



Preliminary investigation into personality and effectiveness of livestock guarding dogs in Namibia



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ABSTRACT

Livestock guarding dogs (LGDs) are used all over the world to help in carnivore conservation by mitigating human-wildlife conflict. In Namibia, LGDs are used in cheetah conservation to prevent depredation of stock and reduce retaliatory killings. However, behavioral problems in the dogs, such as chasing wildlife and harassing livestock, exist leading to poor dog performance and farmer dissatisfaction. In most other types of working dogs, behavior tests for suitability are reported and/or validated within the scientific literature. To date this has not been done for LGDs. In this paper, we design a composite behavioral test and a questionnaire to rate the dogs' effectiveness as an LGD. This test was used on 14 LGDs, 7 of which were operational and 7 of which were being used as breeding stock. In total, 16 behavioral variables were measured. A Principal Components Analysis reduced these to 5 underlying personality traits: "Playfulness," "Trainability," "Independence," "Sociability with people" and "Reactivity." When 14 dogs were tested 3 times, 20 days apart, the traits "Playfulness," "Trainability" and "Independence" were found to be consistent. "Trainability" was negatively correlated to dog age. Dogs with a higher "Trainability" and lower "Reactivity" showed a tendency to be rated as more effective by their herdsman. Dogs scoring higher for "Playfulness" were more likely to be reported to harass stock, and dogs that chased a moving object under experimental conditions were generally rated higher for tendency to chase predator wildlife when working. This study suggests that there are personality attributes which can be measured and are consistent across time in LGDs. Several of these are linked to better performance in trained dogs. Whether these are predictive of later performance in untrained dogs, is yet to be ascertained.

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Introduction

Human-wildlife conflict is an ancient phenomenon and is becoming more widespread as the human-wildlife interface is increasing, especially for agricultural land (Graham et al., 2005; Woodroffe et al., 2005). Livestock predation is a source of conflict all over the world, where the farmers rely on livestock for their economic income (Ogada et al., 2003). This predation often leads to retaliatory killing of predators by farmers, which, in areas where predators are threatened, can have conservation implications (Meriggi and Lovari, 1996; Marker et al., 2005). A

strong relationship has been reported between levels of livestock depredation and retaliatory killing of predators (Ogada et al., 2003; Shivik et al., 2003). In Namibia, farmers still legally kill cheetahs (*Acinonyx jubatus*) and other predators if people or livestock are in danger (Marker et al., 2018).

Livestock guarding dogs (LGDs) are an ancient tool that have been used for thousands of years, originating in Europe and Asia (Gehring et al., 2010). LGDs are raised with domesticated livestock and employed to guard the flock or herd from predation. Some work accompanying a human herder, while others live alone with the flock. The Cheetah Conservation Fund (CCF) in Namibia, began a LGD program in 1994, using Anatolian shepherd and Kangal dogs, with the aim of enabling farmers to coexist with wildlife on their land, without retaliatory killing (Marker et al., 2005). These dogs have been shown to be effective at reducing predation, with nearly 75% of Namibian farmers reporting a decrease in livestock losses

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after obtaining an LGD (Marker et al., 2005). Farmers are generally highly satisfied with the performance of their LGD (Potgieter et al., 2013) and hence there has been a reduction in retaliatory killing of cheetahs (Marker et al., 2005). There is, however, a high prevalence of behavioral problems in LGDs with over 90% of dogs being reported as having had a problem at some time in their working life (Marker et al., 2005). The most common problems reported are chasing wildlife, harassing stock, and staying at home instead of going out with the herd (Marker et al., 2005; Potgieter et al., 2015). These behavioral problems could lower the farmer's satisfaction and trust in their dog, which could potentially result in increased retaliatory killings of wildlife (Potgieter et al., 2013). They may also have other welfare implications, such as reducing safety for the dog and livestock, and further conservation implications, if the dog attacks endangered species. Previous studies have noted these problems, but research has not yet investigated their causation. Understanding methods to mitigate such problems is integral to optimizing dog performance (Marker et al., 2005; Potgieter et al., 2013).

Behavioral responses expressed by an animal are a result of their current living environment and past experiences, but also their individual personality (Svartberg and Forkman, 2002). Definitions of personality differ, but here we define personality as individual differences in behavior that are consistent across time and context (Wolf and Wessing, 2012). For many different working dog roles, research has found that variations in personality are associated with differences in performance (e.g., Goddard and Beilharz, 1986; Marker et al., 2005; Maejima et al., 2007; Sinn et al., 2010). Behavioral tests are now commonly used to select dogs and breeding stock for numerous working roles (Sinn et al., 2010) including military dogs (Rooney et al., 2007), police dogs (Wilsson and Sundgren, 1997; Slabbert and Odendaal, 1999) and guide dogs (Asher et al., 2013). To ensure a test is useful, its efficacy must be assessed. Empirical studies have started to ascertain if existing dog behavior tests are reliable by checking for test-retest consistency (Diederich and Giffroy, 2006) and valid by assessing how well they correlate with the outcome measure (Jones and Gosling, 2005). Coppinger and Coppinger (1980) suggested that the traits “protectiveness,” “attentiveness,” and “trustworthiness” as important in LGDs. There is potential value in designing a behavioral test to identify how these and other traits are linked to success in LGDs.

