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ABSTRACT

The processing of mental structures in perception appears to be serial, in that viewers can fill in missing parts from an impoverished stimulus following a top down process. To investigate the effects of unfamiliarity, complexity, and legibility on object and layout perception of unfamiliar stimuli, ten subjects were shown one of four ribbon objects, containing 2-14 panels representing different levels of legibility (skewed, nonskewed junctions; low or high occluding junctions). The eye movements of six subjects were also recorded as they viewed the ribbon objects. An analysis of the results showed the perceptual schemata were comprised of "chunks" of information and that eye fixation represented such a chunk. The physical size of the chunk, in degrees of visual angle, varied according to the distribution of stimulus information and the availability of processing resources. (Drawings of the ribbon objects and data analyses are appended). (BL)

PERCEIVING LAYOUT WITHOUT EFFECTIVE SCHEMAS

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The study of mental structures in perception should include stimuli that are (1) unfamiliar, (2) complex, and (3) are designed so that information required for task performance can be systematically manipulated. We found that processing of such stimuli, the ribbon figures, appears to be serial. This was indicated by a linear relationship between response latency and stimulus complexity. We also found a positive correlation between response latency and the number of eye movements executed. It is suggested that an eye fixation represents a "chunk" of visual information whose processing requires cognitive resources.

One method of demonstrating the importance of mental structures in perception is to present an impoverished stimulus to the viewer and find that he or she can "fill in" what's missing from the stimulus. Thus, top-down processes in perception have been demonstrated by showing that people can see forms made up of subjective contours (e.g., Coren, 1972) or can recognize a pictured scene presented too briefly to allow for eye movements (Biederman, 1972). While often quite compelling, such demonstrations leave unanswered the questions of what these mental structures are like and how they are acquired.

A second method of demonstrating the importance of mental structures in perception is to use unfamiliar stimuli, that is, stimuli for which the viewer has not yet acquired an appropriate mental structure (Hochberg & Klopfer, 1981; Klopfer, 1983). Without a mental structure or perceptual schema (Hochberg, 1968) to guide it, perception of an unfamiliar stimulus should be relatively slow and should depend both on the complexity of the stimulus and on the distribution of information in that stimulus. The ribbon stimuli were designed with these characteristics in mind to show the course of perceiving without effective schemas.

The first figure shows a ribbon figure used in an earlier experiment (Hochberg & Klopfer, 1981); with it I would like to describe the subjects' task. Suppose we were to paint one surface of this depicted object blue while leaving the other surface white, as shown in this figure. The subjects' task was to indicate what color the surface of the last panel should be, given that the surface of the first panel is blue. The actual stimuli that the subjects saw were not shaded as this one is. Essentially, we asked the subject to judge whether the surfaces of the two end panels were the same or if they were different, or opposite surfaces. I'll refer to the task as the "Same/Different" task for the rest of the paper.

The ribbon stimuli used in the present research were made by attaching together panels at various angles according to numbers drawn from a random number table (see Attneave & Arnoult, 1956; Hochberg, 1971): The ribbon stimuli are unfamiliar in that the relationship between any two nonadjacent surfaces, that is, whether they are the same or different, cannot be reliably predicted.

The second feature of the ribbon stimuli is that we can vary their complexity by varying the number of panels. In doing the Same/Different task, every junction of a ribbon stimulus serves as a potential decision point. We felt that by varying the number of decision points, that is, the number of panels, we were also varying the complexity of the stimuli.

The final feature of the ribbon stimuli is that we were able to manipulate the distribution of stimulus information that is relevant for making the Same/Different judgements. We call this variable Legibility. The ribbon stimuli used in the present research differed in the proportion of informative junctions and in whether or not they contained a skewed junction. The second figure illustrates these two Legibility manipulations.

