Canine Performance Sciences

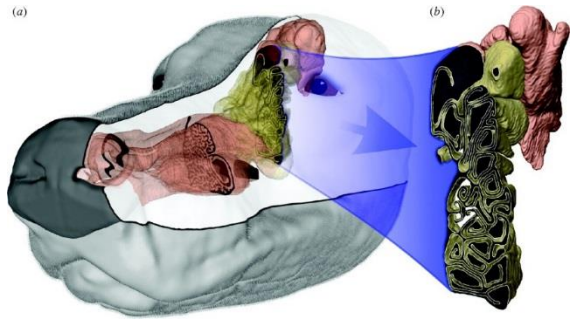
Advancing the Mobile Sensor Technology

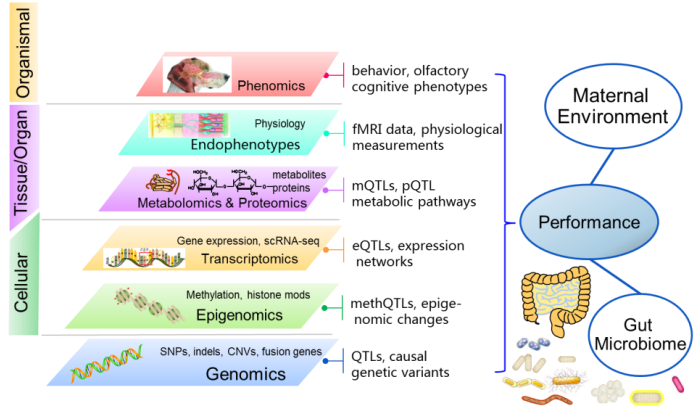
Building a Better Detector Dog

Pamela Haney, MS
Lucia Lazarowski, PhD

MISSION STATEMENT

To innovate canine detection technology by exploring basic and applied research frontiers in olfaction, behavior, genetics, and physical performance.





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CPS Vision

VISION STATEMENT

To enhance the power and lives of our canine partners so they can make the world a safer place.

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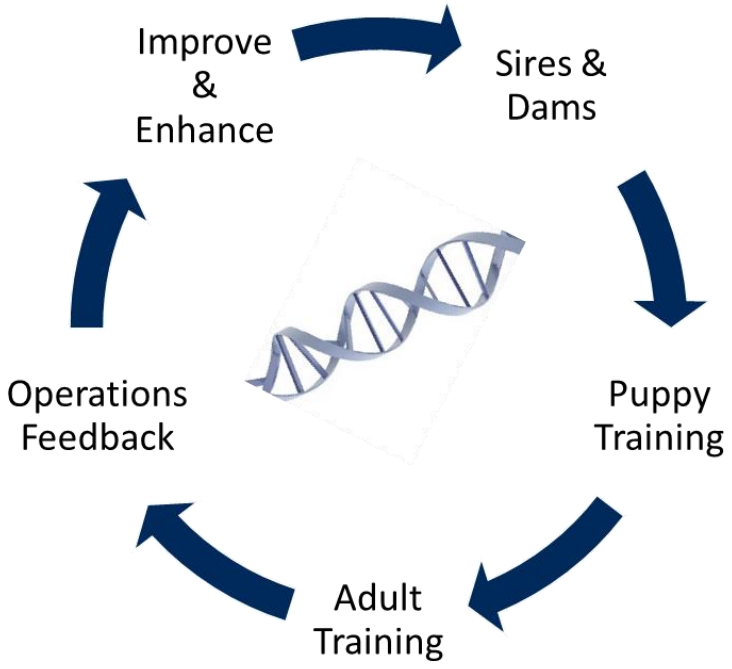
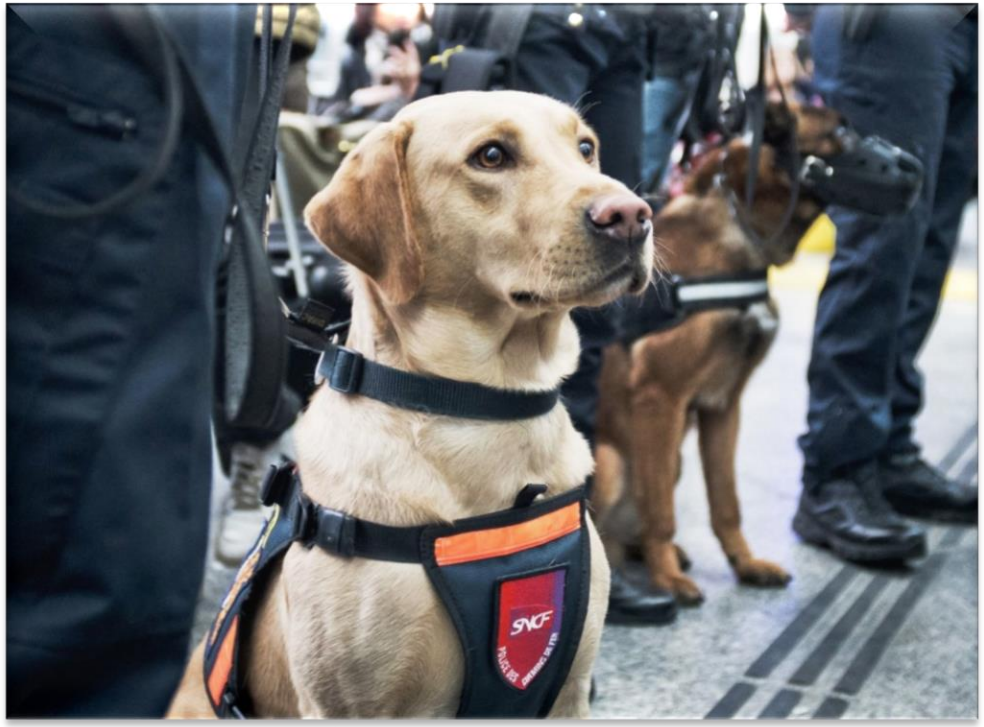
Breeding Program

