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The Creative Canine: Investigating the Concept of Creativity in Dogs (*Canis lupus familiaris*) Using Citizen Science

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There is no shortage of anecdotal evidence that domestic dogs (*Canis lupus familiaris*) can solve problems in individual or creative ways. Whether it is figuring out a new way to knock over the trash can or combining puppy-dog eyes with a whine for some table scraps, dogs approach their world in many ways. In recent years, dogs have been studied for a number of cognitive functions, but their ability to demonstrate creative behaviors has not been empirically studied. The present study extends training of the create behavior, as previously trained in dolphins, to dogs. The criteria of the create behavior required the dog to present a behavior that had yet to be performed in the session; therefore, the only incorrect response was a repeated behavior. Mastery of the create command was coded on three components: repetition, energy, and novelty. Possible implications of this research are discussed. This study adds to the literature on dog cognition and supports the utilization of citizen science for canine cognition research.

Keywords: animal behavior, animal cognition, citizen science, companion animals, create, dog, innovate

Non-human animals, hereafter referred to as animals, have continued to demonstrate that they possess behaviors we once thought were unique to humans, such as cooperation (Jaakkola et al., 2018; Kuczaj et al., 2015; Plotnik et al., 2011), problem-solving (Bird & Emery, 2009; Cheke et al., 2011; Köhler, 1925; Kuczaj & Walker, 2006), planning (Kuczaj et al., 2009), performing quantitative and qualitative tasks, differentiating between size, object and color, and understanding the concept of zero (Pepperberg, 2009). More recently, researchers have begun to investigate the creative and innovative abilities of animals (Dudzinski et al., 2018; Hill et al., 2022; Kuczaj & Eskelinen, 2014; Lawrence et al., 2016; Lilley et al., 2017; Melzer et al., 2022).

While creativity and innovation are often used interchangeably, Bateson and Martin (2013) argue that there are differences. They define innovation as changing the way something is done while creativity is defined as the ability to produce new ideas (Bateson, 2014; Bateson & Martin, 2013). Furthermore, creativity can be broken down into three main components: fluency, flexibility, and originality (Bateson, 2014; Hill et al., 2022; Kaufman & Kaufman, 2004; Melzer et al., 2022; Torrance, 1972, 1974). Fluency refers to an individual's ability to produce a number of unique ideas, flexibility references an individual's capacity to switch between approaches, and originality references the novelty of ideas produced by an individual (Bateson, 2014; Torrance, 1972, 1974). It should be noted, however, that to be creative one need not to possess all three components, but demonstrate at least one, as creativity is believed to vary across individuals (Bateson, 2014; O'Hearn et al., 2015).

In recent years, many studies on animal innovation have centered around problem-solving, such as the ability to solve novel problems and to produce novel solutions to familiar problems (Manrique et al., 2013; Reader et al., 2016). For example, Manrique et al. (2013) examined innovative problem-solving in different species of captive great apes, including chimpanzees (*Pan troglodytes*), bonobos (*Pan paniscus*), orangutans (*Pongo abelii*), and gorillas (*Gorilla gorilla*). The great apes were given an apparatus with a food reward inside, and if they were able to successfully obtain the food reward 20 times across a maximum of five sessions, they would move on to a slightly different but more difficult apparatus where the previous solution would not work. All species of great apes that were tested were able to successfully obtain the food reward 20 times in all three apparatuses except for the orangutans, who were unable to solve the final puzzle. The great apes illustrated innovation in this task because they were able to abandon old solutions and produce novel solutions to complete a problem.

Foerder et al. (2011) conducted a similar problem-solving experiment with a seven year old Asian elephant (*Elephas maximus*) bull named Kandula. Researchers baited a bamboo branch with fruit on a cable in the elephant yard at the Smithsonian National Zoological Park in Washington, DC. Kandula, who had previous experience with standing on large objects for husbandry behaviors, was provided with a large plastic cube that he typically received for enrichment (Foerder et al., 2011). Kandula demonstrated spontaneous problem-solving by moving the large plastic cube near the bamboo branch and then standing on it to acquire the food (Foerder et al., 2011). Researchers then took the study a step further and provided Kandula with several small objects rather than one large cube. Kandula generalized his use of tools, stacking the smaller objects on top of each other in an attempt to reach the bamboo branch, demonstrating both behavioral flexibility and insightful problem-solving (Foerder et al., 2011).

