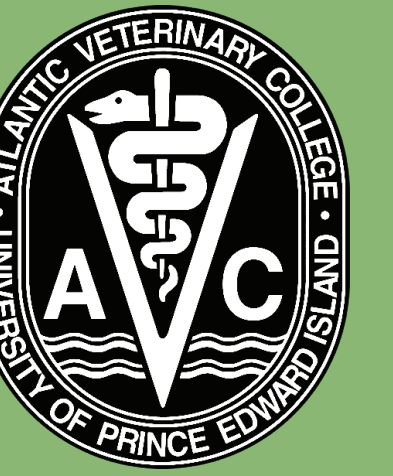


Neurobehavioral development in puppies: Responses to landmark and referential human signalling



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Introduction

Normative behavioural neurodevelopment is unexplored in dogs. We know from human studies that assessment of developmental landmarks acts as an early indicator of emergent non-normative/problematic behaviours.

Using a domain-centered approach that assesses social learning, spatial learning/memory, executive function (inhibition/impulse control/perseverance), and spontaneous behaviour/response to sensory stimuli, we evaluated 39 puppies at 3-, 6-, 9-, and 12-months using 7 domain related tests (Table) and a client-completed questionnaire, the Working Dog Questionnaire pet version (WDQ-Pet). Here, we report on tests 5 and 6 which focus on communicating about hidden objects.

Table: Complete list of tests in larger study (tests discussed here in bold)

1. Approaching a novel human (*Domain 1: Social learning*)
2. Tracking a moving toy (*Domains 1 & 4: Social learning/Executive function*)
3. Responses to behavioural requests (sit, down, stay) when you can and cannot see the person's face (*Domains 1 & 4: Social learning & Executive function*)
4. Open field test (boxes, toys, balls) (*Domains 2 & 4: Spatial learning & Executive function*)
- 5. Looking for a toy they have seen hidden (*Domains 2 & 4: Spatial learning & Executive function*)**
- 6. Looking for a toy they have not seen hidden but where info is provided (knock, point, flag) (*Domains 1, 2 & 4: Social and Spatial learning & Executive function*)**
7. Noise test (*Domains 3 & 4: Spontaneous behaviour/Executive function*)

Domesticated dogs consistently outperform wolves and non-human primates at tasks requiring them to use human social signalling to find a hidden object. Most human infants can easily complete these tasks by 14 months, but most chimpanzees cannot complete these tasks without extensive training/experience.^{1,2,3}

Signals indicating a hidden object which have been used in previous studies include gazing, pointing, tapping, or placement of a marker. Pointing and knocking/tapping are referential signals – intentional movements/gestures which convey information to a recipient. Placement of an object that acts to mark information is a discriminative/landmark signal.

The objective of this project is to determine how tests 5 and 6 can be used in conjunction with other tests and an owner questionnaire to predict future behavioural pathologies in puppies.

Materials and Methods

In test 5, after getting the dog's attention, the toy was squeaked, moved, and placed in a box, after which the dog was called to get it. This instructional test informs the dog that toys can be in boxes.

Test 6, the signalling test, used 3 boxes. One contained a hidden toy which the dog did not see placed. The location of the toy was indicated by knocking, pointing or placement of a flag. Signals and locations of toy were randomized for 12 trials (3 signals; 4 repetitions). Dogs had 2 minutes (120s) at 3-months and 1 minute (60s) at 6-, 9-, and 12-months to find the toy in tests 5 and 6.

Metrics from the 3- and 12-months test were scored alongside the WDQ-Pet, which evaluates the dog's behaviour and responses in a variety of physical and social environments.

