Nutritional Impacts on Behavior

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Animal Behavior Wellness Center

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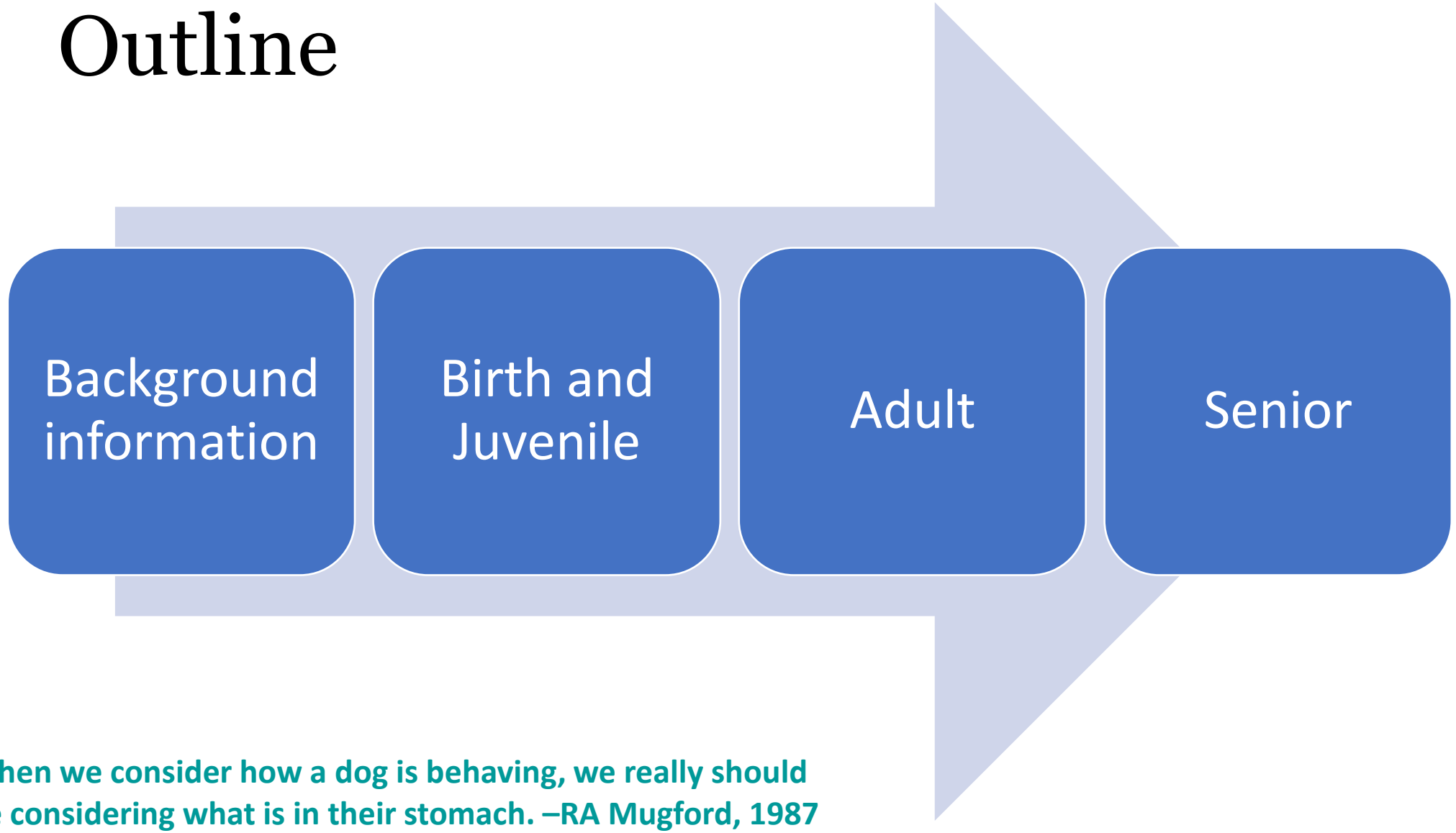
Outline



When we consider how a dog is behaving, we really should be considering what is in their stomach. –RA Mugford, 1987

Background

Why is nutrition important in behavior?

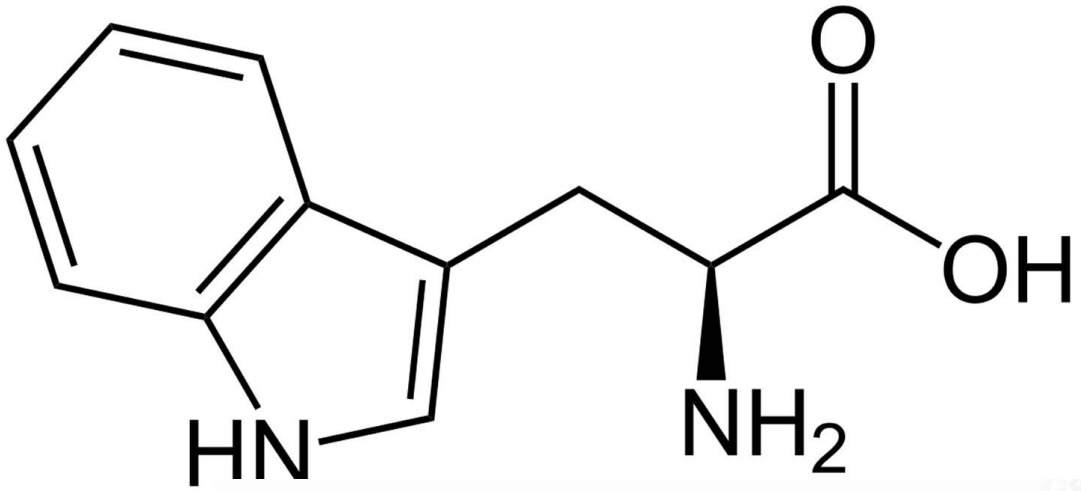
- Behavior is regulated by neurotransmitters and hormones
  - Changes in availability of NTs and hormones (over or under) influences behavior
- Nutrient availability influences precursor availability and absorption
- Amino acids used for synthesis of:
  - Enzymes and other proteins
  - Precursors of neurotransmitters and hormones
- Availability of amino acids is determined by:
  - Timing and amount of food intake, diet composition and digestibility
- Fatty acids play role in brain development, cognitive performance and behavior

