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Feline Object Play: The Influence of Catnip

by

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Abstract

Catnip triggers a unique olfactory response that releases opioids in the brain and results in a play-like activity in felines. This invoked response to the catnip herb appears similar to, but more exaggerated and intense, than regular play. The play behavior of 24 cats with two identical toys, one of which was infused with catnip differed significantly in both duration and form. Play with the catnip toy was dramatically longer and tended to be accompanied by stereotypic high levels of intense biting, rubbing, stretching and rolling, while play with non-catnip toys remained relaxed, more varied with short intervals of high intensity batting, stalking and pouncing interspersed with moderate and low intensity sniffing and biting. A distinction between endogenous and external motivation for play-like activity suggests that the catnip response resembles mating/courting behavior of cats that is distinct from the predatory behavior of regular feline object play.

Keywords: catnip response, feline object play, criteria for play, predatory and sexual behavior, enrichment and welfare

Feline Object Play: The Influence of Catnip

Scientists believed until fairly recently that play-like activity in domestic cats (*Felis silvestris catus*) has no survival or reproductive benefits and as a result, they tended to ignore play as a topic for research (Pellis & Pellis, 2009). Darwin (1871) discussed play as a commonality between humans and other animals, and Baldwin (1896), a founder of evolutionary psychology, proposed that learning guided the evolution of behavior, and that much learning of functional behavior took place during play (as cited in Burghardt, 2006). Psychologists have recently claimed that play underlies the acquisition of social competence and, thus, lives worth living (Brown, 1996; Huizinga, 1995; Pellis & Pellis, 2009; Groos, 1898; Schiller, 1967).

Theories of play fall into three major categories: *Instinct Practice Theories, Recapitulation Theories, and Surplus Energy Theories* (Baldwin, 1977; Fagen, 1981; Groos, 1898; Lindsay, 1879; Thompson, 1998; Panksepp, 1987; Siviy,1988; Normansell, 1984). *Instinct Practice Theory* was first proposed by Lindsay (1879) who suggested that "playfulness, sportiveness, or friskiness in the young" was "instinctive practice necessary to master the skills" (as cited in Burghardt, 2006, p.131) of species typical functional repertories. Thompson (1998) later described how animals master skills and assess the abilities of themselves and others through play. *Recapitulation Theory,* most closely associated with G. Stanley Hall (1904), suggested that play was not to be understood in terms of future needs but rather as a function of the evolutionary past; as the species evolved, play would reflect the behavior from preceding evolutionary stages. *Surplus Energy Theory* first proposed by Friedrich Schiller (1795) suggested that play emerges when the animal was not under compulsions from the external demands of hunger, predation, illness or other stresses.

While there has been substantial literature on the theories of play for almost two hundred years, there is no generally accepted definition of play. Burghardt (1984, 2006) described the need for an operational definition. He suggested five criteria that are now widely used by animal behaviorists to identify and describe play in humans and animals. The following is an outline of the five criteria, described on pages 70 to 77 and 81 in Burghardt (2006) as an operational definition of play:

> (1) Limited immediate function—"the behavior is not fully functional in the form or context in which it is expressed" (p.70)
>
> (2) Endogenous component—spontaneous, voluntary, or intentional and pleasurable, rewarding, reinforcing, or autotelic—"done for its own sake" (p. 73)
>
> (3) Structural or temporal difference—from "ethotypic behavior" with altered rhythm or pacing, awkward or exaggerated actions, flexible sequencing, or altered targeting (p.74)
>
> (4) Repeated performance—during at least a portion of the animal's ontogeny (p. 75)
>
> (5) Relaxed field—that is, the animal must be "adequately fed, healthy, and free from stress" (p. 77).

Burghardt (1984, 2006) required that at least one characteristic from each of the five criteria be met before the label "play" could be confidently attached to any activity and his operational definition appears generally accepted in the play literature (Pellis and Pellis, 2009; Burghardt, 2010; Pellegrini & Smith, 1998; Palagi, 2014). A minimal requirement of criterion two, the endogenous component, involved evidence of a spontaneous or voluntary or intentional engagement in or the pleasurable or rewarding or reinforcing or autotelic feelings aroused by the behavior.

Annabelle Beaver, in an unpublished 2013 class project, queried Burghardt whether catnip might act as a "competing system" since the behaviors such as biting to release nepetalactone, excessive rubbing, and prolonged very intense activity might indicate the catnip

response was involuntary. She found differences in the intensity and durations of activity and behavior between catnip and non-catnip toys in a single cat. Beaver observed that the toy infused with catnip resulted in longer bouts of activity and higher frequencies of sniffing, rubbing, and rolling. The catnip response appeared to be neither voluntary nor spontaneous while remaining both pleasurable and rewarding; thus, fulfilling the second criteria of Burghardt's operational definition of play without appearing either voluntary or particularly playful.

Burghardt answered Beaver (personal communication):

> I think they [the catnip responses] fit [the criteria for play], although catnip is a rather unusual chemical. Still, just because it is a very salient chemical cue, the same could be said for objects, such as rubber mice, that are particularly attractive to some animals and not to others. … criterion two just needs to satisfy one of the several terms. [Criterion] five would seem to be applicable as well: Catnip is a pleasure system so is not competing [with play].

Burghardt said that the catnip response showed at least one component from all five of the play criteria and could, therefore, be considered play.

Beaver's (2013) study raised the questions pursued in the present study: (1) does the catnip response differ significantly from object play with a non-catnip toy; (2) what about the catnip response suggests that it is an involuntary drug response and if so, does this have implications in regard to qualifying as play according to the operational definition. Such a reconfiguration of the criteria for play would demand that play be both (2a) *voluntary or spontaneous* and (2b) *pleasurable* or *rewarding*. (3) Is it predatory play or a chemically triggered response that resembles the precopulatory behavior of cats. The present study recruited twenty-four cats to explore Beaver's question. Is catnip activity play?

The similarity between object play and the catnip response in cats has rarely been the subject of a comparative study (Ellis & Wells, 2010; Beaver 2013). Catnip (*Nepeta cataria*), an

herb that belongs to the mint family, is widely used to induce vigorous activity associated with intense feelings of pleasure in felines (Ellis & Wells,2010) The response to catnip is a heritable trait that affects only about 70-80% of cats (Hart & Leedy, 1985). Cats have a highly developed olfactory system, and catnip is frequently introduced as an olfactory stimulant to induce play-like activity. Studies show how the active essential oil in catnip, nepetalactone, has a strong effect on the dopaminergic opioid system (Bernardi, Kirsten, Salzgeber, Romoff, Guilardi-Lago, & Lourenco, 2010). Previous studies associated the oil with antidepressant properties but there was little consistency in the evidence for stress reduction or calm with exposure to nepetalactone (Bernachon, Beata, Crastes, Monginoux, Gatto, et al., 2015). Hatch (1972) observed that the catnip appeared to have a hallucinogenic or euphoric effect, and he called the set of behaviors that accompanied its administration "the catnip response." The response included sniffing, licking, chewing, biting, and face and body rubbing.

Most of the literature evaluates the catnip "response" with mixed recommendations for use as enrichment for shelter and house-bound cats (Bernachon et al., 2015). Researchers associated exposure to nepetalactone with antidepressant properties, but they found little consistency in the evidence for calming or the reduction of stress. Evidence for catnip's contribution to feline well-being has been inconclusive despite the clear interaction between the nasopharyngeal odor receptor cells and the release of dopamine into the system (Hatch,1972; Hart & Leedy, 1985; Burnachon et al., 2015).

This study analyzes the differences between non-catnip object play and the response to catnip infused objects of similar appearance in order to clarify these questions about the nature of play and the spontaneity and "playfulness" of the catnip response. Given the olfactory-dopaminergic system links, one assumes that the catnip response is linked to primitive sexual

rather than predatory behavior (Pellis & Pellis, 2009; Hart & Leedy, 1985). Can a drug evoked behavior be considered voluntary or spontaneous despite the pleasure cats' show in their responses to the substance? Can an externally driven high intensity response be consistent with the voluntary choice and control considered a foundation for play?

Cats typically engage in solitary object play after a very early period dominated by rough and tumble social play with littermates (Pellis & Pellis, 2009). Object play, sometimes difficult to distinguish from object exploration, involves cats pushing, pulling, grasping, lifting, hitting, carrying, and other manipulations of objects that, unlike food or nesting material, offer no survival or reproductive benefit (Burghardt, 2006). Cats, like other felines, incorporate predatory stalking, pouncing, and biting actions into their play with objects (Burghardt, 2006). Hall (1998) suggested that object play in cats was the precocious expression of an innate predatory repertory.

The behavioral repertoire exhibited during object play differed from that of a hunting cat. A predatory cat stalks, waits, and pounces on its prey when the moment is right. It grasps the prey with both paws and bites it at the nape of the neck. It may bat the prey item around once it is sufficiently weakened or killed. In object play, cats rarely stalk a toy for an extended period of time. They spend more time batting the object around and fail to deliver a killing bite. There are bouts of play where they pounce on, bat, toss, and carry a toy object, pause and, then, resume the activity. These repetitive sequences are typical of play and rare in real predatory behavior. The repetitive actions involved in predatory object play do not fit the sequence or form of the actions performed while hunting and appears unlikely to serve as practice for hunting or stalking.

