# Digital event recorder capable of simple computations and with computer access for behavioural studies

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An event recorder which can summate and display stored data is described. This instrument can be used to record behavioural events or sequences in the laboratory or the field and produces a punched tape record which may be read by a computer, without need for an interface. Its ability to perform simple calculations for immediate data reduction gives this event recorder a capability superior to that of other behavioural recorders.
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'n Gebeure-registreerder wat gestoorde data kan optel en vertoon word beskryf. Hierdie instrument kan gebruik word om gedragsgebeure of volgordes in die laboratorium of in die veld op papierband te registreer. Die papierband kan later deur 'n syferrekenaar gelees word sonder die vereiste vir 'n tussenvlak tussen die instrument en die syferrekenaar. Die vermoë om eenvoudige berekeninge vir onmiddellike dataverwerking te doen verleen aan hierdie gebeure-registreerder 'n groter toepassingsmoontlikheid as ander gedragsregistreerders.
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Recording behavioural events accurately and processing the accumulated data can be a tedious, time consuming and often cumbersome operation. To avoid much of the drudgery involved in data processing, ethologists have developed a variety of events recorders, some of which give computer access through analogue tape recorders (White 1971; Dawkins 1971; Butler & Rowe 1976) or digitally via a paper punch (Goude *et al.* 1972).

In sensitive or critical experiments it is frequently necessary to have results available immediately at the site of experimentation. This enables one to keep abreast of events and to adjust or cease experiments as expedient. Such a facility is especially important to ethologists who might otherwise lose opportunities to follow behavioural trends due to the unmanageable bulk of their data. To avoid delays inherent in the use of tape-recorders and other devices which require a computer for data analysis, an event recorder was developed capable of simple computations and with digital display for immediate read-out. In addition, computer access via a paper-tape punch could be mobilized if required.

The instrument described below has wide application in the behavioural sciences for both observational and experimental work. It is portable and the keyboard can be operated underwater. If used underwater the power supply and event recorder would remain on a raft or boat, linked to the keyboard (via a cable).

Although designed specifically to record behavioural events, this instrument can be used to monitor physical parameters, botanical or physiological conditions.

The event recorder, its principal application and its attributes are described below.

## Functions

Although the event recorder may aid in a study of the behaviour of any group of animals, it was originally designed to handle behavioural data generated by experimental studies of cichlid fish. We were interested in the number of activities performed by different populations of fish (Ribbink 1971, 1972). The relative frequencies of activities such as tail-beats, side-shakes, bites, lead-swim and others were counted and stored. Furthermore, the period of time spent in any display or activity such as lateral display

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during aggression or side-shake during courtship was recorded. Finally, as the sequence of behavioural events could be altered by experimented manipulation, these were also recorded. Thus, the event recorder can record three aspects of behaviour: the number of occasions any specific activity is performed; the time spent in any display or activity; and, the sequence of behavioural events. The first two of these are totalled by the event recorder itself. Behavioural sequences are punched onto paper tape which provides a permanent record and computer compatability. The computations of the event recorder may also be recorded on paper tape in addition to being read directly from a digital display.

## Operation

Before a sequence of events is recorded the instrument is reset by clearing all previous data. Entry is via a keyboard where 16 keys are provided for arbitrary event allocation. The number of keys may be considerably increased to cope with multiple behavioural events. Depressing any key results in the recording of that key's code number as well as the time of depression. Each utilization of a key is recorded. At the end of an experiment, therefore, the total number of times any behaviour pattern occurred will be given. The event recorder (Fig. 1) operates against an internal digital clock which may be present for intervals (time units) of one second, 500 or 250 ms. Timing commences with depression of a key to denote the current behavioural event. The event recorder may be preset to automatically terminate the experiment after a fixed time or allowed to run until stopped manually.

When two or more behavioural events occur simultaneously it is often necessary to record both. This is done by depression of a 'register advance' key ahead of the next 'event' key which has the effect of steering the current input to the next register in the stack, whilst summation in the base register is unaffected. For example, if a fish, while in lateral display begins to tail-beat then this is recorded by depressing the register advance key followed by depression of the 'tail-beat' key. Both lateral display and tail-beating are then recorded simultaneously. A maximum of four events can be recorded at the same time by the event recorder. This enables one to either record four simultaneous events from one animal (a fish seldom performs four simultaneous events but a mammal, such as a canid, may do so. For example, a fox while snarling with bared fangs, arches its back, lifts its leg and urinates), or, one may record interactions of two or more animals simultaneously. For example, two fish while fighting may both be in lateral display and tail-beating. The activities of both may be recorded simultaneously. Return to base register is via a 'return' key. The use of register 'advance' and 'return' keys is also recorded by the instrument.