Human Literature and Research

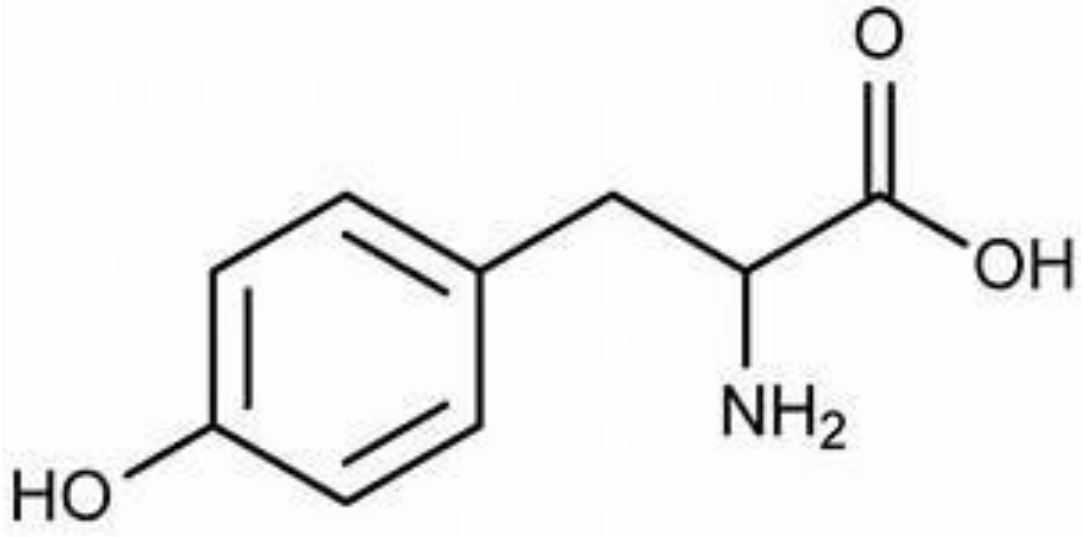
- Diets rich in vitamins and minerals decrease anti-social behavior in kids
- Supplementation of vitamins, minerals and fatty acids decrease violence among prisoners
- Neonatal Iron deficiency causes cognitive delays as children

Amino Acids of Importance

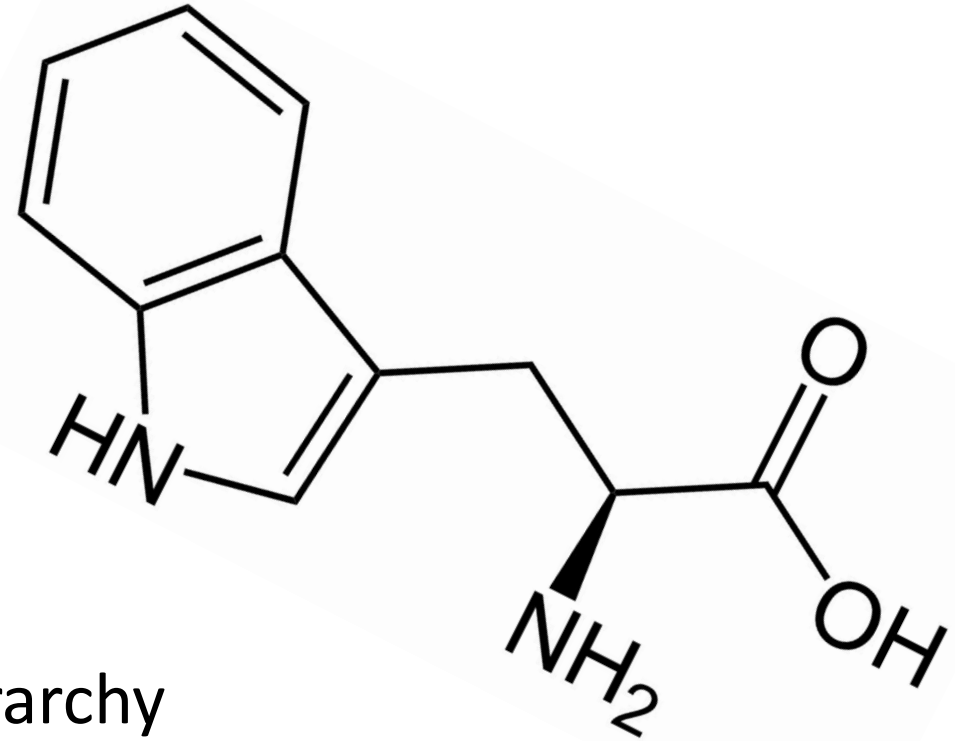
- **Tryptophan**



- **Tyrosine**



Tryptophan

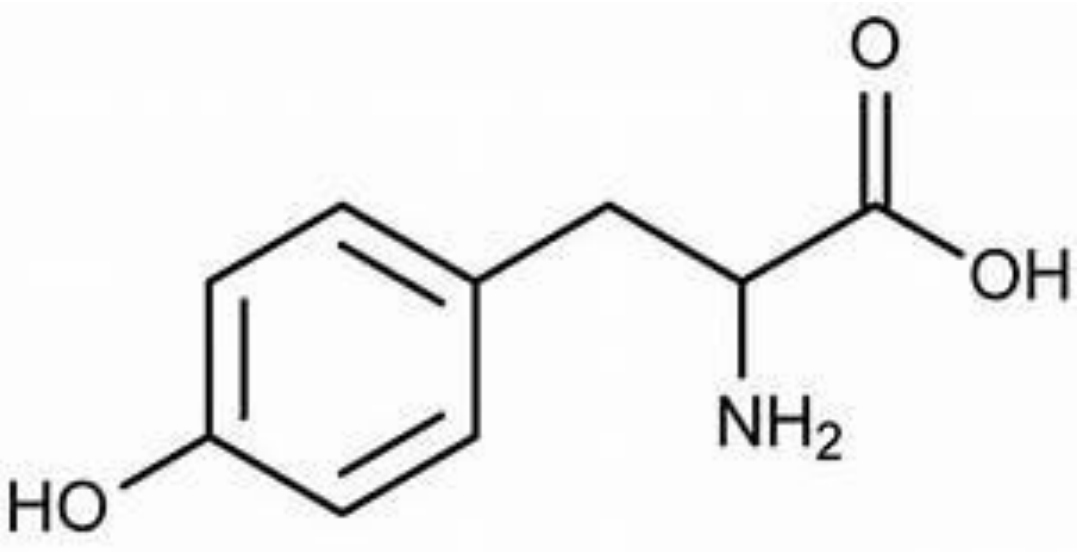


- Precursor for SEROTONIN
- Essential amino acid
  - Must be obtained via food
- Protein absorption has a hierarchy
  - Large neutral amino acids (tyrosine, phenylalanine, leucine, isoleucine, valine)
  - Tryptophan
- Protein binding is important too!
  - Albumin bound= 80-90%
  - Only albumin bound crosses BBB

Tryptophan has been shown to:

- Decrease mouse killing in rats
- Decrease aggression in vervet monkeys
- Increase exploratory behaviors in silver foxes
- Decrease self-injurious behavior in rhesus monkeys
- Influence resistance and tolerance to stress
- Enhance/expedite recovery in pigs exposed to social stressors
- Decrease cortisol concentrations in humans following stressful math
- Decrease aggression in dogs