The surplus-energy theory seems more likely to motivate the release of predatory or sexual elements in feline object play. Female cats go through hormonal cycles which solicit mating behavior from male cats (Romagnoli, 2017). These precopulatory sexual behaviors that

lead up to copulation are characterized by rubbing the head and neck against an object, allo-grooming, neck bites, and lying side by side. (Crowell-Davis, Curtis, & Knowles, 2004). The females appear restless and roll, crouch, or arch their bodies (Romagnoli, 2017). Both males and female cats are seen to rub against one another's bodies prior to the male mounting the female. The behaviors leading up to copulation can appear aggressive; the female often strikes at the male with her front claws, while the male grasps the back of the female's neck with his teeth. Thus, as in so many animals, object play in cats may exhibit behavior common to predatory and/or sexual repertories (Pellis & Pellis, 2009).

Object play and the catnip response will also be compared to behavioral repertories associated with courting and mating or predatory stalking and hunting. The catnip response is widely assumed to be play; however, there is evidence that the activity is not endogenous but involuntary and stereotypic. Although, catnip promotes a highly pleasurable response in most cats, it is not known that this response enriches and, thereby, promotes the welfare of the house or shelter-bound cats.

The main purpose of this study was to extend the research and questions raised by the research of Beaver (2013), a comparison of the behavioral repertoires of feline object play with and without the influence of catnip based on the behavior of a single cat to a larger group of subjects. The hypotheses addressed in this study are:

(1) Does the catnip response differ significantly from object play with a non-catnip toy?

(2) Does evidence of the involuntary nature of the catnip response fit the operational definition of play as an activity that is both *voluntary or spontaneous* and *pleasurable* or *rewarding*?

Method

Subjects

Twenty-four domestic cats (*Felis silvestris catus),* were selected from an unpublished study conducted across the Hudson Valley, NY in 2016 on temperament and coat color. The subjects were described in the previous study as social-with-strangers, unstressed, and playful. There were an equal numbers of male and females in three age groups ages 1-4, 5-8, and 9- 12 years old. Because kittens appear unaffected by catnip, kittens under 1 year old were not included. The study was conducted in the familiar environment of the cats' home. All subjects were fed approximately an hour before the introduction of the toys so as to minimize hunger. Individual subjects were separated from their housemates in multi-cat households. All cats had been previously exposed to catnip at least once in their lifetime. This was done to avoid unexpected adverse reactions to the drug such as increased aggression or confusion. All subjects had been to a veterinarian within the past year for a routine examination and declared in good health. Table 1 provides the name, age, sex, breed for all 24 cats. The order in which they encountered the catnip toy (C) or no-catnip toy (NC) was randomly determined—twelve cats received the (C) toy first and the other twelve the (NC) toy .

Table 1: Subject, Descriptions, and Order of Treatment Conditions

Subject	**Age**	**Sex**	**Breed**	**Toy C (Catnip)**	**Toy NC (No Catnip)**
Glenn	4yr	M	Buff *Tabby	Presented First	Presented Second
Queenie	6yr	F	Brown Tabby **	Presented First	Presented Second
Merrick	10yr	M	Grey/White Tabby*	Presented First	Presented Second
Mitsu	4yr	F	Tortishell*	Presented First	Presented Second
Buddy	11yr	F	Brown Tabby *	Presented First	Presented Second
Moe	8yr	M	Grey **	Presented First	Presented Second
Rex	4yr	M	Brown/white tabby*	Presented First	Presented Second
Zyra	7yr	F	Bengal	Presented First	Presented Second
Thomas	12yr	M	Orange/White Tabby *	Presented First	Presented Second
Piglet	3yr	F	Sphinx	Presented First	Presented Second
Frank	6yr	M	Grey/White Tabby *	Presented First	Presented Second
Vladmir	1yr	M	Grey *	Presented Second	Presented First
Jazey	10yr	F	Black *	Presented Second	Presented First
Charlie	9yr	M	White *	Presented Second	Presented First
Cammie	4yr	F	Tortishell *	Presented Second	Presented First
Tigger	6yr	M	Grey/white tabby *	Presented Second	Presented First
Evee	12yr	F	Brown Tabby *	Presented Second	Presented First
Cassie	7yr	F	White **	Presented Second	Presented First
Bruce	9yr	M	Black *	Presented Second	Presented First
Lightning	4yr	F	Brown tabby **	Presented Second	Presented First
Littleman	7yr	M	Brown tabby *	Presented Second	Presented First
Pixie	12yr	F	Tuxedo *	Presented Second	Presented First
Rick	4yr	M	Grey Tabby *	Presented Second	Presented First

Notes: * Domestic Short Haired **Domestic Long Haired

Materials

The toys used were identical Great Choice stuffed mice toys purchased from Petsmart. One toy rubbed with catnip and one without catnip was presented to each cat one week apart at approximately the same time of day. Toy (C) was infused with Petlinks organic catnip by rubbing the dried catnip into the outer fabric of the toy for ten seconds. Toy (NC) was left untouched and presented to the cat straight out of the packaging. A Windows Surface Pro tablet was used to video record all observations as the cats seemed less shy of the tablet than a camera on a tripod. Time-stamped behavioral observations were coded using the ethogram derived from Beaver's (2013.) study. These are described in Tables 2a to 2d. The following

are the contents for the ethogram for behavioral coding.

Table 2a (***States)*** coded the duration of engagement with and disengagement from toys.

Table 2b (***Events)*** coded the frequency and sequence of acts in states with and without toys.

Table 2c and Figure 1 (***Modifiers)*** coded states and events such as body positions.

Table 2d ***(Intensity***) coded the intensity of the activity.

A video coding program, GriffinVC (Singh & Ragir, 2017) was used to record states and events in real time (https://svirs.github.io/griffinVC). All the codes appeared on time-marked observation log spreadsheets and were then exported to Microsoft Excel for analysis (Singh & Ragir, 2016). Observations include comparisons of duration of engagement, frequency and variety of behavioral events, fluctuations in intensity, and body positions. The ethogram is presented in Table 2.

Table 2a: Behavioral States with Corresponding Operational Definition

STATES	**Operational Definition**
Engaged	Subject manipulates, stares at, or moves toward the toy.
Unengaged	Subject is not engaged in object manipulation, looking at toy, or laying on toy.
Off Camera	Subject's behavior is not visible. Object may have gone under piece of furniture or not visible to researcher

Table 2b: Behavioral Events with Corresponding Operational Definition

EVENTS	**Operational Definition**
Bite	Subject grasps the object with his mouth, licks, or holds object in mouth
Chew (bite series)	Subject bites in the toy in a series or two or more without any other events in between
Roll	Subject rolls from one side of the body to the other
Kick	Subjects kicks toward or on toy with one back paw
Rake (kick series)	Subject scrapes on or toward the toy with one or both hind paws in a sequence.
Bat	Subject hits with one or both front paws in a singular movement
Bat Series	Subject performs "bat" in a sequence of 2 or more times
Sniff	Subject sniffs the object or directly next to the object
Face Rub	Subject rubs its face, chin, or head against sometimes holding the object in place with forepaw(s). If unengaged with object, subject may rub face on ground. Subject may do this either once or in a series.
Tail Swish	Subject moves tail back and forth in a singular or repetitive motion
Pounce	Subject runs/springs in the direction of the toy landing with its front paws next to or on top of the toy.
Pause	Freeze of disengagement that will shortly resume to engagement.
Stare	Subject is looking in direction of the toy but not actively moving toward or manipulating it
Stalk	Subject is staring at toy in crouched position leading up to a run/ brisk walk or pounce toward the toy. Subject may wiggle hind end in crouched position.

Table 2c: Body Positions with Corresponding Operational Definition

POSITION		**Operational Definition**
Side curl	SC	Subject lies on either his left or right side. Front paws are in close proximity with back paws. Back is in a curved/ arched position. May be engaged or unengaged with toy
Back	B	Subject lies on his back with his belly up. Front and back legs are in air.
Side Spread	SS	Subject lies on his side with his hind legs fully extended away from the body. Back is in an extended/swayed position
Crouch	CR	Subject is down on his stomach with four paws underneath body. Front paws are on ground but bent at the elbow joint.
Standing	SD	Subject is standing over the toy on all fours
Sitting	SG	Subject is sitting on back haunches. Torso is erect.
Laying	LA	Subject is laying with front legs splayed forward, elbows on ground, and back legs to either side of body or directly under body

Table 2d: The Level of Intensity that Modifies the Engaged State

INTENSITY	**Operational Definition**
High	Subject extremely attentive to the object. Intensity of actions is high, marked by any of the following: rapid tail swishes occur at a frequency of 2 to 3 per second, Body position changes frequently over course of 7 seconds. Event changes or is repeated at least once per 3 seconds; State is always engaged
Moderate	Subject manipulates object, but focus fluctuates between object and surroundings. Intensity of actions is moderate, marked by any of the following: tail swishes occur at a slower rate with an approximate frequency of 1 to 2 per 5 seconds; body position changes at least once per 10 seconds; behavior changes or is repeated at least once per 5 seconds
Low	Subject may be in contact with the object, but focus is elsewhere. Intensity of actions is low, marked by at least two of the following: tail swishes occur minimally or not at all; body position does not change; behaviors are not directed towards object (e.g. grooming or scratching or distraction).Events occur intermittently.

