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ABSTRACT

The relationship between television program variables and children's attention was examined using sample shows from two nationally distributed educational programs. Shows were coded at 30-second intervals on four measures of program complexity and two measures of the relationship between verbal and visual content. Children's visual-attention levels were measured individually and averaged over the sample. Single time series analysis indicated the predictability of children's attention levels to be no more than 30 seconds. Younger children's attention in adjacent program segments was found to be more highly interdependent than was older children's attention. Multiple time series anlaysis indicated the attention of older children could be explained very well, based on the program variables measured. Older children also appeared to be affected more by variations in program complexity and, in particular, by visual complexity. Younger children were more affected by verbal variables, and attention levels were found to be more due to children's consistently attending than to program variables. Forty-four percent to 58% of the variance in attention was explained by these models. (Author)

CHILDREN'S ATTENTION TO THE TELEVISION SCREEN: A TIME SERIES ANALYSIS

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Abstract

The relationship between television program variables and children's attention was examined using sample shows from two nationally distributed educational programs. Shows were coded at 30 second intervals on four measures of program complexity and two measures of the relationship between verbal and visual content. Children's visual attention levels were measured individually and averaged over the sample.

Single time series analysis indicated the predictability of children's attention levels to be no more than 30 seconds. Younger children's attention in adjacent program segments was found to be more highly interdependent than was older children's attention.

Multiple time series analysis indicated the attention of older children could be explained very well based on the program variables measured. Older children also appeared to be affected more by variations in program complexity and, in particular, by visual complexity. Younger children were more affected by verbal variables, and attention levels were found to be more due to children's consistently attending than to program variables. Forty-four to 58 percent of the variance in attention was explained by these models.

CHILDREN'S ATTENTION TO THE TELEVISION SCREEN: A TIME SERIES ANALYSIS

Introduction

The bulk of television effects research has been based on survey designs in which viewers are assumed to watch programs the same way with the exception of the frequency of tuning in. The ease of data collection this assumption allows probably has contributed to information gained from surveys, but it is possible that some contradictory findings about television's effects may be due to variability in the behavior of viewers in front of the set.

Experimental studies of television viewership, including those of filmed violence, have generally concentrated on the behavior of viewers after programs are over. Less information about behavior during programs has been gathered. However, a growing body of research has shown considerable variability among viewers here. For example, it has been found that viewers engage in several activities while viewing and that different types of programs are watched with different degrees of attentiveness (Robinson, 1969; Bechtel, Achelpohl, and Akers, 1972; LoSciuto, 1972; Murray, 1972). Few studies have closely examined which aspects of programs stimulate viewer interest.

In this paper we have examined the effect of a small number of television program variables on the visual attention of children watching two educational series. The program variables used include four measures of form complexity and two measures of the interaction between visual and verbal content. The objective was to determine how long children take to react to these variables, how large the effects on attention are at their strongest point, and how long the effects endure. Making these assessments necessitated our using a technique called time series analysis.

In the following sections we shall review research on viewer attention, on program complexity and on cognitive development as it relates to television viewing. A short section on the unusual aspects of the research method is also included. A longer description is given in Appendix B.

Research on Attention to the Television Set

Most of the research on viewer attention has dealt with what viewers do rather than on the relationship of that behavior to program attributes. Of two bodies of research concentrating more on programs, one deals with advertising and the other with Children's Television Workshop programs.

In one study of television commercials Ward, Levinson and Wackman (1971) found that younger children (ages 5-10) paid slightly higher attention to the screen during both programs and commercials than did older children (ages 11-12). In a subsequent study (Ward and Wackman, 1973), they found that higher cognitive level children, who also tended to be older, were more discriminating in the attention they paid to different kinds of content. In another related study, Wartella and Ettema (1974) found that second graders and kindergarteners paid higher levels of attention to programs than did nursery school children, that older children paid higher attention to relevant commercials, and that there was a slight tendency for commercials of high auditory complexity to elicit higher levels of attention.

The most elaborate set of program variables which has been related to attention is that used by the Children's Television Workshop (CTW). In surveying formative research on Sesame Street, Reeves (1970) reported children's attention to be very fluid, and to be higher for segments containing animation, children, animals, and rapidly paced action. Anderson and Levin (Anderson and Levin, 1976; Levin and Anderson, 1976) found the number and duration of visual fixations of children on the TV screen to increase between the ages of one and four years. They also found that attention correlated negatively with the length of program content segments (bits) and positively with the appearance on the screen of adult females, children, non-human characters, physical activity, lively music and special effects. They also noted that one dimension underlying many of their variables is the amount of action present.

Taken together, these two sets of studies indicate that children are flexible in attention and that they become more selective as they get older.

Research on Program Complexity

The measures of program form complexity we used are a subset of a larger group based on the Information Theory concept of entropy. The four measures used are Set Time Entropy, Verbal Time Entropy, Shot Entropy and Nonverbal Dependence Entropy. Definitions of these variables are given in Appendix A, and more detailed descriptions are available elsewhere (Watt and Krull, 1974).

The rationale for a relationship between program complexity and viewing behavior is that television viewers are likely to choose programs on the basis of the amount of information processing offered. The Information Theory variables were developed to measure some aspects of program form which could be processed by viewers.

In previous studies complexity has been found to be related to audience ratings. While the levels of complexity of commercial programs appear to be near the optimum for drawing large audiences, public television programs were found to be lower in complexity with increasing complexity correlating with increased ratings (Krull and Watt, 1975).

Program complexity was also found to be related to habitual viewing, as measured by the average frequency of turning in programs, and to liking of programs. Viewers were found to cluster their viewing around certain complexity values (Watt and Krull, 1974), but were not found to cluster their liking of programs (Krull, Watt and Lichty, 1974). However, young adults were found to prefer higher levels of program complexity for both viewing and liking (Krull, Watt and Lichty, 1977).

These studies support a link between program complexity and the selection of whole programs by viewers; they reveal little about viewer behavior during viewing. It is possible, for example, that viewers prefer attributes of programs which covary with complexity, such as violence (Watt and Krull, 1976), and that they only attend to violent segments, ignoring the changes in complexity. A closer examination of viewing behavior is necessary to eliminate such possibilities.

One study of the effects of program complexity and violence on viewers over time has been done. Physiological changes in viewers were found to correlate with changes in program complexity, when both groups of variables were measured over 2 minute segments (Watt and Krull, 1975). It has been argued that the kinds of physiological changes observed are indications of attention (Lacey, Kagan, Lacey and Moss, 1973), and this would lend additional support to the rationale for viewer preference for complexity.

The time interval in the study just described is still rather long for estimating the effects of program variables on children. The advertising studies described earlier showed differences in the way children reacted to commercials varying from 10 to 60 seconds in length (Ward, Levinson and Wackman, 1972). Reeves (1970) reported the average duration of visual attention of Sesame Street viewers to be less than one minute; and Levin and Anderson (1976) found that program segments in Sesame Street shows were sufficiently long to show decreases in attention during the segments.

We used an interval of 30 seconds in this study. This interval seemed to be sufficiently short to assess some short-term effects, but not so short that values of the program variables would become unreliable. The 30 second interval does not change the overall rationale for a relationship between complexity and attention either, but it does introduce several theoretical and methodological problems due to interactions among adjacent time intervals. These are discussed in a description of time series procedures in Appendix B. Next we will describe two program measures used in addition to the complexity variables.

Visual/Verbal Interaction Program Variables

To the complexity variables we added two variables, Congruence and Independence, which assessed the relationship between the verbal and visual parts of the show.

Congruent verbalization was defined as any meaningful, spoken utterance which described, referred to, or was generally "about" something that was simultaneously being projected on the screen. The utterance could be of any length or type - it merely needed to be correlated with an image in the visual frame to count as congruent.

A great variety of utterances fell under the heading of "congruent". For example, the spoken word "one" (with an accompanying visual graphic) was counted as a congruent utterance. Similarly, letters of the alphabet which were recited with accompanying graphic representation were each treated as individual "utterances". At a more complex level, statements like "Look at all this old stuff I have lying around here", "There's a bird on me", and "And now we have a picture of Bert" were also counted as congruent utterances.

Independent utterances were any utterances which did not focus on something in the visual frame. Typical examples are statements like "How was your day", "Hey, I'm just kidding", and "I've got a little system that I use sometime".

The rationale for coding these variables was provided by Piaget's theory of intellectual development. The bulk of Piaget's research investigating children's cognitive processes has dealt with the child's understanding of physical, logical, and causal relationships. The aim of these investigations has been to construct a model of the child's cognitive processes which will account for its understanding of such relationships. (Ginsburg and Opper, 1969).

The essence of Piaget's theory is its "logical" (in the formal sense) character. Piaget uses the formal language of symbolic logic to describe the development of the child's patterns of thought. In this framework, the child's perceptions of the world are assimilated to schemes of action which change in the course of development from perceptually bound, non-reversible (or semi-reversible) systems, to mobile systems of transformation which are characterized by reversibility. In more common terms, the child gradually moves from a position in which his judgments are based on immediate perceptual states to a position in which he is capable of considering the physical transformations which produce any particular perceptual state.

An important feature of the child's thought process prior to adolescence is its "concrete" character. Even after the child has developed the capacity to consider transformations as opposed to states, he is only capable of mentally transforming phenomena which he can concretely experience. The ability to perform a mental experiment, i.e. to consider a problem at a purely abstract level, is not developed until approximately the period of adolescence.

It is, in fact, the concrete character of child thought which provided the strongest basis for expecting differences in children's attention as a function of whether segments had a high degree of visual/verbal congruence or a high degree of visual/verbal independence. Since visual/verbal congruence implied that information was being presented concretely (i.e. with visual reference), we felt that children should be able to assimilate this information and thus would be attuned to what was occurring on the screen; whereas, since visual/verbal independence implied that information was being presented at a primarily symbolic level (i.e. verbally as opposed to visually) we felt that children would have difficulty assimilating this information and thus would tend not to pay attention to it.

Time Series and Causal Relationships

Several theoretical issues intruded into our attempt to tie independent and dependent variables closer together by measuring variables over short time intervals. First there were the theoretical issues we wanted to investigate--length of the delay between the action of the independent variables and the response of the dependent variable, the rate of the response of the dependent variable once the response occurred, and the strength of the relationships between the independent and dependent variables at their strongest point. Secondly there were theoretical and methodological issues regarding the interactions among variables in adjacent time periods.

Our handling of these issues forced us to use a technique called time series analysis. Theoretical ramifications of the technique for the study of children's attention are described below, methodological aspects are described in Appendix B. Readers unfamiliar with the method can omit Appendix B on a first reading. Readers interested in detailed information on the method should see Box and Jenkins (1970) and Fuller (1976).

Interdependence in Attention Levels. Children are not likely to be completely erratic in their viewing behavior. If a child is paying attention to the screen at one point, it is also likely to be paying attention to the screen a short time later. This may be the case irrespective of what is on the television screen. A child who is not watching at some point is also likely to continue not to watch for some time irrespective of what happens on the screen.

