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ABSTRACT

Rudolf Arnheim, former Harvard Professor of the Psychology of Art, developed a theory that the perception of the structure of things in the world is based on simultaneous use of two primary systems: (1) the cosmic system of concentricity and (2) the parochial system of the Cartesian grid. The Cartesin grid imposes order, while the concentric system provides a midpoint or balancing center for everything that is seen. This paper provides experimental evidence in support of Arnheim's theory by demonstrating that a drawing's balancing center is measurable and that the measurement can be reliable and valid when compared with human judgment. The measure is then applied to test the hypothesis that the child's placement of a balancing center changes predictably with age. Thirty drawings, each representing one of 13 hypothesized balancing center locations, were collected from students in grades K-6; location of the balancing center was determined by computer and teacher judgments using (x,y) coordinates on a grid. Computer generated estimates of balancing point position on the vertical and horizontal axis of picture space displayed a very strong relationship to subjective teacher judgments of balancing centers. A set of 140 drawings from students in grades K-6 was also examined to determine whether the balancing centers changed predictably with age. Results suggest that children in grades K-6 show a strong bias for balancing centers situated near the geometric center of picture space. Five figures depict study results. An appendix shows the 30 drawings used in the balancing center analyses. (Contains 14 references.) (AEF)

The Power of the Center Revisited

Gail C. Delicio

Introduction

Rudolf Arnheim, former Harvard Professor of the Psychology of Art, searched for and truly believed that he found a key to spatial organization in the arts. His premise is that our perception of the structure of things in the world is based on two primary systems, (a) the cosmic system of *concentricity*, and (b) the parochial system of the *Cartesian grid*. Elements of the cosmic system organize themselves around a central point, and include snow crystals, hurricanes, ring-molecules, planetary motion and other wondrous things in the array of symmetrical objects and events that comprise most of the natural world. The parochial system, with everything "in a state of arrested downward motion", adjusts for the constraints of gravity, and is organized around conveniently rigid horizontal and vertical surfaces based on the Cartesian grid (1982, p. 10). The Cartesian grid imposes order in our lives, while the concentric system provides a midpoint or balancing center for everything we see. The simultaneous use of both systems is necessary to perceptually organize and visually understand every object within our view.

The Balancing Center

We take it for granted that the "center" of a regular shape like a circle, square, or triangle is always in the geometric middle of it, that it defines a structural constant, and that its location can be derived through measurement. The centers of irregular shapes, like those in free-form drawings, are not in the geometric middle, and occur in a place where compositional pushes and pulls are perceived as counterbalanced. The "balancing center" is the point at which visual forces converge to hold a composition in equilibrium.

A balancing center generally is not made explicitly visible, but rather is graphically emphasized by the artist and intuited by the observer. Although the location of this point is determined primarily by the structural characteristics of the picture, most studies that investigate it deal with the recording of eye movements over, around, and toward it (e.g., Nodine & Locher, 1988; Van Sommers, 1984; Vurpillot, 1976). In 1974, Arnheim himself recognized the methodological weaknesses inherent in modeling visual perception, and observed that "no known method of rational calculation can replace the eye's intuitive sense of balance" (p. 19). Today however, advances in computer technology have enabled researchers to analyze pictorial structure and test various models of visual perception (see Delicio, 1989).

Development And The Balancing Center

A child's first experience with drawing starts with the act of looking. In the preverbal child, it is difficult to determine whether the balancing center of a drawing can be identified as the place where he begins to scan it, or the point at which he decides to rest. Ghent (1961) hypothesized that the balancing center marks the point of departure for visual exploration, and that the location of this point changes predictably with age. She demonstrated that the very young child tends to visually explore a picture in a vertical direction, from top to bottom. Presumably, this bias toward the vertical occurs because it is coincident with the longitudinal axis of the body, and with the earth's gravitational attraction to it. It is almost as if the child's body itself serves as the frame of reference for the structure of representational space. Since visual exploration begins at the top of the picture, objects situated in the upper half of picture space are given privileged status, and are perceived as more likely candidates for the balancing center.

Further evidence supports the notion that, by age six, when a child first experiences reading, a left-right scanning strategy is adopted, and the upper left portion of the visual field is given priority in visual-motor tasks. In her research concerning visual fixations on balancing points, Vurpillot (1976) determined that children aged three to five years consistently preferred to inspect the left center of a stimulus. Older children maintained their preference for the geometric center, but viewed the left and right portions of the stimulus as equally important.

