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# Seasonality in Television Viewing

## *A Mathematical Model of Cultural Processes*[1]

*This article examines the seasonal pattern of television viewing. A mathematical model that describes the frequency of television viewing as a function of time is presented. We hypothesize that it is composed of three components: an oscillation that describes the seasonal variation in viewing; a logistic translation, to account for the increase in viewing due to the diffusion of television; and a time-independent term. The model is evaluated with monthly data from the Nielsen Television Index (N = 460). It fits the television-viewing data, explaining about 99.9% of the variance in viewing. All three components are statistically significant. Next, the seasonal nature of television viewing is explored. It may be accounted for by environmental factors—temperature, precipitation, and daylight. The relations among these variables are demonstrated through spectral analysis. The implications for other cyclic processes in communication are discussed.*

The study of cultural processes, especially those related to the diffusion of innovation, has gained a central position in communication theory and research (see Barnett, 1988b). Generally, this research has focused on the role of communication in facilitating cultural change, such as the adoption of an innovation (Rogers, 1983). Alternatively, the adoption of a new communication innovation may constitute a complex innovation (Barnett, 1988a), which may lead to the spread of a new cultural form among a population (Hamblin, Miller, & Saxton, 1979) and alter the patterns of interaction among the members of the adopting society.

One such complex innovation is television. Robinson (1981) has described how the incorporation of television into American society has altered our

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everyday use of time. For example, in the United States, television watching competes for leisure time with out-of-the-home activities, such as religious activities, social visiting, going to bars and parties, and shopping. One significant aspect of these latter activities is that they involve social interaction, which is limited when people watch television. Similar results have been found in other societies (Robinson, 1972).

Much of the research on cultural processes has focused on the incidence of use of an innovation by the members of a society (Hamblin et al., 1979). An innovation with special relevance to communication is television (Fink, Barnett, & Chang, 1988). This article evaluates a mathematical model that describes the change in the frequency of television viewing from 1950 to 1988 by the average American household.

It has long been recognized that television viewing is seasonal. For example, Comstock, Chaffee, Katzman, McCombs, and Roberts (1978, p. 6) said, "[The] average hours of weekly viewing are less in summer and greater in winter." Gensch and Shaman (1980) have reported an annual cycle for viewing using the sum of the network rating reported in the Nielsen Television Index. Using trigonometric regression models, they found multiple correlations predicting the sum of network ratings ranging from .44 to .85, depending on the time of the day. The daily cycle with the greatest significance was found at 7:30 p.m. The multiple correlations declined as the evening progressed. Peak viewing occurred between January 9 and 11. Spectral analysis of the residuals did not reveal any other important information.

Barnett (1982) examined the frequency of television viewing in monthly intervals for the period from 1972 to 1979. He found that a mathematical model that included an oscillation term describing an annual cycle accounted for 93.2% of the variance in viewing.[2] Spectral analysis confirmed only an annual cycle.

The cyclic pattern in television viewing may be explained by environmental factors, such as the weather or the amount of daylight. People watch less television when the weather permits them to be outside and engage in alternative activities (Gould, Johnson, & Chapman, 1984). People also tend to be outside when there is more daylight. Gensch and Shaman (1980) found a more pronounced cycle in television viewing for early evening hours, during those times when there is daylight in the summer and darkness in the winter. The amplitude of the cycle was smaller for those times later in the evening that are dark the year around. They suggested that the seasonal variation in viewing may be due to the amount of daylight.

In addition to being governed by the cycles of nature, human behavior such as television viewing may be regulated by cycles that are socially defined





(Zerubavel, 1981). For example, whereas the year, month, and day are defined by the natural motions of the earth and the moon, the week is socially defined. Its near-universal acceptance evolved from the Judeo-Christian-Islamic belief system that required a sabbath in 7-day intervals. These periodic events prescribe certain media behaviors. For example, the scheduling of television programs requires viewing at prescribed intervals of one week. New programs are scheduled seasonally beginning each autumn.

In addition to the cyclic patterns in television viewing, we also find a secular trend: The frequency of viewing has increased over time (Robinson, 1981). A. C. Nielsen (1977) reported a 10% increase in television viewing between 1965 and 1975. The total increase over the 10-year period amounted to about an hour per day (Comstock et al., 1978). Roper (1974) found a 15% increase between 1964 and 1974. Bower (1973) found a increase in "likely viewing time" of 20% between 1960 and 1970. Robinson (1981) reported an increase in television viewing of 57 min between 1965 and 1975. Barnett (1982) found an average increase of 6 min and 40 s per month over the 8-year period from 1972 to 1979, based on Nielsen data. The mathematical model evaluated here includes both a cyclic component and one that describes the increase in viewing.

