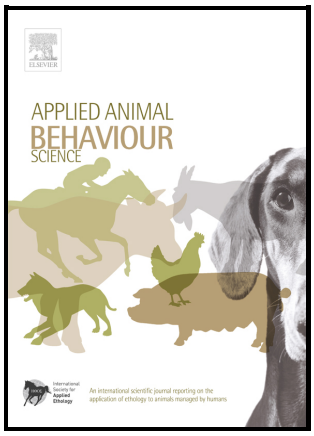
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PII: S0168-1591(22)00168-X

DOI: https://doi.org/10.1016/j.applanim.2022.105710

Reference: APPLAN105710

To appear in: *Applied Animal Behaviour Science*

Received date: 19 January 2022
Revised date: 21 July 2022
Accepted date: 25 July 2022

Please cite this article as: Pamela J. Reid, Victoria A. Cussen, L. Kristen Collins and Randall Lockwood, The Utility of Model Dogs for Assessing Conspecific Aggression in Fighting Dogs, *Applied Animal Behaviour Science,* (2022) doi:https://doi.org/10.1016/j.applanim.2022.105710

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The Utility of Model Dogs for Assessing Conspecific Aggression in Fighting Dogs

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Abstact: This paper describes a study to assess the utility of a life-sized plush model dog as a screening tool for conspecific aggression in a population of dogs bred for use in dogfighting. Because the dogs in this sample experienced similar selective pressures and life histories, we hypothesized conspecific aggression, when present, would be a stable trait readily elicited by the model. Thus, we predicted that aggressive dogs would behave consistently toward both the model and live conspecifics. We tested our prediction with a sample of 292 animals (165 females and 127 males) confiscated during a large dogfighting raid. We found evidence of substantive predictive value with 75% of the dogs exhibiting aggression to the model also exhibited aggression to the same-sex stimulus dog. Similarly, sensitivity was high, with 81% of same-sex-aggressive test dogs detected by the model, indicating the model can discriminate between dogs with and without conspecific aggression. Finally, we found evidence of concurrent validity – with dogs exhibiting similar levels of aggression in all scenarios but with a significant sex*scenario interaction (p=0.03) driven by higher level of aggression in the same-sex stimulus dog condition for male subjects. Based on our findings, we recommend using a model dog first when evaluating fight-bred dogs. If no physical aggression is exhibited to the model, or the behavior is ambiguous, the dog should be tested with a same-sex stimulus dog. Opposite-sex stimulus dogs alone are insufficient to screen for conspecific

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aggression because aggression is reduced in this test scenario for male subjects. Screening for conspecific aggression with model dogs does not completely eliminate the need for live conspecifics, but it substantially reduces the risk to stimulus dogs and evaluators alike by screening out the majority of extremely conspecific-aggressive animals. Using this procedure, a small number of dogs will be mistakenly identified as aggressive, but few truly aggressive dogs will be missed. This is the first in-shelter study on model validity to use a large, homogenous sample of dogs with known life histories and to report the predictive value of models to screen for conspecific aggression in fight-bred dogs. Comparisons of a canine model's validity in other populations of dogs known to exhibit conspecific aggression are needed to determine if fight-bred populations are qualitatively different from other domestic dogs in their response to a model conspecific.

Keywords: Conspecific Aggression, Dog, Shelter, Assessment, Models

1. Introduction

Artificial models are used extensively in research because they effectively elicit species-typical social behavior while simultaneously controlling the features and behavior of the stimulus "animal" between test subjects (e.g. Griffin et al., 2000). For instance, models were used to influence lekking behavior in greater prairie chickens (Patricelli & Krakauer 2009) and to study territorial and aggressive behaviors in fish (e.g. Halperin et al., 1997; Peeke *et al.* 1969). Modern animal models can be quite sophisticated, up to and including robotic models as in Patricelli and Krakauer (2009), but they need not be complex to be effective. Both classic and recent studies show that rudimentary models reliably elicit species-typical behavior, as long as they encode salient features (such as Tinbergen's herring gull heads, replicated by ten Cate et al., 2009). As early as 1971, Fox noted that dogs initially reacted to paintings

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of a conspecific as if it were another dog by orienting to the ear, mouth, inguinal and anal areas (Fox, 1971). Models are also used in applied research. Examples include predator-avoidance training of captive-bred endangered species (Griffin et al., 2000), evaluating the impact of cosmetic surgery on the social behavior of domestic dogs (Leaver and Reimchen, 2008), and evaluating the suitability of puppies for detection work (Lazarowski et al. 2021).

Outside research, model dogs are used in practical settings like animal shelters as one component of a behavior assessment. Though largely unvalidated (Patronek and Bradley, 2016), standardized behavior evaluations remain common and potentially useful tools (Clay et al., 2020). A conspecific subtest is included in most shelter behavior evaluations. It is a necessary precaution to screen for aggression prior to allowing close interaction between new intakes and dogs already residing in the shelter (such as in playgroups), and to aid in determining whether the dog poses a threat to other dogs in the community following adoption. Using live conspecifics as stimulus animals can be dangerous and stressful for both the evaluators and the dogs; furthermore, affiliative or neutral stimulus dogs may not be available in the shelter (Barnard et al., 2019).

When there is reason to suspect extreme conspecific aggression (see Schilder et al, 2019), as in the case of dogs removed from organized dogfighting operations (Miller, Touroo et al. 2016), physical contact between the test and stimulus dogs must be limited for safety reasons. However, it can be difficult to differentiate between an excited dog and an aggressive one without allowing direct interaction—even for seasoned behaviorists (e.g., Tami and Gallagher, 2009). This is because both aggression and affiliative excitement involve increased physiological arousal and have overlapping appetitive behavior patterns, with excitement often

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preceding aggression (Sherman et al., 1996). Using model dogs mitigates interpretation difficulties, especially as regards aggression. It allows direct contact between the test dog and the model stimulus dog, enabling observation of consummatory sequences (see Ball and Balthazart 2008 for a discussion of appetitive and consummatory behavior) including physical attack (see Bonnani et al., 2017 for an example ethogram).