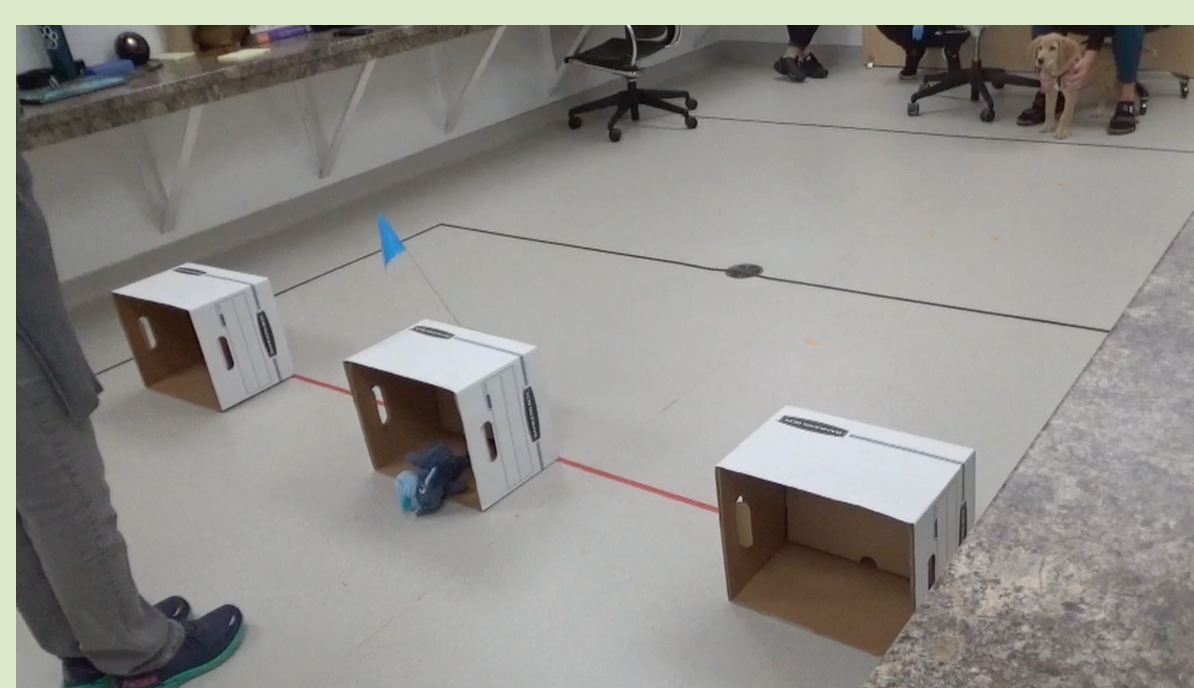
