Memory & Cognition
1976, Vol. 4(2), 215-220

Apparent duration of long meaningful events and meaningless intervals

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Time estimates of 1½-, 5¼-, and 14½-min intervals were obtained from 12 American graduate students and 12 Indian graduate students by the methods of verbal estimation and cross-modality matching. Material presented during stimulus intervals varied in degree of meaningfulness. Each subject was tested on 4 successive days with basically the same material in order to determine the effects of repetition. The relationship between perceived and physical time was found to follow Stevens' power law, and confidence limits of exponents obtained in this study include the exponents previously reported for short durations. Neither actual judgments nor exponents were affected by cultural background or by cognitive factors such as memory for material presented in the interval, familiarity, complexity, degree of meaningfulness, and repetition. It had previously been reported that time judgments were dependent on these cognitive factors. In light of the present research, it is necessary to review and replicate those studies which support a cognitive view of time perception.

Despite a long history of interest in the perception of time, its psychophysics remains relatively unstudied. Stevens (1957) and others have shown that a power law ($\psi = k\Phi^n$) might describe the relationship between psychological and physical time (Carlson & Feinberg, 1968; Chatterjea, 1964; Gregg, 1951; Ross & Katchmar, 1951; Ekman & Frankenhaeuser, Note 1), with reported exponents varying from .78 to 1.55 for durations ranging from 400 msec to 32 sec, and with no consistent relationship between duration magnitude and exponent magnitude. These exponents were derived from magnitude estimates of very short intervals which were empty or were filled with white noise or a steady tone. But time is usually filled with differentiated events, not with featureless white noise, and those events have been reported to alter the apparent duration of the period in which they occur (Goldfarb & Goldstone, 1963; Jerison & Smith, 1955; Loehlin, 1959; Roelofs & Zeeman, 1951), although no such effects have been looked for in the exponents derived from duration estimates.

If such effects were unsystematic, there would, of course, be little consequence to the study of the psychophysics of filled vs. empty intervals. In fact, however, the reported effects appear, in many cases, to be lawful ones: Apparent duration is affected by the number of events presented in the interval (Fraisse, 1963; Jones & MacLean, 1966; Matsuda, 1966; Ornstein, 1970; Suchoon, 1971); by the complexity of events (Ornstein, 1970; Van der Waals & Roeloffs, 1946); by the familiarity of events (von Sturmer, 1966; Warm, Greenberg, & Dube, 1964); by memory for events (Frankenhaeuser, 1959; MacLeod & Roff, 1935; Ornstein, 1970). In short, apparent duration is apparently affected by the organization of the events that fill the interval. Since organization as such was not explicitly manipulated in the above-mentioned studies, however, it becomes important to determine whether the organization does indeed affect the apparent duration of that interval in a lawful fashion: If the effects are lawful, psychophysical exponents derived from estimates of filled and unfilled intervals should differ, and the magnitudes of the exponents should vary with the organization of events.

But even more important is the possibility that such effects may make apparent duration a tool with which to measure the cognitive processing of the material with which the interval is filled. Indications that organization might affect time judgments come mainly from the work of Ornstein, and indirectly from the reported relationship between memory for events and duration estimates. Ornstein (1970) reports that organization does, in fact, affect time judgments: estimates of duration were found to vary inversely with the degree of organization of stimulus material.

Since organization has been reported to increase the amount of material remembered for lists of words (Cohen, 1963; Mandler, 1966; Tulving, 1962) and for sentences (Glanzer & Razel, 1974), and to decrease perceived duration, both memory measures and time estimates should be useful in predicting organization and, in fact, duration estimates should vary as a function of memory for material. Frankenhaeuser (1959) has reported an inverse relationship between amount remembered and time judgments, while Ornstein (1970) reports a direct relationship. These contradictory results could be due to procedural differences (e.g., Frankenhaeuser only *estimated*

This paper is based on a dissertation submitted to Columbia University in partial fulfillment of requirements for the PhD degree. I am indebted to Thomas Bever, Norma Graham, and Julian Hochberg for criticism during conduct of this research.

amount retained, while Ornstein measured it). It is difficult, however, to reconcile Ornstein's memory results with the hypothesis that flows most naturally from the results of his experiment on the effect of organization on perceived duration and the reported increase in memory with organization (Cohen, 1963; Glanzer & Razel, 1974; Mandler, 1966; Tulving, 1962); time judgments should vary inversely with memory rather than directly. Because organization was not an independent variable in either of Ornstein's experiments, however, the interrelationship between organization, time estimation, and memory has not been determined.