This consistency on the part of children may affect the relationship between program variables and attention. If the consistency in attention is very strong, the effect of program variables on attention will appear to be reduced. The correlation between these variables for short time periods could be small or variable. To make an accurate assessment of the effect of the independent variable one must take the consistency of attention into account. One way of doing so is to compute the correlations between attention levels in neighboring measurement intervals, the autocorrelation. The stronger the interdependence between adjacent time periods, the higher the autocorrelations.

To determine the point beyond which interdependence can be ignored safely one should compute the partial autocorrelation. The partial autocorrelation is the correlation between distant time periods with the values of intermediate time periods held constant. The partials are nonsignificant statistically beyond the time distance where interactions can be ignored.

See Appendix B for information about the computation of autocorrelations and partial autocorrelations.

Independent and Dependent Variables Over Time. To assess the delay between the actions of the independent and dependent variables, time series methods employ the cross-correlation. This correlation is merely the ordinary correlation between the variables, but it is computed between scores of the variables for different time intervals.

If there is some delay in the reaction of the dependent variable, one would not expect to find a correlation between the variables during that delay. The effect has not taken yet, so to speak. One would only expect a correlation between the variables after the delay. This would appear as statistically significant cross-correlations after a group of near zero correlations. In the case of children's television viewing we would expect some delay in reaction to program variables and the cross-correlations would tell us the length of that delay.

The rate of response of the dependent variable can also be assessed in terms of the cross-correlations. If the response is rapid once it begins, the cross-correlations should rise rapidly to a maximum. If the response is relatively slow, the cross-correlations may only reach a maximum over several time periods. It is highly likely that children will react at different rates to different program variables. The cross-correlations should allow us to make comparative judgments regarding their response rates. See Appendix B for a description of cross-correlation graphs.

Multivariate Analysis of Attention Effects. We expected it would be necessary to separate the effects of interactions among adjacent values of both the television program variables and attention. For this paper we chose to use ordinary multiple regression based on autocorrelations and cross-correlations in building our empirical models. While more efficient estimating procedures are available (Box and Jenkins, 1970), the unusual results we found in the data made them unusable.

Hypotheses

We have taken an information processing approach to the relationship between television program variables and attention. The essentials of this approach, as they apply to both complexity variables and visual/verbal interaction variables, were outlined in the preceding section. Here we will apply the arguments presented above to changes in children's attention levels over time.

The hypotheses are divided into three sections. The first deals with the pattern of single series over time, the second deals with the relationship of program complexity to attention and the third with visual/verbal interaction and attention. The hypotheses formulated were tested on younger children watching Sesame Street and older children watching The Electric Company. This research setting is described in the Method section.

Single Variables Over Time. The hypotheses concerning the pattern of single variables over time are almost descriptive. We expected to find some interdependence among values of both the attention and program variables, but since time series analysis is so new, there are few guidelines as to the degree of interdependence to be expected. Our only strong expectation was that there would be a difference in the attention patterns of younger versus older viewers.

Both the advertising and CTW studies indicated that older children have a more integrated approach to watching television. We, therefore, expected more directed and fewer random changes in attention from older viewers.

This should appear as higher interdependence between attention levels in adjacent time periods, although the average attention levels need not necessarily be higher for older viewers. Since the program structure over time of the Electric Company and Sesame Street appeared to be roughly the same, we expected that a comparison between the viewers of the two programs would provide some information about this age difference. We hypothesized that:

> H_1. Older children pay attention to the television screen in a more stable way than younger viewers.

Since we had little information about the behavior of program variables over time for large samples of programs, we decided to produce no formal hypotheses here. Instead we decided to compare the behavior of these variables to see which variables were relatively less predictable over time and to see how similar the Electric Company and Sesame Street sample shows were in structure.

Program Complexity and Attention. Program complexity was found to correlate with the selection of programs for viewing and liking, and with physiological reactions to viewing. Some aspects of program complexity were also found to correlate with attention to the TV screen in the advertising and CTW studies. Extending these findings to short term attention, we expected that segments of programs with higher levels of complexity would draw greater attention from the children viewing. Program segments with higher levels of complexity would provide a good deal of perceptual information to process and children would therefore spend longer periods doing the processing. Program segments with lower levels of complexity would require less processing time on the part of children. This rationale held for each of the program complexity variables:

H_2. The higher the Set Time Entropy, the higher the level of children's attention to the television screen.

H_3. The higher the level of Verbal Time Entropy, the higher the level of children's attention to the television screen

H_4. The higher the level of Shot Entropy, the higher the level of children's attention to the television screen.

H_5. The higher the level of Nonverbal Dependence Entropy, the higher the level of children's attention to the television screen.

At this stage of theoretical development we did not feel prepared to formulate hypotheses about differences between younger and older viewers.

Visual/Verbal Interaction and Attention. The division of verbalization into congruent and independent utterances was based on assumptions about the kind of cognitive processing required for understanding. Generalizing to children's processing television programs, we expected that utterances accompanied by concrete visual representation would be easier to assimilate than utterances unaccompanied by such visuals. It seemed reasonable that children would pay less attention to program segments which they were not equipped to process and more attention to segments they could process. We hypothesized that:

H_6. The higher the level of Visual/Verbal Congruence, the higher the level of children's attention to the TV screen.

H_7. The higher the level of Visual/Verbal Independence, the lower the level of Children's attention to the TV screen.

Since the ages of children in both the Electric Company and Sesame Street viewing group fell within the period marked by concrete cognition, these hypotheses were expected to hold for both groups.

Method

Samples

Television Program Material. CTW provided us with four videotapes, two Electric Company and two Sesame Street shows. These shows were taken to be representative of the two series, but no comparative figures for the program variables were available. The Sesame Street shows were 47 (SS #1) and 58 (SS #2) minutes in length; the Electric Company shows were 28 (EC #2) minutes and 19 (EC #1) minutes in length. The second Electric Company program was a slightly truncated version, but was similar to the rest of the series in other respects. Descriptive statistics are given in table 1.

Viewing Samples. CTW also provided attention data on children viewing the four videotapes. Ten children watched each of the four tapes. The Sesame Street viewers were 4 to 5 years old; the Electric Company viewers were 7 1/2 to 8 1/2 years of age.

Measurement Procedures

Program Complexity Measures. Scoring the videotapes proceeded in several stages. First the videotape was timed to determine the boundaries of program content segments (bits) and the program was divided into 30 second segments. This was done to provide markers to check the accuracy of later measurements with respect to time in the program. Then an entire videotape was coded for one complexity variable, 30 seconds at a time.

One coder ran the videotape machine and stopped it every 30 seconds using machine's pause control. The other coder scored the variables on a machine consisting of ten electric clocks and a keyboard and noted the results each 30 second interval. Some program segments were of very high complexity and the average values of several coding passes was taken to represent these segments.

Entropy values were computed for each complexity variable for each 30 second interval after coding was completed.

Visual/Verbal Interaction Measures. The verbal parts of each videotape were transcribed. Then, using the rationale given above, we determined whether each utterance fell into the congruent or independent category.

Since the length of utterances varied greatly, the number of words per utterance was used as a weight. For example, the word "one" or the letter "g" were counted as single utterances. So was the statement "Look at all this old stuff I have lying around here." The latter utterance clearly occupies more "space" of the interval than either of the unit utterances. We felt that a weighted measure of verbal density would take this into account.

Each scale was completed by summing the number of weighted utterances in each category.

Children's Attention Measure. The attention data was collected by CTW as part of its research program (see Reeves, 1970, for a full description of the procedures). Children were individually shown a videotape. A colored-slide projector, changing slides every 7.5 seconds, was placed at the same height as the television set and about 45 degrees to one side.

With the exception of one Sesame Street tape, the attention of each child was noted every 7.5 seconds by a coder using a push-button connected to a recording device. Attention was weighted as follows: 3 -- eyes on the screen throughout the interval, 2 -- eyes on the screen more than half the time, 1 -- eyes on the screen less than half the time, 0 -- eyes off the screen through the interval. One of the Sesame Street tapes was only scored for attention every other 7.5 second interval.

The attention data provided were averaged over 30 seconds to make the measurement intervals comparable to that used for the program variables. This was possible because four 7.5 second intervals corresponded to one 30 second interval and the boundaries matched.

Results

Single Series Over Time

Children's Attention. We ~~had expected that~~ the attention levels of younger children watching Sesame Street would be less stable than the attention levels of older children watching the Electric Company (H_1). Figure 1 shows that autocorrelations for the attention of children in both groups drop fairly rapidly to near zero, ranging between .09 and .24 by a lag of 90 seconds. This seems to indicate that the interdependence between attention levels in neighboring measurement intervals lasts for less than 90 seconds.

The partial autocorrelations for attention for all four videotapes were found to be very near zero after a first significant one at 30 seconds. Since the first partial autocorrelation is equal to the first autocorrelation because there are not intermediate intervals to hold constant, the first partials may also be read from Figure 1. Higher order partials cannot be read from Figure 1, but since none were statistically significant at the .01 level we did not graph them.

The autocorrelations do not support our hypothesis that older children would show more stable levels of attention because the correlations are higher for the younger children until they fall into the statistically nonsignificant range. The partial autocorrelations for the younger children indicate that 40 percent of the variance in attention in one show and 47 percent in the other show can be accounted for just based on the interdependence between adjacent 30 second intervals (these figures were obtained by squaring the coefficients). The partials for the older children indicate only 16 percent and 27 percent of the variance in attention is accounted for by the 30 second interdependence.

If the pattern of autocorrelations for the program variables for the Electric Company programs is similar to that for the Sesame Street programs, the programs are very likely to be structured the same way over time with respect to other unmeasured program variables. In that case Hypothesis 1 is not supported. On the other hand, if the autocorrelations for the program variables for Sesame Street dropped more slowly towards zero, the hypothesis may not be disconfirmed. Younger children might just be following more slowly changing program variables and may appear to be more stable in attention as a result.

Program Complexity. Figures 2 through 5 show the autocorrelations for program complexity. With the exception of Electric Company show 1, the patterns for all of the variables are rather similar. The autocorrelations drop to a statistically nonsignificant level very rapidly and in several instances not even the first correlation is significant at the .01 level. These patterns indicate that there is very little interdependence between the neighboring values of these program variables.

The Electric Company show 1 autocorrelations for Set Entropy are statistically significant at the .02 level in two places. The partial autocorrelations were found to be .34 at 30 seconds and -.38 at 90 seconds. Further data anslysis revealed these correlations to be part of a 210 second cycle in the data (Krull and Paulson, in press).

Visual/Verbal Interaction. The autocorrelations for Visual/Verbal Independence are given in Figure 6. The patterns for all of the sample programs are similar with nonsignificant correlations after one approaching significance at 30 seconds. The first lag autocorrelations range from .18 to .40 with the Sesame Street shows falling at the upper end of the range.

