Long-term temporal estimation in humans

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Although the ability of subjects to judge the duration of a temporal interval has been investigated using a variety of paradigms, most of the studies have used very short intervals ranging from a few hundred milliseconds to several seconds. Therefore, the purpose of the present study was to examine the psychophysical relationship between judged and actual durations of longer intervals ranging from months to years. In Experiment 1, college students were asked to estimate the ages of 12 major news events which had occurred during the previous 5 years. Analysis of median estimates of each item showed that subjects underestimated the ages of the oldest items and overestimated the ages of the most recent items. To determine whether this regression effect was due to a response bias or to the context effect produced by other items on the questionnaire, Experiments 2 and 3 systematically varied the range of allowable response alternatives and the age of the background items that formed the context in which the experimental items were judged. Although the range of allowable response alternatives had a significant effect upon the estimates, no evidence was obtained for an item context effect. The data are interpreted in terms of a memory-based hypothesis which suggests that the subjects were attempting to recall the time of occurrence of the items and then deriving elapsed time rather than directly judging duration.

The ability of subjects to judge the duration of a temporal interval has been closely investigated via a variety of paradigms (see Dember & Warm, 1979, Eisler, 1976, Fraisse, 1963, Ornstein, 1969, and Schiffman, 1976, for summaries). One indication of the extent of this work is evident in Zelkind and Sprug (1974), who cited nearly 1,200 studies relevant to human time perception. Virtually all of this work has been conducted using experimentally generated intervals ranging from a few hundred milliseconds through approximately 30 sec, with the intervals typically defined by the onset and offset of a stimulus. Although the data are not entirely consistent, there seems to be a consensus (e.g., see Eisler, 1976) that duration estimates, when plotted against actual duration, are best fit by a power function with a slope less than 1.0 and an intercept greater than 0, thus yielding overestimation and underestimation of the shortest and longest intervals, respectively.

It would seem to be possible, at least from a methodological viewpoint, to extend this work by examining the functional relationship between judged and actual duration for much longer intervals, ranging over months or even years. Such intervals could not, of course, be generated directly in the laboratory, but

appropriate data might be obtained by asking subjects to judge the amount of time that had elapsed since the occurrence of some event. Relevant psychophysical data could then be obtained by varying the actual ages of the items being judged.

Although a few studies have measured judgments of longer intervals, these studies have not used procedures that allow the discovery of psychophysical relationships between judged and actual durations for intervals lying within the realm of the subject's personal experience. For example, Squire and his associates (Squire, 1975; Squire, Chace, & Slater, 1975; Squire & Slater, 1975; Squire, Slater, & Chace, 1975) have used a multiple-alternative forced-choice technique for obtaining relative recency judgments about the elapsed time since various television shows were aired. Their data, although establishing that these judgments became less accurate over time, cannot be used to assess the functional relationship between actual and judged duration. On the other hand, Bratfisch, Ekman, Lundsberg, and Kruger (1971), using a magnitude estimation procedure, did obtain psychophysical data for the judgment of long temporal intervals. The intervals used in their experiment ranged across several centuries (e.g., "How long ago did William the Conqueror live?"), and the subjects' estimates were found to be fit by a power function with an exponent of .43. However, the estimation of such intervals, which extend beyond the lifetime of the subject, presumably require judgmental processes fundamentally different from those involved in the immediate perception of temporal intervals. Therefore, the purpose of the present study

This research was partially supported by Grant 2-S06-RR08090-10 from the National Institute of Mental Health. Part of this work was presented at the annual meeting of the Southeastern Psychological Association in March 1981, Atlanta, Georgia. R. P. Ferguson's mailing address is: Department of Psychology, Box 79, Virginia State University, Petersburg, Virginia 23803.

was to examine the psychophysical relationship between judged and actual durations for intervals that exceeded those in the traditional literature on time perception but were within the immediate experience of our subjects.

EXPERIMENT 1

Method

Subjects. The subjects were 40 female and 23 male college students. All subjects were volunteers and were members of two introductory psychology classes at Virginia State University.