Figure 1: Clips From the Videos of the Body Positions Described in the Ethogram.

Procedure

The session began when the researcher dropped a toy in front of the cat. The behavior of each cat beginning from first moment of exposure to the end of the session was video recorded. The engagement with the object began the first physical or eye contact with the toy. The "play bout" and session ended when the cat abandoned the toy for at least 3 minutes, left the room, or took a nap. The owners were present for the study but instructed to not interact with or talk to the cats.

Experimental Design

Coding of the videos was continuous in real time and the spread sheets were exported to and analyzed in Excel. The independent variable was the catnip (C) or non-catnip (NC) condition of the toy. The activities were described as the (1) actual time in seconds each cat spent "engaged" with the toy, (2) the average frequency of behavioral events and their relative proportions, (3) the proportion of total time spent engaged at high levels of intensity for each

subject with each toy, and (4) the proportion of total time spent in one of seven body positions during the entire session length. The duration of engagement in seconds, body positions, frequency of different events, and time spent at the high intensity level, were calculated for each participant in the C and NC conditions. In addition the patterns of intensity during engagement with catnip and non-catnip toys were compared. The cats chosen for this analysis were the eight cats who engaged for the longest duration of time in the NC condition. The subjects (refer to Table 4) were Evee, Glenn, Jazey, Lightning, Mitsu, Pixie, Queenie, and Thomas. Intensity was treated as an independent state with three levels: high, moderate, low/none. Intensity levels were compared for the first 30 seconds of the C and NC condition for the previously mentioned eight subjects.

Results

The 24 cats described in Table 1 ranged from 1 to 12 years old with equal numbers of males and females in each age group. In order to control for effects associated with the presence or absence of catnip infused in the toy, 12 cats were tested first with catnip (C) and a week later without catnip (NC). The other 12 cats were tested in the opposite order. To determine whether order of presentation had an effect on session length (defined below) the mean in seconds for the 12 cats presented with the catnip toy first (M = 260 , SD=154) was compared to session time of the cats presented with the catnip toy second (M = 226 , SD = 156). This difference was not significant, t (22) = .56, p = .29. The mean session length for cats who received the NC condition first (M = 87 , SD = 63) and those that received the NC condition second (M = 88 , SD = 62) were not significantly different t (22) = .02, p = .48. Therefore, as expected because treatment order did not have an effect, in the following analyses the data of those who received the catnip toy first and those who received it second were not considered separately.

Under both the C and NC conditions, the moment the toy was dropped all cats looked at or touched the toy. *Session length*, the time between this evidence of *initial engagement* until *final disengagement*, a period of at least 3 minutes during which the cat showed no interest in the toy, is summarized for all cats in Table 3. Although session length was the total period of time that the cat was first introduced to the toy to the moment of final disengagement the session might include short periods during which the cat became unengaged and then re-engaged with the toy. Table 3 is arranged in the order of ascending duration of engagement with the catnip toy because this is the most salient difference between the two conditions (see Table 4).

Table 3. Session Length in Presence (C) and in Absence (NC) of Catnip

Subject	Catnip Toy (C) (seconds)	No Catnip Toy (NC) (seconds)
Rick	44	31
Charlie	66	35
Zyra	79	28
Frank	97	53
Precious	100	105
Little Man	138	184
Vladimir	145	23
Pixie	149	73
Evee	154	198
Piglet	185	35
Thomas	191	155
Rex	211	41
Queenie	223	240
Cammie	228	108
Bruce	236	31
Lightning	237	60
Buddy	254	54
Tigger	285	105
Glenn	341	111
Moe	423	90
Cassie	431	39
Merrick	484	35
Mitsu	540	107
Jazey	595	160

Within each session, under both the C and NC conditions, there were periods of less than three minutes during which the cat did not actively interact with the toy. There were also periods when the subject was out of view. These time periods when removed from the analysis define the engaged state. Only the engaged state was used in the calculation of average frequency, relative proportion of the events and changes in body position. The total time spent in the engaged state was calculated. Engagement is defined as when the subject is actively manipulating, staring at, or moving with evidence of attention on the toy. Table 4 describes the time that each cat spent in an engaged state. The table is arranged in ascending order of the total time spent in seconds in the engaged state with the catnip toy (C).

Table 4. Engagement in Presence (C) and in Absence (NC) of Catnip Under Both Conditions.

Subject	Catnip Toy (C) (seconds)	Non-Catnip Toy (NC) (seconds)
Tigger	14	5
Zyra	15	3
Rick	17	3
Frank	28	25
Evee	37	48
Cassie	40	5
Charlie	58	21
Rex	66	7
Pixie	83	43
Precious	85	7
Little Man	93	12
Vladimir	95	9
Thomas	102	67
Piglet	115	11
Buddy	123	10
Lightning	144	31
Cammie	149	15
Queenie	178	71
Merrick	200	12
Bruce	220	10
Glenn	201	32
Jazey	241	86
Moe	268	29
Mitsu	333	39

As can be seen in Table 4, the time spent engaged showed enormous variation between the two conditions; the C condition ranged from 14 seconds to 333 seconds, and the NC condition ranged from 5 seconds to 71 seconds. Twenty-one cats engaged with the toy for 30 or more seconds in the catnip condition, while only eight cats engaged with the toy for 30 or more seconds in the NC condition. Fourteen cats responded to the catnip toy for over 90 seconds while none of the cats responded to the non-catnip toy for more than 71 seconds. The average duration of engagement in seconds was (M= 120.76, SD= 86.51) for the C condition and (M= 25.56, SD= 23.36) for the NC condition. The difference was highly significant $t\ (23) = 5.21, p<.00001$. The proportion of time spent in the engaged state was calculated by dividing the number of seconds that each subject spent in the engaged state in each condition the session length of that condition. The average proportion of engagement was (M= 0.52, SD= 0.23 for the C condition and (M= 0.30, SD= 0.17) for the NC condition. The results were highly significant $t\ (23) = 3.64, p=.0003$.

Figure 2a represents the duration of engagement that each subject spent in the C and NC condition arranged in the ascending order of engagement in the C condition and Figure 2b represents the proportion of time spent in the engaged state. Figure 2b shows that there is a low correlation between the time that the subject engaged with the toy in the C condition and the time that they engaged in the NC condition (r=.305). This provides evidence that there are differential effects in the C and NC condition.