This study sought to identify those personality attributes deemed to be most important for LGDs and to develop a behavioral test to measure these attributes. We explored whether the traits were reliable over repeated tests and whether they varied with age and sex of dog. We tested validity by determining whether specific personality traits were more prevalent in more effective LGDs, compared with less effective ones. We also examined 2 potential problematic attributes which were commonly reported by farmers: chasing wildlife and harassing the livestock through play behavior while working or when housed in the enclosure or “kraal” with the stock (Marker et al., 2005; Potgieter et al., 2015).

Previous studies of the behavior of multiple pet dog breeds have found the measured traits “chase” and “play” are positively correlated with playful “chasing” and “human-directed play interest” when rated in an owner questionnaire (Svartberg, 2005b). Understanding the development of these behavior patterns in LGD may help to reduce the number of dogs with behavioral problems, thereby maintaining the farmers' high satisfaction with their dogs. We tested the hypotheses that:

- a) Important aspects of personality of a LGD can be measured via a behavioral test;
- b) Personality traits will be consistent over repeated testing;
- c) Personality traits will vary with age and sex;

d) Performance as a LGD will correlate with measurable aspects of personality:

- i) Dogs that are more playful will more likely have behavioral problems such as chasing prey or harassing stock.
- ii) Dogs with a higher motivation to chase an object will be more likely to chase wildlife when out working.

Methods

Subjects

The subjects were 14 Anatolian shepherds (4 males, 10 females) housed at the Cheetah Conservation Fund (CCF) in Namibia (Table 1). They were ambassador dogs working at CCF Namibia, which are used to demonstrate to local farmer show a LGD should behave. These dogs regularly spend full days out with the live stock and herder, protecting them from predators. The organization has both working and breeding dogs, belonging to the same genetic pool. Seven of the dogs were working, and 7 were used for breeding. Of the 7 breeding dogs, 1 was also currently a working dog, while the remaining 6 were ex-working dogs.

All dogs were kept in the same kennel establishment, but working dogs spent the full day out with the stock and the herder approximately once a week. Breeding dogs were kept in kennel and walked usually daily for approximately half an hour by staff and volunteers. On the days when the working dogs were not out with the stock, they were not usually walked. This was believed to be best practice to avoid having them become too human-oriented. None of the dogs had any formalized obedience training, although farmers rearing the dogs were given information about optimal rearing protocols and behaviors to expect to see at each stage of development.

Behavioral tests

The behavioral test was designed following a literature review of LGDs and based on input from academic experts in the working dog field during a workshop. Tests were designed to measure aspects of “protectiveness,” “attentiveness,” and “trustworthiness,” previously suggested as important traits in LGDs (Coppinger and Coppinger, 1980) and other desirable and undesirable behaviors described in the literature (Marker et al., 2005). A list of behavioral attributes was compiled, and a subtest was designed to measure each.

Overall, the test consisted of 8 separate subtests, and was carried out in the same room at the Cheetah Conservation Centre, approximately 55m² in size. This room was unfamiliar to most of the dogs; however, 1 dog had been in it before. The room layout was kept identical for all tests. The test was performed 3 times, to test for test-retest reliability, with a gap of 10 days between each test. The subtests 2–7 were completed in this order and repeated on all 3 testing occasions. The subtest *meeting a new person* was performed on a separate occasion before the other tests and only performed twice (in test 1 and 2), due to limitations in finding new novel people. All subtests were filmed using a GoPro camera, which was mounted in a same corner of the room for all tests. Behavior during each subtest was scored from video using the scoring system reported in Table 2.

Meeting a new person

A familiar person collected the dog from its kennel and walked it on a leash to approach the novel person who was standing in the testing room. In test 1, the familiar person was the Dog Manager at CCF and the novel person was the Test Leader (TL). In test 2, the familiar person was the TL, and the novel person was a new

