Linear representation of temporal location and Stevens's law

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Ss were asked to indicate points 1 week, 7 months, 3 years, and 9 years in the past and future on two time lines representing birth to present and present to death. Data for 90 college-age Ss fit a psychophysical power function following Stevens's law, with negatively accelerated growth indicating proportionately greater linear representation of periods nearer to the present. Variability was greater for the representations of the future than of the past, with monotonic increases in variability as distance from the present increased.

Human temporal concepts have been shown to play important roles in personal and social functioning (Fraisse, 1964; Frazier, 1966; Orme, 1969). However, unlike sensory and spatial concepts, they have received relatively little attention. If one believes, as Thorndike did, that "Whatever exists, exists in some quantity and can (in principle) be measured [cited in Cattell, 1965]," then the scaling of subjective temporal continua by humans should provide meaningful psychophysical relationships with objectively measured temporal continua as marked by clocks and by calendars.

One of the first attempts to scale temporal continua was attempted by Cohen, Hansel, and Sylvester (1954), who, in several studies, presented Ss with 10-in. lines and asked them to mark off various points representing their subjective estimates of past time. They reported that subjective estimates of times from 1 day to 6 months past produced a logarithmic Weber-Fechner relation to calendar time but that for periods extending beyond 6 months, the relationship of subjective estimates to calendar estimates was essentially linear. Recently, Ekman and Lundberg (1971) performed three time-scaling experiments which employed the complete method of ratio estimation. In their first study, the time points to be estimated were points ranging from 1759 to 2174 with an anchor point of 1967, the year in which the experiment was conducted. In their second experiment, a narrower range of nine stimuli ranging from 1892 to 2041 was employed, and in their third experiment, Ekman and Lundberg (1971) presented the names of generations ranging from "great-grandparent" to "great-grandchildren." In each experiment, stimuli were presented in pairs and Ss were asked to indicate

which of the two stimuli was most distant in time and were further asked to estimate with a percentage scale the perceived distance of the other stimulus in relation to the standard stimulus (the present). Unlike the findings of Cohen et al, Ekman and Lundberg found that their data fit a simple power function of the form $t = cT^n$, where T is chronological time distance and t is subjective time distance. The exponents found for past time and future time were, respectively, .89 and .72.

The present study was designed to extend the previous findings of Cohen et al (1954) and Ekman and Lundberg (1971) by asking Ss to produce subjective estimates of times in the past and future which could be reasonably expected to be experienced within the Ss' own life spans so that scalings of personally relevant time spans could be achieved.

METHOD

Subjects

The Ss were 90 undergraduate volunteers (45 men, 45 women) who were serving as Ss in a larger study of time and personality. All Ss answered questions anonymously and received academic credit for their participation. The median age for the group was 21.5 years, with a range of 18 years to 43 years of age.

Procedure

The Ss were presented with two 254 x 17 mm outlines of elongated rectangles or "ribbons" printed on separate 215-mm mimeographed sheets.¹ The ribbon on the first page had as its respective left and right anchor points the words "birth" and "now" with instructions to Ss to "consider the above ribbon as representing time for you." Ss were instructed to draw and label vertical lines through the ribbon representing 1 week, 7 months, 3 years, and 9 years in the past. On the second page, Ss were presented with a line of identical length marked "now" and "death" with instructions to represent 1 week, 7 months, 3 years, and 9 years in the future.

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Table 1
Means, Standard Deviations, and Coefficients of Relative Variability of Subjective Time Estimates

Time	Past			Future			F**
	Mean Length	SD	V*	Mean Length	SD	V	
1 Week	7.5778	9.2201	1.2167	9.1556	14.3471	1.5670	2.4213 ^{††}
7 Months	37.1778	23.7806	.6396	40.4778	36.1828	.8939	2.3150 ^{††}
3 Years	90.0555	40.1725	.4436	80.6667	50.8556	.6304	1.6026 [†]
9 Years	158.6333	41.1062	.2591	123.6000	58.3574	.4721	2.0155 ^{††}

*Coefficient of relative variability

**F test for homogeneity of variance

[†]p < .05

^{††}p < .01, df = 89,89

Measurements of each of the four time estimates on each of the two ribbons was made from the "now" point and was recorded in millimeters. All measurements were made from the top edge of the ribbon where, it was assumed, the S had begun to draw his vertical lines.

RESULTS

The arithmetic mean lengths, standard deviations, and coefficients of relative variability (V_x) of 1 week, 7 months, 3 years, and 9 years in the past and in the future are presented in Table 1. F tests of homogeneity of variances of the estimates of corresponding past and future time estimates are also presented in Table 1.

Visual examination of the mean ribbon lengths suggested that a power law relationship (Stevens, 1957, 1966; Stevens & Galanter, 1957) existed between ribbon lengths and chronological time expressed in weeks. Therefore, mean ribbon lengths and chronological times were transformed into their respective common logarithmic values. In common logarithmic form, the least-squares fit of the relationship of subjective past time t to objective chronological time T was $\log t = .494 \log T + .8713$, or in exponential form, $t = 7.43 T^{.494}$. For future time estimates, the least-squares equation was $\log t = .423 \log T + .9706$, or $t = 9.34 T^{.423}$. The correlation coefficients between log ribbon lengths and log calendar times for both the past and the future time estimates were each .999 ($p < .01$), indicating a nearly perfect fit to power functions.

Comparisons of the variances of corresponding past and future time estimates revealed that the future estimates had larger coefficients of relative variability and were significantly more variable than each of the corresponding estimates of past time.