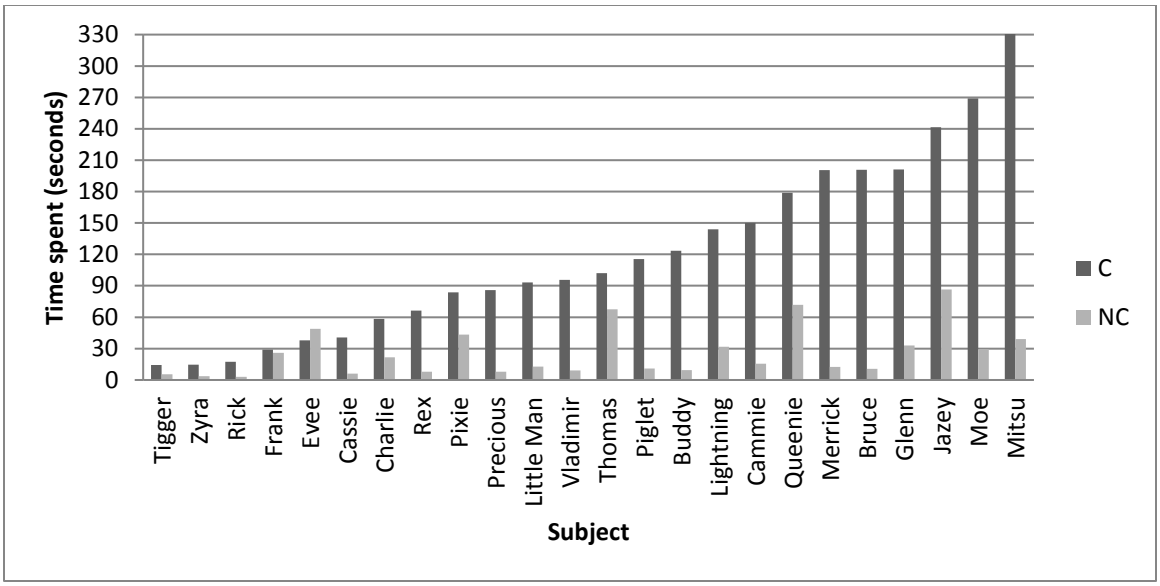

Figure 2a. The Time Each Subject Spent Engaged with the C and NC Toys

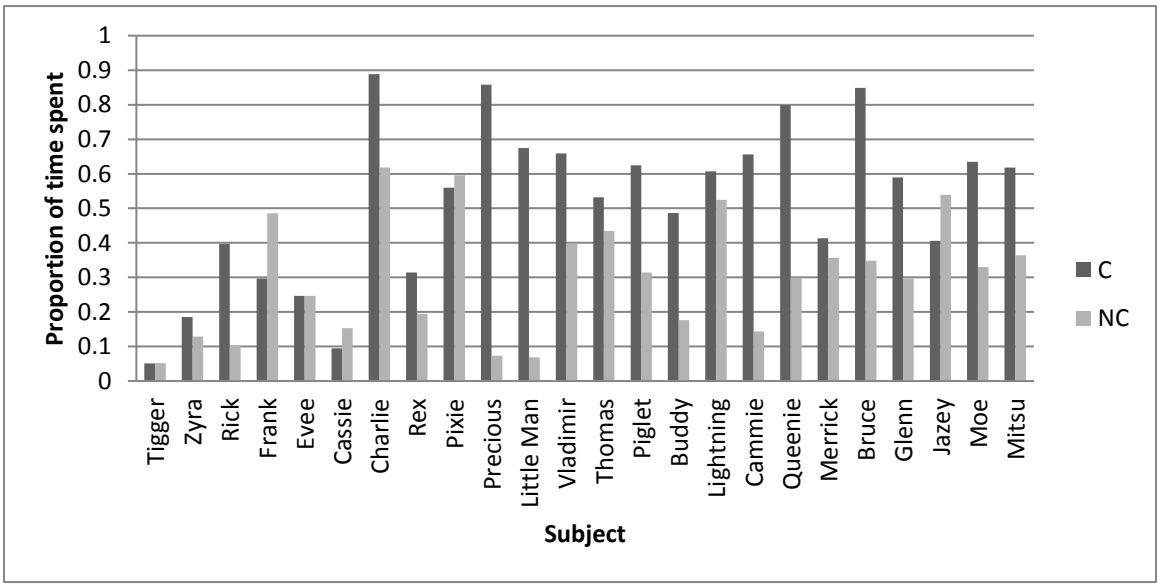

Figure 2b. The Proportion of Time Each Subject Spent Engaged with the C and NC Toys

Figure 3 shows the average frequency of the seven behavioral events during the C and NC conditions. The average frequency of an event was obtained by dividing the total number of occurrences of the event performed while engaged with the catnip or non-catnip toy divided by 24 (the number of subjects). The relative proportion in which an event occurred during

engagement in the C or NC condition was obtained by dividing the total number of events from the 24 trials into the total frequency of each event. A total of 1322 events occurred in the prolonged catnip condition; only 225 events were recorded in the shorter NC condition. The frequency of each event was divided by the total number of events in all engagements from the 24 sessions in each condition in order to understand the relative proportion of each event and compared to the two conditions. These proportions give a more accurate representation of the relative frequency of particular events in each condition because of the high significance in difference of session length and engagement times between the C and NC conditions. Figure 4 shows the average frequency and the proportion of the seven events in the two conditions.

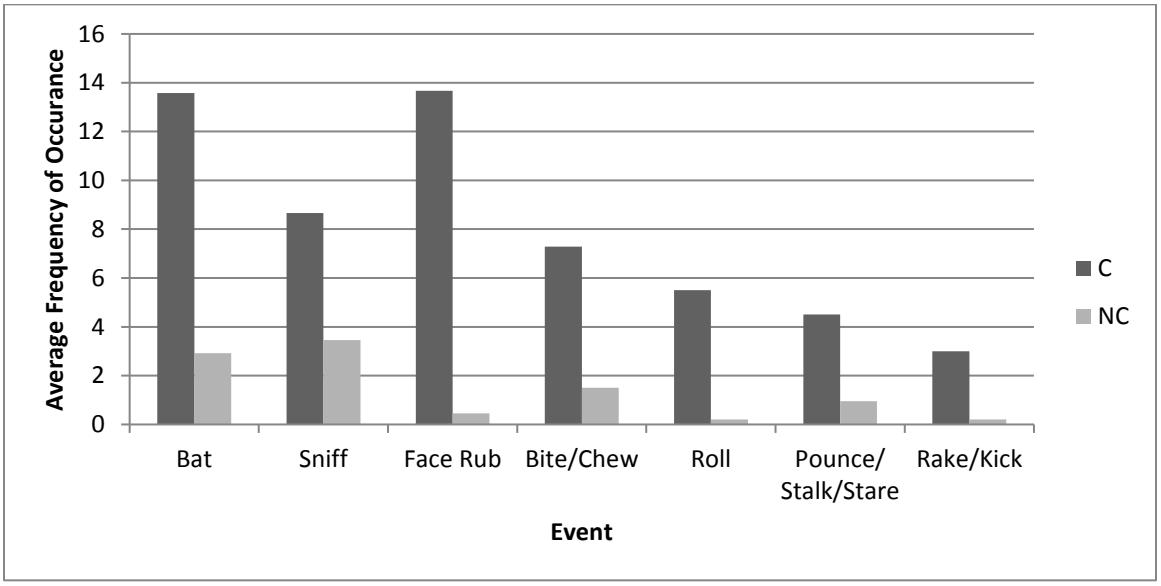

Figure 3a. The Average Frequency of Coded Events in the C and NC Condition

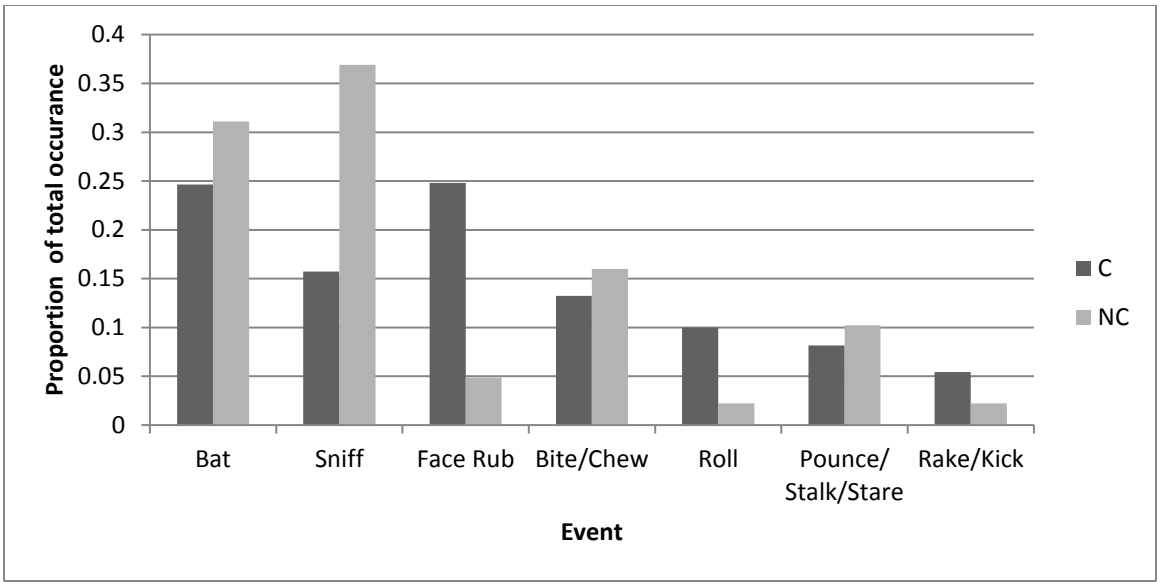

Figure 3b. Occurrence of Total Events as a Proportion in the C and NC Condition.

The activity with the catnip toy involved more time being spent in a variety of in body positions than with the non-catnip toy. The total time spent in each body position for each test condition was calculated for all subjects and divided by 24 to obtain the average time spent in each body position for the C and the NC conditions. The variation in body position differed dramatically between the C and NC conditions. The cats with the catnip toy spend between 30 and 40 seconds curled, spread, standing, sitting, and crouching, and more time on their back and stomach than cats with the non-catnip toy (Figure 4a). Activity with the non-catnip toy takes place standing and sitting for almost 70% of the time and less than 25% of the time in with the catnip toy. “Side curled “and “side spread” occurs almost exclusively in the C condition, while “laying on stomach” is twice as likely to occur in the C as the NC condition (Figure 4b). Figure 4a shows the average and Figure 4b shows the percentage of time spent in different body positions.