Stimuli. The stimuli consisted of 12 major news events which pilot data had indicated were familiar to our subject population. The age of 12 events, as measured by the number of months intervening between the occurrence of the event and the time of testing, ranged from 3 through 55 months. Typical events included the capture of Patty Hearst (55 months) and the visit of Pope John Paul II to the U.S. (7 months). These 12 items were ordered randomly on a two-page questionnaire with a time line accompanying each item. Each time line represented time ranging from the present through 5+ years in the past, with various temporal points (e.g., 6 months, 1 year, 2 years, etc.) that served as anchors marked at appropriate points on each line. At the top of the first page of the questionnaire there also appeared blanks for the subject's age and sex along with the instructions for the experiment. The instructions indicated that the subject was to judge how long ago each event had occurred and to indicate his or her estimate by making a vertical mark at an appropriate point on the time line for the item. The instructions also included the statement that an item was to be left blank if the subject could not recall hearing or reading about the event at the time of its occurrence.

Procedure. The subjects were tested during one regular class meeting for each of two sections of an introductory psychology class, with approximately 30 students in each section. After a brief introduction to the nature of the task and a statement that participation was voluntary, the questionnaires were distributed and time was provided for the students to read the instructions. Any questions were then answered and the subjects were allowed to fill out the questionnaires. The total time required for the procedure was approximately 15 min.

Results

Responses to each item were scored by measuring the distance of the subject's vertical mark from the point on the time line that indicated the present, and then converting from inches to months. On those

Table 1
Summary Data for the Subjects' Estimates in
Experiment 1

Item Age	Median	SD
3	6	10.3
4	8	11.1
6	10	7.0
9	15	17.4
11	12	7.7
14	12	10.4
21	18	12.7
29	24	13.8
38	36	11.2
48	33	18.4
55	48	14.7

Note—Item age in months.

Figure 1. The data from Experiment 1 showing median estimates for the judged items along with the best-fitting linear regression function in log-log coordinates ($y = .45 + .66x$).

relatively rare occasions when the mark fell in the region labeled "5+ years," a response of 65 months was recorded. These data were then tabled and inspected to determine the number of subjects who responded to each item. In spite of the fact that the items had been pretested for familiarity, one of the items (the New York City blackout) was left blank by 28 of the 63 subjects. Since this omission rate was more than twice that of any other item, this item was dropped from all subsequent analyses. The data were then reinspected to determine the total number of events estimated by each subject. Ten of the subjects failed to provide estimates on at least 4 of the remaining 11 items. The data from these subjects were discarded, yielding estimates from a total of 53 subjects, each of whom responded to at least 8 of the 11 items. These data are summarized in Table 1.

Median estimates for each item were calculated and plotted as a function of actual item ages (Figure 1). These data were found to be fit by a straight line with a slope of .66 and an intercept of .45 when expressed in log-log coordinates ($r = .97$). Inspection of the standard deviations of the estimates in Table 1 also indicates that there is little systematic change in absolute response variability across increasingly long intervals. A regression analysis performed on the standard deviations across item age yielded a slope of .111, which was not significantly different from 0 ($\alpha = .05$).

DISCUSSION

The data from the regression analysis, along with the variability data, are strikingly similar to results

obtained when much shorter intervals are investigated (see Allan & Kristofferson, 1974, Eisler, 1976, Gilliland & Humphreys, 1943, Poppel, 1978, and Stevens & Greenbaum, 1966, for both reviews and original data on these issues). These similarities between the present data and the previous literature may, of course, be fortuitous. However, they may also suggest the operation of one or more common factors which influence subjects' judgments of both long and short temporal intervals. The nature of any such variables is unclear, although it seems unlikely that they involve the subjective experience of time, per se, since the tasks the subjects are asked to perform in the two procedures are so discrepant. That is, it is difficult to envision any mechanism for temporal perception that would be equally applicable for duration judgment of intervals that span both a few seconds and a few years. Thus, it seems more reasonable to expect that factors other than those involved in temporal perception per se are responsible for the observed similarities in the data.

One obvious possibility is a phenomenon that has been called the regression effect (Stevens & Greenbaum, 1966) and Vierordt's law (Bobko, Schiffman, Castino, & Chiapetta, 1977; Underwood, 1966). This effect, which has been repeatedly demonstrated in the previous time-estimation literature, (1) refers simply to the fact that subjects tend to overestimate short intervals and underestimate long intervals, and (2) has been suggested to depend either upon the range of response alternatives available to the subject (Stevens & Greenbaum, 1966) or the range of other stimulus durations presented in the experiment (Bobko et al., 1977; Schiffman, Bobko, & Thompson, 1977). We therefore designed Experiment 2 in an attempt to isolate these two explanations of the phenomenon and to determine the extent to which either is operative in the present procedure.

