



Differential Effects of Aging on Behavior in Working and Untrained Companion Dogs

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Abstract – Aging related declines in cognition and behavior may have a detrimental impact on working dog performance and welfare. However, while aging related changes have been well documented in companion dogs, no work has determined if those findings generalize to working dogs. In the current study, we examined the effects of aging on cognitive and behavioral traits that are important for career success in working dogs using a questionnaire distributed to detection dog handlers/owners. We also included a group of breed-, age-, and sex-matched untrained companion dogs in order to directly compare the effects of age on these traits between working and non-working dogs. The questionnaire comprised a validated measure of impulsivity using the Dog Impulsivity Assessment Scale (DIAS), responses to positive and negative stimuli (Positive and Negative Affect Scale; PANAS), and canine cognitive dysfunction (CCD; Canine Cognitive Dysfunction Rating Scale; CCDR). While detection dogs demonstrated the typical relationship between increased age and prevalence of CCD, it was not associated with retirement, suggesting that detection dogs are not retired due to cognitive decline. Further, in contrast to untrained companion dogs, detection dogs demonstrated no aging related declines in aspects of behavior, including those shown to be important for working success (e.g., energy and interest). These findings are the first to demonstrate a differential effect of aging on some aspects of behavior between working and non-working dogs. We discuss these results in relation to previous findings on the declines in similar traits shown in companion dogs.

Keywords – Working dogs, Aging, Cognition, Behavior

Dogs experience aging related declines in cognition that may pose welfare and behavioral management concerns. In extreme cases, some dogs develop Canine Cognitive Dysfunction (CCD) characterized by neurodegenerative changes and behavioral abnormalities that influence daily activities (Head, 2013). In addition to welfare concerns, understanding whether working dogs experience these declines is critical for implementing interventions or informing retirement, as certain cognitive skills and behaviors are imperative to working dog effectiveness. For example, detection dogs rely on memory when searching for target odors (Lazarowski et al., 2021) and inhibitory control when faced with distractions in dynamic searching environments (Tiira et al., 2020). Indeed, studies have shown relationships between cognitive-behavioral measures, including reactions to positive and negative stimuli, inhibitory control, and short-term memory, and performance outcomes in working dogs (see Bray et al., 2021 for a review). However, the influence of age on these measures in working dog populations is unknown.

Multiple studies have reported the effects of the normative aging process on dog cognition through owner-reported evaluations and short behavioral tests (see Chapagain et al., 2018 for a review). For example, cognitive functions such as learning and memory, as well as features of behavior, such as

sociability and exploratory behavior, all decline with age. More recently, these evaluations have been used to detect early cognitive decline or CCD in companion dogs (Ruple et al., 2022). However, aging related decline of certain cognitive and behavioral processes in companion dogs may not generalize to working dogs for several reasons. The life history of a working dog is very different from that of companion dogs, which may influence the normative aging trajectory across the lifespan. For example, working dogs undergo higher levels of physical activity than most companion dogs throughout life, which could enhance cognition by creating a neuroprotective effect against aging processes (Snigdha et al., 2014). Previous work suggests a positive effect of exercise on aging in companion dogs such that a higher level of physical activity was associated with a lower rate of CCD (Bray et al., 2023, but see Chapagain et al., 2020). In addition, enriching effects of training and occupational activities may confer cognitive advantages (Chapagain et al., 2017; Szabó et al., 2018). Several studies have demonstrated that higher levels of training for work or sport are associated with better problem solving (Brubaker & Udell, 2018; Carballo et al., 2020; Marshall-Pescini et al., 2008, 2016), inhibitory control (Barrera et al., 2019; Bray et al., 2015; Cavalli et al., 2017), social cognition (Cavalli et al., 2019; Lazarowski, Thompkins, et al., 2020; Mongillo et al., 2017), and responsiveness to training (Wallis et al., 2020). However, these differences could be due to selection for certain traits that are more amenable to such activities rather than effects of training and life history. Regardless of the origin of such differences, it is possible that working dogs are more robust to the aging related cognitive and behavioral changes that have been documented in companion dogs.