Research with owned pet dogs suggests models can effectively screen for conspecific aggression in domestic dogs. Barnard and colleagues found that pets labelled as dog-aggressive based on owner reports were more likely to direct aggression toward a model dog compared to child-aggressive or unaggressive dogs. All groups exhibited more social behavior to the model compared to a control object (Barnard et al., 2012). Shabelansky and colleagues also compared within-individual responses to a dog model and to a live conspecific, using dogs in an animal shelter. Social behavior was directed to both the live conspecific and the model. However, within individuals, the type of the social behavior exhibited varied between the two stimuli. The authors concluded that a model dog can be useful for identifying friendly behavior toward other dogs, but its ability to identify aggressive or fearful behavior is limited (Shabelansky et al., 2015). More recent shelter-based research supported Barnard and colleagues (2012), reporting a high correlation between the social behavior directed at a model and that directed at live conspecifics (Barnard et al., 2019). The canine literature, therefore, is clear that models elicit species-typical social behavior in domestic dogs, but it is ambiguous as to the utility of models for detecting or predicting aggression in other contexts. Some of the ambiguity may be a methodological artifact, as even minor differences are known to influence behavior evaluation results (e.g. Brown et al., 2020). Also, shelter samples are heterogeneous

with regard to their experiential and genetic background. Life history and artificial selection are known to impact behavior, including aggression, both within and among breeds (Wilsson, 2016).

This paper describes a study to assess the validity of a model stimulus dog as a screening tool for conspecific aggression in a population of dogs bred for use in dog fighting (hereafter “fight-bred” dogs). Because the dogs in this sample experienced similar selective pressures and life histories, we hypothesized conspecific aggression, when present, would be a stable trait readily elicited by the model. Therefore, we predicted that aggressive test dogs would behave consistently toward both the model and live conspecifics. We tested our prediction with a sample of almost 300 animals confiscated during a large dogfighting raid. This is the first in-shelter study of model dog validity to use a large, homogenous sample of dogs with known life histories. It is also the first to report the predictive value of models to screen for conspecific aggression in fight-bred dogs.

2. Materials and Methods

2.1 *Subjects*

The subjects for this study consisted of dogs seized from illegal dogfighting operations in July 2009. A total of 387 dogs were removed from 26 different sites. Another 20 dogs were surrendered by law enforcement officers who had served as undercover investigators. Age, sex, and breed type were determined and recorded during standardized forensic medical exams conducted by veterinarians. Age estimates were based on the eruption of all permanent teeth and the degree of dental wear. Illnesses and/or injuries were documented and treated by the veterinary

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staff. Of the 407 dogs, 115 were excluded from the study because they were under six months of age, were medically compromised, or were determined to be companion rather than fighting dogs (based on forensic crime-scene evidence). Therefore, the study sample comprised 292 fight-bred pit bulls. We use the term “pit bull” in the colloquial sense used by dog fighters; the dogs were not genotyped and were not necessarily American Pit Bull Terriers or any other pure breed. There were 165 females and 127 males, ranging in age from 6 months to approximately 10 years. All were reproductively intact except for one male. A few of the dogs in the study sample had physical disabilities from old injuries, including missing eyes and limbs; they were cleared for testing by veterinary staff. While being held as evidence in the criminal cases, the animals were sheltered at a temporary facility inside a warehouse. All were housed singly, typically in standard kennels measuring 1.5m x 3m constructed with powder coated, welded wire panels joined by brackets. Given the temporary field-shelter and need to house a large number of dogs, some variation existed in kennel size. Lactating females were housed with their puppies. Dog were removed from their housing for cleaning and for walks.

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2.2 *Behavior Evaluations*

Dogs were screened for conspecific aggression as a component of a standardized behavior evaluation developed by the authors. Behavior evaluations began 15 days after the dogs were seized from the suspected fighting yards and moved to the temporary shelter. It took six days to complete all of the evaluations. During the evaluation, dogs were exposed to same- and opposite-sex dogs, a model dog, and a control object. Their reactions to each of these stimuli were classified as

Aggressive, Friendly, *Fearful*, *Neutral*, *Pushy*, or *Sexual*. Classifications were defined as follows:

Aggressive, the dog exhibited a slow, tense approach with hard staring or a direct rushing in, followed by any of these clear-cut indicators: growling, baring teeth, snarling, muzzle punching, snapping or biting. *Friendly,* the dog had to play bow, jump on, paw at the stimulus dog or model, with loose body and relaxed muscles. *Fearful,* the dog approached with a lowered head and a lowered/tucked tail, *Neutral,* the dog ignored the stimulus dog/object or approached with neutral body carriage, sniffed, and then disengaged. *Pushy*, the dog approached directly with assertive-looking body language and behavior including some of the following: ears erect and forward, tail up and stiff, prolonged direct gaze toward the stimulus dog or model, hackles raised, tense muscles, erect body, leaning forward toward the stimulus dog or model, and/or placing their head or a paw over the withers of the stimulus dog or model. *Sexual*, the dog mounted and thrusted, may have shown 'flirty' posture and behavior before mounting: tail up, ears erect and rotated backward, tall posture with loose body, may sniff test dog's ears and or mouth, may paw at test dog or play bow.