Table 1
Sample of dogs used for the study

Dog ID	Dog name	DOB	Dog age in years at time of test	Sex	Used for both working and breeding	Usage at time of test
1	Aleya	05/07/2010	7	F	Yes	Working
2	Sheperd	14/06/2015	3	M	No	Working
3	Spots	17/12/2007	10	M	No	Working
4	Karibib	10/02/2010	8	F	No	Breeding
5	Susie	11/11/2015	2	F	No	Breeding
6	Lady	10/09/2012	5	F	No	Breeding
7	Bolt	20/05/2016	2	M	No	Breeding
8	Repet	11/04/2013	5	F	Yes	Working
9	Firat	31/08/2010	7	M	No	Breeding
10	Kiri	10/02/2010	8	F	No	Breeding
11	April	01/08/2017	10 months	F	Yes	Working
12	Taya	17/02/2013	5	F	Yes	Working
13	Tika	08/08/2017	10 months	F	Yes	Working
14	Hediye	05/03/2009	9	F	No	Retired

volunteer. The dog was kept on its leash, but the handler allowed the dog to explore and to greet the person as they chose (modified from [Svarberg and Forkman, 2002](#)). The novel person interacted with the dog if it approached, however the novel person did not call the dog, or actively encourage it to interact. We measured the time the dog spent close to (<50cm) the novel person out of a maximum of 5 minutes ([Table 2](#)).

Open field test

The dog was unleashed and allowed to roam the testing room for 5 minutes. We measured the time spent “exploring” which was defined as the dog either walking around the room, or if stationary, sniffing.

Obedience test

The TL called the dog to them and asked it to sit. This was done straight after the open field test, when the dog was at least 4m away and focusing on something else. Both the keenness to respond to the call and whether they sat and it so how quickly were recorded.

Target training

The TL attempted to teach the dog to associate touching a wooden spoon with its nose to receiving a treat over a 5-minute period (modified from [Rooney and Cowan, 2011](#)). None of the dogs had previous experience with target training. The TL placed the spoon down, and if the dog touched the spoon with its nose, it received a treat. The dog was scored on 4 aspects: how interested it was in the task, the extent to which it learned the task (number of times touched/total number of time spoon was presented), the total number of times it touched the wooden spoon, and the latency to touch the wooden spoon each time it was placed down by the TL.

Novel object test

The TL placed a motorized child’s toy (Chuckle Ball™) approximately 1m from the dog and turned it on. After 20 seconds, the toy automatically turned off, was removed and placed out of sight and reach from the dog. If a dog showed any signs of extreme fear or stress (as described in [Rooney et al., 2016](#)), the test would have been stopped. The dog was scored on 4 aspects: level of startle, time interacting with object, time with TL (within approximately 1 m) and interest in object.

Play test

This consisted of 3 components: play with TL (without a toy), play with a rope and with a ball. The play with TL (without a toy) involved the TL enticing the dog to chase her, the play with a rope

involved the TL encouraging “tug of war” with the dog, and the play with the ball involved the TL throwing the ball for the dog. In each case, the TL encouraged the dog to play using movement and vocalizations for approximately 30 seconds. The dog was rated for its engagement in play behavior with the person, the rope and the ball ([Table 2](#)).

Chase

A rag was attached to a long string and dragged back and forth in front of the dog by the TL, then dragged away from the dog (modified from [Svarberg and Forkman, 2002](#)). The dog was scored on whether it followed the fleeing object and for how long.

Performance rating

A questionnaire was designed to score relative performance of the dog as an LGD. It was only used for the 7 current working dogs. The components of performance in the questionnaire were chosen after an extensive literature review on LGDs and speaking to those who regularly work LGDs. The dogs’ attributes were:

1. Responsiveness to herder’s commands
2. Likelihood of remaining close to herd
3. Bond to stock
4. Likelihood of remaining close to herder
5. Level of vigilance to the environment
6. Confidence when out working
7. Activity level when out working
8. Likelihood of barking if detecting a predator
9. Tendency to play with stock when out working
10. Tendency to play with stock in kraal
11. Tendency to chase prey wildlife
12. Tendency to chase predator wildlife
13. Tendency to play with people
14. Ability to learn from being rewarded.

Each trait was rated on a score from 1–5, with 1 being very low and 5 being very high. Ratings were made by CCF’s small stock herder and Livestock Guarding Dog handler who has worked for CCF for over 20 years, and with livestock guarding dogs for over 50 years. Since 1996, he has helped raise and worked all CCF’s dogs. He was therefore very familiar with all the subject dogs. The questionnaire was delivered and scored verbally using a translator. The herder first rated the ideal LGD for each of the attributes, and he then rated the 7 current working dogs for each attribute. Since the herder was likely unfamiliar with the dogs’ behavior in the kraal, the Dog Manager rated attribute 10. The herder ranked all dogs identically for 7 of the traits (bond to stock, likelihood of remaining close to herder, level of vigilance to the environment, con-

Table 2
Scoring used for each of the 16 variables in the 7 different behavioral sub-tests