Despite potential enriching effects of training and working on cognition, detection dogs face a variety of work-related stressors such as kenneling, transport, and unpredictable work environments (Rooney et al., 2009) that, over time, may impact cognition and behavior. While detection dogs are typically selected for higher levels of stress resilience (Lazarowski, Waggoner, et al., 2020), chronic exposure to stressors and repeated activation of allostasis (i.e., the process of adjusting to a stressor) can accelerate aging related declines (Yegorov et al., 2020). Additionally, aging is associated with declining resilience, which could have negative impacts on working dog performance (Fleyshman et al., 2021).

The purpose of this study was to characterize the effects of aging on cognition and behavior and their potential implications for working dogs. Specifically, we examined whether aging effects observed in companion dogs are generalizable to a population of working dogs, focusing on measures that have been shown to relate to career outcomes in detection dogs (Brady, Cracknell, et al., 2018). To this end, we collected canine demographic information and assessments of impulsivity and temperament. We also assessed diagnosable levels of CCD (Salvin et al., 2011b). We hypothesized that detection dogs would show the typical relationship between increased age and prevalence of CCD as well as aging related declines in cognitive and behavioral traits that are specifically associated with their success, similar to companion dogs (Chapagain et al., 2018). Lastly, we compared data from detection dogs to a sample of companion dogs matched for age, breed, and sex to provide a direct comparison of the effects of age on cognition and behavior in working and non-working dogs.

Methods

Ethics Statement

The study protocol received Not Human Subjects Research (NHSR) determination by the Auburn University Institutional Review Board.

Participants and Questionnaire

To collect data on detection dogs, questionnaires were distributed to a global audience through social media (Facebook and Instagram) on personal and interest group pages as well as e-mail to personal contacts (approximately 30) at various working dog organizations. Recruitment messaging invited responses from individuals that currently owned a dog that was at some point trained for detection work (“if you are currently the owner or handler of an actively working detection canine or have adopted a dog

that was formerly trained or deployed as a detection canine, we invite you to participate in this questionnaire-based study”). Detection careers included any discipline in which the dog was deployed for (i.e., not for sport, competition, or recreation) odor-based detection tasks.

Participants accessed the questionnaire using a secure link which sent them to an online questionnaire platform. The questionnaire contained an introduction which explained that the purpose of the study was to examine causes of retirement in detection dogs and dog demographic questions consisting of the dog’s sex, age, breed, housing situation (i.e., kennel facility or in home), working status (i.e., actively working or retired), and detection discipline. If participants indicated that their dog was retired, they were asked the age of the dog at retirement.

Cognitive and behavioral assessments included validated assessments of impulsivity (Dog Impulsivity Assessment Scale; DIAS; Wright et al., 2011) and responses to positive and negative stimuli (Positive and Negative Affect Scale; PANAS; Sheppard & Mills, 2002), as scores on these assessments have been shown to relate to success in working dogs (Brady, Cracknell, et al., 2018), and a validated assessment of CCD (Canine Cognitive Dysfunction Rating Scale; CDDR; Salvin et al., 2011b). The DIAS consists of 18-items on a 5-point Likert type scale (1: strongly disagree to 5: strongly agree) and is made up of four subscales (Behavioral Regulation, Aggression and Response to Novelty, Responsiveness, and Overall Questionnaire score) with higher subscale scores representing higher levels of the trait, except for Behavioral Regulation in which higher scores represent lower levels of the trait (i.e., higher impulsivity) (Wright et al., 2011). Behavioral Regulation refers to the ability to control actions and thoughts; Aggression and Response to Novelty refers to aggressive behavioral tendencies as well as avoidance of novelty; Responsiveness refers to trainability and awareness; and the Overall Questionnaire score refers to general impulsivity (Piotti et al., 2018). The PANAS consists of 21-items on a 5-point Likert type scale (1: strongly disagree to 5: strongly agree) and is made up of five subscales (Negative Activation and Overall Positive Activation, the latter of which is further broken down into Energy and Interest, Persistence, and Excitability) with higher subscale scores representing higher levels of the trait (Sheppard & Mills, 2002). Negative Activation refers to fearful reactions to stimuli and changing environments; Overall Positive Activation and its components refer to dogs’ responses to rewarding stimuli (Brady, Cracknell, et al. 2018). The CDDR consists of 13-items on 5-point Likert type scale which assesses behavioral abnormalities associated with age. These items are summed to give a level of cognitive impairment from normal to diagnosable levels of CCD (Salvin et al., 2011b).