In the present studies, inferred organization was manipulated, and various measures of organization were obtained in order to determine the interrelationship between those measures. Specifically, time judgments, memory measures, perceived familiarity, and perceived complexity were used as measures of organization. Inferred organization was manipulated by using as stimuli stories that were known to vary in cultural familiarity, and by replicating this study with a group of subjects known to be differentially familiar with the stories. It is assumed that culturally familiar stories are more meaningful and better organized than unfamiliar stories. The two cultures represented are America and India. India was chosen because: (a) it is, to a great extent, an English-speaking country, (b) it is reported to have a different attitude toward time (Meade, 1966, 1968, 1972), and (c) the myths from that culture are different from the myths of Western cultures.

METHOD

American Subjects

Twelve male engineering graduate students at Columbia University between 21 and 26 years old and with a median age of 22.5 were paid $12 for their participation.

Indian Subjects

Twelve male engineering graduate students at the Institute of Indian Technology, Powai, Bombay, between 21 and 26 years old, with a median age of 23 years, were recruited with the help of an acquaintance at the Institute. Eight subjects were of the Brahmin caste, two were of the Vaisya caste, and two were of the Kshatriya caste. Subjects were offered $3 for their participation (an amount comparable to that given American subjects), but they refused the money and instructed the experimenter to donate it to charity.

Materials

Rating scales were used to elicit judgments of stimulus familiarity and to elicit judgments of stimulus complexity. Possible ratings for both scales ranged from 1 to 7, 1 being not at all familiar/complex and 7 being very familiar/complex.

Stimulus material consisted of tape recordings of three Indian myths—"The Virtue of Compassion," "Uma," and "Manasa Devi" (Nivedita & Coomarasevamy, 1967)—and three Greek myths—"Glaucus and Scylla," "Arachne," and "Pentheus" (Warner, 1967)—spoken by an American female; tape recordings of the same three Indian and three Greek myths spoken by an Indian female; and tape recordings of three durations of tones. Each Indian and Greek myth was adjusted to one of three lengths, as measured by the number of words the myth contained—i.e., 256, 906, and 2,556 words. This was done by deleting some descriptive words or events irrelevant to the main theme. In order to insure that such elimination of words did not disrupt the continuity and clarity of the stories, three Indian students at Columbia University were asked to read the shortened Indian myths and three American students at Columbia College were asked to read the shortened Greek myths. Readers reported no difficulty in understanding the shortened myths. Durations in seconds for the myths read by the American were: Greek myths, 83, 315, and 862 sec; Indian myths, 88, 319, and 864 sec. Durations in seconds for the myths read by the Indian were: Greek myths, 95, 335, and 952 sec; Indian myths, 93, 348, and 939 sec.

A tone generator was used to make tape recordings of a 121.5-Hz tone for three different durations: 98, 315, and 870 sec.

Experimental apparatus consisted of a Sony casette tape recorder, Model TC 110 A, two sets of monaural headphones, a Sony microphone, a 5 lb cone of twine (approximate yield: 900,000 cm), a pair of scissors, and a 25-cm length of twine (used as the length of twine corresponding to the 315-sec duration tone which is designated as the standard duration).

Procedure

All subjects were tested individually by the experimenter. Indian subjects were tested in India, and American subjects in America. The subjects sat in a quiet room at an empty desk facing a bare wall, with their backs to the experimenter. They were informed at the beginning of the session that this was an experiment in time perception, and were therefore requested to give their watches to the experimenter. They were also informed at this time that they would be paid either $12 (American subjects) or $3 (Indian subjects) at the end of the experiment, regardless of how they performed.