If preference for the departure point of perceptual exploration changes with age, it seems reasonable to assume that its physical placement within the child's drawing also changes. Van Sommers (1984) showed that, in sketching and dot-making tasks, a position near 11 o'clock is the preferred starting point for adults, regardless of handedness. In random line drawing, right-handed children aged three to six consciously avoided the upper left region in favor of the lower right of center, while left-handed children showed the reverse pattern. In dot-cluster tracing, right-handed children aged three to four preferred to start at lower right, but by age six, showed a tendency to start at the preferred adult position—upper left.

Method

Purpose

This paper will first provide experimental evidence in support of Arnheim's theory by demonstrating that a drawing's balancing center is indeed measurable, and that the measurement can reliable and valid when compared with human judgment. Second, it will apply the measure to test the hypothesis that the child's placement of a balancing center changes predictably with age.

Deriving a Measure of The Balancing Center

In order to measure the location of a drawing's balancing center as Arnheim described it, the picture must first be encoded within a Cartesian grid, or converted to a digitized image. According to Marr (1982) and other representationalists (Gregory, 1981; Sutherland, 1973; Zimmerman, 1987), invariant key patterns like the balancing center are embedded in pictures, and they can be decoded by analyzing the surface geometry of the picture. This principle can be easily demonstrated using a composition which has been transferred to ordinary graph paper (see Klee, 1953), or, for a more sophisticated interpretation, a bitmapped picture. In both of these examples, assuming a high contrast drawing is used, each (x,y) element in the pictorial array can be coded with either a 1 (figural space) or 0 (ground space). The processes involved in perceiving the drawing of a black shape on a white background would require the "summation" of the retina's response to the individual picture elements, taken together as a whole (Cornsweet, 1970). Hubel & Wiesel (1962) emphasize that an exact point-for-point relationship between the drawing and the receptive field map does not exist, but rather a correspondence between the picture surface and encoded information in the retina. Nevertheless, the bitmap can be viewed as a mathematically convenient way of reproducing the geometric organization of the drawing as well as a model of how the drawing is believed to be projected in early visual pathways.

Figure 1
HYPOTHESIZED BALANCING CENTER LOCATIONS

TL	TC	TR
CLT		CRT
ML	C	MR
CLB		CRB
BL	BC	BR

(a) TL, top-left
(b) TC, top-center
(c) TR, top-right
(d) ML, middle-left
(e) C, center
(f) MR, middle-right
(g) BL, bottom-left
(h) BC, bottom-center
(i) BR, bottom-right
(j) CLT, center-left-top
(k) CRT, center-right-top
(l) CLB, center-left-bottom
(j) CRB, center-right-bottom

Procedure

Computing the Balancing Centers

Six hundred fifty-two 6" X 6" high contrast ink drawings on white card stock were collected from students in grades Kindergarten through grade six. Thirty drawings labeled AA to Z (Appendix) were selected from the pool of 652 on the basis of their representativeness of hypothesized balancing center locations spanning the entire page. The 13 possible balancing center locations under consideration are found in Figure 1.

A file was generated containing computer-generated (x,y) coordinates corresponding to black pixel locations for each picture. Each picture contained one balancing center which was computed by estimating the mean of all black pixels in terms of their distances along the X-axis, and the mean of all black pixels in terms of their distances along the Y-axis. The balancing center was plotted as a function of the intersection of these means.

Deriving Human Judgments Of Balancing Center Location

The purpose of the following procedure was to establish a set of perceived balancing center locations for each of 30 drawings. Ten Kindergarten through twelfth grade art teachers volunteered to participate in this phase of the study.

Stimulus materials consisted of the set of 30 black and white high contrast original ink drawings for which computer estimates of balancing center location were already obtained. Each of the 30 drawings was backed on white paper, and covered with a sheet of clear acetate. A water soluble marker was provided for marking on the acetate.

In order to establish a frame of reference, the entire collection of 30 drawings was presented to each individual art teacher at the outset. The teachers were then asked to "locate and mark the center of balance on each single drawing". Teachers were encouraged to interpret the meaning of "center of balance" in any way they deemed appropriate, drawing upon past experience or training.

For each of the ten marks (across 30 drawings), the distance along the horizontal (x) axis and the distance on the vertical (y) axis was digitized and measured. For each of the thirty drawings, the mean of all judgments of balancing center distances along the x-axis and along the y-axis were computed. This set of means was used to represent the set of perceived balancing center locations each of the 30 drawings .