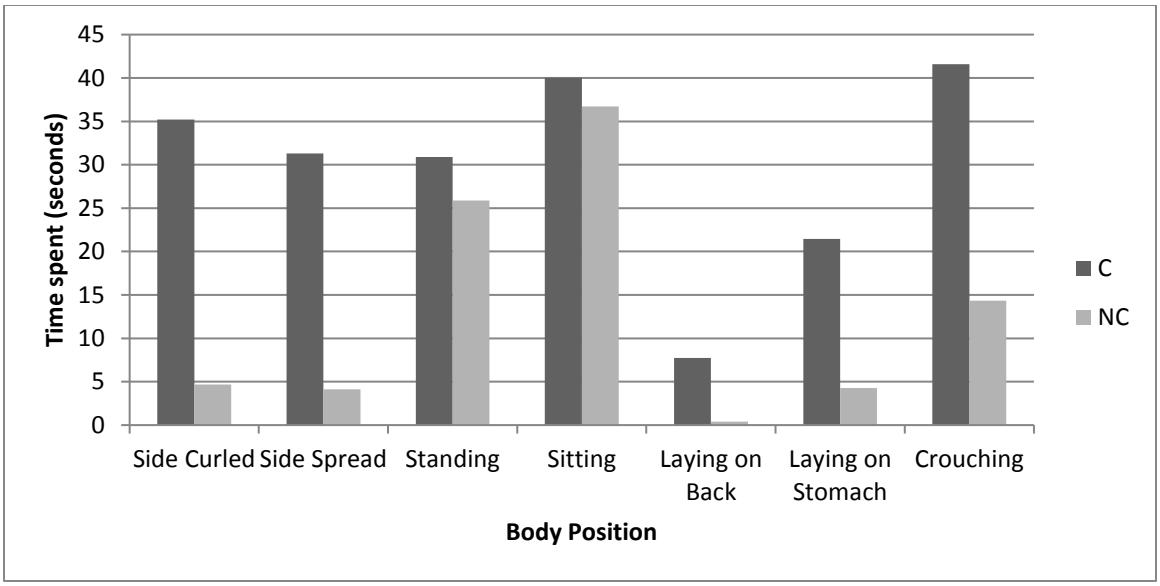

Figure 4a. The Average Time Spent in Each Body Position in the C and NC Conditions.

Figure 4b. The Proportion of Time Spent in Each Body Position in the C and NC Conditions

Another important aspect of body position that was observed across cats was the increasing amount of body position changes in the C condition. The cats were more likely to change body positions more frequently in the C condition.

Figure 5a is an example of the relative body position of one subject as it changed through time in the NC condition. Figure 5b shows how the body position of this cat changed through time in the C condition. The figures show positional data for the first 100 seconds of both the C and NC sessions for the subject, Moe. While this is only an example for one subject, the trend was consistent for all subjects.

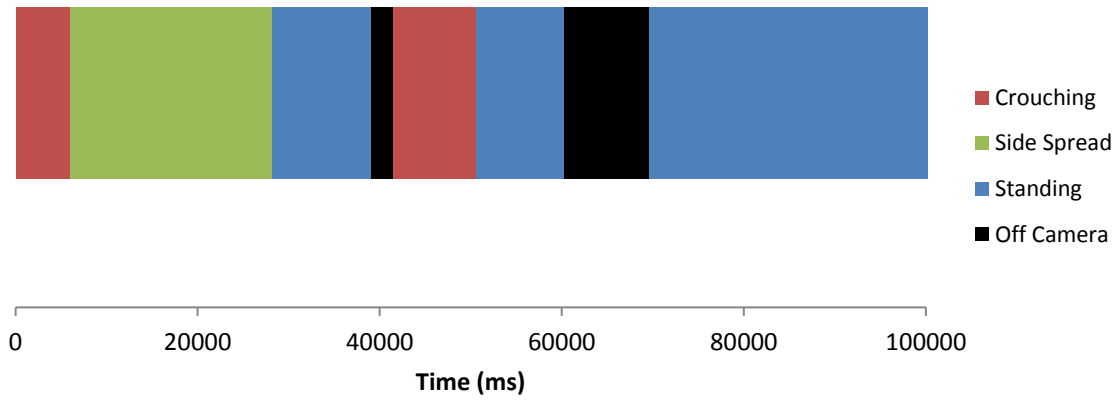

Figure 5a. The Time Spent in Each Body Position in the NC Condition

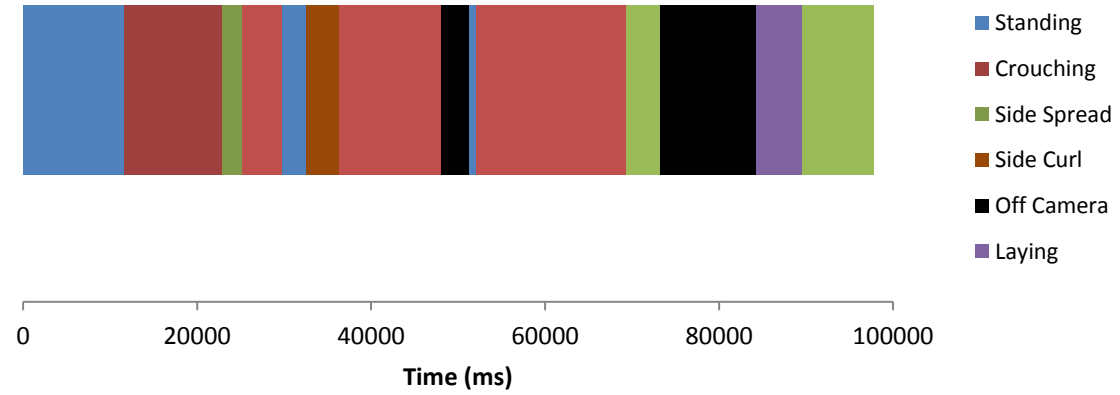

Figure 5b. The Time Spent in Each Body Position in the C Condition.

Rapid performance or repetition of events, such as rapid tail swishes (2 to 3 per/second), and relatively frequent changes of body position were used to identify the behavior as a high intensity response. Twenty-one subjects engaged at high levels of intensity with the catnip toy as compared to only nine cats with the non-catnip toy. Mitsu showed the largest difference in the effects of catnip. She performed at the highest intensity with the catnip toy (259 seconds), the longest time observed and virtually refused to play with the non-catnip toy. Her behavior was dramatically different from that of Little Man who played longest with the non-catnip toy at high intensity (87 seconds) and engaged with the catnip toy at high intensity almost as long.

Two cats (Rick, Tigger) never engaged at high intensity. Five cats, (Charlie, Queenie, Mitsu, Bruce, Precious) showed high levels of intense engagement with the catnip toy over 70% of the time. Pixie showed a relatively high proportion of high intensity activity in both conditions. She engaged at the high intensity level for 25 of 43 seconds with the non-catnip toy and 45 of 85 seconds with the catnip toy. Figure 6a shows the time and Figure 6b the proportion of time each cat spent in high intensity engagement with the catnip and non-catnip toys.