Figure 8 shows that, with the exception of Electric Company show 2, the autocorrelations for Visual/Verbal Congruence approach nonsignificance fairly rapidly. However, the first lag autocorrelations are fairly high, being in the .40 to .50 range. With the exception of the one Electric Company show, higher order partials were found to be insignificant statistically.

The high autocorrelations for Electric Company 2 in the 180 and 210 second range were found to be indicative of a 200 second cycle in the data. Description of that analysis goes beyond the scope of this paper.

Both the Independence and Congruence variables show more interdependence between adjacent intervals than do the nearly random complexity variables. Children might find changes in the former variables easier to follow than in the latter. On the whole, the Electric Company and Sesame Street shows seem to follow roughly the same pattern and little explanation for the greater stability of attention of the younger viewers can be found in differences in the program variables we measured. Hypothesis 1 does not appear to be supported.

Children's Program Variables and Attention

Effects of Program Complexity. Cross-correlations between the four entropy measures of program complexity and children's attention are given in figures 8 through 11. The horizontal axis in the figures indicates how far the dependent variable leads (negative lags) or lags (positive lags) the changes in the values of the independent variable. The vertical axis indicates the sizes of the correlations between the independent and dependent variables at different given lags. We had expected the pattern of cross-correlations to look approximately as follows: insignificant correlations until some point after changes in the independent variable occurred (a positive lag of the dependent variable), a small number of statistically significant correlations, and then another series of insignificant correlations. The point at which correlations became significant would indicate the delay in children's reacting to a program variable. The point at which correlations again reached insignificance would indicate the duration of the effect.

Figure 8 shows cross-correlations between Set Entropy and attention. The older viewers of the Electric Company seem to be affected very rapidly by changes in Set Entropy since the correlations for zero lag are already fairly large. The effects seems to decay by 60 to 90 seconds. However, the pattern is complicated by correlations in the negative lags at 120 to 60 seconds.

Significant correlations at negative lags generally indicate changes in the dependent variable precede changes in the independent variable. In other words, the causal order is the reverse of that expected. Another possibility is that an unmeasured variable, affecting both the independent and dependent variables, produced this odd set of correlations. However, an explanation which has particular appeal for our theoretical problem is that children are anticipating changes in the Set Entropy variable before they happen. This implies that the older children watching the Electric Company know the program sufficiently well to predict some of the things which will occur.

The data in Figure 8 do not indicate a significant effect of Set Entropy on the younger viewers of Sesame Street. Hypothesis 2 appears to be supported for older, but not for younger children.

Figure 9 shows the cross-correlations between Verbal Time Entropy and attention. The pattern of correlations found is not as pronounced as that for Set Entropy, with only Electric Company 1 and Sesame Street 1 showing correlations approaching statistical significance. There appears to be rather weak support for Hypothesis 3.

The cross-correlations between Shot Entropy and attention in Figure 10 are weakly significant (.05 level maximum) for both Electric Company programs, but the correlations are positive for one program and negative for the other. Both sets of correlations also indicate some anticipation by children since the maxima are reached at 60 to 30 second negative lags. Sesame Street 1 showed significant correlation only at a lag of 180 seconds, and Sesame Street 2 showed only an anticipation effect. These results indicate weak support for Hypothesis 4 in some cases and no support at all in others.

Figure 11 gives the cross-correlations between Nonverbal Dependence Entropy and attention. The Electric Company data again seems to indicate anticipation on the part of children, with negative correlations appearing about 60 seconds negative lag. The Sesame Street data show relatively small correlations throughout. These data indicate no support for Hypothesis 5.

Effects of Visual/Verbal Interaction. Figure 12 shows the cross-correlations between Visual/Verbal Independence and attention for all shows to be that expected. Although there is some variability in the strength of the correlations, the effect is most strongly negative at zero lag and appears to be of rather brief duration. Hypothesis 6 appears to be supported.

Some of the cross-correlations between Visual/Verbal Congruence given in Figure 13 are stronger than those for Independence, but the pattern is less consistent among the sample programs. One Electric Company program has medium positive correlations for Congruence and attention, the other has weak negative correlations. One Sesame Street program has strong positive correlations, the other has moderately negative ones. These data give rather inconsistent support for Hypothesis 7.

Multiple Time Series Analysis.

Multiple time series were run to determine if the relationships among the program variables were affecting the cross-correlations. Some of the cross-correlations implied anticipation on the part of children which would require a feedforward type model to analyze. We were not prepared to modify multiple time series computing algorithms to handle this situation, so we decided to obtain good preliminary empirical models by using simple multiple regression. Were a feedforward model to be used, a better fit than that we got would be highly likely.

The best multiple regression models for Sesame Street are given in Table 2. There are three important features to these models: they explain a large amount of variance in attention, the bulk of the variance explained is due to autocorrelation with attention at a lag of 30 seconds, and the remaining variance is explained by measures of the verbal aspects of programs. Note that the negative lags of the independent variables in the table correspond to positive lags of the dependent variables in the cross-correlation figures.

The best multiple regression models for the Electric Company are given in Table 3. Three important features of these models are that: they explain a large amount of variance in attention, the bulk of the variance explained is due to cross-correlation with the program variables, and the effects of the program complexity variables are stronger than those of the Visual/Verbal Interaction measures.

Both the Sesame Street and Electric Company models exceed our expectations. They account for about half the variance in children's attention with a small number of predictor variables. Although some of the regression coefficients for the Sesame Street program variables are only marginally significant, the overall models are highly statistically significant in every case. It is also interesting to note distinct differences between the models obtained for older and younger viewers. These differences will be discussed in the next section.

Discussion

At the outset we indicated that we were going to examine the relationship between a small number of television program variables and children's attention. We also indicated that we would do so taking into account the interdependence between adjacent time intervals, and the delays and rates of response of attention to the different program variables.

The data indicated the pattern of children's responses to be fluid and variable. Autocorrelations of children's attention indicate little consistency beyond about 60 seconds, the interdependence between two adjacent lags. Cross-correlations were found to vary between programs in the same TV series, and significant cross-correlations were found in unexpected places. However, the data also indicated children's attention is not totally unpredictable. Several hypotheses about children's behavior received at least partial support and the multiple time series models accounted for unexpectedly high amounts of variance.

The expectation that older children would show more stable attention was not supported by the data (H_1). This was shown both by their autocorrelations and by their low weights in the multiple regressions for 30 second lag attention levels. Although comparing the behavior of viewers attending to two different TV series is not a clean test of age differences, these data do indicate some age differences are likely.

One interpretation we have made of our data is that older children are more attuned to changes in the content of television programs and are more able to adjust to those changes by varying the amount of attention they pay. Younger children seem to be more rigid in their viewing, being unable to make adjustments in their processing of program content as content varies over time. This interpretation is consistent both with the previous research literature and with the greater relative predictive power of program variables in explaining the attention of older viewers. Comparisons of viewers of different ages watching the same show would be required to validate the argument.

Comparisons of the delays and response rates of attention to the different program variables proved to be rather interesting (H_2 to H_7). Strong cross-correlations were found at long lags to either side of zero lag. In several instances the zero lag cross-correlations, which are the equivalent of ordinary cross-sectional correlations, were rather small. More interesting yet, a few variables seem to show children's anticipating changes in programs. Such apparent anticipation would certainly not have been found using cross-sectional methods.

If our interpretation of the cross-correlations' indicating anticipation is correct, much more sophisticated theoretical models of children's viewing behavior will have to be developed. Levin and Anderson (1976) reported children developing from random to purposive viewing by the age of 3 years. Our data seem to indicate that children have enough experience with television viewing by the time they are 8 to predict some aspects of programs. We intend to develop and test a theoretical model including anticipation effects in the near future.

Table 1

DESCRIPTIVE STATISTICS

Variable	Show	Mean	Standard Deviation
Children's Attention	EC #1	34.3	9.3
	EC #2	62.3	15.4
	SS #1	73.3	15.7
	SS #2	66.0	15.2
Set Time Entropy	EC #1	.41	.53
	EC #2	.50	.67
	SS #1	.29	.56
	SS #2	.47	.89
Verbal Time Entropy	EC #1	.76	.61
	EC #2	.83	.54
	SS #1	.88	.66
	SS #2	.89	.70
Shot Time Entropy	EC #1	.76	.44
	EC #2	.88	.40
	SS #1	.73	.52
	SS #2	.79	.50
Nonverbal Dependence Entropy	EC #1	.77	.31
	EC #2	.68	.28
	SS #1	.45	.36
	SS #2	.65	.29
Visual/Verbal Independence	EC #1	28.4	23.8
	EC #2	28.6	21.4
	SS #1	28.9	22.3
	SS #2	25.2	23.5
Visual/Verbal Congruence	EC #1	16.4	13.8
	EC #2	19.2	14.5
	SS #1	19.4	21.6
	SS #2	24.2	20.4

EC #1 N = 38
EC #2 N = 56
SS #1 N = 93
SS #2 N = 116

Table 2

MULTIPLE REGRESSIONS OF CHILDREN'S ATTENTION ON TELEVISION PROGRAM VARIABLES FOR SESAME STREET

Show #1

Predictor Variable	Beta	Multiple R	F	D.F.	P <
Attention_{t-1}	.53	.76	20.28	6,86	.001
$\text{Verbal Time Entropy}_{t}$	.11				
$\text{Verbal Time Entropy}_{t-2}$	.13				
$\text{Nonverbal Dep. Entr.}_{t-1}$	.12				
$\text{Visual/Verbal Indep.}_{t}$	-.13				
$\text{Visual/Verbal Cong.}_{t}$	.28				

Show #2

Predictor Variable	Beta	Multiple R	F	D.F.	P <
Attention_{t-1}	.62	.70	26.85	4,111	.001
$\text{Nonverbal Dep. Entr.}_{t-3}$	-.14				
$\text{Visual/Verbal Ind.}_{t}$	-.20				
$\text{Visual/Verbal Cong.}_{t-2}$	-.17				

