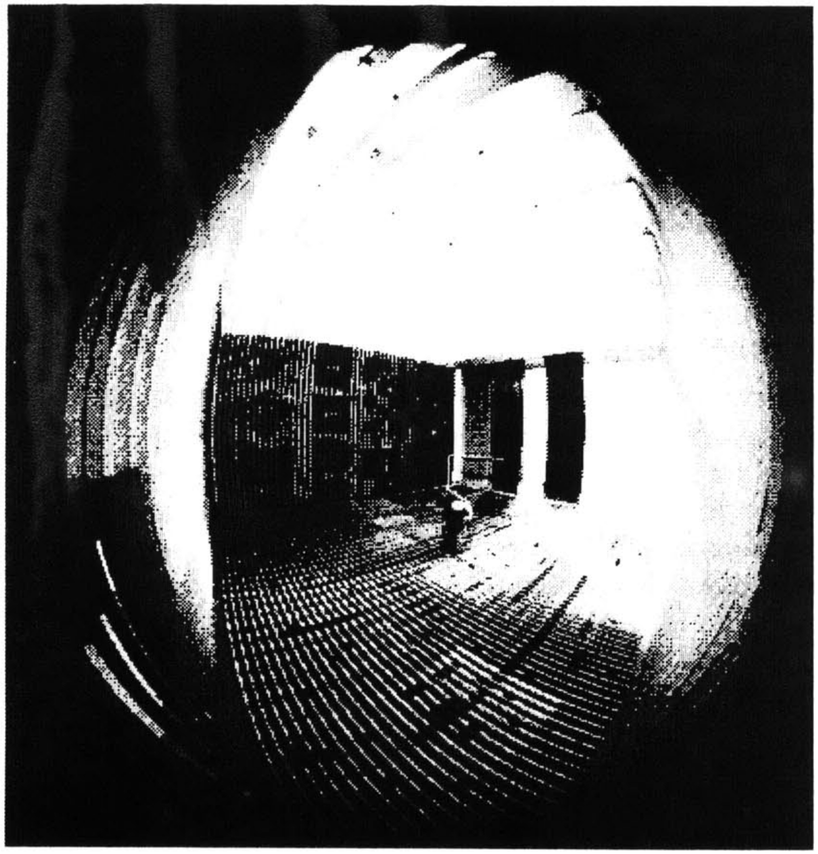


The Eighteen Levels

In Popper's words,

> They [represent] not fixed states, but possibilities, or incitements to play. . . . He is anxious not to produce mere 'tombstones,' which will record some past experience, but to represent life, to represent a process of becoming that has no definitive ending and can be prolonged to infinity. It is this constant attempt to approach the instant of experience, rather than confining the artistic statement within the bounds of definitive plastic form, that unifies Agam's concern with play activity throughout his career. [36]

It is Agam's example I endeavor to follow, for I too want my sculptures to act as incitements to actual physical play. Agam has shown that the invitation to the artistic magic circle is not only possible, despite Huizinga's predictions, but that the public is more than ready to accept such an invitation.



A roomful of Agam's works

Chapter References

(Please see the Bibliography for complete publication information for book citations.)

[1] *Homo Ludens* by Huizinga, p. 165.

[2] *Ibid*, p. 166.

[3] *Ibid.*

[4] *Ibid*, pp. 166-7.

[5] *Intimate World of Alexander Calder* by Marchesseau, pp. 74-5

[6] *Calder's Universe* by Lipman, p. 33.

[7] *Calder's Circus* by Alexander Calder, p. 124.

[8] *The Intimate World of Alexander Calder* by Marchesseau, p. 12.

[9] *The Intimate World of Alexander Calder* by Marchesseau, deciphered from figure on p. 67

[10] See the Philpot and Hendriks catalog for a broad selection of work by Fluxus artists.

[11] This is my own translation from the French text of *Happenings and Fluxus* by Dreyfus, p. [OOPS].

[12] This material is covered in *On the Renaissance Rediscovery of Linear Perspective* by Edgerton, pp. 126 - 138.

[13] Perspective boxes are mentioned briefly in *History of Art* by Janson and in *Logic and Design in Art, Science & Mathematics* by Barratt. One of Van Hoogstraten's boxes is shown in detail in *Anamorphoses: Games of Perception and Illusion in Art* by Schuyt and Elffers.

[14] From *Anamorphoses: Games of Perception and Illusion in Art* by Schuyt and Elffers, caption for Figure 8.

[15] Ibid, note for Plate 67.

[16] *De Stijl: The Formative Years*, edited by Loeb & Loeb, pp. 58 -9.

[17] *Kandinsky*, by Düchting & Taschen, p. 38

[18] *Max Bill* by Hüttinger, p. 15

[19] *Max Bill*, p. 61. This is from the biographic information by Eduard Hüttinger, whose notes about this quote read as follows:

> In the catalogue of the exhibition *Zeitprobleme in der Schweizer Malerei und Plastik (Current Problems in Swiss Painting and Sculpture)* Max Bill formulated in 1936 the principles of concrete art, conceived as an elaboration of the ideas Theo Van Doesburg expressed in 1930 in the publication *Art Concret*. He revised his text in 1949 for the introduction to the catalogue of the exhibition *Zürcher Konkrete Kunst (Zurich Concrete Art)* which travelled in Germany. This text is included in the publication *Konkrete Kunst* edited by Margit Staber (in *Gesammelte Manifeste* by Margit Staber, 1966, Edition Galerie Press, Saint Gallen)

[20] *Kandinsky* by Düchting & Taschen p. 39

[21] .*Despite Straight Lines* by François Bucher and Josef Albers. This Albers quote from 1942 described a particular group of lithographs.

[22] *Vasarely* by Spies, p. 5.

[23] From Hoek's article on Mondrian in *De Stijl*, Loeb & Loeb, ed., p. 71

[24] Ibid, p. 72.

[25] *Groupe de Recherche d'Art Visuel*, p. 2 (my translation from the original French).

[26] Ibid, p. 9.

[27] *Calder's Universe*, by Lipman, p. 268.

[28] *Calder's Universe*, by Lipman, p. 261.

[29] Ibid.

[30] *George Rickey: Skulpturen, Material, Technik,* by George Rickey, p. 29.

[31] *George Rickey: Kinetic Sculptures,* catalog of the Institute of Contemporary art.

[32] Ibid.

[33] *Le Mouvement (The Movement),* catalog of the Galerie Denise René, p. 13.

[34] *Agam* by Popper, p. 139

[35] Ibid.

[36] Ibid, p. 141.

Figure Credits

Page 41: Calder roaring with the Circus lion, 1971, *Calder's Universe* by Lipman, p. 63.

Page 41: Chess Set designed by Bauhaus teacher Josef Hartwig, 1924, from Bauhaus by Whitford, p. 149.

Page 42: Teeny and Marcel Duchamp's chess set, *The Intimate World of Alexander Calder* by Marchesseau, p. 67.

Page 48: Small Worlds VI by Wassily Kandinsky from *Kandinsky* by Düchting, p. 68.

Page 49: Variation 1 of "fifteen variations on a single theme" by Max Bill and Page 49: Variation 2 of "fifteen variations on a single theme" from *Max Bill* by Hüttinger, pp. 70 -71.

Page 51: Vega by Vasarely, 1857 by Victor Vasarely, from History of Art by Janson, p. 680.

Page 54: Rotorelief by Duchamp from Le Mouvement, The Movement, Galerie Denise René, p. 27.

Page 57: The Eigteen Levels, from *Agam* by Popper, fig 291.

Page 58: A roomful of Agam's works, from *Agam*, by Popper, fig 457.

Framework

The sculptures that comprise the project part of my thesis are one expression of my own ideas about the relationship between form, pattern, transformation, and playfulness. My perceptions of this relationship have been the basis of most of my artistic work, and my ideas about this relationship are still developing and evolving. The following sections document my discoveries and opinions over the past few years, and describe the theory behind the mechanics of my sculptures, which are based on geometric forms called "jitterbugs," a term invented by R. Buckminster Fuller.

A Personal Conception of Form

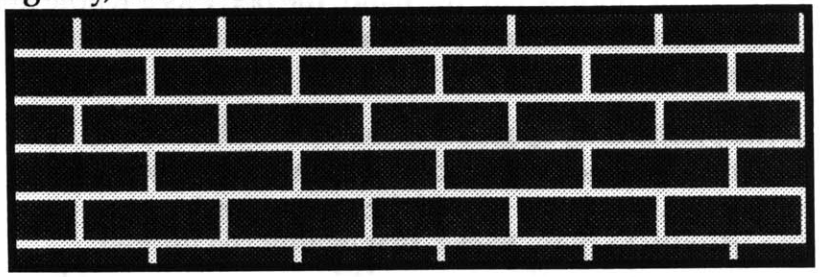
I postulate form as the foundation, the basis of interpretation in space. This view is reminiscent of the ancient Greek philosophers, Plato in particular, who proposed that form was the foundation of everything, propounding theories of geometric atoms combining according to the properties of their shapes.

On the other hand, other artists, such as Johannes Itten and Wassily Kandinsky, have taken color combined with form as their foundation, however, my interest is in experiencing space through both vision and touch—it is form that is common to these modes. Understanding one's surroundings requires recognition and categorization of objects and voids: determining which way is up, what is level or horizontal, what is reachable and what is unreachable, which spaces can be traversed, which spaces can be viewed, what is flat, what is curved. The eye, the middle ear, the hand, the body as a whole all send information about physical space to the mind to interpret.

In the plastic arts, spaces often cannot be traversed, sometimes cannot (or, by convention, should not) be touched. A barrier to any of the senses creates an opportunity to play 'tricks' that exploit the limited perception of the other senses. When a space cannot be traversed, walked on, or climbed on, the middle ear cannot test the eye's sense of the vertical and horizontal. When a space cannot be reached, or when the forms within a space cannot be touched, the hands, the body, cannot verify the eye's judgement of levelness, distance, texture, hardness, softness. The eye becomes the sole transmitter, and the mind interprets the eye's signals through filters of purely visual experience and expectation.

Visual Pattern

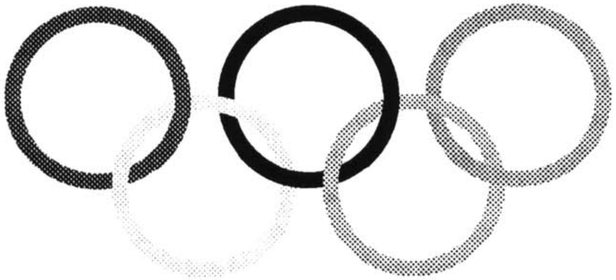
If the forms in an image or sculpture are familiar, or are geometrically and visually simple, the 'voice' of visual experience gains power in the mind's effort to analyze the object. On this basis, the mind creates strong expectations for which the eye seeks substantiations. This is a quest for pattern, in which the expectations have to do with repetitions, with conformance to a known figurative or abstract shape or sequence of shapes. The eye seeks these repetitions and looks for symmetries, which are specialized repetitions. Finding everything in place according to prediction can produce responses ranging from calm, resolution, familiarity, and security to stasis, rigidity, and boredom:



Symbolic Forms

In categorizing the elements of a scene, the beholder may take certain forms as emblems or symbols, images whose connotations transcend the attributes of shape. I find it interesting that words for very simple geometric forms and formal attributes often carry a host of meanings, particularly slang meanings: "He's a real square." "She's pretty sharp." "Look at it from this angle." "I want to hear some straight talk." "That idea's really bent." The very words 'imagery' and 'figurative language' denote mental relationships between meaning and shape.

Every culture that has ever made images at all has developed particular images and patterns that reach the status of emblems, universally recognized by those within the culture, but generally meaningless to those who are outside the culture, and, for those who recognize them, nearly impossible to divest of their iconographic weight:



In general, patterns and images that attain this emblematic status share certain traits:

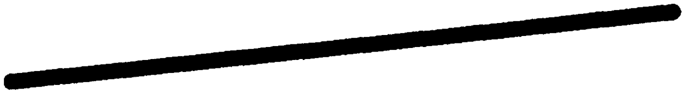
- those who recognize the symbols expect them to appear in certain places and orientations, but will recognize the forms even when distorted or shown out of their usual context, and in colors other than the standard
- the majority of those who recognize the pattern or image may not know the history, origin, or inventor of the symbol

- the set of connotations is usually vastly more complicated than the image

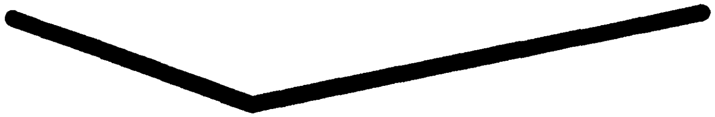
While working on my sculptures, I began to recognize and develop my personal iconography, my own interpretations of the 'meanings' of certain forms, particularly pure geometric forms, which have been the foundation of myriad philosophies for thousands of years. My personal symbology often differs from the interpretations of similar forms in various cultures' pattern systems, including interpretations that are accepted in Western, predominantly Christian cultures such as that of the United States. In the discussion below, traits ascribed to particular shapes are my own creation, unless specifically stated to be otherwise.