Each subject participated in four sessions occurring on 4 successive days. The first session (Day 1) lasted approximately 2.5 h, and the remaining sessions (Days 2, 3, and 4) lasted approximately 1 h each. On Day 1, subjects listened to a standard tone (315 sec) followed by the three tones (98, 315, and 870 sec) in counterbalanced order. After a brief rest (approximately 5 min), the subjects listened to the "standard" tone followed by the six myths in counterbalanced order. In the latter case, the only constraint on order was that no two myths of the same culture or of the same duration follow each other. On Days 2, 3, and 4, the subjects listened to the "standard" tone followed either by the three tones (98, 315, and 870 sec) or by the middle-duration Greek and Indian myths. After a brief rest, subjects listened to the "standard" tone followed either by the middle-duration Greek and Indian myths or by the three tones. Presentation orders of tones and myths were counterbalanced over days. Stimulus material was presented binaurally through headphones, with intensity remaining constant throughout a session. For each subject, the experimenter adjusted the intensity until the subject said the intensity level was comfortable. Myths recorded by the Indian reader were presented to Indian subjects, and myths recorded by the American reader were presented to American subjects.

After hearing each stimulus, the subjects were asked to estimate the duration of the stimulus-filled interval. Two methods were used to estimate duration. The subjects were first asked to use a magnitude estimation technique. This was always followed by a verbal estimate in minutes and seconds. The magnitude estimation task (which has not been used previously) consisted of cutting off a piece of string from a 5 lb cone of twine, whose length corresponded to the duration of the preceding interval. This procedure was devised in order to obtain estimates of time which were not dependent upon subjects' experience with the number system and with traditional time units, and to test a nonverbal method for possible future use. A standard duration (315 sec) and its corresponding string length (25 cm) was presented prior to the presentation of the three tones and again prior to the presentation of the six myths. The subjects were not informed of the accuracy of their time judgments.

On all 4 days, following the estimation task, the subjects were asked to retell as much of the myth as they could remember, taking as much time as they required. Recitations were tape-recorded. The subjects were then asked to rate the familiarity of the myth they had just heard. Following this, the next myth was presented. After all myths had been presented, the subjects filled out the complexity rating questionnaire. The experiment was not discussed with the subject until all 4 days had been completed.

RESULTS

Throughout this section, results are given for the "string length" magnitude estimation technique only. Since all subjects gave string length estimates first, it is possible that, when comparing verbal estimates, one might in fact be comparing how subjects translate string length estimates into verbal estimates. Results obtained from verbal estimates are consistent with string length estimates, i.e., correlations between exponents derived under the two methods range from .52 to .88 within comparable conditions, with a median of .66.

It appears that Stevens' power law ($\psi = k\Phi^n$) does, in fact, describe the relationship between psychological and physical duration for long durations when the medians of all subjects' estimates are considered, and that this relationship is relatively stable regardless of the type of material presented in the interval (see Figure 1).

The magnitude of the exponent (n) is not appreciably affected by the duration of the interval estimated, by the type of material presented in the interval, by the cultural background of subjects making the judgments, or by the number of repetitions of the interval. Exponents derived from median magnitude estimates of long durations are similar to those reported previously for short durations: Confidence intervals computed for the median exponents (Walker & Lev, 1953, p. 440) include exponents previously reported (see Table 1).

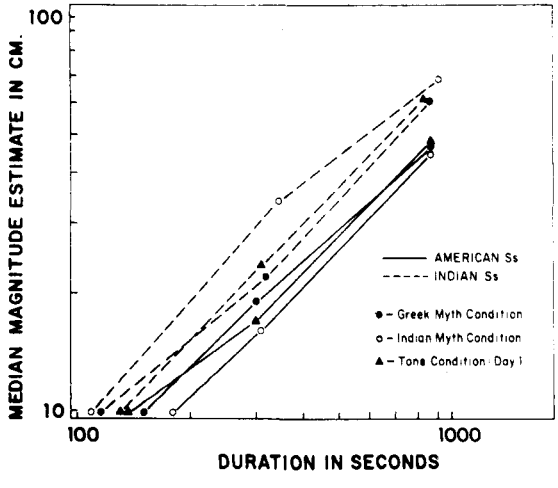

Figure 1. Median magnitude estimates of duration as a function of duration plotted in logarithmic coordinates.