Although each junction serves as a potential decision point for the Same/Different task, not all of them are equally informative. Specifically, occluding junctions are informative; non-occluding junctions are not. Occluding junctions, marked little i on the figure in the upper left of this figure, are junctions where panels are partially occluded by preceding ones. Non-occluding junctions, marked little double i, are those where the panels forming the junction are entirely in view. Occluding junctions mark regions where adjacent panels are of different surfaces; at non-occluding junctions the adjacent panels are of the same surface.

Now, looking only at the pair of stimuli on the left, you can see that both of these figures have eight panels, but that they differ in the proportion of occluding junctions. The top figure has a Low proportion of ocluding junctions; the bottom figure has a High proportion.

The ribbon stimuli could also differ in whether or not they contain a skewed junction. Look at the figure in the upper left again. All of the panels in this figure are attached end-to-end on opposite sides of the hexagons. The little 'a' points to two such junctions, called Parajunctions. Now, look at the figure in the upper right. If instead of attaching a panel to the opposite side from where a previous panel is attached, we attach it to a neighboring side, we get a skewed junction. The little 'b' points to two skewed junctions, called Meta- junctions. Stimuli containing only Para- junctions are called Para- figures; stimuli containing Meta- junctions are called Meta- figures.

In this figure, then, are the four cells of a 2 X 2 Legibility manipulation used in the present research: going from left to right, the stimuli could be either Para- or Meta-; going from top to bottom the stimuli could contain a Low or a High proportion of occluding junctions.

All together, four sets of drawings were made. Each set contained figures ranging from 2 to 14 panels long, and each set represented a different level of Legibility. From these drawings, four sets of ribbon objects were constructed.

Based upon manipulation of the three variables, Unfamiliarity, Complexity, and Legibility, we expected to find that: First, because the stimuli are unfamiliar, perceptual processing should be slow and effortful; Second, processing time should vary directly with complexity, or the number of panels; Third, because processing is effortful, additional mental load should interact with complexity; and Fourth, processing time should be a function of Legibility.

In Experiment I, 10 subjects saw drawings of the ribbon stimuli projected onto a screen; in Experiment II the ribbon objects were placed directly in front of ten different subjects. For half of the trial blocks in both experiments, subjects made the Same/Different judgements while simultaneously performing mental artihmetic; these are referred to as the Loaded trial blocks.

The third figure shows the data that were averaged across subjects and across trial blocks for drawings of the ribbon stimuli. The Loaded trial blocks for all four levels of Legibility are in the two right-hand panels; Unloaded trial blocks are displayed in the pair on the left. Para- figures are the left-hand, red members of each pair; Meta- figures are the right-hand green members. Finally, figures having a High proportion of occluding junctions are plotted with a dashed line, Low figures are indicated by solid lines. Note that the effect of secondary task performance is to increase the slopes of the response latency functions, suggesting that processing of these stimuli is not automatic but requires mental resources. Also note the differences in slope between the High and Low figures; these differences contribute to the significant interaction of Legibility X Complexity.

In the fourth figure are the response latency functions for objects. Again: Loaded trial blocks are the pair on the right, Unloaded are on the left; Para- and Meta- are the red and green members of each pair; and High and Low are indicated by dashed and solid lines. Here, as was the case with drawings, response latency varies directly with object complexity, object complexity interacts with mental load, and object complexity interacts with Legibility.

In a third experiment eye movements were recorded from six subjects who viewed either the ribbon objects or drawings of those objects. The average size of the eye movements was roughly 2.5 degrees for both drawings and objects. The small eye movement size suggests that subjects were looking at the stimuli by linking together adjacent foveal fields, quite possibly looking at every junction. Moreover, the average correlation between response latency and the number of eye movements was .65 for objects and .84 for pictures, with no differences across Loaded and Unloaded trial blocks.

Based on these results, it is tempting to speculate that perceptual schemas are comprised of "chunks" (Miller, 1956) of information to process and that an eye fixation represents a "chunk." The significant effect of Legibility suggests that the physical size of a "chunk," in degrees of visual angle, can vary according to the distribution of stimulus information. The significant effect of simultaneous mental load suggests that the size of the "chunk" also depends upon the availability of processing resources.

