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CATNIP AND OESTROUS BEHAVIOUR IN THE CAT

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Wild animal hunters and photographers have long taken advantage of the attraction that catnip holds over members of the cat family, while domestic cat owners purchase dried catnip leaves for use as a rejuvenator and exerciser that will bring old cats to new life. Indeed, when cats have the leaves placed near them, they immediately approach, sniff, and shortly thereafter rub their faces into the leaves and roll back and forth over them.

The first group to take any scientific interest in the phenomenon were chemists, who concentrated on isolating the aromatic component that causes the reaction. It had been assumed and was subsequently verified by Todd (1963), that the odour and not the taste of the catnip causes the response. Catnip (*Nepeta cataria*) or catmint, is a member of the mint family and grows wild over a large area of America and Europe. By distilling the crushed plant to obtain the volatile oil, fractionating this into its constituents and testing with both African lions and domestic cats, an unsaturated lactone, trans-cis nepetalatone, was identified as the active ingredient (McElvain, Bright & Johnson, 1941; McElvain, Walters & Bright, 1942; Bates & Sigel, 1963). This type of chemical analysis, however, does not explain why the substance elicits the reaction. A possible answer was not suggested until Todd (1962) studied the inheritance of the catnip response. He had observed that only a proportion of cats reacted to catnip, and through controlled breeding experiments found that the predisposition to respond was inherited as a dominant autosomal gene. It was during the course of these investigations that he incidentally observed that the rolling pattern of the catnip reacting cat was strikingly similar to some aspects of female oestrous behaviour (Todd, 1963). On the strength of this observation Todd suggested that the catnip odour might be related to oestrus in some way, perhaps resembling a sex odour or pheromone.

To test this hypothesis, he collected urine from males, anoestrous females, and oestrous females, then bio-assayed the samples for the ability to elicit 'catnip' behaviour by presenting them to two female and two male cats which were catnip reactors. There were no reactions to the female urine, but one of the males and one of the females responded to the male sample. Although recognizing that the data were not conclusive, Todd (1963) suggested that 'catnip coincidentally mimics a pheromone of the cat which is capable of eliciting or reinforcing specific postural displays of courtship'.

Before implications such as the above can be accepted, it is necessary to evaluate experimentally the suggested hypothesis that catnip elicits a portion of oestrous behaviour.

General Procedures

The subjects were thirty-seven male and twenty-eight female cats of mixed stock obtained locally. Those animals housed in the laboratory were sexually segregated and maintained on both wet and dry commercial cat food.

All laboratory observations were made in two identical boxes 6 ft × 4 ft × 2 ft high. The top and front of each box was constructed of 1 in. chicken wire, the floor and remaining walls of plywood. Because of the persistent odour of catnip, the boxes were located in well separated rooms, one being used only for catnip conditions and the other for no-catnip conditions. For the same reason, the experimenter wore different gloves and laboratory coat in each room. The cats were observed from behind cardboard screens which had small viewing windows. The catnip used for all the experiments was an undiluted synthetic catnip oil which contained nepetalactones obtained from Fritzsche Bros., Toronto, Ontario, and was dispensed from an atomizer.

Experiment I

Todd has analysed the catnip reaction into four components: (1) sniffing; (2) licking, chewing, and head shaking; (3) chin and cheek rubbing; and (4) head-over rolls and body rubbing. It is possible, however, that some of these behaviour patterns were artifacts resulting from the testing technique. In this part of his research, the cats were presented with dried catnip leaves, thus compounding the odour of the leaves with

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the leaves themselves which could be eaten or played with. The catnip may have been only unspecifically arousing the cat which then reacted in a normal but aroused manner with the leaves. To test this possibility, cats were observed in an empty test box which had catnip sprayed in the air, and their reaction was compared to the behaviour shown when they were observed in the other test box without catnip. If the catnip is a non-specific arouser then there should be a general increase in frequency or duration of most behaviour patterns, while if the catnip actually elicits specific patterns, only these should increase in frequency.

In addition to this experiment, an attempt was made to determine if the catnip would alter the cats' behaviour towards relevant objects. This was tested by pairing the cats, in both catnip and no-catnip conditions, with either a live rat or a stuffed, cloth bag approximately the size of a cat. If the catnip has anything to do with hunting or prey killing, this should be evident from a comparison of the cats' behaviour towards the rat in both conditions. A comparison of the cats' interaction with the stuffed object might reveal motivational states relating to fighting or sexual behaviour.