Other studies have examined the relationship between motor diversity and innovative problem-solving. Benson-Amram and Holekamp (2012) hypothesized that wild spotted hyenas (*Crocuta crocuta*) that use the greatest range of behavioral strategies when confronting a novel problem, such as biting, digging, flipping, pushing/pulling, and investigating the apparatus, were more likely to solve an innovative problem box. They collected 417 trials across 62 individuals, and nine hyenas were able to solve the problem box. Wild hyenas that exhibited more exploratory behaviors on their first trial were significantly more likely to solve the problem box. Additionally, Benson-Amram and Holekamp (2012) found that hyenas were more likely to succeed when individuals were more persistent and less neophobic towards the puzzle box. Benson-Amram and Holekamp (2012) concluded that because the puzzle box required an individual to change their behavior to solve the problem, the task required innovation.

Although there is growing evidence for animal innovation, the literature for animal creativity is scarce. Pryor et al. (1969) first studied the create behavior with two rough-toothed dolphins (*Steno bredanensis*). Pryor et al. (1969) hypothesized that the rough-toothed dolphins would be capable of creativity, therefore, the methodology involved training the dolphins to use their creativity upon request. Trainers conditioned the dolphins to associate a discriminative stimulus (S^D), a concept-oriented cue that signals correct performance of the behavior will be reinforced, with the desired create behavior. The criteria for the create behavior was that an individual must perform a behavior, either within its repertoire or a novel behavior, that they have not performed previously within a training or testing session. Therefore, they should produce a new response each time (Dudzinski et al., 2018; Kuczaj & Eskelinen, 2014; Melzer et al., 2022; Pryor et al., 1969). Both rough-toothed dolphins demonstrated the ability to produce new responses on cue of the S^D (Pryor et al., 1969).

Kuczaj and Eskelinen (2014) replicated this study with three bottlenose dolphins (*Tursiops truncatus*): Alfonz, Kimbit, and Leo. The dolphins differed in the number of behaviors they were able to produce, as Alfonz and Kimbit both reached 15 behaviors while Leo reached 24 behaviors. Hill et al. (2022) also replicated the study with nine killer whales (*Orcinus orca*), the largest member of the oceanic dolphin family. While the killer whales performed mostly low or moderate energy responses, the type of responses performed ranged from motor behaviors to vocalization or combinations of the two (Hill et al., 2022). Overall, the killer whales

varied in the fluency, flexibility, and originality of their responses, suggesting that they too can be creative, much like their rough-toothed and bottlenose dolphin relatives (Hill et al., 2022). Melzer et al. (2022) further replicated the study, implementing a cross-species methodology comparing the creative abilities of bottlenose dolphins and children, finding that once they understood the concept of the task, both children and dolphins were able to produce a number of non-repeated behaviors.

Pryor et al. (1969), Kuczaj and Eskelinen (2014), Hill et al. (2022), and Melzer et al. (2022) demonstrate that dolphins possess the ability to remember which behaviors they have already produced, as not to replicate previously performed behaviors, demonstrating that they can learn to produce novel behaviors as a response. Furthermore, these studies suggest that dolphins may possess different short-term memory capacities, as performances varied between individual dolphins (Kuczaj & Eskelinen, 2014; Pryor et al., 1969).