Sub-test	Variable	Score	Description
Meeting a new person	Time with novel person	1	Dog does not approach person, ignores greeting, for whole duration (0%)
		2	Dog approaches and stays in close proximity (<50cm) or touching of person for <25% of duration
		3	Dog approaches and stays in close proximity (<50cm) for 25%-90% of duration
		4	Dog approaches and stays in close proximity (<50cm) or touching for >90% of duration
		5	Dog approaches immediately and stays in close proximity (<50cm) or touching for whole duration (100%)
Open field test	Time spent exploring	1	Dog spends 0%-10% time spent exploring
		2	Dog spends >10%-20% time spent exploring
		3	Dog spends >20%-30% time spent exploring
		4	Dog spends >30%-40% time spent exploring
		5	Dog spends >40%-50% time spent exploring
		6	Dog spends >50%-60% time spent exploring
		7	Dog spends >60%-70% time spent exploring
		8	Dog spends >70%-80% time spent exploring
		9	Dog spends >80%-90% time spent exploring
		10	Dog spends >90%-100% time spent exploring
Obedience	Keeness of response	1	Dog ignores command and does not come
		2	Dog hesitates and the command has to be repeated and then comes at any gait
		3	Dog walks over straight away
		4	Dog trots over straight away
		5	Dog runs over straight away
	Speed to sit	1	Dog does not sit
		2	Dog sits after being asked several times or needs a treat
		3	Dog sits first time asked
Target training	Level of interest	1	Dog pays attention to the task for <30 s
		2	Dog pays attention to the task for 30-150 s
		3	Dog pays attention to the task for >150-299 s
		4	Dog pays attention for 300 s
	Performance	1	Number of times touches/total number of time spoon is presented = 0%
		2	Number of times touches/total number of time spoon is presented 1%-75%
		3	Number of times touches/total number of time spoon is presented >75%
		4	Number of times touches/total number of time spoon is presented = 100%
	Number of touches		Number of times the dog contacts the wooden spoon in the 5-minute period
		Latency to touch	Average time taken for the dog to first touch the wooden spoon from when the TL puts it down asking the dog to touch it (in secs)
Novel object test	Extent of startle	1	Dog does not run away from object
		2	Dog hesitates for >15 s, before running away from object
		3	Dog hesitates for 5-15 s, then runs away from object
		4	Dog hesitates for <5 s, then runs away from object
		5	Dog instantly runs away from object
	Interaction with object	1	Dog does not approach or interact with the object
		2	Dog approaches to within 1m of object for <10 s, but does not interact with it
		3	Dog approaches to within 1m of object for ≥10 s, but does not interact with it
		4	Dog approaches within 1m of object and interacts with it for <20 s
		5	Dog approaches within 1m of object and interacts with it for ≥20 s
	Time with TL	1	Dog does not go to TL
		2	Dog spends <10 s with TL
		3	Dog spends 10-19 s with TL
		4	Dog spends 20 s with TL
		5	Dog spends 20 s with TL
Interest in object	1	Dog ignores object	
	2	Dog watches object for <10 s	
	3	Dog watches object for 10-19 s	
	4	Dog watches object for 20 s	
	5	Dog watches object for 20 s and even after removed	
Play	Playfulness with person	1	Dog ignores play attempts
		2	Dog walks after TL to play
		3	Dog trots after TL to play
		4	Dog shows playful running or gamboling behavior
		5	Dog shows playful running or gamboling behavior
	Playfulness with rope	1	Dog ignores play attempts
		2	Dog watches for <10 s
		3	Dog watches for ≥10 s
		4	Dog watches and uses paws to grab rope
		5	Dog watches and tries to grab rope with mouth
	Playfulness with ball	1	Dog doesn't follow ball
		2	Dog follows ball, but doesn't pick up with mouth
		3	Dog follows ball and picks up with mouth
		4	Dog follows ball and picks up with mouth
		5	Dog follows ball and picks up with mouth
Chase	Reaction to fleeing object	1	Dog ignores object
		2	Dog watches but doesn't follow
		3	Dog follows for <10 s
		4	Dog follows for ≥10 s
		5	Dog follows and uses paws or tries to grab with mouth

Table 3
Loading factors of each variable onto the 5 components derived from Principal Components Analysis which jointly explained 75% of the variance

Sub-test	Variable	Factor 1 Playfulness	Factor 2 Trainability	Factor 3 Independence	Factor 4 Sociability with people	Factor 5 Reactivity
Meeting a new person	Time with novel person	-0.002	0.096	0.13	0.923	0.081
Open field test	Time spent exploring	0.237	-0.106	0.442	0.193	0.194
Obedience	Keeness of response	0.414	0.313	0.035	0.19	0.539
	Speed to sit	0.066	0.499	-0.412	-0.355	0.435
Target training	Level of interest	0.029	0.326	-0.747	0.278	0.05
	Performance	0.102	0.927	-0.098	0.066	0.047
	Number of touches	-0.223	0.822	-0.282	0.043	-0.133
	Latency to touch	-0.067	-0.949	0.096	0.004	0.069
Novel ob-ject test	Extent of startle	-0.121	-0.319	0.244	0.174	0.755
	Interaction with object	0.781	0.037	0.005	0.286	-0.217
	Time with TL	0.209	0.096	-0.766	-0.318	-0.126
Playfulness with person	Interest in object	0.814	-0.268	-0.255	0.012	0.179
	Playfulness with person	0.57	-0.077	-0.016	0.452	0.382
	Playfulness with rope	0.889	0.07	-0.103	-0.046	0.156
	Playfulness with ball	0.819	0.254	0.295	-0.13	-0.18
Chase	Reaction to fleeing object	0.776	-0.014	0.028	-0.067	0.081

The key variables are bold, which represent all those with at least half the maximum loading factors for that component in a positive or negative direction.

