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ABSTRACT

A study was conducted to examine the influence of visual complexity in a televised presentation on attention and learning among young children. (Visual complexity is defined as a composite variable that assesses the number of perceptual elements in a visual display and accounts for the extent of movement or activity in a scene.) Forty-eight preschool children were exposed to half-hour segments of "Sesame Street" programs in an environment that contained toys and other sources of distraction. Each child's visual attention to the television program was recorded by an unseen observer. Following the exposure, each child was asked a number of specific recall and recognition questions about the program. Results indicated a slight negative relationship between visual complexity and attention and a strong negative relationship between visual complexity and recall. Attention was found to be positively associated with recognition but not with recall. The findings suggest that visual attention was related to the learning of visually presented information but not necessarily to the learning of aurally presented information. (Author/FL)

THE INFLUENCE OF VISUAL COMPLEXITY ON CHILDREN'S ATTENTION TO AND LEARNING FROM "SESAME STREET"

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Introduction

The educational effectiveness of television has been demonstrated in well over 100 experiments, with all age groups and a great variety of subject matter and method (e.g., Carpenter and Greenhill, 1958; Brandon, 1956; Gropper and Lumsdaine, 1961). Unfortunately, this early research was typically carried out with intact classes. Consequently, the conclusions reached are not generalizable to the world of television viewing in the home where audiences have considerable latitude of choice to attend to particular programs.

Commercial televison's predominantly entertainment fare has also been studied extensively, but primarily from the point of view of incidental learning or socialization, rather than specific educational goals (e.g., Siegal, 1969; Ward and Wackman, 1973; Busby, 1975; Atkin, et al , 1972).

When the Children's Television Workshop emerged in the late sixties and proposed a television program that would both entertain and teach a variety of school-readiness skills to preschoolers at home, the question of attention to programming became crucial. To this end, educators, television producers and researchers working to create "Sesame Street" tried to utilize on instructional content the attention-eliciting and sustaining skills associated with commercial television (Lesser, 1972; 1974).

The ensuing popularity of the program attests to their success in achieving this goal. The actual educational effectiveness of "Sesame Street", however, has been a matter of some controversy (cf., Ball and Bogatz, 1970; Bogatz and Ball, 1971; Sprigle, 1972; Cook, et al., 1975; Minton, 1975). Ball and Bogatz, who were commissioned by CTW to study the learning impact of "Sesame Street", found significant learning gains for both encouraged and nonencouraged viewers. However, Ball and Bogatz's conclusions have been criticized methodologically (Cook, et al. 1975). Furthermore, other studies have generally found that viewing "Sesame Street" has had little or no impact on school-readiness skills (Sprigle, 1972; Minton, 1975).

Results of experimental and quasi-experimental studies concerning the effects of short-term exposure to"Sesame Street" on learning have been less conflicting although the relationships have tended to be small. Lorch, et al. (1979) found generally significant relationships between attention and comprehension for information presented audiovisually and auditorally among low-attention subjects. Watt and Krull (1977) found a slight positive relationship between attention and recall.

The conflicting nature of some of these findings taken together with the small size of relationships found in other of the studies suggests that attention to program and learning of program contents are not necessarily isomorphic. Such an idea, of course, is hardly news (Klapper, 1960). Attention alone may be necessary but insufficient to ensure learning.

To date, a good deal of research on "Sesame Street" has concerned the attention-gaining properties of some of the formal characteristics of the program (e.g., Anderson and Levin, 1976; Flagg, et al., 1976; Krull and Husson, 1979; Watt and Krull, 1977). Often, formal properties of television are described in terms of specific visual production techniques, such as pans, zooms, or slow motion shots. However, form and content are actually different ways of conceptualizing the same stimuli. One may consider them within an abstraction hierarchy, where form consists of the information at a more primitive, sensory level, and content consists of it at a higher, semantic level. Thus, the sensory data are the form, and the meanings attached to these data are content.

