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ABSTRACT

A study investigated the attention of 116 children in 6 second- and third-grade classrooms while they participated in 4 lessons involving progressively more difficult stories. Analysis of videotapes of the lessons revealed that the likelihood of a lapse of attention was highest during the first 15 seconds of attention episodes. Lapses in attention were more likely among second graders than among third graders, among boys than among girls, in low groups than in middle groups, and in middle groups than in higher groups. The more difficult the story, the more likely were lapses in attention, especially among younger and less able students. Reading-group membership was more strongly related to attention than were reliable measures of children's individual comprehension and fluency. A leading hypothesis to explain this finding is that reading groups have subcultures that differentially support paying attention. The most newsworthy finding of the study was the sharp drop in attention following oral reading errors. This drop was observed in all reading groups in both second and third grades. (Two tables and seven figures of data are included; 41 references are attached.) (Author/RS)

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PROPERTIES OF ATTENTION DURING READING LESSONS

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Abstract

A study investigated the attention of 116 children in six second- and third- grade classrooms while they participated in four lessons involving progressively more difficult stories. Analysis of videotapes of the lessons revealed that the likelihood of a lapse of attention was highest during the first 15 seconds of attention episodes. Lapses in attention were more likely among second graders than among third graders, among boys than among girls, in low groups than in middle groups, and in middle groups than in high groups. The more difficult the story, the more likely were lapses in attention, especially among younger and less able students. Reading-group membership was more strongly related to attention than were reliable measures of children's individual comprehension and fluency. A leading hypothesis to explain this finding is that reading groups have subcultures that differentially support paying attention. The most newsworthy finding of the study was the sharp drop in attention following oral reading errors. This drop was observed in all reading groups in both second and third grades.

PROPERTIES OF ATTENTION DURING READING LESSONS

Our premise is that attention in classrooms is inherently a dynamic process that unfolds over time. No doubt the attention being displayed at any moment is the result of many forces--the traits of students and teachers, classroom organization, routines that govern conduct and work. However, beyond factors that for any limited episode can be considered to be fixed, our working hypothesis of this paper is that attention changes moment by moment in response to classroom events. This is the sense in which we say that *attention is dynamic*.

Attention is a construct with a checkered history in psychology. The term was not even admissible during the behaviorist era. Over the past two decades, however, the term *attention* has been readmitted to the psychologist's lexicon. The major accomplishment during this period has been the refinement of the concept of *automaticity*, the theory that frequently repeated mental processes require little attention (cf. Schneider & Shiffrin, 1977). Research in this area is fascinating, but as far as we can see, it is largely irrelevant to attention in classrooms. Classroom research is better served by concepts about attention with origins in another era. According to William James (1890, p. 453), attention is "taking possession by the mind, in most clear and vivid form, of one out of what seems several simultaneously possible objects or trains of thought." In other words, James emphasized that attention is selective, and this is the feature we shall emphasize as well. We shall attempt to build a partial model of the network of factors that determine students' selective attention.

Because the construct of attention comes from psychology, one is predisposed to account for attention in terms of properties of individuals. But our starting assumption, subject to empirical verification, is that attention arises as much from the social logic of groups as the inner logic of individuals. The unit of social organization for reading instruction in most American primary classrooms is the reading group, a subgroup of children in a class selected to be more or less homogeneous in ability. Sharp differences in the behavior of students and teachers in low, middle, and high reading groups have been documented (Barr & Dreeben, 1991; Hiebert, 1983; Weinstein, 1976). The leading theory to explain the variation in behavior is that reading groups have different subcultures that reinforce different norms of behavior (Cazden, 1985; McDermott, 1978). However, the still-defensible alternative theory is that the behavior of a reading group is predictable in terms of the traits of its members.

To be useful in classroom research, the very definition of attention must be social and normative. We will say that a student is attentive if the student is looking where he or she is supposed to be looking. In a traditional classroom, "supposed to be" can be further defined in terms of the explicit or implicit intention of the teacher. During a conventional small-group reading lesson, most often, looking at a page from the day's story counts as attention; less frequently, looking at another person in the group who is speaking counts as attention, provided the speaker has a right to speak considering operative norms.

Attention in classrooms can be conceived as part of a network of interacting factors. It is useful to categorize factors as *antecedent*, *concurrent*, and *consequent*. Antecedent factors are more or less fixed prior to a certain series of lessons. Examples of antecedent factors are children's gender, reading level, and reading group membership. To be sure, level and group membership do change, but the likelihood of dramatic change is low during a single lesson or series of consecutive lessons. *Concurrent* factors are time-varying. In the present context, this means that concurrent factors vary within and across a given series of lessons. An example of a concurrent factor that may vary from lesson to lesson is the difficulty of the stories the children are reading. Examples of concurrent factors that may vary within a lesson are the page-by-page difficulty of the story and the measured fluency of the children called upon to read the pages aloud. Other concurrent factors, such as whether the oral reader of the moment makes an error on a sentence being read, vary on an even finer time scale. *Consequent* factors follow, and are conditional upon, episodes of attention during a certain lesson or series of lessons. Examples include changes in teachers' behavior, mastery of material covered in the lesson, and transfer of abilities that may have been enhanced. Our study considers selected antecedent and concurrent factors and their interactions and attempts to gauge how these factors influence attention moment by moment.

The percentage of time students spend paying attention--looking where they are supposed to look, doing what they are supposed to do--is a good predictor of reading achievement. For example, Lahaderne (1968) observed for 37 hours over a two-month period in four sixth-grade classrooms, scanning the students repeatedly and recording whether each was attentive or inattentive. She found that the percentage of time students were attentive during the period of observation correlated from .39 to .51 with their scores on reading tests. Samuels and Turnure (1974) completed a similar study in first-grade classrooms with comparable results; attentiveness correlated .44 with a reading measure. These two studies are representative. Rosenshine and Stevens (1984) located 10 classroom studies of attention completed during the past 25 years and found that the average correlation between measures of attention and measures of reading was about .40.

Whereas previous classroom studies suggest that attention may play an important role in academic success, most of these studies have treated attention as though it were a static trait of students that is invariant across time and context. To the best of our knowledge, only three studies have examined what concurrent, situational factors affect students' attention (Cazden, 1973, cited in Cazden, 1981; Eder & Felmlee, 1984; Felmlee & Eder, 1983; Felmlee, Eder, & Tsui, 1985; Hess & Takanishi, 1974).

Hess and Takanishi (1974) examined student "engagement" in 39 elementary school classrooms during mathematics and language arts instruction. They found that student engagement was strongly related to teacher behavior, but not to classroom architecture (self-contained vs. open-space), nor to student characteristics such as age, gender, and ethnicity. Moreover, engagement was not related to specific teaching behaviors, such as frequency of feedback or types of question, but to the social organization of the classroom, such as group size and degree of teacher involvement. They found greater engagement when children were working in small groups and when children were working with the teacher rather than with other students or alone with materials.

Cazden (1973, cited in Cazden, 1981) observed students in 10 primary- grade classrooms while they were watching the children's television program, *The Electric Company*. Attention was coded using two independent measures: (a) a group measure that entailed scanning the entire class at 30-second intervals and counting the children who were visually oriented toward the TV screens, and (b) a highly reliable individual measure that entailed continuously monitoring the visual attention of each student. Among the interesting findings emerging from this study were that children in more highly structured classrooms showed greater attention and that attention was related to children's individual reading abilities (the relationship was curvilinear). Even more interesting was the finding that attention was related to reading group membership. Pooling data across classes, Cazden found that children of the same tested reading level showed less attention and more attention shifts when they were in low reading groups than when they were in high reading groups. In other words, reading group assignment affected attention above and beyond individual reading level.

Eder and Felmlee (1984) reported a similar finding. They coded attention continuously from videotapes of four lessons from the high and low reading groups in a single first-grade classroom. The interesting conclusion reached by Eder and Felmlee was that reading group membership had

> a strong and significant effect on student attentiveness. By doing a quantitative analysis we were able to show that this effect is due to differences in group environments rather than to differences in individual characteristics or amount of group management. (p. 207)

One shortcoming of the Cazden (1973, as cited in Cazden, 1981) and the Eder and Felmlee (1984) studies undermines the conclusion that attention depends on group membership rather than on individual reading level or other individual characteristics. In both studies, the measure of reading level was a single, one-shot test: a standardized reading test administered in second grade in Cazden's study; and a reading readiness test administered in kindergarten in Eder and Felmlee's study. Thus, it could be that individual reading ability had weak effects because it was weakly measured. In the present study, we painstakingly measured reading levels. This should enable a better answer to the question of whether the reading level of individuai children or the culture of reading groups has the strongest influence on attention.