Enhance Domestic Production of Detector Dogs





Determine the Best Production Model of Detection Dogs

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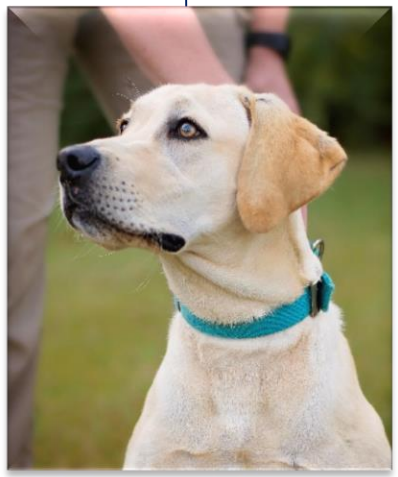
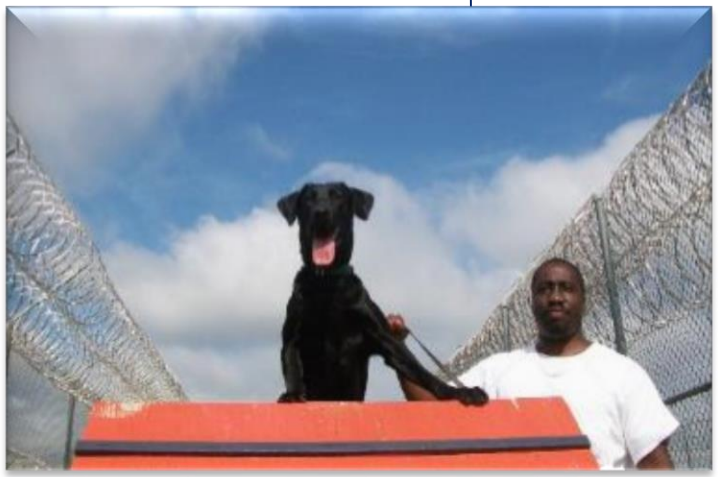
Breeding Program Phases

Breeding → Pregnancy and Whelping → Birth to 7 weeks: Early Development at CPS → 7 wks to 6 months: Intermediate Development at CPS → 6 to 10 months: Intermediate Development at Prisons → 10 to 12 months: Final Evaluation/ Placement