Table 3

MULTIPLE REGRESSIONS OF CHILDREN'S ATTENTION ON TELEVISION PROGRAM VARIABLES FOR THE ELECTRIC COMPANY

Show #1

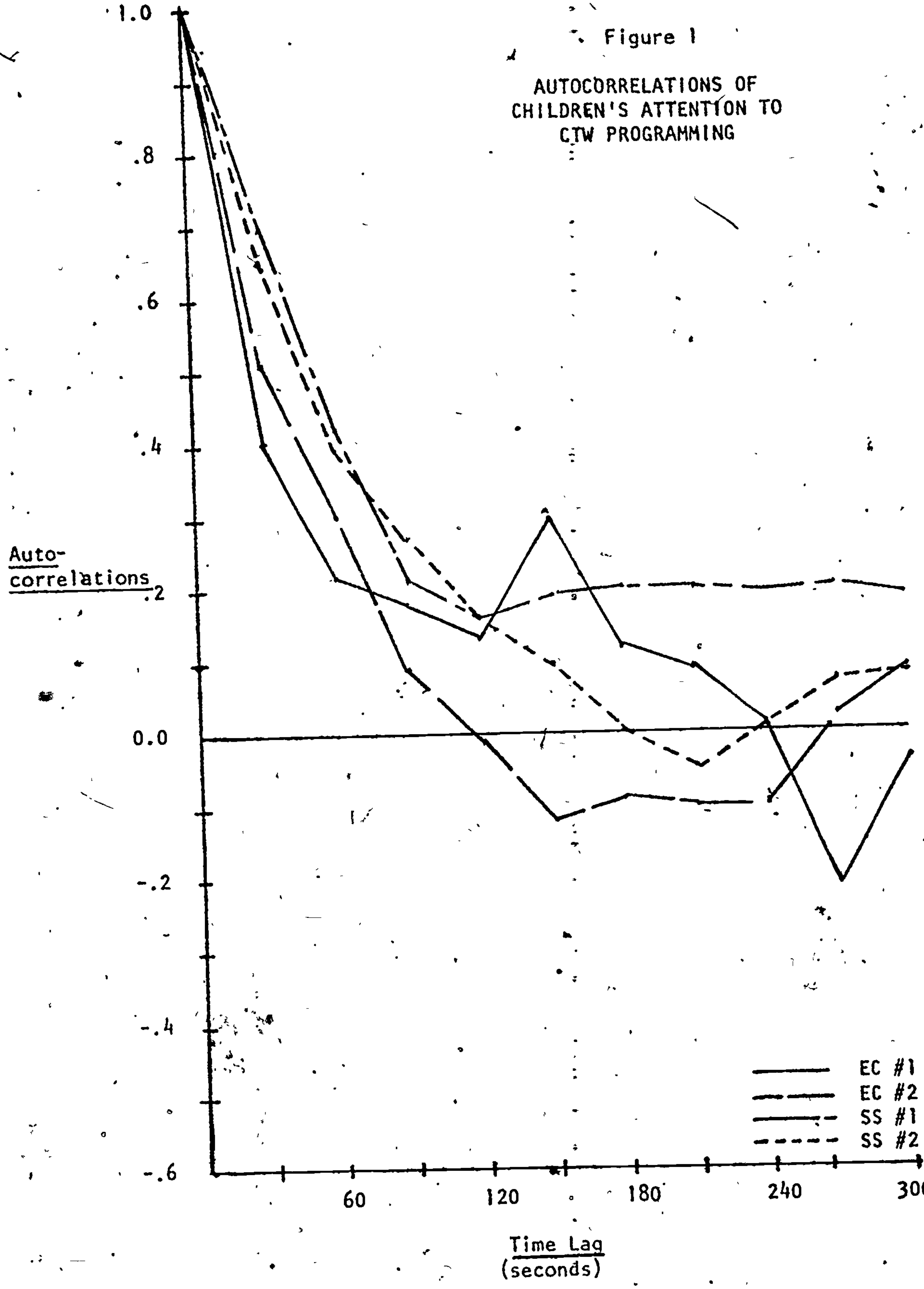
Predictor Variable	Beta	Multiple R	F	D.F.	P ≤
Set Entropy$_t$	.39	.66	6.22	4,33	.001
Set Entropy$_{t-3}$	.41				
Verbal Time Entropy$_t$	.36				
Shot Time Entropy$_{t-2}$	.33				

Show #2

Predictor Variable	Beta	Multiple R	F	D.F.	P <
Attention$_{t-1}$	.31	.73	7.67	7,48	.001
Set Time Entropy$_t$	.33				
Set Time Entropy$_{t-3}$	.18				
Verbal Time Entropy$_{t-2}$	-.32				
Shot Entropy$_{t-2}$	-.29				
Nonverbal Dep. Entr.$_{t-6}$	.24				
Visual/Verbal Cong.	.36				

Figure 1

AUTOCORRELATIONS OF CHILDREN'S ATTENTION TO CTW PROGRAMMING



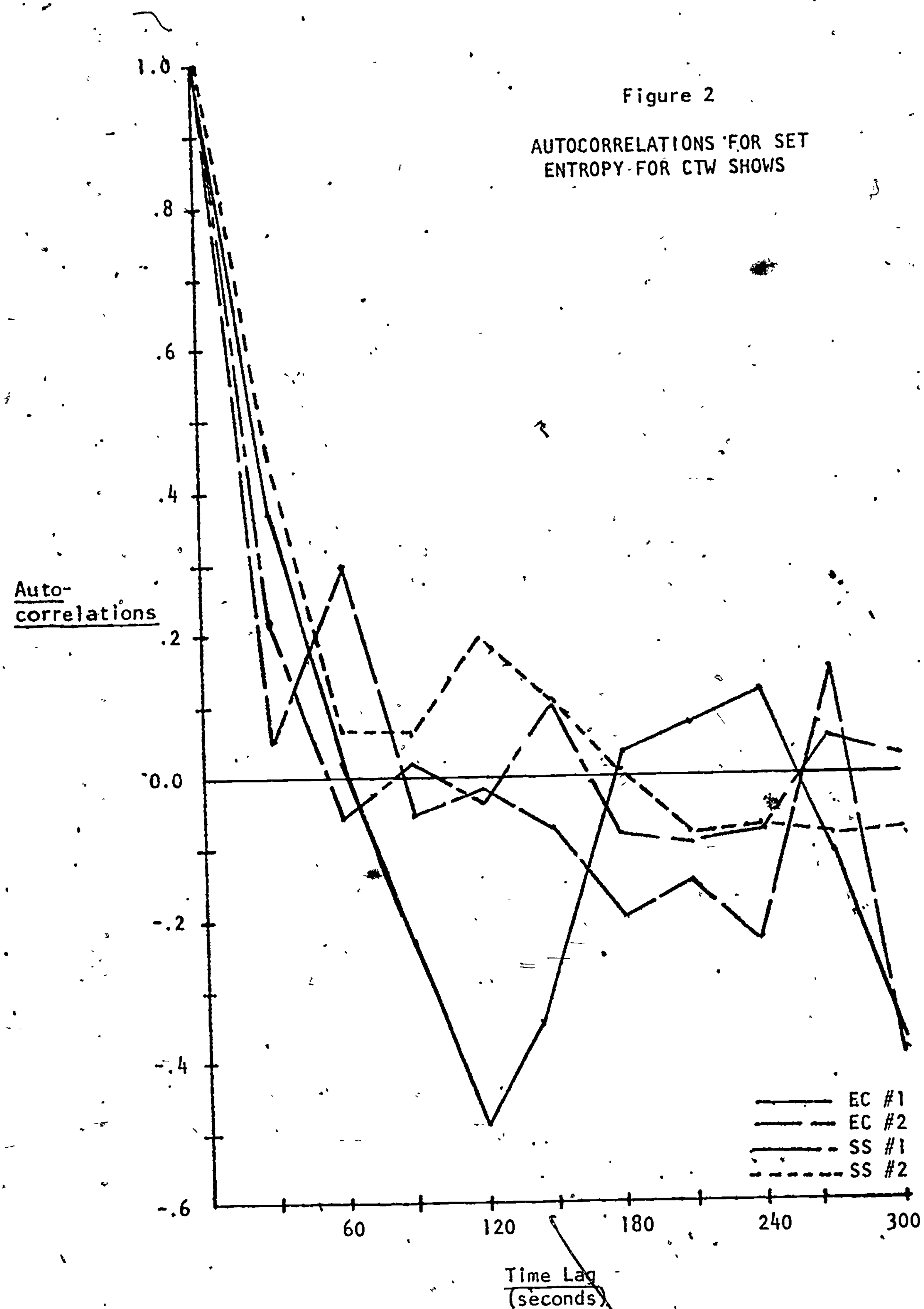


Figure 2
AUTOCORRELATIONS FOR SET ENTROPY FOR CTW SHOWS
1.0
.8
.6
.4
.2
0.0
-.2
-.4
-.6
Auto-correlations
60
120
180
240
300
Time Lag (seconds)
EC #1
EC #2
SS #1
SS #2