EXPERIMENT 2

Method

Subjects. The subjects were 78 college students, primarily from introductory psychology courses, who volunteered to participate in the study.

Stimuli. The stimuli consisted of 24 major news events. Eight of the items, termed critical items, were from 5 to 25 months old at

the time of testing and were judged by all subjects in the experiment.

Of the remaining 16 events, which were termed background items, 8 were 6-24 months old (the "new" background items) and 8 were 27-60 months old (the "old" background items). The 8 critical items were combined with either the new or the old background items and then randomly ordered on a 3-page questionnaire. Each item was accompanied by a time line on which the subjects marked their estimates of the item ages. At the top of the first page of each questionnaire were blanks for the subject's age and sex along with printed instructions for filling out the form, which were identical to the instructions in Experiment 1.

Procedure. All subjects were tested during regular class meetings in groups of 15-30. Three forms of the questionnaire, representing three experimental conditions, were distributed randomly in each class. Following a brief introduction, the subjects were asked to read the instructions, any questions were answered, and the forms were completed. The entire procedure required approximately 15 min.

For approximately one-third of the subjects (Group 1), the eight critical items were combined with eight "new" background events and accompanied by time lines which allowed responses of 0-2+ years. A second group (Group 2) judged the same 16 items but were provided with response lines for 0-5+ years. For the remaining third of the subjects (Group 3), the eight critical items were intermixed with the eight "old" background items and were accompanied by time lines for 0-5+ years. Thus, all subjects in the experiment judged the same set of eight critical events, which were either the same age or newer than the eight background items. The 5-year lines were identical in scale to the 2-year lines; they were simply replicas of 2-year lines extended for 3 additional years.

Results

The answer sheets were scored using the same method employed in Experiment 1, and the median estimate for each critical item was calculated for each group (Table 2). When plotted against the actual item ages, these medians were found to be fit by power functions (Figure 2), the parameters of which are shown in Table 2.

Comparison of the slopes and intercepts of these three regression lines (Kleinbaum & Kupper, 1978) indicated that the two groups using the 0-5+ year response line (Groups 2 and 3) did not differ from each other in either slope or intercept, whereas both groups differed from Group 1, which used the 0-2+ year response line.

In addition, as in Experiment 1, the standard deviations of the estimates (Table 2) remained relatively constant across the ages for all three experimental conditions. Regression analyses performed on the standard deviations across age for each experimental

Table 2
Median Estimates, Log-Log Regression Parameters, and Correlation Coefficients for Experiment 2

Condition	Item Age (Months)															S	I	r	
	5		7		11		13		17		21		23		25				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean				SD
2-Year Items; 2-Year Lines	9	5.7	12	6.0	13.2	6.3	12	7.3	18	6.7	24	6.6	17	7.3	24	6.6	.54 ^a	.57 ^c	.91
2-Year Items; 5-Year Lines	6	10.0	11	9.6	12	3.8	10.7	4.7	15	9.7	21.5	8.4	24	7.7	24	9.5	.79 ^b	.28 ^d	.95
5-Year Items; 5-Year Lines	6	8.8	12	7.1	12	10.3	10.5	5.5	16	9.4	24	9.9	23.5	6.5	24	11.7	.79 ^b	.26 ^d	.93

Note—Slopes (S) and intercepts (I) with different letter designations are statistically different ($\alpha = .05$).

Figure 2. The linear regression functions for the median estimates for the three groups in Experiment 2. The slope and intercept of each regression line is given in Table 2.

group yielded slopes of .024 (new items, 5-year lines), .085 (old items, 5-year lines), and .050 (new items, 2-year lines). None of these slopes was significantly different from 0 with an alpha level of .05.

If all 16 items judged by the subjects in Group 3 in this experiment are considered together, then this group represents a replication of the conditions of the first experiment, although a different set of judged events was used. Therefore, we compared the slope and intercept of the least squares regression line for the 16 medians of Group 3 with the corresponding values from Experiment 1. The data for the two experiments did not differ in either slope [$t(23) = 1.82$, $p > .05$] or intercept [$t(23) = 1.53$, $p > .05$].

Discussion

The data from Experiment 2 support several general conclusions concerning subjects' estimates of long temporal intervals. First, power functions with slopes less than 1.0 and intercepts greater than 0 were again found to fit the data, and the variability of the temporal estimates was relatively constant across item age in all three experimental conditions. Second, the range of allowable response alternatives had a significant effect upon the slopes and intercepts of the regression lines, with a flatter slope occurring when the response range was reduced from 5+ to 2+ years. Finally, no evidence was obtained for an item context effect. That is, subjects are apparently capable of estimating the age of an item independently of the age of the other items they have judged in the task, because the age of the background items had no measurable effect upon the regression lines for Groups 2 and 3.