Table 4
Reliability analysis using Cronbach's alpha on the 5 personality traits over the 3 tests over 20 days

Trait	Cronbach's alpha
Playfulness	0.938
Trainability	0.722
Independence	0.823
Sociability with people	0.150
Reactivity	0.653

Bold denotes traits showing high levels of consistency.

confidence when out working, likelihood of dog barking if detecting a predator, tendency to play with stock when out working, tendency to chase prey wildlife). Therefore, these attributes did not reflect variation and were not used further in the study. For the remaining attributes, the discrepancy was calculated between the ideal dog score and each individual dog for each attribute, and these were summed to give an overall discrepancy.

$$\text{Overall discrepancy} = \sum \sqrt{(\text{Perfect dog score} - \text{individual dog's score for trait } x)^2} \text{ (Rooney et al., 2007)}$$

The herder was also asked to rank the dogs in order of working ability, from 1-7 (1 = most effective, 7 = least effective). The discrepancy scores were ranked from least to most (1-7) and added to the herder's rankings to obtain a composite performance score. Before the addition, both ranked scores were inverted to ensure that a higher performance score meant a higher performing dog.

$$\text{Composite performance score} = \left(\frac{\text{Overall discrepancy scores}}{\text{ranked and inverted}} \right) + \left(\frac{\text{Herder's effectiveness}}{\text{ranking inverted}} \right)$$

Behavioral analysis

From the video recording of the 7 subtests, 16 variables were scored (Table 2). Since LGDs are a distinct and unusual population of dogs, it was not possible to use scoring systems devised for other populations, as that would have resulted in all scores being clustered at 1 end of the scale, with consequently very little

variation. Therefore, we used the recorded tests to devise scoring systems for each variable that were meaningful, reproducible and reflected the variation in the population. We used histograms to inspect the data and examination of percentiles, aiming to have an approximately even spread of dogs across each point on the scale. Most traits were scored on a scale of 1-5, but for a minority 3 point or ten points scales were deemed more appropriate.

Statistical analysis

All data was analyzed using SPSS 24.0 (SPSS, inc.).

Identification of personality attributes

Principal Component Analysis with Varimax rotation was performed on the 16 variables to identify the underlying personality traits in the 14 dogs. All 3 tests were included, so there were 42 lines of data. Kaiser-Meyer-Olkin Measure (KMO) for sampling adequacy was checked and all components with eigenvalue >1 were retained. The key variables, which had a loading factor greater than half of the maximum for that component, were examined (Rooney and Bradshaw, 2003). Standardized factor scores were extracted in SPSS and used for further analysis.

Examination of trait consistency over time and variation with age and sex

We used Cronbach's Alpha to test for test-retest reliability between the 3 tests for each of the extracted Principal Component score. Cronbach's Alpha values >0.7 were considered to have high consistency (Nunnally, 1978). We used Mann Whitney U tests to compare each component between male and female subjects and Spearman Rank correlations to explore associations with age.

Examination of whether performance as a LGD correlates with measurable aspects of personality

Spearman's rank correlations tested for associations between the composite performance score and each of the personality traits. A Spearman's rank correlation was also used between the behavioral subtest play and the questionnaire attribute "tendency to play with stock in kraal" and between the behavioral subtest chase and the questionnaire attributes "tendency to chase prey wildlife" and "tendency to chase predator wildlife."

Table 5
Variation between dogs in the herder's ratings for each of the retained performance attributes

Questionnaire attributes	Ideal dog score	Lower percentile	Median	Upper percentile
Responsiveness to herder's commands	5.0	5.0	5.0	5.0
Likelihood of remaining close to herd	4.0	5.0	5.0	5.0
Activity level when out working	5.0	4.0	4.0	5.0
Tendency to play with stock in kraal	1.0	1.5	2.0	3.0
Tendency to chase predator wildlife	4.0	3.0	4.0	4.5
Tendency to play with people	1.0	3.5	4.0	4.5
Ability to learn from being rewarded	3.0	1.0	1.0	1.0

Results

Identification of personality attributes

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.64, ($P < 0.001$), suggesting the data were adequate. The PCA resulted in 5 components with eigenvalues >1 , which together explained 75% of the variance in the data (Table 3).