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2.2.1 Evaluation Areas

Evaluations took place in one of three indoor areas, each approximately 3.7 m x 4.6 m. Areas were enclosed by solid walls and/or chain-link fencing covered in opaque material to minimize visual stimulation from outside the evaluation space. Handlers and dogs entered through a door or a chain-link gate approximately 1 m wide. Inside each area was a chair, placed in the area's center, and a table holding evaluation supplies.

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2.2.2 Evaluation teams

Dogs were evaluated by one of three evaluation teams. Each team consisted of four people: two animal behavior specialists, one Animal Control Officer (ACO) from the Humane Society of Missouri (HSMO), and one videographer. The behavior specialists (all females) worked for the American Society for the Prevention of Cruelty to Animals (ASPCA) and the HSMO; they had extensive experience conducting shelter dog evaluations. One of the two behavior specialists served as the primary handler for each team, with the other observing and recording responses of the dog being evaluated. The ACO (all males) served as assistant handler for each team.

For safety reasons, the three teams were assigned to separate sections of the warehouse to avoid crossing paths while dogs were walked to and from the test area. Consequently, dogs were not assigned to teams randomly; assignment was based on home-kennel proximity to the test area. Evaluation teams were randomly assigned to the test areas, however, and dogs were not clustered in the shelter according to site of origin. Therefore, there was no reason to expect a systematic pattern in the assignment of dogs to evaluation teams.

2.2.4 Behavior Evaluation Process

Each dog being evaluated (hereafter referred to as the “test dog”) was walked on a slip lead from their home kennel to the evaluation area. Dogs that were too frightened to walk (a relatively common phenomenon in under socialized dogs) were carried. Once secured in the testing area, the dog was released for a 60-second

period. The primary handler sat in the chair and ignored the dog. The dog was free to explore the area, stay put, or interact with the people. After 60 seconds elapsed, the primary handler called to entice the test dog to approach her, and the evaluation subtests began. During the conspecific subset, each dog was presented with a series of four stimuli: an opposite-sex conspecific, a same-sex conspecific, a model dog (Melissa and Doug® Yellow lab giant stuffed animal, 55cm x 76cm x 28cm, Figure S1 supplemental materials), and a control object of similar size that was relatively formless (a chair covered in a white sheet, Figure S2 supplemental materials).

For this component of the evaluation, either the ACO handled the test dog, and the primary handler, one of the team's behavior specialists, handled the stimulus dog and the model, or the roles were reversed. The other behavior specialist on the team observed and rated the test dog's responses during all four stimulus presentations. The rater was, therefore, not blind to the test dog's previous response. However, test dogs were randomly assigned to one of four presentation orders: (1) opposite-sex stimulus dog, same-sex stimulus dog, model dog, control object; (2) opposite-sex stimulus dog, control object, same-sex stimulus dog, model dog; (3) model dog, opposite-sex stimulus dog, control object, same-sex stimulus dog; and (4) control object, model dog, opposite-sex stimulus dog, same-sex stimulus dog. Order of presentation was varied such that half of the test dogs experienced a live stimulus dog prior to the model dog and half experienced the model dog before the real dogs; this approach prevented systematic rater bias in classifying behavior toward the model dog based on behavior to live conspecifics, or vice versa.

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We chose to always present the opposite-sex stimulus dog before the same-sex stimulus dog because we expected that the test dogs were more likely to direct aggressive behavior toward a same-sex conspecific (Borchelt, 1983). We didn't want an aggressive reaction toward the same-sex stimulus dog to carry over and affect the response of the test dog toward the opposite-sex stimulus dog. Multiple live stimulus dogs from the sample population were used; all were known to be dog friendly. Each night, the model dogs were wiped clean, and any significant tears were sewn up so they could be reused. A model dog was retired if it was so badly damaged that it could not stand upright or if both of its eyes or ears had been torn off. Replacement model dogs were always the same item from the same manufacturer.

Stimulus Dog Test: The procedure for presenting the stimulus dog was identical for both same and opposite-sex stimulus dogs. The stimulus dog was brought, on leash, to the outside of the evaluation area. Once the dog arrived and the handler announced arrival, a visual barrier (a sheet) was lifted to reveal the stimulus dog, and the test dog, inside the evaluation area, was permitted to approach the barrier on-leash. The dogs were permitted to interact through the chain link gate. If the test dog behaved aggressively (e.g. growled, lunged, snapped), the live conspecific subtest was discontinued. If the test dog was not aggressive at the gate, it was walked to the far side of the evaluation area and turned to face the wall while the stimulus dog was brought into the evaluation area. When the test dog was permitted to turn around, its reaction to the stimulus dog was first assessed at a distance. Again, if the test dog exhibited aggressive behavior, the subtest was discontinued. If not, the two dogs were brought closer (within 7 cm of each other) and, if the handlers deemed it safe, were permitted to greet and interact with each

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other. Interaction time ranged from approximately 30 – 120 seconds. If the handlers felt a nose-to-nose greeting might be unsafe, the test dog was muzzled before moving close enough to make contact.