Tyrosine



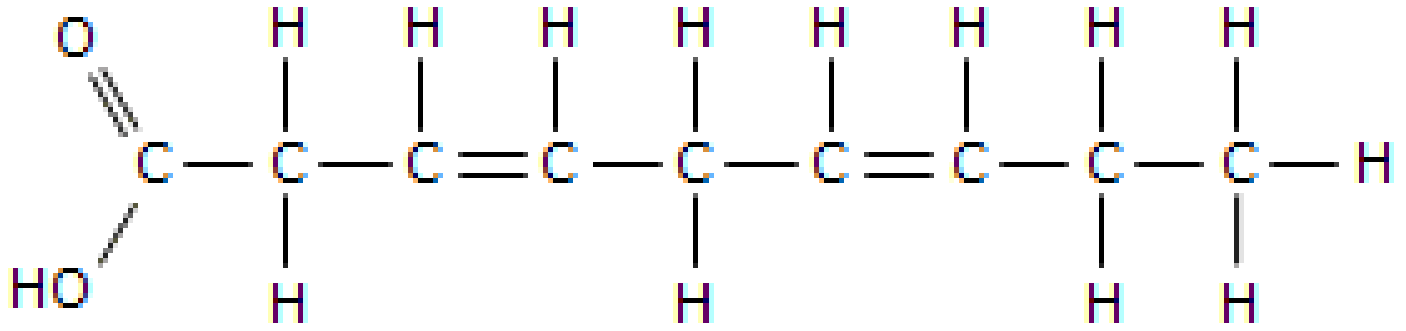
- Can be synthesized from phenylalanine or absorbed directly
- Precursor for DOPAMINE, NOREPINEPHRINE, EPINEPHRINE
- Tyrosine competes with other LNAA for blood brain access

Tyrosine has been shown to:

- Be beneficial in rats during times of high stress as it reduces the catecholamine depletion during a time of high activity and demand

Dietary Lipid Content is Important Too

- Make up cell membranes
- Precursors for chemical messengers (espec steroid hormones)
- Energy source in the body
- Secondary to adipose tissue (fat), the brain has the highest concentration of lipids
- Polyunsaturated fatty acids (PUFA) are the most important for brain and behavior



PUFAs have been shown to

- Increase learning ability in rats
- (Lack of) Increase aggression in rats when intruder invaded residence
- Increase expression of stress-related behaviors in rats
- (Lack of) increased in anxiety in mice and rats
- Influence dopaminergic and serotonergic pathways
  - Roles in cognition, learning, emotion and impulse control

It is WAY more complex than that

- Ratio of each LNAA to tryptophan
- Tryptophan transport across the BBB affected by breed, age, sex, social status, arousal and activity levels
- Carbohydrate induced insulin increases push LNAA into skeletal muscle (but not tryptophan) so relative advantage of tryptophan to cross BBB then
- Studies in dogs have been limited and not well controlled
- Higher tyrosine diets impair tryptophan absorption
- High tyrosine diets do not increase catecholamine levels
- Many areas to influence- Increased concentrations of NTs in one part of brain but decreased in another
- Fiber content plays a role in this too
  - interaction b/t digestion and absorption of starch, fats and protein
  - Compulsive disorders that are feeding oriented

Birth and Juvenile

Neonates and juveniles

- The most susceptible to and the highest age impacted by dietary deficiencies
- Direct or indirect malnutrition
- Long term behavioral effects direct result of malnutrition and/or abnormal maternal-offspring interaction/relationship
- Both kittens and puppies demonstrate food preferences based on maternal feeding habits (type, source, flavor)

Research shows-

- Maternal diets low in PUFAs led to puppies with delayed retinal sensitivity
  - Retina and grey matter have similar concentrations and use of PUFAs
- Fear and aggression in feral cats result from maternal malnutrition
- Malnourished mothers display inadequate maternal behavior
- Protein deficiency in the queens diet led to kittens with increased vocalization
- Cannibalism of kittens may be a result of her own malnourished state
- Gestational malnutrition leads to nervous puppies that resist handling
- Gestational malnutrition leads to behavioral and developmental delays in kittens (NOTE: kittens were nursed on a normally nourished queen)
  - Juveniles showed marked anti-social behavior and cognitive delays
  - Second generation kittens also showed delays

Take-aways

- Maternal malnutrition and neonate nutrition can impact later behavior significantly
  - Breeders, fosters, and feeders need to be aware of the unique dietary constraints of pregnant and lactating moms
- Ferals, strays, and rescues/imports can all have significant behavioral concerns as a result of malnourishment
- Bottle babies are a “thing” ?? Cross-foster litters when possible
  - Malnourishment versus lack of social interaction
- Adoptive owners and fosters should be warned and intervention sought immediately

What to feed pregnant and lactating pets

- AAFCO certified
  - To meet nutritional needs for gestation and lactation
  - Performed through AAFCO feeding trials of gestating and lactating pets
  - All life stages is slightly different
- Last 3 weeks of gestation and first 4 weeks of lactation
  - Feed free choice
- Offer variety of textures, types of food, and protein sources if possible
  - Enhances ability for puppies and kittens to be more open to a variety of foods

Diets to feed

Training starts right away

See
Mark
And
Reward
Training

Adult

Appropriate protein content

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Effect of dietary protein content on behavior in dogs.

Dodman NH[1], Reisner I, Shuster L, Rand W, Luescher UA, Robinson I, Houpt KA

Author information

Journal of the American Veterinary Medical Association, 01 Feb 1996, 208(3):376-379
PMID: 8575968

Effect of dietary protein content and tryptophan supplementation on dominance aggression, territorial aggression, and hyperactivity in dogs

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DOI: https://doi.org/10.2460/javma.2000.217.504

Volume/Issue: Volume 217: Issue 4 Online Publication Date: 01 Aug 2000

VETERINARY BEHAVIOR SYMPOSIUM PROCEEDINGS
AUSTIN, TX
June 22, 2022

RELATIONSHIP BETWEEN DIETARY PROTEIN CONTENT AND BEHAVIOR IN GOLDEN RETRIEVERS

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Research support from Morris Animal Foundation.
No conflicts of interest.

Introduction: Previous studies have suggested that diets which are higher in protein may be linked to increased aggression in dogs.[1,2] The objective of this study was to evaluate the relationship between the protein content in commercially available dry food and behavioral scores via a validated behavior questionnaire in Golden Retrievers.

Methodology: Health history and lifestyle factors were obtained from owner-completed questionnaires for Golden Retrievers taking part in a large, prospective, validated canine health study, which also included a validated behavioral survey.[3] The dogs had to be eating commercially available dry food that comprised at least 80% of the daily intake when the questionnaire was completed. A total of 1,618 Golden Retriever dogs met inclusion criteria. Diets were categorized as high (>30%), medium (21-29%), or low (<20%) protein level. The association of dietary protein level and eight behavior outcomes of interest were estimated, adjusting for sex, reproductive status, and dog's primary use.

Results: Compared to dogs fed medium protein diets, dogs fed high protein diets were 1.4 times more likely to have owner-directed aggression. Compared to dogs fed medium protein diets, dogs fed low protein diets were 1.4 times more likely to have separation-related behavior. However, results were not statistically significant.