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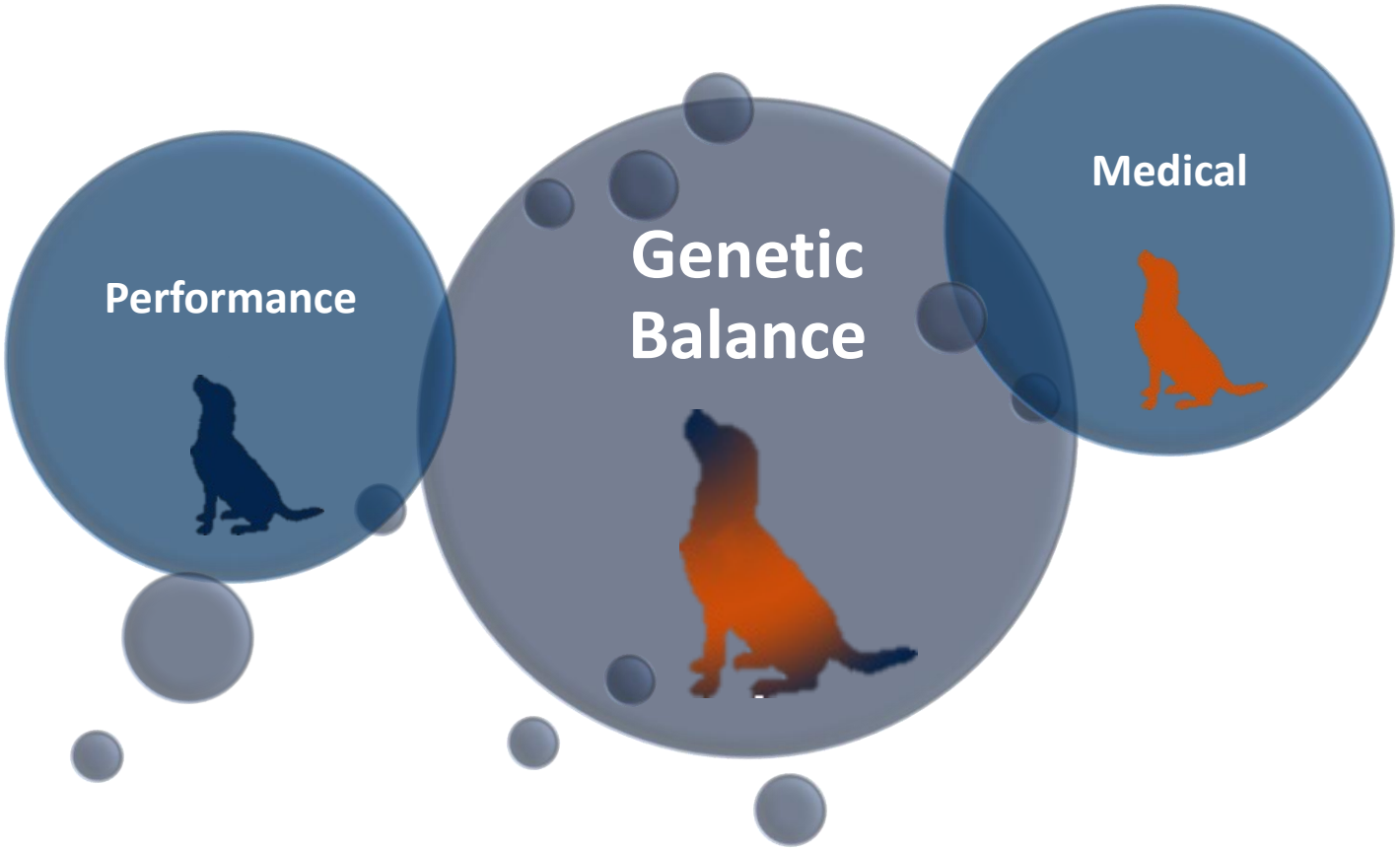