Another interesting finding reported by Eder and Felmlee (1984, Table 3, p. 196; Felmlee et al., 1985, Table 3, p. 224) was that in some analyses a high rate of oral reading errors was associated with a lower likelihood of lapses in attention. This flies in the face of common sense in the field of reading. Nonetheless, on the basis of the Eder and Felmlee finding and on our own circumstantial evidence, Anderson, Wilkinson, Mason, Shirey, and Wilson (1988) conjectured that an oral reading error may give rise to "a tension that increases attention and instigates deeper processing" (p. 271). The present study was designed to provide dependable evidence about the relationship between oral reading errors and attention. It is likely that individual reading level, group membership, or both are associated with attention and oral reading errors. Therefore, simply studying the association between attention and naturally occurring oral reading errors would confound oral reading errors with individual reading level or group membership. In this study, one gambit used to disentangle oral reading errors from reading level and group membership was to experimentally manipulate text difficulty.

To recapitulate, the general purpose of this study was to explore attention moment by moment during reading lessons and to investigate some of the factors, concurrent as well as antecedent, that may influence attention. The specific purpose was to disentangle the influences on attention of individual reading level, group membership, and oral reading errors.

Method

Subjects

Our subjects were 116 students, 56 girls and 60 boys, who were enrolled in either a second-grade or a third-grade classroom from each of three schools in east central Illinois. The schools were chosen so that the sample would be as diverse as possible: one was in a rural, farming area, the second in a low-income area of a small city, and the third in a middle-class area of another small city. Eighty-one of the students were white, 22 were black, and 13 were of other ethnic backgrounds. On the reading comprehension subtests of the Metropolitan Achievement Tests (MAT), administered in the fall when the study was conducted, the students had an average stanine of 5.9 with a standard deviation of 1.8, which compares with a national average of 5.0 and a national standard deviation of 2.0.

Design and Materials

In each of the six classes participating in the study, there were three reading groups. As a part of the study, each group received four lessons that featured one of four texts. Hence, altogether the study involved 72 lessons (6 classrooms x 3 reading groups x 4 texts), each of which was videotaped.

The difficulty of the texts was manipulated in a within-subjects design. Difficulty was determined by three judges who selected stories of representative difficulty and interest from among first-grade through fifth-grade basal anthologies not in use in the cooperating schools. Each reading group received four stories ranging over four grade levels. The easiest story was one grade level below the children's current nominal grade level; the second easiest was on the current grade level; the third easiest was one grade level above the current grade level; and the most difficult was two grade levels above the current grade. The stories were edited as necessary to be exactly 10 pages in length. Each group read one story a day for each of four days. The four stories were read in the order of increasing difficulty from the easiest to the most difficult. This was done so as not to discourage students with the most difficult texts at the beginning. As a result, however, order was confounded with text difficulty.

Procedure

The format of the lessons involved having students take turns reading pages of one of the stories aloud, with help from the teacher as needed, followed by brief discussions in which the students answered questions, mostly about story details and word analysis. The lessons were taught by the regular classroom teachers, all of whom indicated that they usually had students take turns reading segments of stories aloud during small-group lessons. The teachers were provided with a brief lesson guide prepared by the research team. During the study, every reading group completed a story each day. This was a faster pace than normal for the low groups in the participating classrooms, especially when they were reading the difficult stories. A member of the research team videotaped every lesson. After the lessons individual oral retellings of the stories were collected; these data have not been analyzed and are not reported in this paper.

Scoring of Attention and Reading Errors

The attention of every student in a group was scored moment by moment throughout the reading turns in the lessons. A *reading turn* was defined as the interval that began when the teacher nominated a student to read aloud a page of text and ended when the student had finished the last word on the page. Because there were 72 lessons and 10 reading turns within each lesson, there were 720 intervals during which attention was evaluated.

Trained raters coded attention with the aid of a computer program. The rater followed one student at a time on the videotape of the lesson, pressing a key on a computer terminal whenever the student shifted from a state of attention to a state of inattention, or vice versa. The computer program calculated the duration of each state and also compiled the database, keeping track of the student's attention and individual characteristics, group characteristics, and text characteristics. The basic criterion for attention was whether the student was looking at the place he or she was supposed to look at the moment: When the reader was reading the text, the student was supposed to look at the text; when the reading was interrupted by an error, teacher feedback, or both, it was considered attention if the student was looking at the text, the reader, or the teacher. To check interrater reliability, six raters scored the attention of 20 children from different groups reading different stories. The average Pearson product-moment correlation among the attention durations recorded by the six raters was greater than .95. Altogether, about 8,000 episodes of attention, ranging in duration from 1 second to several minutes, were recorded.

Oral reading errors were also scored from the lesson videotapes by trained raters. The raters employed an error analysis scheme similar to the one developed by Hoffman et al. (1984). Four raters averaged 72% agreement in a reliability check, which was adequate but not as high as we might have hoped. For the main data analysis, an *oral reading error* was simply defined as any deviation from the text. About 3,000 oral reading errors were recorded that fit this broad definition. Also recorded were various features of each error, such as its degree of semantic and graphophonemic overlap with the correct word, whether the teacher provided feedback and, if so, whether the feedback was terminal or sustaining. These features were considered in subsidiary analyses. The raters recorded the time at which each error occurred. The time was read from a digital clock display encoded onto the videotape. This enabled precise calibration with the attention data.

Individual Differences in Reading Level

Five measures were used to assess students' level of reading comprehension and fluency. These were the following: (a) scaled scores from the reading comprehension subtests from the MAT, Primary 1 and Primary 2, Forms L (in the standardization sample, K-R 20 = .93 for both levels; Prescott, Balow, Hogan, & Farr, 1986); (b) scaled scores from the reading comprehension subtest of the Illinois Goal Assessment Program (IGAP; in a standardization sample, coefficient α = .84; Valencia, Pearson, Reeve, & Shanahan, 1988); (c) teachers' ratings of students' comprehension measured on a 6-point Likert scale (factor loadings with other measures of comprehension from the study sample provided lower bound estimates of reliability, which were .86 for Grade 2 and .68 for Grade 3); (d) time, in hundredths of a second, to read two passages from the Gray Oral Reading Tests-Revised (in the study sample, coefficient α = .92 for Grade 2 and .89 for Grade 3; Weiderholt & Bryant, 1986); and (e) time, in hundredths of a second, to pronounce two lists of pseudowords adapted from Stanhope and Parkin (1987) and Stanovich, Cunningham, and Feeman (1984) (in a study sample, coefficient α = .90 for Grade 2 and .81 for Grade 3). We took the mean of reading times on the two passages and the mean of pronunciation times on the two lists of pseudowords.

These measures were used to estimate comprehension and fluency factor scores. The factor scores were computed in three steps. First, when necessary, measures were transformed by applying normalizing transformations. Scaled scores from the IGAP were expressed as proportions of the total possible score and measured in radians following an arcsine transformation (2 arcsine $\sqrt{P}$). Mean passage reading time and mean pseudoword pronunciation time were normalized by taking natural logs, and the scales were inverted so that high scores indicated high fluency.

Second, any missing data on the measures were estimated using ordinary least-squares regression. The data were missing on one or two measures for 10 subjects. When possible, comprehension measures having missing values were regressed on the remaining comprehension variables and grade, and fluency measures having missing values were regressed on the remaining fluency variables and grade. For each subject having missing values, estimated scores on the variables were computed by substituting values of variables for the subject into the regression equation and solving the equation.

Third, a two-factor model was fit to correlations among the five measures. The comprehension factor was indexed by the MAT, the IGAP, and teacher ratings, as well as by passage reading time; these measures had factor loadings of .88, .69, .68, and .44, respectively. The fluency factor was indexed by pseudoword pronunciation time and passage reading time, and these measures had factor loadings of .89 and .60, respectively. The correlation between the factors was .65. This yielded a $x^2(4, N = 116) = 3.28, p = .51$, root mean square residual = .03. The fit was significantly better than that of a one-factor model, difference $x^2(2, N = 116) = 33.93, p < .01$. Estimated factor scores for comprehension and fluency were computed by the regression method and converted to local stanines. The estimated factor scores were approximately normally distributed. Comprehension and fluency scores correlated .76. Table 1 summarizes the factor scores of the children in each reading group.

[Insert Table 1 about here.]

Variables

The variables measured during the study and included in the data analysis were as follows: *Grade* was coded according to whether children were in Grade 2 or Grade 3. *Comprehension* factor scores were expressed in local stanines. *Fluency* was also a factor score scaled as a stanine. For *gender*, boys were coded 0, and girls were coded 1. For *ethnicity*, children from ethnically mainstream homes were coded 1, and nonmainstream children, including Blacks, Hispanics, and Asians, were coded 0. For *group*, high, middle, and low reading-group membership was coded 3, 2, and 1, respectively, permitting an investigation of the linear component of group membership.