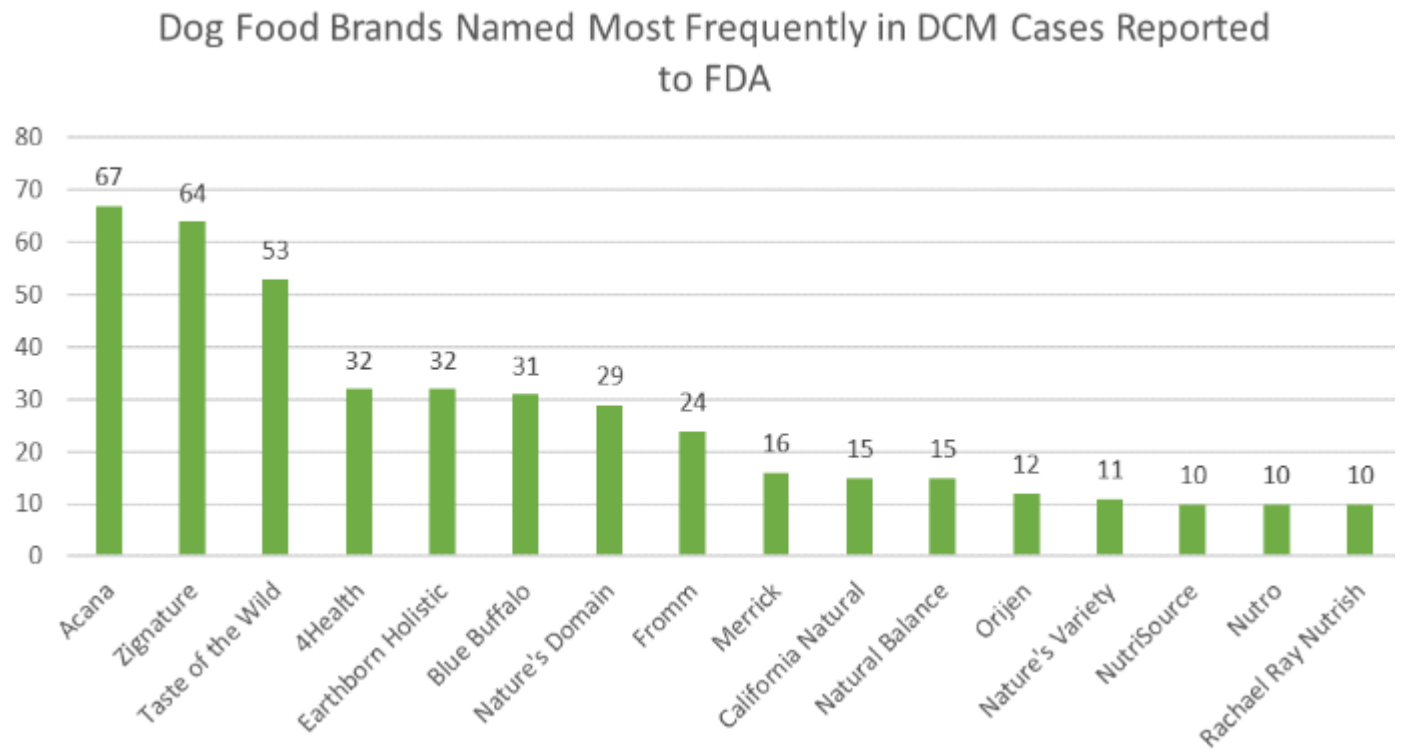
Conclusions: Dietary protein levels do not appear to have a measurable impact on the behavior of Golden Retrievers. The results of this study are somewhat dissimilar from previous studies. When assessing, diagnosing, and treating aggression, separation related behaviors, and other behavioral problems, clinicians must evaluate several factors.

Grain Containing

U.S. FOOD & DRUG ADMINISTRATION

Animal Behavior Wellness Center

FDA Investigation into Potential Link between Certain Diets and Canine Dilated Cardiomyopathy



Nutritional Intervention for Behavior

Immune System & Behavior

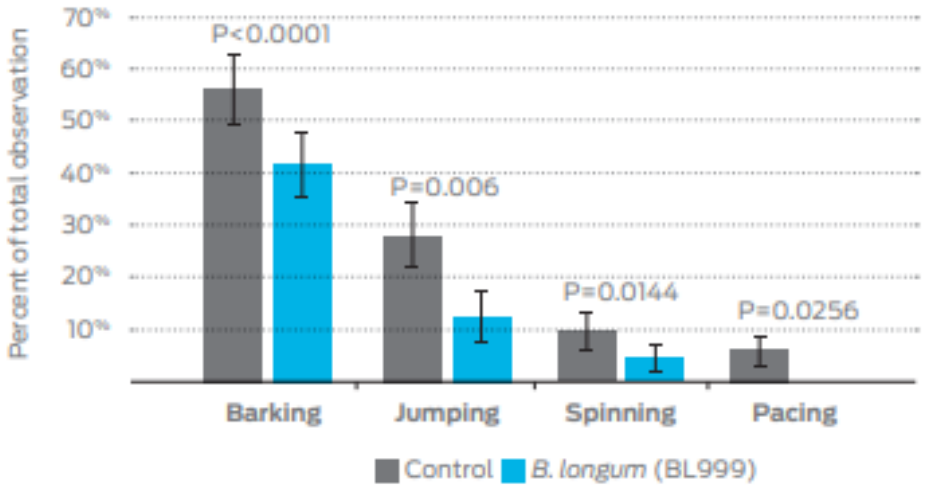
- Immune system and brain connection
  - Higher incidence of IBS/IBD in people with anxiety
  - Higher incidence of allergy/derm disorders in people with anxiety

- When experiencing a flair of any medical disorder, patients behavior can be worse due to trigger stacking

Probiotics and stress

RESULTS: GENERAL BEHAVIOUR

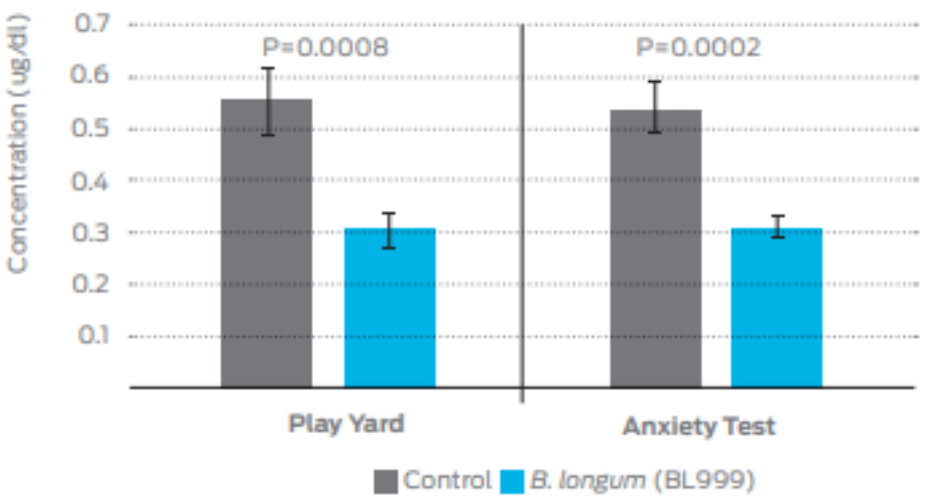
PERCENT OF SCANS WHERE PROBLEM BEHAVIOUR WAS OBSERVED



Significant impact of BL999 on dogs displaying day-to-day anxious behaviour (including significant reductions in barking, jumping, spinning and pacing) when supplemented with BL999 as compared to a placebo.[3]