This article presents a mathematical model that precisely describes an indicator of a cultural process, the monthly average daily frequency of television viewing. Consistent with the verbal description presented above, it is presented as a function of time. Thus it will add to our understanding of the cultural processes involved with this medium. The model is first evaluated, and then the factors that may account for the process are examined.

## The Model

The frequency of television viewing as a function of time may be modeled with three components: an oscillation term, a translation term, and a time independent term. The oscillation component (Equation 1) is used to describe the seasonal or cyclic aspect of television viewing. As presented, the oscillation remains constant over time and does not dampen out.

$$Y_t = B1\,\{\cos\,[B2\,(t - B3)]\}, \tag{1}$$

where

$Y_t$ = the predicted frequency of television viewing at time $t$;
$B1$ = the amplitude of the oscillation;
$B2$ = the frequency of the oscillation, expressed in radians; and

$B3$ = the phase shift. $B3$ is the value required to shift $B1(\cos B2\, t)$ so that it reaches its peak amplitude at $t = 0$.

The frequency, $B2$, may be determined using Equation 2,

$$T = 2\pi/\theta, \tag{2}$$

where

$T$ = the period of the oscillation, and
$\theta$ = the frequency = $B2$.

$B3$ is dependent on the value of $B1$ and $B2$ at $t_1$.

The oscillation component represents the first hypothesis:

*Hypothesis 1:* The oscillation component (Equation 1) explains more variance than could be expected by chance in the frequency of television viewing.

Television viewing oscillates about a changing equilibrium. The translation component describes the rate of increase or decrease in viewing over time as the cultural system moves to a new equilibrium. The translation must take account of the fact that the amount of television viewing per day is limited, to be less than 24 hours. One way to model the translation is with a logistic equation.

The logistic function (Equation 3) specifies the S-shaped diffusion curve (Barnett, 1988a; Hamblin, Jacobsen, & Miller, 1973; Mahajan & Peterson, 1985; Rogers, 1983). It describes both exponential growth and a decaying exponential. This translation is ideal, because television may be considered an innovation and the rate of viewing behavior an indicator of the level of adoption of television.

$$Y_t = B4/\{1 + B5\,[e^{-(B6\,t)}]\} \tag{3}$$

The logistic translation component represents the second hypothesis:

*Hypothesis 2:* The logistic translation component (Equation 3) explains more variance than could be expected by chance in the frequency of television viewing.

$B7$, simply takes into account the time-independent factor in television viewing. It represents the third hypothesis:





*Hypothesis 3:* The time-independent factor $B7$ explains more variance than could be expected by chance in the frequency of television viewing.

Thus, the overall model becomes

$$Y_t = B1\,\{\cos\,[B2\,(t - B3)]\} + (B4/\{1 + B5\,[e^{-(B6\,t)}]\}) + B7. \tag{4}$$

In sum, the general model describing the frequency of television viewing as a function of time is composed of three components, the first of which describes the oscillating pattern of viewing. The second, the logistic, describes the long-term increase in viewing due to the adoption of television. The third indicates the time-independent frequency of viewing. This model is evaluated. Then, the relations between the exogenous variables that may determine the seasonality in viewing are examined.

## Method

### *The Data*

The data used to evaluate the model were the Nielsen Television Index describing the average daily viewing hours (the number of hours television sets are turned on) per household expressed at monthly intervals for the period September 1950 to December 1988 (A. C. Nielsen, 1988). There were 460 data points (38 complete viewing years and 4 additional months). The lowest average amount of daily viewing occurred during July 1951. It was 3 hours and 31 min. The peak for that year occurred in March, 5 hours and 35 min. The maximum average daily viewing occurred in January 1985, 7 hours, 58 min. In 1988, the last year for which there are complete data, the maxima and minima were 7 hours and 44 min (January) and 6 hours and 28 min (June). For analysis purposes the raw data were transformed into minutes. The data are summarized in Table 1.

To examine the relationship between the frequency of television viewing and the environmental factors that may be responsible for the cycle in viewing, data were gathered on the average monthly temperature, the total monthly precipitation and the number of minutes of daylight. The average monthly temperature and total monthly precipitation were taken from the National Oceanic and Atmospheric Administration's ([NOAA] 1988a, 1988b) publications, which report the nationally areally weighted statistics for each month from 1931.[3]

Table 1
*Descriptive Statistics for Television Viewing and Environmental Data*

| Variable | Mean | *SD* | Maximum | Minimum |
|---|---|---|---|---|
| Television viewing | 351.552 | 60.086 | 478.20 | 211.20 |
| Daylight | 727.478 | 111.745 | 900.00 | 578.00 |
| Temperature | 52.940 | 15.288 | 76.40 | 22.80 |
| Precipitation | 2.419 | 0.561 | 4.15 | 0.54 |

*Note.* $N = 460$. All variables reflect monthly averages for the United States. See text for complete description and data sources.

