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ABSTRACT

Television wide-angle lenses expand distances and increase apparent velocity, while long lenses compress space and reduce apparent velocity. Based on these assumptions, a study was conducted (1) to examine the ability of viewers of different ages to recognize how lenses change the "real world" they project and (2) to extend Jean Piaget's research on cognitive development to television. Subjects were 46 third grade students, 47 seventh grade students, and 54 undergraduate college students. These grade levels were chosen to represent individuals in the concrete operational stages, in transition from concrete to formal operational stages, and in the formal operational stages as identified by Piaget. The subjects were asked to judge velocity and distance in three conditions in which images photographed by lenses of different focal lengths were compared. In addition, the subjects completed tests to measure their experience with television. The results suggest that the focal length of a television camera lens influences how a large percentage of viewers perceive velocity and distance in televised events. The results also confirm a progression in cognitive development from concrete operational thought to formal operational thought as discussed by Piaget. (FL)

SPEED, SPACE, KIDS AND THE TELEVISION CYCLOPS:

Viewers' perceptions of velocity and distance in televised events

by

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Viewers' Perceptions of Velocity and Distance in Televised Events

ABSTRACT

Television wide-angle lenses expand distances and increase apparent velocity while long lenses compress space and reduce apparent velocity. This study examines the ability of viewers to recognize how lenses change the "real world" they image and extends research on children's understanding of the interrelationship among time, distance and velocity to television. A discriminant analysis using grade level and score on a media knowledge test correctly classified about 80 percent of those who did and those who did not notice the effect of lens choice on televised velocity and distance. As the effect of lens choice became more extreme, judgment errors concerning both velocity and distance increased. Subjects explained the reasons for their judgments. As expressed in Piaget's developmental hierarchy, a shift from concrete-to formal-operational explanations occurred as grade level increased.

VIEWERS' PERCEPTIONS OF VELOCITY AND DISTANCE IN TELEVISED EVENTS

Television brings many events into the home, which a child might never have experienced or might have experienced very differently in an interpersonal context. The content of these televised events has earned the attention of most media effects researchers. Developmental studies have examined the effects of violent content (Surgeon General's Report, 1972), sexual explicitness (Commission on Obscenity and Pornography, 1970), stereotype learning (Dominick and Rauch, 1972) and the like.

The way the television medium structures events through selected production techniques has been less studied. Salomon (1979, p 55) addressing the imbalance between form and content studies notes:

> "assuming that the major media of communication differ--to a smaller or larger extent--in their modes of gathering, selecting, packaging and presenting information, it becomes important to examine the psychological consequences of the differences."

And Olson (1977, p 10) concerned with developmental issues adds:

> "The knowledge that children acquire bears a direct relationship to several different 'languages of experience' each of which has a biasing effect on the cultures that use them and on the cognitive processes of the children who master them."

This study examines the ability of viewers of different ages to recognize how television lenses re-structure velocity and distance in events imaged on television. The study is grounded in Piaget's developmental theory and extends research on children's understanding of the interrelationship among time, distance and velocity to television.

VELOCITY, DISTANCE AND TIME

Velocity is a concept derived from interrelating information about time and distance (velocity = distance/time). To an adult this mathematical equivalence is reasonable and obvious. Yet according to stage theorists in developmental psychology, this interrelationship is poorly understood by children (Piaget, 1969, 1970).

Piaget argues that cognitive development proceeds through stages which appear in an invariant order. The final stage, formal-operational, characterizes adult thought and evolves around the age of eleven. Formal operations imply an understanding of abstract, logico-mathematical relationships of which velocity = distance/time is an example (Beard, 1969). The concrete-operational stage precedes the formal-operational stage and is dominated by a reliance on perceptual information and not logical congruity (Flavell, 1977).

Piaget (1970, p 38) describes a child's growing understanding of the velocity, distance and time interrelationship as "the gradual passage from intuitive thinking, still tied to the information of the senses, toward operational thought which forms the basis of reasoning itself." He goes on to conclude: "the essential problem studied is moving from *image-using* or perceptual intuition to the forming of operational systems" (Piaget, 1970, p 39, emphasis added).

The difference between concrete-operational thought and formal-operational thought can be seen in the different judgments people make when asked to interrelate time, distance and velocity. An individual using formal operations treats the task as a problem of inserting values into a pre-existing equation. In other words, if time and distance are known, then velocity is determined and that determination is used to make sense of perceptual information by balancing that equation. Solutions that fail to meet the logical demands of the equation are rejected as impossible.

An individual using concrete operations has not established the logical framework in which to cast his or her observations. A user of concrete observations does not apply a pre-determined solution and does not demand that the observational data conform to the solution. Rather, the tenuous and incomplete understanding of the interrelationship among time, distance and velocity can be overridden by what appears to be the case in the single instance under consideration.

The transition from concrete-operational to formal-operational thought is studied by devising problems for children of different ages that rely on the child's understanding of velocity, distance and time for solution. For example, two ceramic dogs are "run" around two concentric circles, with one circle having a radius twice that of the other. Both dogs start off at the same time and "run neck and neck," arriving at the finish line together.

Adults indicate that the dog in the outer lane must have gone faster because it covered more distance in the same length of time. Children younger than eight typically center on the equal starting and finish points of the race and the side-by-side racing of the dogs and conclude the race was a tie (Piaget, 1970).

Another task involves two dolls attached to a single wire rod pivoted in a circle about a point. Since the rod joins both dolls there is a strong appearance that the dolls are moving together at the same speed. Yet, as with the dogs, the outer doll must be traveling more quickly to cover the greater outside arc in equal time. Pre-formal-operational children have great difficulty understanding this conclusion (Piaget, 1970).

Current researchers (e.g., Siegler and Richards, 1979; Levin, 1979, 1977;

Brendt and Woods, 1974) have followed in the Piagetian tradition of asking children to watch an event and then make a time, distance or velocity judgment. These judgments and subsequent explanations are used as indicants of the child's level of cognitive development. In all of these past studies the children have based their judgments on nonmediated materials. In the present study the materials are first mediated (and modified) by a television camera lens.

LENS EFFECT ON VELOCITY AND DISTANCE

Television's normal lens produces images nearly equal in size and angle of view to images produced by the unaided human eye (Cornsweet, 1970). Other lenses see the world differently. For example, long lenses (focal lengths greater than normal) compress space and reduce apparent velocity while wide-angle lenses (focal lengths less than normal) extend distances and increase apparent velocity relative to the normal lens (Monaco, 1977). Thus, special-effects films optically expand tabletop starship battles to fill all of space. And children's commercials taped through wide-angle lenses make toy cars look faster and model homes more expansive than they will on the living room carpet (Vision Films, 1976)..

The visual information that specifies depth and velocity on a television screen consists of: (1) the three-dimensionality and movement that existed in the event when it was taped, and (2) a lens effect, or modification of depth and velocity that depends on the difference in focal lengths between the television lens used and the human eye.

The effect attributable to a lens' focal length is easily illustrated. Image size (I) depends on the size of the object (O) imaged, the focal length (fl) of the imaging lens, and the distance (d) between the object and the lens. These variables are related as $I = O \times fl/d$ (Horder, 1976).