Table 1
Exponents and Confidence Limits of Exponents Derived from Median Magnitude Estimations for Filled Durations

Condition	Exponent	96% Confidence Limits
American Subjects		
Greek Myths	.86	.72-1.10
Indian Myths	.89	.60-1.16
Tones		
Day 1	.81	.70-1.16
Day 2	.88	.70-1.07
Day 3	.86	.76-1.02
Day 4	1.01	.83-1.10
Indian Subjects		
Greek Myths	.91	.58-1.04
Indian Myths	.93	.67-1.02
Tones		
Day 1	.97	.79-1.11
Day 2	.81	.72-1.03
Day 3	.87	.77-1.10
Day 4	.90	.71-1.09

Analyses of variance indicated that exponent magnitude is not affected by type of material presented in the interval for either Americans or Indians, both ps $> .25$. Exponents derived from American and Indian subjects do not differ significantly under the three conditions: tone condition-Day 1, tone condition-Day 2, tone condition-Day 3, tone condition-Day 4, Greek myth condition, and Indian myth condition, all ps $> .25$. In addition, analyses of variance indicated that exponents derived under the tone condition are not significantly affected by number of repetitions for either cultural group, American subjects or Indian subjects, both Fs < 1.

In order to determine whether familiarity of stimulus material affects duration estimates, as distinct from exponents, subjects' actual duration estimates for the three durations were compared across the three conditions, i.e., Greek myths, Indian myths, and tones. Since short, middle, and long intervals differed slightly in duration under the three conditions, individual estimates were divided by the appropriate string length for that duration (i.e., the middle duration tone of 315 sec was equal to 25 cm, and, by interpolation, appropriate line lengths for the other durations were computed), yielding corrected centimeter estimates. All calculations presented in this section are based on such corrected estimates.

Although magnitude estimates are not normally distributed (Stevens, 1958), time estimates have been treated parametrically in previous research, and parametric tests were used here as well as nonparametric ones in order to make the present results comparable. Because so few of the results were significant, and because the nonparametric tests performed on the data yield results similar to the parametric treatment, results of the nonparametric tests are not reported.

A 3 by 3 by 2 (Duration by Type of Filling by Cultural Background) analysis of variance was performed on the corrected centimeter estimates obtained on Day 1. Because variances were not originally homogeneous, and because a logarithmic transformation did not result in homogeneity of variance, the following results should be considered cautiously. The type of event with which the interval is filled does not significantly affect duration estimates, $F < 1$, and the interaction effects (i.e., Type of Filling by Subjects and Duration by Subjects) are not significant, both ps $> .25$. Both culture, $F(1,22) = 5.29$, $p < .05$, $MS_e = .08$, and duration, $F(2,44) = 8.12$, $p < .01$, $MS_e = .03$, significantly affected duration, with Indian subjects giving the longer estimates under all conditions. For example, for the three conditions combined, means and ranges of corrected estimates obtained from Indian subjects are: short duration, 1.19 with a range of .45 to 2.23; middle duration, 1.04 with a range of .63 to 2.08; long duration, .88 with a range of .32 to 1.66. For American subjects, means and ranges of corrected estimates are: short duration, .99 with a range of .38 to 1.92; middle duration, .75 with a range of .43 to 1.21; long duration, .77 with a range of .31 to 1.49. The direction of this difference holds up over the remaining 3 days under the tone condition, long duration. However, under the other conditions and durations, corrected estimates are generally higher for American subjects than for Indian subjects, although the differences between the two groups are smaller than on Day 1. Over the remaining 3 days, means for Indian subjects range from 1.09 to 1.14 for the short duration, from .80 to .96 for the middle duration, and from .90 to 1.00 for the long duration. Means for American subjects range from 1.10 to 1.18 for the short duration, from .85 to 1.10 for the middle duration, and from .85 to .91 for the long duration. Cultural background may affect duration estimates, therefore, even though this factor does not affect exponents derived from estimates. And the apparent duration is indeed affected by the physical duration.