Data on companion dogs for comparison were obtained from a separate questionnaire. The questionnaire was the same as the detection dog questionnaire except that the introduction explained that the purpose of the study was to identify factors associated with aging in companion dogs, and it did not include detection dog-specific questions but included an additional question to rate previous level of training on a scale from 1 (none) to 4 (advanced). The companion dog questionnaire was distributed through Facebook via personal and research group pages inviting owners of pet dogs to participate.

Data Cleaning and Analysis

There was a total of 820 responses to the larger questionnaire from which the detection dog sample was harvested. In order to capture aging related changes and not development/maturation effects, any dogs under six years of age were removed for this study. Additionally, to enhance the validity of the sample of detection dogs with respect to working experience, we removed dogs who worked less than five years. Subscale scores were calculated for the DIAS as outlined in Wright et al. (2011), for the PANAS as outlined in Sheppard & Mills, (2002), and a CCD score from the CDDR as outlined in Salvin et al. (2011b). If a respondent completed less than 85% of a scale, that data were excluded from the analyses for that scale. First, we used generalized linear models (GLM), constructed and tested using the “lme4” package (Bates et al., 2015) in RStudio, to evaluate effects of age, sex, and the interactions between them on each questionnaire subscale for the cleaned detection dog sample. We removed non-significant interactions to find the minimal adequate model.

There were a total of 1008 responses to the companion dog specific questionnaire. In order to capture differences between groups due to work history, we removed any companion dogs that received advanced training. We then we created pairs based on age group (Harvey, 2021), sex, and breed to control for the effects of these characteristics. We used GLMs to evaluate effects of group (detection or companion dog), age, and the interaction between them on each questionnaire subscale.

Results

Detection Dogs

The sample of detection dogs that remained after data cleaning ($n = 210$) was on average 9.62 years old (range: 6-15 yrs), with 84 F; 126 M. Breeds consisted of German shepherd ($n = 29$), German Shorthaired Pointer ($n = 23$), Labrador retriever ($n = 53$), Belgian Malinois ($n = 36$); all other breeds were grouped as “Other” ($n = 69$). Regarding working status, 138 were reported to be actively working and 72 were retired, with an average age of retirement of 8.87 years which did not differ between males ($M = 8.87$) and females ($M = 8.87$). The presence of CCD was indicated in 12% of the sample ($n = 25$ dogs) with a mean age of 10.23 yrs, 14 of which were reported to be actively working. Of the 25 dogs indicated to exhibit CCD, 24 were categorized as “at risk” for CCD and 1 dog was categorized as having “diagnosable levels” of CCD, as calculated from the CCDR. There was a main effect of age on CCD such that older dogs displayed significantly higher CCD scores ($t(177) = 2.43, p = .016$). There was no effect of age, sex, or the interaction between them on any of the DIAS or PANAS subscale scores ($ps > .05$).