If a wide-angle, normal, and long lens are positioned different distances from an object, the three image sizes of the object can be presented as identical. Still photographs are inherently ambiguous in presenting size-distance relationships (Hagen, 1974), and without knowing the focal length of the imaging lens, a viewer cannot accurately estimate the distance separating an object from the lens (See Figure 1).

FIGURE 1 ABOUT HERE

Visual perception of physical reality is not ambiguous in terms of size/distance relationships because the focal length of a person's eyes does not change. However, in television the focal length of the lens often changes. In a very real sense, judging distances and velocity on television is analogous to trying to drive a car while looking at the world through binoculars of unknown magnification power.

How the focal length of a lens influences apparent velocity can be illustrated by movement of the object pictured in Figure 1. If the object moves toward the three lenses at a fixed rate of speed, the three images will change at different rates, giving the appearance that the velocity of the object is different. The apparent velocity is "fast" when presented by the wide-angle lens, equivalent to the rate of change as seen by the unaided eye when imaged by the normal lens, and "slow" when taped through the long lens.

The differences in apparent velocity are caused by changes in perspective as the object moves toward the lens. If an object moves at a fixed rate of speed, its change in image size increases as it moves closer to the imaging lens. A comparison of distance/velocity relationships among three lenses offering different perspectives is illustrated in Figure 2.

FIGURE 2 ABOUT HERE

From Figures 1 and 2 one can see that a viewer who is unaware of the focal length of the imaging lens has no frame of reference for accurately judging distance and velocity in televised events. Before judging velocity and distance on television, a viewer must determine the focal length of the lens producing the image. If unaware of the lens effect on velocity and distance, a viewer might assume a normal lens was used (just as the viewer would see it if he were standing beside the camera during taping).

However, it has been shown that wide-angle and long lenses produce velocity and distance relationships that differ from normal; and viewers who assume the perspective of a normal lens will be misled if the scene is photographed by a wide-angle or long lens.

EXPERIMENTAL HYPOTHESES

This study examines whether viewers of different ages are aware that different lenses manipulate the apparent velocity and distance of events presented on television. In developmental studies, experience as well as age is an important predictor of performance on many developmentally-sensitive tasks. In this study experience with visual media was measured with respect to personal <u>use</u> of media tools (i.e., skills as a photographer, videographer) and (2) viewing skills (i.e., the ability to extract information from a televised presentation).

The specific questions addressed in this study are:

1. Does focal length of the lens influence a viewer's judgment of velocity and distance in a televised event?
   a. Is the perceived velocity of a moving object greater

when photographed by a short focal-length lens than when the same motion is photographed by a long focal-length lens?

b. Is perceived distance within a scene photographed by a short focal-length lens greater than the perceived distance if the same scene is photographed by a long focal-length lens?

c. Does the magnitude of error in estimating velocity and distance correspond to the magnitude of difference between focal lengths of comparative lenses?

2. Do age and experience with visual media facilitate recognition of a lens effect on velocity and distance?

a. Are older viewers more likely to recognize this effect?

b. Are viewers who have experience with the tools of the visual media more likely to recognize this effect?

c. Do viewers who exhibit skills in viewing televised messages also exhibit greater recognition of this effect?

3. Do explanations for velocity and distance judgments among viewers of different age groups conform to Piaget's hierarchy of cognitive development?

METHOD

Subjects

Subjects for this experiment were 76 males and 71 females. A middle-class suburban school provided 46 third-grade subjects. An additional 47 seventh-graders came from a different middle-class suburban school and 54 subjects were undergraduates enrolled in a Communication course at a western

University. These grade levels were chosen to represent persons in the concrete-operational, in transition from concrete- to formal-operational and formal-operational stages, respectively. The average age of the third-graders was 103 months (SD = 4.2 months) and for the seventh-graders the average age was 151 months (SD = 4.3 months).

Apparatus

A five-foot length of Lionnel train track (width = 1 inch) was laid down and bordered by four equally-spaced toy billboards and twelve equally-spaced plastic telephone poles. A trestle was placed at the beginning of the track and a railroad crossing was set at the end of the track. All materials used were Lionnel-scale in size.

First a blue Lionnel engine (length = 9 inches) and then a black Lionnel engine (length = 9 inches) traversed the track, covering the five-foot distance in exactly 3.5 seconds. Each train began at the trestle and exited the field of view after passing the railroad crossing. The trains were identical except for color.

Each train ran the length of track three times and was videotaped with an IVC 300 television camera (1-inch tube) outfitted with a 15mm-150mm zoom lens. On the first run of each train, the lens was set at 15mm (wide-angle) to record the train's travel. In the second run the setting was 30mm (normal) and in the third run the lens was set at 60mm (long). In each taping the trains ran directly toward the camera lens with the camera positioned so that the lens looked slightly down on the track (this angle was held constant for each taping).

The perspectives (distances between the camera lens and the railroad crossing) were manipulated so that in each taping the image sizes of the trains were identical at the point where the train passed the railroad crossing. Changing camera perspectives to keep the image sizes of the trains identical at the railroad crossing (the end point) necessarily created differences in the image sizes at the trestle (the starting point). In the wide-angle lens condition the initial image size of the train was one-half of its final size. In the normal lens condition the initial image size was two-thirds of its final size and in the long lens condition the initial image size of the train was four-fifths of its final size.

The change in image size is expressed as the ratio of the end-point image size to the starting-point image size. Thus the image size of the train recorded by the wide-angle lens doubled (1/ 1/2), the image mapped by the normal lens increased 1.5 times (1/ 2/3) and the long lens recorded an increase in image size of 1.25 (1/ 4/5) times. Figure 3 shows the model layout and the camera positions actually used in taping.

FIGURE 3 ABOUT HERE

These videotape segments were edited together using a split-screen technique to achieve four comparisons: (1) a train photographed through a wide-angle lens compared with a train photographed through a long lens (WAL), (2) a train photographed through a wide-angle lens compared with a train photographed through a normal lens (WAN), (3) a train photographed through a normal lens compared with a train photographed through a long lens (NL), and (4) two trains photographed through a normal lens (NN).

These four conditions present duplicates of an event imaged side-by-side in different ways. The differences in the images represent a range of lens effects. The most extreme lens effect is produced in Condition 1 in which the image size of the train taped through the wide-angle lens doubles while the image size of the train taped through the long lens increases only 1.25 times. Condition 4 is the control condition as the changes in image sizes are identical for each train. Table 1 presents the relative lens effect for each condition.

TABLE 1 ABOUT HERE

Another videotape segment in which a car and a truck raced for fifty yards was also prepared. In the first race both vehicles started from the same point, at the same time, and crossed the finish line together. In the second race both started together from the same point but the car crossed the finish line fifteen yards ahead of the truck. Both races were taped using a normal lens.