The *difficulty* variable pertained to text difficulty, which was represented on a 4-point scale ranging from *one grade below level* (1) to *on grade level* (2), to *one grade above level* (3), to *two grades above level* (4). As with reading group, this coding allowed for an assessment of the linear component of text difficulty. The *page* variable was measured by the serial position of pages within stories and was coded 1 through 10. *Prior inattention* was coded 0 if a child had not been inattentive during a reading turn and 1 if the child had previously been inattentive one or more times during this reading turn. *Error* was coded 1 when the current state of attention terminated within 5 seconds of an oral reading error; otherwise it was coded as 0. *Previous time* is the time in seconds from the beginning of a reading turn until the onset of the current episode of attention.

Approach to Analysis

To explore attention as a dynamic process, rather than a static trait, we employed *event history analysis*. An event history is a longitudinal record of when events happened among a sample of individuals or other entities. An event is a change of state. The change of state with which we were concerned was a shift from attention to inattention. Each student's history of attention shifts were recorded and the relationships between attention shifts and various factors were examined. Three characteristics of event history analysis make it the statistical method of choice.

First, attention shifts are discrete events. These are coded with a dummy variable indicating whether the event (a shift from attention to inattention) has occurred. Hence, a discrete-state model is required, as opposed to a model suitable for continuous dependent variables, such as ordinary least-squares regression analysis.

Second, attention shifts can occur with some probability at any point in time. In other words, the data provide information not only about whether an event occurred, but also about the timing of the event, given that it occurred. Event history models exploit the continuous-time aspect of attention.

Third, event history analysis accommodates so-called *censored events*, which constitute a problem for standard statistical procedures when these are applied to time data. Censored events are observations that must be discounted because of factors that are irrelevant to the issue being studied, for instance, a patient in a cancer research project who dies, not from cancer, but in an automobile accident. In our study, no less than one third of the total observed number of episodes of attention were censored because a reading turn ended when the child finished reading a page, and a few additional observations were censored when children left the room for remedial instruction, lessons were interrupted by announcements over the public address system, or when other such distractions occurred. Simply discarding these cases would have led to severe bias (Tuma & Hannan, 1978). Event history analysis allows estimation of parameters with censored cases included in the data. The analysis produces estimates that are asymptotically unbiased and which also have good small-sample properties with moderate degrees of censoring (Tuma & Hannan, 1978).

To make the problematic status of censored observations intuitively clear, consider an illustration from education (Willett & Singer, 1988). Suppose you want to estimate the length of time it currently takes people to get doctoral degrees in various fields. It should be obvious that you cannot base the estimate solely on the data of people who already have their degrees, discarding the data of people who still are degree candidates, or you will underestimate the length of time.

Reflecting the origins of event history analysis (or survival analysis, as it is also called) in biomedical research, the basic descriptive summary of event data is called a *life table*. For an illustration of how a life table is constructed, imagine that a cancer researcher follows 100 patients for a period of five years from the point at which cancer is diagnosed and examines the relationship between the likelihood of the "event" of a patient's dying and factors such as type of treatment, gender, and age. During Year 1, suppose that 13 patients die of cancer. The *hazard rate* during the first year is the proportion who die, or .13. The *survival rate* at the end of the first year is the proportion still alive, or .87. During Year 2, an additional 17 patients die of cancer. Only the 87 who survived the first year are still at risk, therefore the hazard rate for the second year is 17 divided by 87, or a little less than .20, and the survival rate is a little more than .80.

In our case, the variables of interest were the proportion of children during a lesson who were still attentive after a period of time and, conversely, the proportion whose attention lapsed during this period. The unit of time was the second rather than the year; otherwise, the construction of a life table was the same as in the cancer example. Also, inattention is more like a skin disease than cancer, in the sense that children were observed repeatedly and many suffered from recurrent episodes of inattention. This meant that each child contributed multiple observations to the data base.

In addition to life-table analyses, we performed multivariate analyses using the proportional-hazards model developed by Cox (1972; see also Allison, 1984). The dependent variable was the hazard rate, in our case the probability that an attentive child would become inattentive during a certain interval of time. The hazard rate was allowed to depend on time, time-invariant explanatory variables, and time-varying explanatory variables. The basic model is as follows in the two- variable case:

$$\log h(t) = a(t) + b_1 x_1 + b_2 x_2(t)$$

where log $h(t)$ is the log of the hazard rate, x_1 is a time-invariant explanatory variable, x_2 is a time-varying explanatory variable, and $a(t)$ is any function of time. The coefficients b_1 and b_2 give the hazard rate change in logits for 1-unit changes in x_1 and x_2. The estimation procedure Cox proposed is a derivative of maximum likelihood called partial likelihood estimation. The procedure works by representing the problem as two factors: One factor contains information only about the coefficients b_1 and b_2; the other contains information about b_1, b_2, and $a(t)$. Partial likelihood estimation simply discards the second factor and treats the first factor as though it were an ordinary likelihood function. This first factor depends only on the order in which events occur, not on the exact times of occurrence. The proportional-hazards model has been widely employed by researchers, because it avoids the difficulty of specifying a priori how the hazard rate depends on time.

The proportional-hazards model gets its name from the assumption that the ratio of the hazard functions for any two individuals in the population is constant over time. The model is robust in the face of violations of this assumption (see, e.g., Kalbfleisch & Prentice, 1980, pp. 89-95). Nonetheless, we checked for violations by comparing log-log plots of survival rates as a function of time for all of the major subdivisions of the data. Departures from proportionality were small with one exception. The exception was whether the child had displayed one or more previous episodes of inattention during the current reading turn. The problem was solved in this case by stratifying the analysis on the factor of prior episode of inattention (see Allison, 1984, p. 39). Smaller departures from proportionality were observed for grade and reading group. The problem was solved in this case by including the interaction of time with reading group within grade in the model.

Results

The overall characteristics of attention during reading turns are displayed in Figure 1. The top curve shows the proportion of children who were continuously attentive moment by moment during reading turns. This curve, traditionally called a cumulative survival function, is simply a line drawn through the proportions observed during successive 5-second intervals. The bottom curve shows the rate of lapses in attention, or hazard rate, as it is traditionally called, during successive 5-second intervals. The bottom curve is a smoothed function and the points around the curve represent the observed values. Hereafter the figures will show only proportion of children still attentive, because this measure is, perhaps, more easily understood than attention-lapse rate (Willett & Singer, 1988) and the two measures embody basically the same information.

[Insert Figure 1 about here.]

Notice that attention declines sharply over the first 15 seconds and then levels off. The same pattern appears in all subgroups under every condition in the study. Evidently children are most vulnerable to becoming inattentive in the early moments of episodes of attention. Because most of the data represented in Figure 1 come from short episodes of attention, the values plotted in the figure are more stable at short than at long durations. As a rule of thumb, the values are very trustworthy up to 60 seconds, fairly trustworthy up to about 90 seconds, and less trustworthy beyond 90 seconds.

Table 2 summarizes the principal multivariate analyses of attention-lapse rate. In each model, the data have been stratified according to whether the child has previously been inattentive during the reading turn. The coefficients and standard errors are expressed in logs.

[Insert Table 2 about here.]

The first model presented in Table 2 shows the influence of antecedent factors representing characteristics of the children. Four of the five factors included in Model 1 had a significant influence on attention. Third graders were less likely to become inattentive than second graders (cf. Figures 2 and 3); children high in comprehension and fluency were less likely to become inattentive than were children who scored low on these factors; and, as is depicted in Figure 4, girls were less likely to become inattentive than boys.

[Insert Figures 2, 3, & 4 about here.]

Group was entered in Model 2, and proved to have a pronounced effect on attention. Figures 2 and 3 show the proportions of children still attentive at successive 5-second intervals throughout a reading turn for the three levels of group within Grades 2 and 3, respectively. It is apparent that group membership has stronger effects on attention than does individual reading level. Comparing Model 1 with Model 2, the influence of fluency has been attenuated whereas the influence of comprehension has vanished altogether, and neither factor remains significant.

In Model 2, and each subsequent model, ethnicity was significant. Ethnically mainstream children were more likely to have lapses of attention than nonmainstream children, everything else being equal.

Two concurrent factors that encode features of the materials were entered in Model 3. The difficulty of the stories had a significant influence on attention, whereas the serial position of a page within a story did not. Figure 5 shows that attention generally declined as the difficulty of the stories increased.

[Insert Figure 5 about here.]