Detection vs Companion Dogs Comparison

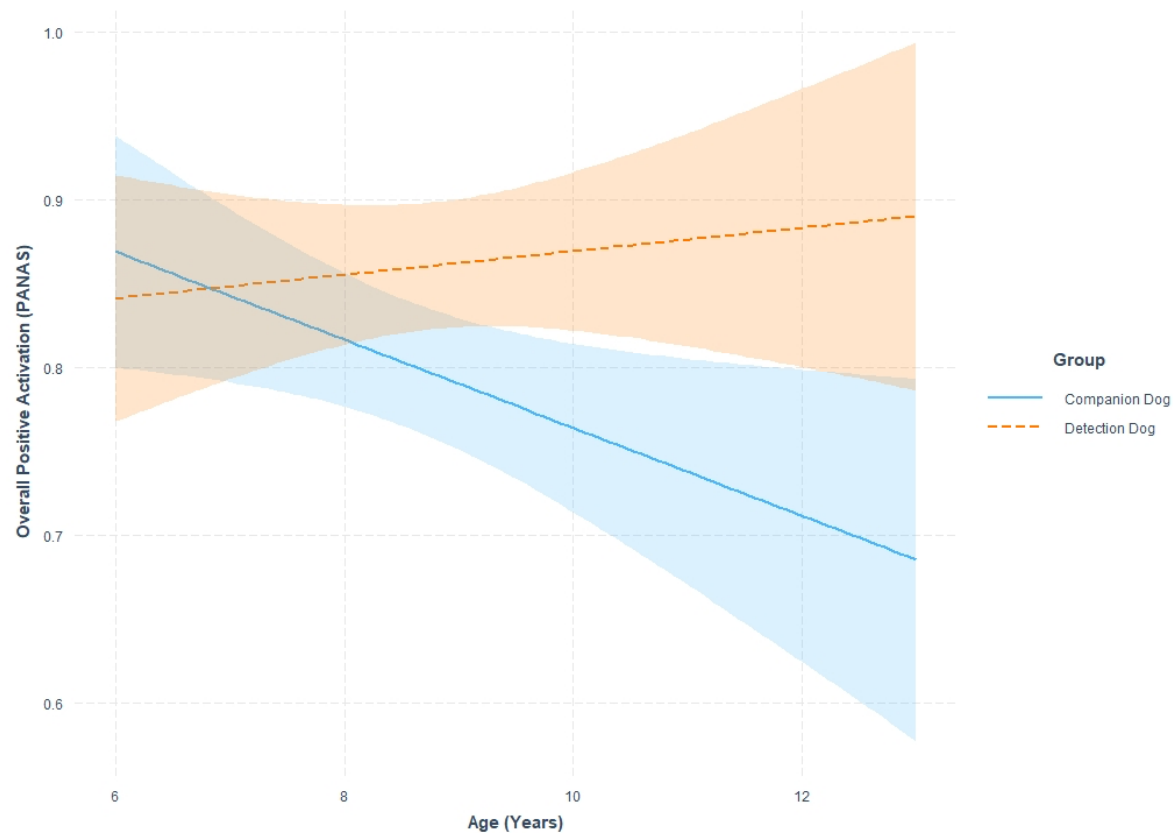
Based on the criteria for matched pairs it was possible to create 45 pairs for a total of 90 dogs (mean age = 8.78, 50 F/40 M, breed = German Shepherd Dog = 48, German Shorthaired Pointer = 12, Labrador retriever = 30).

On the DIAS, there was a main effect of group where detection dogs displayed significantly higher scores than companion dogs on the Responsiveness subscale ($t(83) = 1.99, p = .05$) and significantly lower scores than companion dogs on the Aggression/Response to Novelty subscale ($t(83) = -2.94, p = .004$). On the PANAS, there was a main effect of group where detection dogs scored significantly higher than companion dogs on the Excitability subscale ($t(83) = 2.75, p = .007$) and significantly lower on the Negative Activation subscale ($t(83) = -4.04, p < .001$).

There was an interaction between group and age on the Energy and Interest and Overall Positive Activation (Fig 1) subscales of the PANAS ($t(83) = 2.06, p = .043$ and $t(83) = 2.72, p = .008$, respectively), therefore, the effect of age on these subscales was analyzed separately for each group. The effect of age was significant for companion dogs such that there was a significant decrease on Energy and Interest and Total Positive Activation scores ($t(41) = -2.33, p = .025$ and $t(41) = -2.39, p = .022$, respectively) as a function of age. There were no significant effects in detection dogs ($ps > .05$). Lastly, there was an interaction between group and age on the Persistence subscale of the PANAS ($t(83) = 2.24, p = .028$), therefore, the effect of age was analyzed separately for each group. The effect of age was significant for detection dogs such that there was a significant increase in Persistence scores ($t(41) = 2.14, p = .039$) as a function of age, with no effect in companion dogs ($p > .05$). No other effects were significant ($ps > .05$).