Each set of memory registers in the event recorder is capable of storing the total number of operations and the total time accrued by each of the allocated keys to a maximum of 1 000 operations and time units per key. At the end of a recording period the totals within a memory set are displayed on the front panel and may be transcribed or recorded on paper tape. The front panel display consists of eight digits and four discrete lights. The lights show the register level (how many behaviours are being recorded

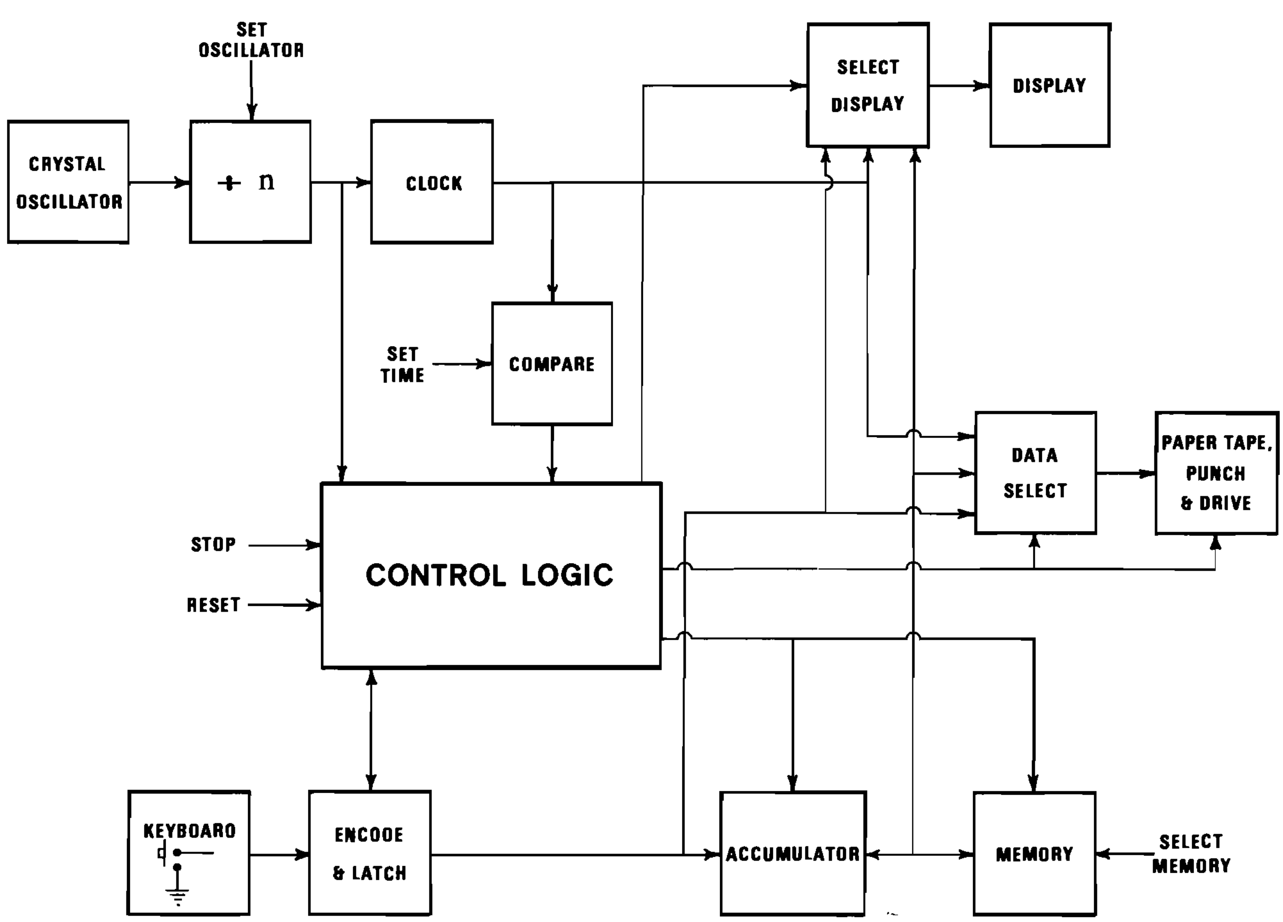


**Fig.1** Diagram of event recorder.

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simultaneously) during keyboard entry whilst the numeric display is organized as follows:

— during key-in operation the two left-hand most digits display the number of the key most recently depressed, these are followed by one blank digit and a five digit elapsed-time display. For example, 12 215 where 12 denotes the behaviour pattern (lateral display) and 215 the elapsed-time in the chosen time units (1 s, 500 or 250 ms) and

— at the end of an experiment and memory is automatically switched to read-out during which all the stored information is displayed for transcription. Once again, the two-left-hand-most digits display the register number whilst the remaining six are divided into two sets of three (separation is by decimal points) which display the total number of events and the total accrued to that register for that selected memory set. An example of a read-out may be

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  where 08 is the courtship behaviour, nest-shake; 026 indicates that it occurred on 26 occasions and 215 shows that nest-shake behaviour was recorded for 215 time units which is the total amount of time spent in that behaviour during the experiment. To facilitate transcription the memory contents are recycled indefinitely on the display screen and each register is displayed sequentially at two s intervals.