Figure 3

AUTOCORRELATIONS FOR VERBAL TIME ENTROPY FOR CTW SHOWS

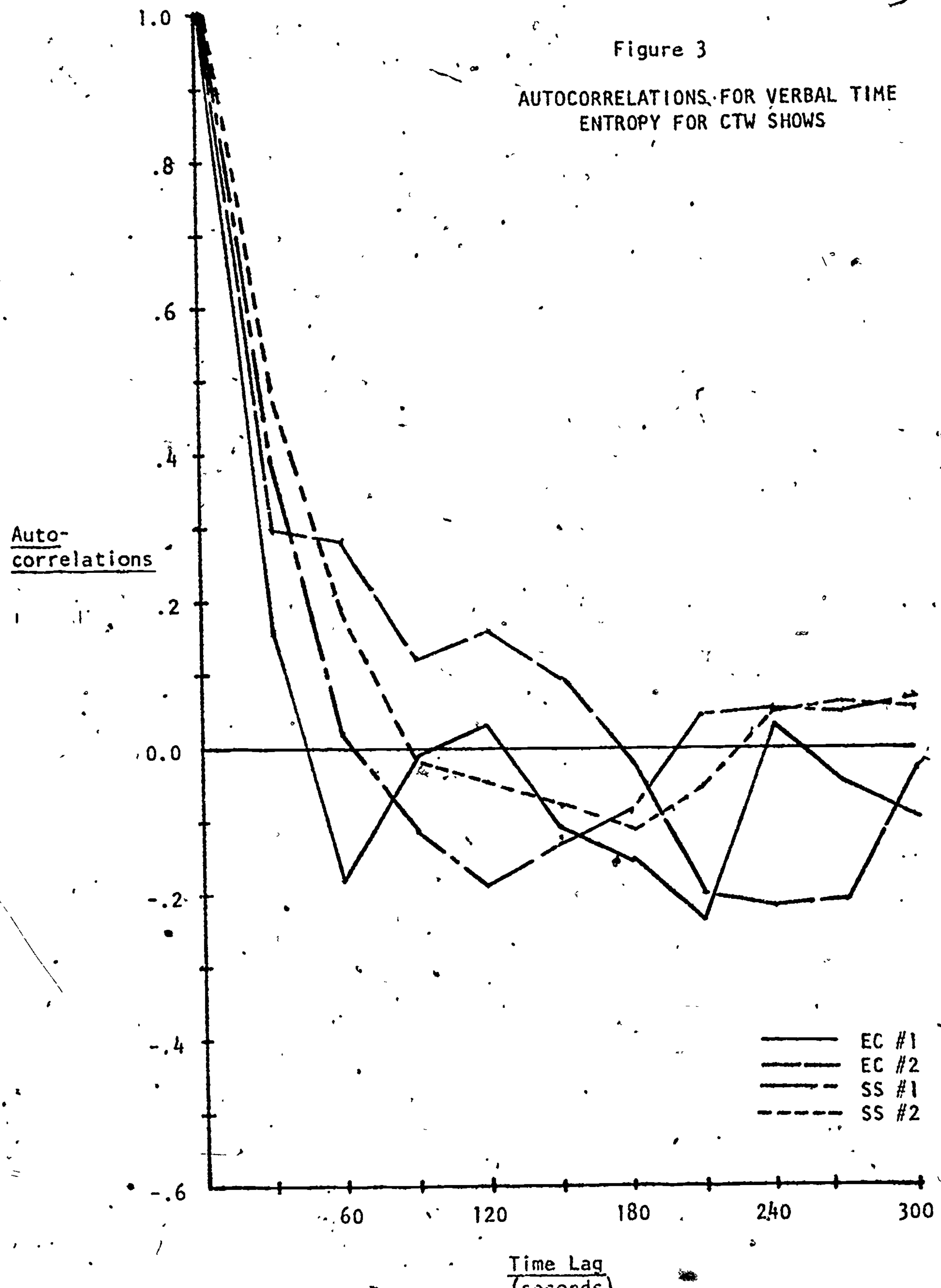


Figure 4

AUTOCORRELATIONS OF SHOT ENTROPY FOR CTW SHOWS

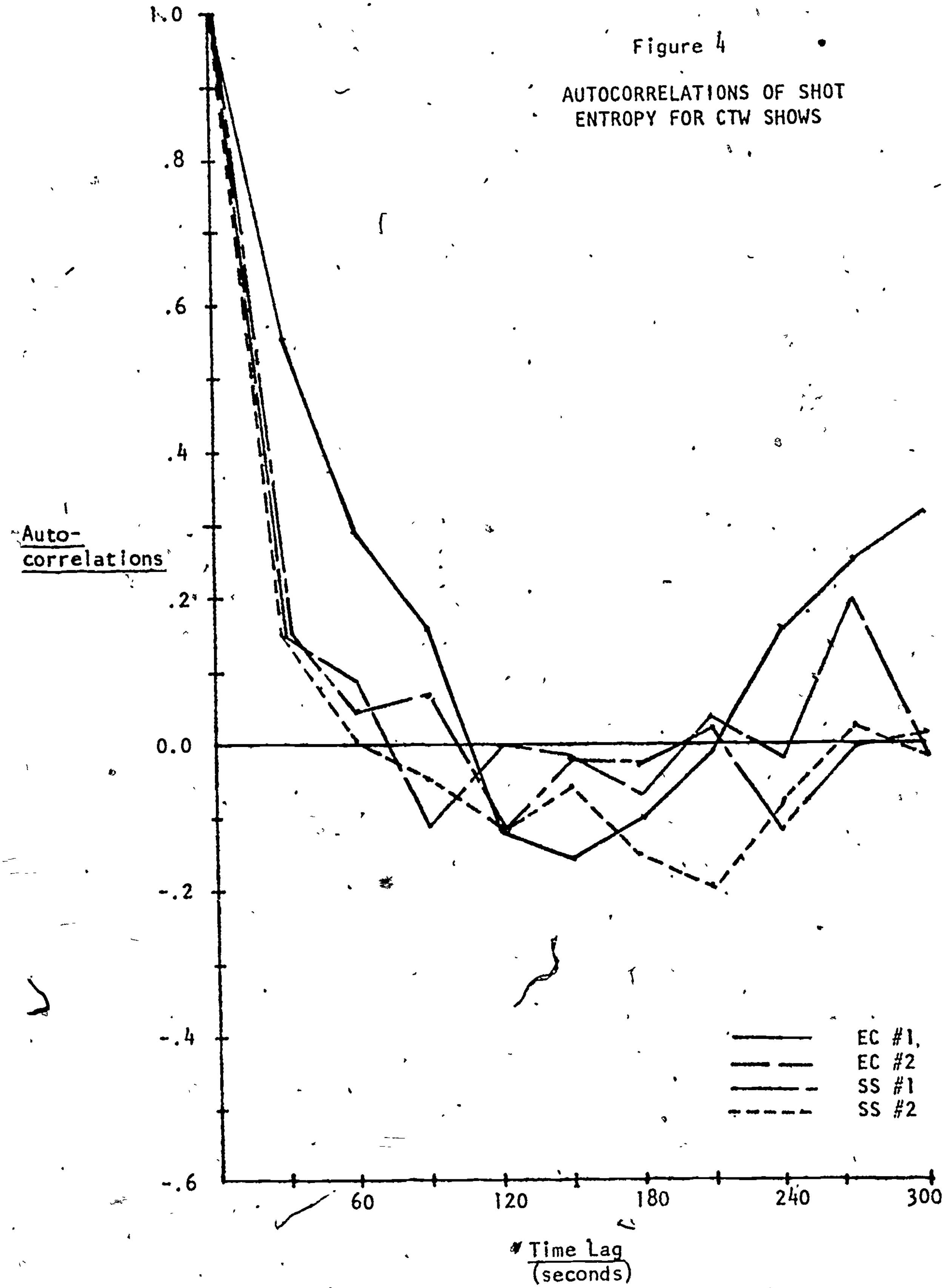


Figure 5

AUTOCORRELATIONS OF NONVERBAL DEPENDENCE ENTROPY FOR CTW SHOWS

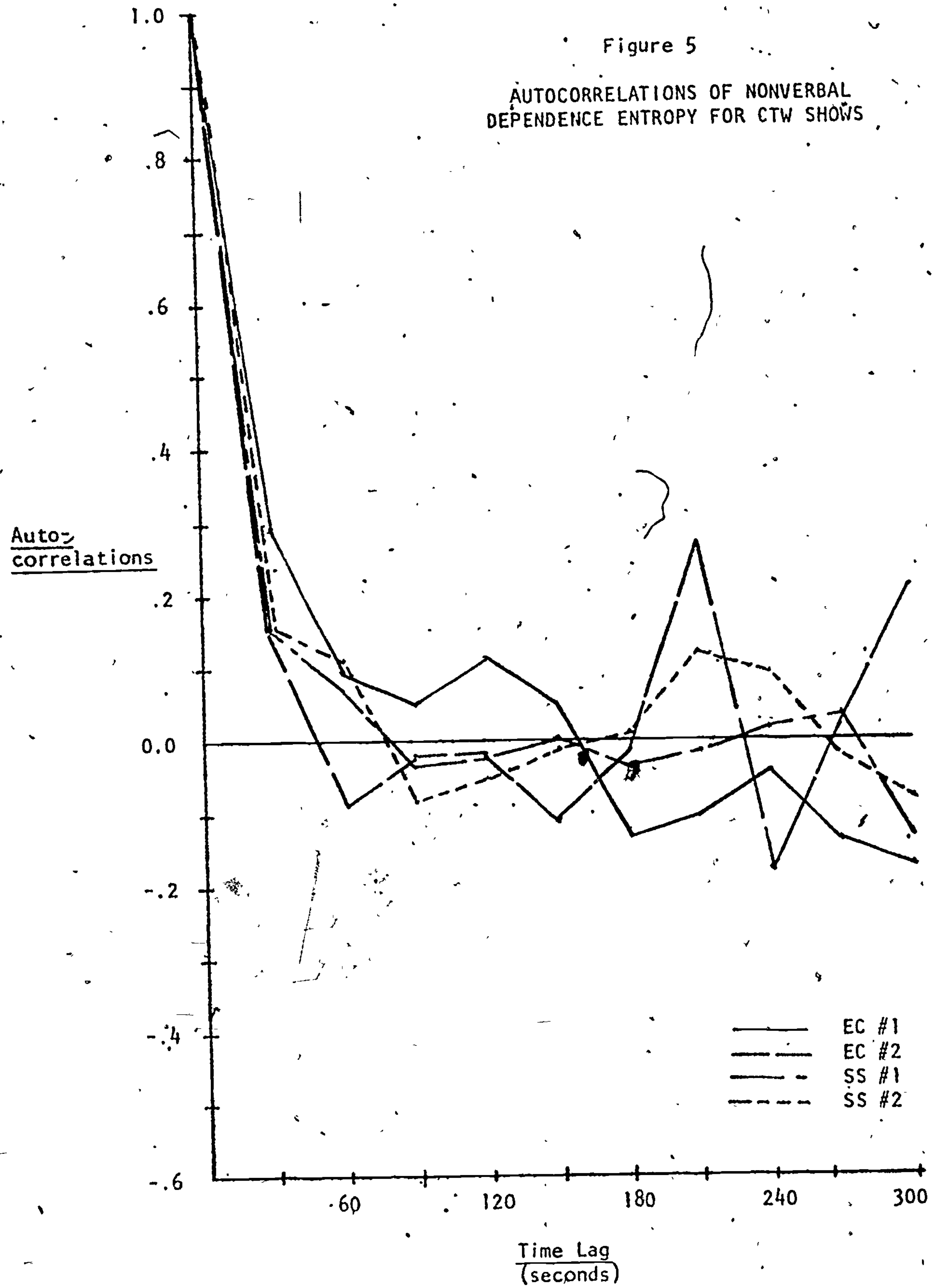


Figure 6

AUTOCORRELATIONS OF INDEPENDENT VERBALIZATION FOR CTW SHOWS

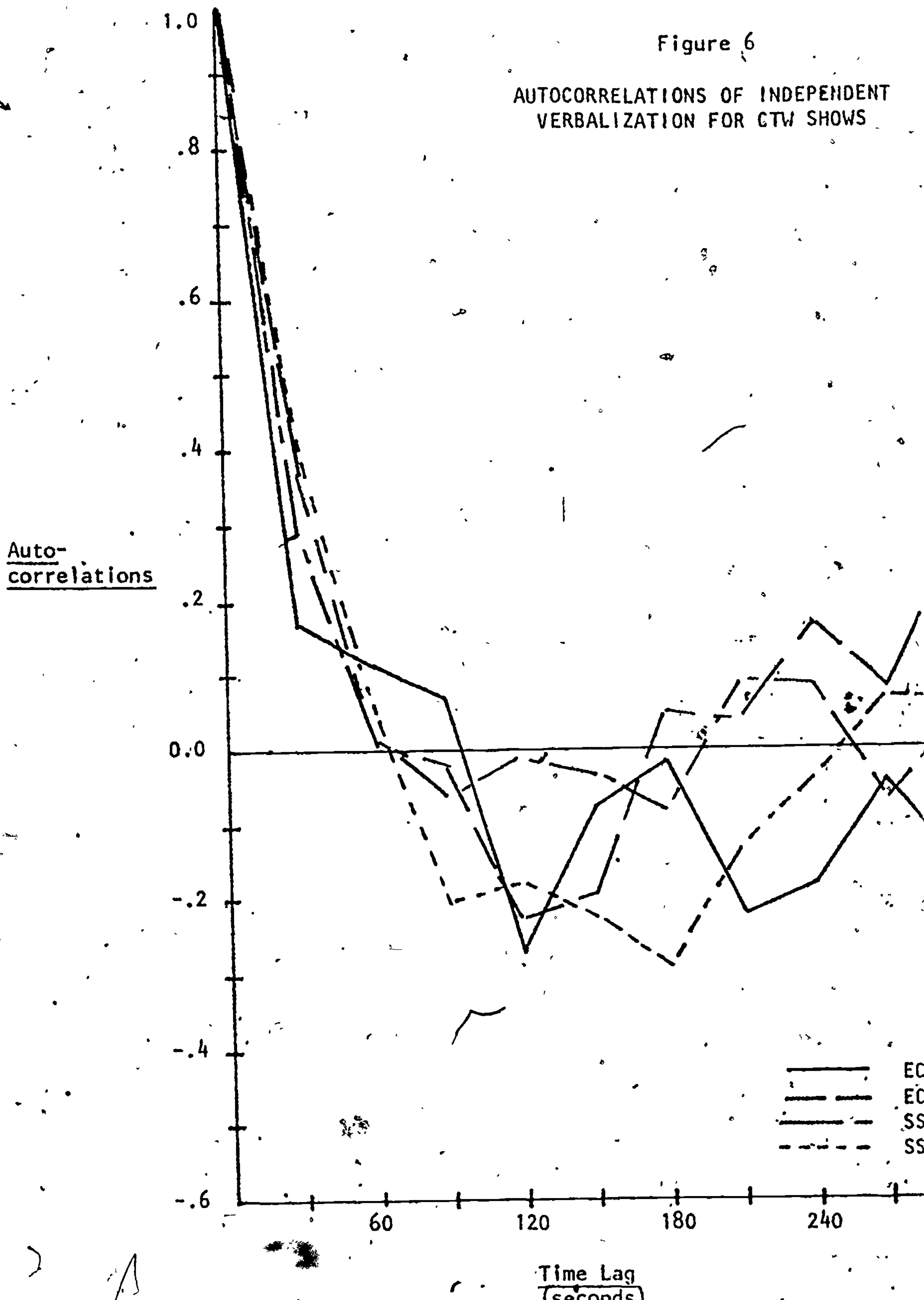


Figure 7

AUTOCORRELATIONS OF CONGRUENT VERBALIZATION FOR CTW SHOWS

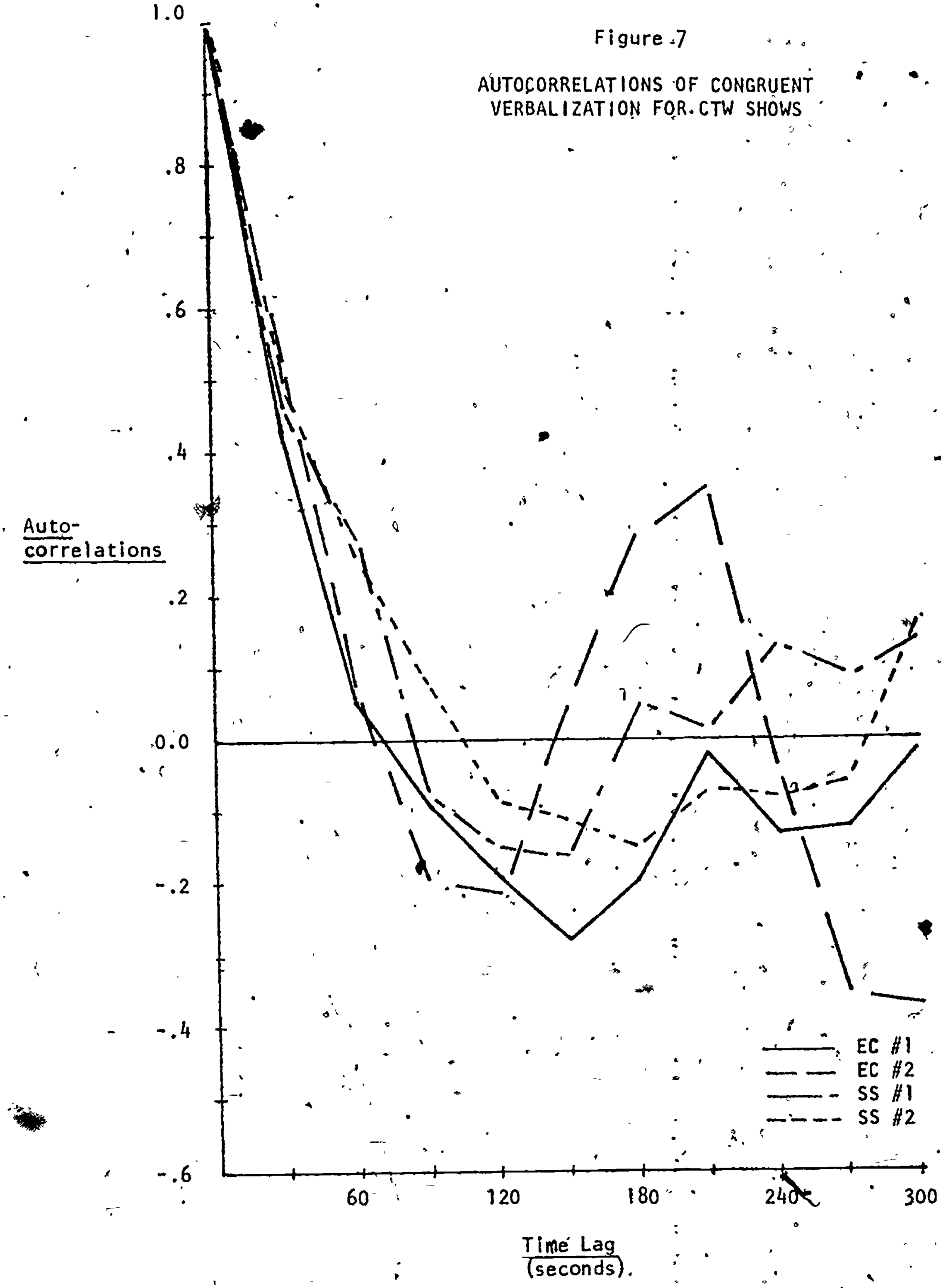


Figure 8

CROSS-CORRELATIONS BETWEEN SET ENTROPY AND CHILDREN'S ATTENTION

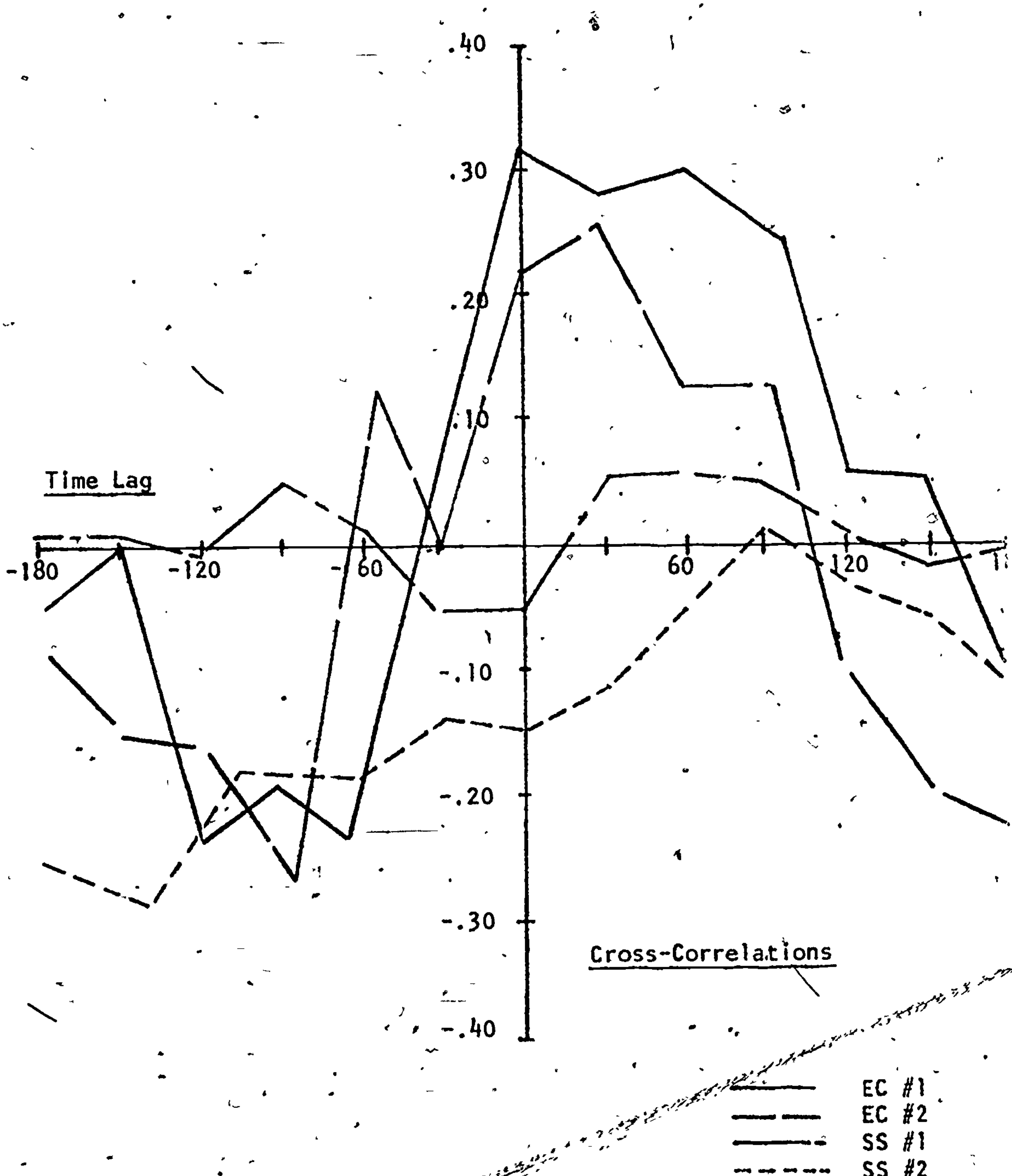


Figure 9

CROSS-CORRELATIONS BETWEEN VERBAL TIME ENTROPY AND CHILDREN'S ATTENTION

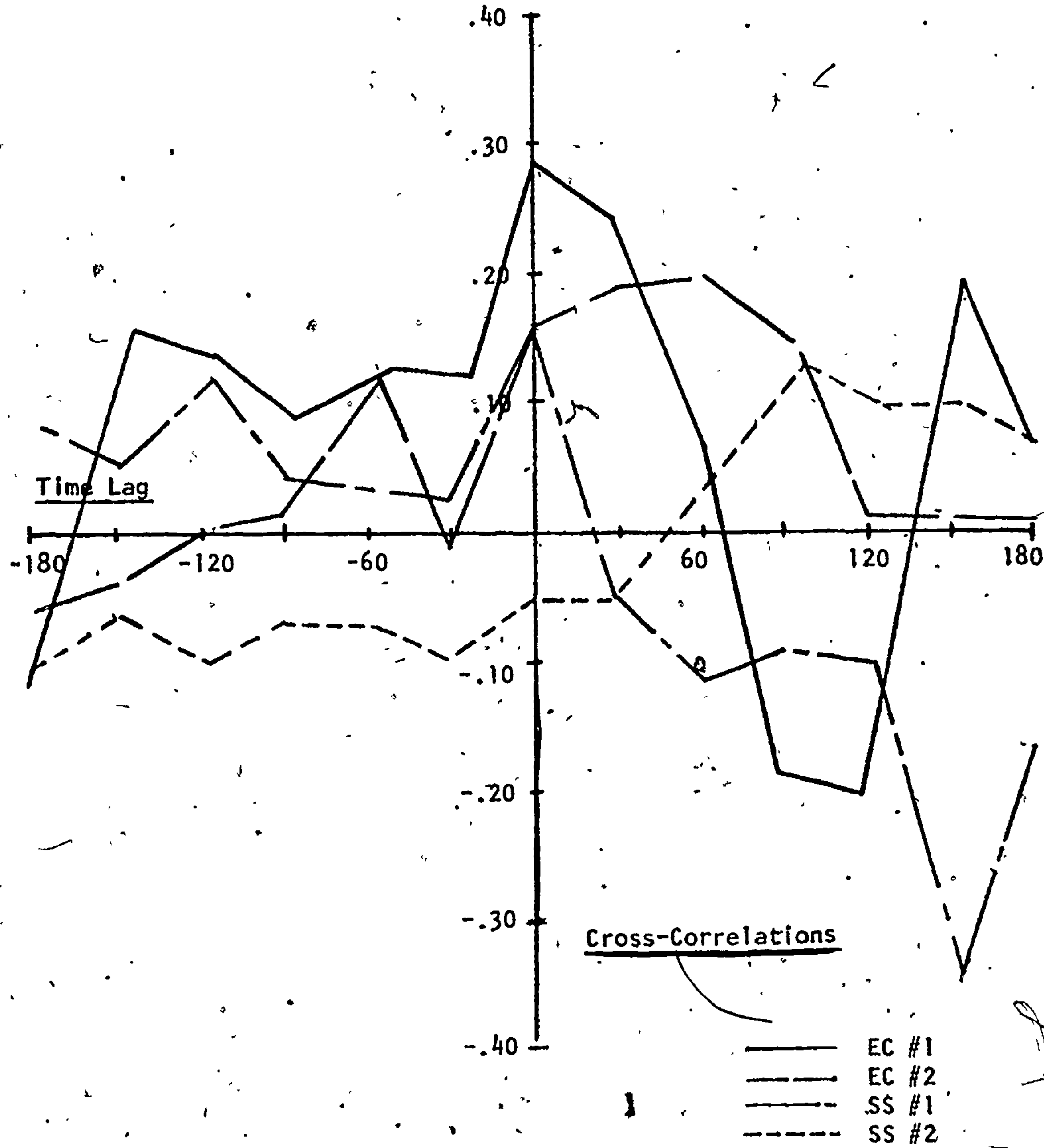


Figure 10

CROSS-CORRELATIONS OF SHOT ENTROPY AND CHILDREN'S ATTENTION

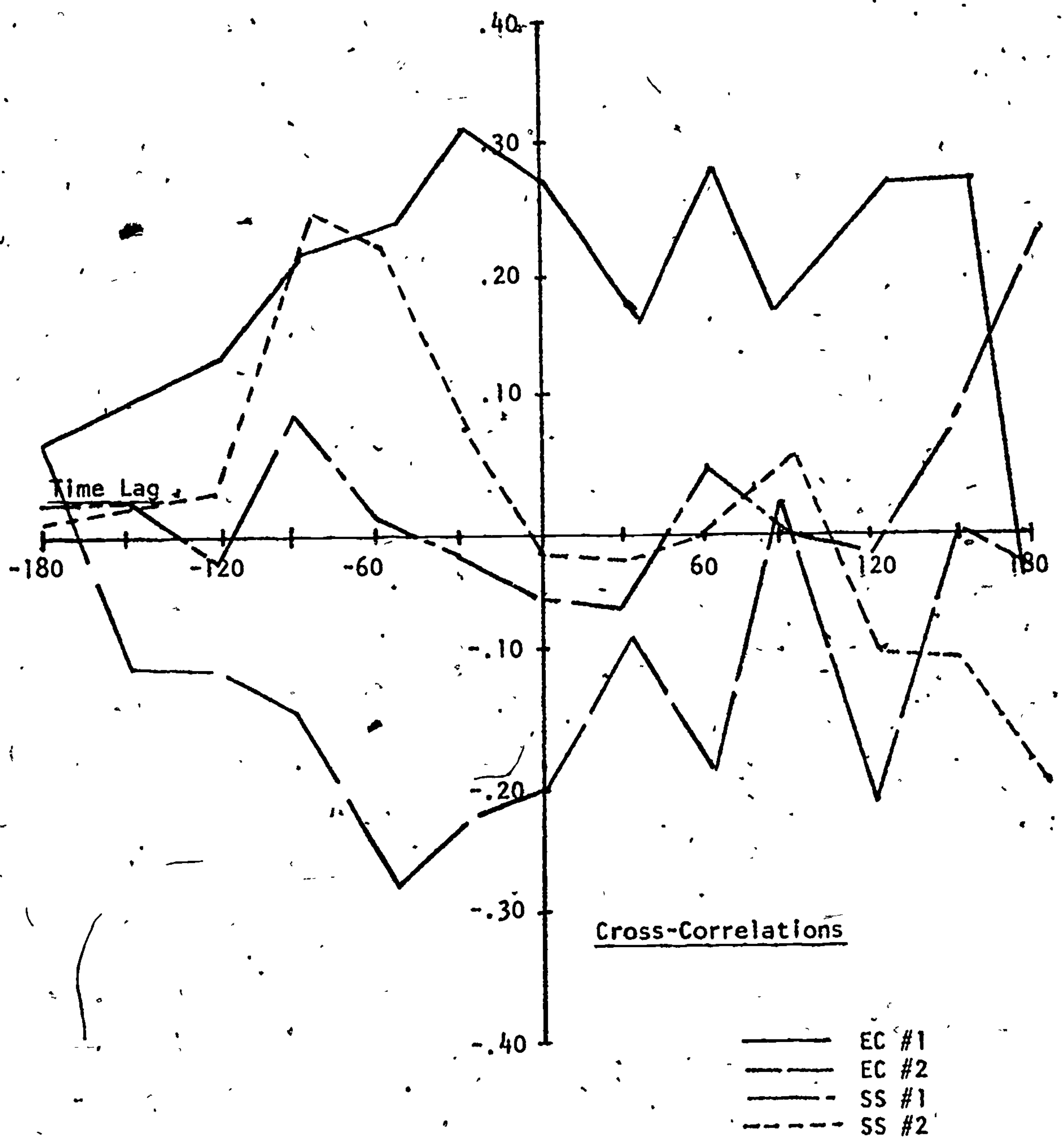


Figure 11

CROSS-CORRELATIONS OF NONVERBAL DEPENDENCE ENTROPY AND CHILDREN'S ATTENTION

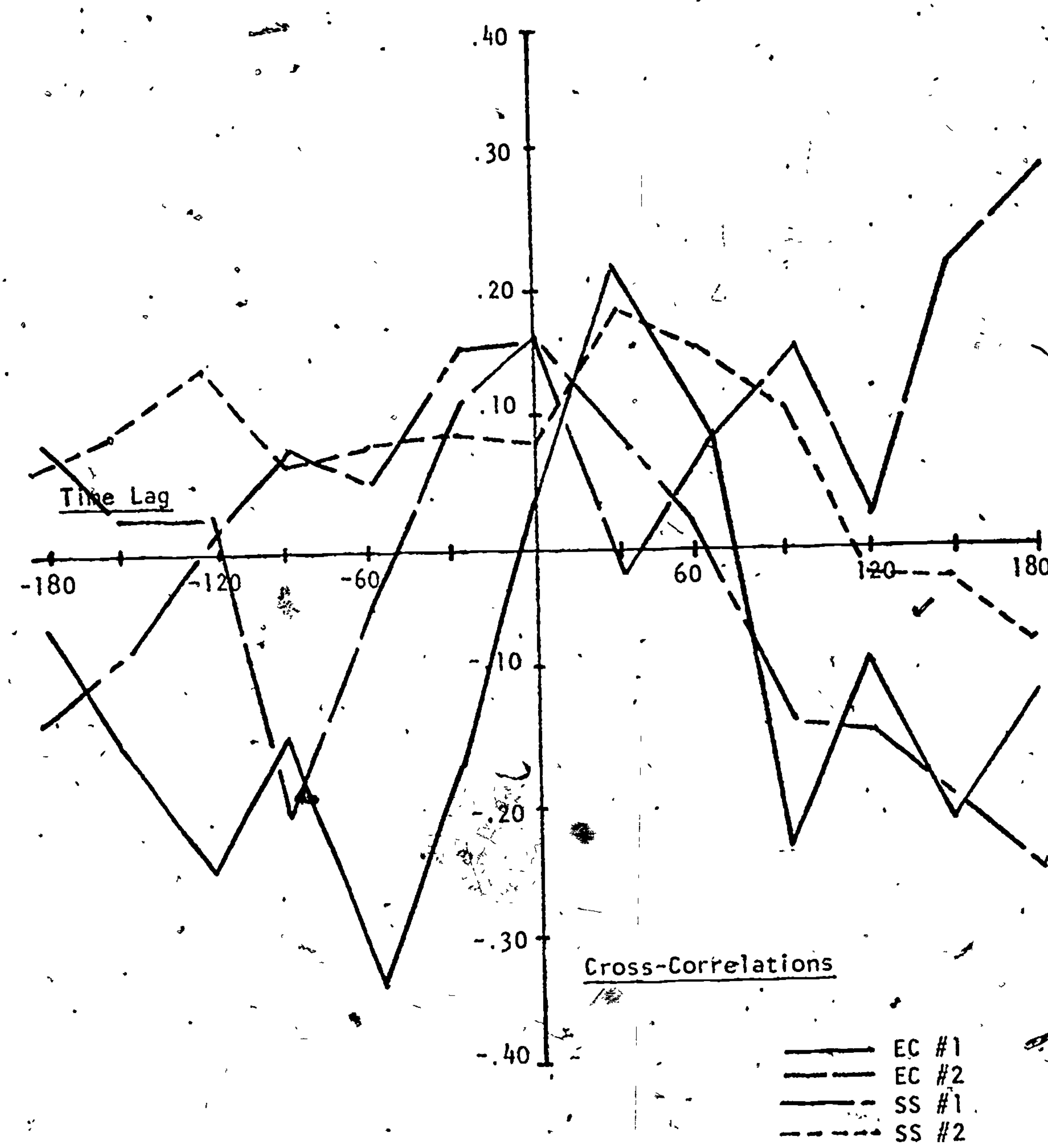


Figure 12

CROSS-CORRELATIONS BETWEEN INDEPENDENT VERBALIZATION AND CHILDREN'S ATTENTION

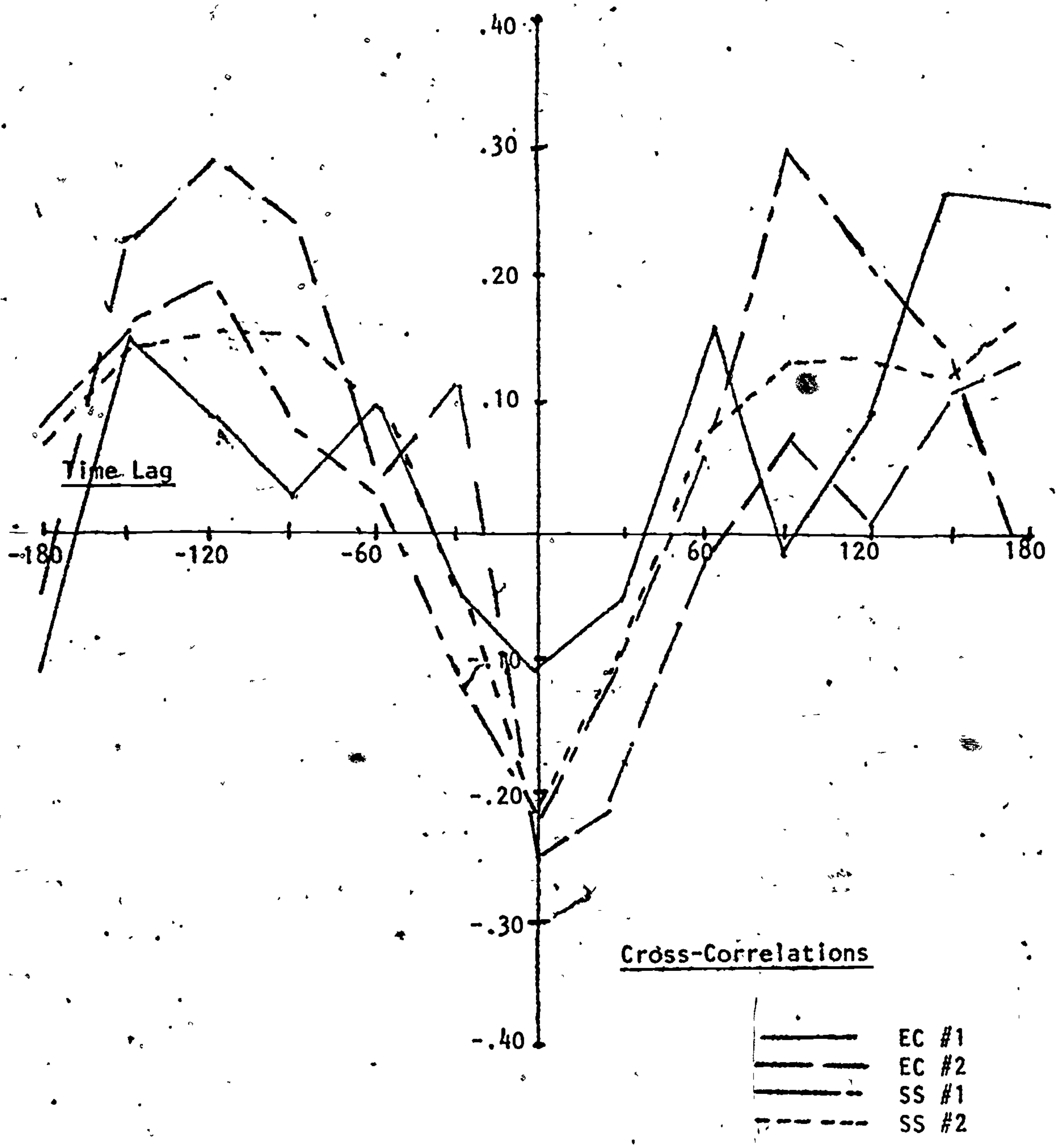
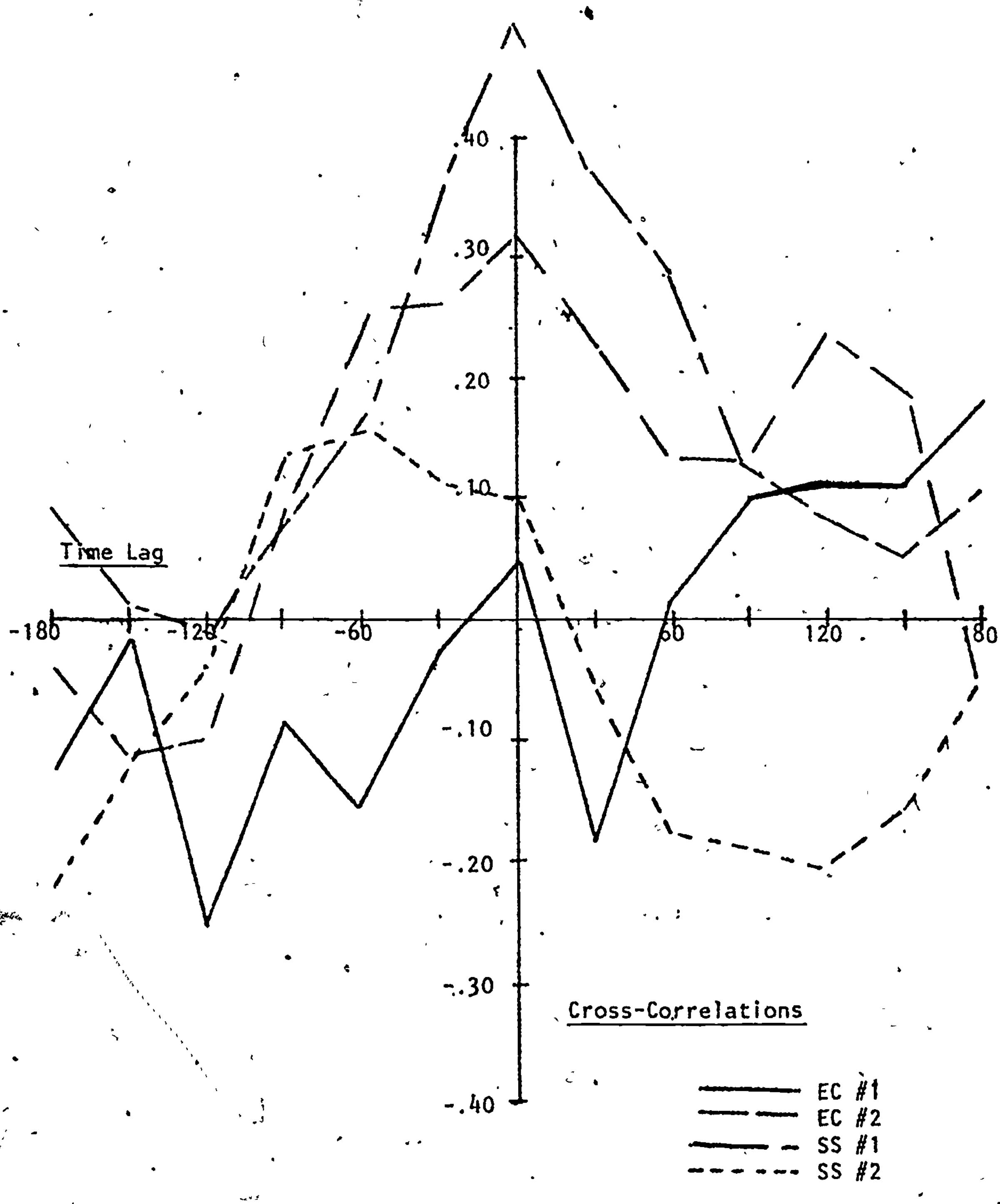


Figure 13

CROSS-CORRELATIONS BETWEEN CONGRUENT VERBALIZATION AND CHILDREN'S ATTENTION



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Appendix A