Reliability and Validity of Human Judgments

A reliability estimate of the ten teacher judgments on balancing center location was obtained by intercorrelating the (x,y) coord'nate values in 30 pictures for

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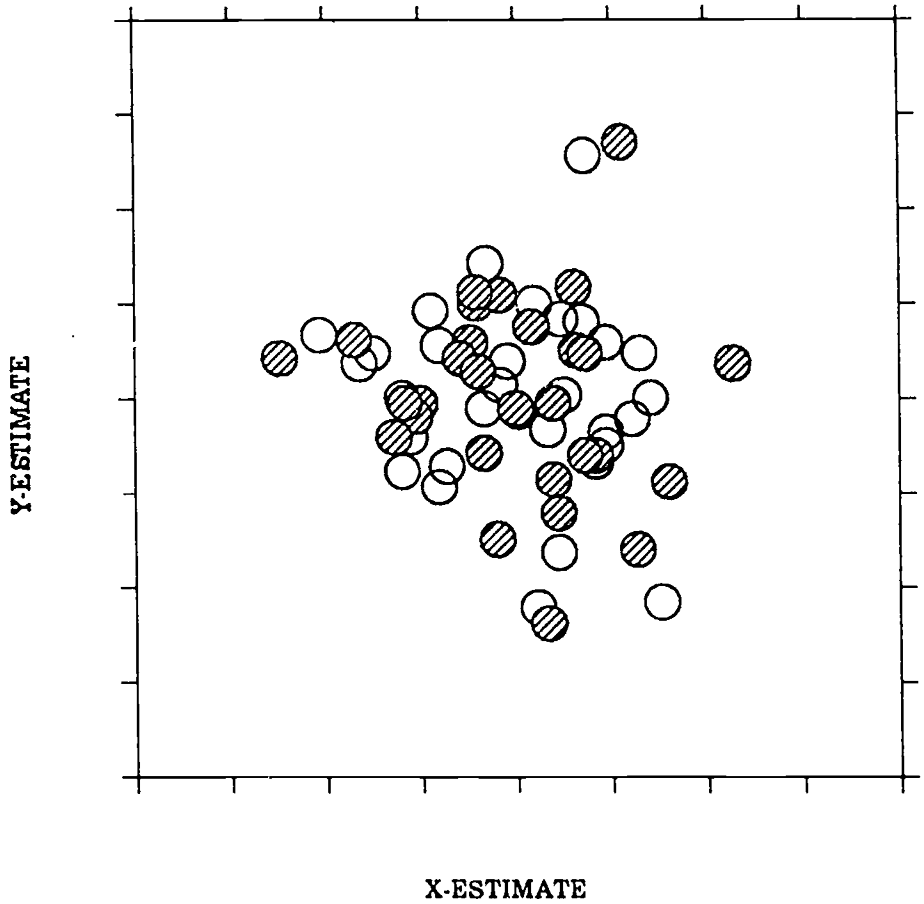
every possible pair of the teachers. The average intraclass correlation coefficient calculated for the 10 X 10 matrix for x-axis values was 0.647. For y-axis values, the obtained intraclass correlation coefficient was 0.753. Overall, teachers were in moderately high agreement on the vertical dimension of balancing center locations, and and in moderate agreement on the horizontal.

Teacher judgment means for the 30 balancing centers were correlated with corresponding computer estimates to produce a strong agreement on the horizontal axis (r=.843), and a very strong agreement on the vertical axis (r=.912). A plot showing the computer estimates and teacher judgments of balancing center locations for the 30 drawings is found in Figure 2. The overall pattern of subjectively judged coordinates is strikingly similar to the plot of computer estimates. The Euclidian distances between teacher-judged and computer-generated balancing centers is presented in Figure 3. The greatest difference between computer and human judgment occurs for Picture EE (30 mm), while the greatest similarity occurs for Picture G (1 mm). These differences are interpretable within a 152.40 mm X 152.40 mm picture space (equivalent to 6" X 6", the original drawing size).