Should one prefer to run a number of experiments consecutively without a pause for transcription, this may be done by selecting one memory after another. Provided it is not cleared deliberately, or the event recorder is not switched off, each memory set will hold its contents until it is convenient to transcribe.

The paper tape-punch records each key depression, punching the key number, the register level and a five digit elapsed-time value. The numbers separated by spaces and followed by carriage return and line characters, which separate records and provide teletype and computer compatibility. If required, the totals held in memory may also be punched, in the displayed form and followed again by carriage-return and line feed character. All information obtained from an experiment or period of observation may be stored on paper tape and used later for statistical analysis.

## Discussion

In its several hundred hours of use to date, the event recorder proved to be invaluable both in saving time and in keeping experimenters abreast of behavioural trends. Although primarily as event recorder, this instrument's computational ability, coupled with its computer access, sets it apart from other event recorders. It was also designed to facilitate precise and unobstrusive implementation of experimental procedures; for example, setting the instrument to record for a predetermined period ensures that all experiments will run for the same duration and will be terminated automatically and silently, causing no disturbance to the animals. Under conditions in which the experimenter does not have recourse to the read-out of the event recorder — such as when using a remote keyboard — the operator will need to remain aware of the time in order to prevent unnecessarily long exposure of subject animals to experimental situations.

The event recorder was limited to 1 s, 500 ms and 250 ms time units in the belief that operator stimulus-response lag in selection of the correct key was so slow by comparison that greater resolution of time lapse was unwarranted. Behavioural events occupying fractions of a second are better recorded and analyzed on cinematograph film.

The speed of the paper tape-punch is another limiting factor in the choice of a time-base. Fast punches (100 characters per second) are expensive and often bulky. The model used here was capable of 40 characters per second.

Commercial event recorders are largely chart recorder based with the required number of channels, each having a limited movement and providing an ON/OFF type record against a clock (which may be one of the channels). They are usually bulky devices with a limitation on the number of channels set by the physical size of the instrument. The record produced has to be analyzed manually which is often extremely awkward and time consuming.

The instrument described in this paper has several advantages over those described elsewhere. To illustrate these a brief comparison with certain other event recorders has been made.

Frequency-shift encoding (Dawkins 1971) has the advantage of simplicity. It is restricted, however, as the number of possible 'keys' is limited as frequency shifts need to be large for reliable recovery and only one key may be depressed at any one time. There is no data redundancy. No clock exists on the record itself and has therefore to be created by the computer, taking possible changes in tape speed into account.

The system used by White (1971) is more elegant; any number of keys may be depressed simultaneously, there is a built in data clock and time intervals are defined by record and inter-record gap lengths. The total elapsed time does, however, have to be totalled by the computer.

Another approach was that of Butler and Rowe (1976) in which an audio tape recorder was used to record tones superimposed upon a spoken number (each tone is a separate, concurrent, experiment and the number is the relevant activity). Frequency selective circuits sum the number of occurrences of a particular tone and measure the 'length' of the tone burst whilst the experimenter noted the parameters. An advantage in this system is the very significant reduction in the number of keys, the main disadvantage is the time taken to analyze the data — equal to the recording time for each tone.

The use of an audio tape recorder (Butler & Rowe 1976; Dawkins 1971; White 1971) has a distinct advantage in silence; however, the absence of data compression is a decided disadvantage in each system. An audio tape recorder of suitable quality would cost from half as much as the paper tape-punch and any link to a computer would require a dedicated interface. The paper tape produced by the instrument described here may be decoded by a teletype directly or read by a computer without a special purpose interface.

The internal memory system can make results available immediately. Four sets of memory registers were installed although provision was made for ten sets. A large number of memory circuits could enable an experimenter to conduct many experiments and immediately compare the totalled

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data.

The instrument described was built in our laboratories for approximately U.S. $1 200, including the cost of the paper-tape punch, and it has been constructed as a 47,5 cm rack mount instrument weighing about 14 kg complete. Power is drawn from AC mains.

An advanced form of this event recorder is under consideration for future construction. It would make use of a microprocessor as well as a digital cassette recorder to provide a compact, lightweight instrument capable of data storage and having low power consumption.

Instruments such as the event recorder in this paper will find growing use amongst ethologists in the future. This view is influenced by trends which indicate that ethology is becoming increasingly analytical and therefore in need of accurate and sensitive methods of data accumulation and analysis. Furthermore, continuing advances in electronics are increasing the scope and efficiency of such intruments while decreasing their size and cost.

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