INTRODUCTION

The vast majority of organisms seem to be adapted to the daily and annual motions of our planet. It is easy to understand why this should be, since there are dramatic rhythmic changes in temperature, light, plant productivity, and in the behavior of potential competitor and predator species in the community. A strong selective advantage exists for the individual organism that can maximize its chances for survival by synchronizing its behavior and physiology with daily or yearly events. Consequently we see rhythmic changes in any number of parameters throughout the physiology and behavior of organisms (e.g., Halberg, 1959; Luce, 1970; Bünning, 1973), and thus the study of biological rhythmicity — Chronobiology — encompasses all levels of biology from the biochemistry through the ecology of a species. Until recently, however, there has been remarkably little focus on the interactions between social behavior and biological rhythms. The available information and discussions have lacked organization around a body of generally known literature or around a set of clear issues and questions. This relative neglect can be explained in terms of historical and technological factors.

For many years the emphasis in chronobiology was to discover the physiological basis of rhythmicity. Experiments were carried out in the climate of a general interest among chronobiologists in constructing predictive models, both in an attempt to discover the mechanism(s) for rhythmicity and in an attempt to understand the role of rhythms in health and disease. Animals

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were studied in isolation so that precise effects upon rhythms of simple variables such as light, temperature, and even some drugs could be determined. With such objectives and procedures social effects on rhythms were apt to go generally unstudied.

In addition it is technically more difficult to study the rhythms of several interacting animals than of singly-caged animals. If a microswitch is depressed, or a photoelectric beam broken, which of two or more individuals was responsible? How do we separately monitor the activity of several commonly caged animals?

Further, how shall we quantify social interaction? There has been a lack of obvious means to characterize, either statistically or graphically, rhythms of complex social interaction. This has been a major barrier in the development of a Social Chronobiology.

In this paper we first review selected elements of the somewhat scattered literature, as are appropriate to a discussion of questions that are suggested by the recent findings. Next we discuss experimental techniques that we used successfully to study the rhythms of animals in social situations. We detail our progress in finding methods to quantify such studies.

SOCIAL SYNCHRONIZATION

Circadian Rhythms.

Some workers use the term circadian (about daily) in a restricted sense: only when a rhythm persisting under constant conditions has been experimentally demonstrated. Similarly, a synchronizer could not be claimed unless a circadian rhythm sensu strictu has been demonstrated. We generally use the term in the original, less exclusive sense of Halberg (1959) and as followed by the International Society for Chronobiology (Halberg et al., 1977) although the restricted criteria have been met in several of the experiments cited by us. Obviously where strict criteria have not been met the question remains of whether activity patterns have been proximally modified or whether physiological "timing" mechanisms have been "reset".

The social synchronization (occurring together in time) of daily, circadian rhythms in man is obvious. In our society, at least, conditioning plays an important part in this. Children may be scolded or punished if they do not go to bed "on time". Both children and adults may be aroused with loud alarms or by physical shaking to get them up "when they are supposed to". Certainly, more subtle cues are operating as well. Social conditioning, though, is so much a part of our lives that it is not clear to what extent we can generalize from the available studies on our own highly specialized species