A COMPARATIVE STUDY OF SEVERAL METHODS FOR RECORDING SPONTANEOUS MOTOR ACTIVITY IN MICE UNDER DRUG EFFECTS

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Summary: Various existing methods of recording motor activity in animals are briefly reviewed. An electronic adaptation of an old one, the Jiggle cage, is described. The relative advantages and demerits in recording behaviour of mice under drug effects are compared with those of the traditional Jiggle cage, an electromagnetic activity counter and observational ratings.

Key words: Jiggle cage polygraphic adaptation behavioural methods comparative assessment

INTRODUCTION

Spontaneous motor activity (SMA) of small animals, singly or in groups, is an important parameter of measurement in behavioural studies. SMA usually incorporates both purposive and nonpurposive locomotor activities as well as nonambulatory movements like grooming, scratching, shivering, gnawing etc, provided that the registering device is sensitive enough. Devices which record such total motility suffer from this lack of discrimination (9, 12), whereas, those for recording translational locomotion only are incapable of providing any qualitative information as to the nature of activity and behaviour, particularly, under the effect of drugs. Complex changes in behaviour are all masked by a set of crude numbers or counts (1).

Various types of apparatus or activity cages have been designed and used for recording motor activities. These fall in three main categories : cages moving up and down, those which rotate, revolve or tilt and those which remain fixed (12). The first type includes the traditional 'jiggle' cages which may be supported on air tambours (18) or spring-mounted and the activity recorded on kymograph (13). These cages measure total activity, but the kymographic recording makes quantitative treatment of the results difficult. To circumvent it, various adaptations have been tried to control and translate the cage movements into numerical counts by ratchet--operated work-adders (6, 14) or electrical circuits (3,19). The second type includes rotating wheel cages (16) or revolving turntables (4) which move around a horizontal or vertical axis, and the number of revolutions can be recorded on kymographs or mechanical (7) and electrical (11) counters. The revolving wheel only registers running activities of the animals and not small movements. Another type of cage tilts in any direction (5) or only in one plane (1) by the movements of the animals which are recorded mechanically or electrically.

The third type of fixed activity cages measure the activity of animals more directly. The earlier methods of direct observation of animals moving across squares and self-recording animals moving on smoked paper, sand-covered gauze or pulling threads and chains attached to

mechanical counters have been well reviewed (12). The later modifications of such activity cages were based on capacitance changes (8), photocell counters (15, 20), make-and-break type of electrical circuits (9) or electromagnetic induction coils as used in the 'Animex' activity counter (17). These methods permit automatic recording of walking, rearing or running activities selectively, but not the small movements like tremor, shivering, gnawing, clonic jerks etc., which do not involve any appreciable change of location but do provide relevant information about the behavioural status of the animals, especially after drug treatments, and for which direct observational data are indispensable.

Several workers have compared some of these methods for recording motility of small animals as well as larger primates. While a few found good correlation between them including observational ratings (6), others failed to obtain persistent correlation, particularly, when measuring drug-induced hyperactivity, and found direct observation to be more dependable than photocell counters, (10). Although it registers total motility, the jiggle cage was also found to be recording drug-induced hyperactivity much better than motimeter, an electrical activity counter (2).

MATERIALS AND METHODS

We have endeavoured, in this paper, to compare the activity of grouped mice under the influence of amphetamine as recorded by direct observation, mechanical and electrical adapted jiggle cage and the electromagnetic 'Animex' activity counter, respectively. The jiggle cage was tambour-mounted (Fig. 1) but, instead of recording on kymograph through another tambour (13,18), which was done only in few experiments for comparison, the pressure fluctuations were fed into a polygraph (model 5D, Grass) via a volume transducer. This adaptation not only permitted to select a suitable range of sensitivity or paper speed over the obvious limitations of a kymograph, but also allowed to filter out the high-frequency activity of artifacts like 'jiggles' considerably by working within a low frequency-selector range on the driver amplifier when recording fine movements like tremor, shivering, ataxia etc (Fig. 2). Such behavioural events could be recorded and reasonably identified by this method in good correlation with direct observational protocols. On the other hand, they could not be registered either on the kymographic tracing of the jiggle cage or in the Animex counter to any appreciable extent.