Both levels may be independently responsible for eliciting and maintaining viewer attention. However, it is plausible that formal properties may be relatively more important for very young children than for older individuals. Piaget's theory of cognitive development suggests that the thinking of children under about the age of seven is very much tied to concrete, perceptual reality (Flavell, 1963). Also, it is plausible that young children, having had fewer experiences of any kind that older persons, will have fewer or weaker meanings attached to perceptual events. Furthermore, there is indirect evidence that form perception may precede semantic interpretation in time (e.g., Liberman, et al., 1967; Liberman and Studdert-Kennedy, 1977; Chomsky, 1957).

Therefore, concern with the effects of the formal characteristics of "Sesame Street" on young chilren is well placed. Anderson and Levin, (1976) found that a variety of formal features including activity on the television screen enhanced visual attention among one to four year olds. Watt and Krull (1977) found a slightly positive relationship between their form complexity measures and visual attention. Flagg, et al. (1976), in their study of eye movements in preschoolers viewing "Sesame Street", found that several visual factors influenced attention. Krull and Husson (1979) found support for a small positive relationship between certain form complexity variables and visual attention.

However, as noted earlier, attention alone is often insufficient to produce learning in young children. The more interesting question then becomes: in what ways do specific formal characteristics of the television stimulus influence learning among young children, either alone or via the visual attention process? The present study is an attempt to better understand the effects of some of these relationsips among viewers of "Sesame Street" in a quasi-experimental setting. Four variables are measured. The first one, visual complexity, is a formal attribute of the television stimulus that taps both the static and dynamic aspects of complexity within a moving visual field. One might think of it as the number of perceptually distinct objects in a visual display and the activity, or movement, of these objects (activity is actually the successive presentation of objects over time on different parts of the screen). The second variable is visual attention to the program, while the final two variables, verbal recall and recognition, assess learning of the program contents. In this study, verbal recall requires verbal responses to closed-ended questions, while recognition only requires such nonverbal behaviors as pointing to or picking out the correct picture or object from an array in response to a closed-ended question.

Hypotheses

The literature reviewed here points fairly unambiguously to a positive relationship between visual complexity and attention.

When one adds recall to the mix, however, anticipated relationships become a good deal less clear-cut, for the following reasons. It is plausible to expect a positive relationship between attention and recall, insofar as exposure is a necessary if insuf. :ient precursor to learning. In fact, some evidence for such a relationship has been cited. Unfortunately, however, there is reason to expect that relatively complex stimuli, by themselves, will hinder the learning process in very young children. Watt and Krull (1977) in fact found a slightly negative relationship between form complexity and recall, in contrast to the positive links found between form complexity and attention, and attention and recall. Their tentative explanation for these findings is that the actual relationship between form complexity and learning is a nonmonotonic one.

Flagg, et al. (1976) found that high levels of "visual complexity" led to diffused and otherwise instructionally inappropriate eye gaze patterns. Based on their research, Friedlander, et al. (1974) also inferred that complex stimuli might hinder learning in young children.

A plausible theoretical explanation is Piaget's concept of centration (Flavell, 1963), whereby young children are incapable of focusing on more than a very limited amount of information perceptually available to them. If a great deal of information is presented visually, they will focus on one dimension which may or may not be relevant to the primary instructional purpose.

These considerations lead us to predict a curvilinear (inverted u-shaped) relationship between visual complxity and recall due to the mediating influence of visual attention. At low levels of complexity, the visual field should not be so ditracting as to detract from learning. As complexity begins to increase, so does attention, which initially offsets any negative effects of complexity on lrarning. However, at some point the visual field becomes sufficiently complex to produce distracted attention patterns. At this point, the relationship between complexity and learning becomes an increasingly negative one.

H1: There will be a positive relationship between visual complexity and attention.

H2: There will be an inverted u-shaped relationship between visual complexity and verbal recall. The peak of this curve is not specified.

H3: There will be an inverted u-shaped relationship between visual complexity and recognition. The peak of this curve is not specified.

H4: When effects of visual complexity are controlled, there will be a positive relationship between attention and verbal recall.

H5: W- -n effects of visual complexity are controlled, there will be a positive relationship between attention and recognition.