RESULTS: SALIVARY CORTISOL

SALIVARY CORTISOL CONCENTRATION AFTER EXERCISE AND ANXIETY TEST



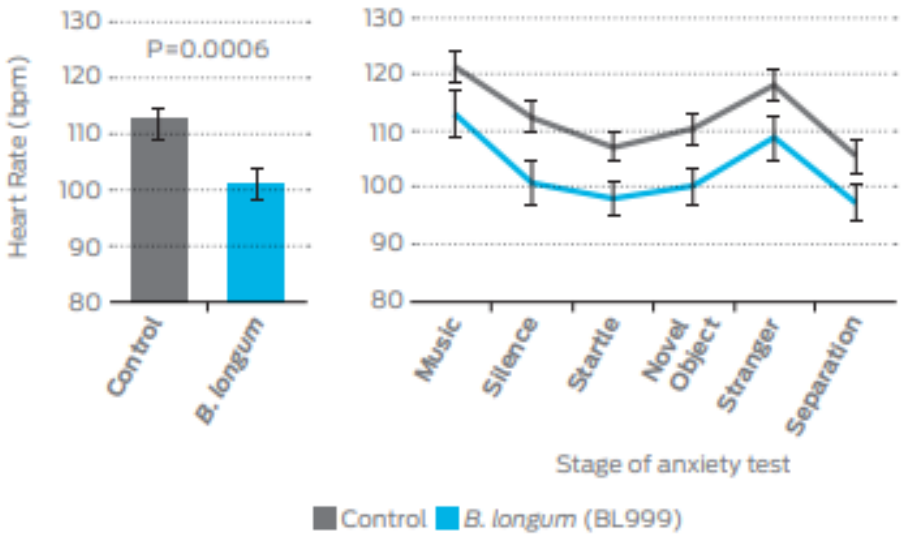
Dogs showed increased exploratory behaviour in a novel environment and had reduced salivary cortisol concentrations in response to both exercise and anxiety-inducing stimuli when supplemented with BL999 as compared to a placebo.[3]

1. Denenberg, S., Landsberg, G. M., Blizzard, T. (2013). Prevalence of Fearful and Anxious Behaviors in Dogs in the United States. *Proc of the ACVB/AVSAB Veterinary Behavior Symposium*. Chicago, 50-51. In an online survey of 1201 owners of 1960 dogs using multiple answer format.
2. Seksel, T. (2014). Stress and Anxiety - How Do They Impact the Pet? *Proc of the 39th Congress of the World Small Animal Veterinary Association*. Cape Town, South Africa.

Probiotics and stress

RESULTS: HEART RATE

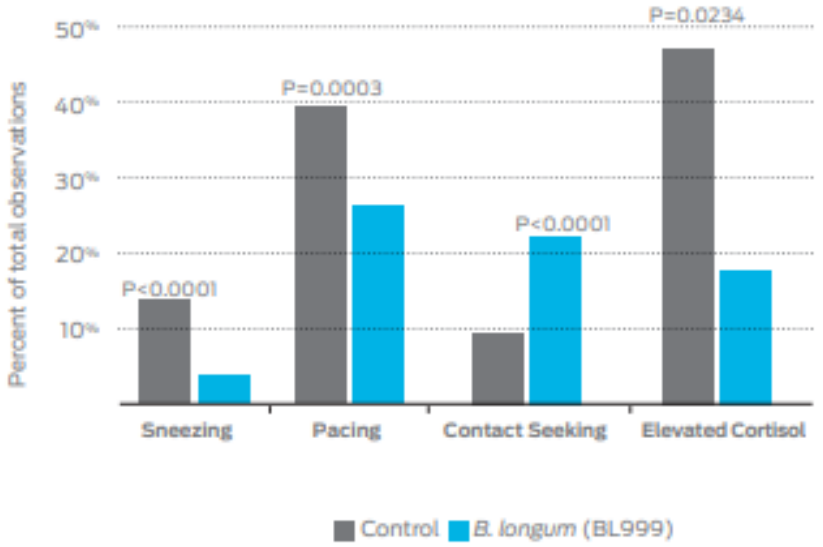
MEAN HEART RATE DURING ANXIETY TEST



When considering cardiac activity, dogs showed a decrease in heart rate, indicating a more positive response to anxiety-inducing stimuli when supplemented with BL999 compared to a placebo.[3]

RESULTS: GENERAL BEHAVIOUR

PROPORTIONAL COMPARISONS OF CATS SUPPLEMENTED WITH BL999 OR CONTROL AND SUBJECTED TO MILD STRESS FROM CHANGE IN HOUSING



During the stress periods, cats supplemented with BL999 were significantly less likely to have sneezing associated with reactivated FHV-1, to have abnormal serum cortisol concentrations, and to pace in cages, and were more likely to reach out to the scorers through the cage bars as compared to placebo.[4]

3. Trudelle-Schwarz McGowan, R. Tapping into those 'gut feelings': impact of BL999 (*Bifidobacterium longum*) on anxiety in dogs. ACVB Symposium 2018.
4. Davis H., Franco P., Gagné J., et al. Effect of *Bifidobacterium longum* 999 supplementation on stress associated findings in cats with feline herpesvirus 1 infection. ACVIM Forum 2021 Proceedings.

Gut brain connection

‹ ZOOLOGICAL SCIENCE

The gut microbiome correlates with conspecific aggression in a small population of rescued dogs *(Canis familiaris)*

Research article | Animal Behavior | Bioinformatics | Microbiology

Nicole S. Kirchoff[1], Monique A.R. Udell[2], Thomas J. Sharpton[1,3]

Published January 9, 2019

Our results indicate that there are statistical associations between aggression status and the gut microbiome. For example, microbial composition differs based on aggressive and non-aggressive evaluations. Additionally, the relative abundances of specific bacterial taxa and lineages are different across aggressive and non-aggressive groups. These observations are important because they indicate that either (a) aggressive dogs manifest physiological conditions in the gut that influence the composition of the gut microbiome, (b) the composition of the gut microbiome may influence aggressive behavior, or (c) that aggressive dogs are subject to some biased covariate relative to non-aggressive dogs that also influences the gut microbiome. Future studies should seek to confirm