Procedures

Subjects were individually tested at their own school in a room which housed a 17-inch color monitor linked to a videocassette playback unit. Two desks were positioned five feet in front of the monitor. The two trains which had been videotaped and two sections of train track were located on the experimenter's desk. This provided the subject with three-dimensional references for the images they were about to see on videotape. The measurement instrument, a cardboard rectangle on which two speedometer dials divided into 16 equal parts and two distance scales (replicas of the train track) divided into 16 equal sections with Finish Line marked at one end, rested on the subject's desk.

The experimenter told the subject that he had videotaped races between a car and a truck and that he wanted the subject to show him with the dials which vehicle had traveled farther and faster. It was stressed that all races could be ties and that either vehicle could be faster and at the same time cover a shorter distance.

The subject was told each race would be run twice and that after the second presentation the experimenter would show the subject how fast and far the truck had traveled. The subject's task was to show the relative speed and distance traveled by the car. The subject was taught to indicate equal speeds and distances by matching the experimenter's dial settings. Subjects also learned that nearly equal dial settings meant that the speeds and distances covered by the vehicles were nearly equal and that greater differences were shown by more disparate dial settings.

For each of the two races the experimenter selected 8 to indicate the speed and distance traveled by the truck. Subjects who understood the dials matched the experimenter's settings for the tie-race and set the velocity dial somewhere between 9 and 16 for the race in which the car beat the truck. Any ambiguities regarding the measurement instruments were cleared up during these practice trials. All but two third-graders graduated to the next round of testing.

Before the train tests began, subjects were reminded that all races could be ties and that any combination of faster-slower, longer-shorter were possible in the races. They were reminded that the two trains on the desk in front of the experimenter were the ones used in taping. The equal size of the trains was pointed out.

The order of presentation of the conditions: (1) wide-angle versus long, (2) wide-angle versus normal, and (3) normal versus long was balanced across subjects. The control condition, (4) normal versus normal, was always presented last. The color of the train presented by the comparatively wider-angle lens and the side of the screen on which the train taped through the relatively wider-angle lens were also balanced across subjects. These precautions were included to make it difficult for a subject to hypothesize that one of the trains was always faster or that the faster train always appeared on one side of the screen.

After the second presentation of each condition the experimenter would stop the tape and position of his speedometer dial on 8 and his distance token on 8. The subject would then position his or her dial and token. The difference between the experimenter's settings and the subject's settings were recorded for both velocity and distance.

The fifth race in the series of six was presented three times, although a subject's judgments were recorded after the second presentation. The added presentation in the fifth condition was used to probe how the subject reasoned in determining his or her judgments.

After the images of the two trains appeared on the screen for the third time but before they began to move the experimenter placed the videocassette player in pause mode. Then the experimenter asked the subject to restate his or her distance judgment. A subject's distance judgment necessarily fell into one of three categories: (1) the train imaged by the comparatively wider-angle lens covered the greater distance, (2) the train imaged by the comparatively longer lens covered the greater distance, or (3) the two trains covered the same distance.

Within each category different explanations for the comparative distance judgments were given. Those who indicated that the train imaged by the comparatively wider-angle lens covered the greater distance supported this observation with some variation of: (a) It was smaller (in image size) so it must have been further back.

Those who felt the trains covered the same distance responded: (a) the trains were sitting side-by-side in the picture, (b) different lenses made the train imaged by the wider-angle lens look farther back but they were actually side-by-side, or (c) "it looked that way."

Few subjects felt the train imaged by the longer lens was further away. Their explanations fell into two categories: (a) the train imaged by the longer lens was closer to the top of the picture so it was further away, or (b) "it just looks that way."

After the subject had explained his or her distance judgment the experimenter pressed the play button and the trains traveled down the track and out of the picture.

In judging velocity, subjects had responded that: (1) the train imaged by the wider-angle lens had traveled faster, (2) the trains had traveled at the same speed, or (3) the train imaged by the comparatively longer lens had traveled at the faster speed.

Within each category of velocity responses, different explanations were offered. For those who chose the train imaged by the comparatively wider-angle lens as faster the following explanations were offered: (a) it caught up with the train imaged by the comparatively longer lens, (b) it covered more distance than the train imaged by the longer lens did in the same length of time, (c) it just looked that way.

Those who felt the relative velocities were equal responded: (a) they started at the same time and stopped at the same time so the speeds were equal (i.e., they confused time with velocity), (b) different lenses made the apparent velocities different but the velocities of the two trains were actually the same, or (c) it looked that way.

Few subjects selected the train imaged by the comparatively longer lens as faster. Several said: (a) "it looked that way." One subject replied:

(b) "it was filmed in slow motion so it really went faster!"

Comparing a subject's velocity explanation with his or her distance explanation, provided insight regarding the cognitive level exhibited by the reasoning presented. Because those at the formal-operational level of cognitive development display an understanding of logico-mathematical relationships, and since both trains traveled for the same length of time, subjects who responded that one train had covered a greater distance had to respond that the same train traveled faster to be categorized as formal-operational. Similarly, a distance judgment of "equal" had to be paired with a velocity judgment of "equal" if formal operations were used.

On the other hand, a subject was considered in the concrete-operational stage (i.e., overwhelmed by perceptual information) if he or she failed to balance the velocity = distance/time equation. Judging one train to be faster and concurrently judging the other to cover a greater distance or that both trains covered the same distance is logically impossible. A subject using concrete operations could easily accept this incongruity, if he or she centered on distance information and ignored the velocity information. Similarly, velocity information could convince the subject centering on speed that the wider-angle train was faster while the subject still ignored the apparent difference in distance.

Within the category of formal operations, one more division is meaningful. Some viewers said that differences in the lenses used in taping created apparent differences in distance and velocity that did not exist in fact. This group of formal operations users is labeled sophisticated because they exhibited an understanding of the production technique used in creating the videotapes. The other set of formal operations users who equated their distance and velocity estimates is labeled naive. They had

<u>not</u> noticed the lens effect but still had made logical (mathematically-balanced) sense of the perceptual information on which their judgments were based.

A very small number (n = 5) of the subjects responded idiosyncratically. They were labeled <u>other</u> to indicate they fell outside of the anticipated categories. Table 2 presents the parameters of the response pairings that led to the different classifications.

TABLE 2 ABOUT HERE

After responding to the six videotaped races, subjects took two tests designed to measure their <u>experience</u> with the media. The first test consisted of nine questions relating to the subject's use of the tools of pictorial media. Of interest were such things as: (1) type of camera used (e.g., 35mm, Super-8, television), (2) frequency of use (e.g., rolls of film shot) and (3) sophistication of the equipment used (e.g., existence of interchangeable or zoom lenses). This part of the test was individually administered to the third- and seventh-graders. Adults responded in small groups.

The second test was the <u>Television Information Game for Commercial Messages</u> (Copyright 1978, James A. Anderson and Milton E. Ploghoft). In this test, viewers answer 40 questions relating to ten one-minute videotape commercials.

The questions appear on the screen one at a time. Several multiple choice answers appear with each question. An announcer reads the question and the answer choices. Subjects mark the number of the answer to indicate their choice. Small groups of eight to ten students took the test at one time. They were seated three across in three or four rows.