Linear and Planar Figures

The finite straight line, detached from any other figure, symbolizes conflict, tension, and opposition. The endpoints strain away from each other, impinging beyond the line's visible extent. Simultaneously indicating two directions without attaining either, the line denotes polarization, indecision, and risk.

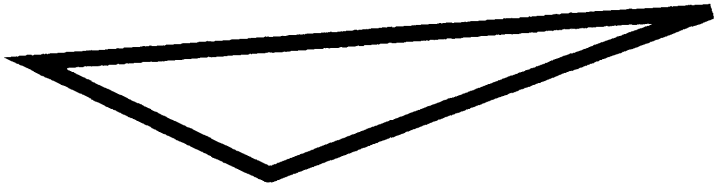


The finite bent line, the angle, signifies choice, chance, alternative, opportunity, option, decision, viewpoint, perspective. The bend is a 'meeting point,' a balance point between possibilities. It simultaneously denotes the divergence of potentials, as in the forking of a road, and their convergence, as in the narrowing of a funnel.

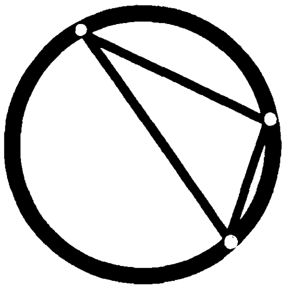


The arms of the angle admit mediation, they share an inclination toward a specific direction—unlike the undifferentiated straight line—but still fundamentally counter each other's pull.

I view the triangle as the fundamental closed figure in two dimensions. The dual triplets of the triangle's vertices and its edges define a fixed relationship, and are, for me, the image corresponding to the words specific, definite, fixed, balanced, set, stable, distinct, established, resolved. The triangle has the physical property of rigidity, but not, for me, its negative connotations of stubbornness and inflexibility. I prefer to think of the attribute as stability or firmness.



Selecting three non-collinear points simultaneously establishes a single triangle, circle, and plane.Thus the circle and the triangle are not independent figures. The triangle is the seed of the circle, the circle is the perfection of the triangle's closure and balance. The triangle's three angles counterbalance each other—any one of them mediates between the other two, acting as a restraint to their attempted divergence. The circle is the culmination of this mediation, transforming counterbalance into equanimity.



The triangle is an image tied in my mind to the word 'thus,' meaning both 'in this manner' and 'therefore,' or 'hence,' for my triangle defines not only the space it encloses ("it is thus here"), but also indicates the extension of the plane beyond the enclosure ("thus it is elsewhere"). I attach great importance to the use of a triangular arrangement of dots in mathematical proof to mean 'therefore'. . .

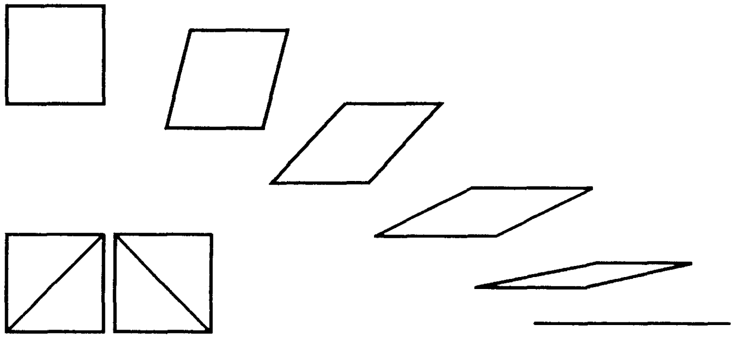
∴

. . . and to mean 'because':

∵

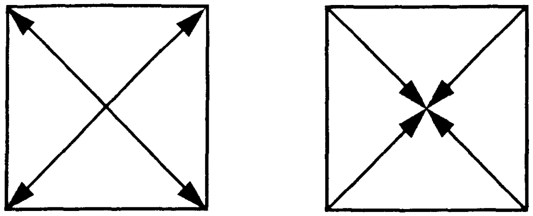
In my symbol system, the development from straight line, to bent line, to triangle corresponds to the advance from struggle to dialogue to concord.

The planar quadrilateral reintroduces discord to the system because, as a frame, it is not a rigid, stable form. A square frame confined to the plane can collapse without its edges changing in length, becoming first a rhombus and eventually a straight line, unless the frame is braced by a strut along either of its diagonals.



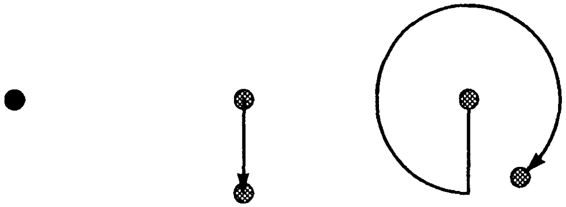
It is important in my symbology that the "collapsing" of the square is visually similar to a series of perspective views of a square turning in space from the perpendicular view to the corner-edge-on view, as if we have entered Abbott's *Flatland*. The symbolic importance is that a quadrilateral is an enlargement of a line, a generalization of opposition—the borderline between conflict and collapse among factions of human society is tenuous, the crossing of the border merely a matter of perspective.

The most regular quadrilateral, the square, represents an escalation of linear polarization, with the four mutually-perpendicular rays that extend outward from the square's center indicating an intensification of the line's symbolic strain, the rays extending inward from the square's corners indicating an intensification of conflict.



I am not at all unique in regarding the basic geometric forms as having specific symbolic meanings and visual effects. The assignment of meaning to these forms is as old as geometry itself. Egyptian, Greek, ancient Islamic, and ancient Chinese cosmological writings all include mention of the basic planar shapes, but the meanings of those shapes differ. As an example, according to the researches of Keith Critchlow, recorded in his book *Islamic Patterns: an analytical and cosmological approach,* the fundamental shapes and meanings of Islamic art develop as follows.

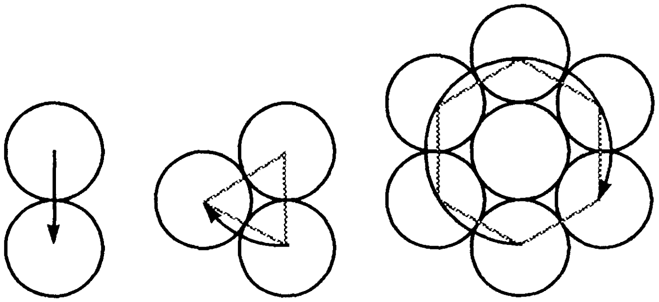
First, there is the point, which symbolizes unity and source, "the centre—the elusive controlling point of all forms."[1] The point "departs" from itself, moving in a specific direction, creating a line. The line rotates around the original center, creating a circle.



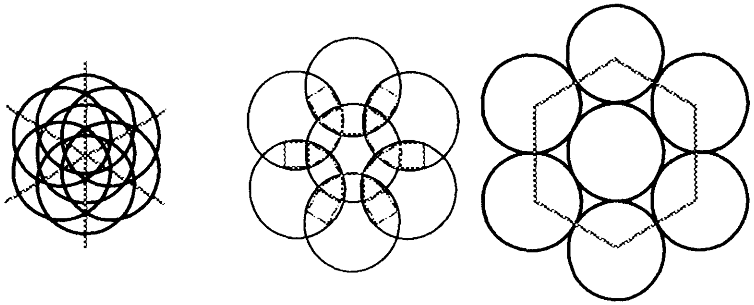
The circle symbolizes another unity:

> The circle is not only the perfect expression of justice—equality in all directions in a finite domain—but also the most beautiful 'parent' of all the polygons, both containing and underlying them. [2]

The circle repeats the motion of the point: it departs from itself in a specific direction, then the outer copy of itself rotates around the original circle, creating copies of itself that just touch the "previous" copies. This produces the equilateral triangle, when three circles appear, and the hexagon when seven circles appear. These three-circle and seven-circle groups are considered other unities:



What Critchlow calls "the simultaneous expression of direction," in which all six of the outer circles "depart" from the center at once, produces another set of symbols, and, in one of the intermediate phases, the square first appears:

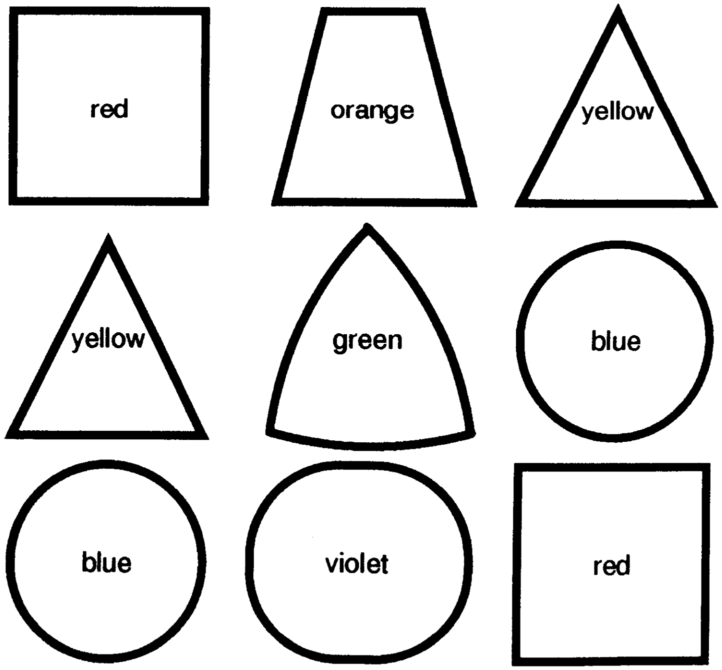


> An indefinitely extending pattern emerges made up from the exact balance of triangles, hexagons and squares. This integration of the three primal regular shapes that can fill a plane has significance both as a symbol and as an archetype of fundamental surface pattern. [3]

Turning for a moment to the symbolism of simple geometric forms in art, Johannes Itten includes in his book *The Elements of Color* a section on the relationship between form and color. He states that "shapes have their 'ethico-aesthetic', expressive values" that must be considered in relation to color such that the "expressive qualities of form and color should be synchronized." He takes as his fundamental forms the square, the triangle, and the circle, and describes his assignment of correspondences as follows:

> The square, whose essence is two horizontal and two vertical intersecting lines of equal length, symbolizes matter, gravity, and sharp limitation... A marked tension is felt when the straight sides and right angles of the square are drawn and experienced as motion... The square corresponds to red, the color of matter. The weight and opacity of red agree with the static and grave shape of the square.
>
> The triangle owes its nature to three intersecting diagonals. Its acute angles produce an effect of pugnacity and aggression... It is the symbol of thought, and among colors its weightless character is matched by lucid yellow.
>
> A circle is the locus of a point moving at constant distance from a given point in a plane. In contradistinction to the sharp, tense sensation of motion produced by the square, the circle generates a feeling of relaxation and smooth motion. It is the symbol of the spirit, moving undivided within itself... The incessantly moving circle corresponds among the colors to transparent blue.
>
> To summarize, the square is resting matter; the radiating triangle is thought; and the circle is spirit in eternal motion. If we look for shapes to match the secondary colors, we find the trapezoid for orange, a spherical triangle for green, and an ellipse for violet. [4]

In contrast to Itten, I ascribe the essence of motion to the square, and balance and equanimity to the triangle and circle respectively. In a sense, however, we both order the shapes in the same way, assigning the least spiritual qualities to the square, and the most to the circle. In this we follow Western, Christian tradition to a certain degree, echoing the elevation of the triangle, and its association with the Holy Trinity, and the supremacy of the circle, and its association with eternity, ultimate Unity, and God.