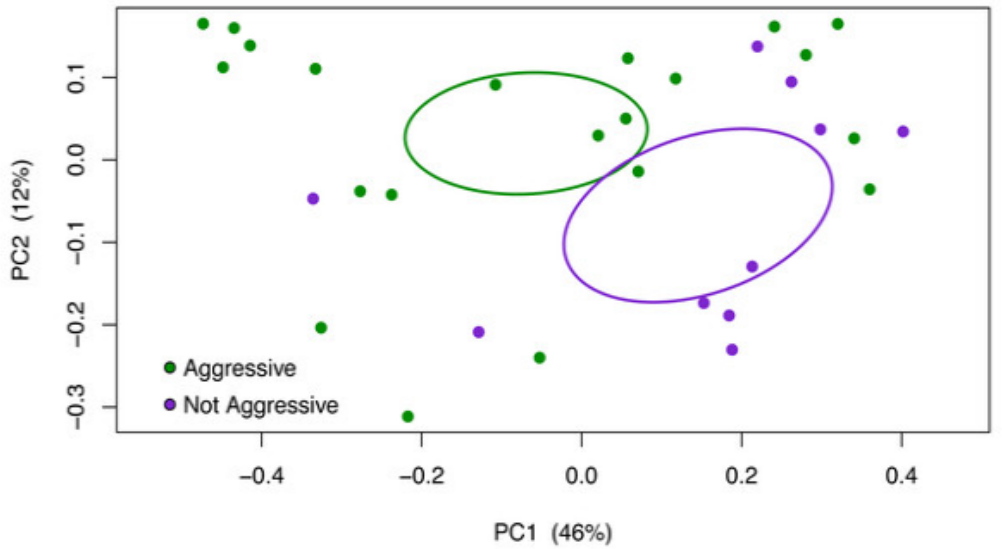


Figure 1: Aggressive and non-aggressive dogs differ in beta-diversity using the weighted UniFrac metric.
Visualization of the phylogenetic differences in fecal microbiota of aggressive (green) and non-aggressive (purple) dogs using principal coordinates analysis (PCoA) of OTU abundances and weighted UniFrac distance. The separation between aggressive and non-aggressive samples in the PCoA plot was confirmed with an environmental fit analysis ($p = 0.0250$, $R^2 = 0.1297$), which supports aggression status as being a variable that is separating the microbial composition of the samples. The gut microbiome structure of aggressive and non-aggressive dogs is also significantly different with the weighted UniFrac metric using PERMANOVA ($p = 0.0346$, $R^2 = 0.0349$). Ellipses are based on 95% confidence intervals and standard error.

Investigating the Relationship between the Composition of the Canine Gut Microbiome and Aggressive and Phobic Behavioral Disorders

NIYATI AMBATI, UTTARA DAS, ANJALI PAGIDI, Amy Pike, Masoumeh Sikaroodi, Patrick M. Gillevet

Microbiome Analysis Center, George Mason University, Science & Technology Campus, Manassas, VA

The 2021 Aspiring Scientists' Summer Internship Program

Introduction

Canines come from a different background and like humans, dogs also face the same mental distress from traumatic experiences leading them to become aggressive. Aggressive behavior in dogs is usually influenced by their genetic makeup or the environment in which they are living. There are different forms of aggression or anxiety including territorial, predatory, fear-based, hyperarousal, confinement, separation, conflict, redirected, inter-dog aggression, global, noise, vet visits, travel, PTSD, compulsive disorder, neophobia, house soil, cognitive dysfunction, and general anxiety. Phobia in canines is the result of traumatic experiences and can develop from several different stressors. A dog is phobic when they experience an episode of intense fear, when it is confronted by a threat. The major categories of phobia include sound, blood injection, situational, and any interactions with strangers. The purpose of this experiment was to observe whether there was a difference in the composition of the gut microbiome in aggressive versus non-aggressive dogs. Based on results from previous studies, we expected to find that the most relatively abundant taxa in the fecal samples include Firmicutes, Bacteroidetes, Fusobacteria, and Proteobacteria (Kirchoff 2019, Mondo 2020). In addition, we predicted that the relative abundance of several taxa such as Lactobacillus, Fusobacteria, and Firmicutes will significantly differ between aggressive and non-aggressive dogs.

Methods

Samples collected from Animal Behavioral Wellness

DNA extraction of v1-v2 regions of 16s rDNA using QIAGEN Blood and Tissue kit, MagMAX Microbiome Ultra Nucleic Acid Isolation Kit (using a KingFisher instrument), and/or the FastDNA Spin kit for Soil

Performed PCR (27F and 355R)

Gel electrophoresis & PCR clean-up

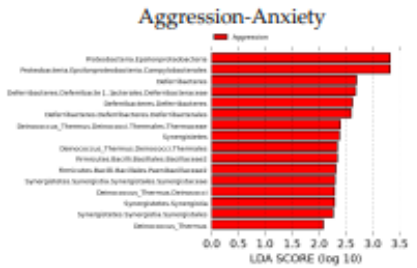
Fingerprinting, Template amplification

Sequencing clean-up, Enrichment
Sequencing with Ion Torrent

RDP 11 Bayesian Classifier,
LEfSe analysis and correlation networks with Cytoscape

Results

Figure III. Lefse Plot Showing LDA Scores between Aggressive and Anxious Dogs



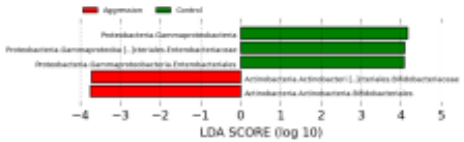


Figure IV. Lefse Plot Showing LDA Scores between Aggressive and Control Dogs

Figure V. Lefse Plot Showing LDA Scores between Anxious and Control Dogs

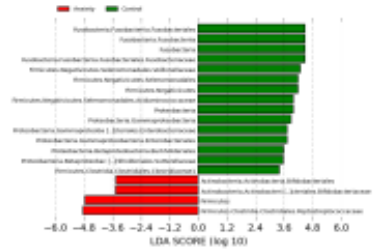


Figure VI. Directional correlation analysis of cortisol in aggressive dogs

Discussion & Conclusion

- The LEfSe plots show that the difference between the gut microbiomes of anxious and control dogs is greater than the difference between the other two groups.
- Based on this, aggression is less influenced by the gut microbiome compared to anxiety.
- Fusobacteria were abundant in the control and can cause oral diseases and infections.
- Firmicutes were abundant in the anxiety group and can correlate with obesity and diabetes.
- Bifidobacteriaceae were found in both aggressive and anxious dogs and can help with digestions.
- It was expected that there would be a positive correlation between cortisol and Coriobacteriaceae because they are both found in higher abundance in animals with higher stress levels. However, cortisol was found to negatively correlate with Coriobacteriaceae in aggressive dogs.
- These results demonstrate that an improvement in the health of the gut microbiome in dogs may aid their behavior. We recommend dietary probiotic supplements such as Visbiome Vet.

Figure I. Ion Torrent machine used for sequencing all samples

Figure II. Fingerprinting machine was the Genetic Analyzer 3130x

Major Citations

Kirchoff, N. S., Udell, M. A., & Sharpton, T. J. (2019). The gut microbiome correlates with conspecific aggression in a small population of rescued dogs (Canis familiaris). *PeerJ*. https://doi.org/10.7717/peerj.6103

Mondo, E., Barone, M., Soverini, M., D'Amico, F., Cocchi, M., Petrulli, C., Mattioli, M., Marliani, G., Candela, M., & Accorsi, P. A. (2020). Gut microbiome structure and adrenocortical activity in dogs with aggressive and phobic behavioral disorders. *Heliyon* 6(1). https://doi.org/10.1016/j.heliyon.2020.e03311

Acknowledgements

We would like to acknowledge Dr. Amy Pike and the Animal Behavioral Wellness for sample collection and assisting us in diagnosing the dogs.

Clinical case load

- Clinical case load
  - Non-specific GI signs
  - Non-response to medications
  - GI side effects with medications Text

Training treats and enrichment

What about obesity?

JSAP JOURNAL OF SMALL ANIMAL PRACTICE | BSAVA BRITISH SMALL ANIMAL VETERINARY ASSOCIATION

PAPER

Impact of feeding method on overall activity of indoor, client-owned dogs

D. K. Su, M. Murphy, A. Hand, X. Zhu, A. Witzel-Rollins

First published: 22 April 2019 | https://doi.org/10.1111/jsap.13003

Objective

To compare the total daily activity time, walking time and running time using food-dispensing toys *versus* bowls in a group of client-owned, primarily indoor dogs.