The current study extended the concept of creativity to domesticated dogs (*Canis lupus familiaris*). Dogs were chosen as subjects based on previous literature that suggests they have the capacity to perform complex problem-solving behaviors (Aria et al., 2021; Bensky et al., 2013; Hare & Ferrans, 2021; Lea & Osthaus, 2018; Marshall-Pescini et al., 2008; Overall, 2011; Rao et al., 2018), are able to use social cues from both humans and conspecifics (Hare et al., 1998; Hare & Ferrans, 2021; Hare & Tomasello, 1999; Miklösi et al., 1998; Pelgrim et al., 2021; Udell et al., 2010), and are able to imitate human actions and sequences, such as transferring objects from one location to another (Topál et al., 2006). Dogs have also demonstrated their ability to use spatial memory in radial arm mazes (Craig et al., 2012) and detour paradigms (Fiset et al., 2007). Border collies in particular have been studied for their ability to learn by exclusion (Kaminski et al., 2004; Pilley & Reid, 2011).

Aside from testing dogs' natural cognitive abilities, dogs have also been tested on their ability to perform trained cognitive tasks. Scagel and Mercado (2022) tested whether dogs could reproduce actions on cue immediately after performing those actions and after a delay. Three domestic dogs were trained to associate a hand gesture and spoken word with the "repeat" behavior (Scagel & Mercado, 2022). They were then tested on their ability to repeat behaviors in four different scenarios: (a) single-repeat testing, (b) delay testing, (c) double-repeat testing, and (d) tests with novel actions and innovated actions (Scagel & Mercado, 2022). The performances of the dogs for repeating behaviors were significant in the first three scenarios, but varied in the final scenario, with dogs repeating some behaviors but not others. The results of this study suggest that dogs are able to acquire an abstract concept of repeating actions and are able to repeat their actions on cue (Scagel & Mercado, 2022).

Based on previous literature on canine cognition, we hypothesized that dogs would perform similarly to bottlenose dolphins, rough-toothed dolphins, and killer whales, and possess the ability to be creative. We also hypothesized that there would be individual variability within their performances.

Method

Subjects and Recruitment

This study was approved by the Eckerd College IACUC (approval #18-SU-03). This study utilized citizen science. Training participants, hereby referred to as trainers, and their dogs ($N = 7$; average age = 4.14 years) were recruited through colleagues and dog training associations (see Table 1). Trainers and their respective dogs were located throughout the world and stayed connected with researchers via an online social media group page. It is important to note that the dogs were pets and not working dogs. Additionally, it is important to note that three of our trainers were professional dog trainers, and another was a marine mammal trainer. Six dogs were owned by their respective trainers, but Brutus was not.

Before training the create behavior, trainers submitted a list of behaviors in their dog's repertoire so that researchers could distinguish between a previously trained behavior and a novel behavior. This research was supported by an Association of Professional Dog Trainers Foundation grant, which allowed researchers to supply trainers with tripods for videotaping and offer a small gift card for their participation in the study.

Table 1*Experimental Subjects. Breed, Age, and Sex*

Name	Breed	Age (years)	Sex
Surfer	Border Collie	1.25	M
Rey	Brittany	1.25	F
Brutus	Beagle Pitbull Mix	6	M
Wellington	Pitbull Boxer Mix	4	M
Spot	Kelpie Labrador Mix	3	M
Gus	American Staffordshire Terrier Mix	4.5	M
Frankie	Pointer Pitbull Mix	9	M

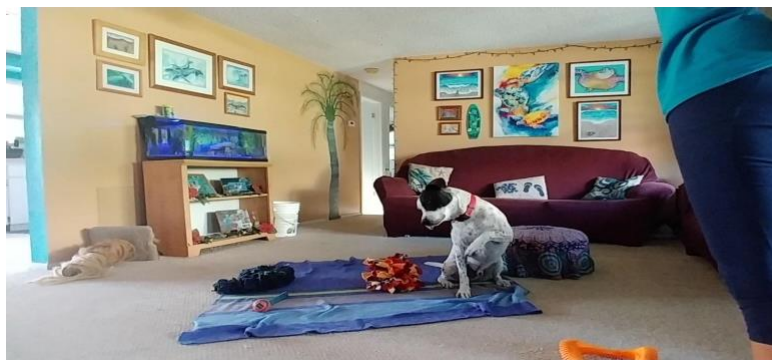
Training Procedure

The training methodology was adapted from Dudzinski et al. (2018). To condition the dogs to a verbal discriminative stimulus (S^D), trainers were instructed to reinforce any presented behavior. Trainers were then instructed to reinforce movements in between behaviors to help the dog understand that the S^D for the create behavior means that the trainer is asking for different responses. Next, trainers were instructed to move around the training environment, as this step encouraged dogs to interact with their environments and incorporate items within the environment into their responses to the create behavior.