The polygraphic tracings of the movements of the jiggle cage were recorded both at slow (0.25 mm/sec) and fast (25 mm/sec) paper speeds at a sensitivity of 5 mV/cm. The frequency of the oscillograph pens at fast speed reflected the actual SMA which could be counted per min, largely disregarding the low-amplitude jiggles. The amplitude of the low-speed tracing was taken to be indicative of the excitable state of the animals, i.e., it was higher when the mice were moving more vigorously like jumping, scampering, fighting etc., in contrast to walking or running *fast* which mainly contributed to the increase in frequency. Besides, the number of leaps and fights could also be roughly counted from the long spikes in the slow speed tracings where the associated jiggles were merged in the background. However, the

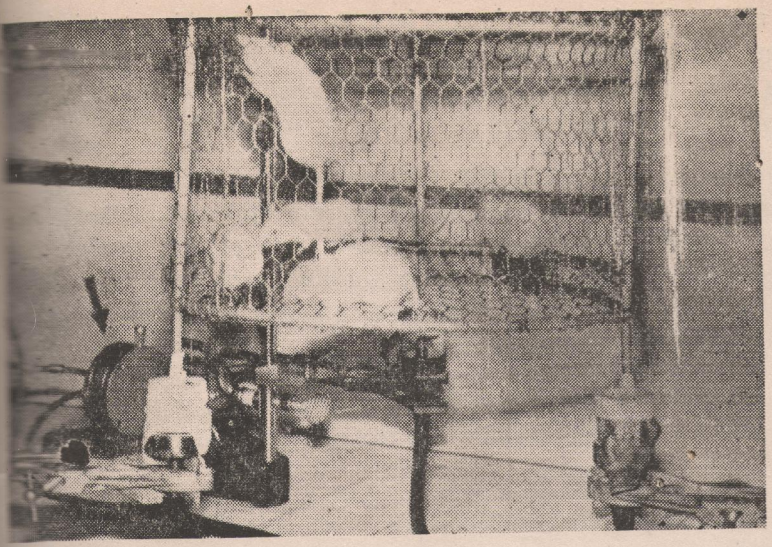

Fig. 1: An aluminium wire-mesh circular cage supported on 3 tambours and convergingly connected to a volume transducer (*arrow*) for translating the displacement changes into electronic impulses which are fed into a polygraph (*not shown*) for recording.

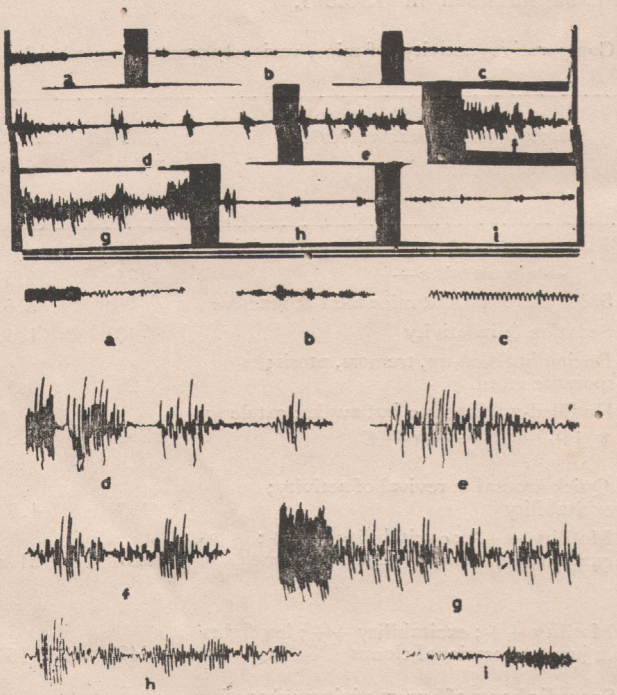

Fig. 2: An illustration of samples of kymographic ink-recording at slow (0.26 mm/sec) and fast (8.53 mm/sec) speeds, depicting different behavioural events. Corresponding polygraphic tracings of the same events (*below double line*) recorded at 0.25 mm/sec (*solid black*) and 25 mm/sec speeds show : control SMA (a); tremor (b) and shivering (c) at $1\frac{1}{2}$ and 24 hr after reserpine; jumps (d), scampers (e), scuffles(f) and fights (g) after amphetamine in reserpinized mice; clonic convulsions (h) and ataxic motility (i) were late amphetamine effects.

observational protocol was needed for this, since jumps, leaps or fights could not strictly be differentiated from each other just by studying the tracings, *per se*. These events could then be arbitrarily graded on the basis of a 5-plus rating scale (3-4 jumps/ 1-2 fights/1 convulsion =1+), which tallied well with a separately maintained observational protocol.