The number of minutes of daylight was operationalized as follows: According to the United States census (*Atlas of the United States*, 1986), the 1980 population center of the United States was located in Jefferson County, Missouri at 38° 30′ 30″ north latitude. Lambert Field (St. Louis's airport) is located at 38° 45′ north latitude, a difference of about 15 miles. The time of sunrise and sunset for the 15th of each month as reported by the *St. Louis Post-Dispatch* was gathered. From these data the number of minutes of sunlight was calculated. These 12 monthly values were the same for all cycles.

## *Analysis Procedures*

The model was tested using SAS NLIN (SAS Institute, 1984). NLIN performs nonlinear regression. Goodness-of-fit is determined through the method of least squares. It is an iterative procedure in which the user provides a theoretical model and initial estimates of the model's parameter values. These starting values are continually improved until the sum of the squares of the error is minimized.

Estimates of the starting values of the parameters were as follows.

$B1$, the amplitude of the oscillation, was estimated by subtracting the mean of the annual minima from the mean of the maxima for each year; $B1$ was initially estimated to be 50.7.

$B2$, the phase angle, was estimated using Equation 2. Because the theoretical period of oscillation is one year, and time is measured in monthly intervals, the theoretical value of $B2$ ($\theta$), could be determined.

$$T = 12,$$
$$12 = 2\pi/\theta$$
$$\therefore \theta = .52.$$[4]

$B3$, the value required to set $t_1 = 0$, was set equal to the value of $t_1$; $B3$ was estimated to be 5.00, the number of months from September, the first data point to January, the month with the greatest average frequency of daily television viewing.





The starting value for the time-independent term, $B7$, was estimated by taking the mean of first year of data, 283.35.

The starting values for the translation component, the logistic, were as follows: $B4$, 237.00, the maximum value, 478.2, minus the initial estimate of $B7$, the time-independent term (Mahajan & Peterson, 1985); $B5$, .6885; and $B6$, .007. The final two values were determined by trial and error.

To evaluate the goodness-of-fit of the model, several tests were employed. The $R^2$ from the nonlinear regression and the plausibility of the derived parameters were examined. Further, the residuals from the regressions should be homoscedastic, normal, and not exhibit any systematic patterns (see Bauer & Fink, 1983). To the extent that the data fail to conform to these assumptions, the model will be considered incomplete, that is, some important factor that "explains" the systematic character of the residuals has been left out. The procedures to evaluate the contributions of the three individual components of the model are described in detail by Kaplowitz, Fink, and Bauer (1983).

To determine the relationship between the environmental and television-viewing data, a time series analysis was conducted. In order to determine the relationship between the frequency of television viewing, minutes of daylight, monthly temperature, and precipitation, cross-spectral analyses were conducted (Davis & Lee, 1980; Gottman, 1979; Granger & Hatanaka, 1964; Jenkins & Watt, 1968; Krull, Husson, & Paulson, 1978). Two time series can be correlated with one another at various time periods, and similar to regression analysis, a coefficient, coherence squared ($\kappa^2$), can be defined that is analogous to the square of the correlation coefficient (Gottman, 1979). The spectrum of a series is the Fourier transform of the autocovariance function of a series, and the cross-spectrum is the Fourier transform of the cross-covariance function between the series. The strength of association between two series can be determined by examining the coherence at various length periods after removing the overtime trend or nonstationarity in the data. To evaluate this model, the logistic trend was removed before conducting the spectral analysis.

The slope of the phase spectrum may be examined to determine the time lag between the time series. This provides assistance in determining the direction of causality. The lag is equal to the slope of the phase spectrum. A positive slope would indicate how much the changes in one series precede (or follow) another. A negative slope indicates that the second series lags the first series.

# Results

## *The Overall Model*

The descriptive data for each variable are provided in Table 1. The results of the test of the three-component model are presented in Table 2. The model fits the data very well, explaining about 99.9% of the variance in the frequency of television viewing. All of the model's parameters are statistically significant. The oscillation coefficients are plausible (i.e., they are nearly equivalent to the theoretically derived values), and the standard errors are quite small. Because the estimate for *B*2 matches its theoretical value, it may be taken as a confirmation of the 12-month cycle. The coefficients for the translation component are also likely, because *B*4 (the maximum level of adoption) plus *B*7 sum to a value very close to the observed maximum. Further, the standard errors are small relative to the size of the coefficients. The time-independent term is also as predicted, and its standard error is quite small.

An analysis of the residuals revealed that they are approximately normally distributed. The skew is 0.003 and kurtosis is –0.055. There are 229 cases with residuals greater than 0 and 231 with negative residuals. There are 20 cases (4.4%) greater than 2 standard deviations of the residuals. Eight are negative, and 12 are positive. The total is less than what one would expect by chance (23). The hypothesis that the residuals come from a normal population cannot be rejected ($p < .15$; SAS Institute, 1984).