The only required criteria for the create behavior was that the behavior offered had not yet been performed during that session. Trainers were instructed to train their dogs using positive reinforcement, such that if a dog incorrectly performed a previous behavior, the owner was instructed to simply ignore the behavior and ask for the create behavior again. Since this study utilized citizen science, prior to beginning the four experimental sessions, trainers videotaped their training sessions and uploaded them to an online social media group page for clarification and monitoring. After review of training sessions, participants were given the go-ahead to continue with experimental sessions if it was evident that the trainer understood the concept of how to train the create behavior.

Analysis

Trainers were asked to complete four experimental sessions. For these sessions, trainers were instructed to ask for the create behavior repeatedly until the dog either performed more than three incorrect (repeated) behaviors consecutively, or the dog lost interest. All experimental sessions were videotaped by the trainer and coded by the research team (see Figure 1).

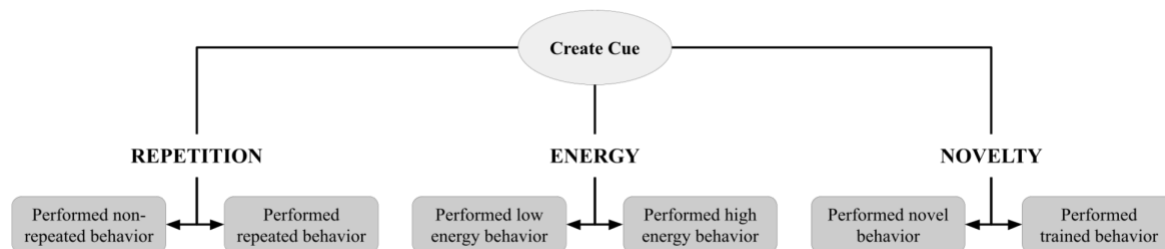
Figure 1*Frankie Offering a Create Behavior*

Note. Screenshot of dog, Frankie, offering a create behavior during a training session. See full video [here](#).

To measure the three components of creativity—fluency, flexibility, and originality—the dogs’ performances were coded on three items: repetition, energy, and novelty (see Figure 2). Repetition captured fluency, as the dogs were required to produce a number of new, non-repeated behaviors. Repetition was coded into either repeated or not repeated. Responses were rated on the amount of energy expended to assess their flexibility between approaches. Energy was coded into either high energy (i.e., involved excessive movement or effort; e.g., jumping, spinning, and rolling over) or low energy (i.e., behaviors that required little to no effort, e.g., giving paw, sitting pretty, and walking). Novelty measured originality, as dogs performed behaviors both previously trained and outside of their repertoire. Novelty was coded into either novel or non-novel. In addition to coding behaviors, researchers also provided a description of the behavior offered by the dog.

Figure 2

Dogs’ Behavior Coded on Three Items: Repetition, Energy, and Novelty



Before conducting statistical analyses, the data were reviewed to confirm that the dogs were asked for the create behavior repeatedly until they either performed more than three incorrect (repeated) behaviors consecutively or lost interest. Both Brutus and Spot did not reach this criterion, as their sessions were not terminated following more than three incorrect behaviors, so their data were not included in further analyses.

Because trainers filmed their dogs across four experimental sessions, the first trial of each session was removed from the repetition analysis, as the dogs could not repeat a behavior on the first trial. However, the first trial of each session was kept for the energy and novelty analyses to measure flexibility and originality. IBM Statistical Package for Social Sciences (SPSS) (SPSS Inc., Chicago, IL 60606, USA) software Version 26 was used to run one-sample binomial tests for each dog individually on repetition, energy, and novelty.