Paired t tests comparing corrected estimates given under the three conditions over the 4 days of testing for each duration yield one significant difference ($p < .05$) out of 36 comparisons—a result expected by chance alone. Thus it is clear that, for both cultural groups of subjects, mean estimates of durations that are filled with relatively meaningless and unchanging material (tones) do not differ significantly from those of durations filled with meaningful material (myths), nor do estimates of the two types of myths differ significantly from each other is most cases.

The effect of repetition on duration estimates was also investigated for the three durations of tones and for the two types of myths. It was expected that culturally unfamiliar material would become more meaningful (and therefore better organized) with repetition, and that this increase in meaningfulness would be reflected in changes in the duration estimates. To determine whether changes in duration estimates occurred with repetition, paired t tests were used. With repetition, increases in duration estimates were significant at the .05 level for only 2 out of 40 comparisons (5%) and decreases in duration estimates were significant at the .05 level for only 1 out of 40 comparisons (2.5%). Since significant results would be expected by chance alone for 5% of the tests, repetition does not appear to affect time judgments. Repetition might still affect meaningfulness as measured by memory for the myths, however. This question was approached by examining memory protocols obtained from subjects.

Counting the number of words each subject used to retell each of the myths, it was found that such word count scores were generally greater for culturally familiar myths than for culturally unfamiliar myths (Table 2), indicating that culturally familiar myths are indeed better remembered. The percentage of facts recalled by each subject was computed for middle-duration myths on all 4 days and the correlation between these two scores—percentage fact and word count—for middle-duration myths was positive and significant, $r(190) = .86$, $p < .01$. In most cases, correlations between time judgments and either word count scores (23 out of 24) or percentage fact scores (14 out of 16) are not significant, indicating that the relationship between amount remembered and perceived duration is not a very strong one for either cultural group, if such a relationship exists at all.

In order to determine whether the culturally familiar myths were, in fact, more familiar to the subjects, sign tests were used to compare each individual's familiarity ratings for the two types of myths. In all cases, subjects rated the culturally familiar myths as more familiar, and in most cases, significantly more familiar. Correlations between

Table 2
Mean Word Count Scores of American and Indian Subjects for the Different Myths Over the 4 Days of Testing

Myth Condition	Day 1	Day 2	Day 3	Day 4
		American Subjects		
Short Greek	169			
Short Indian	196			
Middle Greek	365	474	571	618
Middle Indian	289	445	607	725
Long Greek	650			
Long Indian	1116			
		Indian Subjects		
Short Greek	114			
Short Indian	173			
Middle Greek	191	289	394	413
Middle Indian	308	434	568	569
Long Greek	381			
Long Indian	587			

Table 3
Sign Tests Comparing Complexity Ratings for Greek and Indian Myths Obtained from American and Indian Subjects Over the 4 Days

Myth Condition	Day 1			Day 2			Day 3			Day 4		
	N	X	P	N	X	P	N	X	P	N	X	P
American Subjects												
Short	11	2	.03									
Middle	12	1	.00	12	0	.00	12	0	.00	11	0	.00
Long	11	4	.27									
Indian Subjects												
Short	11	2	.03									
Middle	10	2	.06	8	3	.36	6	3	.66	4	2	1.00
Long	11	4	.27									

Note–N is equal to the number of pairs showing a difference. X represents the number of fewer signs, i.e., plus or minus. P refers to the probability associated with the occurrence of a particular number of pluses or minuses.

duration estimates (i.e., differences in duration estimates) and familiarity ratings (i.e., differences in familiarity ratings) are not reliably significant across conditions and over days. It is therefore reasonable to conclude that although the culturally familiar myths tended to be perceived as more familiar than culturally unfamiliar myths, perceived duration did not reflect perceived familiarity.