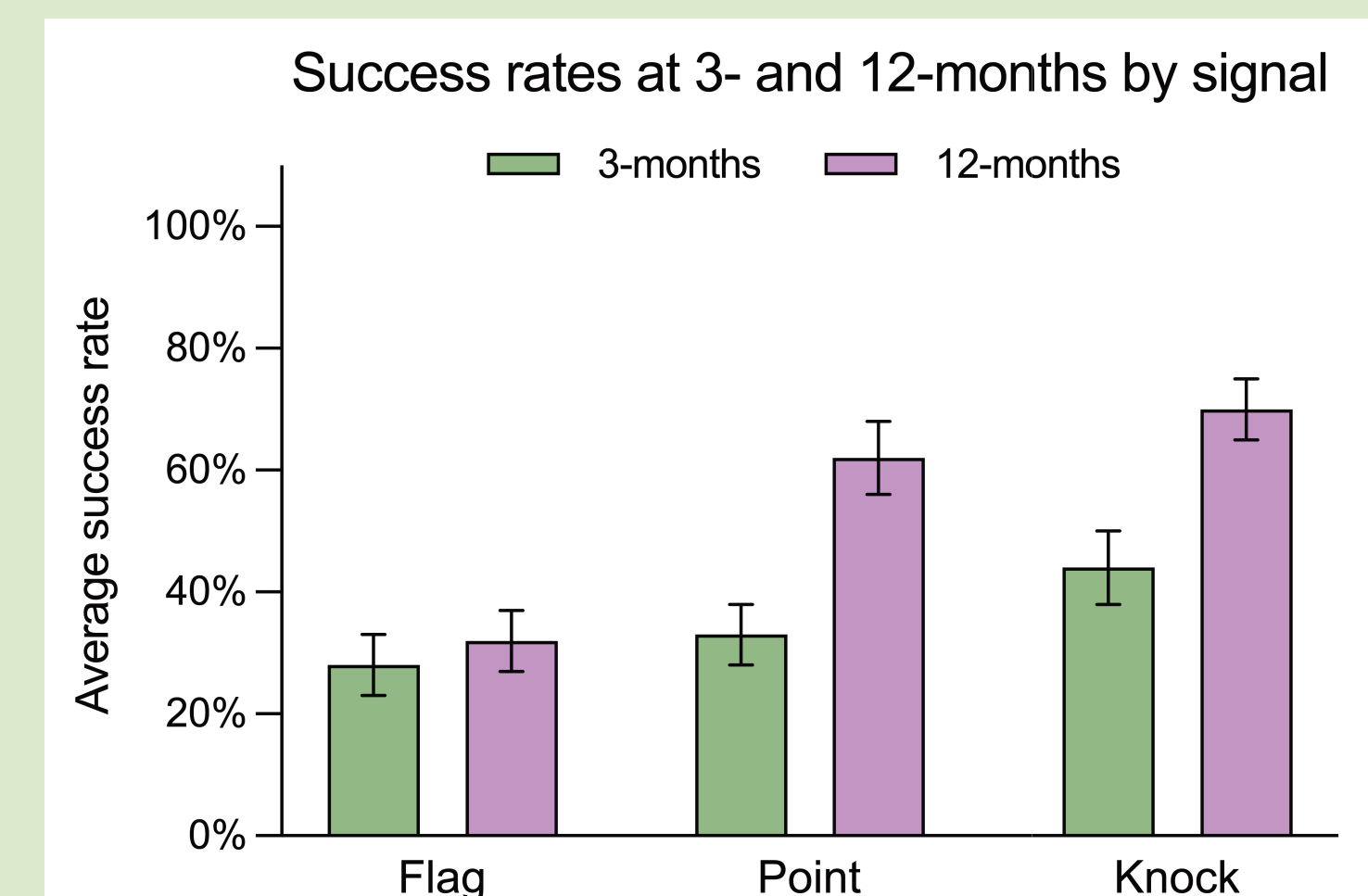