Figure 2
COMPUTER-ESTIMATED AND TEACHER-JUDGED BALANCING CENTER LOCATIONS FOR 140 DRAWINGS



Clear = Teacher Judgments
Shaded = Computer Estimates

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Figure 3
EUCLIDIAN DISTANCES BETWEEN TEACHER-JUDGED AND COMPUTER-GENERATED ESTIMATES OF BALANCING CENTERS FOR 30 PICTURES

Picture Code	Distance (mm)	Picture Code	Distance (mm)
AA	5	H	9
A	7	J	3
BB	8	K	2
B	11	L	9
CC	12	M	11
C	15	N	5
DD	15	P	6
D	12	Q	4
EE	30	R	16
E	16	S	8
FF	14	T	20
F	18	W	8
GG	16	X	16
G	0	Y	9
HH	9	Z	15

Cluster Analysis of Balancing point Location

The purpose of this analysis was to determine whether the balancing centers in the set of 140 randomly selected drawings from children in grades Kindergarten through Six, changed predictably with age, or whether they varied randomly. Input data for this analysis were composed of the sets of computer estimates of balancing center position on the (x,y) axes for the 140 pictures. The procedure involved computing the (x,y) coordinates for six cluster centers, and classifying pictures so that members of the same cluster were similar with respect to balancing point location. Clusters are interpretable within a picture space scaled, in pixels, from -100 to +100 on both axes, with the origin at the center.

The graphic interpretation of the six cluster centers reveals that most of the balancing points in the 140 drawings tend to be situated near the geometric center of the picture space (See Figure 4). Forty-three per cent of the drawings in the largest cluster, slightly to the lower left of center, are primarily from children in Kindergarten and first grade. Clusters appear to be heterogeneous with respect to grade level, with the exception of clusters three and four (no representation by Kindergartners), cluster four (no representation by first graders), and cluster six, (no representation by fifth graders). The breakdown of the cluster membership by grade is presented in Figure 5.

Figure 4
FINAL CLUSTER CENTERS FOR 140 DRAWINGS

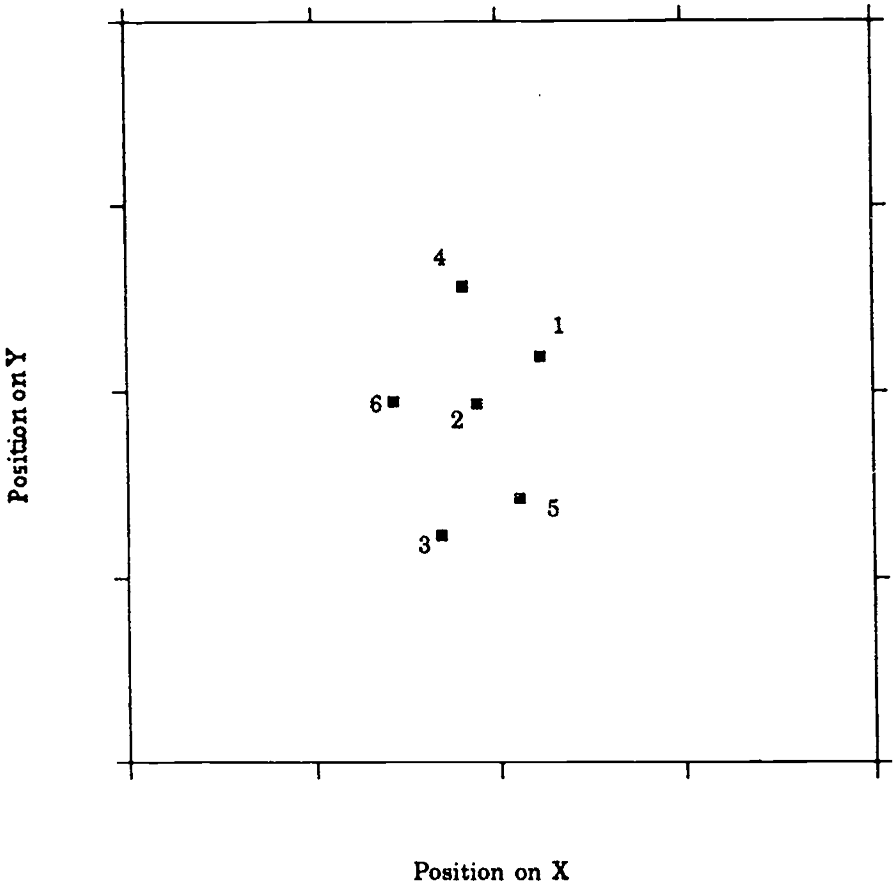


Figure 5
CLUSTER MEMBERSHIP BY GRADE

Grade	Cluster Membership 1	2	3	4	5	6
K	5	13	0	0	1	1
1	4	11	1	0	2	2
2	4	4	1	4	3	4
3	4	5	2	2	6	1
4	4	5	2	3	1	5
5	5	8	2	2	3	0
6	4	9	1	3	2	1

A Grade X Cluster Membership ANOVA was performed to determine whether clusters differed significantly with respect to grade level. The results indicate that grade level makes no significant contribution to explaining the variability in cluster membership ($F=2.03$, 6,133; $p=.07$).