The correlation of the residuals with the dependent variable is significant ($r = .208$, $p < .0001$). Although the correlations between the residuals and frequency of viewing are of some concern, a visual examination of the scatterplot of the residuals with the frequency of television viewing failed to reveal any systematic pattern.

The correlation between the residuals and time is not significant ($r = -.001$, $p = .984$). However, there appeared to be a systematic nonlinear pattern in the residuals. This will be discussed later.

## *The Hypotheses*

Table 3 presents the results of the tests of the significance of the oscillation and logistic components of the model. Hypothesis 1 asked whether the oscillation component explains more variance than expected by chance. As indicated in Table 3, this component is statistically significant ($F = 52.48$, $p < .001$). Thus we reject the null hypothesis that the oscillation occurred by chance.[5]





Table 2
*Descriptive Parameters for the Model*

| | Coefficient | *SE* | *t* | *p* |
|---|---|---|---|---|
| Oscillation Term | | | | |
| *B*1 | 50.155 | 0.831 | 60.355 | <.0001 |
| *B*2 | 0.524 | 0.000 | ∞ | <.0001 |
| *B*3 | 5.183 | 0.062 | 83.597 | <.0001 |
| Logistic translation term | | | | |
| *B*4 | 217.187 | 22.814 | 9.520 | <.0001 |
| *B*5 | 7.844 | 1.753 | 4.475 | <.0001 |
| *B*6 | 0.008 | 0.001 | 8.000 | <.0001 |
| Time-independent term | | | | |
| *B*7 | 256.584 | 8.953 | 28.659 | <.0001 |
| Goodness-of-fit | | | | |
| $R^2$ | .9988 | | | |
| Residual analysis | | | | |
| *SD* | 12.497 | | | |
| Skew | .002 | | | |
| Kurtosis | –.055 | | | |
| Correlation of residuals with frequency of viewing | .208 | | | <.0001 |
| Correlation of residuals with time | –.001 | | | <.984 |

*Note.* *N* = 460.

Hypothesis 2 concerns the significance of the logistic component. It is also significant ($F = 2.36$, $p < .05$). Thus we reject the null hypothesis that the oscillation occurred by chance.

Hypothesis 3 concerns the significance of the time-independent factor of the model. As indicated in Table 2, the null hypothesis that its value could have occurred by chance may be rejected, $t = 28.659$ ($p < .0001$).

## *Time Series and Spectral Analysis*

The autocorrelations and partials for these four series are summarized in Table 4. They indicate that all four variables have the same annual cycle. All the autocorrelations are approximately zero at lags 3, 9, and 15. They achieve their maximum value with a lag of 12 months and their minimum values (maximum negative autocorrelation) at 6 and 18 months.

Spectral analysis of these data revealed that the three independent variables, temperature, precipitation, and minutes of daylight, had their maximum coherences between period 12.11 months and 11.79 months, indicating that all share the same annual cycle as television viewing for which

Table 3
*Stepwise Analysis of Variance for the Oscillation and Logistic Components of the Model*

| Source of variation | Sum of squares | *f* | Mean square | *F* |
|---|---|---|---|---|
| Total variation | 58,508,045.280 | 460 | | |
| Explained by oscillation | 57,416,530.525 | 4 | 14,354,132.631 | 52.48* |
| Unexplained by oscillation | 1,091,514.755 | 456 | 2,393.673 | |
| Increment explained by logistic | 1,019,831.937 | 3 | 2,235.433 | 2.36** |
| Still unexplained | 71,682.818 | 453 | 158.240 | |

*Note.* $N = 460$.
*$p < .001$; **$p < .05$.

Table 4
*Autocorrelations and Partial Autocorrelations for Selective Lags for Television Viewing, Daylight, Precipitation, and Temperature* (N = *460)*

| Variable | $\rho_3$ | $\rho_6$ | $\rho_9$ | $\rho_{12}$ | $\rho_{15}$ | $\rho_{18}$ |
|---|---|---|---|---|---|---|
| Television minutes | .04 | –.85 | .02 | .93 | .02 | –.85 |
| Partial | .04 | –.85 | .43 | .70 | –.19 | .01 |
| Daylight | –.00 | –.98 | –.00 | .97 | –.00 | –.95 |
| Partial | –.00 | –.98 | –.38 | .26 | –.19 | .01 |
| Precipitation | .02 | –.16 | –.02 | .33 | –.02 | –.21 |
| Partial | .02 | –.16 | –.02 | .31 | –.05 | –.15 |
| Temperature | –.01 | –.96 | .00 | .96 | –.01 | –.94 |
| Partial | –.01 | –.96 | –.25 | .38 | –.01 | .02 |

the period was verified as 12. No other cycle was revealed in the analysis. The values of $\kappa^2$ for the period 12.11 time units long were television viewing-precipitation, .948; television viewing-temperature, .979; television viewing-daylight, .979. For these data, a $\kappa^2$ of .38 is required to reach significance at the .05 probability level (Granger & Hatanaka, 1964, p. 79).