Figure 1. Layout of test 6 (signalling test). The flag signal is shown indicating the toy in the middle box. The puppy can see only the flag.

Results

No significant difference between test 5 (toy location disclosed) and test 6 (toy hidden).

Of the 35 dogs who were consistently visible during test 6 at 3-months, 5 did not cross the start line; 8 did not enter the testing arena. For these same 35 dogs on test 5, where toy placement was disclosed, 4 did not cross the start line (3/4 of these dogs did not do so on test 6); 7 did not enter the arena (5/7 of these dogs did not do so on test 6). No dog who did not cross the start line entered the arena. At 3-months, latency to cross either the start line (Mann Whitney U test, 2-tailed, $z=0.01478$, $p=0.99$) or to enter the arena (Mann Whitney U test, 2-tailed, $z=-0.15522$, $p=0.87$) was not different between dogs in test 5 where the toy location was disclosed, or test 6 where it was hidden.



"Success" is defined as looking in the correct box within the time limit, without requiring a lure, and without first checking an incorrect (empty) box.

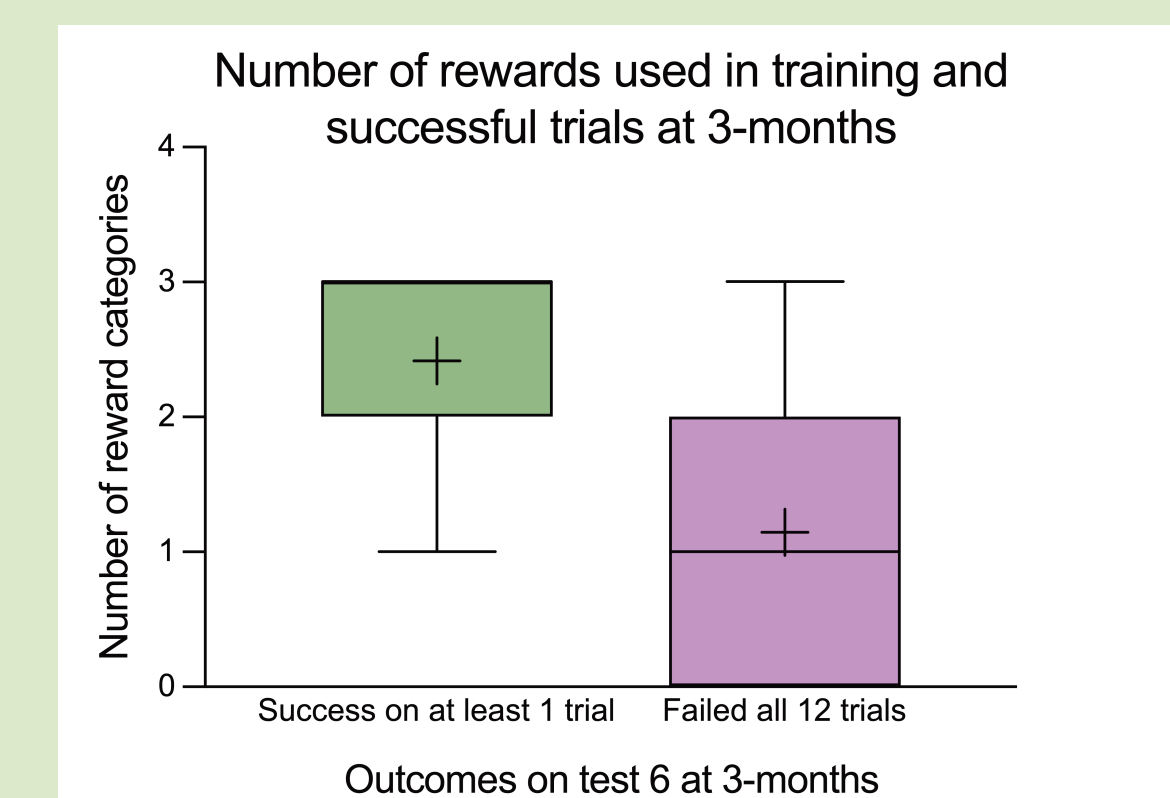


Figure 3. Number of reward categories used in training and presence of at least 1 successful trial at 3-months.

Puppies who succeeded on at least 1 of 12 trials (test 6) experienced more different categories of rewards during training (praise, treat, toy) (WDQ-Pet) than did dogs who failed on all 12 trials (Mann Whitney U test, 2-tailed, $U=35.5$; $z=2.61808$; $p=0.0088$). Both dogs who received no rewards in training failed on all 12 trials.

