On the other hand, in temperature regions more distant from the adaptation temperature, object temperature determines sensation. The most obvious advantage conferred by this is protection from damaging effects of temperature extremes. This is particularly the case for temperatures between 40 and 45 °C, close to where protein denaturation begins. At these temperatures not only adaptation but also spatial summation [5] fails to have any effect

on temperature sensation. Some aspects of reproductive behavior are also linked to object temperature; this is not restricted to human beings, as the moundfowl's behavior in regulating nest and egg temperature shows. Last, but not least, behavioral thermoregulation also benefits from object temperature sensation, since the thermal load resulting from skin contact with an object depends ultimately on object temperature and contact area.

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Analysis of Periodicities in Human Reaction Times

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A considerable amount of psychological research has been done using the reaction-time (RT) paradigm. If as a result of an RT experiment we have a probability distribution, one of the essential tasks is to describe its most significant characteristics. The implicit assumption of most statistics (e.g. ANOVA) used frequently is that the data follow a Gaussian distribution or that at least the data are unimodally distributed. An RT experiment generally does not provide a continuous distribution because time is measured by sampling and discretizing. This causes a dilemma. If one does not look at the distribution of data carefully enough there is only little chance to observe multimodalities [1]. If, however, one looks for additional peaks long enough one is apt to find them sooner or later [2].

In this paper a method is presented which allows one to determine whether or not RT distributions reflect oscillatory mechanisms and which also allows one to estimate occurring periodicities. Apparently there is evidence suggesting oscillatory mechanisms in human information processing ([1, 3] for review). Multimodal RT distributions could imply the existence of oscillations and the distance between adjoining peaks of the distribution might be regarded as an estimation of the period. Vorberg and Schwarz [4] have shown by simulations, however, that the method of estimating periodicities from RT histograms used by Pöppel [1] might produce artifacts. One way to improve Pöppel's method would be the enlargement of the sample size proposed by Vorberg and Schwarz [4]. Unfortunately, psychological research generally deals with small sample sizes. We assume a simple discrete RT model: $RT = nT + \phi(t)$, in which RT is the product of the time constant T and an integer random variable n. $\phi(t)$ can be considered to be a time(t)-dependent variable we have named 'phase' which has local stability and the following property: $|\phi(\Delta t)| < T$. If the RT's follow a multimodal distribution, the distribution of all possible RT differences in the sample is also multimodal. The use of this property was suggested by Scheidereiter [5]. There are two reasons for calculating a histogram of RT differences. First, one obtains $\binom{N}{2}$ data although the original sample size is N. Second, $\phi(\Delta t)$ reduces multimodalities in the distribution of the original RT's, whereas the use of differences weakens this effect for most RT pairs. (If one substituted a time-independent random

error variable for $\phi(t)$ the effect on the distribution would be even stronger as a result of the increase in variance.) The question arising is: What does the existence or the absence of peaks in the histogram of RT differences imply? According to the model, the RT differences d_{ij} can be decomposed into

$$d_{ij} = |RT_i - RT_j| =$$
$$|n_iT + \phi(t_i) - n_jT - \phi(t_j)|$$

with integer n; $i = 1,2....N-1$ and $i < j \le N$.

We briefly consider the probable conditions under which RT differences are equal.

For the case: $d_{ij} = d_{kl} = |n_iT + \phi(t_i) - n_jT + \phi(t_j)| = |n_kT + \phi(t_k) - n_lT - \phi(t_l)|$ we assume the following conditions:
$\phi(t_i) = \phi(t_j)$; $\phi(t_k) = \phi(t_l)$ and $|n_i - n_j| = |n_k - n_l| = c$
with integer $c > 0$; $i = 1,2....N-1$; $i < j \le N$ and $k = 1,2....N-1$; $k < l \le N$.

Therefore, we may write: $d_{ij} = d_{kl} = cT$.

If the RT's are unimodally distributed, the distribution of absolute RT differences decreases continuously with the increase of d. This can be derived from the theory of probability: If X and Y are independent random variables and follow the same distribution, one can write:

$X - Y = Z$ and $|X - Y| = Z'$.