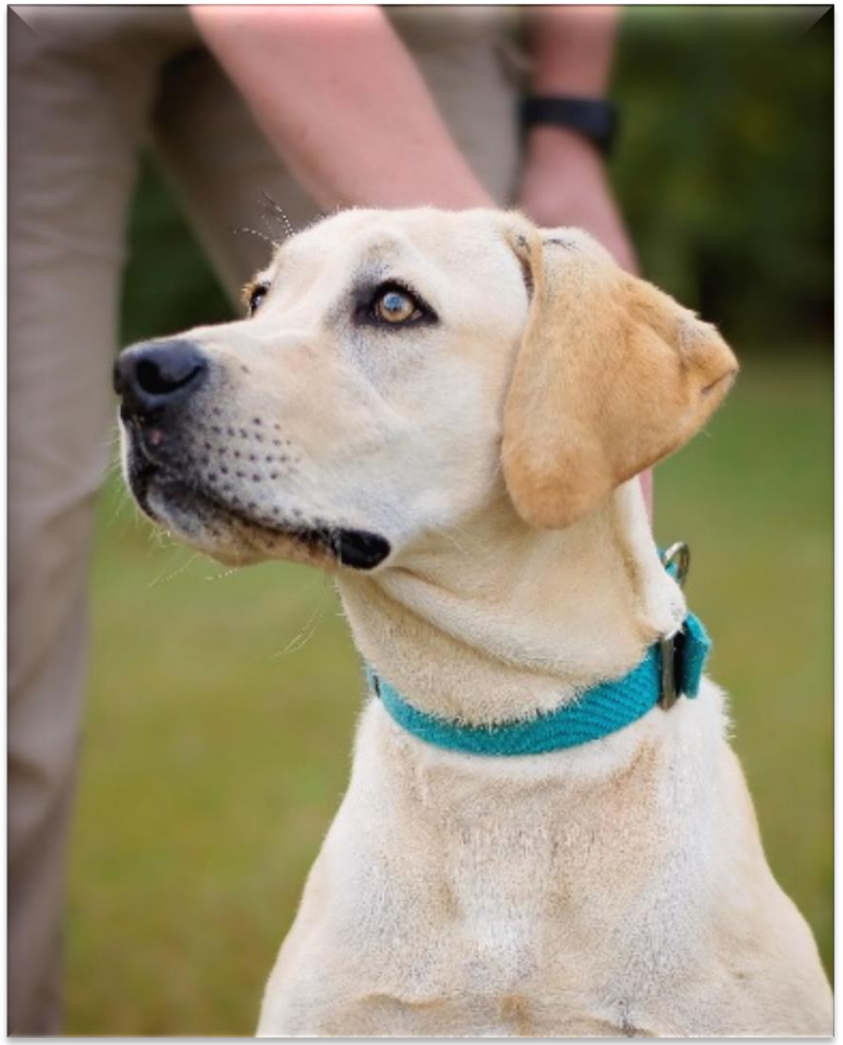
CPS Breeder Requirements