These data thus suggest that the regression effect is sensitive to the range of allowable response alternatives such that, if the response variable is "artificially

restricted to a short range, a large regression effect will most likely ensue" (Stevens & Greenbaum, 1966, p. 444). The data are not, however, consistent with the expectation that item context effects should influence temporal judgment. The lack of context effect may have been due to insufficient exposure to the contextual items (Bobko et al., 1977) or to the fact that the present methodology is similar to the more traditional method of verbal estimation, which has been reported to be relatively insensitive to item context effects (Schiffman et al., 1977). We therefore designed Experiment 3 in an attempt to replicate the line-length effect and to determine whether item context effects might become apparent under conditions of more extreme manipulation.

EXPERIMENT 3

Method

Subjects. A total of 192 students enrolled in introductory psychology courses at Virginia State University volunteered as subjects. Approximately half of the subjects were males, and half were females.

Stimuli. Two major news events (the Russian invasion of Afghanistan and the departure of the Shah from the United States for Panama following surgery) were termed "critical" items. These events were 12 and 11 months old, respectively, at the time of testing and were familiar to more than 90% of subjects tested in pilot work. Twenty-four additional "background" items were also used in the experiment; half were 1-7 months old (the "new" items) and half were 26-60 months old (the "old" items). Pilot work had indicated that a minimum of 75% of our subjects were familiar with each of these items. A total of 13 items—1 critical and 12 background items—were combined into test booklets with a single item plus a response line on each page.

Procedure. The design of the experiment was a $2 \times 2 \times 2$ between-groups factorial, with the three variables being (1) the age of the background items (old vs. new), (2) the serial position of the critical item in the test booklet (first vs. last), and (3) the range of allowable response alternatives provided by the response line (0-2+ years vs. 0-10+ years). The two critical items were counter-balanced across and within the eight experimental conditions.

All subjects were tested during regular class meetings in groups of 20-40. After a brief introduction, instructions identical to those used in Experiments 1 and 2 were read, any questions were answered, and the booklets were distributed. The eight forms of the booklets representing the eight experimental conditions were distributed randomly in each class, yielding an approximate N of 24 in each condition. The entire procedure lasted approximately 15 min.

Results

The responses to all 13 test items per subject were scored using the same procedure as in Experiments 1 and 2. Mean estimates of the critical items for each of the eight experimental groups (Table 3) were then calculated and analyzed by a $2 \times 2 \times 2$ between-groups analysis of variance. None of the main effects and none of the interactions were significant at an alpha level of .05.

The data from the 12 background items were also analyzed. In order to perform these analyses, the data from the two groups that used the 0-2+ year

Table 3
Mean Estimates of the Critical Item in Experiment 3

Line Length	Background Item Age							
	1-7 Months				26-64 Months			
	Serial Position 1		Serial Position 2		Serial Position 1		Serial Position 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0-2 +Years	11.13	4.73	14.29	6.80	12.13	6.42	13.09	7.51
0-10+Years	13.14	6.84	13.36	6.02	13.83	7.36	17.86	10.80

response lines to judge the old items were discarded because they were judged to be essentially meaningless (i.e., the modal response for all of the items in these conditions was either 24 months or 2+ years). Since the analysis of variance revealed no significant effects due to the serial position of the critical item, the data from the background items for the remaining six groups were combined to form three groups: (1) new items, 2-year line; (2) new items, 10-year line; and (3) old items, 10-year line. The slopes and intercepts of the least squares regression lines that best fit these data are shown in Table 4. Since the correlation coefficients for these three sets of data were lower than those obtained in the first two experiments, an analysis of variance to test for goodness of fit was performed on the data from each group. All three analyses yielded statistically significant effects for linear regression ($\alpha = .05$), while none showed a significant effect for departure from linearity, thus reconfirming that data from this type of task are adequately represented as power functions with slopes less than 1.0.

Although the slope of the regression line for the subjects judging recent events on a 10-year line appeared to be much lower than the slopes of the regression lines for the other two groups, statistical comparisons of the slopes (Kleinbaum & Kupper, 1978) indicated that they did not differ significantly from each other.