All the 16 subtest variables were present in at least 1 of the 5 components. When named according to their composite variables these were labeled: "Playfulness," "Trainability," "Independence," "Sociability with People" and "Reactivity." "Playfulness" explained 26.1% of the variance and was composed of 6 key variables all describing high levels of playful interaction with a novel object, people and fleeing objects. "Trainability" explained 22.7% of the variance in the data and included high performance, high frequency and short latency to touch an object during target training, as well as a high speed to sit in the obedience subtest. "Independence" explained 1.8% of variance and dogs scoring highly, generally showed little interest in the target training, and spent little time with the test leader during the novel object subtest. "Sociability with people" explained 1.3% of data variance and had only 1 key variable: time with a new person. Finally, "Reactivity" explained 1.1% of variance and the highest contributing variables were the extent of startle to the novel object and keenness of response to in the obedience subtest.

Examination of trait consistency over time and variation with age and sex

Cronbach's alpha tests revealed that 3 traits ("Playfulness," "Trainability" and "Independence") had significant (>0.7) consistency (Nunnally, 1978) in the 3 tests over 20 days, whilst "Sociability with People" and "Reactivity" did not (Table 4). No traits differed significantly between the sexes ($MWU < 0.29$, $P > 0.30$), but "Trainability" ($Rho = -0.66$, $P = 0.01$) was seen to decrease significantly with age, whilst "Playfulness," exhibited a similar but non-significant tendency ($Rho = -0.45$, $P = 0.105$).

Examination of whether performance as a LGD correlates with measurable aspects of personality

Composite performance score and personality traits

Although all dogs were scored identically for 7 of the 14 questionnaire attributes, the remaining 7 attributes showed variation (Table 5). No significant correlations were found between the composite performance scores (derived from the herder's ratings) and any of the 5 traits measured during the behavioral test, however 2 traits were significant at the 10% level: "Trainability" ($r_s = 0.741$, $P = 0.057$) and "Reactivity" ($r_s = -0.704$, $P = 0.077$; Table 6 and Figure 1).

Table 6

Spearman's rank correlation between the performance score and each of the 5 personality traits

Trait	r_s	P value
Playfulness	0.482	0.274
Trainability	0.741	0.057
Independence	0.185	0.691
Sociability with people	-0.037	0.937
Reactivity	-0.704	0.077

Bold indicates significant at 10%.

Behavioral problems and subtests play and chase

There was a significant correlation between the questionnaire attribute "Tendency to play with stock in kraal" and the measured variable *play with person* ($r_s = 0.821$, $P = 0.024$), but not *play with rope* ($r_s = 0.519$, $P = 0.232$) or *play with ball* ($r_s = 0.184$, $P = 0.692$). When comparing the behavior during the subtest *chase* to the questionnaire attribute "Tendency to chase predator wildlife" a significant correlation was found ($r_s = 0.755$, $P = 0.050$). The attribute "Tendency to chase prey wildlife" had no variation so was not used.

Discussion

Although only trailed on a small sample of dogs, the behavioral test described here shows potential for quantifying traits important in a livestock guarding dog (LGD).

Identification of personality attributes

Five personality traits were identified in this study: "Playfulness," "Trainability," "Independence," "Sociability with people," and "Reactivity."

The traits playfulness and sociability have been found in many studies of personality in the domestic dog (Svartberg and Forkman, 2002; Barnard et al., 2017; Turcsan et al., 2018). Other studies have found chase-proneness to be a trait of its own (Svartberg and Forkman, 2002; Arata et al., 2014); however, in the current study the variables from the *chase* subtest aligned in the trait "Playfulness," while playfulness with person also contributed to both "Sociability with people" and "Reactivity." "Playfulness," although consistent between tests, unsurprisingly showed a tendency to decrease with age of dog, but this was not significant.

Aggressiveness has been identified as a trait in previous studies (Svartberg and Forkman, 2002; Foyer et al., 2014), but was not in the current study. Only 1 subtest, the *novel object*, was likely to elicit an aggressive reaction, and no dogs behaved in an aggressive manner towards it. This was unsurprising, as the breed is renowned for low aggression levels. Some dogs showed a startle response towards this object, and these responses were clustered with the variables from the obedience subtest in the PCA and aligned in the component "Reactivity." This association between dogs that reacted with a startle to a moving object and showed