Definitions of Variables

Visual Complexity. Operationally, visual complexity was measured by attaching 20 light-sensitive photo cells to sampled areas on the screen of a video monitor which was showing an edited version of a "Sesame Street" program. These photo cells were calibrated to one another to produce equivalent readings. The raw photo cell readings assesed the amount of light on the sampled portions of the screen and were converted to numerical scores via an analogue to digital converter and computer. The light levels were sampled every second for the duration of the program.

A rough measure of both the static and dynamic aspects of visual complexity was obtained by using the standard deviation of all the light level scores across all sampling periods within each segment. While no attempt was made to partition the static from the dynamic aspects, conceptually, static complexity would be the variance across the 20 photo cells at one time point, while dynamic complexity would be the variance in scores from the same photo cell over time.

Further details on the operatinal procedures for this and other variables may be obtained from the authors.

Attention

Visual attention consisted of the percentage of time within each segment that the viewer looked at the screen. It was measured continuously be trained observers who watched the viewers through a one-way window and mechanically recorded all times that viewer eyes were off the screen.

Learning

Learning was assessed by a verbal recall measure as well as by a nonverbal recognition measure in which children had to pick out or point to pictures, objects, etc. Learning was measured for only six of the twelve program segments in order to avoid subject fatigue. For each segment tested, there were three closed-ended verbal recall questions and three closed-ended nonverbal recognition items. Questions were preceded by a freeze frame photo of that segment designed to cue memory. If the subject answered incorrectly or not at all, the experimenter gave a prompt which provided additional information but not the correct answer. If the subject still answered incorrectly or not at all, the experimenter went on to the next question. Praise was provided frequently. Later, responses for each segment were summed, providing one recall and one recognition score for each segment for each subject.

Procedures

Sample. Following a pretest of procedures on six children, a nonprobability sample of 25 males and 23 females was selected from three preschools. The age range was four years, zero months to six years, zero months. All subjects were Caucasian. While this sample is not representative of the viewing population as a whole, nor of the specific target population to which "Sesame Street" is addressed, it has yet to be demonstrated that children of different income or racial classes behave differently in terms of the variables of interest here.

Stimulus Materials. The videotape was an edited, black and white version of 12 "Sesame Street" segments put together by CTW for experimental purposes. It lasted approximately 30 minutes. This tape was one of the two tapes utilized in the Watt and Krull (1977), Flagg, et al. (1976), and Lorch, et al. (1979) studies. A second tape was prepared in which the position of segments was reversed, except for the opening, to control for order effects.

Experimental environment and procedures. Subjects were brought into an experimental room that simulated a family room, with comfortable furniture, a rug, indirect lighting and colorful posters on the wall.

A variety of toys were placed in the room to help distract the children from the television screen. The presence of a one way window was pointed out.

It was explained to the subjects that they could watch the "Sesame Street" program or play with toys as they wished, and that someone would be observing them occasionally from behind the window.

While the program was being shown, the subjects were alone in the room while the experimenter recorded attention next door through the observation window.

Immediately after the program ended, the experimenter returned to the experimental room and administered the learning questionnaire. The entire procedure took just under an hour.

Results

A repeated measures design was employed. For Hypothesis 1, each sampled second was treated as a separate observation. For the remaining four hypothese in which learning scores were summed across an entire segment, each segment was considered a separate observation. In these cases, visual complexity and attention scores were summarized for the entire segment.

Descriptive statistics. The mean attention level across all sampling periods was 68.85 percent with a standard deviation of 28.79. The mean score on verbal recall was 3.45, from a range of zero to six. The standard deviation was 1.89. The mean score for recognition was 4.04, from a range of zero to six. The standard deviation was 1.76. Not surprisingly, subjects scored somewhat higher on this learning measure, which did not require that they verbalize responses, and which provided for them specific physical referents (see Brown, 1975). One way analyses of variance were performed across all segments on attention, verbal recall and recognition. In all cases, the F values were significant at or beyond the .01 level, indicating significant variation on the measures.

With regard to visual complexity, there was one score for each experimental segment. Consequently, descriptive statistics and variance tests could not be performed for this variable.