As a check on the placement of "birth" and "death" on the respective curves, the data were extrapolated to these points. By extrapolating these data, "birth" would be located 23.5 years in the past and "death" would be located at 45.5 years in the future for this group of Ss. These locations fit well the Ss' known birthdates and their approximate actuarial date of expected death.

DISCUSSION

The findings of the present study are in accord with Ekman and Lundberg's (1971) finding of power law

relationships between subjective estimates of time and objective chronological time. The present results, however, differ with the findings of Cohen et al (1954), who reported that estimates of 1 day to 6 months in the past bore a logarithmic or Weber-Fechner law relationship to chronological time and that longer time estimates bore a linear relationship to chronological time. In the present study, the results indicated that the best data fit for either past or future time estimates could be achieved with a log-log linear or Stevens's law power function (1957) throughout the entire range tested. One could also, of course, calculate a line of best fit between linear subjective estimates of time and chronological time that would form a reasonable fit, but this would not be as accurate as a power function.

The finding that estimates of future time were more variable than those of corresponding periods in the past suggests that there was greater uncertainty concerning future as opposed to past time. The notion of variability reflecting uncertainty or lack of consensus is further bolstered by the findings that for both past and future time estimates, there are monotonic increases in the variances as estimates go farther from the anchor or "now" point.

Having obtained a power function, we are left with an intriguing puzzle, namely, that of explaining why such a function exists for these data. A number of possibilities present themselves. Perhaps, a simple but tautological explanation would be that the estimates of subjective time were made on lines by the Ss, and as linear estimates of many sensory and cognitive stimuli form power functions with objective stimulus measures (Stevens, 1957, 1966), these data conform to the typical findings. This explanation, however, is rather static and excludes consideration of the conceptual processes involved in making these judgments. Another possibility has been suggested by Cohen et al (1954), who stated that the disproportionately larger representation of time closer to the present and the disproportionately smaller representation of time further removed from the present might be attributed to a retention process. According to this viewpoint, retention diminishes with time so that events closer to the present are retained more than past events, or at least are more accessible. It must be remembered that Cohen et al (1954) obtained estimates of past time and that the present study and Ekman and

Lundberg's (1971) study obtained estimates of both past time and of future time which both fit power functions. In the case of future estimates, therefore, it would be extremely difficult to explain "retention" of future events by Cohen's hypothesis.

A more plausible explanation was suggested by Ekman and Lundberg (1971), who stated that as temporal locations become more remote, they appear to be less real and therefore are given only cursory attention. This viewpoint could be supported by the present results in which there were monotonic increases in the variances of time estimates as these estimates departed from the present and, hence, might reflect greater uncertainty or smaller consensus regarding these remote temporal locations.

Another explanation might be that the experimental task requires the S to produce a linear representation of temporal perspective. If temporal perspective could be considered to be analogous to visual linear perspective, in which closer objects occupy larger and more distinct proportions of the visual field than distant objects, then it might be considered that near temporal events receive disproportionately more attention than distant temporal events. As vision, in man, is probably the primary sensory and perceptual modality while temporality is a more abstract cognitive function, our Ss might have been translating their more abstract temporal conceptions into representations with which they were familiar: visual distances.

Some personality correlates of linear estimates of the kind of time units employed in this study have been reported by Rychlak (1972), who found that anxious Ss tended to expand the near present and thereby also tended to make the distant past and future more remote. Ekman and Lundberg (1971) have found that subjective temporal distance and emotional involvement are exponentially related. Differences between various age, ethnic, and occupational groups might fruitfully be explored with the time line or ribbon technique as in the present study. As the limits of the scales were found to approximate the realistic chronological limits of the expected life span of our Ss, this suggests that with different groups, similar power functions would be found, but with different constants and exponents obtained for each group.

In conclusion, this study and previous investigations found consistent psychophysical relationships between chronological calendar time and magnitude estimations or linear representations of subjective temporal location. The psychophysical function best fitting past and future subjective estimates appears to be Stevens's law with an exponent less than one, which on linear plots represents a trend of negatively accelerated growth with the curvature somewhat more pronounced for future time. Undoubtedly, the Ss' ages and the particular experimental tasks affect the specific numerical values obtained. The proportionately greater magnitude of the representation of the near past and future relative to the distant past and future indicates their relative dominance in the phenomenal field.

REFERENCES

- Cattell, R. B. *The scientific analysis of personality*. Baltimore: Penguin, 1965.
- Cohen, J., Hansel, C. E. M., & Sylvester, J. D. An experimental study of comparative judgements of time. *British Journal of Psychology*, 1954, 55, 108-114.
- Ekman, G., & Lundberg, U. Emotional reaction to past and future events as a function of temporal distance. *Acta Psychologica*, 1971, 35, 430-441.
- Fraisse, P. *The psychology of time*. London: Eyre & Spottiswoode, 1964.
- Frazier, J. T. (Ed.) *The voices of time*. New York: Braziller, 1966.
- Orme, J. E. *Time, experience, and behaviour*. New York: American Elsevier, 1969.
- Rychlak, J. E. Manifest anxiety as reflecting commitment to the psychological present at the expense of cognitive futurity. *Journal of Consulting & Clinical Psychology*, 1972, 38, 70-79.
- Stevens, S. S. On the psychophysical law. *Psychological Review*, 1957, 64, 153-181.
- Stevens, S. S. A metric for social consensus. *Science*, 1966, 151, 530-541.
- Stevens, S. S., & Galanter, E. H. Ratio scales and category scales for a dozen perceptual continua. *Journal of Experimental Psychology*, 1957, 54, 377-411.

NOTE

1. This procedure is a modification of an earlier procedure devised by Rychlak (1972).

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