Materials and Methods

A two-way, two period, randomised repeated measures mixed-effects crossover study performed on 26 client-owned, primarily indoor dogs.

Results

Toy feeding increased average daily total activity time by 12% and walking time by 26%. Average daily total activity time and walking time were reduced by 8 and 7% respectively with each increase in year of age. Gender, body condition and muscle condition had no significant effect on average daily total activity or walking time. Toy feeding, time, their interaction, age, gender, body condition and muscle condition had no significant effect on average daily running time.

Clinical Significance

Feeding toys may be helpful during weight loss programs to achieve the goal of increasing daily exercise duration in dogs that need to lose weight.

- Approximately 40% of pets are obese
  - 97% found to be owner related factors

- Calculate actual needs and intake
- Use food for treats
- Save calories for treat and training
- Use feeder and puzzle toys
- Increase satiety to decrease begging behavior

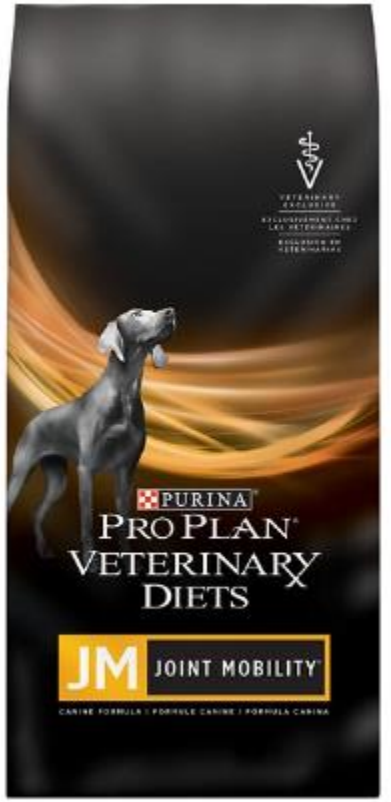
What about allergies?

- Fruits and veggies
- Hypoallergenic
- Marshmallows
- Protein source

Senior

Pain and osteoarthritis

- Nutritional supplements
- Diet changes
- Obesity and calorie reduction



Noise Sensitivities in Dogs: An Exploration of Signs in Dogs with and without Musculoskeletal Pain Using Qualitative Content Analysis

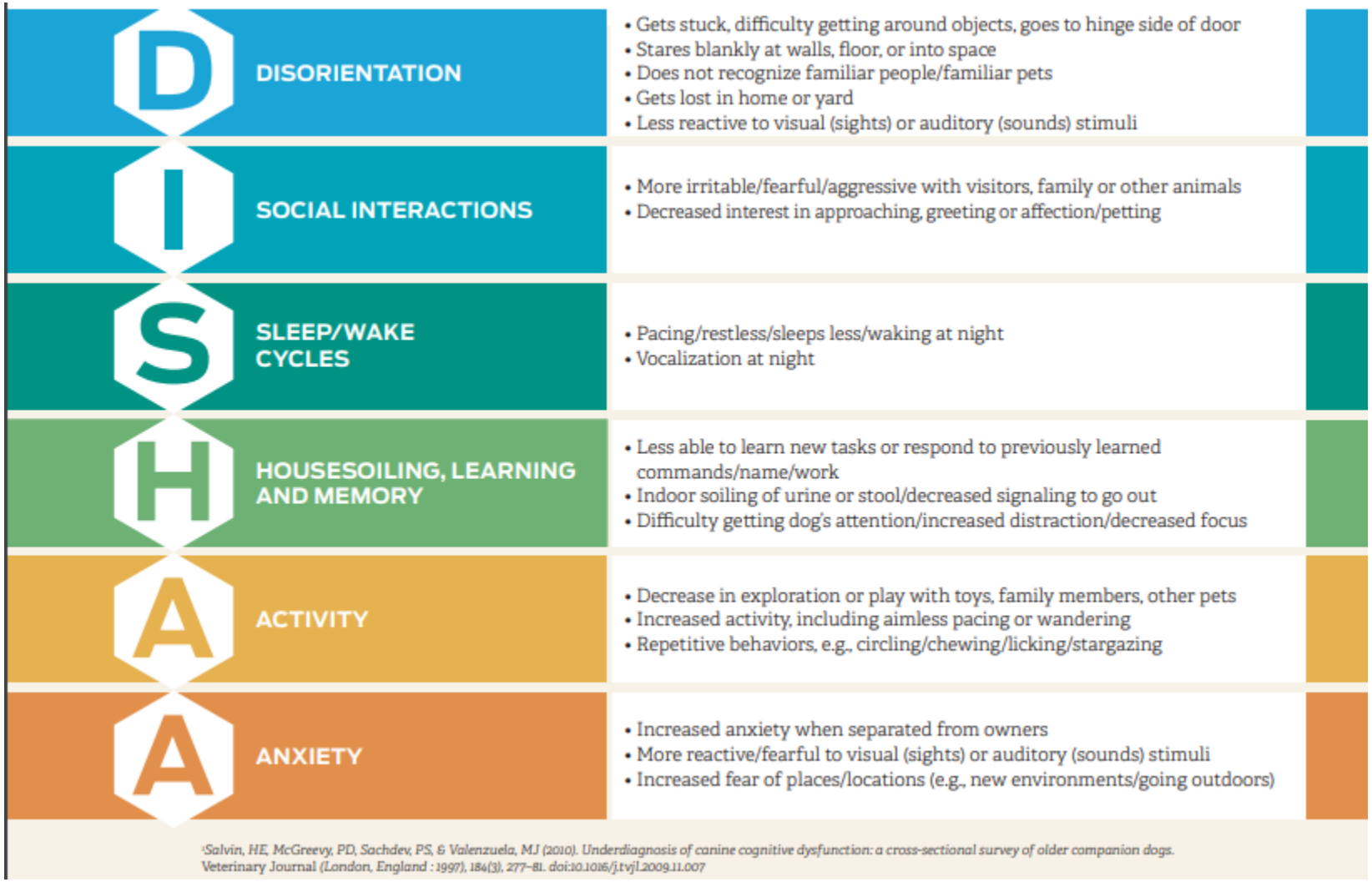
Ana Luisa Lopes Fagundes[1], Lynn Hewison[2], Kevin J. McPeake[2]*, Helen Zulch[2] and Daniel Simon Mills[2]

[1]Centro Universitário de Belo Horizonte, Belo Horizonte, Brazil

[2]Animal Behaviour Clinic, School of Life Sciences, University of Lincoln, Lincoln, United Kingdom

Noise sensitivity is a common behaviour problem in dogs. In humans, there is a well-established relationship between painful conditions and the development of fear-related avoidance responses. Whilst it is likely that a relationship exists between noise sensitivity and pain in dogs, this does not appear to have been investigated. The aim of this study was to explore the signs of noise sensitivity in dogs with and without musculoskeletal pain by comparing case histories using qualitative content analysis. Data were extracted from the clinical records of 20 cases of dogs presenting with noise sensitivity seen by clinical animal behaviourists at the University of Lincoln, composed of 2 groups—10 "clinical cases" with pain and 10 "control cases" without pain. Loud noises as a trigger of noise sensitivity were a common theme in both groups but ubiquitous among "clinical cases." In "clinical cases" (i.e., those where pain was identified), the age of onset of the noise sensitivity was on average nearly 4 years later than "control cases." In addition, strong themes emerged relating to widespread generalisation to associated environments and avoidance of other dogs in the "clinical cases," which did not appear in the "control cases." "Clinical cases" responded well to treatment once the involvement of pain had been identified. Veterinarians and behaviourists should carefully assess dogs with noise sensitivities for pain-related problems especially if presenting with these characteristics.