Hypotheses tests. Hypothesis 1 predicts a positive relationship between visual complexity and attention. For this analysis, both variables were measured at one second intervals. The beta weight for visual complexity predicting attention at the same second is -.06, as can be seen in Table 1. Unfortunately, this relationship is significant but in a negative direction, rather than the positive one hypothesized. Hypothesis 1 is not supported.

Hypothesis 2 predicts an inverted u-shaped relationship between visual complexity and verbal recall. This hypothesis was tested by means of a polynomial equation in which $\hat{y} = a + b_1 x_1 + b_2 x^2$. The polynomial term, x^2, represents the parabolic or inverted u-shaped curve predicted by the hypothesis. A new variable was therefore computed having the value of visual complexity squared. A hierarchical multiple regression equation was performed in which verbal recall was the dependent variable, and visual complexity and visual complexity squared were the two predictors.

When visual complexity alone was entered into the equation, it produced an R squared of .22 (following the correction for repeated measures). This value is significant beyond the .005 level, with an F value of 13.26 and 6, 235 df. The introduction of visual complexity squared at the next step did not change the R squared, however, which indicates that the parabolic term did not contribute to the explanation of variance, and that the relationship is probably a linear one. Consequently, the curvilinear relationship anticipated by Hypothesis 2 is not supported.

Hypothesis 3 predicts a parabolic relationship between visual complexity and recognition. This hypothesis was tested identically to Hypothesis 2, except for the change in the dependent variable.

When visual complexity alone was entered into the equation, it produced an R-squared of .01. The introduction of visual complexity squared increased the R squared to .05. The incremental F test used to test the contribution of the squared term produced a value of 3.33 which is not statistically significant at the .05 level, with 1, 48 df. Consequently, Hypothesis 3 is not supported.

Hypothesis 4 predicts that a positive relationship will obtain between attention and verbal recall, when the effects of visual complexity are controlled. A first-order partial correlation was performed between attention and verbal recall, controlling for visual complexity, which produced a first order partial r of .17. This value yielded an F value of 1.24 with 6, 264 df, a value which is not statistically significant at the .05 level. Hypothesis 4 is not supported.

Hypothesis 5 predits a positive relationship between attention and recognition when the effects of visual complexity are controlled. The first-order partial correlation between the variables is .31. When the repeated measures correction was performed, this correlation became .36 which yields. an F value of 6.13, with 6, 246 df. This value is statistically significant at the .01 level. Hypothesis 5 is supported.

Discussion

No support was found for the anticipated positive relationship between visual complexity and attention, as predicted by Hypothesis 1. On the contrary, evidence was found for a systematic, although small, negative relationship between the variables. One probable cause of this unanticipated result lies in the operationalization of visual complexity. The measurement probably did not adequately tap the dynamic component of the concept because of the relatively long time interval (one second) between measurements. Consequently, fast movement was simply not assessed. It may be that rapid movement is critical when dealing with attentional factors. Certainly, intuitively, it would seem that statically complex or dense scenes with slow movement would be less influential in eliciting visual attention than scenes with rapid movement would be. Static complexity, however, may be more important when dealing with learning insofar as all the perceptually distinct objects represent competing focal points (Flagg, et al., 1976).

A more valid version of the temporal component of this measure could be obtained by increasing the measurement instances from one per second to several per second which would capture more rapid changes. Also, Shea (1974) has proposed a more refined measurement procedure for television displays based on information theory.

Another possible cause for the lack of support for Hypothesis 1 is that the theoretical model posited here may be inadequate in that no attempts have been made to deal with possible time-lagged effects of visual complexity on viewer attention. The appropriate time point to assess the effects of such physical events on behavior may actually be a few seconds following the events.

Currently, research studies are in progress that deal with both the refinement of the measurement procedure as well as the possible time lag problem.