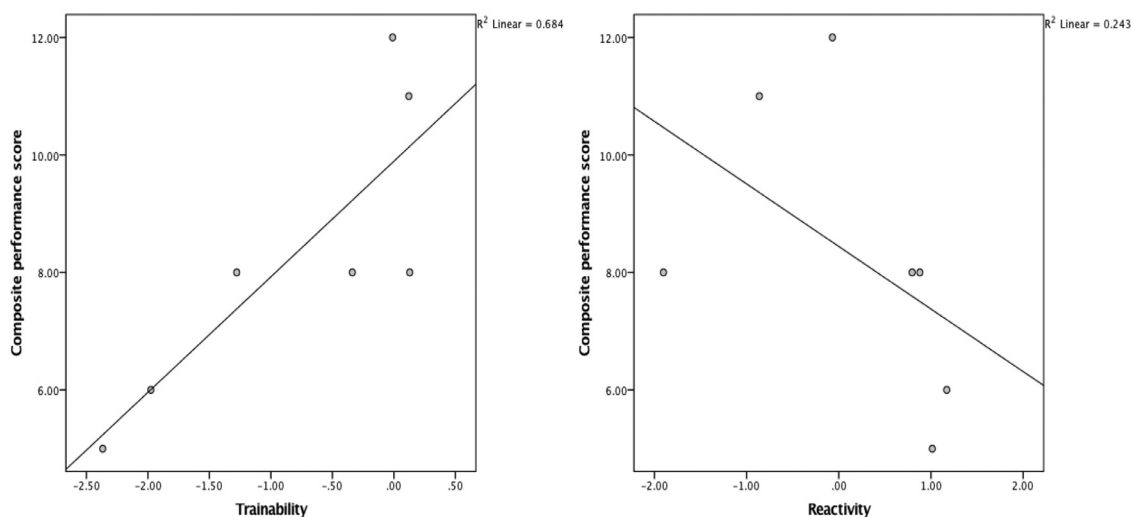


Figure 1. Correlation between the overall performance score and the personality traits, “Trainability” ($r_s = -0.741$, $P = 0.057$) and “Reactivity” ($r_s = -0.704$, $P = 0.077$).

more obedient responses when called, and when asked to sit is not intuitive. We suggest it may signify alert and reactive dogs, but since the component only explained 1.1% of the variance it's unclear if this finding is useful.

LGDs are required to be independent from people, as they must work and live with the herd without human instruction (van Bommel, 2010). These breeds of dogs are selected as they are commonly believed to show high levels of independence, so the trait “Independence” which described dogs which did not spend time with the tester or show interest in target training, is potentially important. Previous studies have similarly classified sociability and independence as 2 separate traits (Turcsan et al., 2018). Turcsan et al. (2018) found independence to have a high loading for activity, but we found “Independence” to have a high loading for exploratory behavior. It would be valuable to have future large-scale studies to help confirm the composition and value of these traits.

Examination of trait consistency over time and variation with age and sex

Three of the 5 personality traits were found to be consistent over a 20-day period: “Playfulness,” “Trainability” and “Independence” indicating that the underlying traits showed repeatability when tested several times over this period (Svartberg et al., 2005a). One study reported the traits playfulness, chase-proneness and sociability to be consistent over tests also with a gap of 20 days (Svartberg et al., 2005a), yet Sinn et al. (2010) found low consistency in the longer-term (30–150 days). We recommend testing for long-term (beyond 20 days) consistency in our traits in future studies. The trait “Sociability with people” was not consistent over the 20 days. The key variable in this component was from the *meeting a new person* subtest which was only performed twice, not 3 times as was the case for other studies and in each test a different unfamiliar person was used. Hence, this may not have been viewed by the dogs as true repeated test.

The trait “Reactivity” was similarly not consistent. This may be because it contained a high loading of the variable *novel object: startle response*. Some of the dogs may have become habituated to the object over time and hence their reaction waned rather than being consistent, and overall, the mean “Reactivity” scores decreased slightly over the 3 tests. This pattern has also been found in other studies when using the same novel object over repeated tests (Turcsan et al., 2018).

Examination of whether performance as a LGD correlates with measurable aspects of personality

Composite performance score

The herder scored all 7 dogs the same on half of the questionnaire attributes, and for all but 1 attribute (“tendency to chase prey wildlife”), this was the same as his rating for the ideal dog, suggesting he saw all 7 dogs as performing perfectly for 6 of the 14 attributes of the role. The dogs studied are used as CCF working ambassadors, to demonstrate model behavior to local farmers, and they may be better behaved than the general LGD population. However, since there was variation for 7 of the questionnaire attributes, there is room for improvement for some of the dogs.

Composite performance score and personality traits

We found that dogs scoring higher for the “Trainability” trait tended to be rated as more effective as an LGD ($P = 0.057$). Trainability has never been thought to be important in LGDs. Their early rearing is being placed with the stock at 3–4 weeks of age, in order for them to bond to the stock. This teaches the dogs to stay with the stock (Smith et al., 2000), and they do not receive any formal training. However, the correlation between behavior during a basic training task and rated performance as a LGD suggests an aptitude for training may be a desirable trait. Dogs with higher “Trainability” may be more likely to listen to the herder, as they are more motivated to work with people, in turn making them better dogs in the herder's eyes. Scoring was predominantly done by the very experienced herder, so reflects what he believes to be important; therefore, dogs which listen to him better may have scored and ranked higher, leading them to having higher performance scores. “Trainability” was however seen to decrease with age, with younger dogs scoring higher, suggesting that their interest in a training task and aptitude to learn wanes with age.