The previously reported relationship between perceived complexity and duration estimates was also evaluated. If memory and/or time estimation is a measure of organization, then perceived complexity might also be such a measure. It was found in both groups of the present experiment that the mean complexity ratings were significantly greater for culturally unfamiliar myths than for culturally familiar myths, as indicated by a sign test, and that mean complexity ratings decreased with repetition (Table 3). Relating these results to inferred organization, one might state that the more unfamiliar the myth, the less meaningful and organized it is and therefore the more complex it is. It was expected that time estimates would correlate negatively with complexity ratings since the former would increase as organization decreased, while the latter would decrease as organization increased. Correlations between time judgments and perceived complexity are significant at the .05 level in only 1 out of 12 cases. Though perceived complexity might be a measure of organization, it does not appear to be related to time judgments.

DISCUSSION

The present experiment was designed to determine the magnitude of an exponent for long durations, to determine the stability of this exponent as meaningfulness and/or familiarity of material presented in the interval was varied, and to investigate the effect of repetition on the magnitude of this exponent. A further purpose of the experiment was to determine the relationship between the perception of duration, on the one hand, and cognitive measures of meaningfulness or inferred degree of organization of material, on the other. In addition, the experiment was replicated cross-culturally to determine the feasibility of this method of manipulating meaningfulness of material and to replicate the duration estimate data obtained in America with subjects of a different cultural background, one reported to have a different attitude toward time (Meade, 1966, 1968, 1972).

Considering the relationship between perceived and actual duration, it is clear that a power function might be used to describe such a relationship, and that the parameters of such a function are relatively stable across duration magnitudes, type of material presented during the estimated interval, and for the two cultural groups considered. We may conclude therefore that exponents derived from the study of apparent duration are not so fragile that meaningful events make the exponents inapplicable to the intervals in which they occur.

Although duration estimates did differ for the two cultures, duration exponents did not. It is possible, then, that the size of the duration units used by Indian subjects differed from that used by American subjects, although, as noted, the heterogeneity of variance may make the significance of that difference more apparent than real. Such a difference does not imply a difference in the perception of time or in the apparent rate of passage of time, but rather a difference in one's use of scales or labels.

As far as the use of estimates of duration as measures of perceived organization or perceived meaningfulness is concerned, however, all of the findings of the present experiment provide evidence that duration measures will not reliably serve that function with meaningful verbal material. The various measures of degree of organization all agree well with each other: Culturally familiar myths are rated as more familiar and less complex, and are better remembered, than culturally unfamiliar myths, so we can infer that familiar myths are better organized and more meaningful than culturally unfamiliar myths. Such an inference rests on the finding that amount remembered and degree of organization are directly related. Cultural familiarity did not affect duration estimates.

In addition, it can be inferred that, with repetition, the subject's organization of a myth will increase. But the present data, obtained over 4 days of repetition, show no correlation between duration estimates of a myth and memory, rated familiarity, or rated complexity of that myth. With repetition, rated familiarity increases and rated complexity decreases,

whereas estimates of duration follow no consistent pattern, while memory scores increase. Thus, if amount remembered, rated familiarity, and rated complexity are related to degree of organization, and if number of repetitions affects organization, then duration estimates are not a valid measure of degree of organization.

Previous research did conclude that duration estimates are affected by cognitive factors (Burnside, 1971; Fraisse, 1963; Frankenhaeuser, 1959; Jones & MacLean, 1966; MacLeod & Roff, 1935; Matsuda, 1966; Ornstein, 1970; Suchoon, 1971; Van der Waals & Roeloffs, 1946; von Sturmer, 1966; Warm, Greenberg, & Dube, 1964). Those studies assumed that differences in cognitive factors existed, post priori, by showing differences in duration estimates rather than by directly measuring or estimating cognitive factors and then proceeding to obtain duration estimates. In the present experiment, we have evidence that meaningfulness or inferred organization was, in fact, manipulated, inasmuch as memory and rated familiarity were greater for culturally familiar myths, while rated complexity was greater for culturally unfamiliar myths for both cultures. Successful manipulation of these cognitive variables did not, however, result in the predicted manipulation of time judgments for either cultural group.

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(Received for publication March 6, 1975; revision received August 4, 1975.)