For period 12.11, the phase spectra had a positive slope for all three environmental variables with television viewing, indicating that there are lags among the series. In all cases, the spectra of the environmental variables precede the cycle for television viewing. For example, daylight reaches its maximum in June and minimum in December. The television-viewing cycle lags slightly: It peaks in January and reaches its lowest point in July. To facilitate the understanding of this result, the average monthly cycles for all four variables are presented in Figure 1.





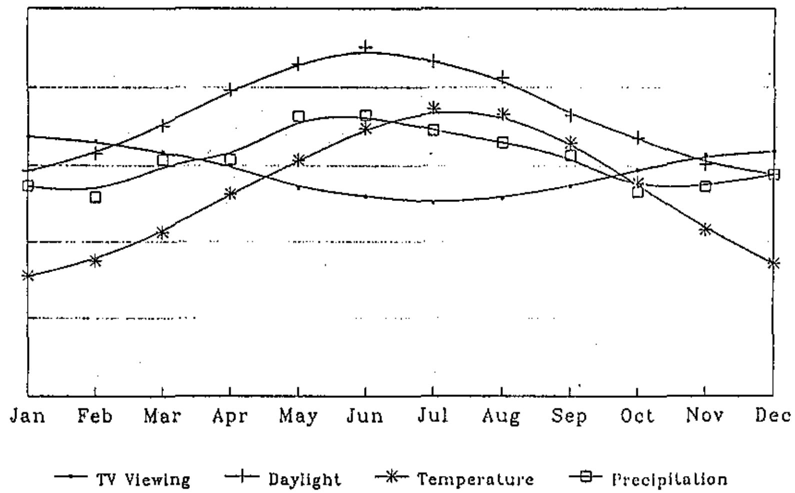


**Figure 1: The average annual cycles: television viewing, precipitation, daylight, and temperature.**
*Note.* X-axis = month; Y-axis = relative value of variables.

It should be noted that whereas daylight and precipitation had positive phases at both periods 12.11 and 11.78, the phase for temperature was positive only at 12.11. It was negative at 11.78. This suggests that the cycle for temperature precedes television viewing by a smaller interval of time than the other two variables. This may be seen in Figure 1.

In summary, the results of the time series analysis of television viewing and environmental factors indicated that all four variables have an annual cycle. There is a strong relationship among the variables, and the cycle of television viewing lags the cycles of the environmental variables.

## Discussion

The results indicate that the model accurately describes the frequency of television viewing over time. It accounts for over 99.8% of the variance in television viewing. The residuals are nearly normally distributed. However, the correlation between the residuals and the frequency of television viewing and the pattern of the scatterplot of the residuals over time suggest that the model may be incomplete, that is, some factor that explains the systematic character of the residuals has been left out.

Gensch and Shaman (1980, p. 308) said, "An annual cosine curve would not fit these [television-viewing] annual cycles because the peaks, high viewing months, are considerably broader than the troughs." They suggested that a model of television viewing should be changed by altering the oscillation term so that it would be composed of some linear combination of cosine curves of varying lengths rather than a single one. This solution seems untenable, because the spectral analysis identified only a single cycle in the data and because there were high coherences between television viewing and the environmental factors. Further, adding additional terms to the model seems unnecessary, considering the theoretical parsimony and large proportion of variance accounted for by the current model.

The pattern of residuals may be accommodated in two ways: (a) by transforming the raw data or (b) by treating television viewing as a moving average process. In these ways the peaks and valleys in the data could be smoothed out. A transformation such as a log or a square root would foreshorten the lengths of the extreme residuals and alter their distribution (see Fink, Barnett, & Chang, 1988). However, because the number of residuals greater than zero is equivalent to the number less than zero, this problem is not particularly important.

The peaks and valleys may also be smoothed out through the use of a moving average in which the value of each data point is considered to be the mean of $n$ adjacent points in the process (Box & Jenkins, 1976). For example, a third-order moving average consists of three points $t_{n-1}$, $t_n$, and $t_{n+1}$. This has the effect of removing random error in the form of local reversals in the oscillation.

Barnett (1982) analyzed third- and sixth-order moving averages for the frequency of television viewing for monthly intervals for 1972 to 1979. He found that the higher the order of the moving average, the greater the proportion of variance explained. From examining the residual pattern, it was clear in that case that the moving average improved the quality of the fit of the model. However, using the moving average as a smoothing technique should be used with caution: "Smoothing the data smooths the function being estimated as well. . . . Smoothing, then can smooth away important effects" (Mosteller & Tukey, 1977, p. 61).