Breeder Requirements

CPS Breeder Medical Requirements

- PennHip - DI at or below 0.30
- OFA - Good/Excellent Hips
- Elbows/Shoulders/Stifles-Normal
- No Transitional Vertebrae
- EIC - Clear
- CNM - Clear
- prcd-PRA – Clear
- Eye CERF - Normal
- Echo-Normal
- Brucellosis - Negative



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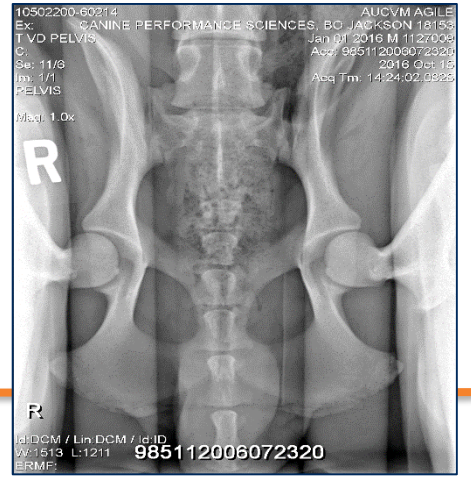
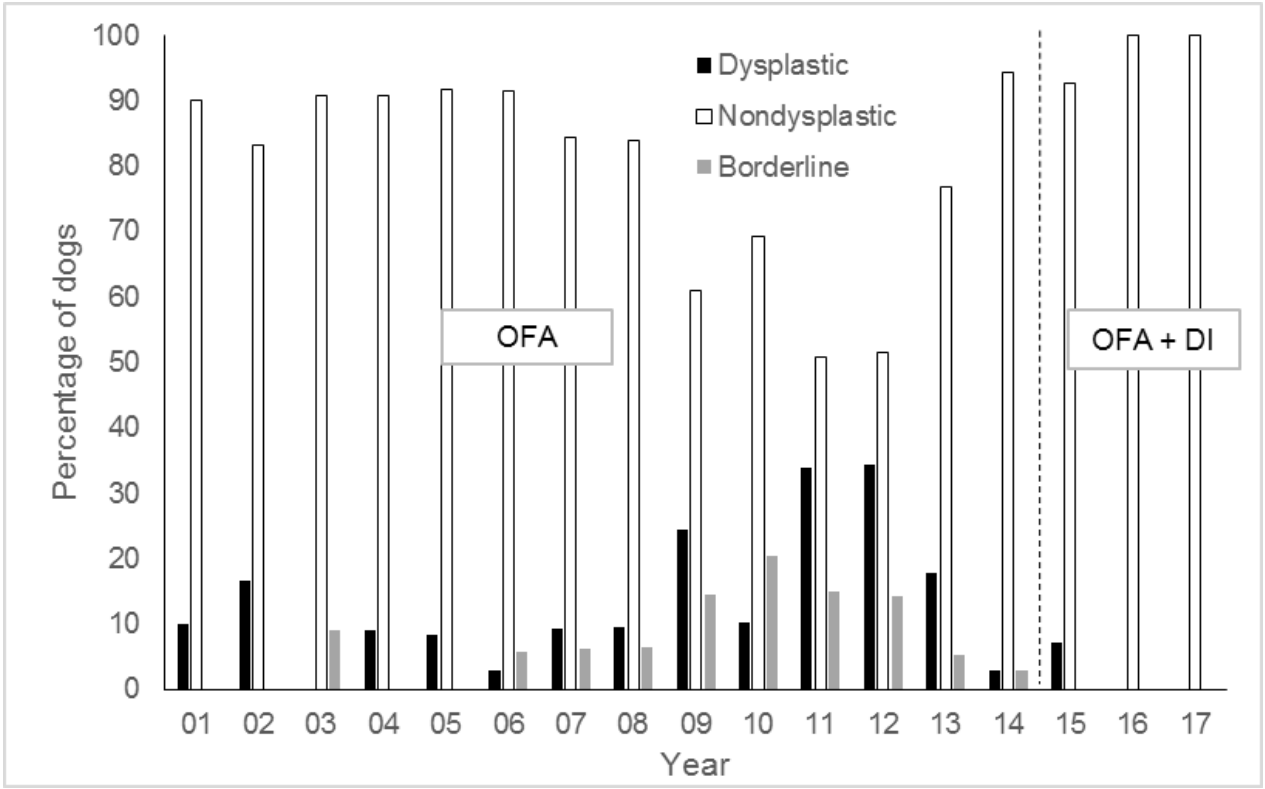
Breeding Program Advancements Eliminating Hip Dysplasia

Haney, P. S., Lazarowski, L., Wang, X., Wang, X, Hathcock, J., Lofton, R., Wilborn, R., Waggoner, L. P. (in press). **Effectiveness of PennHIP and Orthopedic Foundation for Animals hip quality measurements for breeding selection to reduce hip dysplasia in a population of purpose-bred detection dogs.** *Journal of the American Veterinary Medical Association.*





- **Significantly improved population hip quality by 22% with addition of PennHIP DI as breeder selection tool**
- **Effectively eliminated hip dysplasia from population**
- **No dog with hip dysplasia produced since 2015**