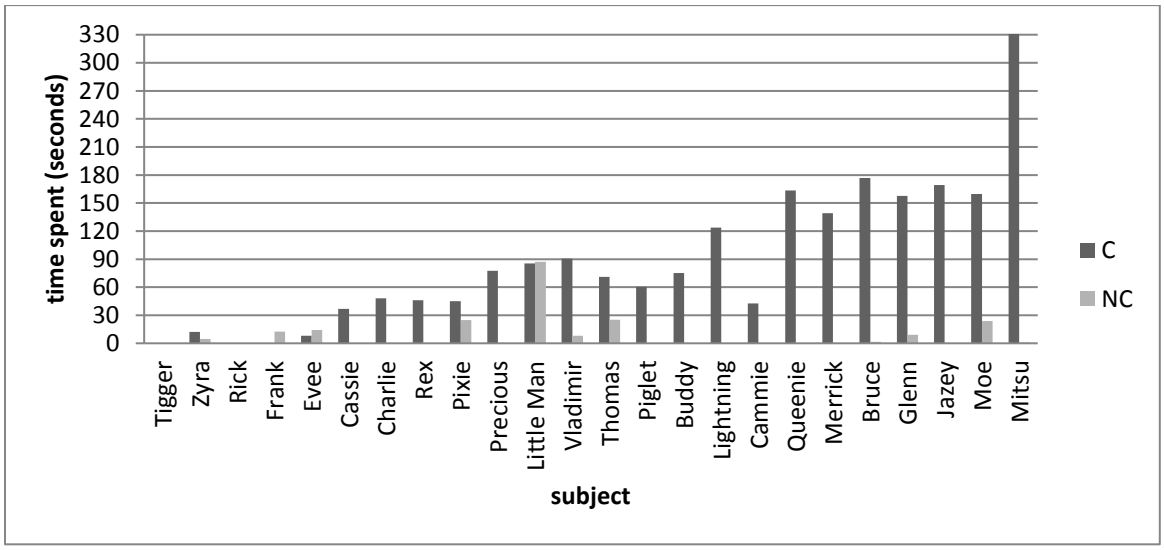

Figure 6a: Total Time Spent at High in the C and NC Conditions

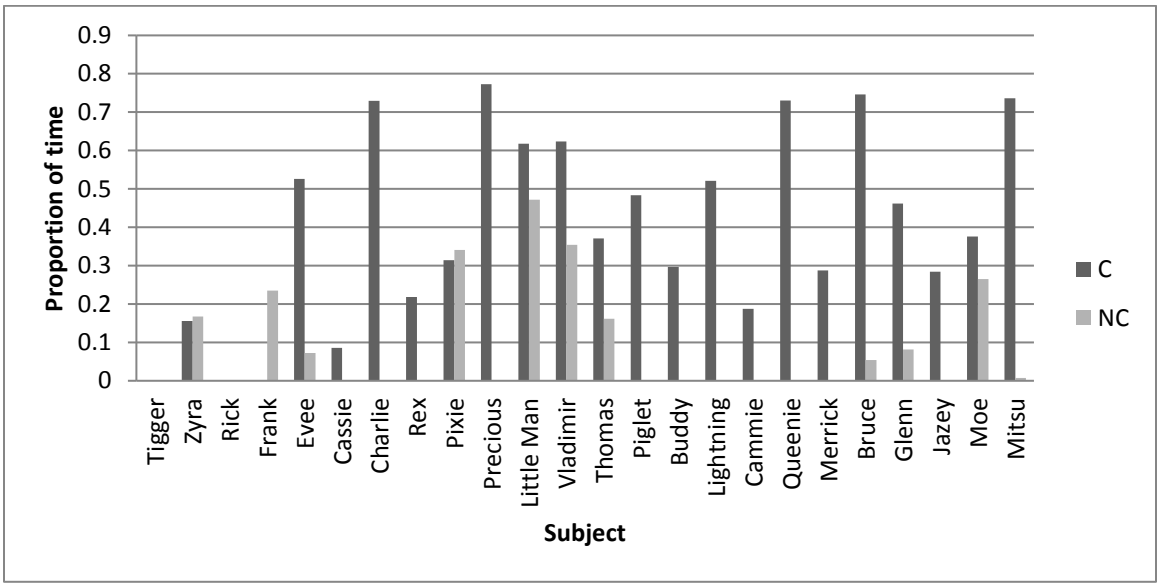

Figure 6b. Proportion of Time in Spent at High Intensity in the C and NC Conditions.

The following examination of changes in intensity of behavior as a function of time was undertaken in order to understand how the structural pattern of the behaviors differed in the C and NC condition. Figures 7a and 7b show how eight individual cat's intensity level changed through time in the NC and C conditions. The changes in intensity were plotted as they occurred through time for the first 30 seconds of the C and NC session for the eight cats had the longest engagement times in the NC condition (Refer to Table 4). During the first 30 seconds of the NC condition, the pattern of intensity appears to vary spontaneously with individual variation among the cats. Because of the high levels of individual variation in the NC condition Figure 7a appears chaotic. Four cats move between medium and low and two between high and medium levels of intensity engagements with the non-catnip toy. Two cats maintained a low intensity engagement for the entire 30 seconds. The cats maintained intensity levels for relatively long consistent intervals. Figure 8a represents how the intensity level changed during 0-30 seconds with the non-catnip toy, while Figure 7b represents 0-30 seconds with the catnip toy.

During the first 30 seconds with the catnip toy (Figure 7b), the cats show rapid changes in intensity that appear rigidly synchronized and stereotypic. The catnip responses begin with at least 15 seconds of unvarying moderate or high intensity activity and, then, most of these cats rapidly alternate between very high and moderately intense activity. One cat maintained high intensity response for the entire 30 seconds. Only two of these cats had short intervals of low intensity before returning to high intensity activity. Intensity levels in the C condition continue to change more rapidly in a rigidly constrained temporal pattern in the longer engagements. One of the cats engaged at moderate and low intensity, and two cats maintained high intensity activity for 30 seconds without a break. The other five cats alternated rapidly between high and moderate intensity at four to six second intervals. Neither this rapid alteration of intensity nor the 30 seconds of high intensity play occurred in the NC condition.

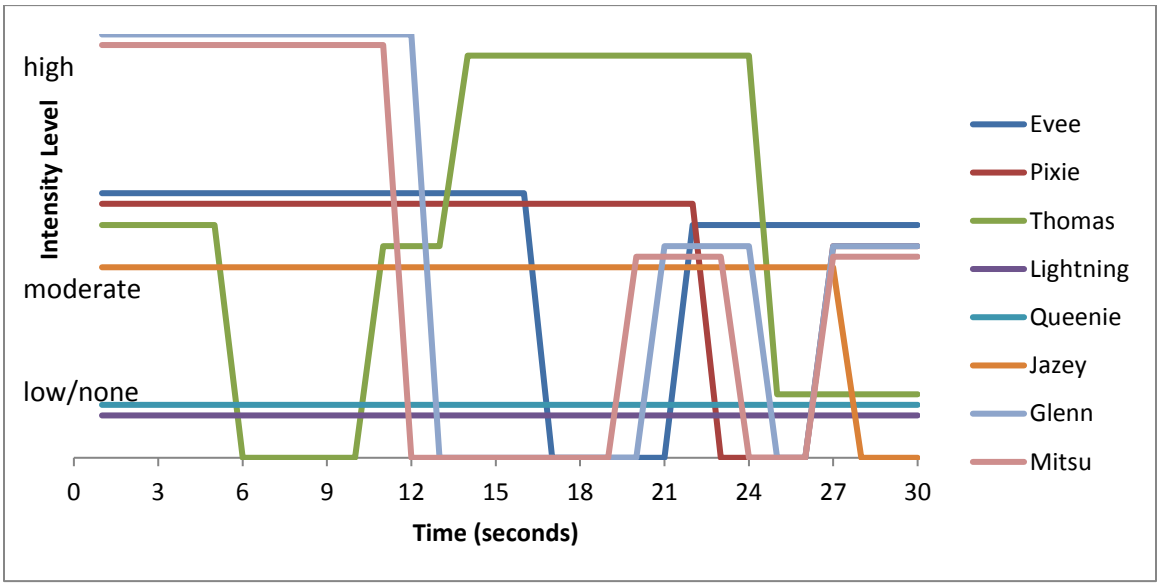

Figure 7a.The Intensity Levels for the First 30 Seconds of the NC Condition for 8 Subjects

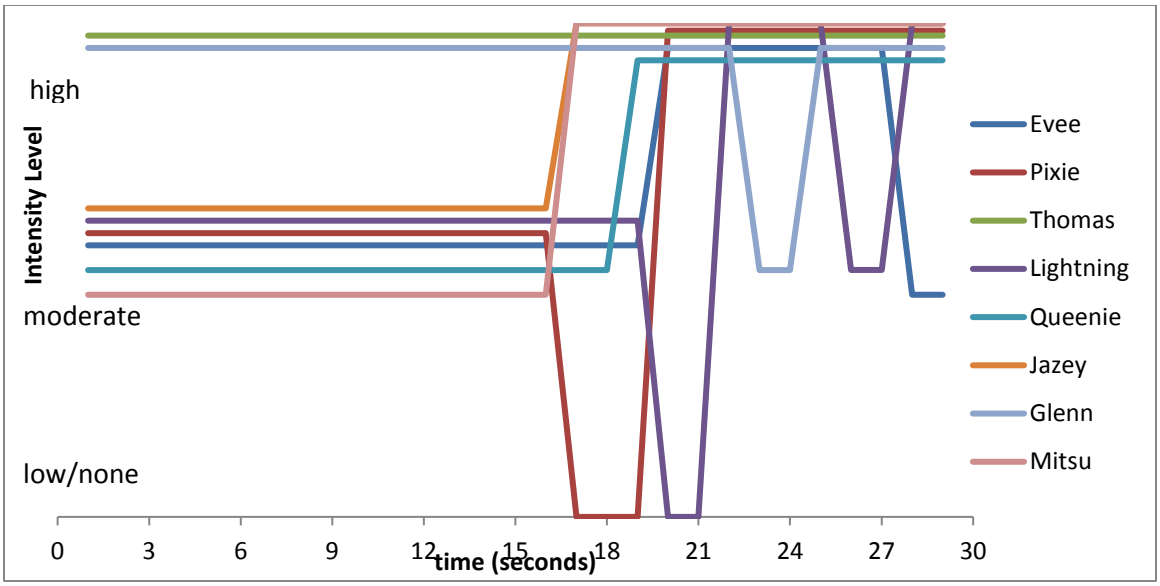

Figure 7b. The Intensity Levels for the First 30 Seconds of the C Condition for 8 Subjects

Discussion

Although catnip is frequently used as an enrichment toy for cats, the effects of catnip on their play behavior is not well studied. The original hypothesis was that the catnip response would differ significantly from object play with a non-catnip toy. This was clearly confirmed. A number of behaviors occurred more frequently in the catnip than non-catnip trials, behaviors such as rubbing, rolling, stretching on the side and stomach, and crouching (Figure 3a; Figure 4a). Both the duration of engagement, and patterns of intensity clearly supported a temporal difference between catnip and non-catnip behaviors for individuals and the group (Figure 2; Figure 7a; Figure 7b). Individual variation characterized the pattern of intensity with the non-catnip toy, and cats appeared in control of their interactions (Figure 7a). The cats playing with the catnip toy burst into a rigid pattern with a relatively long initial intense period of engagement followed by subsequent periods of rapid four to six second alternations of high and moderate intensity (Figure 7b). Such activity appeared rigid and involuntary similar to the behavior that has been described as leading up to copulation in domestic cats. The cats showed little individual

variation in behavior and internal structure associated with the catnip toy except for the total length of the session. The individual structural patterns of behavioral variation and intensity of response characterized encounters with the non-catnip toy.