The relationship between the residuals and the frequency of viewing, however, may be due to television itself. Television may be considered three different innovations—all using the same medium. The first innovation is *broadcast television*. Its diffusion in the United States occurred primarily between 1950 and the early 1970s. *Cable television* is a second innovation. Although still using the same monitor to view the expanded range of programming, the method of receiving the enhanced signal was altered. The third innovation is the *videocassette recorder* or VCR. Its diffusion occurred





in the late 1980s. It altered the use of the medium by expanding the available range of programming. The audience was no longer restricted to viewing what was broadcast or received on the cable. They could choose to watch alternative nonbroadcast programming.

These three innovations have an effect on the frequency of viewing. Television viewing had stabilized in the 1970s. The annual averages between 1972 and 1978 ranged from 6 hours and 12 min to 6 hours and 16 min. The diffusion of cable produced an increment in viewing that occurred between 1979 and 1986. The VCR appears to lessen the viewing of the signal received directly into the home.

An examination of the residuals with respect to time suggests that their pattern may be due to specifying television as a single simple innovation rather than a complex one composed of three simpler ones. This is indicated by the fact that the greatest residuals occur at the end of the diffusion of broadcast television and the beginning of cable (at approximately time 280) and near the end of the data set when television viewing is being discontinued in favor of the VCR. If television were a single innovation and had it continued to diffuse between 1972 and 1978 (times 264 to 336), it would have increased 31.77 min rather than remaining relatively constant. This difference may account for the magnitude of the residuals.

The pattern of the residuals may also be due to the fact that the amplitude of the oscillation appears to be shrinking over time. This suggests that the model should be altered to accommodate a *dampened* oscillation.

The dampening may be due to the migration of the American population to the Sunbelt over the last three decades (Barnett, 1988c). In this region of the country the weather is warmer in the winter, allowing for greater participation in outdoor activity and less television viewing. Also, the summers in the Sunbelt are hotter, forcing people indoors where they watch more television. Future research is planned to investigate these factors.

This article reports an annual cycle based on data measured in monthly intervals. It is likely that other cycles in television viewing exist that may account for the pattern in the residuals. A spectral analysis of the residuals revealed a cycle with a period of approximately 153 months (12.75 years). At this frequency, the residuals had a significant coherence ($\kappa^2$ = .486) with precipitation. An examination of the precipitation data found that dry years tend to occur with this frequency. This cycle would also account for the pattern of the residuals.

Cycles in television viewing other than an annual one may exist. This article found only the one annual cycle, because the data were too crude to discover any cycles with periods less than 4 months (Arundale, 1980). Had daily or weekly measures of the frequency of television viewing been available, other oscillations may have been found. For example, a weekly cycle based on programming has been suggested by Gensch and Shaman (1980), and Davis and Lee (1980) reported cycles of 8.5, 17, 26, and 52 weeks for advertising sales. Thus it is simply not enough to measure processes over time, but these measures should be precise and be measured at frequent enough intervals to be able to discern any oscillations that may constitute a process (Arundale, 1980).

Currently, research is under way to examine the daily, weekly, and monthly cycles in television viewing. Data on the proportion of people viewing television is being collected in a single media market at 15-min intervals. This will allow the examination of cycles as short as one hour (Arundale, 1980).

The interval of measurement in this article was one month. This is far too long to capture the volatile changes in weather patterns and, thus, the irregular impact of weather on television viewing. Data describing the weather in the sample media market recorded at hourly intervals may be obtained from the NOAA and a spectral analysis may then be performed to determine the relationship between weather and television viewing at this time interval.

This research may be criticized for ignoring television content. That is not a valid objection. The focus of our television-viewing research examines television viewing as a behavioral indicator of a cultural process. It is not concern with what people specifically watch, only that they are viewing television rather than engaging in other activities. Thus content is dealt with only in the McLuhanesque sense that "the medium is the message."

### *Implications*

Recent communication research has found many instances of oscillations or cyclic processes. Kaplowitz et al. (1983) examined attitude change at frequent intervals over a period of time. They found that the resultant attitude oscillated around its eventual equilibrium point with a cycle of 13.5 s. Woelfel, Newton, Holmes, Kincaid, and Lee (1986) examined the effects of compound messages on attitude change over a long period of time and found that they changed by what was best described as a dampened oscillating system with a 10-hour period.

In the area of cultural processes, Namenwirth and Weber (1987) report cycles of 152 and 48 years in the content of American political party platforms. Kincaid, Yum, Woelfel, and Barnett (1983) studied the acculturation of Korean immigrants in Hawaii and found that a simple linear model did not describe the process as well as one with a dampened oscillation. Woelfel, Barnett, Pruzek, and Zimmelman (1989) examined the perceptions of the days of the week and certain behaviors over a 23-day period and found a cyclic pattern of 7 days.