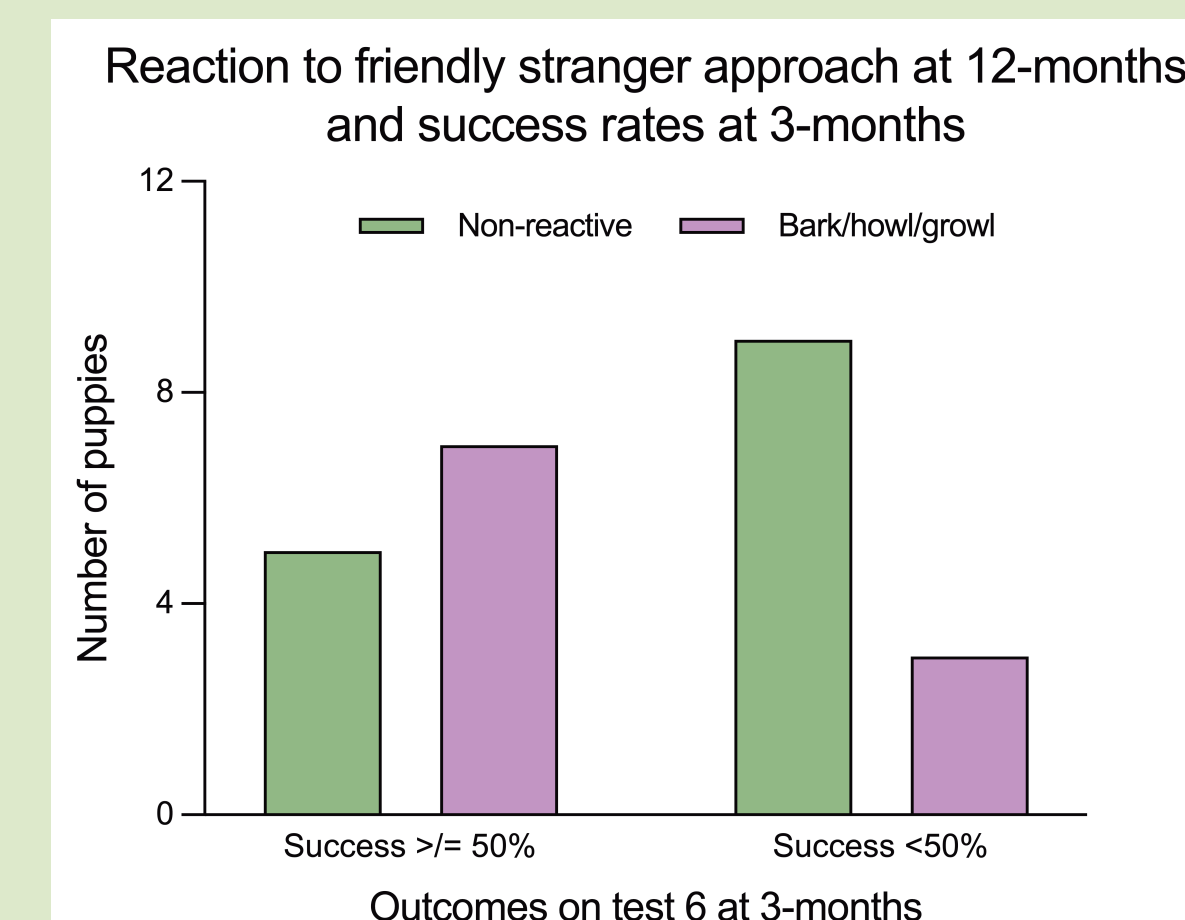


Figure 4. Presence of reactive behaviours to approaching humans at 12-months and success rates on test 6 at 3-months.

Reactivity scores were determined based on response to 5 WDQ-pet questions about approaching humans at 12-months. Puppies who had less than 50% (6/12) successful trials at 3-months were more likely to display reactive behaviours (bark/howl/growl) on approach of a friendly stranger at 12-months. (Z score 1-tailed test: $z=1.6562$; $p=0.04846$).