Method. Four male and two female cats which previously showed rolling behaviour when presented with catnip leaves were used in this experiment, and were housed in individual wire cages 22 in. × 24 in. × 18 in. high. All cats were exposed to the test boxes for 15 min a day for 4 days to familiarize them with the procedure and apparatus. For the actual testing, the cats were run each day according to a fixed order in a 6 × 6 Latin square so that each cat was observed alone in the box, with a rat, and with the stuffed object, under both catnip and no-catnip conditions. The cats were taken individually from their cages as required and brought into the appropriate test room where they were immediately placed in the box. If the rat or object was to be used, it was inserted after the cat, so that the cat's attention was drawn to the stimulus. For the catnip condition, the same procedure was used except that catnip was sprayed into the box before testing when the cat was to be alone, and the rat or object was sprayed before it was inserted. Cats were observed for a 10 min period during which time the experimenter recorded on sequential time sheets the type and duration of any behaviour patterns that occurred including those mentioned by Todd.

Results. Of all the behaviour patterns observed when the cats were tested alone, only rolling and head shaking showed consistent and significant increases in the catnip condition (see Table I, top line). There were no significant differences in the amount of sniffing, licking or chewing. In fact none of the cats was observed showing any chewing movements. Similar results were obtained when a rat or stuffed object was present; only rolling and head shaking increased significantly (Table I, second line). In addition, there was a tendency for box scratching to increase in the presence of catnip, although this was not statistically significant.

Table I. The Effect of Catnip and Oestrus on Selected Behaviour

Groups	n	Rolling			Head shakes			Rubbing			Self licking		
		NC	C	*P*	NC	C	*P*	NC	C	*P*	NC	C	*P*
Experiment 1 Alone	6	56	666	0·05	28	58	0·05	6	4	ns	324	178	ns
Experiment 1 With stimuli	6	64	1074	0·01	40	89	0·05	18	52	ns	274	384	ns
Experiment 2 Replication	9	13	778	0·01	53	91	0·06	0	52	ns	1189	1077	ns
		NE	E	*P*	NE	E	*P*	NE	E	*P*	NE	E	*P*
Experiment 4 Oestrus	4	0	494	0·03	66	117	0·20	10	490	0·03	521	314	0·25

Scores are sum totals and are measured in seconds for rolling, rubbing, and self-licking, and in frequency for head shakes. Cats in experiment 1 were tested once, while cats in experiment 2 and 4 were each tested twice. Difference evaluated by the randomization test for matched pairs (Siegel, 1956, pp. 88–92). NC = no catnip; C = catnip; NE = non-oestrus; E = oestrus.

Table II. Comparison of the Change in Rat-directed *v*. Object-directed Behaviour Patterns when Exposed to Catnip

Behaviour (sec)	Rat			Object			P
	NC	C	Change	NC	C	Change	
Sniffing	84	70	−14	54	104	+50	0·34
Licking	0	0	0	0	68	+68	0·25
Paw batting	234	56	−178	8	48	+40	0·03
Combined (attention)	318	126	−192	62	220	+158	0·03

Scores represent totals of six cats. Binomial distribution used to test hypothesis that there is a greater increase in duration of behaviour patterns under catnip with the object than with the rat.

Along with these behavioural effects, there were other changes which were specific to the rat or object. Table II shows the effect of catnip on paw batting, sniffing, and licking the rat or object. It can be seen that there is a decrease in duration of these behaviours when they are directed to the rat in the catnip condition, and an increase when they are directed to the object. This effect was statistically evaluated by using the binomial expansion to test the hypothesis that there was a greater increase in duration of behaviour patterns in the catnip condition with the object than with the rat. Only paw batting showed a significant change. When these behaviours were combined to form an index of attention, four of the six cats exhibited an increase with the object and none showed a decrease, whereas four cats showed a decrease with the rat and none showed an increase. This was statistically significant.

On the basis of the specific behaviour changes shown in the catnip box, and the differences observed in the cats' reaction to the object as compared with the rat, it is evident that the catnip is not simply an unspecific arouser. It is also apparent that catnip has little if anything to do with hunting. One cat killed the rat only in the no-catnip situation, appearing confused when catnip was present, while another killed the rat in each situation. The behaviour of this cat did not differ in the two situations. No fighting or sexual mounting was observed.

Experiment 2

Experiment 1 identified rolling as the predominant behaviour elicited by catnip, although head shaking and box scratching also showed increases. Experiment 2 is essentially a replication of the first experiment except that more accurate measures were taken of behaviours which were suspected of being implicated in the catnip response. In addition, the rolling pattern was analysed into its components, and male and female cats were compared as to the latency and duration of rolling when they were exposed to catnip.