Model Dog Test: The test dog was turned away from the entry gate prior to the primary handler's entrance, to prevent them watching the model being carried into the evaluation area. A handler carried the model dog, wearing a slip leash, into the evaluation area, put the model on the ground approximately 3 meters from the test dog, and then stood next to it, holding the leash as one would with a live dog. When the test dog was permitted to turn and see the model, the model and the handler began to move forward at an unhurried pace, the handler attempting to manipulate the model to appear like it was walking. (Some handlers held the model's tail and "walked" it forward; others simply used the leash to simulate a walking motion.) The other handler allowed the test dog, also leashed, to approach and engage with the model dog. The model's handler continued to move the model around close to the test dog so that it wasn't motionless. After the initial "greeting" (approach followed by nose to tail positioning) the model dog was toppled over onto its side and then, after a few seconds, was raised back up on all fours. While the model was on its side, the primary handler occasionally used the leash to make the model appear to jerk or twitch briefly to simulate the movements of an injured or incapacitated dog attempting to rise. Finally, the model dog was pulled up onto all fours again and its handler moved it directly toward the test dog, placing its head over the test dog's withers in an assertive, 'T-position' manner (Schenkel 1967). (If the test dog moved such that accomplishing a T-position wasn't possible, the tester instead made the model rear up as if attempting to mount the test dog's back.) The second and third components of the model dog test (simulated injury and assertive

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behavior) were developed specifically for fight-bred dogs. The model dog test was ended after these three steps or after the test dog physically attacked the model, whichever came first. If the test dog did attack the model, testers first attempted to interrupt the dog by offering a paper dish of food (kibble mixed with canned food) approximately 30 cm away from the dog. If this did not work, the testers yelled (e.g., “Hey! No!”) and banged together two metal bowls. If the startling sounds also failed to interrupt the attacking test dog, the testers used a break stick to pry the dog’s jaws apart and physically remove the model.

Control Object Test: Presentation of the control object was like that described for the model dog in that the test dog was turned away while the object was positioned in the room. The primary handler stood next to the control object, holding a leash that was attached to the object. The test dog was encouraged to move toward the object. As the dog approached, the primary handler used the leash to jiggle the object slightly. The test dog was permitted to investigate the object.

The model dog and control object were not presented at the barrier before entering the test arena because previous work shows that dogs investigate and then lose interest in model dogs (Kubinyi et al., 2004). Because we wanted to observe the initial, unrestricted behavior toward the model we did not first provide an opportunity for olfactory investigation. Safety and ethical reasons, however, required a barrier greeting for live conspecifics. After completing the four test scenarios, the test dog was either returned to the kennel, or we continued with additional evaluation subtests not related to conspecific interaction.

2.3 *Data analysis*

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The distribution of test dog response classifications was described for each evaluation scenario: control, model dog, same- and opposite-sex stimulus dogs. A Fisher's Exact test was used to assess what, if any, priming effect live conspecifics had on the test dogs' behavior to the model. The proportion of test dogs exhibiting aggression to the model was compared between those test dogs that encountered the model dog prior to the live stimulus dog (n=148) and test dogs that first encountered a live conspecific (n=144).

To determine the effect of test scenario and sex on aggressive response, we fit a generalized linear mixed model (GLMM) with a binomial distribution and logit link. The model included the main effects sex, test scenario, and a sex*test scenario interaction as independent variables. Individual dog was included as a random effect to account for the repeated measures study design. Aggression was coded as a binary dependent variable, with dogs' response classifications dichotomized as *Aggressive* or *Other*.

We also calculated the model dog's sensitivity, positive predictive value, and false alarm rate for detecting conspecific aggression (Glaros and Kline, 1988). Sensitivity – the model's ability to detect aggressive dogs - was calculated as: (Number of dogs aggressive to both the model & the same-sex stimulus dog / Number of dogs aggressive to same-sex stimulus dog) * 100%; Positive predictive value – likelihood a model-aggressive dog is truly aggressive to conspecifics - was calculated as: (Number of dogs aggressive to both the model & the same-sex stimulus dog / Total number of dogs aggressive to the model) * 100%; False alarm rate was calculated as: (Number of dogs aggressive to the model but not aggressive to the same-sex stimulus dog / Total number of dogs aggressive to the model dog) * 100%.

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Finally, we also ran a secondary analysis including dogs that were categorized as *Pushy* toward the stimulus dog with those categorized as *Aggressive*. We then recalculated positive predictive value and false alarm rate and ran another logistic regression. The rationale for this secondary analysis is as follows. During conspecific testing of fight-bred dogs, defensive handling was necessary to protect the stimulus dog from potential attacks by the test dog. Handlers necessarily interrupted precursor behaviors that could escalate to aggression, such as mounting a same-sex conspecific (an agonistic social signal widespread across taxa, see Lane et al., 2016). When assessed with a model, however, the test dogs were allowed more freedom to physically engage because attacks were not detrimental to the test dogs themselves. Furthermore, stimulus-dogs were selected based on their pro-social behavior toward conspecifics, meaning their behavior could defuse a potentially aggressive interaction (previous work found dominant stimulus dogs elicited aggression in almost a third of the test dogs, van der Borg et al., 1991). For dogs that were *Aggressive* to the model, approximately 41% of males and 33% of females were *Pushy* in at least one stimulus dog test. Furthermore, in the majority of these cases, individuals that were *Pushy* in only one of the stimulus dog tests were *Aggressive* in the other test (see Supplemental Materials for details).

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3. Results

Five dogs had missing results and were excluded from the analysis, leaving a total of 287 dogs (164 females, 123 males) in the dataset. Ninety percent (n=258) were classified as *Neutral* to the control object, meaning they directed no social behavior to the object. Most dogs were not aggressive in any test scenario (n=172,

60%), though this was more common in females (65%) than males (54%). See Table 1 for all responses.

Aggressive responses were recorded for 115 dogs (40%) in at least one test scenario: 46% of males (n=57 of 123) compared to 35% (n=58 of 164) of females. A total of 16 dogs were aggressive only to the model (n=8 for both males and females, 7% and 5% respectively), leaving 35% (n=99) that showed aggression to a live conspecific. Of those 99 dogs, some were aggressive to stimulus dogs of both sexes, while others were aggressive only to same- or opposite-sex conspecifics (Table 2). Aggression at the barrier terminated 44 opposite-sex stimulus dog interactions (test dog sex = 23 female, 21 male) and 61 same-sex stimulus dog interactions (test dog sex = 30 female 31 male).

