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EFFECTS OF TELEPHONE RING ON TWO MENTAL TASKS RELATIVE TO AN OFFICE

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In many cases, there are a lot of noise sources in an office and particularly, telephone ringing often irritates the office workers. Effects of aircraft noise on the mental work of pupils were reported by Ando *et al.* [1]. In spite of its serious effect, it has not yet been found how the physical parameters of the wave form influence the perception of noise. The purpose of this study is to investigate the effects of telephone ringing on two mental tasks. This investigation is based on the human auditory–brain model consisting of the auto-correlation function (ACF) of sound source, the interaural cross-correlation function (IACF) for sound signals arriving at the two ears, and the specialization of the cerebral hemispheres. Under the stimulus of a telephone ringing, an adding task and a drawing task were performed. Results show that telephone ringing influences differently the two tasks: the V-type relaxation was observed only during the drawing task. It is revealed that the interference effect between the drawing task and the noise may occur in the right hemisphere.

1. INTRODUCTION

There are many kinds of noise sources in an office, and telephone ringing is often considered as one of the most irritating sounds for almost all office workers. Prior to this study, Ando *et al.* [1–3] demonstrated that a left hemispheric verbal task is interrupted by ipsi-lateral sound and *vice versa* for a right hemispheric task. But these effects have not been described by the physical parameters of the sound signals as yet. Recently, it has been revealed that subjective attributes have been well estimated by the auto-correlation function (ACF) and the interaural cross-correlation function (IACF) [4].

The purpose of this study is to investigate the effects of telephone ringing on two mental tasks and relate these effects to the physical factors extracted from the sound signal.

In this study, the sound effects were evaluated by V-type relaxation which is associated with hemispheric specialization. V-type relaxation is thought to be caused by an abandonment of effort when mental functions are unbalanced or disordered [1–3].

2. EXPERIMENT

Ten office workers were chosen as the experimental subjects. They were approximately within the ages of 25–35 years old and right-handed. Prior to this research, they were confirmed to have normal hearing ability.

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(a)

4 6 7 3 5 8 7 9 4 . . .

0 3 0 8 . . .

5 8 4 6 7 5 8 9 5 . . .

(b)

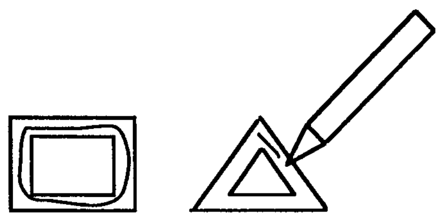

Figure 1. Mental tasks: (a) adding task; (b) drawing task.

They were separated into two groups (A, B). Each group had five subjects. The subjects of group A performed the adding task and those of group B performed the drawing task. In this investigation, the adding task was chosen as a left hemispheric task and the drawing task was chosen as a right hemispheric task, as shown in Figure 1.

Each subject was required to carry out these tasks as fast as possible and to start from the first period ($i = 1$) when the 1 kHz signal of short duration was given and after 1 min start a new set of problems ($i = 2, 3, \ldots, N$) as soon as the same signal was given. Each task was divided into a first and a second half and there was an interval of 5 min for rest. The total time was 35 min for the adding and drawing tasks ($2N = 30$).

Telephone ringing, which was recorded by the digital audio tape with the sampling rate of 48 kHz, was given every two periods with the sound pressure level of no-stimuli (25 dB(A) background noise) 40 and 80 dB(A) in the anechoic chamber. These conditions were selected randomly for each subject. The loudspeaker was placed at the distance of 1·5 m $\pm$ 1 cm in front of the subject. The running ACF and IACF of the telephone ringing was measured by the diagnostic system of sound fields [5] with the integration interval of 0·2 s.

2.1. EVALUATION OF MENTAL TASK

First, the individual work produced in each period, which is called the "working curve", was drawn for all test results. In this investigation, the following scores were calculated, based on the working curve:

$$\bar{M}_1 = \frac{1}{N}\sum_{i=1}^{N} M_i, \quad \bar{M}_2 = \frac{1}{N}\sum_{i=N+1}^{2N} M_i.$$

The score of V-type relaxation is classified into two categories according to the occurrence of a sudden large fall in the working curve during each half of the task. V-type relaxation was assumed to be described by

$$V_1{:}M_i < \bar{M}_1 - \tfrac{3}{2}W_1 \quad (i = 1, 2, \ldots, N), \quad V_2{:}M_i < \bar{M}_2 - \tfrac{3}{2}W_2 \quad (i = N+1, N+2, \ldots, 2N),$$

where W_1 and W_2, which are defined here as the variances of the curve excluding the periods of $i = 1$ and $N + 1$ which usually give a large amount, may be calculated. Thus, a subject was regarded as showing relaxation if any period showed a fall in output below $(\frac{3}{2}) W_j$ $(j = 1, 2)$.