Interpretation

The outcomes of this study can be interpreted as follows:

1. Computer generated estimates of balancing point position on the vertical and horizontal axis of picture space displayed a very strong relationship to subjective teacher judgments.

2. The majority of drawings analyzed in this study were organized around balancing centers situated near the geometric center of picture space.

3. Six (x,y) coordinate positions, all situated near the geometric center of picture space, emerged as possible classification criteria for balancing centers in the 140 drawings analyzed.

4. Using the obtained classification criteria, children's preferences for balancing center location were not explained by differences in chronological age for groups spanning Kindergarten to Sixth Grade.

Arnheim predicted that intuitive introspection alone would be sufficient for the detection of the balancing center (1982, p. 6). This hypothesis was shown to be correct in the high degree of agreement between teacher judged, and computer-generated, balancing centers for 30 drawings.

A cluster analysis was performed on computer estimates for 140 drawings to determine whether a developmental trend occurred in the selection of balancing center locations. Six cluster centers emerged, representing the mean of means (of positions on the x- and y-axis) of all cases associated with the coordinate address of the cluster. The locations preferred by children in Kindergarten and first grade were slightly to the lower left of center, and slightly to the upper left of center, respectively. Under the assumption that the balancing center represents the starting point of visual-motor exploration on the page, these results concur somewhat with those of Vurpillot (1972). They are in contradiction to Ghent's experimental results on children's scanning behavior, and to Van Sommer's work with drawing production tasks.

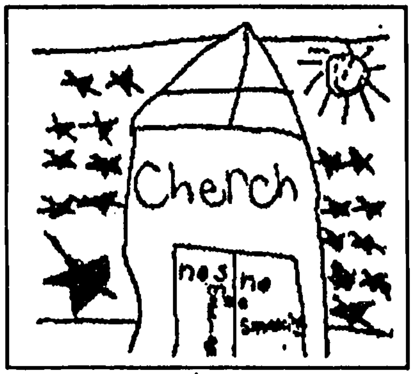
As predicted by Vurpillot, children in all age groups of the present study displayed a preference for balancing centers near the geometric center of the drawing. The position to the lower left of center was dominated by drawings made by the youngest artists (aged six to seven). In Vurpillot's experiment, which used line drawings of houses as stimuli, exactly the same location was cited by three-, four- and five-year-olds as the preferred fixation point in visual scanning.

Van Sommers found that in sketching and dot-making tasks, the lower right was the preferred starting position for drawings produced by right handed children aged three to six. In the present study, however, only thirteen per cent of the pictures displayed balancing centers in the cluster to the lower right of center. Pictures from all age groups were represented in this cluster, with the greatest number (6) from third grade, and the least (1) from Kindergarten and from fourth grade. Only ten percent of the pictures showed balancing centers in a position to the upper left of center. Pictures from all grades, with the exception of Kindergarten and first grade, were represented in this cluster.

These results contradict Ghent's prediction that, due to the influence of visual reading behaviors, the primary location of choice for children six and older would be the upper left region. It is interesting, however, that pictures from the youngest artists are not represented in this group.

The data obtained in this study suggests that children in Kindergarten through the sixth grade show a strong bias for balancing pictures around a balancing center situated close to the geometric center of picture space. The area of picture space that captured balancing centers in all drawings was bordered, on average, by about three centimeters of blank space, in all directions. Preferences for balancing center location were not explained by differences in chronological age. Counter to the expectations of Ghent and Van Sommers, neither the upper half of the picture nor the 11:00 position emerged as privileged areas in the composition of drawings in this analysis.