It has been suggested that the catnip response more closely resembles the relatively involuntary sexual rather than the more voluntary and spontaneous predatory behavior of non-catnip object play. The more frequent occurrence of exaggerated body positions including stretching and crouching (Figure 4a) together with behaviors such as rub, bite and kick/rake (Figure 3a) occurred more frequently with the catnip toy and appear to resemble the typical precopulatory behavior in male and female cats (Crowell-Davis et al., 2004; Romagnoli, 2017). Changes in body position were infrequent during engagements with the non-catnip toy (Figure 6a); cats stood, sat, and occasionally crouched before pouncing. Cats batted, sniffed, pounced and held the non-catnip toy; the actions resembled salient elements of stalking and prey taking without the kill bite.

Beaver's (2013) observations on a single subject were confirmed by observation on the larger number of cats reported above. The high intensity of the catnip response was confirmed and supported the hypothesis that the catnip response was not structurally or temporally similar to the response to non-catnip objects. Beaver also reported that face rub, biting, rolling, stretching, and lying on the side or stomach occurred almost exclusively with the catnip toy. The current study has data that is consistent with these findings. Both studies described intensity increasing within the first fifteen seconds of non-catnip toy play and then gradually declining, while the intensity in the catnip response began high and continued with short pauses for significantly longer intervals that ended abruptly with a retreat and/or collapse.

Body positions, frequency of events, and levels and intensity provided an observable difference between these two conditions. These differences speak to the external stimulation of the herb and the involuntary response it evokes—a very unplay-like configuration of activity. The results were consistent with Beaver's preliminary conclusions that catnip elicited more exaggerated position, higher intensity activity, and different sequences of actions.

Previous literature found approximately 20-30% of cats unaffected by the herb (Hart & Leedy, 1985). There were four subjects that appeared to be either non-responders or non-playful. Evee and Frank, provide evidence that they were not responsive to the catnip. Evee engaged for a longer bout of time in the NC condition and her intensity levels were about equal in both conditions. Frank engaged in both conditions for similar durations but the intensity level was higher in the NC condition. Rick and Tigger both engaged longer with the catnip toy, but neither showed high intensity activity in either condition. The individual observation logs of these cats suggest that the herb had little or no effect on them and resulted in little differentiation in engagement, events, body position, or intensity between the two conditions.

Implications on the Operational Definition of Play

The central second criteria for play, endogenous component—spontaneous, voluntary, or intentional and pleasurable, rewarding, reinforcing, or autotelic—"done for its own sake", includes both intentional criteria and feeling or emotional criteria. The current study and previous literature show ample evidence for pleasurable and rewarding arousal with the catnip toy, but there is little evidence that the behavior is in any way intentional, spontaneous, or voluntary. Burghardt (2006) reminds his readers that play may not always be consistently pleasant, and we do not always know what pleasure looks like in nonhumans. Burghardt added an alternative criterion such as self-control over the entrance to and exit from play (intentional,

spontaneous) and/or endogenous (self) motivation to play (voluntary) both of which can be deduced from the intensity, variability, and flexibility/rigidity of the activity (Kortmuller, 1998).

The structure of the catnip bout suggests that the cats do not engage voluntarily or modulate intensity of their response to the herb. The involuntary response is emphasized by the regular, rapid changes? As shown by plotting the intensity through time in the C condition (Figure 6b), the unvarying intensity of the catnip response in susceptible cats further suggests that the engagement is not spontaneous because the patterns are similar for the eight cats shown. In the NC condition, the patterns are unique and varying. These responses do not appear conducive to a relaxed state that can be interrupted by other interests or appetites as is typical of play. Catnip produces involuntary, stereotypic behavior that is inconsistent with play as an intentional activity. Perhaps intentional, spontaneous and voluntary should be considered separate (sixth) criterion necessary for play as suggested by Beaver (2013).

Welfare Speculations and Future Directions

Previous studies implied that catnip could be used in enrichment efforts to relieve stress because it elicits play-like behavior (Wells, 2009). Cat owners often express concern that stress in their cats is the source of behavioral problems (Strickler & Shull, 2014). According to Strickler and Shull (2014), cat owners who reported that cats with daily five minute play bouts exhibit fewer problems such as aggression, inappropriate elimination, and marking than cats that play less than one minute. One might argue that, unlike play, catnip limits an animal's control over its environment by evoking intense feelings and behavior over which the cat has little or no control. While other olfactory stimuli such as feline specific pheromones may decrease behavior problems, one may wish to examine weather catnip has an effect on unwanted behavior.

Perhaps catnip merely stimulates chemically-triggered pleasure and precopulatory behavior such as face rubbing, stretching, and rolling, etc. If the catnip response is not playful, does it produce the psychological benefits of play or improve welfare? Is there a correlation between catnip use and behavior problems such as ignoring the litter box, asocial actions, or addiction-like cravings? Scientific investigations into the effect of catnip on house bound and shelter animals should determine whether catnip toys not only increase "activity," as shown clearly in the present study, but also relieve stress, reduce aggression, and/or alleviate unwanted behavior. Can catnip deter behavioral problems by inducing some of the pleasure and activity similar to that in play? Is the involuntary nature of the catnip response stressful to some cats? Is so does it exacerbating rather than relieve behavior problems? Additional research is needed before catnip can recommended as enrichment to improve the welfare of house-bound and shelter cats.

Summary

The catnip response is often referred to as play, but the catnip response does not appear playful. The present study showed that catnip invoked structural, behavioral, and temporal changes in behavior. A temporally rigid pattern of rapid changes in intensity and body position, rolling on and repetitive rubbing of the toy are indicative of the involuntary almost stereotypic nature of the catnip response. An analysis of these differences suggests that the response is not voluntary or spontaneous and behavior that is typical of play. The findings suggest that future research needs to investigate the use of catnip for enrichment, relief from behavior problems, and overall benefits to welfare.

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Appendix A: Description of Results

Bruce (9 years, male**)** spent 71% of his time engaged with in the (C) condition and 35% of his time engaged in the (NC) condition. In the (C) condition, he displayed events in decreasing order: face rubbing, sniffing, batting, biting, pouncing and rolling. His body position ranged from crouching, side spread, side curled, and standing. He engaged at the high intensity level for 19% of the time. In the (NC) condition, he displayed events of sniffing and batting. His body position varied between standing and sitting. He did not engage at the high intensity level for any duration of the time.

Buddy (10 years, female) spent 49% of her time engaged in the (C) condition and 18% of her time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: face rubbing, batting, rolling, sniffing, and chewing. Her body positions ranged from side curled, side spread, crouching, lying on back, and standing. She engaged at the high intensity level for 47% of the time. In the (NC) condition she only displayed the sniffing event. Her body position varied between standing and sitting. She did not engage at high intensity level for any duration of the time.

Cammie (2 years, female) spent 66% of her time engaged in the (C) condition and 14% of her time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: face rubbing, sniffing, batting, and rolling. Her body position ranged between side spread, lying on stomach, crouching, standing, lying on back, and sitting. She engaged at the high intensity level for 27% of the time. In the (NC) condition, she displayed events of face rubbing and sniffing. Her body positions ranged from standing, sitting, and crouching. She did not engage in the high intensity level for any duration of time.

Cassie (7 years, female) spent 64% of her time engaged in the (C) condition and 15% of her time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: batting, sniffing, face rubbing, pouncing, rolling, and biting. Her body positions varied from standing, sitting, laying, crouching, and side curled. She spent 78% of the time in the high intensity level. In the

(NC) condition, she only engaged in the sniffing event. Her body positions were standing, sitting, and lying on stomach. She did not engage in the high intensity level for any duration of time.

Charlie (9 years, male) spent 89% of time engaged with toy (C) and 62% of time with toy (NC). In the (C) condition, he displayed the following events in decreasing order: biting/ chewing, batting, sniffing, rolling, and pouncing. He engaged at the high intensity level for 62% of the time. In the (NC) condition he displayed events of sniffing, biting, and staring. His body positions varied from standing, crouching, and sitting. He did not engage in the high intensity level for any duration of time.