$$f_z(Z) = \int_{\infty}^{\infty} f_x(X) * f_y(X-Z)\, dX.$$

$$f_{z'}(Z') = 2 * f_z(|Z|).$$

On the other hand, there should be local maxima in the distribution of RT differences in the case of multimodalities. It is probable that c has a low in-
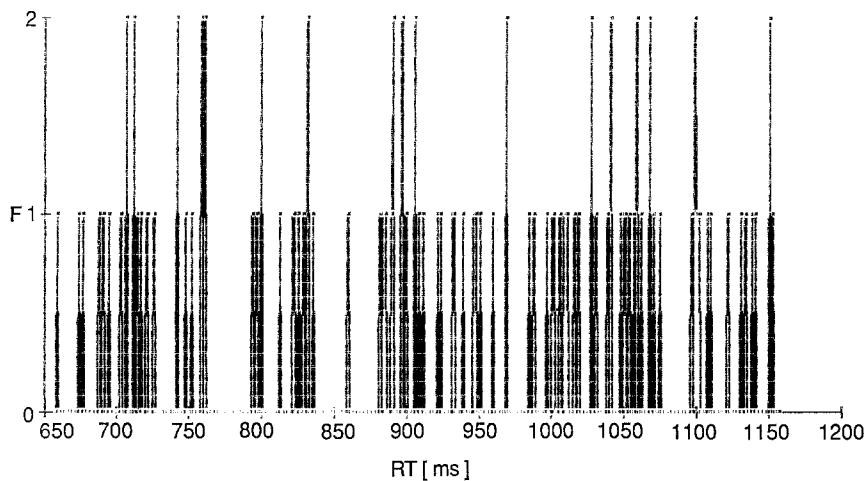
Fig. 1. Frequencies F of reaction times RT for one subject from priming experiment. The histogram contains 152 single reaction times
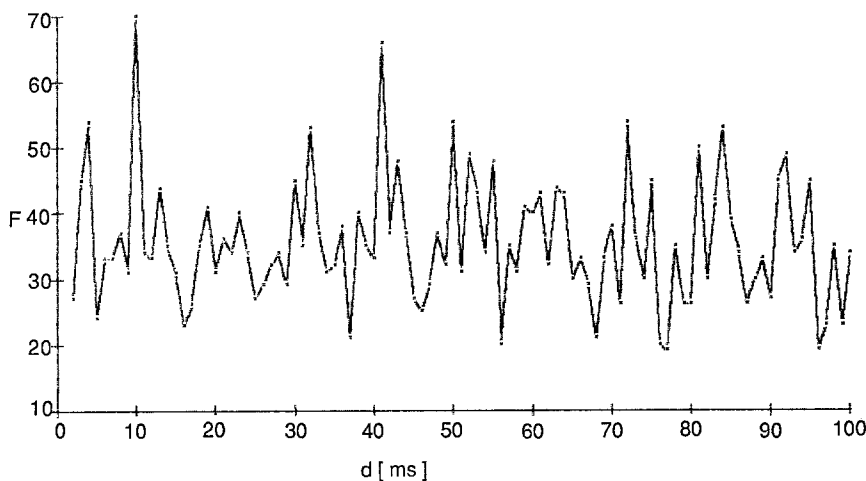

Fig. 2. Frequencies F of ($\binom{152}{2}$) reaction time differences d for data shown in Fig. 1
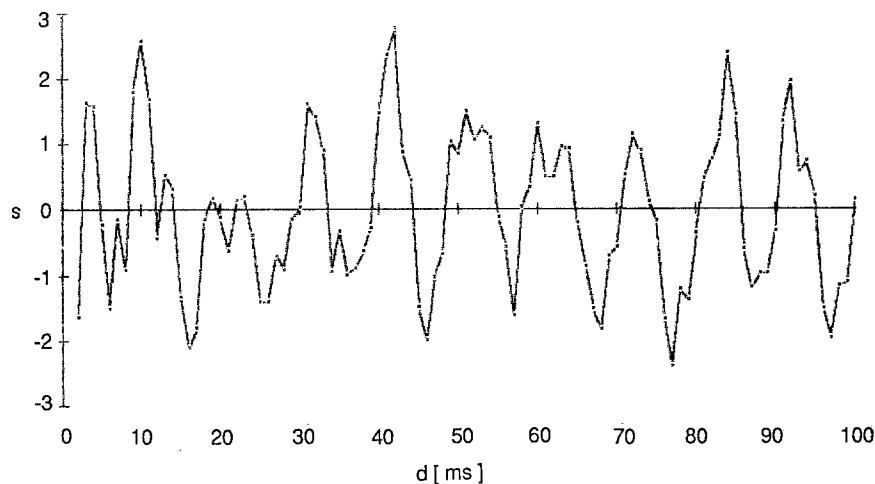

Fig. 3. Standardized, smoothed and trend-reduced histogram of reaction time differences d based on absolute frequencies as shown in Fig. 2