Appendix
Thirty Drawings Used In Balancing Center Analyses



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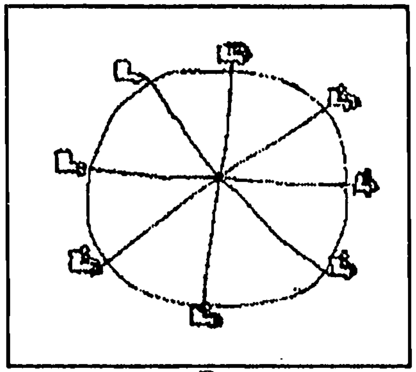
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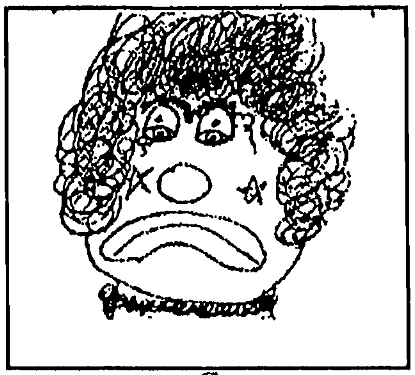
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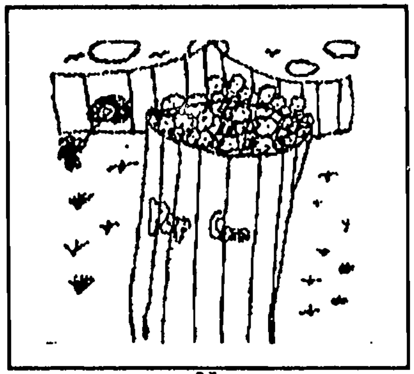
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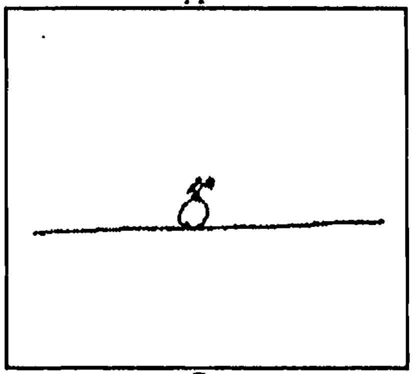
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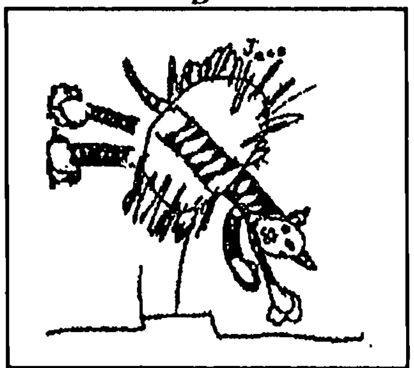
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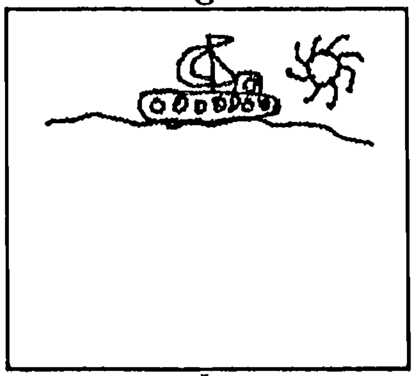
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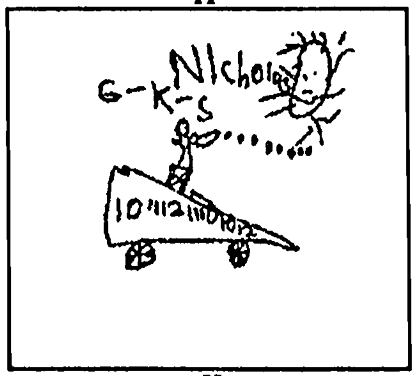

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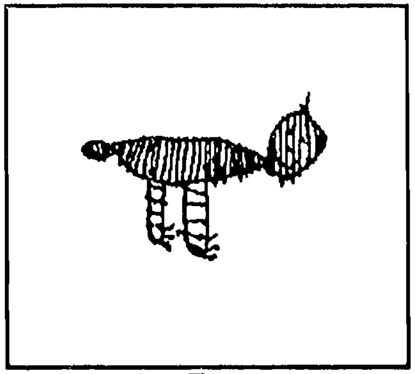
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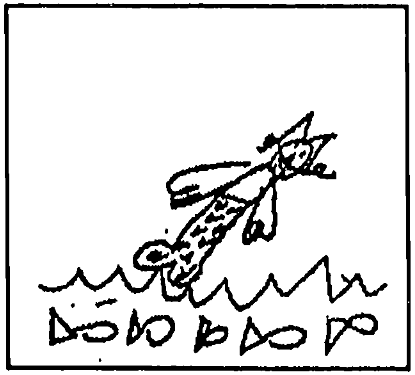
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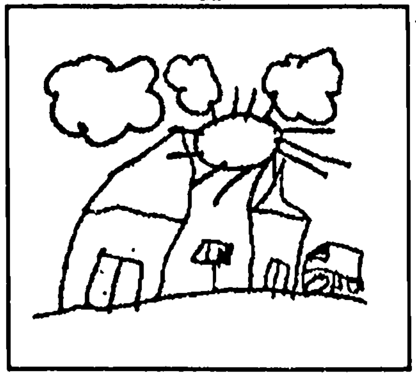
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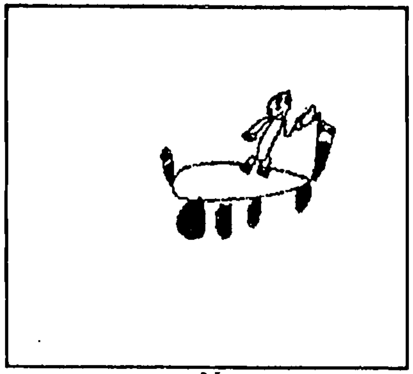