Table 1: Classification of the behavioral responses of fight bred pit bulls during a standardized behavior evaluation, distributed by subtest. Dogs were tested with a same-sex stimulus dog, an opposite-sex stimulus dog, a life-size plush model dog, and a control object (chair draped with a sheet). The control object elicited no social behavior in 90% of fight bred dogs tested, while the model dog exhibited a range of species-typical social behavior comparable to the live stimulus dogs. See text for the definitions of the response classifications.

	Test Condition			
	Same-sex	Opposite-sex	Model	Control
Behavioral Response				
Aggressive	86	73	94	2
Fearful	56	63	56	14
Friendly	41	61	25	12
Neutral	48	31	37	258
Pushy	54	57	22	0
Sexual	2	5	55	1

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Table 2: The number (and percent) of fight bred pit bulls classified as Aggressive during a standardized behavior evaluation, distributed by sex and subtest. Dogs were tested with a same-sex stimulus dog, an opposite-sex stimulus dog, a life-size plush model dog, and a control object (chair draped with a sheet). . Only 2 of 289 fight-bred dogs showed an aggressive response to the control object, whereas the model dog elicited an incidence of aggression comparable to the same-sex conspecific.

Condition	Female	Male	**Total**
Same-sex Stimulus	42 (26%)	44 (37%)	**86 (30%)**
Opp.-sex Stimulus	42 (26%)	31 (25%)	**73 (25%)**
Model Dog	52 (32%)	42 (34%)	**94 (33%)**
Control Object	0	2 (2%)	**2 (0.7%)**

There was no significant difference (Fisher exact test, p=0.71) between the model-first and stimulus-dog-first groups: 34% of dogs that encountered the stimulus dog first exhibited aggression toward the model dog and 31% of dogs that encountered the model dog first exhibited aggression toward it.

Individual dogs varied substantially from one another in the probability of aggression in each test scenario, as indicated by the standard error of the random effect (SE=10.6). The probability of aggression was significantly influenced by an interaction between the fixed effects of Scenario and Sex of the test dog (χ^2 = 12.19, p<0.001). Holding Sex constant, aggression was less likely in the stimulus dog scenarios compared to the model (main effect of Scenario for female level of Sex: χ^2 = 12.19, p= 0.002); however, the significant interaction effect requires that both sex and scenario be considered when considering the GLMM results (See Table 3).

Table 3: GLMM model summary of fixed and random effects for fight bred pit bulls classified as Aggressive during a standardized behavior evaluation. The GLMM included test scenarios with a

same-sex stimulus dog, an opposite-sex stimulus dog, and a life-size plush model dog. Estimates shown are the exponentiated odds ratio. Base levels are Model test condition (Scenario) and Female test dog (Sex).

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]

Family: binomial (logit)

Formula: response ~ scenario * sex + (1 | A.Number)

AIC	BIC	logLik	deviance	df.resid
765.6	798.9	-375.8	751.6	854

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.19365	-0.03195	-0.01597	0.11752	2.70157

Random effects:	**Group**	**Variance**	**Std.Dev**	
	A Number	103.9	10.19	
Fixed effects:	**Odds Ratio**	**LL**	**UL**	**p-value**
Intercept	0.001196	2.90E-03	4.92E-03	<0.001
Scenario: Opp-sex	0.250022	0.082955	0.753554	0.014*
Scenario: Same-sex	0.250022	0.082953	0.753569	0.014*
Sex: Male	0.982610	0.1999164	4.829633	0.98
Opp-sex * Male	0.891028	0.1967094	4.036062	0.88
Same-sex * Male	5.077457	1.1713826	22.00867	0.03*

* Significant at 0.05 level

For each interaction contrast, the test assesses the difference of the differences in mean probability of aggression between groups and conditions, i.e. the magnitude of the difference in the probability of aggression between test scenarios based on the sex of the test dog (Agresti, 2007). The baseline comparator for each contrast is Sex = female and Scenario = model. Male test dogs had a larger increase than females in the probability of aggression between the model dog and same-sex stimulus dog scenario (odds ratio 5.1, p=0.03), while there was no difference for

males and females in their respective change in probability of aggression between the opposite-sex scenario and model scenarios.

The interaction effects are depicted in Figure 1. Both male and female test dogs had the same mean probability of aggression in both the model dog and opposite-sex stimulus dog scenarios. Test dogs of both sexes also had a lower probability of aggression in the opposite-sex stimulus dog scenario compared to the model scenario. Males had a slightly higher mean probability of aggression in the same-sex stimulus dog vs. model scenarios, while females had a much lower probability of aggression for the same-sex scenario compared to the model scenario. Together, the males' slight increase and the females' larger decrease led to a large magnitude difference between those scenarios.

Figure 1:

When *Pushy* behavior to the stimulus dog was combined with *Aggressive* outcomes for dogs that were *Aggressive* to the model, the revised GLMM showed only the Sex-by-Scenario interaction effect (χ^2 8.0, p=0.02). Male and female test-dogs had similar mean probabilities of aggression in the model and opposite-sex stimulus dog scenarios. Male dogs had significantly higher odds of aggression in the same-sex stimulus dog scenario (z=-2.1, p=0.005). See Supplemental Materials for reclassified model results.