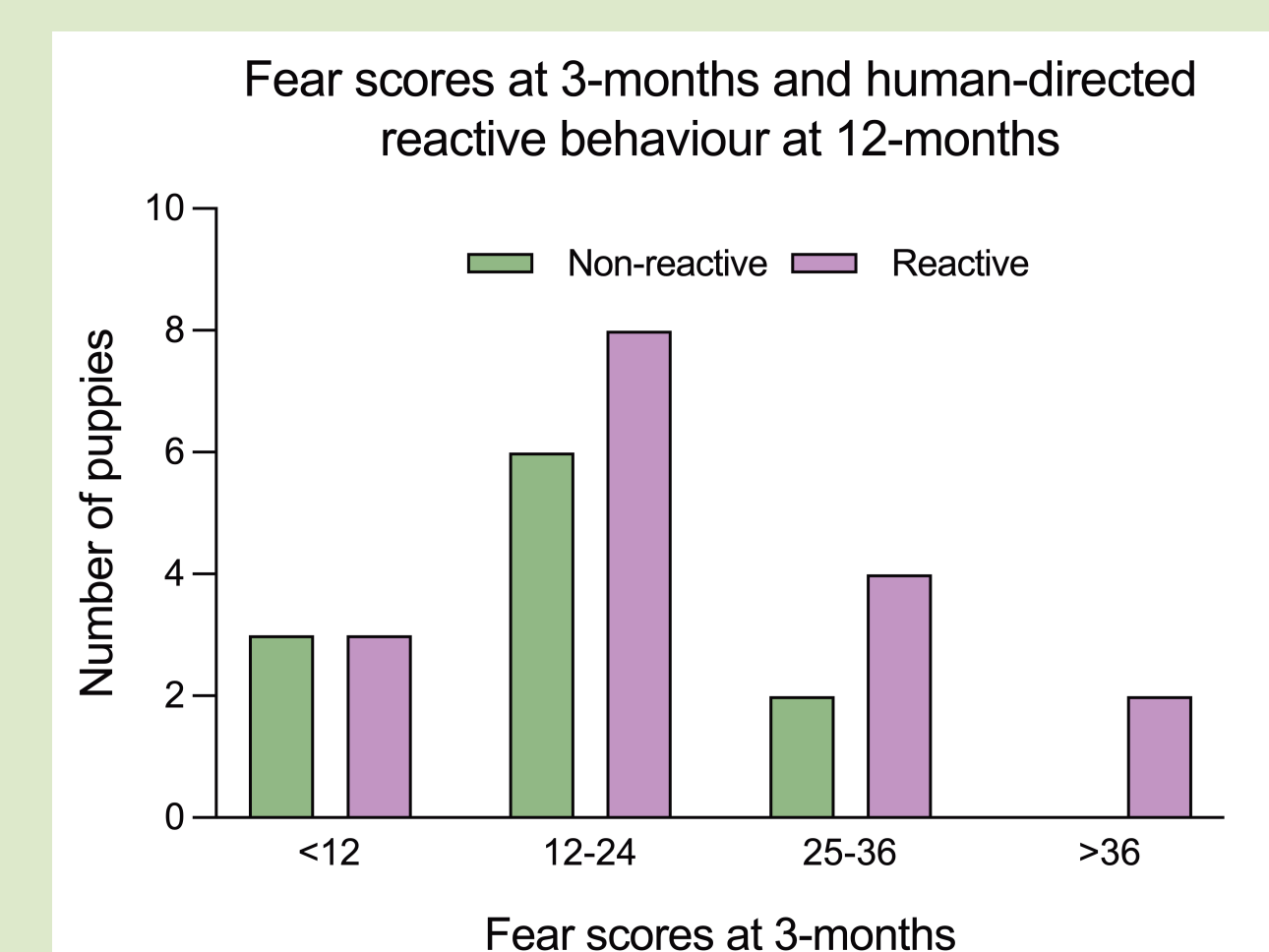


Figure 5. Presence of reactive behaviours to approaching humans at 12-months and fear scores from test 6 at 3-months.

Reactivity scores were determined based on owner responses to WDQ-pet questions about reactions to approaches from humans at 12-months. The proportion of reactive/non-reactive dogs at 12-months is significantly different for dogs with fear scores of >36 ($Z=-2.6394$; $p=0.0083$).

Conclusion

Puppies with more exposure to different rewards in training were more likely to succeed on test 6 at 3-months. Additionally, the 2 puppies who had no exposure to reward-based training at 3-months failed all 12 trials. This result suggests the possibility that early exposure to reward-based training plays a role in the development of a positive cognitive bias in puppies, thus increasing success rates on signalling tests.

Puppies who had higher fear scores and lower success rates at 3-months were more likely to display reactive behaviours upon the approach of a friendly stranger at 12-months. This result suggests that the ability to use human signaling may be associated with the ability to read social cues and accurately assess whether approaches from humans are threats. This is a preliminary finding from a small study, but these results suggest that puppies do not grow out of concerning behaviours and fears.

Owners of fearful puppies should be counselled to seek help from a veterinarian and/or specialist early.

These data, especially when combined with those from other tests, are beginning to allow us to identify and intervene in abnormal puppy behaviour early, when we are best able to improve prognosis and welfare. It is particularly important that we do so, since behavioural problems are the leading cause of relinquishment and euthanasia in dogs under 3 years old.^{4,5}

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