The Television Information Game is designed to measure the ability of viewers to understand televised information. The questions are content-oriented although some address production techniques such as camera positioning as well. Product name recognition and slogan recall are covered by the test. In other questions, viewers are asked to go beyond the information presented and infer such things as the occupation of characters or the relationship between a football star and the sponsor of the commercial in which he appears. This test was used as a measure of a subject's knowledge gained through observing the medium.

To diminish the likelihood of subject fatigue, the Television Information Game was administered several days after the videotaped races and Media Use Test. Consequently, subjects participated in two sessions, each of which lasted approximately thirty minutes. For all sessions a friendly atmosphere was maintained.

RESULTS

Lens Effect on Velocity

If focal length of a lens influences viewers' judgments of velocity, the data should indicate more judgment errors in the experimental conditions than in the control condition. A correct velocity judgment is one that indicates both trains traveled at the same speed. In the control condition, 96 percent of the subjects judged the velocity of the two trains as equal. In the experimental conditions, the percentage of viewers who correctly judged the velocities of the two trains was inversely related to the size of difference between focal lengths. Overall, 66 percent of the subjects judged the velocities as equal in the NL condition. In the WAN condition, only 58 percent of the subjects judged the velocities as equal. The percentage of correct responses fell to 43 percent in the WAL condition.

To assess whether this distribution was likely due to chance, Cochran's correlated proportion procedure was used. The joint frequency distribution was composed of eight cells that crossed four levels of condition (WAL, WAN, NL, NN) with two levels of judgment (same, different). The chi-square value associated with this distribution is 153.4 (df=3, p< .001). This result suggests that the introduction of a lens effect does induce velocity judgment errors in subjects.

Lens Effect on Distance

Analysis of the distance data shows a pattern similar to that found with the velocity data. As with the velocity data, 96 percent of the subjects judged the distance traveled by the two trains as equal in the control condition. As the difference between the compared focal lengths increased, the percentage of subjects who judged the distances as equal decreased accordingly. While 51 percent of the subjects correctly judged the train distances as equal in the NL condition, this percentage of correct responses dropped to 42 percent in the WAN condition and to 29 percent in the WAL condition.

Cochran's correlated proportion procedure was again used to determine if this pattern represented more than random error. The chi-square test resulting from analyzing the joint frequency distribution of distance judgments was 210.8 (df=3; p< .001) suggesting that the lens effect did influence the subjects' judgments of distance.

Recognition of Lens Effect

A subject's age, experience with the tools of the visual media, and skills in processing visual information were predicted to be related to the subject's ability to recognize the lens effect. Those who noted the lens effect were labeled sophisticated. Those who did not recognize the lens effect, and responded as if there were differences in relative velocity and distance, were labeled naive. Five subjects were classified as other to indicate they did not fit the definition of either sophisticated or naive.

Discriminant analysis was used to identify variables useful in classifying sophisticated and naive viewers. Data from subjects classified as other were not used in this procedure. Grade level was used as an operational definition of age, the Media Use Test identified experience with tools of the visual media, and the Television Information Game score was used as an operational definition of visual information processing skills.

The variables were entered into the discriminant function using a stepwise method designed to minimize the residual variation (SPSS, 1975, p 448). Grade level and Media Use Score were selected for the discriminant function but the Television Information Game Score failed the F-to-enter criterion and was not included.

With two variables entered into the discriminant function, 85 percent of the sophisticated viewers and 78 percent of the naive viewers were correctly classified. The discriminant function is:

$$D = .9\ (\text{Grade level}) + .22\ (\text{Media Use Score}).$$

Wilks' Lambda was employed to determine the level of significance of the discriminant function. The resultant Wilks' Lambda=.67 with an associated chi-square equal to 54 (df=2) was significant at alpha < .001.

The results of the discriminant analysis indicate that younger viewers are less likely to notice the lens effect than are older viewers, and that viewers with higher media experience scores more often notice the lens effect than do viewers who score low on the Media Use Test.

Magnitude and Direction of Velocity Judgment Errors

This study also examined whether greater differences between focal lengths of comparison lenses induce greater judgment errors and whether this error is in the direction of attributing greater speed to the train imaged by the relatively wider-angle lens. With these questions in mind, a repeated measures analysis of variance was used to test for significant differences across conditions using data from the 101 naive subjects. A trend analysis was then employed to show the direction and magnitude of the relationship. Cochran's C test showed the velocity data violated the homogeneity of variance assumption ($C=.567$, $df=4, 100$; $p< .01$) so Hotelling's T^2 was chosen as the appropriate test statistic. Hotelling's T^2 test does not require symmetry of the variance-covariance matrix; only that the populations have multivariate normal distributions (Kirk, 1968, p 143). It provides an exact test of the null hypothesis. For the velocity data, a Hotelling's T^2 of 153 was computed; the associated $F=37$ with 4 and 97 degrees of freedom was significant at the alpha $< .001$ level.

Hotelling's T^2 was followed by Dunnet's Multiple Comparison procedure to establish confidence intervals for the following three pairs of means: (1) wide-angle versus long with wide-angle versus normal (WAL-WAN), (2) wide-angle versus normal with normal versus long (WAN-NL), and (3) normal versus long with normal versus normal (NL-NN). Table 3 indicates that the differences between all treatment means are statistically significant, and also presents the results from a trend analysis. The trend analysis shows that 36 percent of the variance in the velocity data is accounted for by treatment effects.

TABLE 3 ABOUT HERE

Magnitude and Direction of Distance Judgment Errors

Parallel questions were considered using distance data. Again, whether greater differences between the focal lengths of comparison lenses induce greater judgment errors and the direction of those errors were of interest. Hotelling's T^2 was again used and its value of 284 with an associated $F=69$ (4, 97) was significant at alpha < .001. Dunnet's Multiple Comparison procedure was applied to isolate differences between treatment means. Table 4 shows that differences between treatment means are statistically significant. The corresponding trend analysis shows that treatment effects account for 52 percent of the observed variance in the distance data.

TABLE 4 ABOUT HERE

Cognitive Level by Grade

A final issue concerns how well the data that describe a subject's cognitive level conform to the pattern predicted by Piaget. Piaget explains cognitive development as a passage through stages that appear in an invariant order. Experimental work has suggested that most third-graders are concrete-operational and that most adults use formal-operational patterns. The transition from concrete-operational to formal-operational thought occurs in early adolescence, generally around the seventh grade.

Table 5 relates a subject's grade level to his or her level of cognitive development as determined in the questioning that followed the presentation of the third experimental condition. In this table, formal operations is further divided into formal-naive and sophisticated. This presentation format clarifies the results of the discriminant analysis showing that most of the sophisticated viewers are college-aged. Additionally, the shift from concrete-operational to formal-operational thought can be seen. Whereas most third-graders rely on concrete operations, the distribution of responses by seventh-graders shows the transition to formal operations is well underway by this age. All but one adult demonstrated the use of formal operations on this task (see Table 5).