The stimuli used in these experiments were designed for examining the effects of unfamiliarity, complexity and legibility on object and layout perception. Objects and layouts are, for the most part, arrangements of surfaces forming dihedral angles. The arrangements of surfaces of familiar objects and layouts are by definition not haphazard. The ribbon stimuli, which are composed of nearly haphazard arrangements of dihedral junctions, allow for the systematic study of object and layout perception and of the mediating mental structures.

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Figure Captions

Figure 1: A 22-Paneled "Same" ribbon figure.

Figure 2: The four levels of legibility: ParaLow, ParaHigh, MetaLow, MetaHigh.

Figure 3: Average response latency as a function of panel number, legibility, and secondary task requirements -- drawings.

Figure 4: Average response latency as a function of panel number, legibility, and secondary task requirements -- objects.

FIGURE I

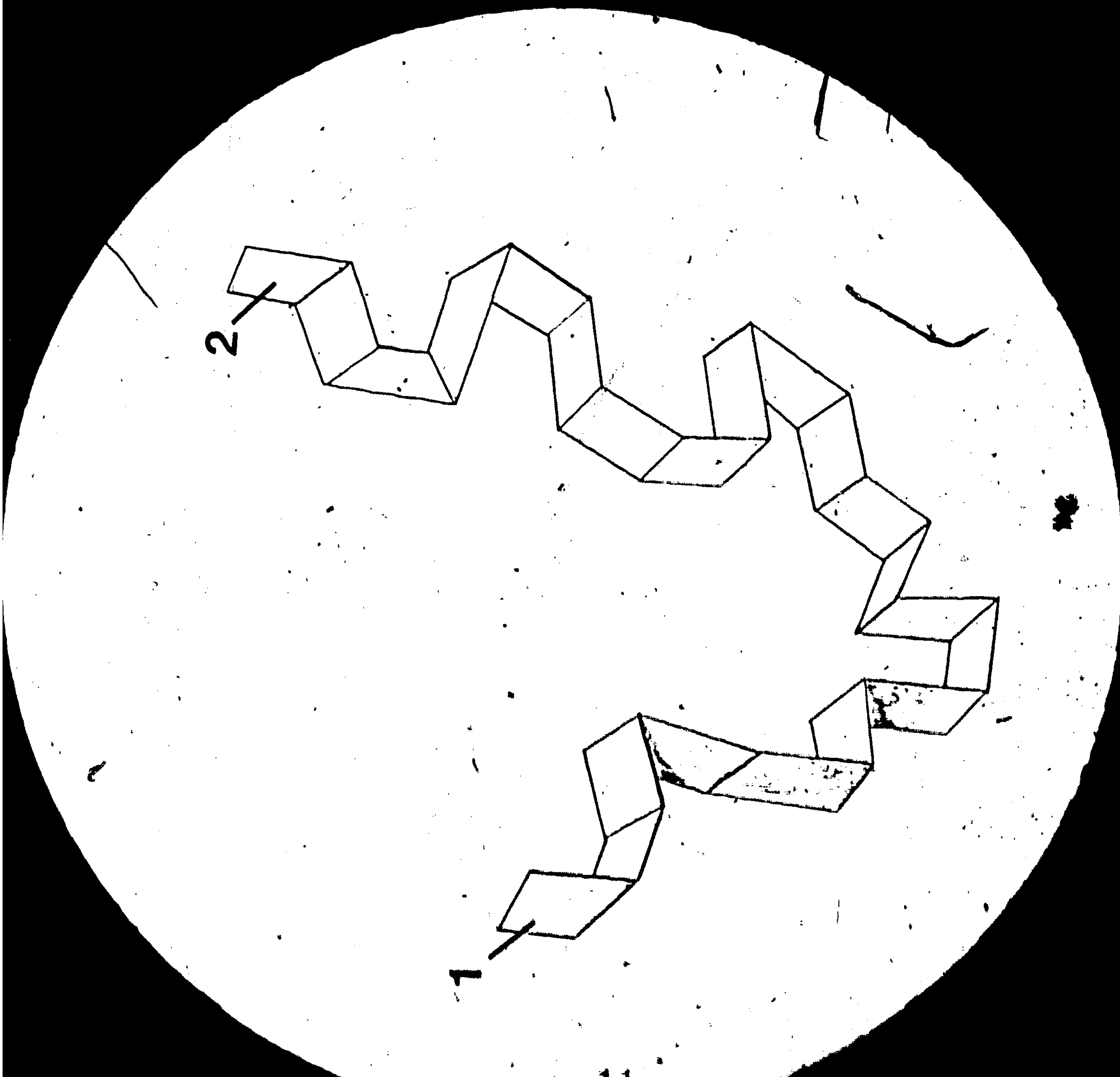
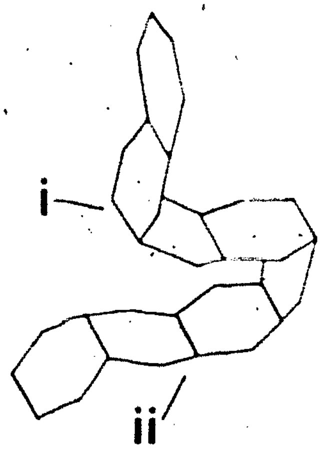
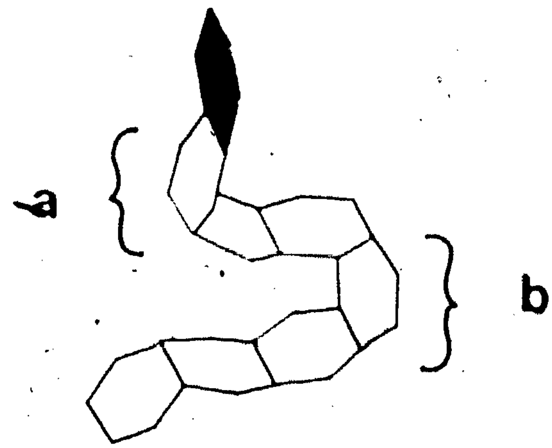