Dogs with lower “Reactivity” tended to be rated as more effective as an LGD ($P = 0.077$). Working dogs are required to have low emotional reactivity to ensure that they focus on their task instead of concentrating on fearful stimuli (Sherman et al., 2015). It is important that the LGDs don't startle easily, but stand their ground and protect the stock, if a predator approaches (Marker et al., 2005; van Bommel, 2010). The dogs should be calm with the stock, to ensure they are integrated into the herd and accepted by them (van Bommel, 2010). It makes sense that dogs that were less reactive, and hence calmer, were rated as better with the stock.

However, in this small sample of 7 dogs, these associations were significant only at the 10% level. The important traits do not obviously correspond to the traits of “protectiveness,” “attentiveness,” and “trustworthiness” which Coppinger and Coppinger (1980) saw as important in LGDs, although attentiveness may correlate to “Trainability.”

Behavioral problems and subtests play and chase

Dogs that were more playful towards people were also more likely to be reported harassing the stock through play behavior. This behavior problem has previously been reported in 9%–25% LGDs in Namibia (Marker et al., 2005; Potgieter et al., 2013). There is anecdotal evidence that Anatolian shepherd dogs mature slowly compared to other breeds, so younger dogs may harass the stock through juvenile play behavior (van Bommel, 2010). Two of the dogs in this study were reported to have a high tendency to play with the stock in the kraal and both were less than a year old (Table 1). The moderate (though non-significant) correlation between age and “Playfulness” also supports this explanation, but suggests that age alone does not explain variation in this trait. Harassing the stock through play was found to be the most prevalent problem in dogs under a year old (Marker et al., 2005). Many dogs naturally outgrow this behavior (Marker et al., 2005), but 1 of the dogs included in this study was 3 years old and still had a high tendency to play both with people and with stock. In such instances, training methods which encourage alternative behaviors can be beneficial.

The behavioral variable *reaction to a fleeing object* measured during the subtest *chase* was significantly associated with the questionnaire attribute “Tendency to chase predator wildlife.” The attribute “Tendency to chase prey wildlife” could not be analyzed, as there was no variation in the dogs’ scoring. Chasing wildlife is the most common reported problem making up almost half the behavioral problem cases (Marker et al., 2005). A dog that chases wildlife is likely to be less attentive to the stock (Potgieter et al., 2013), however, it was remarked by the herder at CCF that chasing isn’t always negative, as it shows the dog is alert. It is therefore the degree of chasing that affects the effectiveness of the dog as an LGD. We recommend that future studies attempt to quantify the time spent chasing wildlife during work. This is a more useful measure than estimating a likelihood to chase wildlife.

These 2 play subtests have potential within a screening tool to determine if the dogs will be more prone to having behavioral problems. All the dogs were scored as intermediate in their “Tendency to chase prey wildlife,” so we cannot know whether this attribute correlates with the subtest *chase*. To understand whether this subtest can be used as screening for all types of chasing, dogs that show variation in “tendency to chase prey wildlife” need to be included, if they exist.

Conclusions

This is the first study to attempt to develop a behavioral test to quantify the personality of LGDs with 5 personality traits identified: “Playfulness,” “Trainability,” “Independence,” “Sociability with people,” and “Reactivity.” The traits “Playfulness,” “Trainability” and “Independence” were found to be consistent across the 3 tests over 20 days, whereas “Sociability with people” and “Reactivity” were not consistent possibly due to differences between TL, in the 2 tests and dogs varying in the extent to which they habituated to the novel object.

There were correlations significant at 10% between both the measured traits “Trainability” and “Reactivity” and the composite performance score. Dogs that had higher “Trainability” and lower “Reactivity” were likely to be rated as more effective LGDs. Dogs

with higher “Trainability” may be more responsive to the herder, and therefore scored higher, although “Trainability” was also seen to decrease with age of subject. Dogs that were less reactive will be less likely to react to changes in their environment and be calmer around stock. This study aids our understanding of behavior problems in LGDs, as dogs seen to be more playful with people, were reported as more likely to harass stock through play behavior. In addition, dogs scored to more likely follow a fleeing object were reported to have a high tendency to chase predators when out working.

In a small sample of 7 working and 7 breeding dogs these findings suggest some interesting associations which require further exploration to ensure they are generalizable. We tested associations in trained dogs, over ten months of age. It is possible that some of these tests may be predictive of later ability if conducted on young, untrained dogs.

In future studies, larger sample sizes should be used with a range of dogs from different farms to increase range in performance and to better ascertain which personality traits are more prevalent in more effective LGDs. Performance should be quantified using multiple raters and, if possible, include objective measures of effectiveness of LGDs.

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Ethical Considerations Statement

This study obtained both animal and human (ref:65501) ethical approval from the University of Bristol. Since CCF staff routinely monitor their dog’s behavior, consent was given for this project by CCF management.

Conflict of Interest

The authors declare no conflict of interest.

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