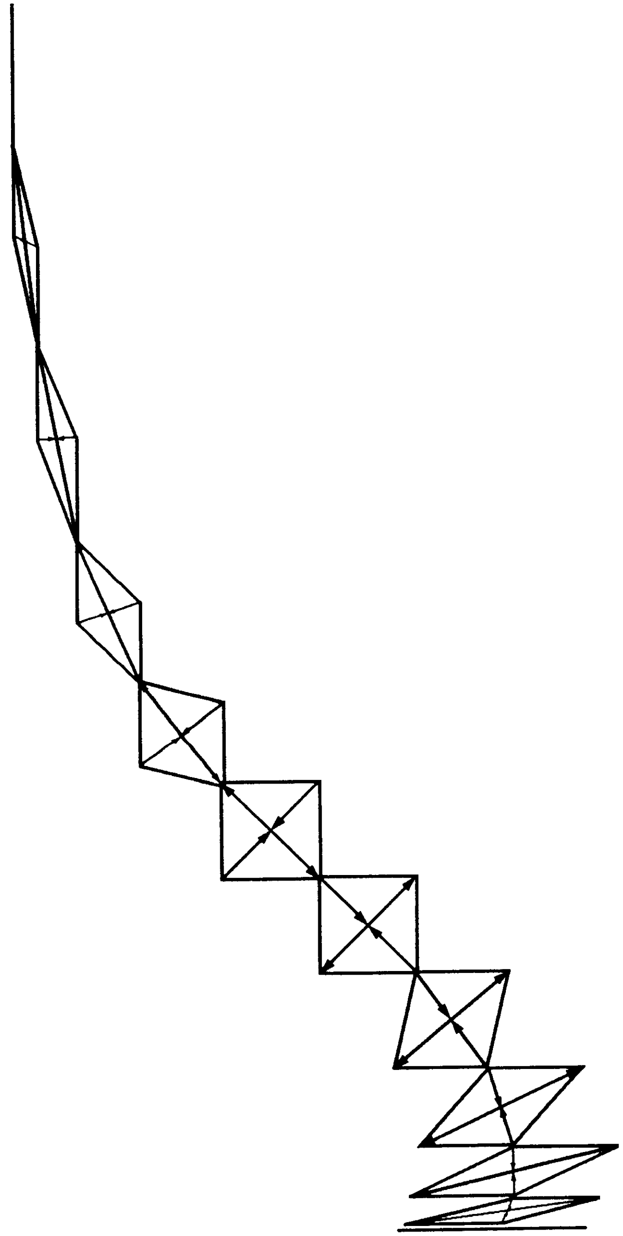


Based on Figure 57 "Association of colors with corresponding shapes", p. 75 of Itten's Elements of Color

Planar Jitterbugs: Meditations on the Square

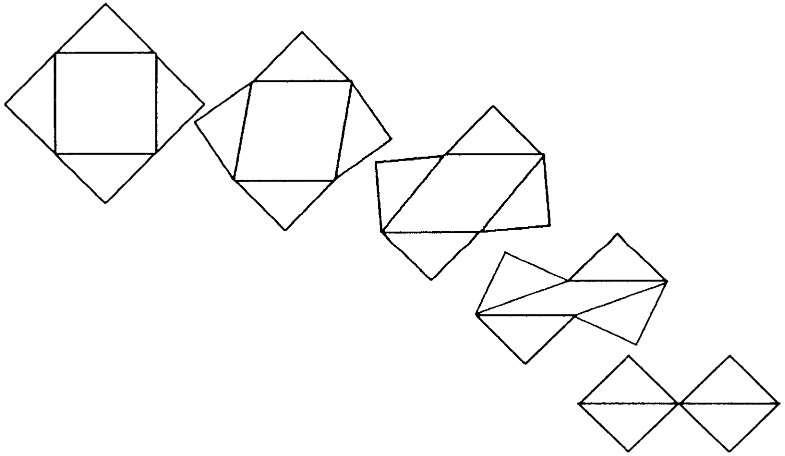
The instability of the square in my symbol system and in actual, built form introduces two aspects that are essential in my sculptures: the ring-like connectivity of forms combined with the possibility of movement.

Unlike the open angle, the self-connected path along the edges of a quadrilateral produces a specific visual definition for 'within' and 'without' in relation to the figure, until the shape's collapse is complete. In transition, the form combines the aspects of outwardly-directed strain with inwardly-directed conflict, as shown:

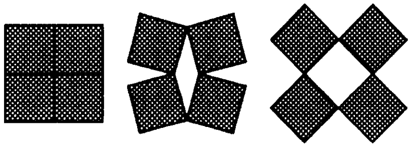


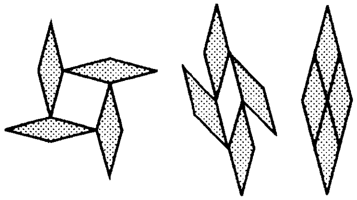
In the sculptures, I employ a reversal of the collapsing square's inner space and outer space, making the bounded area within the quadrilateral into an opening among other shapes. It becomes a shifting core for a complex of forms.

If each rod of a square frame is used as one edge of a polygon that is coplanar with the square, and if there is suitable space around the polygons, the resulting form will 'jitter' around the square 'hole':

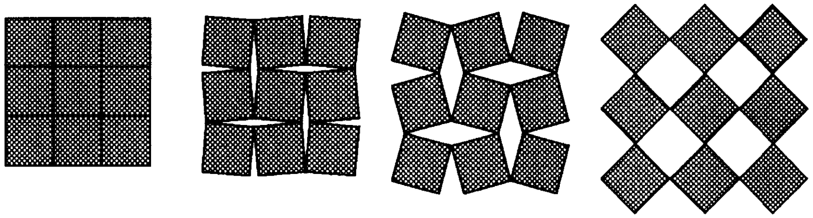


This is the basic idea behind my jitterbug sculptures. If the outer polygons are panels or tiles rather than being open frameworks, changing patterns can be created around collapsing holes. Two examples appear below:

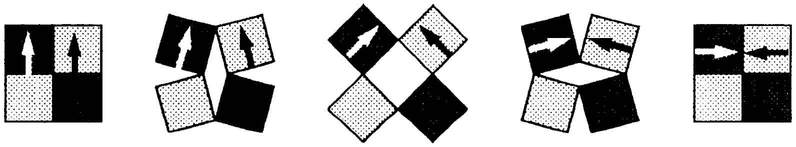




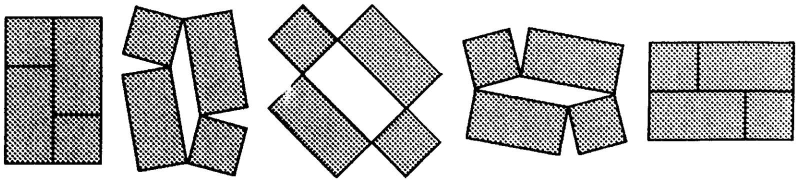
Adding more 'holes' and more 'tile' polygons with suitable hinging produces what I call a panel jitterbug. A 9-square panel jitterbug appears below:



In these panel jitterbugs there are two panel groups, one rotating clockwise, and the other counterclockwise:

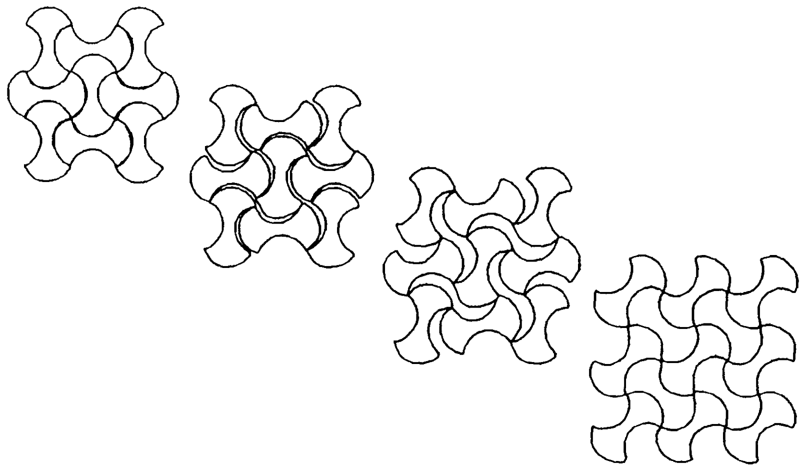


The panels of the jitterbug do not all have to be the same, and the holes do not have to be equilateral. The choice of a hinging position gets a bit more difficult, but the results are interesting:

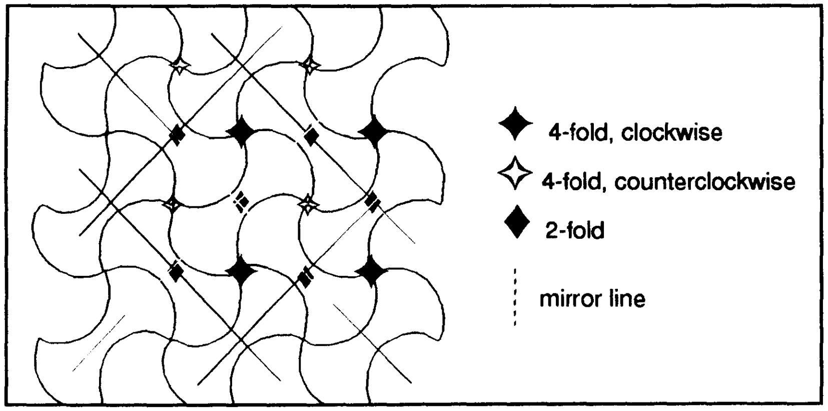


There are non-rigid frames other than quadrilaterals that can act as the 'centers' or 'holes' of panel jitterbugs. Pentagons will work, as will hexagons, and so on.

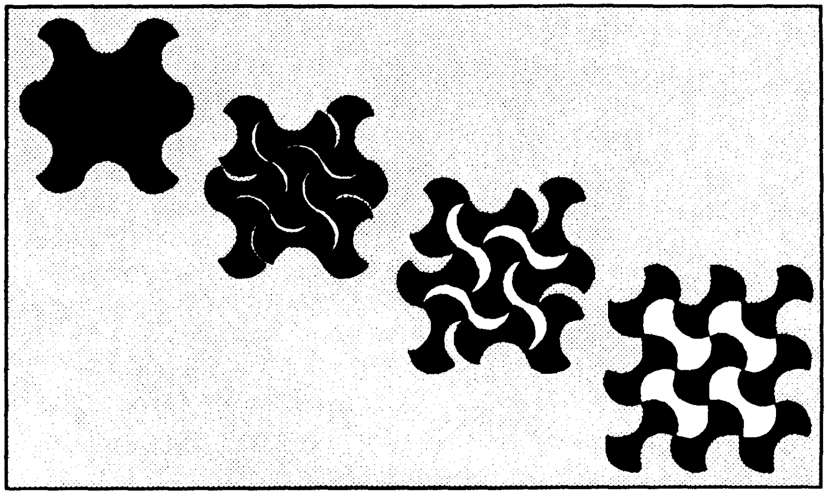
The edges of the jitterbug panels need not be straight lines. So long as panels that will end up being adjacent have the same edge design and the panels do not interfere with each other as the jitterbug opens, the jitterbug will still operate:



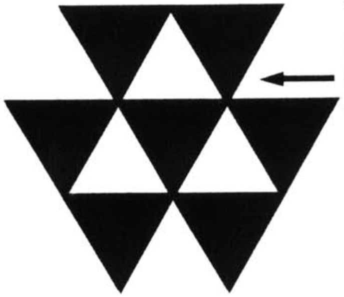
Variations on 2-4-4′ symmetry (two-fold centers of rotation with two different types of four-fold centers of rotation) will work as long as there aren't "effective overhangs" that prevent the jitterbug from opening at all.