TABLE 5 ABOUT HERE

To further interpret the data in Table 5, a chi-square test was used. To meet the assumptions of the chi-square test, the data were collapsed into three categories of cognitive development: (1) sophisticated, (2) formal-naive, and (3) concrete-operational. The concrete-operational category represents the combination of the concrete velocity and concrete distance categories. The five subjects classed as other were not included in this analysis because the explanations given for their judgments could not be interpreted within Piaget's framework.

The data were collapsed since the validity of chi-square is questioned if more than 20 percent of the cells in the joint frequency distribution have expected frequencies of less than five (Siegel, 1956, p 178). Combining adjacent categories (e.g., concrete velocity and concrete distance) was deemed the preferred approach to overcome this limitation (Siegel, 1956, p 178).

With these categories combined, the resulting Grade Level by Cognitive Level distribution (3x3) generated a chi-square value of 7.13 (df=4, $p < .001$). The asymmetric lambda associated with this distribution is .31 with Cognitive Level as the dependent variable. In other words, knowledge of a person's grade level increases the likelihood of correctly predicting that person's cognitive level by 31 percent (SPSS, 1975 p 225).

DISCUSSION

The results of this study suggest that the focal length of a lens influences how a large percentage of viewers perceive velocity and distance in televised events. In three conditions in which images photographed by lenses of different focal lengths were compared, 147 subjects were asked to judge velocity and distance. Of the total 441 judgments, 192 (44%) of the judgments indicated greater perceived velocity in the scene imaged by the wider-angle lens. Across the same three conditions, 59 percent of the total judgments indicated greater perceived distance in the wider-angle image. In contrast, only two percent of all judgments indicated that subjects perceived greater velocity in the image photographed by the longer lens, and only one percent of the judgments represented the train imaged by the longer lens as traveling the greater distance.

Viewers who judged velocity and distance as equal across comparisons often defended their judgment by saying that even though the wider-angle image appeared to have greater depth and velocity, this impression was created by using lenses of different focal lengths. This correct observation earned 28 percent of the subjects the label of sophisticated to indicate that they noticed how television production techniques influenced the presentation of three-dimensional scenes as two-dimensional images. If the judgments of the sophisticated viewers and those five subjects classified as other are excluded, only 44 percent of the 303 judgments indicated the velocities were equal and 24 percent so indicated regarding depth.

Several reasons are possible for a subject concluding that velocity and distance were the same in both images. First, the trains started side-by-side in the television frame and exited the frame at exactly the same point. If the subject ignored the difference in image size, the fact that the trains covered the same amount of screen space would suggest equal distance. Under this assumption, the conclusion of equal velocities is also warranted since the time of travel was identical in both cases.

Another reasonable explanation for subjects judging velocity and distance as equal is that the experimenter consistently indicated the speed and distance of one train as 8 on the measurement instrument regardless of which image he was judging. Since the subject indicated his or her measurement after the experimenter, the subject could be replicating the experimenter's judgment rather than responding to the stimulus information presented on the screen.

More interesting in a theoretical sense, than those who judged velocity and distance as equal, are those who conformed to the prediction that the wider-angle image would be perceived as having greater velocity and depth. These subjects apparently concentrated on the relative image size of the two trains and ignored the different perspective gradients manifested by lenses of different focal lengths. In other words, these subjects relied on distance and velocity information as if they were watching the trains run without viewing them through the intervening camera lens.

It is interesting to notice that in all three experimental conditions, more subjects made judgment errors on distance than on velocity. In the comparison between the wide-angle and long lens, 56 percent of the 147 subjects indicated that the train photographed by the wide-angle lens traveled faster, and 71 percent thought it traveled farther. When the wide-angle image was compared to the normal image, 41 percent thought the train photographed by the wide-angle lens ran faster, and 57 percent indicated that it traveled farther. In the normal versus long condition, 33 percent of the subjects indicated that the train imaged by the normal lens traveled faster, and 47 percent indicated it traveled farther.

Why distance information should be more perceptually compelling is not altogether clear. The possibility is that the misleading information concerning distance is redundant while that concerning velocity is not. Distance, in this case, was specified by the size gradient of the equally-spaced billboards, telephone poles and train track, as well as from the movement of the train down the track. Objects that are far away appear to move more slowly than when close. In contrast to this redundancy, velocity through space is defined only by the rate of change in image size of the moving object.

Regarding the correspondence between the magnitude of difference between focal lengths and the magnitude of error in velocity and distance estimates, one caution must be introduced regarding the strong linearity of the data. This study represents a fixed-model ANOVA, over a restricted range of possible lens effects. The maximum difference between focal lengths was 4 to 1, since the wide-angle lens was one-half the focal length of the normal lens, and the long lens was twice the focal length of the normal lens. Although the long versus wide-angle comparison induced the largest number and magnitude of judgment errors, one would suspect that at some point, extremely long or short focal-length lenses would draw attention to the fact that a "special" lens was being used. For example, lenses of extremely short focal lengths produce a "fish eye" effect in which straight lines appear curved and the image size of nearby objects is markedly exaggerated relative to the image size of more distant objects. At extreme focal lengths, viewers would probably notice the unique perspective and image-size relationship and would be less likely to attribute differences in the images to differences in the original scene.

The discriminant analysis suggests that an individual's age is a key predictor of the likelihood that he or she will notice the effect of lens focal length on depth and velocity. While 65 percent of the college students used in this study were classified as sophisticated, only eight percent of the seventh-graders and five percent of the third-graders were so classified. Unfortunately, grade-level (or age) is only a descriptive variable and not explanatory in nature. Restated, these results indicate that the capacity to observe the effect of lens focal length improves with age, but the results do not identify what skills or aptitudes lead to this ability.

It seems reasonable to assume that this ability may improve with experience in using the tools of visual media, and this was the rationale for creating a test to measure it.

Although the nine-question experience test has face validity, the slight improvement in classifying sophisticated and naive viewers afforded by its inclusion in the discriminant function is troublesome. Either this test does not fairly measure experience with the tools of the visual media or experience is not a relevant variable. In other words, there may be little or no relationship between experience in taking pictures and how one perceives them. Picture perception may be based on aptitudes or skills that develop through systematic interaction, whether from an art appreciation or from a hands-on approach.

Finally, the data from this study have extended research in the Piagetian tradition to the study of television. Results of this study confirm a progression from concrete-operational thought to formal-operational thought as predicted by Piaget. Of most interest is that this progression was evidenced on a mediated task rather than on a task directly perceived. While over one-half of the third-grade subjects conformed to a concrete-operational interpretation of the stimuli, all but one of the adults used formal operations. Slightly over one-fourth of the seventh-graders demonstrated concrete-operational thought and assessed velocity and distance independently.