Over three-quarters of test dogs aggressive to the same-sex stimulus dog (n=86), were also aggressive to the model dog (n=70); therefore, the model's

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sensitivity for conspecific aggression was 81%. Of the 94 test dogs aggressive to the model dog, 70 were also aggressive to the same-sex stimulus dog, meaning the positive predictive value of the model dog was 75%. The remaining 24 test dogs (13 Female, 11 Male) were not aggressive to the same-sex stimulus dog for a false alarm rate of 26%. When *Pushy* responses to the same-sex live stimulus-dog were included (n= 18 *Pushy*, n= 70 *Aggressive*), three quarters of the false positives were removed (10 Female, 8 Male). The model dog's positive predictive value for conspecific aggression increased to 94%, dropping the false alarm rate to 6%, and sensitivity increased to 85%.

4. Discussion

We found the model dog elicited species-typical social behavior in this sample of fight-bred pit bulls. Responses to the model were similar to responses to live conspecifics and dramatically different than reactions to the control object, toward which 99% of individuals did not show any species-typical social behavior. The social nature of the test dogs' response to the model and the similarity of the response to live conspecifics argue against a predatory response triggered by the model dog's movement, but future work could incorporate a moving control object. Our finding of face validity is in line with other reports, where model dogs consistently elicit species-typical social behavior (e.g. Barnard et al., 2012). Some shelter staff have suggested priming with a live conspecific is needed for dogs to be adequately fooled by the model dog (pers. comm.). We found presentation order did not influence the proportion of test dogs exhibiting aggression to the model, consistent with other authors (Shabelansky et al., 2015). Practically, this means using a model as a first-line screening tool for conspecific aggression is supportable, because the model

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effectively elicits social behavior even if presented prior to interaction with a conspecific.

In a recent review summarizing behavior assessments writ large (rather than the model dog test specifically), the calculated mean false alarm rate for shelter dog assessments was estimated at almost 64% (Patronek et al., 2019), which is between double and triple the actual rate we found based on a conservative analysis. In contrast to the review of shelter assessments, van der Borg and colleagues (1991) reported that standard tests had significantly higher sensitivity and negative predictive value than staff opinions. The pattern held true for conspecific aggression assessed with live stimulus dogs (van der Borg et al., 1991). Contrary to our findings, a previous study using model dogs in the shelter reported a low within-subject agreement between the *type* of social behavior directed toward the model and live stimulus dogs, including aggression (Shabelansky et al., 2015), indicating the model may not predict behavior -though predictive validity was not directly assessed.

However, prior studies evaluating model dogs included heterogenous samples of test dogs, frequently comprised of dogs with unknown lineages and life histories. Furthermore, aggression was sometimes absent (e.g., Barnard et al., 2019) or low-level (e.g., stiffening or growling, Shabelansky et al., 2015). This absence could be due to: methodology, such as the exclusion of fractious animals from tests and the prevention of physical contact between test subjects and stimulus dogs; a non-representative sample of unusually sociable animals (*some* aggression would be expected in non-fighting populations); differences in the prevalence in aggression between fight-bred dogs (40% in our sample) and the general shelter dog population - or some combination of the three. For example, in test-stimulus dog dyads matched for size and sex, the reported prevalence of aggression was 32%

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(van der Borg et al., 1991), which is much higher than other reports that did not match for size and sex. Regardless, the low incidence and intensity of aggression in previous studies makes interpretation of model validity for detecting aggression difficult. Using a large, homogenous sample with a relatively high prevalence of conspecific aggression, we found evidence of substantive predictive value: 75% of dogs exhibiting aggression to the model were also aggressive to the same-sex stimulus dog (false alarm rate 26%). Similarly, sensitivity was high, with 81% of same-sex-aggressive test dogs detected by the model.

In addition to high sensitivity and positive predictive value, the results of our logistic regression clearly support the discriminant validity of the model dog for distinguishing individuals with extreme conspecific aggression from those without. Others have argued that discriminant validity—even of extreme behavioral phenotypes—is relatively unimportant compared to predicting behavior in the home and that determining discriminant validity is complicated by the lack of a gold standard when establishing overall validity for shelter assessments (Patronek et al., 2019). However, social behavior, including aggression, reflects a dynamic interaction among individual personality, internal motivational state, social and physical environmental conditions, and learning. Prospective studies tracking behavior into an adoptive home potentially confound changes in behavior due to environment, learning, and/or internal state with failure to detect a “true” personality trait of aggression. This is akin to saying a smoke detector that detects a fire today is faulty because it fails to predict a fire that occurs months or years later in a different home. The difference is detection vs prognostication.

For aggression, particularly, the primary question for an evaluation *is* discriminant validity. In other words, can the test distinguish individuals with

conspecific aggression (currently) from those without? Aggression to conspecifics (currently) is the gold standard comparator. An important purpose of the model dog is to screen out dogs with unambiguous physical aggression (i.e. physical contact with body and/or mouth, including ramming, knocking over, biting, shaking, etc. vs. aggressive posturing or vocal signals) before allowing interaction with conspecifics in the shelter (such as during playgroups) and when making in-shelter housing or management decisions.

Our results show the model is a reliable screening tool for such purposes, in the study population of fight-bred dogs. We did, however, find a scenario by test-dog-sex interaction, with males less aggressive to opposite-sex stimulus dogs and females seemingly more aggressive to the model. The male test dog finding is consistent with evidence that in most canid species, including domestic dogs, same-sex dyads are more prone to agonistic behavior than opposite-sex dyads (e.g. Borchelt, 1983). It is perhaps odd, then, that females showed no difference in likelihood of aggression between same- and opposite-sex stimulus scenarios, especially given the reported frequency and intensity of aggression between bitches (e.g. Bamberger and Houpt, 2006; Sherman et al., 1996). Additionally, fighters often have a sex ratio of 1:1 in their kennels (unpublished data), suggesting males are not inherently more aggressive toward same-sex conspecific than females – although they are more commonly used in organized fights. It is possible that females are more responsive to the non-threatening, friendly behavior of the stimulus dogs. An unresponsive model could be perceived as tense and unfriendly. Since fighting dogs often fail to clearly communicate intent, other fight-bred dogs may be inclined to interpret the lack of friendly signaling as a threat. However, a comparable proportion of male test dogs were aggressive to the model, which is unexpected if the ‘stiff’

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model was causing more aggression. It is also possible that our results reflect true sex differences in response to a model conspecific; other studies of model dogs have not controlled for sex in their analyses, making a direct comparison impossible.