Figure 1

Overall Positive Activation Subscale of the Panas as Function of Age in Detection Dogs and Companion Dogs



Discussion

The current study examined effects of age on cognitive and behavioral traits in detection dogs, specifically those that have been associated with career success, such as impulsivity and temperament (Brady, Cracknell, et al., 2018). While we observed the typical relationship between increased age and prevalence of CCD in detection dogs (Ruple et al., 2022), it was not associated with retirement. In contrast to findings in companion dogs (Chapagain et al., 2018), we found no aging related declines in specific aspects of cognition and behavior, as measured by the DIAS and PANAS. These findings are the first to demonstrate a differential effect of aging on behavior between working and untrained non-working dogs and have important implications for the management of aging working dogs.

Interestingly, despite previous research showing an increase in impulsivity (Bray et al., 2014; Riemer et al., 2014; Watowich et al., 2020) and behavioral reactions to negative stimuli (Piotti et al., 2022; Salvin et al., 2011a; Savalli et al., 2019) as a function of age in companion dogs, we found no aging related declines in these or any of the other DIAS or PANAS traits in detection dogs. It should be noted that while CCD was observed in advanced age in the detection dog sample, this is a measure of rarer and more severe cognitive dysfunction that is atypical to the normative aging process, while the PANAS and DIAS reflect standard cognitive function. These findings could suggest a neuroprotective advantage of lifestyle and experience in working dogs; therefore, we included a comparison to a breed-, age-, and sex-matched group of untrained companion dogs to assess the validity of the measures used in capturing aging related changes in impulsivity (DIAS) and responses to positive and negative stimuli (PANAS).

Consistent with previous research, we found behavioral differences between detection dogs and companion dogs suggesting the importance of these traits for working success (Brady et al., 2018). However, the matched companion dog sample did not display aging related changes in impulsivity as expected. One possibility is that the DIAS may not be sensitive to aging related changes in impulsivity in dogs. However, a previous study found a timepoint effect (declines from first to second time assessed) on the Responsiveness subscale of the DIAS (Riemer et al., 2014), though it is unclear whether the effect was due to age or issues with test re-test reliability of the scale. The lack of construct validity has been a pervasive issue in measures of impulsivity in dogs, as evidenced by a lack of cross-task correlations between behavioral tests of impulsivity (Bray et al., 2014; Brucks et al., 2017; Fagnani et al., 2016; Kelly et al., 2019; Lazarowski, Krichbaum, et al., 2020; Marshall-Pescini et al., 2015; Vernouillet et al., 2018). However, the DIAS has been shown to correlate with a temporal impulsivity task (Riemer et al., 2014; Wright et al., 2012), the cylinder task (Krichbaum & Lazarowski, 2022), the spatial impulsivity task (Brady, Hewison, et al., 2018, see Mongillo et al., 2019 and Stevens et al., 2022 for alternative accounts), and the delay of gratification task (Brucks et al., 2017). Future work should consider a multidimensional approach to defining impulsivity and related mechanisms in dogs.

Typical aging effects were shown in other aspects of behavior as measured by the PANAS in the matched companion dog sample, confirming the validity of the instrument (Savalli et al., 2019). Specifically, companion dogs displayed a decline in Overall Positive Activation (i.e., sensitivity and responsiveness to positive stimuli) and its subscale 'Energy and Interest' as a function of age, while these traits stayed relatively stable in detection dogs. Energy and Interest was found to be associated with long-term success in police and military dogs, and was interpreted to reflect motivation to work (Brady, Cracknell, et al., 2018). Conversely, we found that detection dogs showed an increase in 'Persistence' as a function of age which was not seen in pets. It is also important to note that the groups scored similarly on these scales in mature adulthood, adding confidence that the decrease shown in companion dogs was due to age and not pre-existing differences between the populations. Differential effects of aging on traits related to motivation are important given its critical role in the ability of detection dogs to withstand the challenges and demands of work, such as endurance during long searches in the absence of reinforcement (Hall, 2017).