The data from this experiment as well as the two previous experiments consistently show that subjects overestimate short intervals and underestimate long intervals. Therefore, we decided to plot the data from all three experiments on the same axis so that the patterns of over- and underestimation could be compared more easily. As can be seen in Figure 3,

where proportion of error is plotted as a function of item age, subjects from all experimental conditions in all three experiments greatly overestimated the age of events occurring within the past 9 months, and only slightly underestimated the ages of items that were a year old or older. Thus, the direction and amount of error made by subjects in all three experiments seem to be determined more by the actual age of each item judged than by the context provided by other items or by the range of response alternatives.

Finally, inspection of Table 5 suggests that, as in Experiments 1 and 2, there is little change in response variability across the range of intervals used in the experiment. In order to confirm this observation, regression analyses were performed on the standard deviations across item age. The obtained slopes were .122 (2-year line, new items), .138 (10-year line, old items), and .274 (10-year line, new items), none of which was significantly different from 0 with an alpha level of .05.

In spite of the fact that no significant relationship between response variability and item age was obtained within any of the individual conditions in three experiments, inspection of the data across experiments (see Tables 1, 2, and 5) suggests that a relationship, albeit a weak one, may nonetheless exist. That is, it appears that as the age of the items being judged is increased and the range of response alternatives is widened, there is a small, but rather consistent, tendency for the standard deviations of the responses to also increase. For example, the mean standard deviation for subjects in Experiment 3 who used the 10-year line to judge 2-5-year-old items was 15.2, whereas that for subjects using the 2-year line to judge 1-7-month-old items was 5.6.

Discussion

The results of this experiment show that, first, no item context effects were found, even though the ages of the background items were manipulated so as to be either much younger or much older than the critical item. Although contextual effects have been reported in other studies using much shorter intervals (e.g., Bobko et al., 1977), Schiffman, Bobko, and Thompson (1977) found that when direct scaling procedures were used to estimate intervals ranging from

Table 4
Summary Data from the Background Items in Experiment 3

BIA	LL	S	I	r
1-7	0-2	.727	.320	.795
1-7	0-10	.506	.546	.613
26-64	0-10	.864	.154	.839

Note—BIA = background item age; LL = line length; S = slope; I = intercept.

Figure 3. Proportion of error as a function of item age for all items from the three experiments. Each line represents data from one condition of one experiment.

1 to 49 sec, contextual effects did not occur. Since a similar direct scaling procedure was used in the present experiment, it is likely that item context effects are a function of the psychophysical procedure being used rather than the relative ages or durations of the stimuli being judged.

Analysis of the background items also showed that each new (1-7-month-old) item was overestimated and each old (26-60-month) item was slightly underestimated, regardless of the relative age of the item compared with the others being judged by the subjects. This point is illustrated by the data from the 7-month-old item. In spite of the fact that it was the oldest item judged by those subjects who saw it (and,

thus, should be underestimated if judged relative to the rest of the items), subjects in all four groups overjudged its age, although by a lesser extent than they did the 1-month item. Analogous patterns can be seen in the groups who judged the old (26-60-month) items. In other words, these data suggest that temporal intervals in the range included in this study are estimated on the basis of an absolute scale which is a power function of calendar, or actual, age.

GENERAL DISCUSSION

The data from these three experiments provide consistent support for two general conclusions about

Table 5
Median and Standard Deviations of Estimates from Experiment 3

New Items Condition					Old Items Condition		
Item Age	2-Year Lines		10-Year Lines		Item Age	10-Year Lines	
	Mean	SD	Mean	SD		Mean	SD
1	1.5	2.58	2	4.92	26	30	14.2
2	5.5	5.69	6	6.71	28	25	11.9
3	7.25	8.98	8	6.43	28	29	13.3
3	4	8.92	12	6.98	29	24	11.2
4	4	3.53	6	10.28	33	24	19.9
4	8.5	6.15	11	6.26	34	32.5	12.8
6	7	4.89	8	5.16	35	29	11.65
6	6	4.95	8	4.58	41	30	19.0
6	8	5.15	9	6.14	42	36	17.66
6	10	5.87	5.5	5.74	47	38.5	13.51
7	8	5.21	9	3.81	57	44.5	20.60
					64	60	16.90

subjects' estimates of relatively long temporal intervals. First, it seems clear that individual estimates are largely independent of one another since: (1) none of the experiments yielded any evidence of an item context effect, and (2) the variability of the estimates was constant across the range of item ages used in each experimental condition.