A kymographic inkrecording is compared with corresponding polygraphic records, obtained from identical experiments, in Fig. 2. The sensitivity and resolution of the former were very limited and hence the tracings were scarcely discriminative; yet a pattern, characteristic of the events, could be recognized. On the other hand, the Animex activity counter produced only a set of figures and, apart from a high or low activity, no other information could be gleaned from these directly without consulting the protocols.

Results were noted down every 10 min with either of these methods, were quantitated as described above, and compared with each other and with direct observational ratings obtained from identical experiments by another observer.

RESULTS AND DISCUSSION

The results are summarised in Table I.

TABLE I: Comparative activity of mice, variously treated, recorded by different methods

Treatments & times		*Observational protocols and ratings*	*'Animex' recorder (counts/min)*	*Jiggle cage (polygraph trace)*		
				amplitude mm	*frequency (per min)*	*other events (per min)*
None (control)		Mice showing normal motility & activity	131	4.25	460	0
Saline	10 min	— almost same —	124	4.5	400	0
(0.1 *ml*)	60 „	SMA decreased but mice alert & reactive	88	3.5	360	0
Reserpine :	30 „	Sedation & inactivity	48	1.5	120	0
(2.5 μg/g)	60-90 „	Dozing huddled-up, tremors, ptosis; sporadic motility	26	0.5	50	0
	24 hrs	Huddled-up, inactive but awake; catalepsy + ; ptosis ++; shivering	2.6	0.5	50	0
Amphetamine (7.5 μg/g)	10 min	Quick arousal & revival of activity; excitability	139	4.5	580	jumps 1-2
(1 hr after reserpine treatment)	30-45 min	Motility +++; excitability +++; runs, jumps, scampers, fights frequent	207	21.5	960	jump 12-15 fight 4-5
	60 „	Motility ++; excitability ++; less fights & jumps; occasional clonus	142	16	840	jump 6-8 fight 2 clonus 1
	90 „	Sporadic bouts of hyperactivity; exhaustion & ataxia; 1 or 2 dead	80	5.5	360	jump 1-2
	120 „	Mice exhausted or dead; little sporadic motility	47	3.5	220	0

The figures are the means of 5-9 experiments for each category; the observational protocol includes summarised features commonly seen.

The three methods agreed closely with each other, as seen in Table I, when recording was limited to control and subnormal activities. But, in complete agreement with earlier workers (2, 10), we found that drug-induced hyperactivity states are not registered by direct activity counters, like the Animex or photocell as reliably as by direct observation or even by motility recorders like the traditional jiggle cage (Fig. 2), not to mention the modified one. The maximal hypermotility produced in reserpinized mice by amphetamine, 30-45 min after administration, was recorded by the Animex counter as only 58% and 67% increases over the no-drug and saline controls, respectively. By contrast, similar increases in the frequency counts were 109% and 140% over the no-drug and saline controls, when recorded, in identical experiments, by the polygraphically adapted jiggle cage (Table I). The limitation of the electromagnetic counter, in this respect, appeared to be that the maximal rate of count was 3-3.5/sec only, whereas the polygraphic jiggle cage could record activity at a 2-3 fold higher rate, even after disregarding the elastic jiggles mostly.

Besides, the marked hyperexcitability and associated behavioural events like jumps, runs, convulsions etc. were fairly represented on the polygraphic tracings of the jiggle cage (Fig. 2) and not at all on the Animex counter. In the latter method, information regarding these discrete behavioural events could be obtained from a carefully maintained observational protocol only. The remarkable increase in the excitability of the animals, occurring under reserpine-amphetamine interaction, was scarcely reflected in the mere increase in the numbers registered by the Animex counter. But this was much more emphatically represented in the amplitude of the polygraphic tracings of the jiggle cage, apart from the increase in frequency serving as the main indicator of hyperactivity. The relative lack of discrimination of the jiggle cage would, therefore, be more than balanced by a truer representation of the events as well as by the broad spectrum of activity recorded in close correlation with the observational ratings, given independently. Lastly, the apparatus can be easily assembled and is inexpensive, considering the fact that the polygraph is a standard equipment in modern laboratories of all countries.

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