Model 4 is identical to Model 3, with the exception that Model 4 includes two additional concurrent factors that encode features of the moment-by-moment transactions during reading turns. The results indicate a striking increase in lapses in attention within 5 seconds of oral reading errors. Indeed, oral reading errors had by far the strongest effect of any factor investigated in this study. Children were over 2.5 times as likely to become inattentive during the 5-second interval after an oral reading error as they were during an interval in which there was no error.

A comparison of Model 3 and Model 4 reveals that the size of the effects of most other factors has been attenuated in Model 4. For instance, the coefficient for Group drops from -.223 to a much smaller but still significant -.097. This suggests that oral reading errors mediate part of the influence on attention of the other factors included in the study. This result suggests, for instance, that one reason, although not the sole reason, that high groups are more attentive is that members of these groups make fewer mistakes when reading aloud.

Model 5 adds selected interactions. The Grade x Group interaction is represented in Figures 2 and 3. The Group x Difficulty interaction appeared because story difficulty had more effect on attention in low than in middle and high groups. The Grade x Difficulty interaction appeared because difficulty had more effect on the attention of second graders than third graders.

Model 6 is the same as Model 5, except for the addition of time-dependence in Model 6. The purpose for including this term was to correct for slight nonproportionality. The correction term was significant, confirming the impression from the log-log plots of survival functions. However, the fit of the model improved only slightly over that of Model 5, and the coefficients for the factors in the model were similar regardless of whether the correction term was in the equation. The two largest changes were that grade and group were significant in Model 6, but not in Model 5.

Not shown in any of the models in Table 2 is the influence of prior episodes of inattention on the rate of attention lapses, because, as indicated earlier, we stratified on prior inattention to correct for nonproportionality. Figure 6 shows that children who previously have been inattentive one or more times were much more likely to become inattentive again than children whose attention had been sustained.

[Insert Figure 6 about here.]

Also not shown in Table 2 is the effect of the number of children in a reading group. In an ancillary analysis that included the factors of grade, individual comprehension and fluency, gender, ethnicity, group level, and group size, there was a nonsignificant trend for small groups to have lower attention lapse rates than large groups. This is consistent with the findings of Dreeben and Barr (1987), who reported negligible effects of group size. We did not examine interactions with group size because there was no theory to guide the choice of which interactions to examine and because unguided exploration would have vitiated the power of the analysis.

Lag Between Reading Errors and Lapses of Attention

Logic dictates that for one event to be called the cause of another event, the first event must occur before the second. Furthermore, the first event ought to precede the second event by an interval that is within the *response time* of the physical, psychological, or social system that encompasses the events. For instance, we would not want to say that flipping a switch caused an incandescent light to go out, if it went out 5 minutes after the switch was flipped.

What is the response time of the system that relates one child's attention to another child's oral reading errors? An a priori basis for an answer would be difficult to find. Five seconds was a guess, as it happens not a bad one, but now we may ask whether the peak response is at a longer or shorter interval. Two additional intervals were investigated. The first was 2 seconds, which may be close to the error of measurement inherent in our procedures. The second was 8 seconds. This is enough time for the reader's own reaction to the error and teacher feedback to have an influence. The analyses revealed that rate of attention lapses increases strongly within 2 seconds of an oral reading error, more strongly within 5 seconds, and more strongly still when the interval is extended to 8 seconds. Thus, there is an immediate response to errors and the response intensifies over time, at least through 8 seconds. This may indicate that part of the fall off in attention following an error is attributable to a chain reaction involving secondary events triggered by the error, such as teacher feedback.

Generality of the Effects of Reading Errors

The fact that the influence of reading errors on attention intensifies over intervals up to 8 seconds leads one to surmise that the type of error, the reader's own reaction to the error, or feedback the teacher gives to help the reader correct the error may be important. Accordingly, we completed further analyses to check these possibilities.

We were surprised to find that the likelihood of a lapse of attention seemed equally high whether the error response was semantically or graphophonemically similar to the correct word, whether the child paused following his error or kept reading, whether the teacher provided feedback, and whether, when feedback was provided, it was sustaining or terminal feedback. In other words, all patterns of error and feedback seemed to be approximately equal in so far as lapses of attention were concerned.

Investigating in one grand analysis whether there were interactions between the occurrence of reading errors and the other factors included in the study was not computationally feasible (estimating Model 6 required nearly 20 minutes of mainframe central processing unit time). What we did instead was partition the data by group within grade and estimate simplified models. This analysis revealed that errors strongly increased the rate of inattention in all groups in both grades.

Evidently, oral reading errors have a pervasive, negative influence on attention. The influence does not appear to be conditioned by the nature of the error, the reader's own manifest reaction to the error, the teacher's feedback, group level, or grade.

Probability of Becoming Attentive

The analyses reported so far investigated the likelihood that attentive children would become inattentive. In an ancillary analysis, not described in detail, we examined the likelihood that children who were currently inattentive would again become attentive. Except for the fact that the effects were weaker, the results of the ancillary analysis generally were mirror images of the results of the main analyses. For example, inattentive third graders were more likely to resume being attentive than were inattentive second graders.

The chief difference between the two analyses was that in the ancillary analysis, the serial position of pages within stories significantly influenced the likelihood of the children's becoming attentive, whereas the main analyses showed that the serial position of pages had no influence on the likelihood of becoming inattentive. Specifically, as a story progressed, children who had become inattentive were less and less likely to resume being attentive; however, over the course of a story, there was no change in the likelihood that children who were already attentive would remain attentive.

A conceivable objection to the conclusion that there is a strong relationship between reading errors and attention is that the relationship arises from an artifact in the method of scoring attention. It might be conjectured that, after an error, when a child made a transition from looking at the story to looking up at the oral reader or the teacher, the rater scored the transition as a moment of inattention. If this were true, children would have tended to resume being attentive very quickly after errors. In fact, errors were not significantly related ($p > .25$) to the likelihood that children would resume being attentive, and therefore the objection fails.

Discussion

Several intriguing findings emerged from this study. Most noteworthy was the sharp decline in attention following oral reading errors. The decline was evident within 2 seconds of an error and was even more pronounced after 5 and 8 seconds. Because the study establishes that lapses of attention are highly likely just after oral reading errors, we may venture the claim that errors are a *proximate cause* of inattention.

Errors undermined attention in every reading group in both the second and the third grade. The effect of errors did not appear to hinge on the nature of the error, the reader's own reaction to the error, whether the teacher provided feedback, or, when provided, the kind of feedback. Thus, the distracting effect of errors was pervasive as well as strong.

The finding that oral reading errors undermine attention conflicts with the results of Eder and Felmlee (1984), who reported that attention actually improved following errors. The difference in findings may be explained by the fact that they studied first graders whereas we studied second and third graders, but perhaps their finding should be discounted because it was based on only one classroom with only 11 children. The present finding also conflicts with Anderson et al. (1988), who, reasoning from circumstantial evidence, hypothesized that oral reading errors might lead to increased attention under some conditions. The direct evidence from this study suggests that they were mistaken, at least under any of the circumstances investigated in this study.

A potentially controllable factor in whether children will make errors while they read is the difficulty of the text (Blaxall & Willows, 1984). Because errors lead to inattention, a decrease in story difficulty ought to lead to sustained attention and, indeed, it did, especially for younger children in low reading groups. An interesting way of looking at the relationship between story difficulty and attention is graphed in Figure 7. The figure shows the profile of attention of average groups reading typical material for the grade and the profile of low groups reading material one grade level easier than typical for the grade. The two profiles are identical. Evidently, insofar as attention is concerned, low groups behave like average groups when the stories are easy enough. Also shown in Figure 7 is the attention profile of high groups reading material one grade level above their current grade. Notice that this curve is only slightly above the ones for the low and middle groups.

[Insert Figure 7 about here.]

The child's grade and reading group level, the story's difficulty, and interactions among these factors all influenced attention. However, the size of these effects declined substantially once oral reading errors entered the equation. This suggests that one reason that these factors affect attention is that they affect the frequency of errors. In other words, errors appear to be on the causal path between these factors and attention.

That there is a negative association between errors on classroom tasks and growth in reading is a well-established finding (Anderson, Evertson, & Brophy, 1979; Fisher et al., 1978; Hoffman et al., 1984). On the basis of this finding, previous investigators have wanted to advance the conclusion that classroom tasks should be made easier so that errors are reduced. For example, although careful to reiterate that the evidence was only correlational, Hoffman et al. (1984) suggested that the long-time consensus in reading about the standard for gauging the instructional level of texts--whereby texts are suitable for use in teacher-guided instruction when students can orally read 95% of the words correctly--"may need to be revised to a higher success rate" (p. 381). A problem with this suggestion is that, without exception, the studies showing that errors are negatively correlated with growth in reading employed highly fallible measures to adjust for differences among children in initial reading level. This means that, instead of being the cause of lower growth, error rate on classroom tasks may have correlated negatively with performance on a later achievement measure simply because it provided further information, beyond that contained in initial measures, about children's reading level (see Anderson et al., 1988).