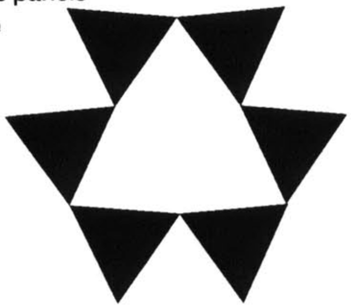
One of the things I find most beautiful about the jitterbugs is the transformation of the negative space between panels. Since the pattern of the spaces in the fully-open "regular" jitterbug is the same as the pattern of the closed jitterbug itself, the moving structure creates an impression of the underlying tessellation emerging from nothingness and collapsing back into nothingness:

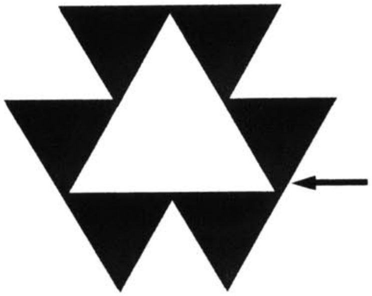


There are, of course, many ways to build a pattern that cannot move regardless of where you place the hinges, but often it is possible to remove certain sections in an unmovable jitterbug, and produce one that will move:



The triangular holes in this jitterbug are rigid—the panels cannot move

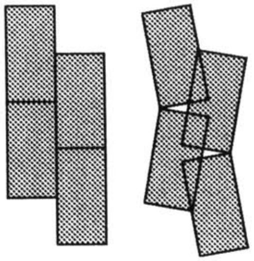


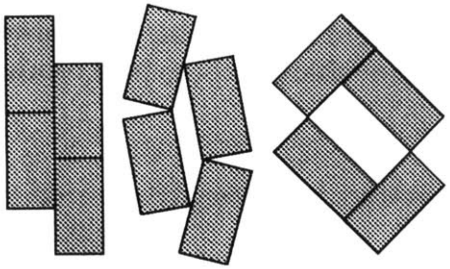


Leaving out one of the triangles in the underlying grid produces a central hole that looks like a triangle, but is really a hexagon

Sometimes the choice of panel shape combined with the choice of hinge positions will prevent the jitterbug from closing completely, and sometimes will prevent it from being able to move at all if the pieces all lie in the same plane:

This choice of shapes and hinge positions produces interference



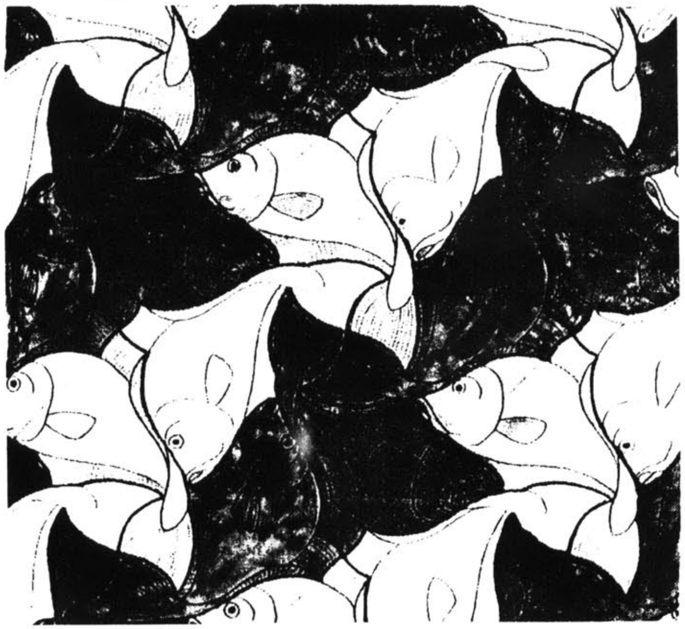


This choice produces a jitterbug that does not have a second 'closed' position

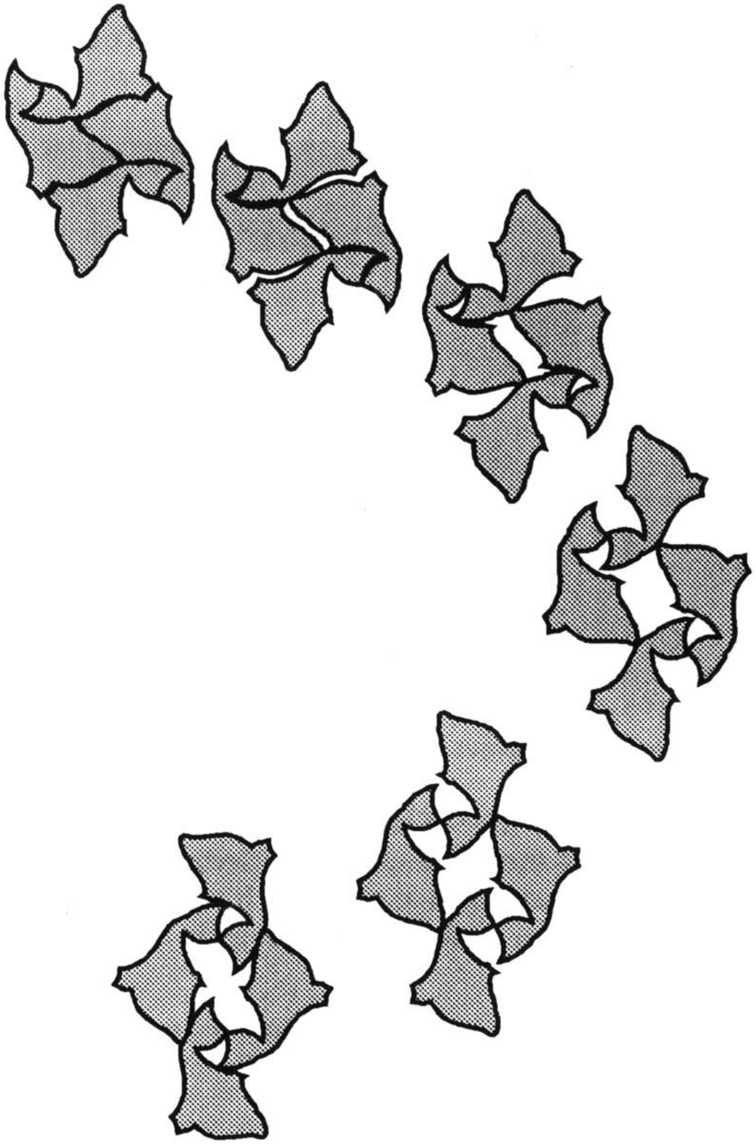
The basic rules for creating a panel jitterbug are:

- the hole polygon must not be rigid
- the panels must not prevent each other from moving around the holes
- the hinges must be positioned properly.

Among M. C. Escher's sketches there are a number of images that could be made into panel jitterbugs by making his tessellating figures into panels or, in some cases, by combining two or more of his figures. Sometimes the figures that will not close as panel jitterbugs are as interesting as the ones that will:

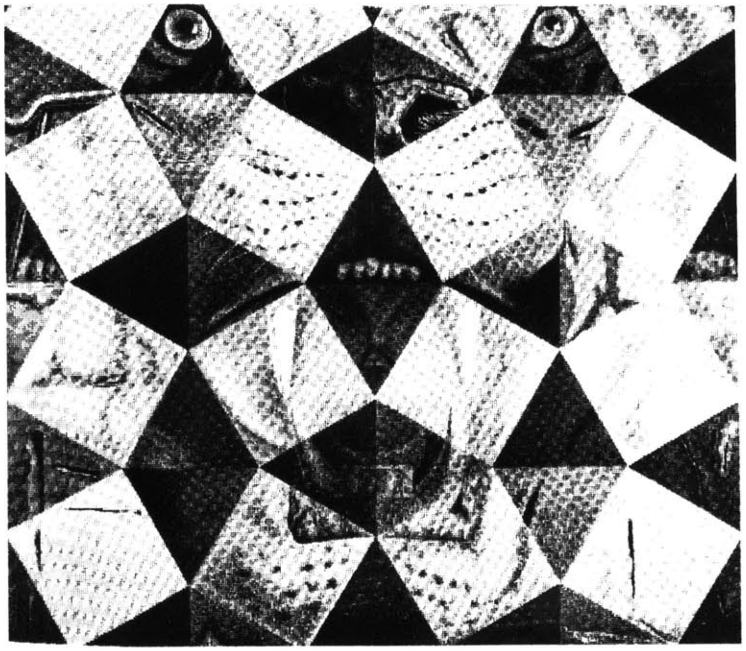


Symmetry Work 20, by M. C. Escher



Jitterbug pattern based on Symmetry Work 20

Curiously enough, one of Salvador Dali's paintings looks as if it was designed as a jitterbug:



"Fifty Abstract Pictures which as seen from Two Yards Change into Three Lenins Masquerading as Chinese and as seen from Six Yards Appear as the Head of a Royal Tiger," by Salvador Dali, 1963

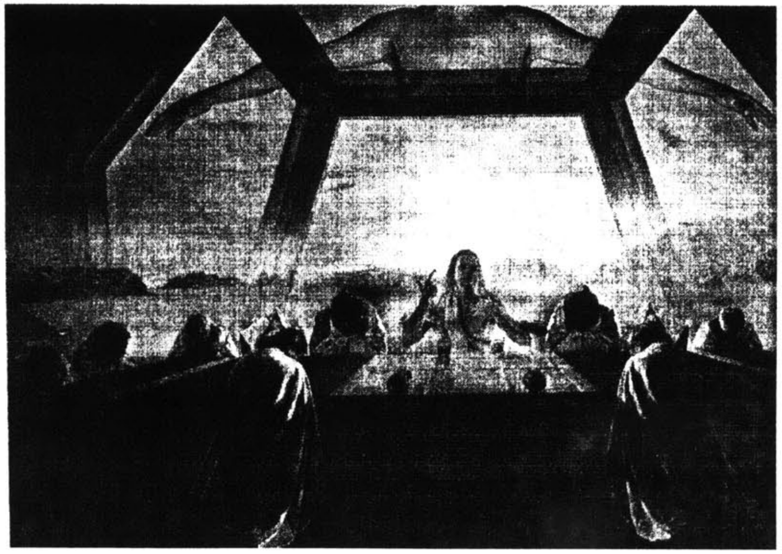
Beyond the Plane

Up to now I have discussed only planar figures, since even three-dimensional panel jitterbugs really only move in two dimensions (in fact, the more they behave like two-dimensional forms, the better). Three-dimensional solids are also important in my symbol system, as they have been in philosophy and cosmology throughout recorded history.

In ancient Greek philosophy, for example, the pentagonal dodecahedron, a Platonic solid with twelve five-sided faces, was considered to be a very special form. In his book, *An Adventure in Multidimensional Space*, Koji Miyazaki gives a brief account:

> The cosmos is filled with . . . regular polyhedra. Nevertheless, the most secret one, the regular dodecahedron, cannot be seen among them. It is sure that Plato was troubled and looked devoutly at the deep starry sky, as everyone does. At such a moment, he understood that the outer shape of the cosmos, a natural vessel for the four elements, would be exactly a regular dodecahedron. Various celestial bodies were attached to its interior. A philosopher of the Middle Ages, Bacon, wrote in *Opus Majus* that Plato was correct because the other four regular polyhedra can be easily inscribed in a regular dodecahedron.
>
> In Kepler's opinion, the zodiac is separated into 12 because the cosmos has a regular dodecahedral shape (*Harmonices Mundi*). Socrates, too, proposed a dodecahedral cosmos, just before his death. [5]

In some circles, it was even thought that the dodecahedron gave those who understood it special access to sacred information, especially because the Golden Ratio, a/b = b/(a+b), appears in the dodecahedron's proportions, and knowledge of the form was kept secret. Judeo-Christian culture associates the number five with man (and six with the Devil), and uses twelve as a fundamental dividing number, tied to the division of the Jews into twelve tribes, and to the number of Christ's disciples, so the numerical relationships of the number and edge-valency of the faces is also somewhat mystical. Thus it is fitting that, in Dali's painting of "The Sacrament of the Last Supper," Christ is depicted among his disciples under a framework that is a portion of a pentagonal dodecahedron, which fades into space behind the table, over which is a shadowy image of a torso with its arms outstretched in protection.



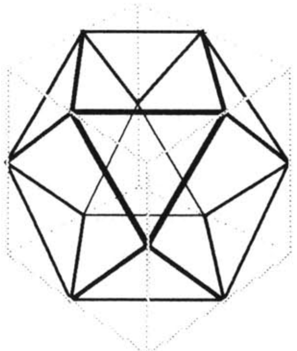
The Sacrament of the Last Supper, by Dali, 1955

But it is not only the three-dimensional solids that interest me—there are also three-dimensional jitterbugs, for the term 'jitterbug' is not my own creation. It was coined by R. Buckminster Fuller, and first mentioned in one of his books in 1960:

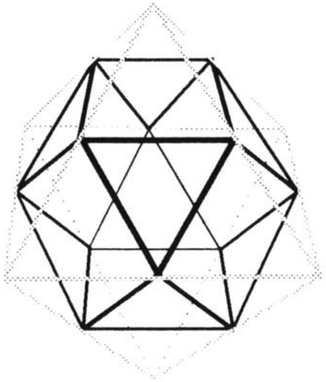
> The jitterbug is simply a vector equilibrium constructed with flexible joints. When supported, it is a perfect vector equilibrium consisting of eight triangles and six squares. When released, however, it contracts symmetrically, going through a series of phases. It becomes first an icosahedron, then an octahedron. Ultimately it becomes a tetrahedron.

A number of people have researched these forms, including H. F. Verheyn (whose article on the theory of the movement of three-dimensional jitterbugs I recommend to anyone with a serious interest in the subject), Professor Arthur Loeb, Bill Varney, Jack Gray, and Dennis Dreyer.

The 'vector equilibrium' is Fuller's name for the cuboctahedron, the form obtained by either truncating a cube down to the midpoints of the original edges, or truncating an octahedron down to the midpoints of its original edges.The vertices of this figure lie at the centers of spheres in one possible spatial closest packing. Fuller's name for the form derives from his observation that the distance from the center to any vertex is the same as the edge-length of both the triangles and the squares in the figure.