Method. A new group of four male and five female reactors were individually tested for 10 min every second day for four test days with catnip being presented only on alternate days. Electrical timers connected to foot or hand switches, were used to determine the amount of time that the cats rolled, rubbed, licked themselves, and scratched. This scratching referred not to wall scratching, but to a rapid fore-paw 'digging' pattern. The scratching measure in experiment 1 did not differentiate between these two types. A second test group consisting of only the four males was similarly observed for 10 min periods to record head shakes, since these were not observed in the original group. The females were not included because they were then being used in another experiment.

Following completion of the behaviour timing experiment, the four males and five females were tested twice in the catnip condition to analyse the rolling pattern and to record latency and duration.

For this experiment and all following experiments performed in the laboratory, the cats were housed in two large wire colony cages 6 ft × 6 ft × 6 ft high. The males and females were segregated. Their cages were placed side by side to allow for some degree of interaction.

Results. As can be seen from Table I, third line, rolling was again identified as the most striking catnip effect. The amount of head shaking was measured in the ancillary study, and although only four animals were used, all four showed an increase in the response. The amount of box scratching again showed a tendency to increase under catnip, and there were no significant differences in either rubbing or self licking.

Another reacting female was added to the four male and five female reactors for the rolling analysis. The ten cats were tested twice in the catnip box, making twenty separate trials in which rolling occurred. Body rolling was always present, face rubbing was observed in nineteen trials, perked ears in eighteen, and extended claws in eighteen. A typical roll began with the cat thrusting his face onto the floor where he swept his jaw back and forth, progressively stretching out, feet extended in front of him, ears perked, and claws out. The cat then twisted his head around and rolled his body over from one side to the other. The duration of the rolling was extremely variable, lasting from a few seconds to 4 or 5 min and being repeated one to fifteen times.

Males and females were compared on latency and duration of the rolling response (Table III). No significant differences were indicated by a Mann-Whitney U test.

Table III. Latency and Duration of Rolling with Males and Females

	Duration (sec)		Latency (sec)	
	Males	Females	Males	Females
	263	214	20	335
	138	95	107	475
	169	156	378	256
	34	171	445	315
		134		281
		74		365
Means	151·0	140·6	237·5	337·8

Scores represent two trial totals.

In summary, experiments 1 and 2 have shown the catnip response to consist primarily of a rolling pattern composed of body rolling and face rubbing. Head shaking also increased during exposure to catnip but unlike Todd's results, there were no significant differences in sniffing, licking, chewing, or rubbing that occurred independently of the rolling pattern. A possible explanation for the differences between these findings and Todd's (1962) analysis is that the other behaviour patterns were specific to the dried catnip leaves and were not elicited by the odour itself.

Experiment 3

If Todd's (1963) assumption that the catnip reaction is a portion of female sex behaviour is correct, it should be determined to what extent the reaction is linked to sex and presence of gonads. Since experiments 1 and 2 did not reveal any striking differences in reaction between males and females, a house-to-house survey was taken in order to gather data from a larger number of cats than would normally be available in the laboratory.

Method. A total of forty-five cats was tested, twelve male, fourteen castrated male, ten female, and seven spayed female; the age of the cats ranging from 2 months to 11 years, the average being 3 years. Each cat was brought by the owner to a convenient test area where it was placed in front of a stuffed bag which had been sprayed with catnip. If the cat showed the typical rolling pattern, it was labelled a reactor; cats that showed little or no interest in the object were labelled non-reactors; and those which sniffed the object for a long time but did not roll were left as questionable. Following testing the owner was asked the cat's age, sex, whether it had been spayed or castrated, extent of experience with catnip, and its previous reaction.

Results. The catnip reaction was found to be independent of sex and gonadal state. Approximately 50 per cent of each group responded to the catnip. Although small differences were observed (see Table IV) these were far from approaching significance. Age did not seem to be an important variable, as reactors were found

Table IV. Relation between Sex and Reaction to Catnip

Groups	n	Reactors (per cent)	Non-reactors (per cent)	Question-able (per cent)
Male	12	50	33	17
Castrated male	14	64	20	14
Female	10	50	30	20
Spayed female	7	43	29	29

with 2-month-old kittens as well as 10-year-old adults, although Todd (1963) has reported that kittens younger than 6 weeks do not react. Cats which had been exposed to catnip before, reacted in the same way again, whether they were reactors or non-reactors.

Experiment 4

Although Todd noted a similarity between the catnip reaction and oestrous behaviour, the comparison was based on incidental observation and not experimental evidence. If the relation is to be accepted it is necessary to analyse oestrous behaviour into its components and compare with the catnip data obtained from experiments 1 and 2.