We suspect, however, that some test dogs classified as *Pushy* in the stimulus dog scenarios would have escalated to aggression given more freedom to physically contact the stimulus dog. Our supposition is supported by the frequency of *Pushy* interactions across test scenarios: ~20% of interactions with live conspecifics versus <10% interactions with the model dog. This discrepancy is even higher in dogs that were aggressive to the model, with 36% of females and 40% of males *Pushy* in one or both stimulus dog tests. Furthermore, other authors have reported relatively high levels of aggression when 'dominant' same-sex stimulus dogs were used (van der Berg et al., 1991) whereas we sought out friendly stimulus dogs. These friendly stimulus dogs may have masked the *Pushy* test-dogs' aggression by tolerating their precursor behavior.

Combining the *Pushy* and *Aggressive* responses in the stimulus dog scenarios for dogs that were aggressive to the model suggested the interaction was possibly driven by male dogs' higher level of aggression to the same-sex stimulus dog. Females were equally likely to aggress across all three scenarios. Additionally, 82% of females classified as *Pushy* in a single stimulus-dog test were classified as *Aggressive* to the other sex stimulus dog (tabulation of *Pushy* responses by sex and subtest and the reclassified logistic regression results are provided in the Supplemental Materials). If this suspicion is correct, it supports the use of models as potentially superior to live conspecifics for detecting aggression, at least in female fight-bred dogs. The less conservative response classification increased the model dog's positive predictive value to 94%, removing three-quarters of the false positives

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(77% for females, 73% for males)., The high risk-potential for severe injury to live stimulus dogs required defensive handling, for the reasons described previously in the Methods section, which likely led to some aggressive dogs classified as *Pushy* rather than *Aggressive*. Muzzles do not fully address this issue because, although their use reduces the risk of injury to the stimulus dogs, it does not prevent other aversive aspects of aggressive behavior. Defensive handling is still required to prevent or interrupt muzzle punches, mounting, clasping, bite attempts, etc. Furthermore, muzzling all dogs would likely introduce more variability into the data because many dogs find the muzzle distracting. Therefore, further carefully designed studies are required to produce direct evidence to support our interpretation that pushy behavior was a precursor to aggression in many cases.

Intraspecific aggression is amenable to artificial selection (Price, 1999). Given directional selection for conspecific aggression in these lines, a larger proportion of individuals are expected to be predisposed to higher than typical levels of conspecific aggression (Lockwood, 2013). Some of these individuals develop extreme aggression due to some combination of artificial selection, early life history, training, and/or fighting experience. One would expect, in those cases, a decreased responsiveness to an unusual conspecific signature from the model dog, making it an effective releasing stimulus for aggressive behavior, as is the case in other species exhibiting high trait aggression (e.g. *Betta splendens,* Halperin et al., 1997). This may explain why we found strong evidence to support the use of model dogs to detect conspecific aggression in fight-bred dogs.

A limitation of applied canine research, the present study included, is the wide range of behavior included in the category of “aggression.” Johnson (1972, in Barrows 2001 pg. 11) encapsulated the situation: ‘The term aggression has so many

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meanings and connotations that it has in effect lost its meaning.' We believe the situation calls for refinement of methodology rather than abandoning the use of model dogs (or behavior assessments generally), as suggested by other authors (e.g. Patronek et al., 2016). When attempting to examine assessment validity, or predict future behavior, explicit and narrowly defined behaviors should be compared rather than umbrella categories such as "aggression," which includes everything from ritualized signals such as growling to physical attacks including some combination of biting, holding, and shaking. Then, the frequency and intensity of those behaviors can be quantified, as is the standard practice for animal models of human violence (de Boer, 2017). Recording latency to attack the model, among other measures, would provide information necessary to address the questions of possible sex differences in response to the model.

Another limitation to the interpretation of the current study is the potential variability introduced by state and/or trait differences in the test and stimulus dogs. Fight-bred dogs tend to be under socialized to typical pet dog stimuli and situations. In our experience with thousands of these dogs, it is common for some individuals to refuse to walk on a leash. In the study subjects, dogs that would not walk on leash were carried to the test arena. It is possible this caused acute stress in the carried individuals. Standardizing transport method, possibly by using a rolling crate, is one potential approach that could be used in the future. It is worth noting, however, that such standardization may actually exacerbate variability because some individuals tolerate rolling crates – or carrying, or leash walking – better than others. Quantifying test-dogs' behavior during their one-minute adaptation periods after evaluation area entry (e.g. Wormald et al., 2016) would allow researchers to control for affective state statistically; transport method could remain tailored to the individual to minimize

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stress. Because multiple stimulus dogs were used, it is also possible that differences in the behavioral responses of the stimulus dogs influenced the behavior of test dogs. It is unclear how this could be avoided, because minimizing the stimulus dogs' repeated exposure to intensely aversive behavior is necessary for ethical reasons regardless of physical harm. Furthermore, in our experience using the same stimulus dog for over a hundred test dogs would also introduce variability because the stimulus dog's behavior would change over time after repeated exposure to pushy and aggressive test dogs. From the practical perspective of detecting extreme conspecific aggression, however, neither current emotional state nor stimulus-dog behavior negate an aggressive response by the test dog. Dogs placed in the community are likely to encounter stressful situations and a wide range of conspecific behavior and an extreme aggressive response in such contexts raises questions of community safety.