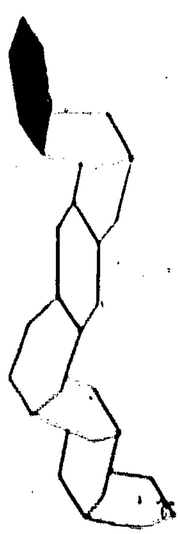
FIGURE 2



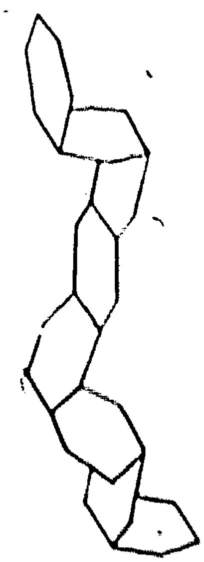
PARA-LOW
(PL)



META-LOW
(ML)



PARA-HIGH
(PH)



META-HIGH
(MH)

FIGURE 3

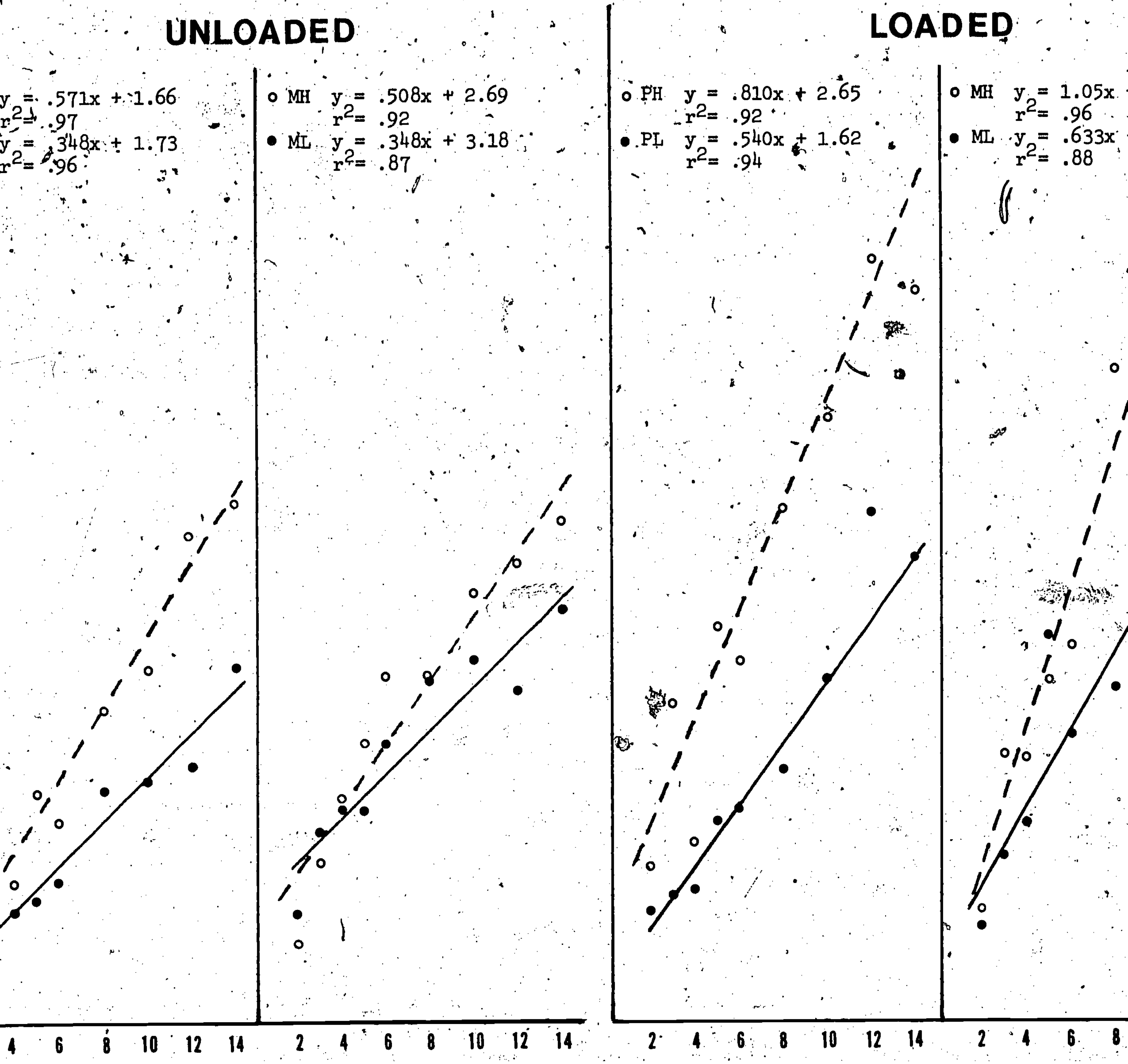
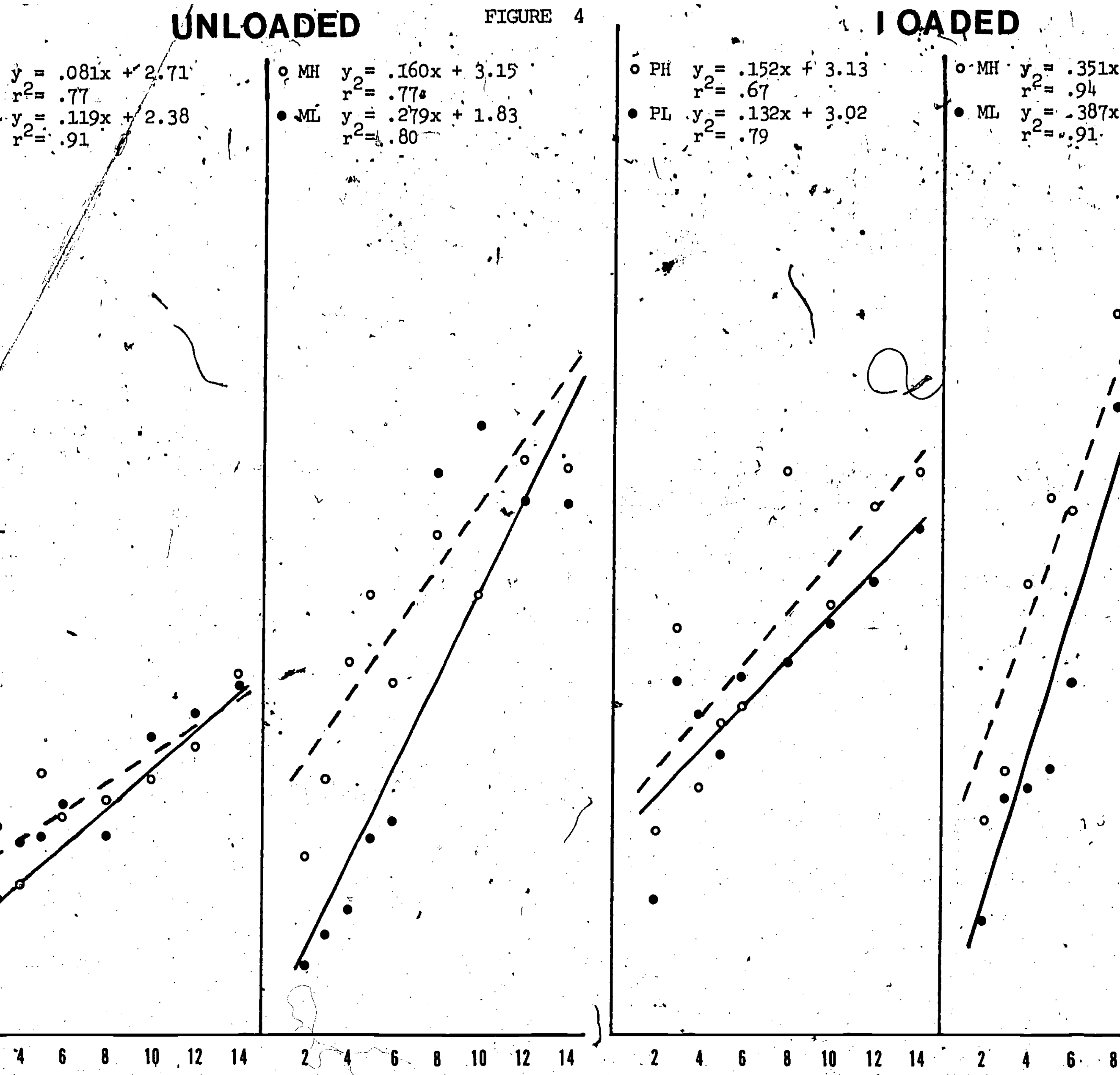

UNLOADED
y = .571x + 1.66
r2 = .97
y = .348x + 1.73
r2 = .96
o MH y = .508x + 2.69
r2 = .92
● ML y = .348x + 3.18
r2 = .87
4 6 8 10 12 14
2 4 6 8 10 12 14
LOADED
o PH y = .810x + 2.65
r2 = .92
● PL y = .540x + 1.62
r2 = .94
o MH y = 1.05x
r2 = .96
● ML y = .633x
r2 = .88
2 4 6 8 10 12 14
2 4 6 8

FIGURE 4


UNLOADED
y = .081x + 2.71
r2= .77
y = .119x + 2.38
r2= .91
MH y2= .160x + 3.15
r2= .77
ML y2= .279x + 1.83
r2= .80
LOADED
PH y2= .152x + 3.13
r2= .67
PL y2= .132x + 3.02
r2= .79
MH y2= .351x
r2= .94
ML y2= .387x
r2= .91
4 6 8 10 12 14
2 4 6 8 10 12 14
2 4 6 8 10 12 14
2 4 6 8