trix. The ferriferous strata contain a rich invertebrate fauna dominated by lamellibranches and ammonites [4].

The *Asteroceras* shell was examined using XRD and SEM. XRD analyses of the ammonite shell show two different carbonate phases, predominant calcite and subordinate siderite. Under SEM the ammonite shell reveals two distinct morphological features (Fig. 2). The main part of the shell consists of rhombohedral crystals ranging in size from 10 to 20 µm. This morphology of the crystals is typical for calcite [5]. Therefore, the second distinct structure can only be siderite as confirmed by XRD. The flaky siderite overgrows the calcite. The flakes stick out of the calcitic substrate and can occur in rosette-like arrays (Fig. 2). The sticking out of these crystals suggests an epitaxial growth of the siderite onto the calcite surface whereby the crystallographic *a*-axes of the siderite are prependicular to the *c*-axes of the calcite. Such an epitaxial overgrowth is also in agreement with the observation of no evidence of dissolution or replacement of the calcite. The epitaxial crystallization of the siderite onto the surface of the calcite can be explained by a change in chemical conditions during the process of diagenetic replacement of the ammonite shell. The change consists of a shift from calcite to siderite precipitating conditions. In diagenetic environments the formation of calcite can take place under a wide range of chemical conditions [6]. Siderite is formed under reducing condition in which ferrous iron can be mobilized. Furthermore a siderite phase is stable relative to calcite in a ferriferous environment with an activity ratio Fe^{2+}/Ca^{2+} higher than 0.0055 [7].

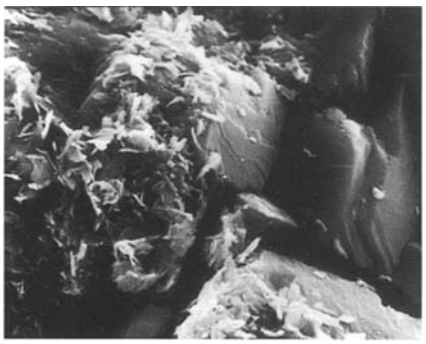

Fig. 2. SEM micrograph of the internal textures of the shell shows the overgrowth of rhombohedral crystals (calcite) by fine crystallized flakes (siderite)

It can be concluded that the formation of siderite was caused by an increase in ferrous iron concentration in the diagenetic microenvironment of the ammonite shell. Such an increase was probably caused by an influx of ferriferous pore water from the surrounding iron oolitic environment. The spatial distribution of the two carbonate phases within the ammonite shell argue for a two-step diagenetic process. It consisted of the formation of calcite as a primary product onto which siderite as secondary product could be precipitated.

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Oscillatory Mechanisms in Human Reaction Times?

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Recently [1, 2], there has been an increasing interest in Pöppel's [4] report of oscillatory mechanisms underlying human information processing published in [3]. From analyses of the distributions of reaction times (RT) to visual and auditory signals obtained from human subjects, Pöppel has inferred oscillatory mechanisms. The aim of this communication is to show that the method used by Pöppel is bound to produce artifacts and that, therefore, his conclusions – as far as they are based on research with this method – have to be reexamined.

Pöppel's method consists of the following steps:

– RTs obtained from a subject under a given experimental condition are histogrammed.

– The number of peaks which have at least half the height of the maximum peak is determined.

– If the histogram contains more than one peak of this sort, the average distance between neighboring peaks is computed. This is interpreted as the period of an oscillatory process.

Using a binwidth of 10 ms and sample sizes of about 260 observations per empirical distribution, Pöppel concluded that signal processing is based on a discrete time sampling mechanism with a sampling period of ca. 30 ms.

From the standpoint of probability theory, Pöppel's procedure is problematic as it overlooks the fact that sample histograms from unimodal populations are quite likely to exhibit multiple peaks unless extremely large sample sizes are used. The exact multivariate distribution of the number N_j ($j=1, 2, \ldots, k$) of RTs falling into bin j can be shown to be

$$P(N_1=n_1, \ldots, N_k=n_k) = \prod_{j=1}^{k} \binom{N-s_{j-1}}{n_j} [F(u_j)-F(u_{j-1})]^{n_j},$$

where F is the RT distribution function, $s_j \equiv n_1+n_2+\ldots+n_j$, u_j gives j-th upper category bound, s_0 and u_0 are defined as zero and u_k is such that $F(u_k)=1$.