In summary, within a dogfighting population, we found strong support for the validity of a model stimulus dog as a screening tool for conspecific aggression, without the need for social priming. Screening for conspecific aggression with model dogs does not completely eliminate the need for live conspecifics, but it substantially reduces the risk to stimulus dogs and evaluators alike by screening out the majority of extremely conspecific-aggressive animals. Based on our findings, we recommend using a model dog first when evaluating fight-bred dogs. If no physical aggression is exhibited to the model, or the behavior is ambiguous, the dog should be tested with a same-sex stimulus dog. Opposite-sex stimulus dogs alone are insufficient to screen for conspecific aggression because aggression is reduced in this test scenario. If stimulus dogs of both sexes are available, opposite-sex testing can provide further information prior to allowing the test dog into playgroups or foster homes, e.g., for

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dogs that were neutral or fearful with same-sex stimulus dogs. Using this procedure, a small number of dogs will be mistakenly identified as aggressive, but few truly aggressive dogs will be missed. There may be sex differences in latency to attack the model that require sex-specific minimum test durations, which we are assessing with a follow-up study on the characteristics of aggressive responses. In addition to sex effects, assessments of the model dog's validity in other populations of dogs are needed to determine if fight-bred populations are qualitatively different from other dogs in their response to a model conspecific. This requires assessing model validity in non-fighting populations known to include individuals with conspecific aggression and using quantitative approaches to assess the intensity and severity of physical aggression. Doing so will extend the current study's findings that models reliably indicate the presence of conspecific aggression in a population of fight-bred dogs.

Ethical Note: The behavior evaluation protocol and the subsequent analysis of test results received full ethical approval from senior management of the Humane Society of Missouri (HSMO), the lead agency responsible for the care of the dogs, and of the American Society for the Prevention of Cruelty to Animals (ASPCA).

Acknowledgements: We thank L. Campbell, Emily Dolan, D. Hill, Patricia McMillan, Margaret Slater, and the Humane Society of Missouri for their expertise and assistance with this project.

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Key words

Aggression; animal models; animal fighting; behavior assessment; pit bull dog

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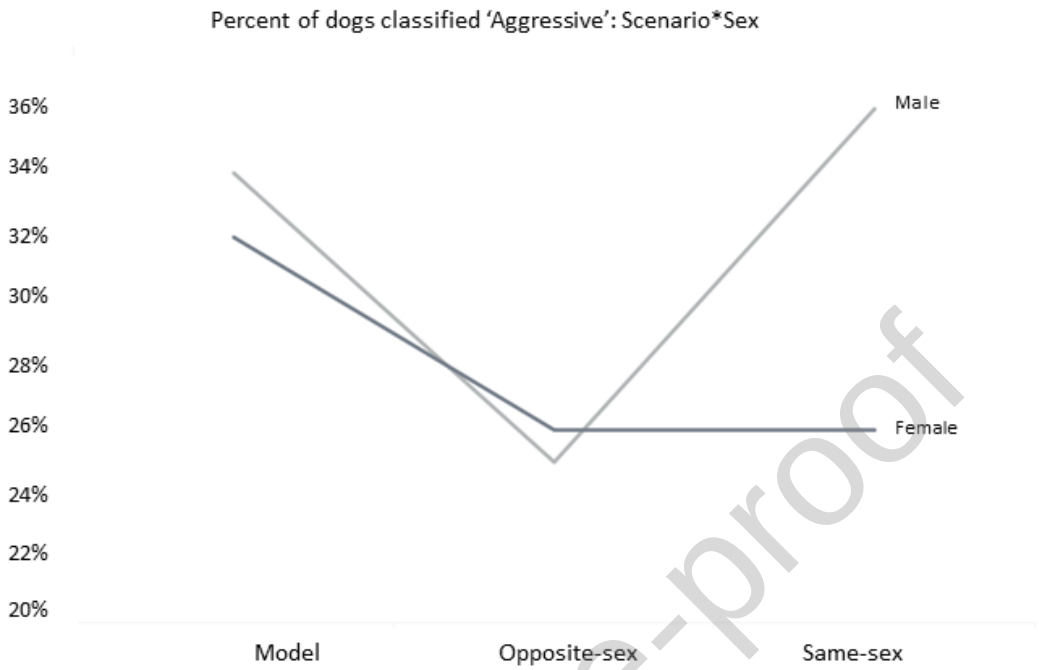


Figure 1: Interaction plot of fight bred pit bulls classified as Aggressive during a standardized behavior evaluation. Dogs were tested with a same-sex stimulus dog, an opposite-sex stimulus dog, and a life-size plush model dog. More females (darker line) directed aggression to the model (32%) than to same- or opposite-sex stimulus dogs (both 26%). Fewer males (lighter line) directed aggression to opposite-sex (25%) than to same-sex stimulus dogs (36%) or to the model dog (34%).

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Highlights

- The behavior of fight-bred dogs to a life-sized plush model, and same- and opposite-sex conspecifics was assessed for within-individual consistency
- The model elicited species typical social behavior, and accurately classified dogs as aggressive or not in most cases
- Sex differences existed in aggression to same- and opposite-sex live conspecifics
- Model dogs are useful screening tools for detecting conspecific aggression in fight-bred dogs
- Further research is needed to quantify the intensity and severity of aggression exhibited to the model by fight-bred dogs, and to assess the utility of models to detect extreme conspecific aggression in non-fighting populations

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