Our study strengthens the case that oral reading errors are a *cause* of poor progress. First of all, the assessment of reading level entailed two facets of reading, comprehension and fluency, based on five varied and psychometrically strong measures. Thus, it is unlikely that the observed oral reading errors contained much residual information about individual children's reading level. Second, text difficulty was manipulated in a design that made it orthogonal to children's reading level. All children to some extent, but especially younger children and children in lower groups were adversely affected by difficult texts.

Third, the study revealed a plausible mechanism by which errors may affect growth in reading: Oral reading errors undermine attention, and attention, it may be supposed, is a vital link in the chain that gives birth to growth in reading. The process can be diagramed as follows:

Difficult ----> Errors ----> Lapses of ----> Slower
texts attention growth

Of course, this report does not present any evidence bearing on the putative link between lapses of attention and slower growth in reading. But considering both the findings it does present and previous findings, the diagramed process seems a reasonable account.

Probably what happens when a text becomes too difficult and errors rise is that children's reading strategies break down and they become discouraged. From the point of view of children who are following along, an error probably breaks the continuity of the story. It signals a hiatus that will be neither interesting nor profitable and, hence, their attention is highly likely to lapse. If this is correct, then it is transparent why a steady diet of texts upon which children make a lot of mistakes would be boring, would undermine the children's self-confidence and interest in reading, and would retard their growth as readers.

We do not care to claim, though, that if easy texts are good for children, even easier ones would be better. Nor would we wish to claim that, beyond the very earliest stages of learning to read, a low error rate--assured because, for instance, children can recite a text from memory--does much to promote growth in reading. For a lesson to promote growth, there must be what Clay (1987) calls "reading work" for children to do. In Reading Recovery, the successful program pioneered by Clay for first graders who are failing to learn to read, a story is judged to be at a suitable level of difficulty if a child can correctly read between 90% and 95% of the words on a second reading of the story.

On the basis of their experience with Reading Recovery, Gaffney and Anderson (1991) have concluded:

> At the heart of Reading Recovery instruction is the scaffolding the teacher provides to keep the child within his or her zone of proximal development. An important scaffold is selecting a book of just the right level of difficulty. Too difficult a book and a child may flounder. Too easy a book and the child will not have enough productive "reading work." The difficulty of a book is affected by such factors as whether it has a predictable pattern, the extent to which the pictures illustrate the concepts, and the familiarity of the words. However, a book is not easy or difficult in and of itself. For a child having trouble learning to read, the difficulty of a book can be intelligibly discussed only in relationship to this particular child. . . . Moreover, whether a particular child will find a particular book easy or difficult depends upon the context in which the book is read and the conditions surrounding its use. (p. 187)

Reading Recovery is an individual tutorial program and the 90%-95% success rate standard for instructional-level stories cannot be generalized to group instruction in the classroom. What it does seems possible to generalize is the principle that stories should be neither too difficult nor too easy.

Another notable finding of our study was that nominal group ability level--represented simply 1, 2, or 3--was more strongly related to attention than were highly reliable individual comprehension and fluency measures. Indeed, once group membership entered the equation, neither of the individual factors was even significant. We will consider three theories to explain this finding. These theories are not mutually exclusive; more than one could be true in part.

First, and most plausible we think, based on everything that is known, is the theory that high groups have a culture that supports attention whereas the norms of behavior in low groups reinforce inattention. Indicative of differences in culture, considerable variation in instructional and social process among high and low reading groups has been documented (Hiebert, 1983). In high groups, the children themselves sometimes police misbehavior and may coach others to pay attention. In contrast, low-group children frequently distract one another. Teachers tolerate more interruptions of lessons of low groups than high groups. Children in low groups respond less adaptively to difficulties than children in high groups; when Butkowsky and Willows (1980) varied children's success and failure on reading tasks, the children in low groups displayed less persistence, attributed failure to factors beyond their personal control, and provided lower estimates of future success than the children in high groups. Children would rather be in high groups than in low groups, and their status among other children depends upon the group they are in (Luchins & Luchins, 1948; Weinstein, 1976).

A second, rival theory attributes variations in level of attention among reading groups to differences in the traits of the children who belong to the groups. The obvious form of this theory is that teachers assign children to groups at the beginning of the year according to initial reading level. The theory continues that, if there seems to be an effect of group membership beyond children's individual initial reading levels, it is an illusion that arises because the measure of initial reading level is not completely valid or reliable. Based on their daily experience with children's reading, teachers "correct for errors of measurement" of initial level when they assign children to groups. If a child is sick, distracted, or, in contrast, performs uncharacteristically well on a short, one-shot test, the teacher can override this faulty test score information when composing groups. The effect, or so the argument goes, is that group membership represents a more valid assessment of the child's reading level than an individual test score. This is a tenable explanation for previous findings, but it is untenable in our study, because of the care that we took in measuring individual reading levels.

Another form of the theory that attributes differences among reading groups to the traits possessed by the members is that teachers may compose groups partly on the basis of noncognitive traits such as tendency to be cooperative, work hard, pay attention, and stay out of trouble. The influence of group "ability" on attention may indirectly reflect these other student characteristics. The present study offers no grounds for accepting or rejecting this theory.

Third, still another theory to explain the association between group membership and attention hinges on the demonstration that text difficulty leads to inattention, especially for less able readers: It could be that children in low groups routinely get texts that are too hard for them, and that this is the source of their trouble in sustaining attention. This theory neatly fits the data from this study, glosses the findings of previous research, and has the virtue of pointing to a clear policy implication: Give low groups easier texts.

The last finding upon which we will comment is the fact that the likelihood of lapses in attention was high during the first 15 seconds of episodes of attention and low thereafter. This was true in all groups under every condition in the study. Evidently, if children can be induced to sustain attention for fifteen seconds, they will be hooked for the remainder of a reading turn. We do not know of any previous study that has reported this finding.

In this study, children's moment-by-moment attention during reading lessons proved to be very orderly and lawful. That we found order rather than disorder is no doubt attributable in part to the meticulous (and tedious!) approach we developed for analyzing attention. Whereas previous investigators usually have scanned all of the children in a classroom at intervals of 30 seconds or so, using videotape we were able to examine the behavior of children one by one, second by second. And then, we analyzed the data in a way that was capable of uncovering dynamic properties of attention.

An improved method surely helped. But, the method could not have revealed order unless attention were fundamentally a lawful phenomenon. Because attention seems to be an especially good proximal index, one that is sensitive to concurrent lesson events, we offer the conjecture that teachers use attention as a major source of guidance for moment-by-moment decisions during lessons.

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Table 1

Group Size and Reading Aptitude by Class

		Comprehension		Fluency	
Class/ reading group	*n*	*M*	*SD*	*M*	*SD*
Grade 2					
Class A					
Low	3	0.72	0.93	0.71	1.23
Middle	10	4.33	0.42	5.04	0.88
High	5	6.13	1.76	5.85	1.66
Class B					
Low	3	1.64	1.41	1.35	0.61
Middle	6	3.08	0.93	2.53	1.24
High	7	6.68	1.39	4.83	1.63
Class C					
Low	7	2.06	1.63	1.61	1.64
Middle	8	5.12	1.02	4.50	1.05
High	9	6.72	1.03	5.22	1.15
Grade 3					
Class D					
Low	8	3.29	1.18	5.28	1.38
Middle	6	5.43	0.77	5.71	1.01
High	5	6.07	0.60	6.88	0.99
Class E					
Low	3	3.74	1.00	3.94	1.54
Middle	9	5.65	1.34	5.74	1.25
High	6	7.55	1.39	6.85	0.98
Class F					
Low	4	4.54	0.95	5.67	0.97
Middle	6	5.12	0.48	6.13	1.10
High	11	6.57	1.20	6.91	0.96

Note. Measures of reading aptitude are estimated factor scores expressed in stanines.