Results

Analysis

A series of one-sample binomial tests were conducted to examine three components: repetition, energy, and novelty (Table 2).

Table 2

One-Sample Binomial Tests

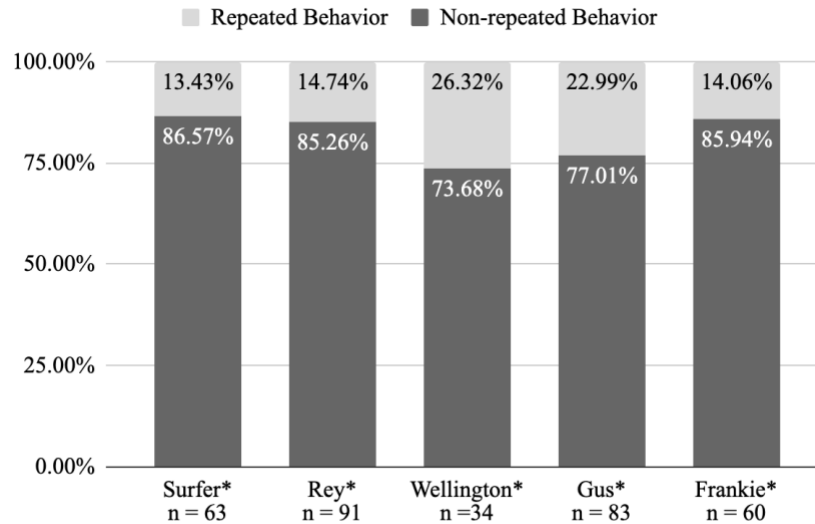
Name	Repetition	Energy	Novelty
Surfer	< .001***	.222	.807
Rey	< .001***	< .001***	.040*
Wellington	.009**	< .001***	.002**
Gus	< .001***	< .001***	.133
Frankie	< .001***	.004**	.061

Note. A series of one-sample binomial tests were conducted to evaluate the repetition, energy and novelty of create responses. Statistically significant differences: * $p < .05$, ** $p < .01$, *** $p < .001$.

All five dogs performed significantly more non-repeated behaviors over the course of their trials (see Figure 3). When asked to perform the create behavior, Surfer performed correctly 54 out of 63 trials (85.71%, $p < .001$). Rey performed correctly 77 out of 91 trials (84.62%, $p < .001$). Wellington performed correctly 24 out of 34 trials (70.59%, $p = .009$). Gus performed correctly 63 out of 83 trials (75.90%, $p < .001$). Frankie performed correctly 51 out of 60 trials (85.00%, $p < .001$). Inter-rater reliability for coding of the repetition variable was 89%.

Figure 3

Percentages of Repeated and Non-Repeated Behavioral Responses of the Five Dogs When Asked to Create

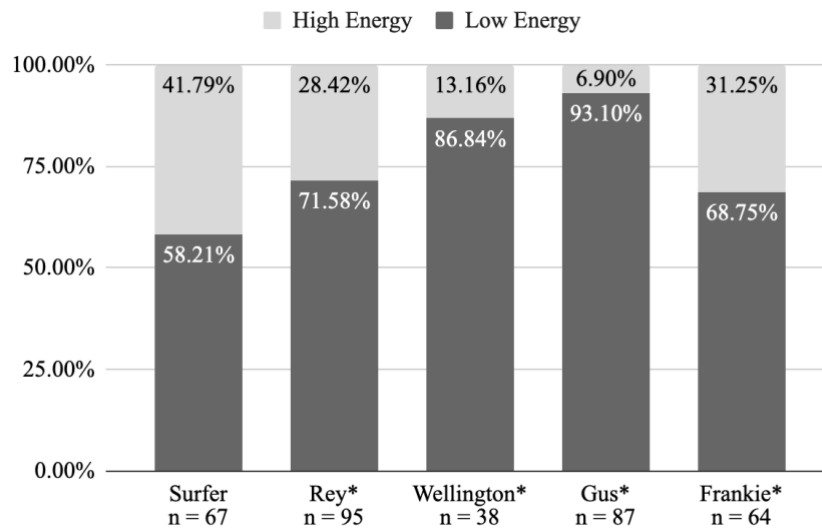


Note. * indicates significant p value ($p < .05$); n = total number of behaviors performed. Because trainers filmed their dogs across four experimental sessions, the first trial of each session was removed from the repetition analysis, as the dogs could not repeat a behavior because they had not previously performed one.