Evee (12 years, female) spent 25% of time engaged in the (C) condition and 25% of time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: sniffing, face rubbing, batting, and biting. Her body positions varied from side spread, standing, crouching, side curled, and sitting. She engaged at the high intensity level for 5% of the time. In the (NC) condition, she displayed the following events in decreasing order; sniffing, batting, biting, rolling, staring. Her body positions varied from sitting, standing, laying on back, laying on stomach, side spread and side curled. She engaged in the high intensity state for 10% of the time.

Frank (6 years, male) spent 30% of the time engaged in the (C) condition and 49% of time in the (NC) condition. In the (C) condition he displayed the following events in decreasing order: sniffing, staring, and batting. His body positions varied between sitting and crouching. He did not engage at the high intensity level for any duration of the time. In the (NC) condition, he displayed the following events in decreasing order; staring/stalking, batting, pouncing, and sniffing. His body positions ranged from sitting, standing, and crouching. He engaged at the high intensity level for 24% of the time.

Glenn (3 years, male) spent 59% of time engaged in the (C) condition and 30% of time engaged in the (NC) condition. In the (C) condition, he displayed the following events in decreasing order: batting, biting, rolling, sniffing, and face rubbing, and kicking. His body positions ranged from side spread, laying on stomach, side curled, lying on back, crouching, standing, and sitting. He engaged in the high intensity

level for 78% of the time. In the (NC) condition, he displayed the following events in decreasing order: sniffing, biting, and batting. His body positions varied between standing and sitting. He did not engage in the high intensity level for any duration of the time.

Jazey (11 years, female) spent 41% of time spent engaged in the (C) condition and 54% of time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: batting, face rubbing, sniffing, biting, rolling, and pouncing. She engaged at the high intensity level for 30% of the time. In the (NC) condition, she displayed the following events in decreasing order: sniffing, batting, and pouncing. Her body positions varied between standing and sitting. She did not engage in the high intensity level for any duration of the time.

Lightning (4 years, female) spent 61% of time engaged in the (C) condition and 53% of time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: face rubbing, batting, biting, and sniffing. Her body positions varied between sitting, lying on stomach, lying on back, standing, side curled, and crouching. She engaged at the high intensity level for 52% of the time. In the (NC) condition, she only displayed the stare event. Her body position remained in the laying on stomach position. She did not engage at the high intensity level for any duration of the time.

Little Man (7 years, male) spent 67% of the time engaged in the (C) condition and 69% of the time engaged in the (NC) condition. In the (C) condition, the following events were displayed in decreasing order: chewing/biting, batting, kicking, face rubbing, sniffing, and stalking. His body positions varied from standing, lying on stomach, side curled, laying on back, and crouching. He engaged at the high intensity level for 62% of the time. In the (NC) condition, he displayed the following events in decreasing order; chewing/biting, batting, kicking, face rubbing, pouncing, and sniffing. His body position ranged from laying on side, side curled, side spread, crouching, and laying on back. He engaged at the high intensity level for 44% of the time.

Merrick (12 years, male) spent 41% of his time engaged in the (C) condition and 36% of his time

engaged in the no (C) condition. In the (C) condition, he displayed the following events in decreasing order: face rubbing, batting, sniffing, biting, and pouncing. His body position varied between sitting and standing. He engaged at the high intensity level for 12% of the time. In the (NC) condition, he displayed events of sniffing and face rubbing. He remained in the standing position. He did not engage at the high intensity level for any duration of the time.

Mitsu (2 years, female) spent 62% of her time engaged in the (C) condition and 36 % of her time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: sniffing, batting, rolling, kicking, and staring. Her body positions varied from standing, sitting, crouching, side spread, side curled, laying on back, and laying on stomach. She engaged at the high intensity level for 41% of the time. In the (NC) condition she displayed the following events in decreasing order; sniffing, batting, biting, and staring. Her body position varied between standing and sitting. She did not engage at the high intensity level for any duration of time.

Moe (8 years, male) spent 63% of his time engaged in the (C) condition and 33% of his time engaged in the no (C) condition. In the (C) condition, he displayed the following events in decreasing order: biting, batting, sniffing, and pouncing. His body position ranged from crouching, standing, side spread, side curled, and laying on back. He spent 47% of time engaged at the high intensity level. In the (NC) condition, the following events were displayed in decreasing order: batting, chewing, pouncing, sniffing, and staring. His body position varied between standing, sitting, crouching, and side spread. He engaged in the high intensity level for 22% of the time.

Piglet (3 years, female) spent 62% of her time engaged in the (C) condition and 31% of her time engaged in the (NC) condition. In the (C) condition, the following events were displayed in decreasing order: sniffing and face rubbing. Her body position varied between standing, sitting, and crouching. She did not engage in the high intensity level for any duration of the time. In the (NC) condition, she only displayed the sniffing event. Her body position varied between standing and crouching. She did not engage at the

high intensity level for any duration of the time.

Pixie (12 years, female) spent 56% of her time engaged in the (C) condition and 60% of her time engaged in the (NC) condition. In the (C) condition, the following events were displayed in decreasing order: chewing/biting, sniffing, staring, and pouncing. Her body positions ranged from standing, sitting and crouching. She engaged at the high intensity level for 23% of the time. In the (NC) condition, the following events were displayed in decreasing order: sniffing, batting, and biting. Her body positions varied between standing and sitting. She engaged at the high intensity level for 34% of the time.

Precious (12 years, female) spent 86% of her time engaged in the (C) condition and 7% of her time engaged in the (NC) condition. In the (C) condition, the following events were displayed in decreasing frequency: biting/ chewing, batting, face rubbing, sniffing, and pouncing. Her body positions ranged from side spread, side curled standing, sitting, and crouching. She engaged at the high intensity level for 56% of the time. In the (NC) condition, she only displayed the sniffing event. Her body positions varied between sitting, standing, and crouching. She did not engage at the high intensity level for any duration of the time.

Queenie (6 years, female) spent 80% of her time engaged in the (C) condition and 30% of her time engaged in the (NC) condition. In the (C) condition, she displayed the following events in decreasing order: face rubbing, chewing/biting, rolling, batting, sniffing, kicking, and pouncing. Her body positions ranged from standing, sitting, crouching, side spread, side curled, and laying on back. She engaged at the high intensity level for 73% of the time. In the (NC) condition, she only displayed the sniff event. Her body position varied between sitting, crouching, and standing. She did not engage at the high intensity level for any duration of the time.

Rex (4 years, male) spent 31% of his time engaged in the (C) condition and 20% of his time engaged in the (NC) condition. In the (C) condition, he displayed the following events in decreasing order: biting/chewing, sniffing, batting, and face rubbing. He remained in the crouching position for the entire

duration. He engaged at the high intensity level for 49% of the time. In the (NC) condition, he displayed the sniffing, and staring events. His body position varied between sitting and standing. He did not engage at the high intensity level for any duration of the time.

Rick (4 years, male) spent 41% of his time engaged in the (C) condition and 10% of his time engaged in the (NC) condition. In the (C) condition, he displayed the sniffing and batting events. His body position varied between standing and sitting. He did not engage at the high intensity level for the duration of the video. In the (NC) condition, he displayed the sniffing event. His body position remained in the standing position. He did not engage at the high intensity level for any duration of the time.

Thomas (12 years, male) spent 53% of his time engaged in the (C) condition and 43% of his time engaged in the (NC) condition. In the (NC) condition, he displayed the following events in decreasing order: face rubbing, chewing/biting, batting, sniffing, pouncing, rolling, and kicking. His body positions ranged from side curled, side spread, standing, sitting, crouching, and laying on back. He engaged at the high intensity level for 65% of the time. In the (NC) condition he displayed the following events in decreasing order; batting, pouncing, sniffing, and biting. His body position varied between crouching and standing. He engaged at the high intensity level for 26% of the time.

Tigger (6 years, male) spent 5% of his time engaged in the (C) condition and 5 % of his time engaged in the (NC) condition. In the (C) condition, he displayed the sniffing and face rubbing event. His body position ranged from side spread, standing, sitting, and crouching. He did not engage at the high intensity level for any duration of the time. In the (NC) condition, he displayed the face rubbing, rolling, and sniffing events. His body position varied between standing, sitting, and lying on back. He did not engage at the high intensity level for any duration of the time.

Vladimir (1 year, male) spent 66% of his time engaged in the (C) condition and 40% of his time engaged in the (NC) condition. In the (C) condition, he displayed the following events in decreasing order: biting/chewing, batting, sniffing, and pouncing. His body position varied between standing, crouching,

and side spread. He spending 64% of his time engaged at the high intensity level. In the (NC) condition, He displayed the following events in decreasing order: batting, pouncing, sniffing, and biting. His body positions varied between standing and sitting. He engaged at the high intensity level for 35% of the time.

Zyra (7 years, female) spent 19% of her time engaged in the (C) condition and `13% of her time engaged in the (NC) condition. In the (C) condition, she displayed the sniffing and biting events. Her body positions varied between sitting and standing. She engaged at the high intensity level for 16% of the time. In the (NC) condition, she displayed the pouncing, and sniffing events. Her body positions ranged between standing and sitting. She engaged at the high intensity level for 17% of the time.