Table 2

Six Models of Attention Lapse Rate

	Model 1			Model 2			Model 3			Model 4			Model 5			Model 6		
Variable	*b*	*SE*	*b/SE*	*b*	*SE*	*b/SE*	*b*	*SE*	*b/SE*	*b*	*SE*	*b/SE*	*b*	*SE*	*b/SE*	*b*	*SE*	*b/SE*
Grade	-.176	.041	-4.260**	-.264	.043	-6.119**	-.260	.043	-6.013**	-.171	.044	-3.868**	-.217	.129	-1.684	-.387	.135	-2.862**
Comprehension	-.064	.015	-4.293**	-.004	.017	-0.249	-.006	.017	-0.335	-.027	.017	-1.577	.027	.017	-1.551	-.023	.017	-1.311
Fluency	-.036	.015	-2.391*	-.029	.015	-1.924	-.030	.015	-1.958	-.001	.015	.051	.007	.016	0.417	.003	.015	0.212
Gender	-.104	.032	-3.237**	-.083	.032	-2.567*	-.086	.032	-2.669**	-.080	.032	-2.487*	-.093	.033	-2.858**	-.094	.033	-2.883**
Ethnicity	.056	.037	1.505	.082	.037	2.186*	.087	.037	2.332*	.098	.038	2.597**	.107	.038	2.841**	.107	.038	2.855**
Group				-.224	.033	-6.903**	-.223	.033	-6.866**	-.097	.033	-2.952**	-.240	.128	-1.871	-.291	.129	-2.265*
Difficulty							.066	.014	4.615**	.036	.015	2.431*	.259	.078	3.309**	.258	.078	3.295**
Page							.006	.005	1.168	.009	.005	1.722	.008	.005	1.612	.009	.005	1.674
Error										.999	.034	29.215**	.990	.034	28.807**	.989	.034	28.836**
Previous time										-.001	.001	-1.685	-.001	.001	-2.244*	-.001	.001	-2.298*
Grade x Group													.099	.044	2.266*	.093	.044	2.120*
Grade x Difficulty													-.061	.030	-2.056*	-.060	.030	-2.020*
Group x Difficulty													-.042	.019	-2.237*	-.042	.019	-2.246*
Time dependence																-.034	.008	-3.996**
Log likelihood		-33,097.63			-33,073.80			-33,062.39			-32,659.78			-32,651.98			-32,643.97	
x^2		280.48			320.56			341.60			1,365.47			1,394.39			1,411.99	
df		5			6			8			10			13			14	

Note. For all chi-square tests, N = 7,996.
* $p < .05$ ** $p < .01$.

Figure Captions

Figure 1. Proportion still attentive as a function of time

Figure 2. Proportion still attentive as a function of time and reading group in Grade 2.

Figure 3. Proportion still attentive as a function of time and reading group in Grade 3.

Figure 4. Proportion still attentive as a function of time and gender.

Figure 5. Proportion still attentive as a function of time and story difficulty.

Figure 6. Proportion still attentive as a function of time and whether previously inattentive.

Figure 7. Joint effects of reading group and story difficulty on proportion still attentive as a function of time.

Figure 1. Proportion still attentive as a function of time

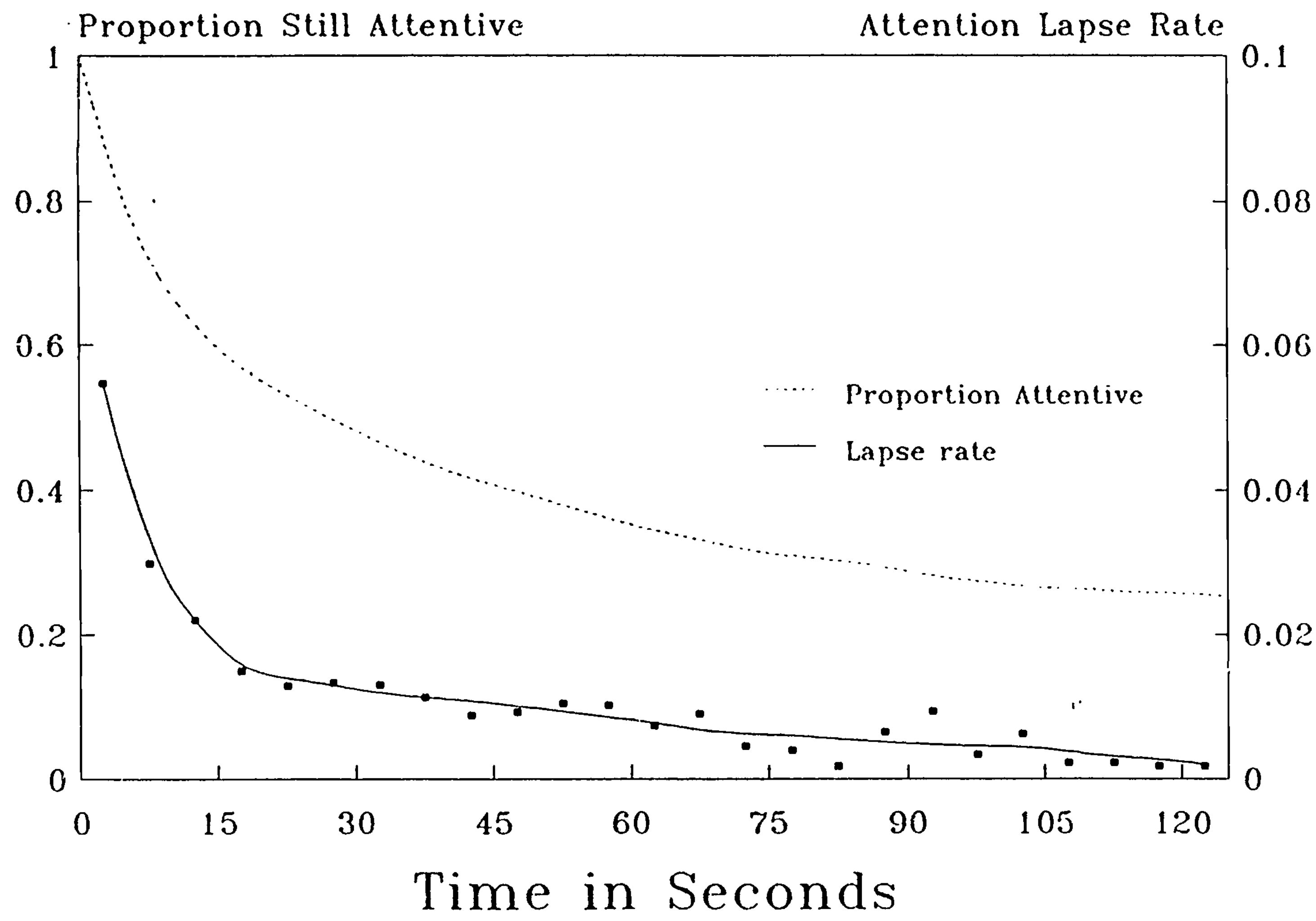

Figure 2. Proportion still attentive as a function of time and reading group in Grade 2

