Peter Kühl
University of Basle, Switzerland
e-mail: Peter-W.Kuehl@unibas.ch

Stochastic time-time interactions in biocatalytic and signalling systems

This contribution deals in general terms with the stochastic interplay of time points (P's, durationless events) and time intervals (I's, eventless or eventful durations). P's are visualized as the heads or feet of time arrows (hitting or leaving an I). I's are represented as simple linear segments on the time axis or as 1-dimensional parts of more sophisticated geometries (time loops, composite time strings, time nets, *zeitgestalten*). The lengths of I's and the placements of P's within I's are assumed to be describable by probability distributions (possessing positive, negative or no memory). Physical carriers of I's are macromolecules, metabolons, "signalons" or whole cells. Physical examples of P's are ligand arrivals at (or departures from) specific sites on macromolecules and - at the cellular level - nerve pulse arrivals at synapses. For the quantitative analysis of P-I interactions we apply matrix-analytic methods as used in Queueing Theory (cf. Kühl PW and Jobmann M (2006) J Rec Signal Transd 26, 1-34).

Analogously to light-matter interactions, we distinguish three major ways how a P may interact with an I: (i) reflection, (ii) absorption and (iii) emission. Depending on the degree of timing-sensitivity of the macromolecular or (sub)cellular structures and on the distributional shape of P's and I's, the overall performance of the system may be optimal, suboptimal or pessimal. Furthermore, the time patterns created by P's and I's may form - analogously to *zeitgestalten* in speech and music - a delicate mean of intra- and intercellular communication and information transfer.

The above-described P-I interactions belong to the theory of timing *sensu latissimo*, termed by us TIMETICS (Kühl PW (2007) FEBS J 274 (Suppl 1) 247); contrary to kinetics, not rates but times and time patterns are of primary concern. TIMETICS (which also includes temporal logic and memory-based phenomena) is a vast field with applications in biological as well as nonbiological sciences.