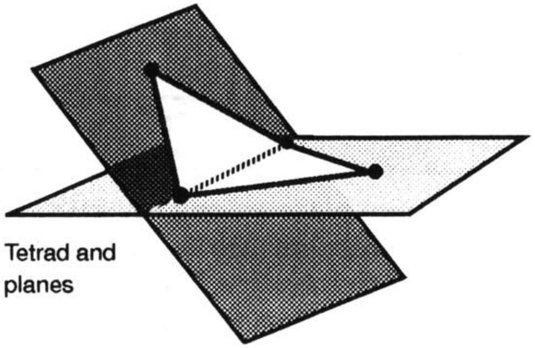
Cuboctahedron inscribed in a cube



Cuboctahedron inscribed in an octahedron

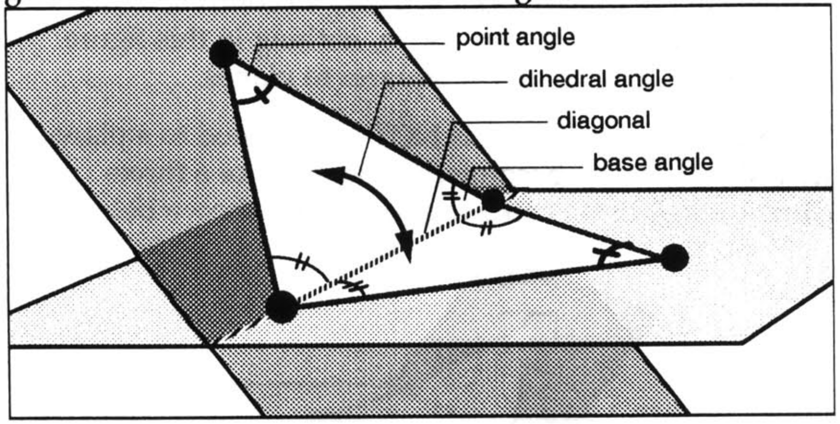
The cuboctahedral frame (by 'frame' I mean a shape made of rods forming the edges rather than of panels or tiles forming the faces) is not a rigid structure because of the squares in the framework.However, in contrast to the planar square I discussed above, nothing in this figure restricts the collapse of the squares to planes.

If a flexible square frame is NOT constrained to a plane, then the struts can become the boundary of a three-dimensional form I call a regular tetrad, shown below.



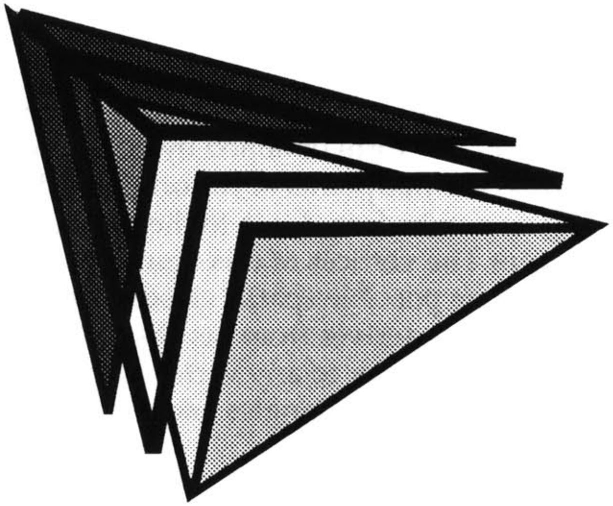
Tetrad and planes

It's easiest to think of this as a kind of bent wing, like a very simple paper airplane. It is 'regular' because all the edges are the same length. The angles of the regular tetrad that lie between the pair of struts in each plane are congruent, and I call them the point angles. The angle between each strut and the line where the two planes meet I call the base angle, and all the base angles of a regular tetrad are congruent. The segment in which the tetrad faces meet I call the diagonal of the tetrad. I call the dihedral angle of the tetrad the angle between the planes that the tetrad faces lie in (this is consistent with the general use of the term 'dihedral angle').



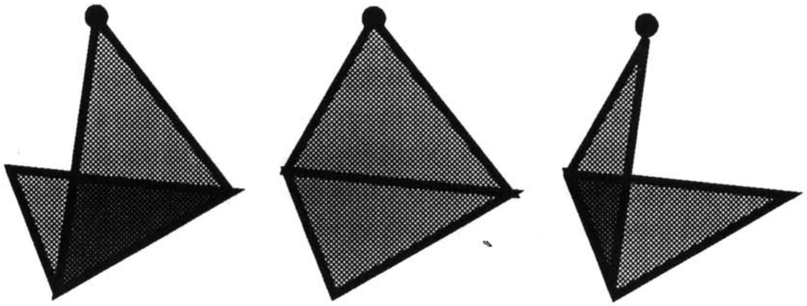
The tetrad has its own place among my geometric forms. It stands in the same relationship to the square as the bent line segment does to the straight line segment. It signifies a more harmonious state than the square's orthogonal opposition—the tension becomes potentiality. The tetrad is the symbol of folding and unfolding, the shape inherent in the hinge, the book, the moth. There is a lunar phase, about three-quarters full, where the moon's disc appears folded. The essence of a fold is the possibility of opposing factions meeting, the willingness to compromise, to acquiesce, to bend. In my symbology, the words 'fold' and 'bend' do not have the connotations of giving in, or of giving up some measure of power. I regard the ability to find compromises a kind of strength in itself.

The tetrad frame mediates between two folded surfaces, called tetrad coverings, which meet around the frame like a child's hands cupped to capture a firefly:

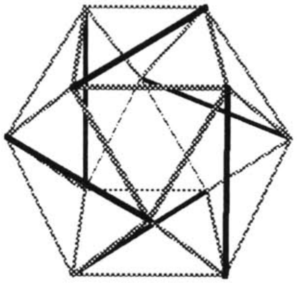


As with the linear angle, these folded forms balance divergence (in the spread away from the spine of the form's 'wings' or 'leaves'), with convergence and enclosure (in the sheltered inner channel along the spine). The tetrad represents the process of decision-making, pondering, considering—the space between the posing of a problem and its solution.

The tetrad covering surface itself represents a decision among alternatives, since, starting with a triangle plus any point outside the triangle, there are three ways to make a tetrad covering:

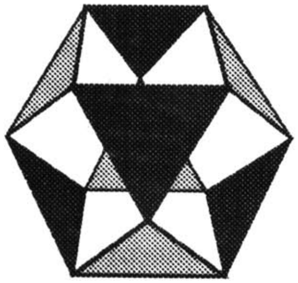


Fuller's cuboctahedral jitterbug's six squares (positioned in the planes of the six faces of the original cube) will only hold their square shape if each is cross-braced in a certain way, or, as Fuller put it, supported:

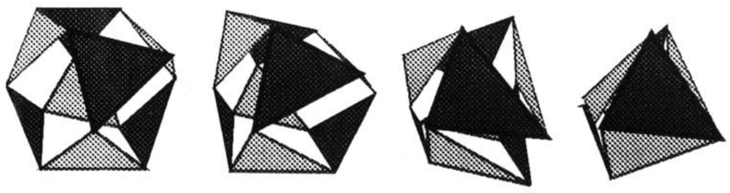


If the squares are braced incorrectly, the cuboctahedron can stretch, shrink, or twist in various ways. If the squares are not braced at all, or, in Fuller's terms, are "released," they can all simultaneously begin to collapse into congruent tetrads. In the following discussion, the tetrad coverings being described are the ones that keep the outer form convex. As the cuboctahedral jitterbug's tetrads begin to collapse, their point angles are decreasing from 90 degrees, their base angles are decreasing from 45 degrees, and their dihedral angles are decreasing from 180 degrees.

There are actually two ways that the cuboctahedron can collapse. Consider the triangles in the frame. Starting with any triangle, give it a color. Color all three of its vertex-wise adjacent triangles with a second color. Each pair of these three triangles will 'share' a vertex-wise-adjacent triangle. Color these shared triangles with the original color. These three original-color triangles all share a single vertex-wise-adjacent triangle that is exactly opposite and parallel to the starting triangle. Color this final triangle with the second color. No two vertex-wise-adjacent triangles will be the same color:



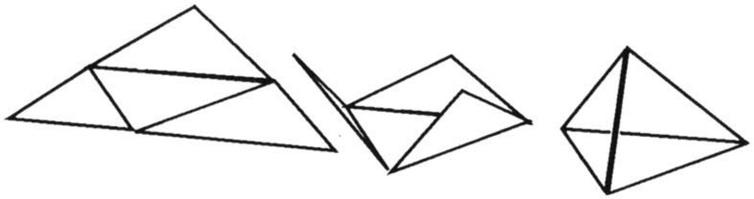
When the cuboctahedron collapses one way, the Color 1 triangles rotate clockwise as the squares deform to tetrads, and the Color 2 triangles rotate counterclockwise. When the cuboctahedron collapses the other way, the Color 1s rotate counterclockwise, and the Color 2s rotate clockwise. One of the two possible collapsings appears below:



When the point angles of all the tetrads are 60 degrees, the outer form of the object is a regular icosahedron, though six of the 30 edges of the icosahedron are missing—in other words, if, at this point, the tetrads were braced across their diagonals, the bracing struts would be the same length as the frame struts, and the framework would be a regular icosahedron.

If the tetrads are allowed to collapse until their point angles are zero, the outer form of the object is a regular octahedron with all its edges doubled.

The top and bottom triangles of the octahedron can now twist to fold the entire structure flat into four equilateral triangles with their edges quadrupled, and the outer three triangles of this can be folded up into a tetrahedron:



This shift to the tetrahedron marks a connection between my symbol system and Fuller's, explained below.

The Symbolism of Jitterbugs

Buckminster Fuller saw the vector equilibrium (cuboctahedron) jitterbug as a fundamental model of the way things move in the universe. He derived the vector equilibrium from a study of closest-packing with spheres, with the vertices of the cuboctahedron representing the centers of twelve spheres packed around a central sphere:

> There are only three possible structural systems in the universe: tetrahedron, octahedron, and icosahedron. As I pumped this closest-packed set of 12-around-one, it went down like that—it went through the icosahedron phase—that's exactly what happened when you took one ball out. . . and then it becomes the octahedron. So this vector equilibrium pumps between the three possible cases of all structural systems. So you begin to see how it is the framework of how things happen in nature. [6]

In *Synergetics*, Fuller restated this belief in the cosmic fundamentality of the vector equilibrium and of its movement in one of his classic convoluted sentences. I have quoted it below as if it were a poem:

> The vector equilibrium's jitterbugging
>
> conceptually manifests
>
> that any action (and its inherent reaction force)
> applied to any system
> always articulates a complex
> of vector equilibria macro-micro jitterbugging
>
> involving all the vector equilibria's ever cosmically replete
> complementations
> by their always co-occurring internal and external
> octahedra—

all of which respond to the action
by intertransforming in concert
from 'space nothingnesses'
        into closest-packed spherical 'somethings'
and vice versa

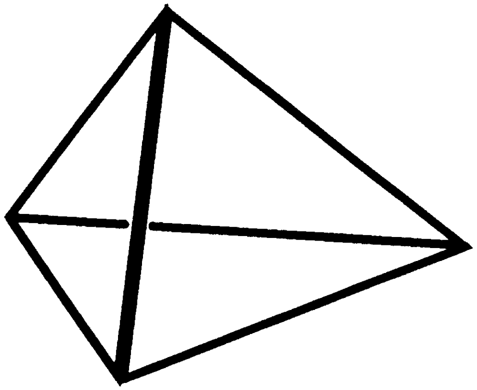
in complex three-way shuttle

while propagating a total omniradiant wave pulsation
operating in unique frequencies

which in no-wise interfere
with the always omni-co-ocurring cosmic gamut
of otherly frequenced cosmic vector-equilibrium
        accommodations. [7]

So, although Fuller concerned himself only with three-dimensional vector equilibrium, and I concern myself primarily with two-dimensional ones, we look at the forms in the same way, as an extension of the magic inherent in geometry itself. Both I and Fuller also ascribe special properties to the tetrahedron and octahedron.

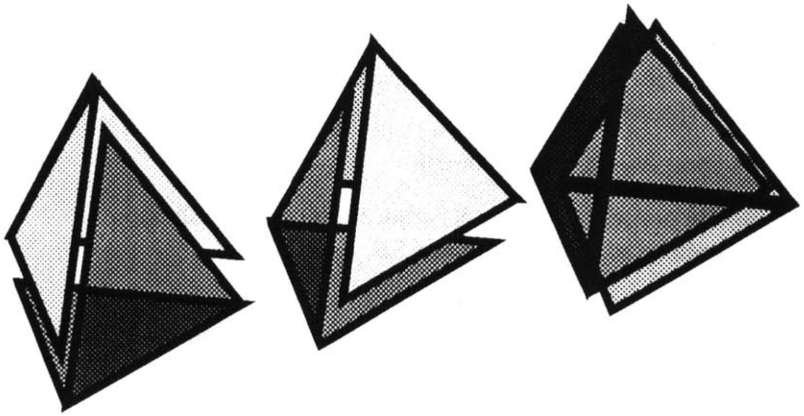
In my symbology, the tetrahedron is the fundamental closed form in three dimensions. As with the planar triangle, the tetrahedron signifies resolution, this time in the form of containment, centeredness, contentment, confidence, gathering, condensation, focus, channelling, distillation. The tetrahedron is the simplest of the Platonic solids, with only four faces, four vertices, and six edges. It is self-dual: connecting the centers of a tetrahedron's faces produces a smaller tetrahedron. It represents complete concurrence, in that every vertex connects along a single edge to every other, and every face meets every other.