teger value at the first local maximum and might even be $c = 1$. Therefore, the first local maximum may be regarded as a preliminary estimation of the time constant T. But the first local maximum in the distribution of differences might also be caused by random multimodalities. With respect to both the RT model and the use of differences it is evident and in accordance with the assumption of periodicities in human RT's that additional peaks have to be localized at integer multiples of T. We make use of this property to improve the estimation of T by computing the autocorrelation function (ACF) and the Fourier spectrum of the histogrammed RT differences. If the histogrammed RT differences were randomly distributed we would not find significant autocorrelation coefficients and power values of the Fourier spectrum. It is essential to reduce the trend in the histogram which should also be smoothed. Our experience is that it is not necessary to group the ($\binom{N}{2}$) differences into intervals and thus the problems of arbitrary binwidth (discussed by [4]) can be avoided if also the original data base is comparably small. Figure 1 shows the histogrammed RT's for one subject from a priming experiment. The RT was measured with an accuracy of 1 ms, N amounts to 152 single reaction times from one session. The histogram of the RT differences can be seen in Fig. 2, Fig. 3 shows Fig. 2 trend-reduced and smoothed. Both figures indicate multimodalities and if they were periodic the ACF necessarily has the same property as shown in Fig. 4 (calculated from $d_{min} = 1$ to $d_{max} = 256$). Obviously, the period value is 10 ms estimated by ACF. Note that there is also a fundamental peak at $d = 10$ ms in the histograms. The Fourier spectrum contains the corresponding frequency of 100 Hz and additional significant frequency components from 20 to 40 Hz (Fig. 5). These lower frequencies are of about the same order as the periods which were found by Pöppel [1, 6]. It follows the multiple periodicities related to human reaction times are more likely than a unitary ocillatory process. Preliminarily we assume that an observable *basic* period amounts to about 10 ms. Results obtained in experiments with different subjects under different conditions and findings reported in [3] support the assumption of periodicities
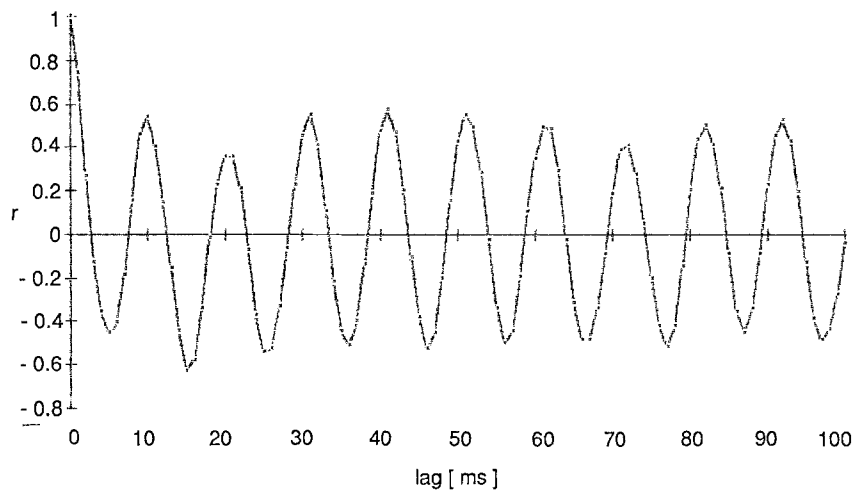
Fig. 4. Autocorrelations r calculated from histogram of differences (shown in Fig. 3) in the range 1 − 256 ms difference
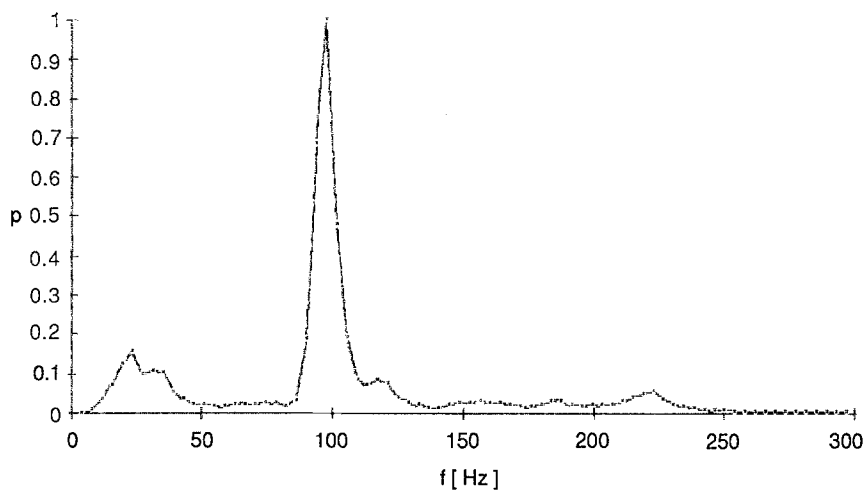
which include a fundamental frequency in the order of about 100 Hz.

Finally, the question of the psychological nature of periodicities in human reaction times has to be answered by further investigations.

Fig. 5. Fourier spectrum analysis for histogrammed reaction time differences (Fig. 3). The power p, scaled to have a maximum of 1.0, is shown relative to each frequency f k * 1000/256 Hz

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Electrical Brain Stimulation Elicits Singing in the Bug *Nezara viridula*

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The green stink bug *Nezara viridula* (Pentatomidae, Heteroptera) uses substrate vibration for communication with other members of the species. The dominant frequency of the song is about 100 Hz. It has already been shown that the bug is able to find its singing sexual partner only by means of vibration which the partner emits on the host plant [1]. The behavioral observations show that these animals do not care about the airborne components of the signal [2]. The bug produces vibrational and acoustic sound with the tymbal (a chitinous organ composed of the fused first and second abdominal tergite). There has been much electrophysiological and anatomical work done regarding the processing of vibratory information in the bug [3], but the sound production mechanism on the neuronal level remains to be investigated. For this reason we established a method of artificial brain stimulation with DC current, similar to the one already described in grasshoppers [4]. The stimulus (0 − 50 μA of both polarities) was applied to the anterior surface of the brain at the level of the antennal lobes by the suction electrode with tip diameter 100 − 150 μm. The myogram