Rey, Wellington, Gus, and Frankie performed significantly more low-energy behaviors (see Figure 4). Rey performed low energy behaviors in 71.58% of her trials ($p < .001$). Wellington performed low-energy behaviors in 86.84% of his trials ($p < .001$). Gus performed low-energy behaviors in 93.10% of his trials ($p < .001$). Frankie performed low-energy behaviors in 68.75% of his trials ($p = .004$). Surfer did not have a preference, performing low-energy behaviors in 58.21% of his trials and high-energy behaviors in 41.79% of his trials ($p = .222$). Inter-rater reliability for coding of the energy variable was 98.15%.

Figure 4

Percentages of Low-Energy and High-Energy Behavioral Responses of the Five Dogs When Asked to Create

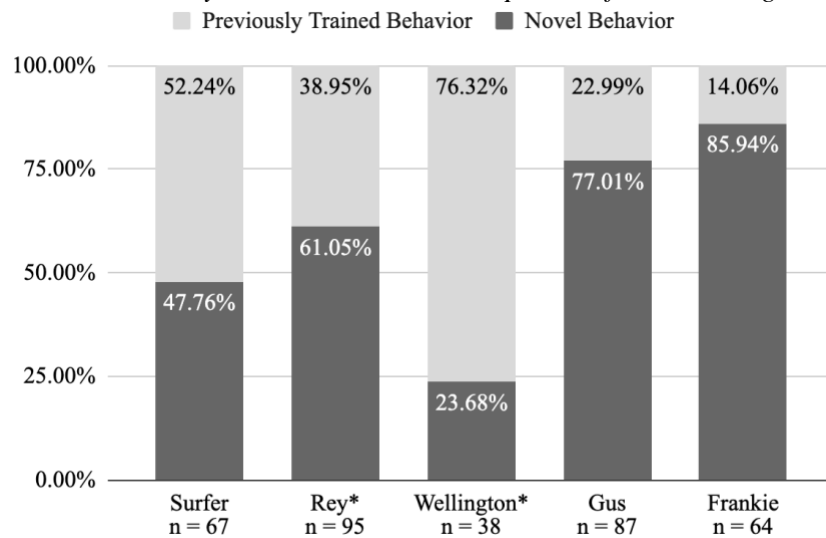


Note. * indicates significant p value ($p < .05$); n = total number of behaviors performed.

The dogs differed in their performances of novel behavior (see Figure 5). Rey performed significantly more novel behaviors (61.05%, $p = .040$), while Wellington performed significantly more previously trained behaviors (76.32%, $p = .002$). Inter-rater reliability for coding of the novelty variable was 88%.

Figure 5

Percentages of Novel and Previously Trained Behavioral Responses of the Five Dogs When Asked to Create



Note. * indicates significant p value ($p < .05$); n = total number of behaviors performed.

Discussion

The Creative Canine

Based on previous literature on canine cognition, we hypothesized that dogs could be trained to perform creatively on cue. The methodology for training the create behavior was adapted from Dudzinski et al. (2018). Participants participated via citizen science, submitting their experimental sessions via an online social media group page. Dogs' performances were coded on repetition, energy, and novelty to measure components of creativity and to capture individual variation.