A standard interpretation of Piaget's hierarchy would suggest that nearly all, rather than slightly over one-half of the third graders should be using concrete operations (Beard, 1969). Flavell (1977) offers a possible explanation for the large percentage of third-graders classified as formal-operational. He argues that task characteristics can either facilitate or inhibit the appearance and use of different modes of reasoning. In this task, the perceptual information suggested that the train imaged by the wider-angle lens traveled farther and traveled faster. Consequently, the experimental situation encouraged a formal-operational solution; i.e., the balancing of the velocity = distance/time equation. If the experimental materials were created such that a conflict between velocity and distance were established, fewer third-graders would be likely to demonstrate formal-operational thought. For example, a train that actually traveled faster could be made to appear slower on videotape by photographing it through a long lens. On tape, one train would appear to travel faster and cover a shorter distance at the same time. A formal-operational thinker would have to explain this videotaped occurrence as an illusion created by the media. One would expect that a much greater majority of third-graders would revert to concrete operations and simply assess velocity and distance independently.

The speculation regarding how a change in the stimuli might induce young viewers to interpret it differently goes to the heart of the representational nature of television. Perceptual information can be manipulated in many ways using production techniques. A viewer solidly entrenched in the formal-operational stage is almost forced to conclude that an "impossible" televised occurrence is fictional and created through the manipulative power of the medium. A concrete-operational viewer is not compelled to reach the same conclusion. The televised information is salient independent of the logical constraints an adult viewer brings to the experience of watching television.

SUMMARY AND CONCLUSIONS

Subjects from third-grade, seventh-grade and college-age levels were asked to judge the comparative velocity and distance traveled by two trains presented on videotape. In each of four comparisons, the velocity and distance traveled by both trains were equal, but photographing the trains with lenses of different focal lengths produced apparent differences between the velocity and distance traveled by the trains.

Children were more likely to interpret the effect of lens focal length as actual differences in velocity and distance traveled between the two trains. Adults more often explained their judgments on the basis that lenses of different focal lengths were used to produce the images of the trains. Nevertheless, 35 percent of the adult sample failed to notice the use of different lenses.

A second thrust of the study was to determine if viewers reasoned about television images as they do about the three-dimensional world in which they live. Piaget has described the developmental sequence by which individuals come to understand the interrelationship among velocity, distance and time. He concludes that by adulthood, persons have come to rely on logical congruity in their environment. However, to children, perceptual information can be so compelling that individuals deal with it outside of logical constraints; appearance dominates the need for conceptual integrity.

In this study, subjects at different ages generally conformed to Piaget's expectations. While adults gave perceptual judgments that were congruent, many third-graders judged velocity and distance independent of one another and ignored any resultant logical contradiction in their answers. The distribution of the responses of the seventh-graders was as predicted; some were formal-operational thinkers while others remained in the concrete-operational stage.

In an effort to see if viewer judgments were proportionally related to the difference in focal lengths of the imaging lenses, three conditions were prepared in which the ratio of the focal lengths of the lenses that were compared differed. The ratios represented comparisons between a normal focal-length lens, a wide-angle lens and a long focal-length lens. The results indicate that within the range of lenses used, larger differences between focal lengths resulted in greater judgment errors for both velocity and distance.

On the basis of this study, the following conclusions are offered:

1. For many viewers of televised events, judgments regarding velocity and distance are influenced by the focal length of the camera lens.
2. If an event is photographed through lenses of different focal lengths, more viewers perceive velocity to be greater in the wide-angle image.
3. Similarly, a wide-angle image is perceived to have greater depth than an image of the identical event photographed through a long lens.
4. As the difference between the focal lengths of the two lenses increases, the difference in perceived velocity and distance increases.
5. Adult viewers are more likely to notice that apparent differences in velocity and distance on television are caused by the lens focal length than are seventh-graders or third-graders.

6. As measured in this study, experience with the tools of visual media is only slightly related to the likelihood of a viewer recognizing how lens' focal length influences velocity and distance on television.
7. As measured in this study, skills in processing the content of visual messages is not related to the likelihood of a viewer recognizing how lens' focal length influences velocity and distance on television.
8. When asked to demonstrate their understanding of the interrelationship among time, distance and velocity on the basis of televised information, adults provide logically consistent explanations. A significant number of seventh-graders and even more third-graders do not fully understand how time, distance and velocity are interrelated. This lack of understanding was demonstrated by velocity and distance judgments which were not logically consistent. This evidence suggests that perceptual intuition dominates a need for logical congruity in the reasoning of young viewers.

Directions for Future Research

One catch-phrase of good television production values is that the production techniques used should not draw attention to themselves. Directors work to help viewers forget the camera; to help their audiences "suspend disbelief." This study suggests many viewers do accept the camera as their stand-in at events and ignore the effect of lens' focal length in modifying the true spatial characteristics of televised events.

Another aspect of television production which deserves very close scrutiny is the editing process--an activity by which a television director makes inferences across time and space for viewers. It seems unlikely that these inferences are equally meaningful or obvious to viewers of all ages. Television editing determines the logical relationships available to the viewer, much as the focal length of a lens determines the perceptual information available to the viewer. Especially within the context of Salomon's (1979) and Olson's (1977) remarks that opened this paper, editing techniques deserve special consideration (see Collins, et al., 1978 for one promising approach).

In many ways the production of a television program separates a viewer from the televised event as much as it brings the viewer to the event. The subtleties of this process are amenable to scientific experimentation and deserve further attention.