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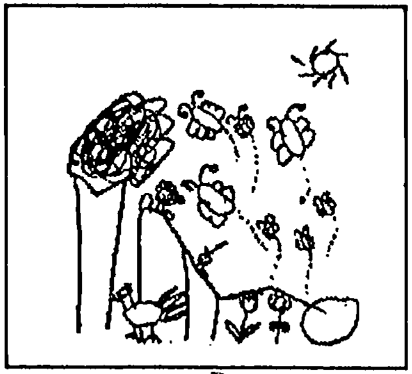

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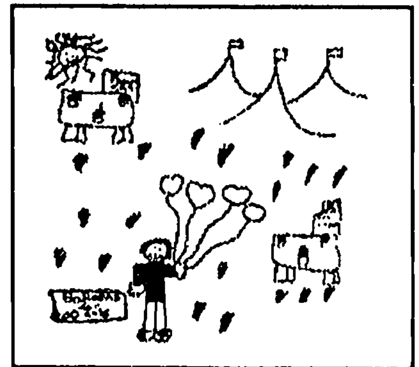

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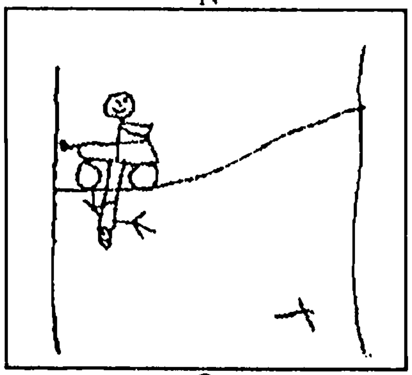

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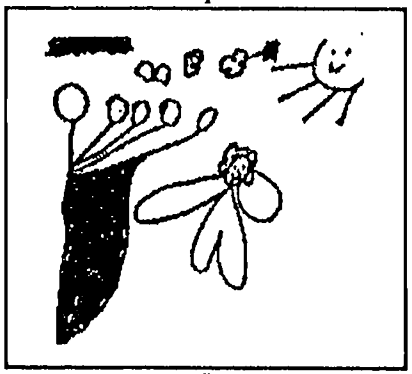

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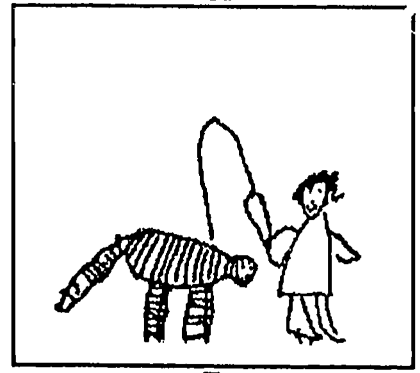

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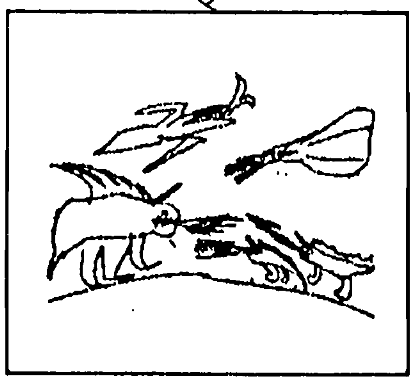

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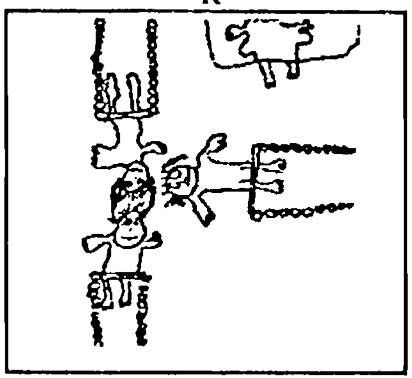