Method. Since it was problematic as to when the female cats would come into heat in the laboratory it was decided to induce oestrus by administering hormones. Four females were injected daily with 10 ml of a 1 mg/ml solution of diethyl stilbestrol dipropionate (synthetic oestrogen) until they came into heat. This state was evident by their rolling and presenting behaviour which was directed to the males in the adjacent cage. The cats were each observed twice in the no-catnip box for 10 min, both before treatment and after. The amount of rolling, licking, rubbing, and head shaking was recorded with electric timers and a counter. The rolling components were also noted. It should be mentioned that it was usually necessary to expose the oestrous females to a male outside the test box in order to elicit the characteristic heat behaviour.

Results. Oestrus resulted in the female cats exhibiting a considerable increase in rolling (Table 1, bottom line). Analysis of this rolling pattern revealed that body rolling and face rubbing were consistent components occurring during each of the eight trials. The cats had extended claws in six trials and perked ears in three of the trials. Head shaking gave some indication of increasing in the oestrous state but this was not significant. There was no significant difference in licking, and no measure of scratching was taken. The cats also showed a great increase in head and flank rubbing that occurred independent of the rolling pattern.

The experimental design was appropriate for the use of the randomization test for matched pairs (Siegel, 1956) but since cat No. 1 became sick and had to be replaced for the oestrous part, its use is not entirely correct. The substitute cat did not reverse existing trends except in the head shaking measure where the change was in a direction opposite to that which would be predicted.

The behaviour exhibited by these cats which had oestrus induced artificially confirmed earlier observations on seven females which were in natural oestrus. Unfortunately, detailed records were not kept, but it was observed that the rolling was composed of body rolling and face rubbing.

In summary, it can be seen from a comparison with the findings of experiments 1 and 2 that the oestrous rolling pattern is, to the observer, very similar to the catnip pattern.

Discussion

A comparison of behaviour patterns observed when cats react to catnip and when females are in oestrus reveals that the cats show what appears to be the same pattern of rolling in each case. So similar is the rolling that naive observers conclude that the catnip cats are in heat. Although there are other similarities such as increased head shaking in both conditions, and differences such as the increased rubbing which occurs with the oestrous cats, the important fact remains that the presentation of catnip to a reactor results in a rolling pattern which is normally only exhibited by oestrous females. While it is possible that the rolling response resulting from exposure to catnip is not essentially related to the oestrous state, this is unlikely since cats do not feature rolling as a part of their normal behavioural repertoire except during oestrus and in the after-reaction following copulation. Cats often roll over, but the rolling is not persistent nor does it include face rubbing. It is not necessary, in establishing a relation between catnip and oestrus, to assume that the rolling syndrome is elicited directly by the catnip. In both cases, the effect of the catnip or the oestrogen could be to alter skin sensitivity about the cat's head which it then relieves by rubbing. It was also observed in experiment 1 that catnip causes an increase in interest in a cat-sized object. This behaviour is very similar to the increased attention oestrous cats pay to the males; they roll near them, rub against them and paw bat them. However, before it could be concluded that the catnip was actually creating the motivational state of the oestrous cat, it would be necessary to verify this behavioural effect and to determine the extent to which catnip causes physiological changes associated with natural oestrus.

The fact that some male cats exhibit this oestrus-like rolling pattern when exposed to catnip presents an interesting problem. Further investigation into the neurophysiological basis of the response and the relation of catnip to a cat pheromone may yield data relevant to the discussion of the similarity of male and female nervous systems (see Diamond, 1965; Harris, 1964). It is currently accepted that the presence of hormones during prenatal development selectively organizes the hypothalamus for either predominately male or female behaviour. It may be possible that this selective organization does not refer to the behaviour-mediating mechanisms themselves but to the threshold level of the hormone-sensitive cells which initiate their excitation.

Summary

This research evaluated Todd's (1963) suggestion that catnip elicits an aspect of oestrous behaviour. A series of experiments revealed that (1) the catnip reaction consists primarily of a unique combination of body rolling and face rubbing, (2) the reaction is independent of sex or presence of gonads, (3) catnip does not result in an increase in killing, fighting or sexual mounting when cats are paired with live rats or a stuffed object approximately cat size, (4) reacting cats show an increase in attention paid to the stuffed object while showing a decrease to rats; this attention being similar to that shown to males by oestrous females, and (5) that the most striking aspect of the behaviour of oestrous cats is a unique rolling pattern which is very similar in its display of components to the catnip rolling.

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