DEFINITIONS OF PROGRAM COMPLEXITY VARIABLES

Set Time Entropy is defined as the degree of randomness of the time of visual duration of discrete physical locations in a program.

Verbal Time Entropy is defined as the degree of randomness of the time of audible behavior on the part of characters in a program.

Nonverbal Dependence Entropy is defined as the degree of randomness of the use of only visuals to carry the narrative in a program.

Shot Entropy is defined as the degree of randomness of the duration of different apparent distances between the camera and the object in view.

This new variable was added to tap visual aspects of television programs not handled by the set entropy measure. It was coded by scoring the amount of time spent on close-up medium and long shots. These three categories were used as a compromise between having sufficient categories to make discriminations and not so many that categorization became unreliable.

Both one and two person close-ups (showing upper chest and head) were coded into the close-up category. Shots which showed more than the upper chest and head, but less than the entire figure, were coded as long shots. These distinctions were rather difficult to make with puppets and some animated figures.

Appendix B

Time Series Methods

There are two related branches of time series methods -- time domain methods and spectral methods. In this paper we have used the time domain approach in which values of variables at different points in time are correlated.[1] Two important statistics in this approach are the autocorrelation (the correlation of a variable with itself) and the cross-correlation (the correlation between two or more variables at different time points). Spectral methods attempt to explain the behavior of variables over time by searching for cycles in the data. These methods are very elegant, but they are also complicated and require a different kind of theory than commonly found in communications.

The Autocorrelation

The autocorrelation is defined mathematically by:

$$r_k = \frac{c_k}{c_o}$$

where K is the time interval between the values correlated, c_k is the covariance between the values at interval K, and c_o is the covariance at lag zero (simply the variance of the variable).

The sizes of the autocorrelations can be plotted against the lag to give a visual impression of the degree of dependence in the variable. These graphs are called correlograms and were used to report the data in this paper.

Partial autocorrelations are analogous to ordinary partial correlations. Partial autocorrelations are useful in determining the exact time lag to which a variable is dependent. For example, if the values of adjacent time intervals were correlated, the effect of the correlation between the first interval and the second interval would also transfer to values in the third interval. This is simply a causal chain in time. The partial autocorrelation of the first interval with the third interval, holding the second interval constant, should be near zero if only adjacent values are interdependent. If it is not, the interdependence in the variable extends beyond just one lag.

The formulas for higher-order partial autocorrelations are complicated and packaged routines are generally used for their computation.

The Cross-Correlation

The cross-correlation is defined mathematically by:

$$r_{xy}(k) = \frac{c_{xy}(k)}{S_x S_y}$$

where k is the lag, $c_{xy(k)}$ is the covariance between X and Y at lag k, S_x is the standard deviation of X, and S_y is the standard deviation of Y.

Cross correlations are generally plotted for lags of the dependent variable. This means that one reads the positive values in the graph as indicating how long after the independent variable changes the dependent variable responds. However, regression models of the relationship are normally written with negative lags of the independent variable. This means that the correlation at Y_{t+k} is equivalent to the correlation at X_{t-k}. A regression equation in two variables would take the following form:

$$Y_t = X_{t-k} + e_t$$