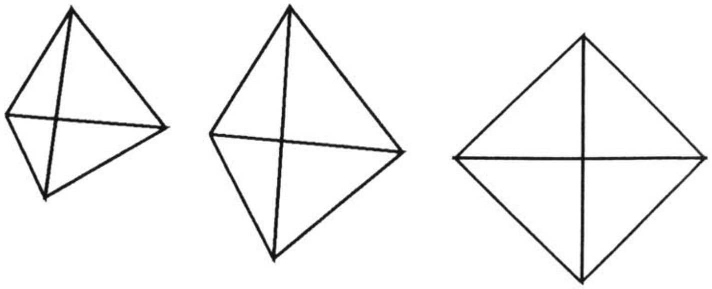
The tetrahedron is a stable form, even when built as a framework instead of a solid. In the lotus position, the human body echoes tetrahedral form, head erect, hands resting palm-up on the knees, weight distributed on the triangle of the buttocks and crossed legs. I liken the resolution and calm of meditation to the symbolic power of the tetrahedron.

Buddha statue

The tetrahedral frame mediates among three pairs of tetrad coverings, since there are three ways to associate tetrads with a given tetrahedron:



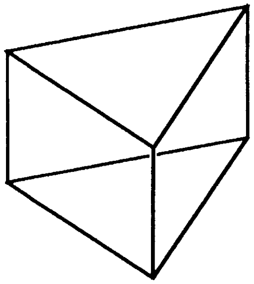
In each pair of tetrad coverings, the segments forming the spines (diagonals) of the coverings are skew-orthogonal, meaning they are at right angles to each other, but are not in the same plane. A transparent regular tetrahedron viewed along one of its planes of mirror symmetry looks like a square with its diagonals drawn in:

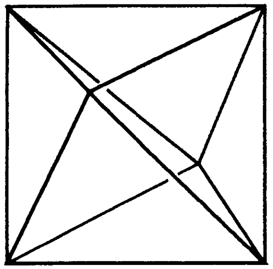


The tetrahedron thus resolves the conflict of the square, reshaping flat opposition into a balance among alternatives.

Selecting four non-coplanar points simultaneously establishes a unique tetrahedron and circumscribed sphere, and 'establishes' three-dimensional space. The tetrahedron is the seed of the space we inhabit, its stable foundation.

The final symbolic figures I will discuss here are the triangular prism, the triangular antiprism, and the hexagon:

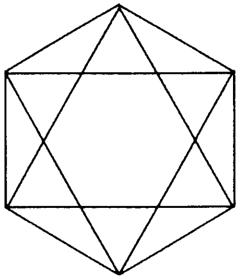


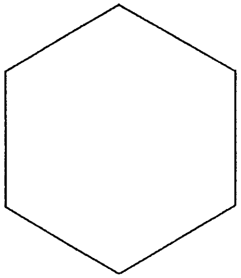


The prism represents the direct, blunt, and stubborn, the triangle advancing through space with a fixed orientation and direction, without regard for any contingencies or limitations. The figure is not rigid when built as a framework—the rectangular 'sides' of the framework collapse. Symbolically, this indicates the folly of pure obstinacy.

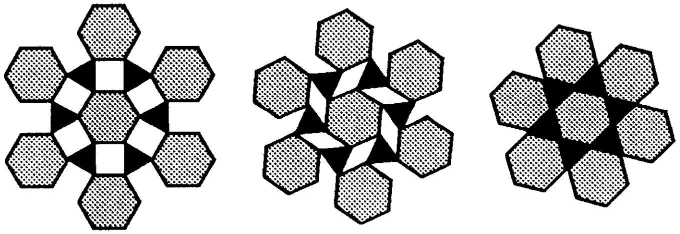
The antiprism combines perseverance with resilience, the triangle advancing through space in a fixed direction, but changing its orientation in order to accommodate change, and to accept support. An antiprism's framework is stable, since the supports are all triangular. The octahedron, a regular antiprism, balances purpose, perseverance, independence, and support.

A transparent regular octahedron, seen face-on, appears as a hexagon with two inscribed triangles. The outer hexagon comes from the zig-zag structure connecting the generating triangle to the resulting triangle of the octagon-as-antiprism. Thus the hexagon symbolizes an intermediary, translator, or bridge.





As a final note, I discovered that, in one of the generative figures in Critchlow's discussion of Islamic cosmology, where the three regular planar shapes, the triangle, square, and hexagon, all appear in a single tiling pattern, the patter works as a jitterbug:



That these three shapes appear together, and that they happen to work as a jitterbug, takes on a special significance for me, taking on a meaning related to the symbolic meanings of the individual shapes.The starting formation represents an unstable community, comprising centers of conflict among areas of fixed, well-established views, and liaisons or intermediaries among the factions. The closing of the jitterbug represents the resolution of conflicts, the working out of disputes—it becomes a beautiful symbol of hope for our world.

The symbolic significances are part of the personal, internal drive to explore these shapes sculpturally, and, particularly, to explore them as kinetic objects, in which I can express my impressions of their shifting meaning in relation to one another, as I will show in the next chapter.

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(Please refer to the Bibliography for complete publishing information for book citations)

[1] *Islamic Patterns* by Critchlow, p. 9.

[2] Ibid.

[3] Ibid, p. 20.

[4] *The Elements of Color* by Johannes Itten, pp. 75-6.

[5] *An Adventure in Multidimensional Space* by Miyazaki, pp. 12-13.

[6] Fuller to Verner Smythe, NYC, Reel 2, p. 1, 25 Feb, '69.

[7] Synergetics, R. Buckminster Fuller and the Synergetics Institute.

Figure Credits

Page 70: Symmetry Work 20, by M. C. Escher, *Escher on Escher: Exploring the Infinite*, p. 37.

Page 71: "Fifty Abstract Pictures which as seen from Two Yards Change into Three Lenins Masquerading as Chinese and as seen from Six Yards Appear as the Head of a Royal Tiger," by Salvador Dali, 1963Gallery of Modern Art, p. 135

Page 72: The Sacrament of the Last Supper, by Dali, 1955, *Salvador Dali*, Maddox, p. 86.

Page 78: Buddha statue, front cover, *Dhammapada*, Easwaran.

Jitterbug Sculptures

I make jitterbug sculptures in order to explore and express several themes:

- the way one responds to and understands a changing pattern
- the power of the moment of recognition of an image
- sensations of confusion and comprehension, the appearance of chaos, the appearance of order
- the symbolic significance of a hinge point
- the essence of rotation, an angle changing

One idea that underlies my work is that chaos and order are matters of perception. What one doesn't understand and cannot predict is both meaningless and chaotic—this concept is contained in the very meaning of the words. Discovering a pattern within a chaotic system changes its character—it ceases to be chaotic. I allege that the majority of human intellectual endeavor constitutes a search for this patter, this order. In the special endeavors of play and art-making, human beings feel free to create order based only on our individual perception: we find patterns within objects and do not require those patterns to match established norms or follow logical principles; we assign meaning and symbolic power to those patterns according to our personal rules; we impose order and sense upon a situation without demanding acceptance or understanding from those outside a special circle.

Another idea I explore is that discovery consists of realizing that one understands, of recognizing that, through logic or through intuition, one has already found a pattern. But there is a special experience before finding the pattern, at that moment when it is just beyond one's grasp, felt rather than found, and then, as in play, "all is movement, change, alternation, succession, association, separation"(see quote, page 16).

The jitterbug's form is simple, but its movement is unfamiliar, and the effect of its movement on surface patterns is difficult enough to predict that it plunges the participant into that moment-before-discovery, that moment of confusion and anticipation.

The magic thing about jitterbugs is their movement, and that is, unfortunately, the hardest aspect to convey about them in text and still images, particularly line drawings and scanned photographs. Unlike Op Artists, I am trying to convey a sense of time for an image of a real object rather than constructing an image from "anonymous and homogeneous forms" to elicit a different time-awareness. I will present a series of pictures of the forms in the stages of their movement but then the reader must try to animate them.

For my final thesis project, I created several jitterbug sculptures. My aim was to create objects that resonate with the magic of the jitterbug's movement, yet which are simple enough to make that magic comprehensible after a few minutes of experimentation. I intend the sculptures to be picked up and manipulated, so they are reasonably small and lightweight.

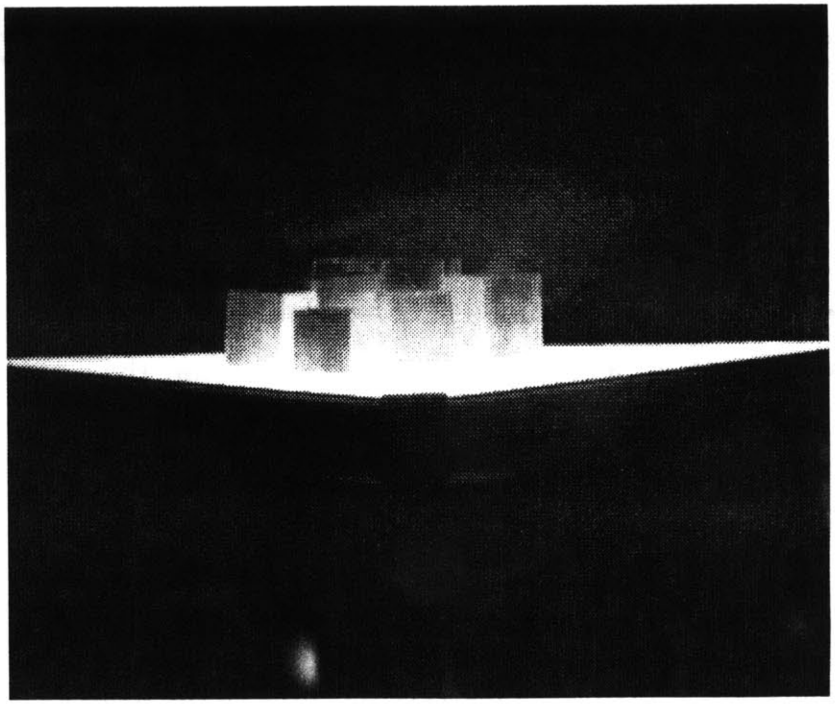
I work in wood, plexiglas, metal, and glass, contrasting transparency with opacity, and playing visual openness against actual openness.

Mirage

Mirage is a jitterbug made of 12 brass tubes with a square cross-section, open on the top and bottom, with insets of stained glass. Closed, the sculpture stands 4 inches high, and is 8 x 8 inches across and when fully open it is approximately 11 x 11 inches across. The display stand for the piece is a light-table made of poplar, plexiglas, and glass.

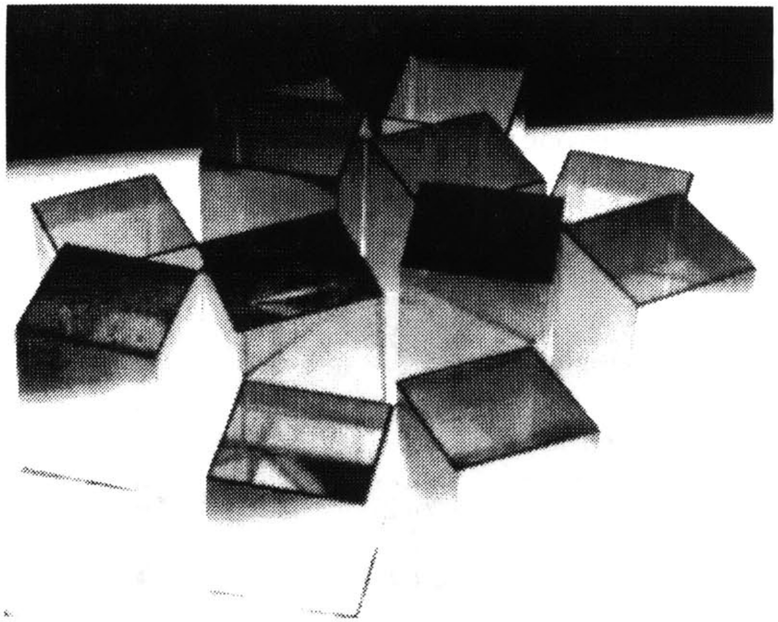
The satin-finished brass tubes or open boxes range in height from 2 inches to 3 1/2 inches. The top edges of the tubes rise unevenly from the edges to the center of the jitterbug, so that, seen from the side, the piece resembles a cluster of buildings, like a pueblo, or a city-scape when the sunset gleams off of skyscrapers of metal and glass.