Hypotheses 2 and 3 predicted inverted u-shaped relationships between visual complexity and the two learning measures but the findings indicate a strong negative linear one for verbal recall and no significant relationship for recognition. The rationale for the predicted curvilinearity was that attention, which was expected to be positively related to both visual complexity and learning, ought to intervene between them, and partially offset the anticipated negative effects of visual complexity on learning. However, the positive link between visual complexity and attention did not emerge in the data. Consequently, the simple theoretical bivariate relationship between visual complexity and learning ought to hold, which it did in the case of verbal recall. A plausible explanation for these findings is based on the information processing demands of the learning situation. It may be that attention to a verbal message represents a relatively difficult information processing task for a young child, and that a complex visual display represents a difficult competing information processing demand, which distracts from attending to the verbal message.

With respect to Hypothesis 3, there are two possible explanations for the null results. First of all, the breakdown in Table 2 indicates that recognition questions were almost exclusively questions about visually presented information (see discussion of this breakdown below). Thus, only the visual information processing mode was required during both the viewing and the measurement of learning situations. Second, the recognition task may have been so easy for the subjects that a threshold of difficulty was not reached where complexity might impair learning.

With respect to Hypotheses 4 and 5, evidence for the anticipated positive relationship between attention and recognition was found, while the relationship between attention and verbal recall did not reach significance. In order to explain these findings, it is necessary to consider the attention process a little more carefully. Actually, there are potentially two types of attention to televised stimuli: auditory and visual, corresponding to the two channels of the medium. However, only visual attention could be assessed. One would expect that visual attention would be more important for gaining visual information, while auditory attention would be more important for gaining auditorally presented information.

Given a learning measure that requires both verbal (recall) and nonverbal (recognition) responses, it seems plausible that the learning of auditory information would be more likely to be assessed by means of questions requiring verbal responses whhile the learning of visual information would be more likely to be assessed by means of questions requiring nonverbal responses. To determine if this was the case, the learning questionnaire was further examined to see how many of the "verbal" and "nonverbal" questions respectively asked about information presented auditorally or visually. Table 2 presents this breakdown.

It can be seen from this table that recognition questions were, with only one exception, questions about information that had been presented visually. Conversely, recal questions concerned primarily, but not exclusively, information that had been presented auditorally. If one accepts the logic that visual attention should mediate visual learning, then the breakdown of questions in Table 2 would lead one to expect the observed positive relationship between visual attention and recognition. On the other hand, two-thirds of the verbal recall questions asked about information that could not be directly tapped by visual attention (being auditory only.) Therefore, the null relationship between attention and recall is not surprising. Obviously, visual and auditory attention could overlap (see Lorch, et al., 1979), but since auditory attention was unmeasured, the extent of the overlap is unknowable in this case.

What conclusions can be drawn from this research about the television viewing and learning process? In terms of a link between programming characteristics and viewer attention, no evidence has been found for increases in attention as a function of increases in visual complexity. However, as noted earlier, the model presented here involving same time comparisons between physical phenomena and viewer reactions may be simplistic. Within these limitations, the present data suggests that, given conditions of at least minimal exposure - that is, presence in a room when the TV set is turned on - attempts by producers to "jazz up" the visual set with many different objects (static complexity) will not produce increases in attention among children of this age group. On the contrary, simple displays may be slightly attention enhancing.

In terms of the link between attention and learning, evidence is obtained here that increases in visual attention will lead to increases in learning of visually presented information, but not of information that is strictly verbal.

Finally, in terms of the link between programming characteristics and learning, rather strong evidence is provided here for a negative effect by static visual complexity on verbal learning. This finding corresponds with those of Flagg, et al. (1976) and Friedlander (1974). It suggests that producers who utilize fairly simple sets will be most successful in effecting learning among children of this age group.

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Table 1

Beta Weights, F values and Associated Probability Levels for Predictors of Visual Attention, with 8 and 3244 df

Dependent Variable = Visual Attention

Variable	Beta Weight	F Value	Probability Level
Visual Complexity	-.06	7.84	< .01

Table 2

Verbal and Recognition Questions
by Visual and Nonvisual Mode of Presentation

	Visual Presentation of Information	Nonvisual Presentation of Information
Verbal Recall Questions	6	12
Recognition Recall Questions	17	1