3. RESULTS AND DISCUSSION

As indicated in Table 1, V-type relaxation occurred during the drawing task only, and the relaxed population was increased significantly under the conditions of both 40 and 80 dB(A) of the telephone ring (sign test: $p < 0{\cdot}05$). As shown in Figure 2, however, a similar result was not observed during the adding task. Considering the cerebral hemispheric specialization, an interference effect may occur in the performance of hemispheric tasks because the left and the right hemispheres are associated with the temporal and the spatial factors of sound fields which are extracted from ACF and IACF respectively [4]. In this experiment, the drawing task is regarded as a right hemispheric spatial task. According to

TABLE 1

Significant differences of V-type relaxation obtained by sign test for each sound environment on two mental tasks

	V-type relaxed subjects/number of subjects		
Task	BN	40 dB(A)	80 dB(A)
Adding task	0/5	0/5	0/5
Drawing task	2/5	$5/5^{\dagger}$	$5/5^{\dagger}$

Note: Background noise (25 dB(A)).
$^{\dagger}p < 0{\cdot}05$.

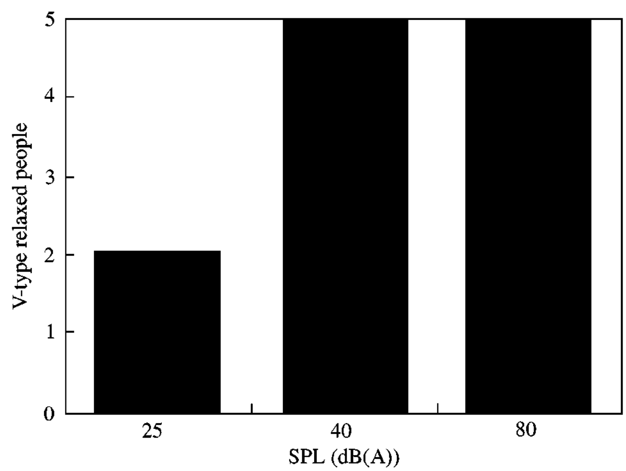

Figure 2. V-type relaxed people for the drawing tasks under the telephone ringing.

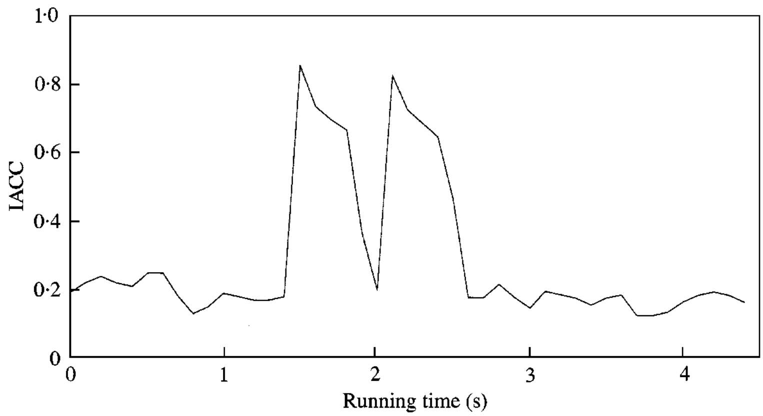

Figure 3. Analysis of the running IACC of telephone ringing with $2T = 0{\cdot}2$ s.

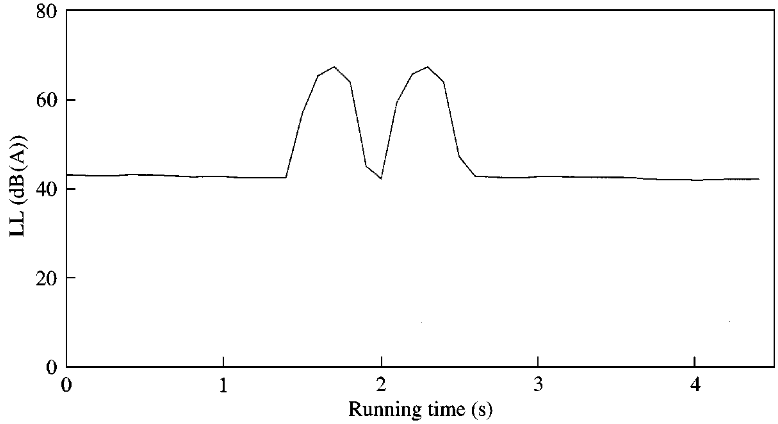

Figure 4. Analysis of the running LL of telephone ringing with $2T = 0{\cdot}2$ s.

the theory of the ACF and the IACF models, it is assumed that the right hemisphere processes the spatial factors of the IACF of the telephone ringing. Namely, it is considered that some features of the IACC, LL (listening level), W_{IACC} or τ_{IACC} typically influenced the drawing task because these physical parameters are extracted from the IACF [6].

Previously, IACC and LL have been demonstrated to be right hemispheric parameters by the use of the physiological method [7]. Additionally, it was observed that variances of the running IACC and LL of telephone ringing were large, as shown in Figures 3 and 4. Therefore, it might be concluded that the right hemispheric drawing task is affected by rapid change of IACC and LL. On the other hand, the left hemispheric adding task was not influenced by a minor change of the running τ_e and τ_1 of the telephone ringing, extracted from the ACF, because the noise did not contain any specific information activating the left hemisphere.

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