Cognitive Dysfunction



[1]Salvin, HE, McGreevy, PD, Sachdev, PS, & Valenzuela, MJ (2010). *Underdiagnosis of canine cognitive dysfunction: a cross-sectional survey of older companion dogs.* Veterinary Journal (London, England : 1997), 184(3), 277–81. doi:10.1016/j.tvjl.2009.11.007

Cognitive Dysfunction

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Prevalence of behavioral changes associated with age-related cognitive impairment in dogs

Jacqueline C. Neilson DVM, DACVB[1], Benjamin L. Hart DVM, PhD, DACVB[2], Kelly D. Cliff DVM[3], a...

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DOI: https://doi.org/10.2460/javma.2001.218.1787

Volume/Issue: Volume 218: Issue 11 Online Publication Date: 01 Jun 2001

CADES study

ELSEVIER

Applied Animal Behaviour Science

Volume 171, October 2015, Pages 138-145

Assessment of severity and progression of canine cognitive dysfunction syndrome using the CAnine DEmentia Scale (CADES)

Aladar Madari [a, 1], Jana Farbakova [a, 1], Stanislav Katina [b, 1], Tomas Smolek [c], Petr Novak [c], Tatiana Weissova [a], Michal Novak [c], Norbert Zilka [c, d]

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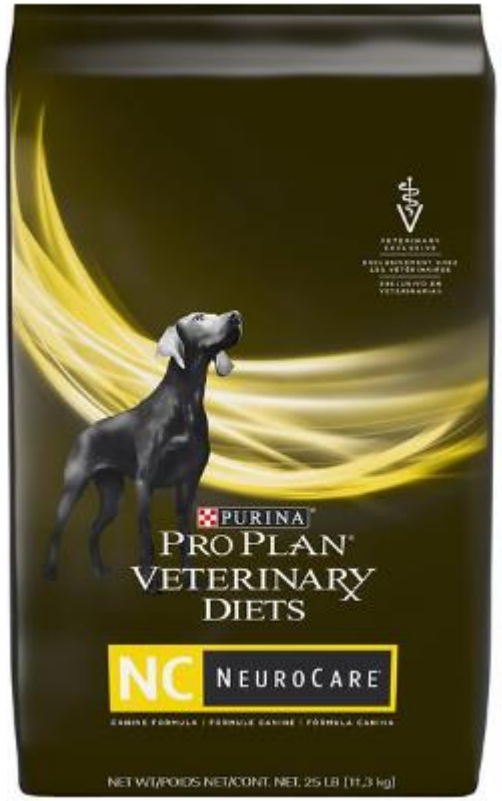

You CAN teach and old dogs new tricks

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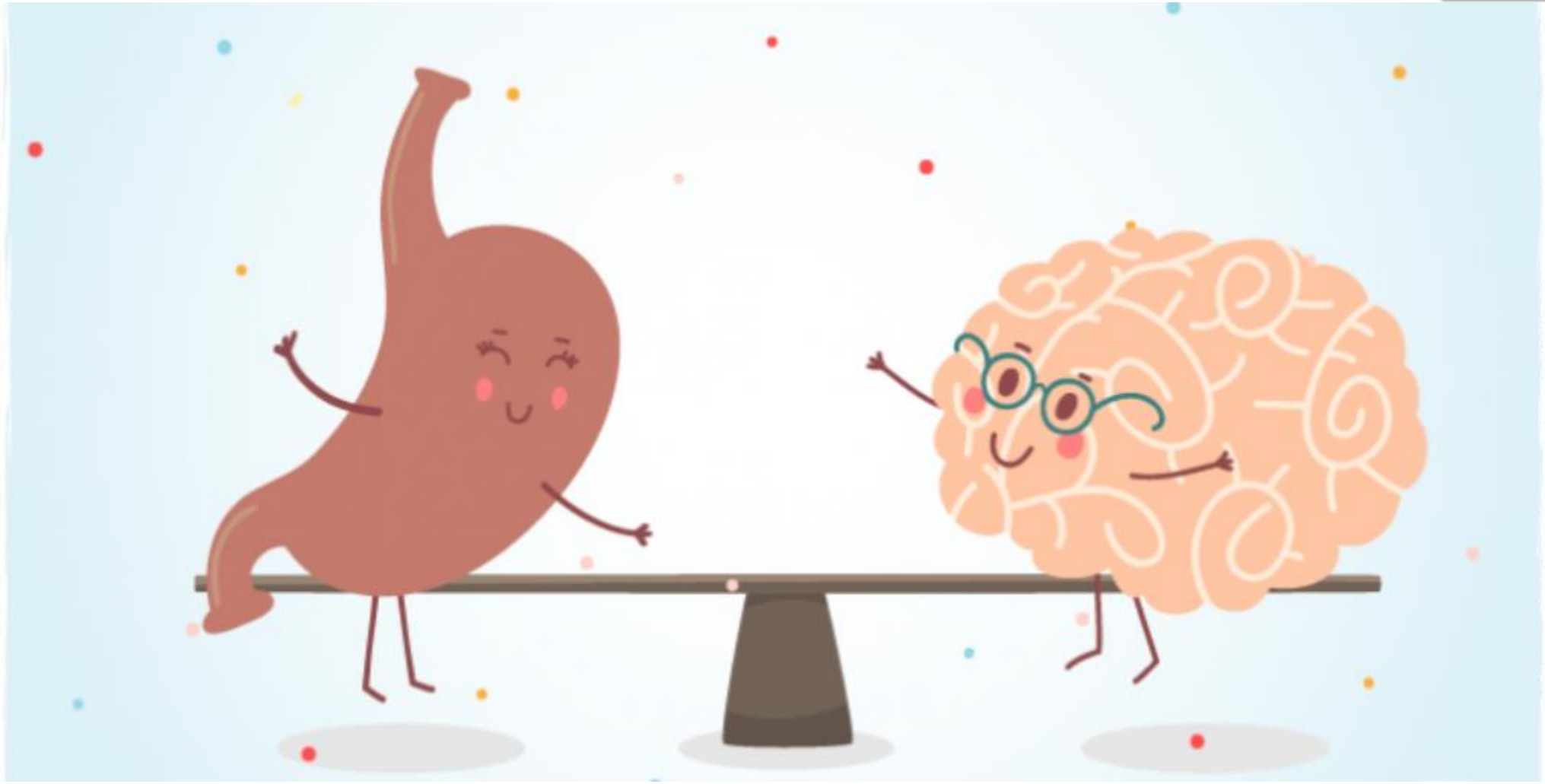
Use It…

or… Lose It

Conclusion



Questions?