Social events are governed by the cycles of nature, as well as others that are socially defined (Zerubavel, 1981). These periodic events prescribe certain communication behaviors. For example, the scheduling of television programs suggests viewing at prescribed intervals of one week. New programs are scheduled seasonally beginning each autumn. Similarly, interpersonal interactions require the copresence of individuals, and this may constrain these interactive events to specific periods, such as weekly church or synagogue attendance or the Saturday-night date. Thus rather than being an idiosyncratic process, the periodic nature of television viewing is probably representative of many cultural processes. In order to examine the cyclic nature of communication and cultural processes, researchers have to improve their precision of measure and examine the phenomena of interest at frequent intervals over long periods of time.





### *Summary*

This article examined the frequency of television viewing in monthly intervals for a 39-year period from 1950 to 1988. A mathematical model composed of three components (an oscillation term, which describes the seasonal variation in viewing; a logistic term, to account for the increase in viewing due to the diffusion of television; and a time-independent term) was proposed to describe the frequency of television viewing as a function of time. An empirical test of the model found that it accurately fit the data, with each component being statistically significant. In an attempt to clarify the causal antecedents of the seasonal pattern of television viewing, a spectral analysis was conducted with total monthly precipitation, average monthly temperature, and minutes of daylight as predictors. The results revealed significant relations among these variables. Finally, the implications for the study of cultural processes were discussed.

## Notes

1. The authors would like to thank Frank Tutzauer, S. Diane McFarland, Young Choi, and Sung-ho Cho for their comments on the earlier drafts of this article and assistance in the data analysis. An earlier version of this article was presented to the International Communication Association, San Francisco, May 1989.

2. The Barnett (1982) model was

$$Y_t = B1 \{\cos [B2 (t - B3)] - B4\} + B5\, t + B6.$$

The model was tested with Nielsen data for 96 months from 1972 to 1979. The obtained values for the coefficients were: $B1$ = 46.619; $B2$ = .524; $B3$ = 2.710; $B4$ = −1.000; $B5$ = .110; $B6$ = 369.780. He did not report the standard errors. The standard deviation of the residuals was 8.960, and the skew was kurtosis were 0.39 and −0.40, respectively.

3. National areally-weighted data weight the weather data by the proportion of area covered by nine census regions. The weights are the following:

| | |
|---|---|
| New England | .02204 |
| Middle Atlantic | .03400 |
| East North Central | .08215 |
| West North Central | .17114 |
| South Atlantic | .09224 |
| East South Central | .06021 |
| West South Central | .14522 |
| Mountain | .28584 |
| Pacific | .10716 |

This procedure may produce biased results, because it weights the regions of the country by area rather than by population. Note, for example, that New England constitutes only 2.2% of the area of the United States and, according to the 1980 census, about 5% of the population. This is of particular importance when using weather data to predict social behavior such as television viewing. A better procedure would be to weight these data by population rather than by area. However, because we do not have access to the original area data, we will use the NOAA reported averages. Thus the NOAA data provide only a crude indicator of the overall weather in the United States as a whole.

4. To verify that there was only one cycle in the data, spectral analysis (Jenkins & Watt, 1968) was performed. The results revealed only a single cycle.

5. The significance tests of the model's two multiple parameter components were conducted with the addition of the constant time-independent term ($B7$).

## References

A. C. Nielsen. (1977). *Television audience, 1976.* New York: Author.

A. C. Nielsen.(1988). *Report on television.* New York: Author.

Arundale, R.B. (1980). Studying change over time: Criteria for sampling from continuous variables. *Communication Research, 7,* 227-263.

*Atlas of the United States: A thematic and comparative approach.* (1986). New York: Macmillan.

Barnett, G. A. (1982, May). *Seasonality in television viewing: A mathematical model.* Paper presented at the annual convention of the International Communication Association, Boston.





Barnett, G. A. (1988a). An associational model for the diffusion of complex innovations. In G. A. Barnett & J. Woelfel (Eds.), *Readings in the Galileo system: Theory, methods and applications* (pp. 55-74). Dubuque, IA: Kendall/Hunt.

Barnett, G. A. (1988b). Communication and organizational culture. In G. M. Goldhaber & G. A. Barnett (Eds.), *Handbook of organizational communication* (pp. 101-130). Norwood, NJ: Ablex.

Barnett, G. A. (1988c). Precise procedures for longitudinal network analysis. In G. A. Barnett & J. Woelfel (Eds.), *Readings in the Galileo system: Theory, methods and applications* (pp. 333-368). Dubuque, IA: Kendall/Hunt.