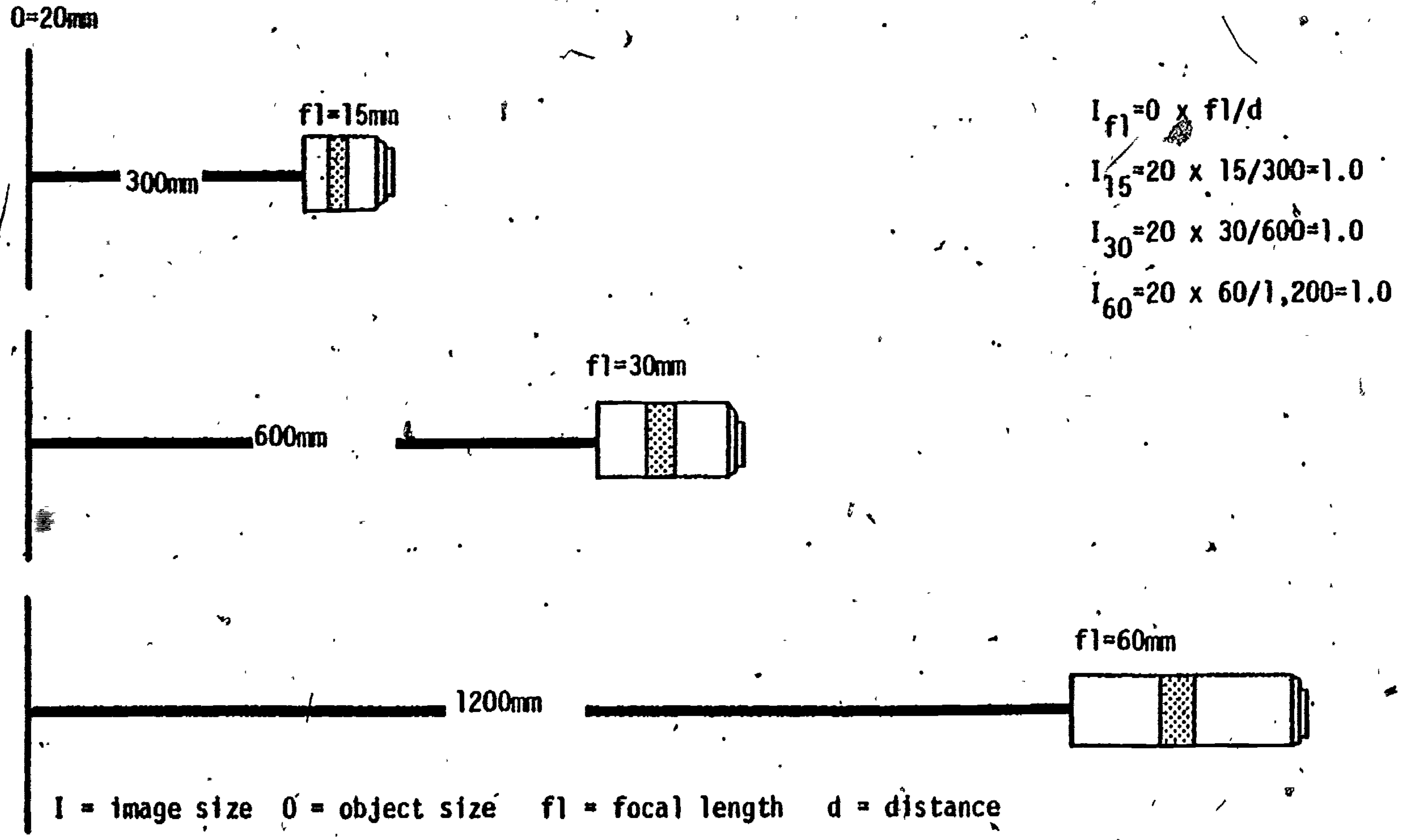
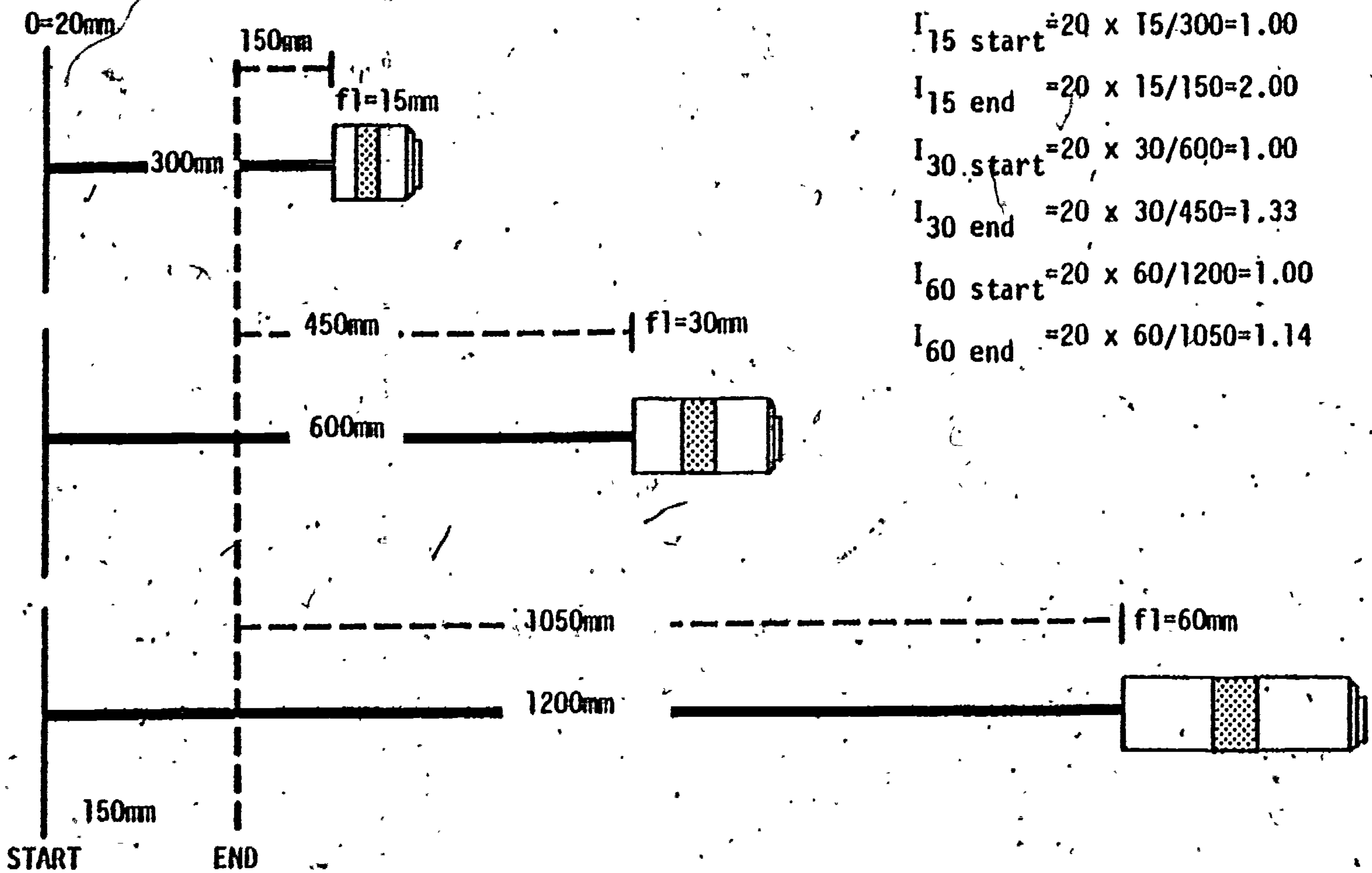
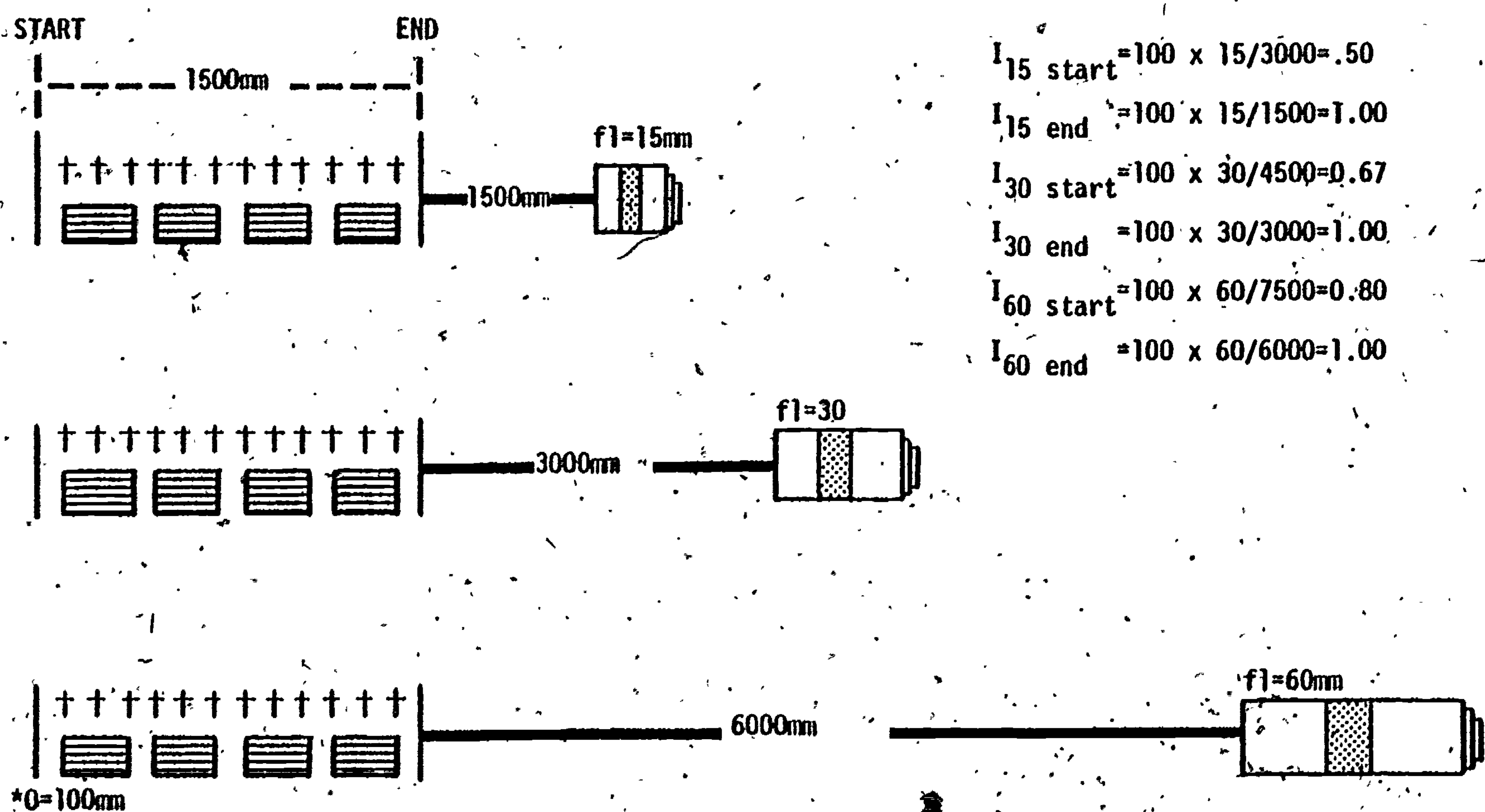