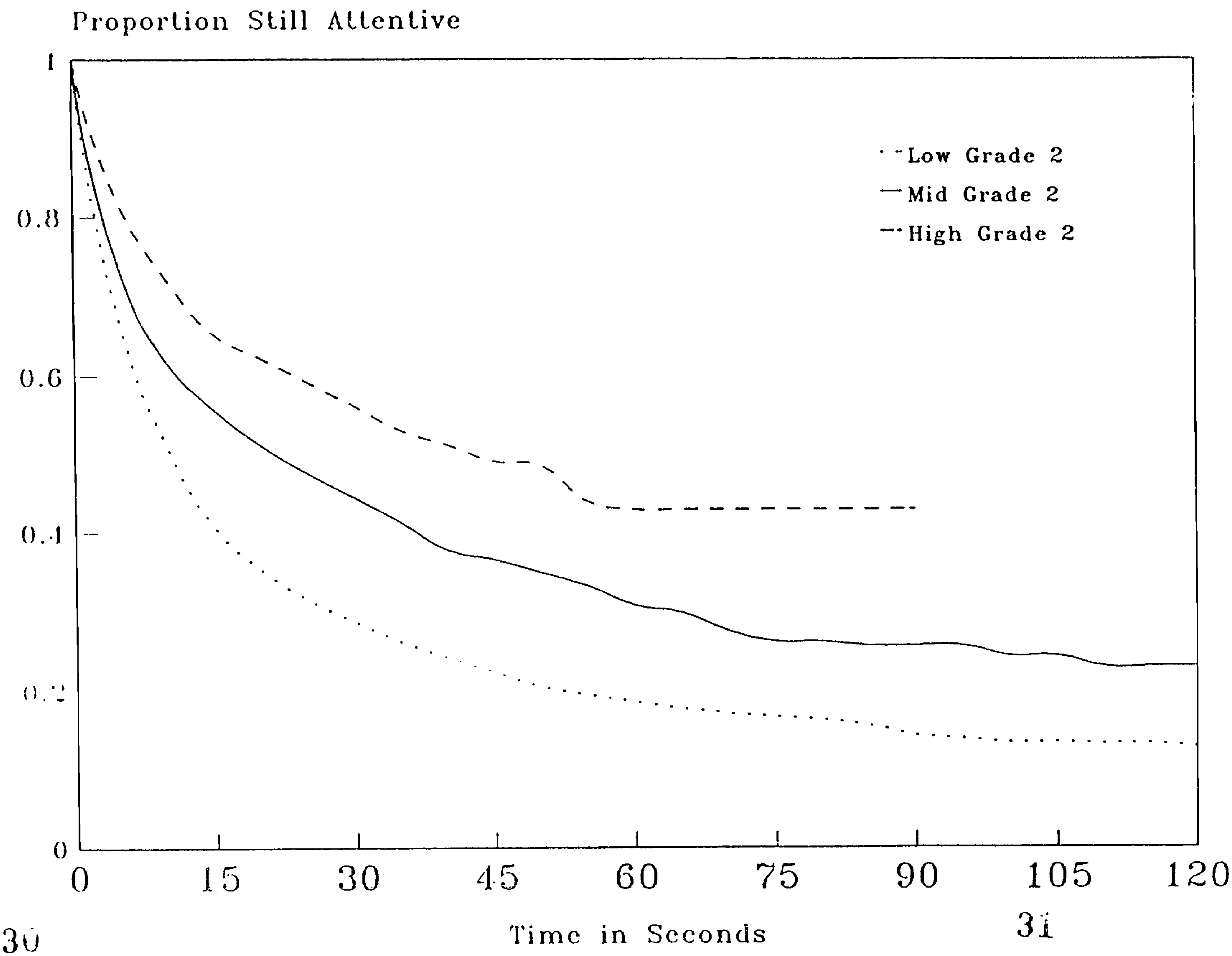

Figure 3. Proportion still attentive as a function of time and reading group in Grade 3