Depending on the way the previous viewer left the sculpture, the boxes will either appear to be clustered haphazardly, or will appear to line up on an invisible Cartesian grid.

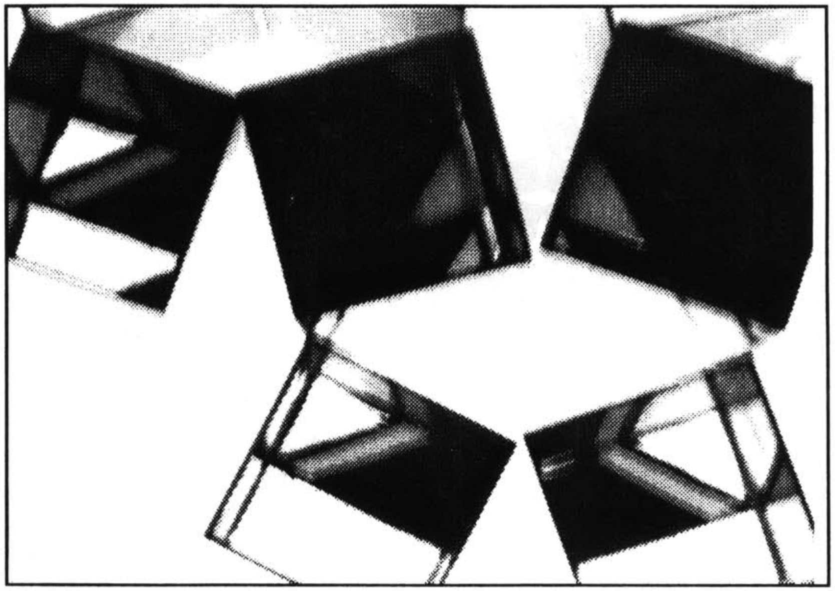


The insets mix very dark areas with very light areas, echoing the alternating sense of simplicity and complexity, clarity and obscurity, that the viewer experiences upon handling the piece. What begins as a mysterious, complex mesh becomes a simple square grid, and then dissolves into complexity again, resisting the viewer's attempts to grasp the pattern of its movement and the shift of the inner pattern.

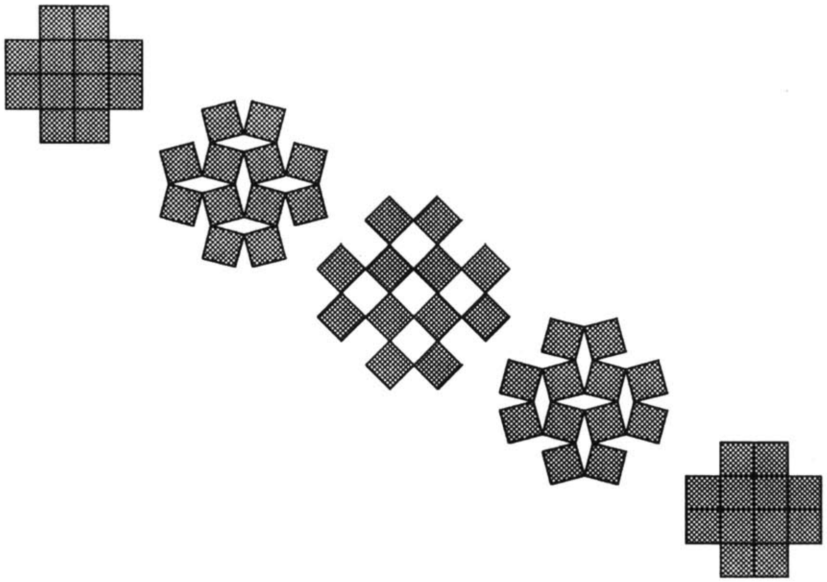
The glass insets are recessed in the boxes, so the viewer approaching the sculpture first sees fragments of pattern reflected in hints of yellow and red, and in areas of light and dark at the top of the boxes.



These glimpses of color invite the viewer to look as straight down onto the sculpture as possible, giving the best view of the pattern and its underlying structure, but, at the same time, producing reflections inside the brass boxes, some matching the patterns in adjacent boxes, some differing.

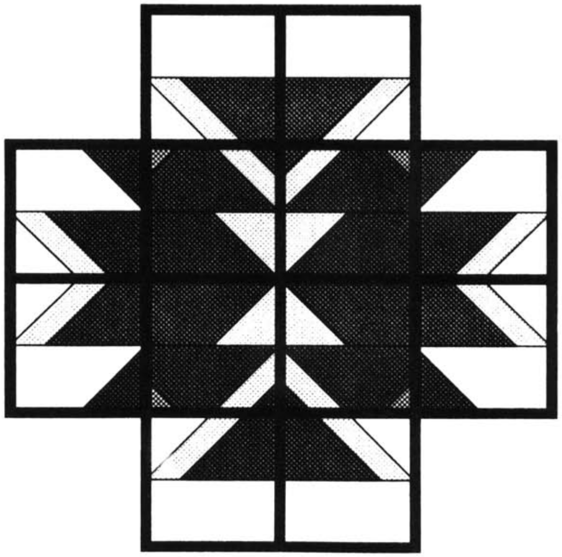


In designing this piece, I was inspired, and, at times haunted, by very personal meanings, symbols, and images. Some elements of the sculpture derive from idiosyncratic expressions of facets of my family history, of my Christian heredity, of the presence of Native Americans among my ancestors. Some of these influences are easy to identify in the finished piece, some are hidden. Consider the following connections: the twelve boxes of the jitterbug hinge together in the shape of a cross around five openings, with four of the openings opening one way, and the last opening the other:

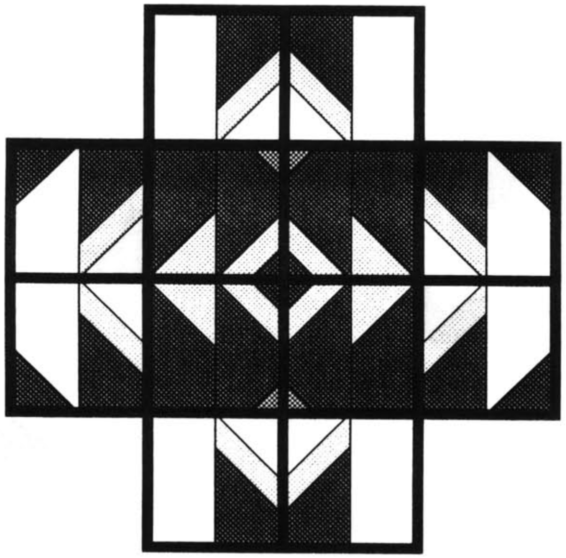


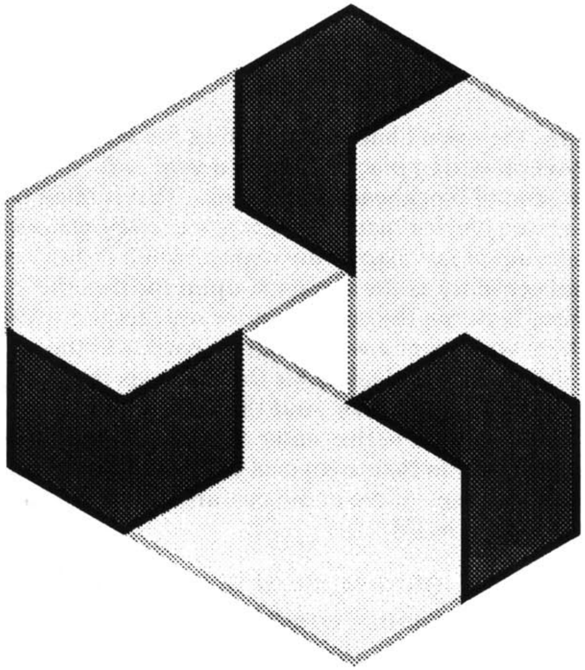
The combination of 12 and 5 relates this jitterbug form to the numerology of the dodecahedron, and the shape of the cross ties it to Christian symbolism. The pieces cannot be connected in any way other than this and still operate as a jitterbug, so the four openings that move the same way, each touching one corner of the central, unique opening, are essential to the working of the jitterbug. As I looked at those four spaces while designing the form, they took on a mystical significance, related in my subconscious to the symbolism of the cross: without my consciously deciding on their meaning, they became symbols of the writers of the four Gospels, Matthew, Mark, Luke, and John, four bridges to a central unity.

In designing the stained glass pattern, I sought a pattern that would express the idea of shift inherent in the jitterbug structure as well as the idea of opposition I associate with the form of the square. I also sought a strongly geometric form, but one based not on the various traditions of geometric form in art described elsewhere in this thesis, but one which was tied to my own history, to my own experience, memories, and creative methods. I found inspiration in a Navajo rug design, and felt a confirmation of the power of that inspiration in the discovery that, after developing my own design using the essence of the rug pattern, I produced a figure that acts in consonance with the very nature of the jitterbug. When the cluster closes one way, the energy of the pattern points inward:



Closed the other way, the pattern not only points outward, but contains, mirrored within it, a design akin to another Native American pattern symbolizing the power of the eagle:





Basic pattern for Spirit Spiral

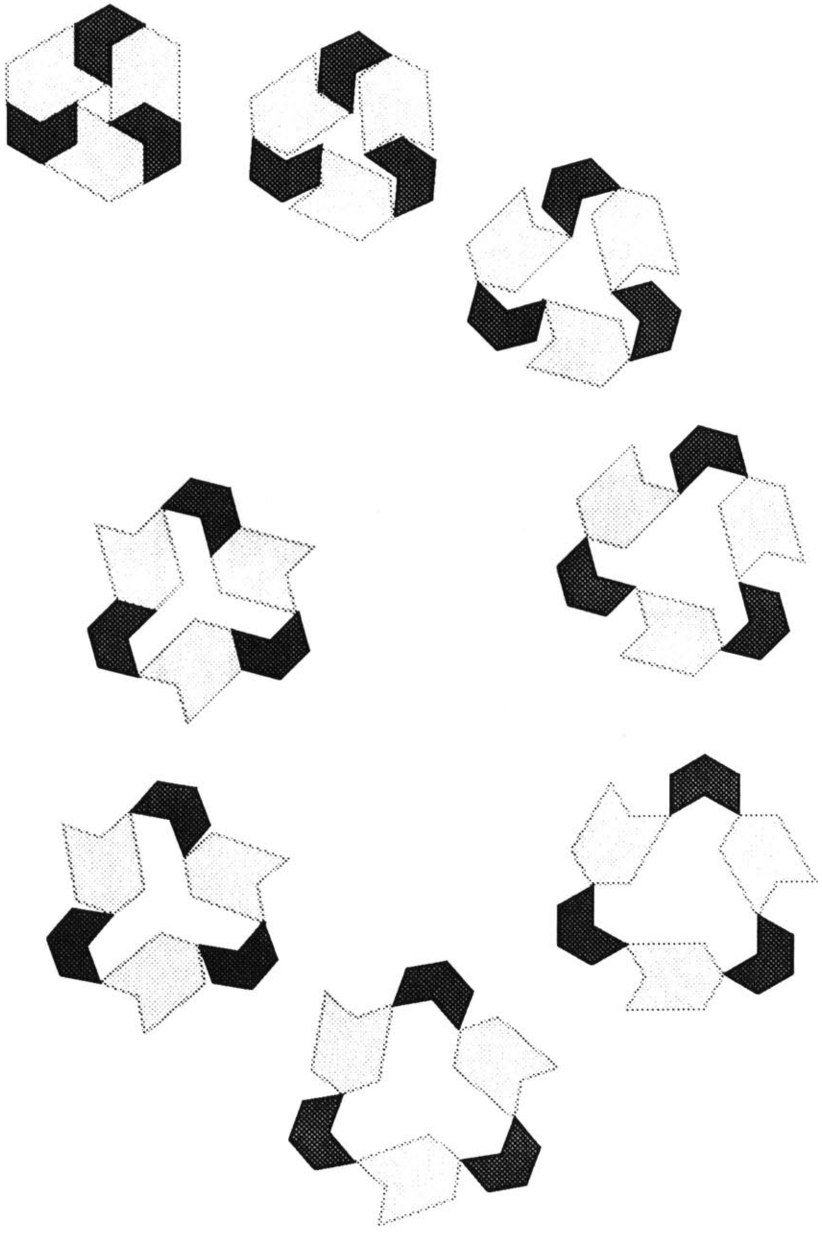
Spirit Spiral has a jitterbug structure based on three-fold symmetry. The piece is made of Honduran mahogany and plexiglas, and has a carved surface pattern. Closed, the sculpture is 8 inches across, and is half an inch thick. The surface pattern (not shown) was inspired by several images: galaxies turning in an expanding universe; spiral swirls carved in the metal of ancient Celtic bronze mirrors and battle ornaments; and Ursula K. LeGuin's description of the Hinge of a valley town she envisioned for her book *Always Coming Home*. I include the full description here for several reasons, first, because the symbolic meaning of a hinge in LeGuin's invented culture so closely resembles my own conception, and second, because I love the way she writes about it:

> I found, at last, the town I had been hunting for. After digging in several wrong places for over a year and persisting in several blockheaded opinions—that it must be walled, with one gate, for instance—I was studying yet once more the contours of my map of the region, when it dawned as slowly and certainly as the sun itself upon me that the town was *there*, between the creeks, under my feet the whole time. And there was never a wall; what on earth did they need a wall for? What I had taken for the gate was the bridge across the meeting of the creeks. And the sacred buildings and the dancing place not in the center of town, for the center is the Hinge, but over in their own arm of the double spiral, the right arm, of course—there in the pasture below the barn. And so it is, and so it is. [1]

LeGuin describes the importance of the hinge in her description of a fundamental word in the language, called Kesh, which she ascribes to the people of the town:

> Heyiya: The first element of this word, hey- or heya, is the untranslatable statement of praise/greeting/holiness/being sacred.
>
> The second is the word iya. This means a hinge: the piece of hardware or leather that connect a door to the opening it closes and opens. Connotations and metaphors cluster thick to this image. Iya is the center of a spiral, the source of a gyring motion; hence a source of change, as well as a connection. Iya is the eternal beginning, the process of energy arising and continuing. The word for energy is iye. [2]

The central turn of the jitterbug seems to have the effect of a secondary spin at the three extremes of the form, as if the outer edges responded to some centrifugal force trying to whirl them away. The dramatic explosion of the central triangle in the piece is energy unlocked.