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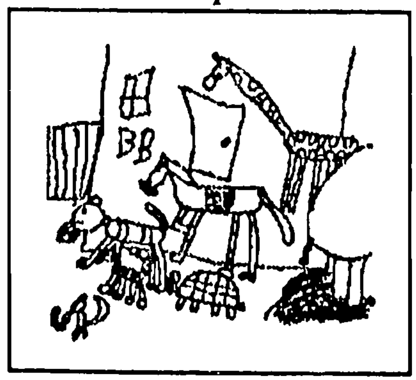

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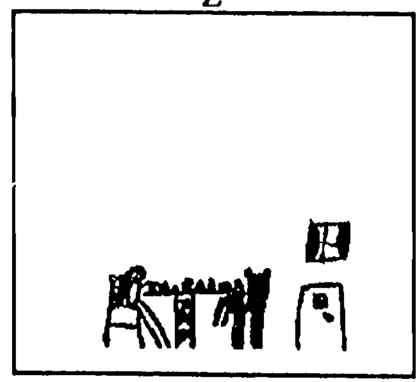

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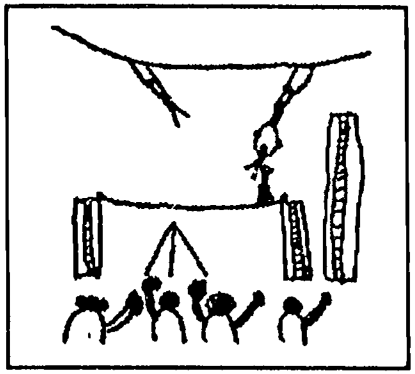

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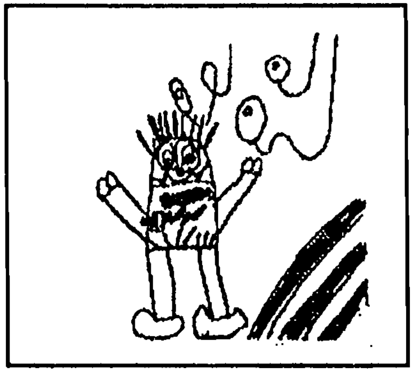

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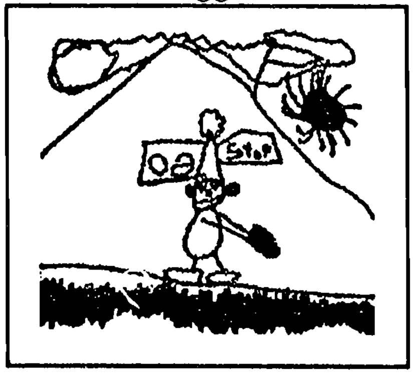

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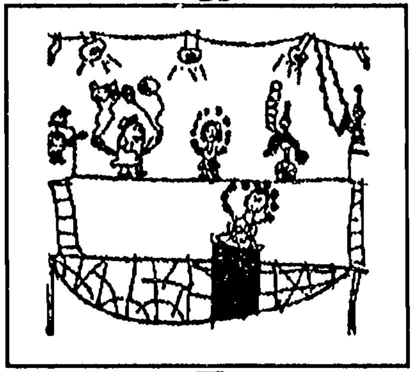

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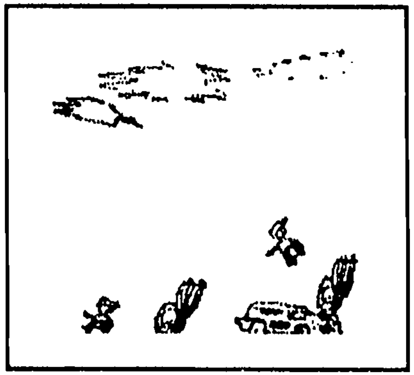

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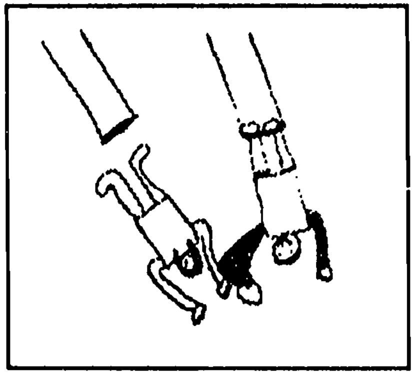

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