The only required criteria for the create behavior was that the behavior offered had not yet been performed during that session. Therefore, the measurement of the repetition variable was the most important when testing the dogs' creative performances. All five dogs performed significantly more non-repeated behaviors over the course of their trials, which supports our hypothesis that dogs would perform similarly to bottlenose and rough-toothed dolphins and possess the ability to be creative (Figure 3). The present study demonstrates that dogs possess the ability to remember which behaviors they had already produced, as not to replicate previously performed behaviors, much like the marine mammals in Pryor et al. (1969), Hill et al. (2022), Kuczaj and Eskelinen (2014), and Melzer et al. (2022). The present study also supports the idea that dogs possess behavioral fluency and the ability to produce a number of unique ideas.

Both energy and novelty variables were examined to learn more about the dogs' approaches to the create behavior. It is important to note that all dogs except Surfer performed significantly more low energy behaviors than high energy behaviors, suggesting that those four dogs possessed less behavioral flexibility. Surfer performed just slightly more low energy behaviors than high energy behaviors. This is interesting, as Surfer is a border collie, a breed known for their cognitive abilities, which supports the notion that future studies should compare the creative abilities of different breeds (Kaminski et al., 2004; Pilley & Reid, 2011). This is also interesting as both Melzer et al. (2022) and Kuczaj and Eskelinen (2014) reported that the dolphins performed more low energy behaviors than high energy behaviors.

In terms of novel behaviors, Rey performed significantly more novel behaviors while Wellington performed significantly more previously trained behaviors. The other three dogs also varied on if they performed novel or previously trained behaviors, but none reached significance. However, it is important to note that there were differences in how many previously trained behaviors were in the dogs' repertoires, as that could be a confound to the dogs' ability to offer novel behaviors (number of behaviors in repertoires: Rey = 12, Wellington = 15, Frankie = 18, Surfer = 24, Gus = 31).

Furthermore, the results of this study suggest that the variations in all three variables, repetition, energy, and novelty demonstrate that dogs possess different capacities to produce novel ideas, supporting our hypothesis that there would be individual variability within the dogs' performances and approaches.

Implications

The present study contributes to the knowledge of animal recall based on internal stimuli, as the dogs were required to remember which behaviors they had previously performed so as to not repeat a behavior. As discussed in Scagel and Mercado (2022), few studies have examined animal memory of internal stimuli, but instead have focused on animals' ability to recall external stimuli, such as delayed match-to-sample (Lind et al., 2015) or spatial memory tasks (Bond et al., 1981; Craig et al., 2012, Fiset et al., 2007). However, studying animals' capacity to remember internal stimuli, such as their own actions, contributes to our understanding of how they cognize events (Scagel & Mercado, 2022).

Practically speaking, studying canine cognition has direct implications for working dogs. From guide dogs to detector dogs to therapy dogs, cognition is believed to be the secret to working dog success (Bray et al., 2021; Hall et al., 2021; Hare & Ferrans, 2021). Therefore, it is important to learn more about a dog's ability to successfully perform trained cognitive tasks. In the future, we would like to extend the use of the create behavior to complex problem-solving tasks. Dogs can often lose motivation when stuck on a task (Rao et al., 2018), so we hypothesize that dogs who have been trained on the create behavior can be prompted to “create” and develop new, creative approaches to solving the task compared to dogs not trained on the create behavior. Since the actions performed by working dogs are often completed with a specific purpose, creative responses could also be evaluated for their appropriateness, as appropriateness is a component of creativity in means-to-end tasks (Mitchell, 2015; Sternberg & Lubart, 1999).

Additionally, since working dogs are often selected based on set behavioral criteria (Bray et al., 2021; Burghardt, 2003), future studies could correlate personality traits with create performances to identify individuals with the most potential for cognitive success, similarly to how Curb et al. (2013) created surveys to match dog and dog-owner personalities to improve pet-ownership satisfaction. Both of these proposed future studies could be especially useful when choosing and training working dogs, as they are often in high risk situations with little room for error.

Overall, this study contributes to the literature on animal creativity and demonstrates that dogs are capable of being fluent in their production of new behaviors and that there are individual variations in dogs' abilities to perform flexibly and originally. This study also contributes to the literature that supports the movement toward citizen science (Stewart et al., 2015).

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