There are two potential explanations for the differential effects of aging found between detection dogs and a matched sample of untrained companion dogs. One possibility is that engaging in a lifetime of continuous training, work that is likely intrinsically rewarding, exposure to stimulating environments, and physical activity that typical non-working dogs do not experience have an enriching effect that results in neuroprotective mechanisms against aging processes. Our sample excluded highly trained companion dogs to ensure we were isolating the effects of work-related activities, so it is possible that similar benefits are seen in companion dogs that engage in high levels of activity and enrichment. Further, our working dog questionnaire did not ask for details about frequency and type of training or work duty cycles that could further elucidate these effects by examining differences in amount or type of such experiences. Alternatively, or perhaps additionally, differences may be due to genetic differences in certain traits that are selectively bred for in working dogs and associated with working success (Fadel et al., 2016; Lazarowski, Waggoner, et al., 2020). While we did not find differences between detection dogs and companion dogs at earlier ages in traits that showed differential decline at older ages, suggesting no pre-existing differences between the two groups, it remains possible that selection for desirable traits in detection dogs has resulted in latent differences in the resilience of these traits to aging that only emerges at later stages of aging.

Limitations of the current study include the small number of matched pairs as well as possible participant factors that were not measured that could influence perceptions of their dog (e.g., owner bias, experience assessing dog behavior, and other owner demographic variables) and could have contributed to some of the observed effects found between groups (Clark et al., 2020; Mariti et al., 2012; Munch et al., 2019). In addition, measures used may not have been sensitive enough to detect the effects of aging in detection dogs that may be relevant to their working performance. For example, olfactory function, learning ability, and memory are all critical aspects of detection dog performance that may be susceptible to aging and would require more rigorous behavioral testing to assess. However, the use of validated questionnaire

measures, specifically those that have previously shown associations with working dog outcomes, provides meaningful insight into previously unexplored questions regarding effects of age on important cognitive and behavioral constructs for working dogs. Furthermore, questionnaires may provide a rapid assessment tool that handlers can use for monitoring changes suggestive of further clinical examination.

The average retirement age in our sample of retired detection dogs was close to nine years old, however, “at risk” to “diagnosable levels” of CCD did not appear until nearly 10 years of age on average. In fact, 14 of the 25 dogs found to have these levels of CCD were still actively working, suggesting that symptoms of CCD were not career-ending concerns. However, it is possible that their performance was impacted despite still being utilized operationally. Future research should evaluate effects of normative aging and related cognitive declines on aspects of working effectiveness. These results, together with our findings of a lack of age effects on other important aspects of behavior, suggest that it is uncommon for detection dogs to retire due to cognitive decline. Therefore, future research should focus efforts on identifying reasons for retirement in detection dogs in order to extend career longevity and determine specific factors predictive of retirement.

Conclusion

In conclusion, our results suggest that detection dogs are robust to some of the typical behavioral declines seen in companion dogs. Importantly, we found no aging related declines in measures that have been reported to be associated with long-term working dog career success (Brady, Cracknell, et al., 2018), such as impulsivity and temperament, but found age effects on these traits in a breed-, age-, and sex-matched sample of non-working dogs. These findings are the first to examine aging related changes in cognition and behavior in detection dogs. It is possible that the life history of detection dogs is particularly enriching in a way that results in resilience to age effects (Bray et al., 2023), however, additional research is needed to tease apart effects of genetics and experience and to determine the specific mechanisms responsible for the neuroprotective effect against aging. While it appears that the career longevity of working dogs is not negatively impacted by aging related cognitive and behavioral declines, it remains important to monitor changes and intervene when necessary.

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Conflict of Interest: The authors report no conflicts of interest.

Data Availability: The data supporting the conclusions of this study are available upon request.

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