Bauer, C. L., & Fink, E. L. (1983). Fitting equations with power transformations: Examining variables with error. In R. N. Bostrom (Ed.), *Communication yearbook* (Vol. 7, pp. 146-199). Beverly Hills, CA: Sage.

Bower, R. (1973). *Television and the public.* New York: Holt, Rinehart & Winston.

Box, G.E.P., & Jenkins, G. M. (1976). *Time series analysis: Forecasting and control.* San Francisco: Holden-Day.

Comstock, G. S., Chaffee, S., Katzman, N., McCombs, M., & Roberts, D. (1978). *Television and human behavior.* New York: Columbia University Press.

Davis, D. K., & Lee, J. W. (1980). Time series analysis models for communication research. In P. R. Monge & J. N. Cappella (Eds.), *Multivariate techniques in human communication research* (pp. 429-454). New York: Academic Press.

Fink, E. L., Barnett, G. A., & Chang, H. J. (1988). *The diffusion of motion picture attendance, monochromatic and color television: Further tests of a mathematical model.* Unpublished manuscript, Department of Speech Communication, University of Maryland, College Park.

Gensch, D., & Shaman, P. (1980). Models of competitive television ratings. *Journal of Marketing Research, 17,* 307-315.

Gottman, J. M. (1979). Time-series analysis of continuous data in dyads. In M. E. Lamb, S. J. Suomi, & G. R. Stephenson (Eds.), *Social interaction analysis: Methodological issues* (pp. 207-229). Madison: University of Wisconsin Press.

Gould, P., Johnson, J., & Chapman, G. (1984). *The structure of television.* London: Pion.

Granger, C.W.J., & Hatanaka, M. (1964). *Spectral analysis of economic time series.* Princeton, NJ: Princeton University Press.

Hamblin, R. L., Jacobsen, R. B., & Miller, J.L.L. (1973). *A mathematical theory of social change.* New York: Wiley.

Hamblin, R. L., Miller, J.L.L., & Saxton, D. E. (1979). Modeling use diffusion. *Social Forces, 57,* 799-811.

Jenkins, G. M., & Watt, D. G. (1968). *Spectral analysis and its application.* San Francisco: Holden-Day.

Kaplowitz, S. A., Fink, E. L., & Bauer, C. L. (1983). A dynamic model of the effect of discrepant information on unidimensional attitude change. *Behavioral Science, 28,* 233-250.

Kincaid, D. L., Yum, J. O., Woelfel, J., & Barnett, G. A. (1983). The cultural convergence of Korean immigrants in Hawaii: An empirical test of a mathematical model. *Quality and Quantity, 18,* 59-78.

Krull, R., Husson, W. G., & Paulson, A. S. (1978). Cycles in children's attention to the television screen. In B. D. Ruben (Ed.), *Communication yearbook* (Vol. 2, pp. 125-141). New Brunswick, NJ: Transaction Books.

Mahajan, V., & Peterson, R. A. (1985). *Models for innovation diffusion.* Beverly Hills, CA: Sage.

Mosteller, F., & Tukey, J. W. (1977). *Data analysis and regression.* Reading, MA: Addison-Wesley.

Namenwirth, J. Z., & Weber, R. P. (1987). *Dynamics of culture.* Boston: Allen & Unwin.

National Oceanic and Atmospheric Administration. (1988a, August). *State, regional, and national monthly and annual precipitation.* Asheville, NC: Author.

National Oceanic and Atmospheric Administration. (1988b, August). *State, regional, and national monthly and annual temperature.* Asheville, NC: Author.

Robinson, J. P. (1972). Television's impact on everyday life: Some cross-cultural evidence. In E. Rubinstein (Ed.), *Television and social behavior.* Washington, DC: U.S. Department of Health, Education and Welfare.

Robinson, J. P. (1981). Television and leisure time: A new scenario. *Journal of Communication, 26,* 120-130.

Rogers, E. M. (1983). *The communication of innovations* (3rd ed.). New York: Free Press.

Roper, B. (1974). *Trends in public attitudes toward television and other mass media.* New York: Television Information Office.

SAS Institute. (1984). *SAS / ETS user's guide* (5th ed.) Cary, NC: Author.

Woelfel, J., Barnett, G. A., Pruzek, R., & Zimmelman, R. L. (1989). Rotation to simple processes: The effects of alternative rotational rules on observed patterns in time-ordered measurements. *Quality and Quantity, 23,* 3-20.

Woelfel, J., Newton, B., Holmes, R., Kincaid, D. L., & Lee, J. Y. (1986). Effects of compound messages on global characteristics of Galileo spaces. *Quality and Quantity, 20,* 133-145.

Zerubavel, E. (1981). *Hidden rhythms: Schedules and calendars in social life.* Chicago: University of Chicago Press.