When the piece is part-way open, the direction of the apparent "spin" of the central space changes from clockwise to counterclockwise, and the piece begins to fall back on itself. Unlike the *Mirage* jitterbug, the ending shape is not the same as the beginning shape—there is a development of form as well as of pattern. This is the quality that evoked galactic imagery—sudden expansion, and eventual recompression, gathering back the farflung pieces into a new form. The same burst symbolizes a flash of intuition followed by deeper, calmer understanding.

Jitterblocks

The final piece is called *Jitterblocks* and is the most traditionally toy-like of my recent sculptures. It started out as a tool for experimenting with stained glass patterns for *Mirage*, but it took on a life of its own.

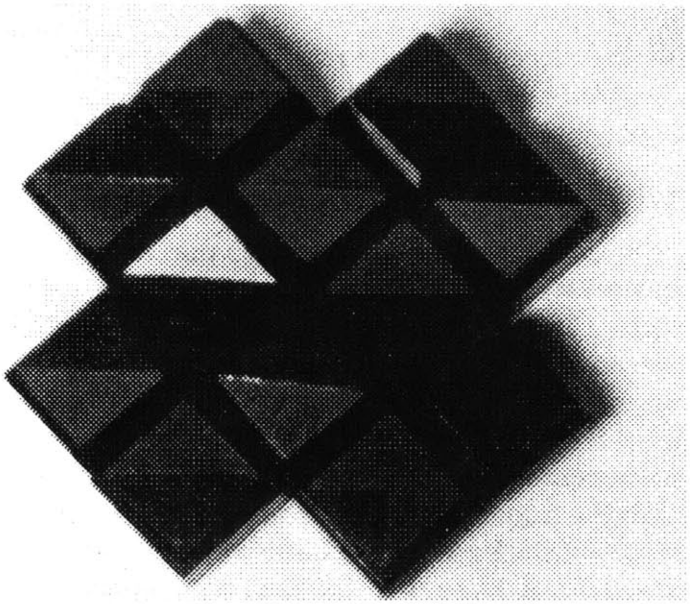
My idea was to make a structure that I could easily drop patterned squares into, observe their pattern transformation, and take them out again. I wanted it to be an interesting and pleasing object on its own, but it had a very specific "practical purpose," to use Huizinga's term (see quote on page 39). This object became a kind of personal test of Huizinga's claim that the aesthetic impulse does not enter into the making of a functional piece.

The making of Jitterblocks

The criteria for the object were:

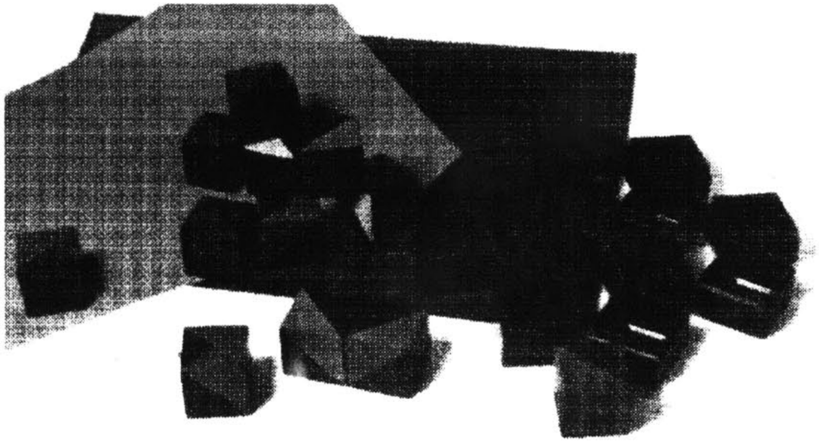
- the surface pattern and its transformation through the jitterbug movement had to be the strongest visual element—the base, the construction method, and the textures could not draw attention to themselves.
- the pieces had to be relatively easy to manufacture, sturdy, small enough to handle very easily and to carry around with me.
- it had to be cheap to make

I decided that the easiest way to make the base would be to start with some object that was already a kind of small square "well" that would be easy to hinge to adjacent pieces. This was where practical concerns and aesthetic impulse first combined: it mattered to me on a practical level that the piece operate smoothly because, if the movement was clumsy, it would attract more attention than the transformation of the pattern, so all of the twelve pieces of the base had to have the same cross-section dimensions. However, the next concern was aesthetic: it mattered to me that they not just be a close enough match not to draw attention away from the pattern, but that they be a perfect match, which meant I had to find something that could be obtained cheaply as an identical dozen. The solution was to use 1"x1" plastic pillboxes from a local crafts store. I chose black so that the base would drop into the background.

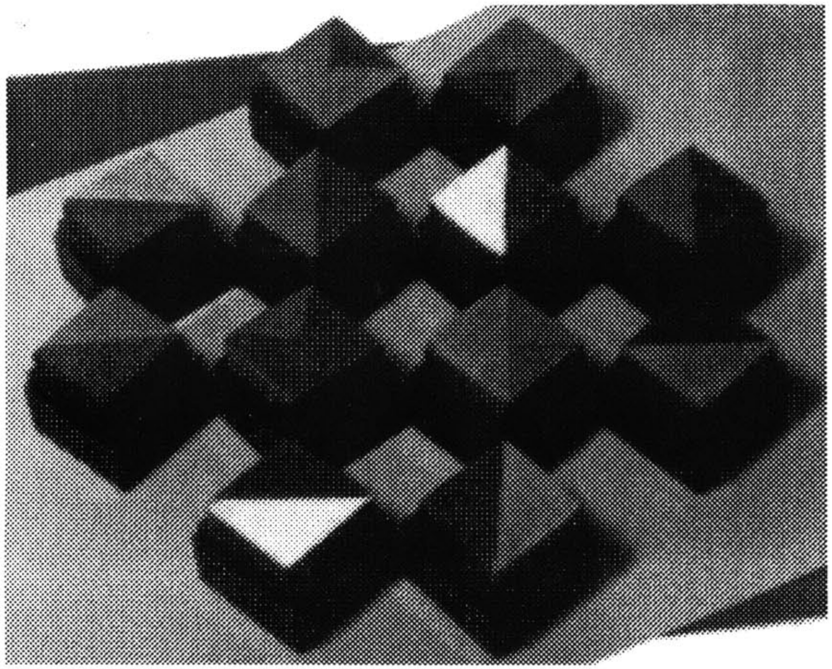


The hinging method had similar constraints: it had to make the movement smooth, to be as unobtrusive as possible, and as sturdy and easy to do as possible. The solution: I drilled holes in the corners of the boxes and tied through them with dental floss, which I then stained black with ink. Practicality would have dictated that I drill all the corners of the boxes, since the drill-holes barely showed from the sides, and didn't show at all from the top, allowing me to mass produce the boxes and not have to take a lot of time worrying about whether I was hinging the right pair of pieces during assembly. Aesthetics, however, dictated otherwise, and it was the aesthetic impulse I followed. I drilled only the minimum number of holes needed.

With the base done, the next concern was the objects to drop into the boxes. At first, I used small squares of paper with designs drawn on them. Most of them fell right out again when I turned the base upside down, making the patterns easy to examine and change. But I became frustrated with the flimsyness of the paper, and with the difficulty of changing only one of the cells at a time, so I made a set of blocks, cut to size from a poplar board, and I painted them with patterns derived from the conflict lines that I imagine within the squares, making the patterns on each side connect with patterns on adjacent faces. Having six patterns on each block allowed me to expand my pattern experiments within the jitterbug. An interesting side effect of using blocks was that now I had a set of small sculptural elements that were interesting even when they weren't in the base:



I now found that I wanted to make more blocks, to create patterns that had nothing to do with pattern experiments for *Mirage*. The jitterblocks had now become a sculpture in their own right, providing a final, personal proof that play, mathematics, and art do, indeed, meet.



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(Please see the Bibliography for complete publishing information for all book citations)

[1] *Always Coming Home* by Ursula K. LeGuin, p. 3.

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Table 1: Arts and Artists **(Continued)**

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Table 2: Mathematics in Art; Perspective; Pattern **(Continued)**

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Miyazaki, Koji	*An Adventure in Multidiemsional Space: The Art and Geometry of Polygons, Polyhedra & Polytopes*	Wiley Interscience Publications, Wiley & Sons	New York, NY	1986
Peterson, Ivars	*Islands of Truth: A Mathematical Mystery Cruise*	W. H. Freeman and Company	New York, NY	1990

Table 3: Mathematicians and Mathematics **(Continued)**

Author	**Title**	**Publisher**	**City**	**Year**
Polya, G.	*Mathematics and Plausible Reasoning*	Princeton University Press	Princeton, NJ	1954
Verheyen, H. F.	*"The Complete Set of Jitterbug Transformers and the Analysis of their Motion" (article)*	Computers and Mathematics with Applications, Vol 17, Nos 1-3, 1989, pp. 203-250 (Pergammon Press)	New York, NY	1989

Table 4: Philosophy, Science, and Cosmology

Author	**Title**	**Publisher**	**City**	**Year**
Eliade, Mircea	*The Myth of the Eternal Return, or, Cosmos and History*	Princeton University Press	Princeton, NJ	1954
Feynman, Richard	*The Character of Physical Law*	The MIT Press	Cambridge, MA	1965
Hofstadter, Douglas R.	*Godel, Escher, Bach: An Eternal Golden Braid*	Vintage Books, A division of Random House	New York, NY	1980
Hofstadter, Douglas R.	*Metamagical Themas: Questing for the Essence of Mind and Pattern (An Interlocked Collection of Literary, Scientific, and Artistic Studies)*	Bantam Books	New York, NY	1985
Hofstadter, Douglas R. and Dennet, Daniel C.	*The Mind's I: Fantasies and Reflections on Self and Soul*	Basic Books, Inc	New York, NY	1981

Table 5: Play, Toys, Games, and Puzzles

Author	**Title**	**Publisher**	**City**	**Year**
Coffin, Stewart	*The Puzzling World of Polyhedral Dissections*	Oxford University Press	New York, NY	1990
Grunfeld, Frederic V.	*Games of the World: How to Make Them, How to Play Them, How They Came to Be*	Swiss Committee for UNICEF, Zurich, Plenary Publications International, Inc.	New York, NY	1975
Huizinga, Johan	*Homo Ludens: a Study of the Play Element in Culture*	Beacon Press (original copyright 1950, by Roy Publishers)	Boston, MA	1955
Slocum, Jerry & Botermans, Jack	*Puzzles Old & New: How to Make and Solve Them*	Plenary Publications International	De Meern, The Netherlands	1986

Table 6: Miscellaneous

Author	**Title**	**Publisher**	**City**	**Year**
Easwaran, Eknath	*The Dhammapada Translated for the Modern Reader*	The Blue Mountain Center of Meditation	Berkeley, CA	1985
Tufte, Edward R.	*Envisioning Information*	Graphics Press	Cheshire, CT	1990
Le Guin, Ursula	*Always Coming Home*	Harper and Row Publishers, Inc.	New York, NY	1985

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