Influence of pause duration on the reproduction of a 2-second interval*

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The influence of pause duration on the reproduction of a 2-sec interval, presented acoustically, was investigated in one S. The duration between the end of the stimulus and the beginning of the reproduction was varied randomly between 0.4 and 50.0 sec. The reproduced interval increased linearly up to a pause duration of approximately 2 sec; longer pause durations did not influence systematically the duration of the reproduced interval. This result is discussed as additional evidence for an oscillatory mechanism with a period in the range of 2 sec underlying time estimation.

Oscillatory mechanisms often control the temporal organization of human behavior. The most conspicuous examples are perhaps the menstrual cycle, the sequence of sleep and wakefulness which is based on an endogenous oscillation (Aschoff & Wever, 1962; Pöppel, 1968), the dream cycle (Dement & Kleitman, 1957), the pulse, and the alpha rhythm in the EEG. Less well known—and less well established—are the "excitability cycles in central intermittency" (Pöppel, 1970), with a period of 30 to 40 msec and an oscillation in the range of 2 sec. This oscillation of about 2 sec has been described on the basis of quite different experimental evidence by Bechinger et al (1969), Pöppel (1969, 1972), and Richards (1964).

The experiment reported here was designed to get further insight into the nature of this oscillation with a period of 2 sec. It can be argued that, given such an oscillation, the reproduction of an interval of 2 sec should be influenced by the duration of the pause between the end of the stimulus and the beginning of the reproduction: a pause duration of 2 sec corresponding to the period of the oscillation should be most appropriate. In this case, the onset of the stimulus, of the pause, and of the reproduction fall into identical phases of the underlying oscillation. Other pause durations should interfere with the ongoing oscillation, perhaps affecting the succeeding reproductions of the 2-sec stimulus.

METHOD

The S had to reproduce a series of 2-sec intervals. The stimulus presented during this interval was a tone with 1,000 Hz. The E started the presentation of the stimulus; the pause following the 2-sec interval had a variable length between 0.4 and 50.0 sec. After this pause, the stimulus turned on automatically and the S had to push a button when she thought the duration of the stimulus had been reached. The entire experiment was done in one session, allowing rests of about 5-10 sec between the single stimulus presentations and reproductions. The sequence of pause durations throughout the experiment was randomized.

RESULTS

The data of this experiment are shown in Fig. 1. The duration of the reproduced interval is plotted as a function of pause duration. The scale on the abscissa is logarithmic. The broken line parallel to the abscissa is drawn at 2 sec and indicates the "objective set-point," i.e., that duration of reproduction which corresponds exactly to the stimulus duration. As can be seen, reproduced intervals increase in duration between a pause duration of 0.4 and approximately 2 sec. This increase appears to be linear. Beyond this pause duration, i.e., between 2 and 50 sec, only random fluctuations of the length of the reproduced interval around a "subjective set-point" of 2.4 sec appear to occur; no further systematic increase (or decrease) of the duration of the reproduced interval is apparent. The stimulus duration of 2 sec corresponds to a subjective duration of 2.4 sec for pause durations longer than 2 sec.

DISCUSSION

It has been shown earlier (Pöppel, 1969) that reproducing temporal intervals of *various* lengths leads to an "indifference interval," where the duration of the stimulus and the duration of the reproduction are identical: shorter stimuli are reproduced longer, longer stimuli are reproduced shorter, than stimulus length at the indifference interval. In a group of 38 Ss, the indifference interval, obtained with a pause duration of 1 sec, was approximately 2 sec. It also gave evidence that the indifference interval is not an artifact of the experimental situation as has been suspected by others, but presumably the result of an underlying oscillatory mechanism with a period of about 2 sec. As practically all reproductions in the experiment reported here were longer than 2 sec, i.e., the duration of the stimulus, the indifference interval of this S, and therefore the period of the underlying oscillation, is longer than 2 sec—at least for the pause durations used in the experiment.

How can the increase of the reproduced interval in the range of 0.4 and 2 sec pause duration and the constancy of the reproduced interval beyond this pause duration be explained? Assuming an underlying oscillatory mechanism with a period length in the range of 2 sec—as has been suggested by the earlier reports (Bechinger et al, 1969; Pöppel, 1969, 1972; Richards, 1964)—the following suggestion can be made: Each stimulus onset starts or immediately synchronizes an oscillation with a period of about 2.4 sec, the subjective duration corresponding to the stimulus duration. If the onset of the reproduction either falls into the same phase of this oscillation—after a pause duration that equals the period of the oscillation—or if the onset of the reproduction occurs later, the period of the oscillation is either unaffected (or even stabilized) or the oscillation is "resynchronized," giving rise in both cases to the period of 2.4 sec. If, however, the onset of the reproduction occurs earlier, this onset interferes with the ongoing oscillation and produces a *phase shift*. The closer in time the onset of reproduction follows the end of the stimulus, the more sensitive seems to be the

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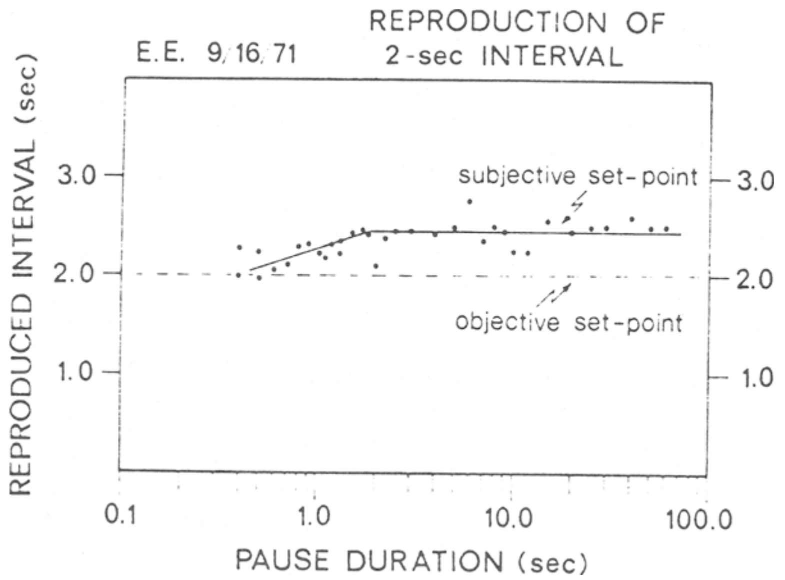

Fig. 1. Duration of a reproduced time interval as a function of pause duration. The scale on the abscissa is logarithmic. The regression lines have been fitted by eye.

oscillation for advancing phase shifts. An onset of reproducation, coming sooner after the stimulus results in a greater "speeding-up" of the oscillation. At a pause duration of 0.4 sec, for example, the length of the succeeding period is reduced to almost 2 sec. Such changes in period after application of stimuli at different phases of an oscillation are well established for other biological oscillations, like circadian rhythms (Aschoff, 1963), and they may–as is suggested in this report–also occur in the oscillatory mechanism underlying time estimation.

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