Second, the present data also clearly demonstrate that items less than 9-12 months old are overestimated, with the degree of overestimation being inversely related to age, while items older than approximately 12 months tend to be judged rather accurately, with some tendency towards underestimation (see Figure 3). Furthermore, this pattern of over- and underestimation is largely independent of the range of item ages presented, but does seem to be influenced somewhat by the range of response alternatives provided to the subject.

One way to account for these patterns is to consider the possible strategies available to subjects in the present procedure. Although the task is presented as one in which the subject is to directly estimate the duration of the interval that has elapsed since the occurrence of the event, another possible approach would be for the subject to convert it to a memory task by attempting to recall the absolute time at which the event occurred, and then to derive the elapsed time (e.g., "I remember reading about the event last Christmas, so it must have been 10 months ago"). Alternatively, for those events about which absolute temporal information is not available to the subject, an attempt can be made to relate the item to another significant event for which the needed information can be recalled (e.g., "I am not sure when event A occurred, but it seems to have been around the same time as event B, and event B happened last Christmas"). If both of these first two approaches fail, the subject can then attempt to estimate directly the length of the elapsed interval.

This hypothesized "time-tag" strategy has the advantage of being capable of accounting for both of the major findings in the present data. First, the hypothesis predicts that the estimate should be independent, since those estimates are viewed as being based largely upon the absolute time of occurrence of the individual events. Second, the hypothesis also accounts for the obtained patterns of overestimation and underestimation. Although the items included on the questionnaires were familiar to the subjects, most dealt with distant events (e.g., the signing of the Egyptian-Israeli peace treaty) which would not be particularly salient in the lives of most college students and therefore might not be "tagged" with absolute temporal information, hence necessitating the association strategy described above. As a result, older critical items, which would be equally likely to be associated with either prior or subsequent events, should yield relatively accurate means or median es-

timates across subjects. Conversely, as item age decreases, it should become more likely that the tested events will be associated with preceding (as opposed to subsequent) events, thus yielding relatively greater degrees of overestimation with decreasing item age.

Although there is no direct experimental evidence that this time-tag strategy was actually employed by our subjects, the spontaneous postexperimental comments made by several of them suggest that it may have been a relatively common practice. For example, one subject indicated that he had moved several times over the past few years and that, in estimating the ages of the items, he attempted to recall which house he was living in when the events occurred. Numerous other subjects made similar types of comments, and indicated that the items they found to be most difficult were those for which that strategy did not work.

In addition to the evidence concerning the independence of the estimates and the patterns of over- and underestimation, the data from Experiment 2 also indicated an effect due to line length or response range. This effect, which is apparently somewhat tenuous, since it was not confirmed in Experiment 3, may be attributable to a simple response bias in which subjects tend to avoid making extreme responses. As a result, restricting the range of allowable responses would have the effect of "pushing" responses relatively closer to the middle of the range, thereby decreasing the slope of the regression line and enhancing the regression effect, as found in Experiment 2. Furthermore, the time-tag hypothesis would suggest that this effect should not be particularly robust, since it should occur only for those events about which the subject has no information concerning the absolute time of occurrence. That is, if a subject can recall that an event occurred last Christmas, his estimate of the age of that item should be only minimally influenced by the range of responses provided by the experimenter; rather, he will simply calculate the number of months that have elapsed since Christmas and then make an appropriate indicator response.

In summary, the three experiments reported here represent one of the first attempts to study subjects' estimates of long temporal intervals using a methodology which makes it possible to identify the functional relationship between actual and estimated duration. Several patterns in the data from the experiments are similar to patterns obtained when much shorter intervals are employed, thus suggesting the possibility that both sets of data represent a common set of underlying processes. However, the fundamentally different nature of the two types of tasks would seem to mediate against this view. Instead, the present data have been interpreted within the context of an explanation that is based upon long-term memory processes and therefore is specific for the

type of task used here. In spite of the fact that this time-tag hypothesis seems to adequately account for the present data, it is nonetheless tentative, since it is based upon data from only three experiments and is entirely post hoc. As a result, the next step in this research needs to focus more directly upon the investigation of those processes and strategies actually employed by subjects in estimating long temporal intervals. Such work will not only provide additional insights into the present data, but also should aid in assessing the relationship of these data to the more traditional literature on time estimation.

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(Manuscript received April 14, 1982;

revision accepted for publication February 14, 1983).