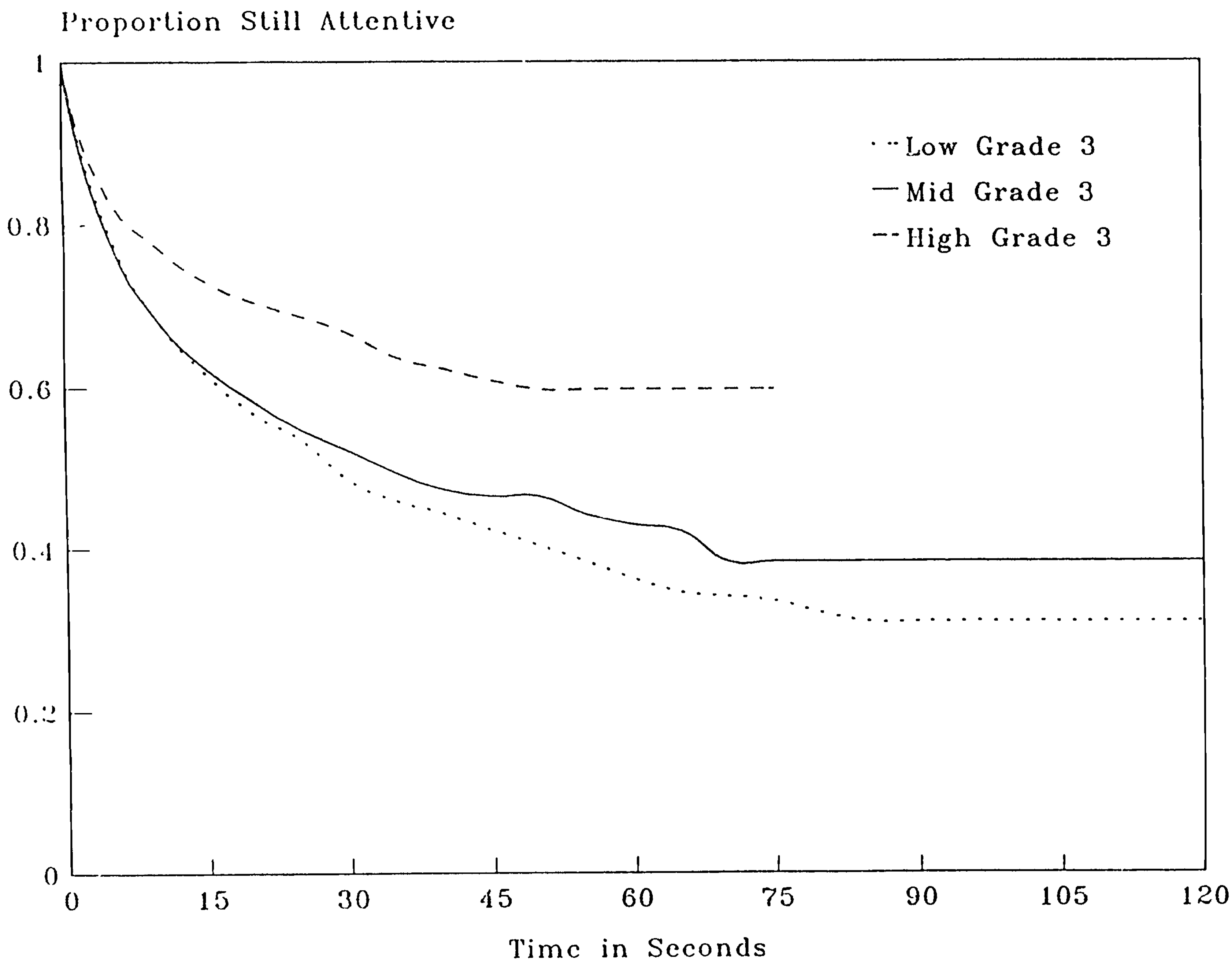

Figure 4. Proportion still attentive as a function of time and gender

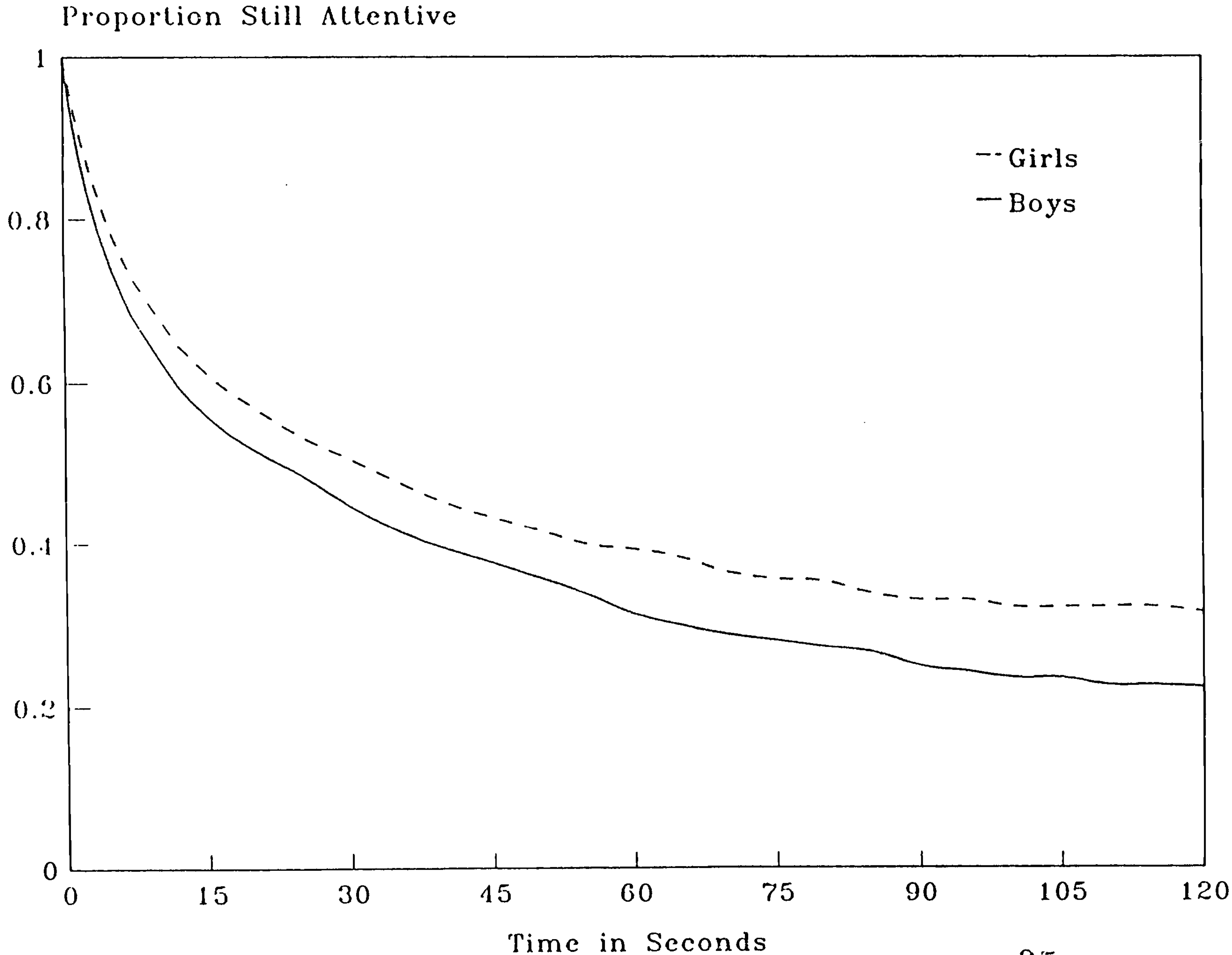

Figure 5. Proportion still attentive as a function of time and story difficulty

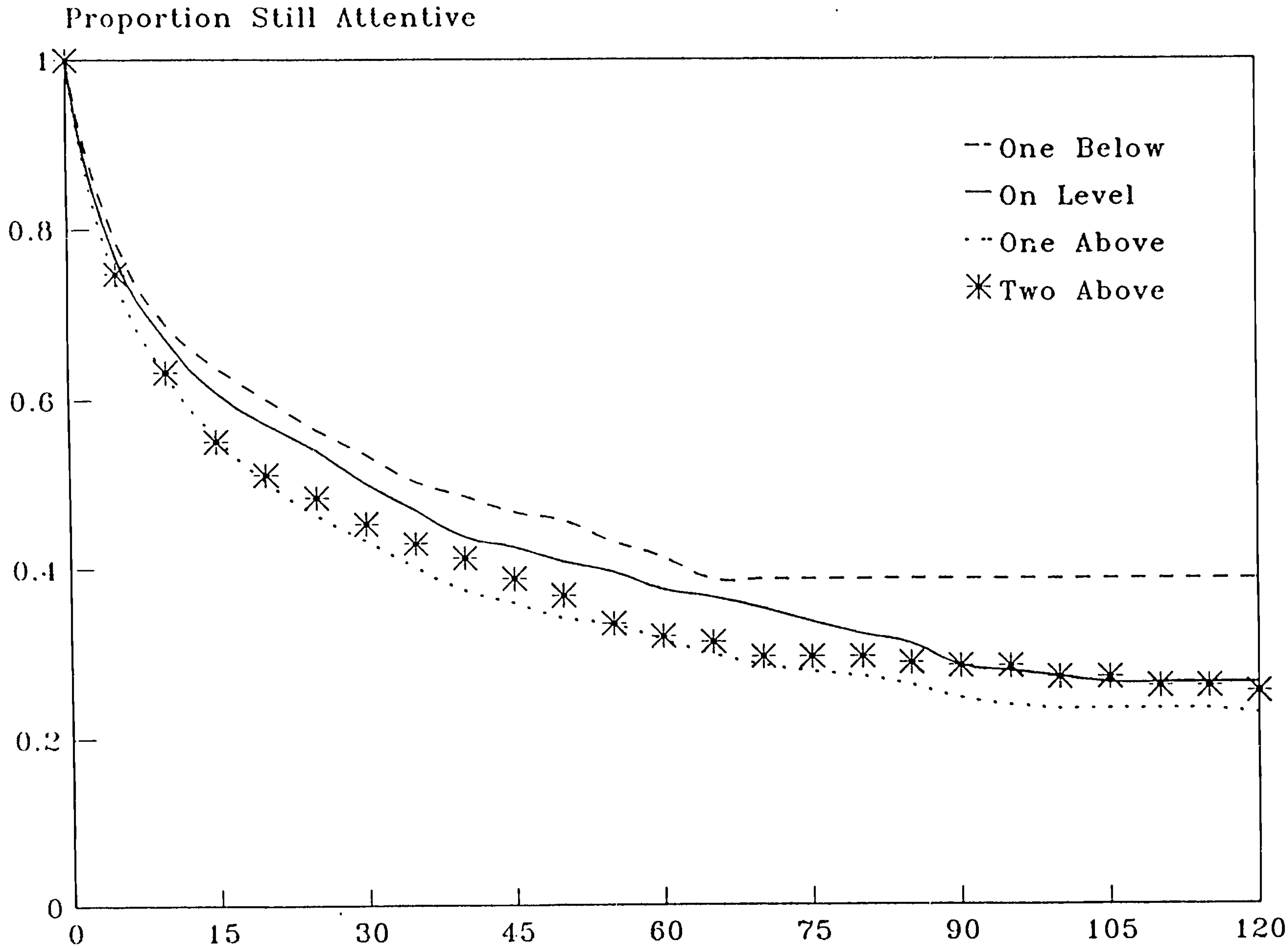

Figure 6. Proportion still attentive as a function of time and whether previously inattentive

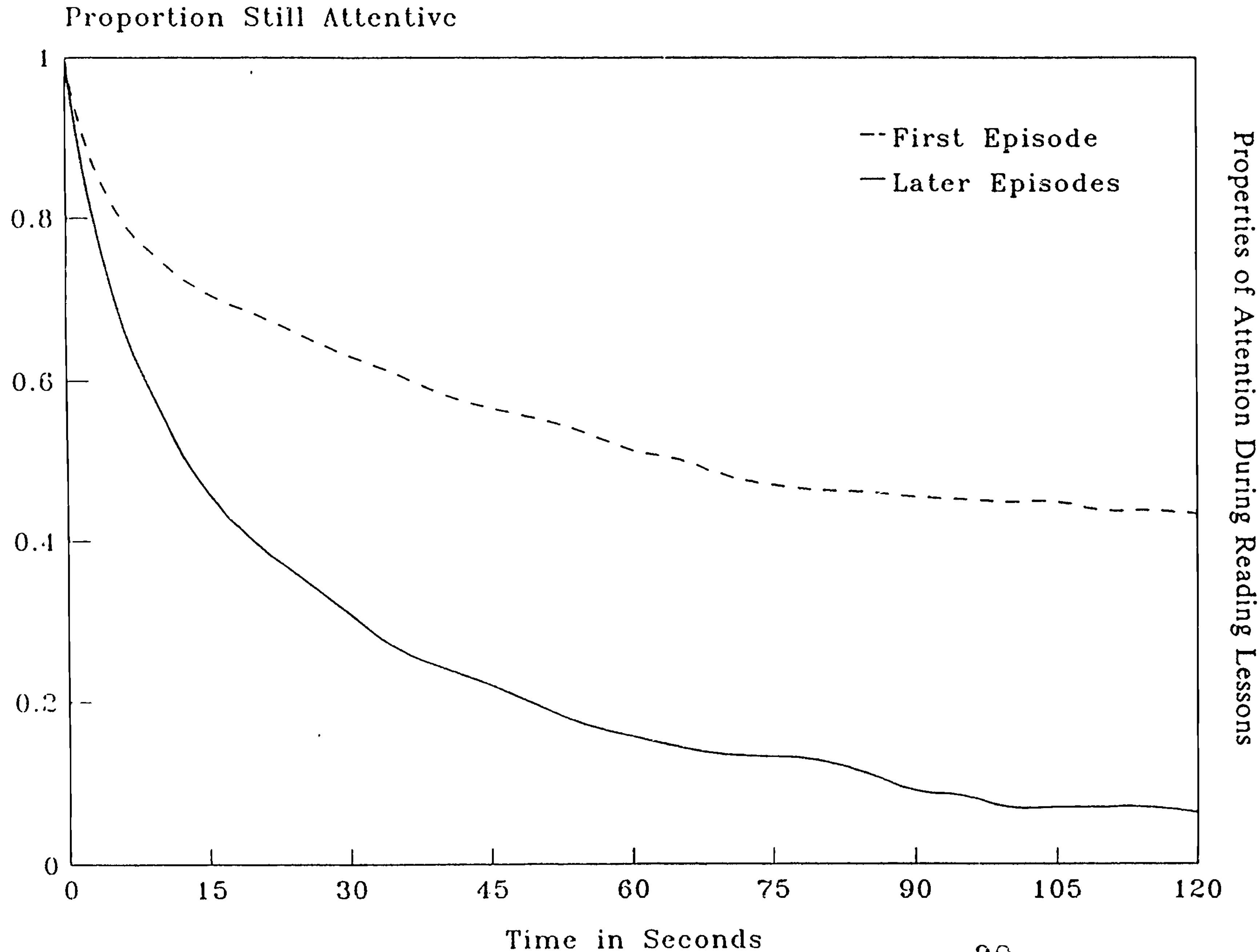

Figure 7. Joint effects of reading group and story difficulty on proportion still attentive as a function of time