Fig. 1. Adjusting the lens' focal length/perspective relationship can result in identical image sizes.



I=image size   O=object size   fl=focal length   d=distance

Fig. 2. Apparent velocity and distance are both influenced by the perspective/image-size relationship.



*Actual object size was 30mm. 100mm used to clarify computations

I=image O=object fl=focal length d=distance

Fig. 3. Schematic of stimulus material and camera positions.

TABLE 1

LENS' EFFECT COMPARISON

Condition	Train 1 vs. Train 2	Increase in Train 1's Image Size	Increase in Train 2's Image Size	Relative Len's Effect
1(WAL)	Wide-angle vs. Long	2.0 times	1.25 times	2/1.25 = 1.60
2(WAN)	Wide-angle vs. Normal	2.0 times	1.50 times	2/1.50 = 1.33
3(NL)	Normal vs. Long	1.5 times	1.25 times	1.5/1.25 = 1.20
4(NN)	Normal vs. Normal	1.5 times	1.50 times	1.5/1.50 = 1.00

TABLE 2

PARAMETERS OF COGNITIVE CATEGORIES

	Recognized Lens' Effect	Velocity/Distance Judgments Logically Consistent	Velocity Judgment Exceeded Experimenter's	Distance Judgment Exceeded Experimenter's
Sophisticate	Yes	Yes	No	No
Naive/Formal	No	Yes	Yes	Yes
Naive/Concrete/Distance	No	No	No	Yes
Naive/Concrete/Velocity	No	No	Yes	No
Other[a]	No	No	No	No

[a]Judgments contrary to expectations. Various explanations offered.

TABLE 3

DUNNET'S CONFIDENCE INTERVALS AND TREND ANALYSIS FOR VELOCITY DATA

$\bar{X}_{WAL}=1.71$ $\bar{X}_{WAN}=.98$ $\bar{X}_{NL}=.59$ $\bar{X}_{NN}=.05$ $MS_e=2.00$

$.29\leq\bar{X}_{WAL} - \bar{X}_{WAN}\leq 1.17$ $tD_{(\alpha=.01;4,100)}=2.68$

$.05\leq\bar{X}_{WAN} - \bar{X}_{NL} \leq .73$ $tD_{(\alpha=.05;4,100)}=2.06$

$.09\leq\bar{X}_{NL} - \bar{X}_{NN} \leq .97$ $tD_{(\alpha=.01;4,100)}=2.68$

SOURCE	SS	df	MS	F	PROB
MEAN	284.0	1	284.00	142.00	.00
ERROR	200.0	100	2.00		
R(1)	143.0	1	143.00	93.00	.00
ERROR	153.0	100	1.53		
R(2)	1.1	1	1.10	2.75	.10
ERROR	40.0	100	.40		
R(3)	1.2	1	1.20	2.31	.13
ERROR	52.0	100	.52		
R	145.3	3	48.40	59.00	.00
ERROR	245.0	300	.82		

TABLE 4

DUNNET'S CONFIDENCE INTERVALS AND TREND ANALYSIS FOR DISTANCE DATA

$\bar{X}_{WAL}=2.80$ $\bar{X}_{WAN}=1.65$ $\bar{X}_{NL}=1.02$ $\bar{X}_{NN}=.05$ $MS_e=3.16$

$.60 \le \bar{X}_{WAL} - \bar{X}_{WAN} \le 1.70$ $tD_{(\alpha=.01;4,100)}=2.68$

$.08 \le \bar{X}_{WAN} - \bar{X}_{NL} \le .71$ $tD_{(\alpha=.01;4,100)}=2.68$

$.42 \le \bar{X}_{NL} - \bar{X}_{NN} \le 1.52$ $tD_{(\alpha=.01;4,100)}=2.68$

SOURCE	SS	df	MS	F	PROB
MEAN	768.0	1	768.00	243	.00
ERROR	316.0	100	3.16		
R(1)	396.0	1	396.00	189	.00
ERROR	209.0	100	2.10		
R(2)	.7	1	.70	.92	.33
ERROR	77.5	100	.77		
R(3)	3.6	1	3.60	4.44	.04
ERROR	81.0	100	.81		
R	400.0	3	133.00	109	.00
ERROR	367.5	300	1.22		

TABLE 5

COGNITIVE LEVEL BY GRADE

	FORMAL OPERATIONS		CONCRETE OPERATIONS		OTHER
	Sophisticated	Naive/Formal	Distance	Velocity	
COLLEGE	35	18	1	0	0
7th GRADE	4	30	13	0	0
3rd GRADE	2	16	15	8	5
TOTAL	41	64	29	8	5

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