This equation can be used to calculate the probability of each conceivable outcome of an experiment of the kind described and, in particular, the expected value of the period estimated by Pöppel's method for any given theoretical distribution F. In practice, however, this leads to cumbersome combinatorial problems. Therefore, we used a simulation approach. On a computer, we generated random variables from specified distributions (see [5] for a collection of related techniques), treated them with Pöppel's method, and studied the results as a function of distribution type and binwidth.

We examined two unimodal (gamma; uniform) and two periodic multimodal distributions. For the multimodal distributions, densities of the type

$$f(t)=[\alpha/(2n)] \sum_{j=1}^{n} \exp(-\alpha|t-j\tau|)$$

were used; they exhibit n peaks spaced τ ms apart. The shapes of these distributions are shown in Fig. 1.

For wide ranges of sample size, N, and binwidth, bw, the findings are unambiguous. The method produces both kinds of errors: it infers periodicities where none exist, and it does not recover the period size of distributions with periodically spaced peaks.

As an illustration, Table 1 presents simulation results obtained with $N=260$. For $bw=2, 5, 10$, and 25 ms, and each of the four distributions, the table gives the mean estimated period, its standard error, as well as the proportion of sample histograms with two or more peaks. The statistics in each cell are based on 1000 simulation runs.

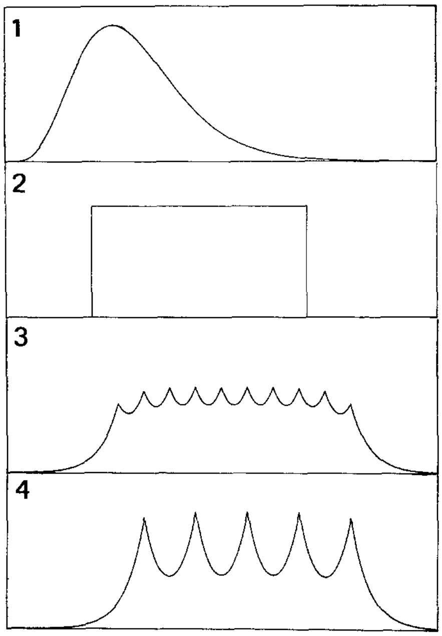

Fig. 1. Theoretical distributions used in the simulations: (1) gamma: $f(t)=[(\alpha t)^{n-1} \cdot \alpha \cdot \exp(-\alpha t)]/(n-1)!$ with $n=6$ and $\alpha=1/50$; (2) uniform on [200, 500]; (3) periodic multimodal with $n=10$, $\alpha=1/21{,}2$, and $\tau=30$; (4) periodic multimodal with $n=5$, $\alpha=1/21{,}2$, and $\tau=60$

Table 1. Expected period estimates, standard errors, and proportion of sample histograms containing two or more peaks, estimated from 1000 simulation runs each

Distribution type	Binwidth [ms]			
	2	5	10	25
(1)	22,0 (0,34; 0,998)	26,4 (0,26; 0,999)	38,3 (0,35; 0,999)	78,2 (0,84; 0,967)
(2)	21,9 (0,42; 1,00)	25,4 (0,26; 1,00)	36,5 (0,26; 1,00)	82,1 (0,91; 0,998)
(3)	21,5 (0,37; 1,00)	25,3 (0,29; 1,00)	37,3 (0,30; 1,00)	78,6 (0,83; 0,989)
(4)	25,0 (0,52; 1,00)	31,6 (0,41; 0,999)	45,9 (0,43; 0,999)	65,9 (0,49; 1,00)

From these results, the following conclusions can be drawn:

- The procedure does not discriminate between data from truly oscillatory (type 3, 4) and those from non-oscillatory (type 1, 2) distributions.
- It "reveals" periods when there are none (distributions 1, 2); the estimated period depends on bw. Note, in particular, that for the binwidth used by Pöppel, $bw=10$, the estimates obtained are of the same order as reported in [3] and [4].
- For samples from periodic multimodal distributions (type 3, 4), the estimates reflect binwidth rather than period size.

For other sample sizes, the situation looks no better. Our impression is that sample sizes at least 50 times as large as those employed by Pöppel are needed if this method is to be used at all. Instead, recent statistical techniques for density estimation [6] which do not require the data to be grouped into intervals seem much more recommendable.

We do not question the notion of oscillatory processes underlying human information processing put forward by Pöppel and his associates; independent evidence exists suggesting the existence of oscillatory periods in human perception [2]. It seems necessary, however, to caution against data analysis procedures which inevitably confirm the hypothesis one wants to test, and to reexamine the implications of findings that were obtained by this method.

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