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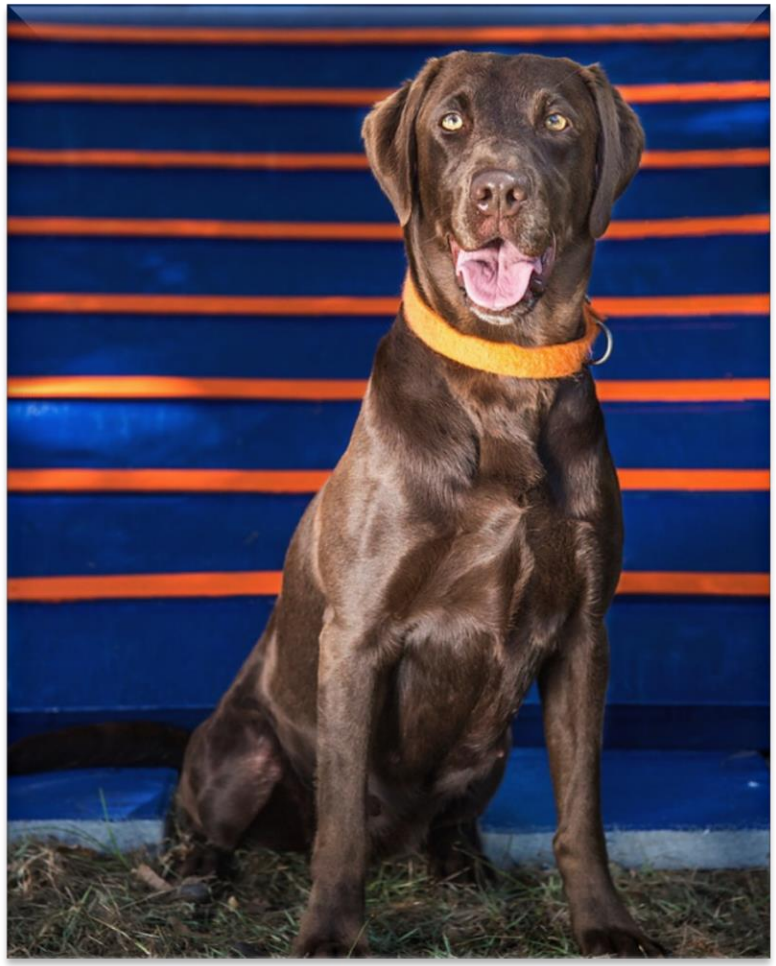
Breeding Program Advancements Eliminating Hip Dysplasia

- OFA measures will eliminate worst hips from population.
- OFA is a good measure for hip quality of a working population.
- PennHIP DI as breeding selection tool can eliminate hip dysplasia from a population.
- PennHIP DI should be the gold standard hip quality measure for entrance into a breeding colony.



Future

CPS population DI

0.38 ± 0.10

Does exercise help reduce hip laxity in growing pups?

Does exercise increase bone density in growing pups?

Do pups with more rear limb proprioception have healthier gaits, which in turn improves overall movement and reduces stress on hip joints?

Breeding Program Advancements
Retrospective Study: Determinates of Litter Size

Multiple factors within a single breeding cycle were examined from AUCVM-CPS breeding program between January 2014 – May 2019

Factors Include

- Age of Dam
- Semen Type
- Semen Quality
- Insemination Method
- Site of Semen Deposition
- Number of Inseminations

Multiple regression including Matings + Semen Type + Natural Tie + Insemination Location + Age of Dam + Estrus Management Drugs significantly predicted the number of pups conceived

55 Breeding Cycles with 26 females

$$F_{(7, 47)} = 9.08,\ p < 0.001,\ R^2 = 0.5116$$

*Unpublished data

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Breeding Program Advancements
Retrospective Study: Determinates of Litter Size

Mean Litter size	Median Litter size	Range Litter size
5.45 ± 3.87 pups	6 pups	0 – 12 pups

# of inseminations per breeding cycle	
Mean 2.47 ± 0.74	Range 1 - 4

Discovery:

One live cover mating ↑ litter size by 2 pups

One TCI mating ↑ litter size by 3 pups

*Unpublished data

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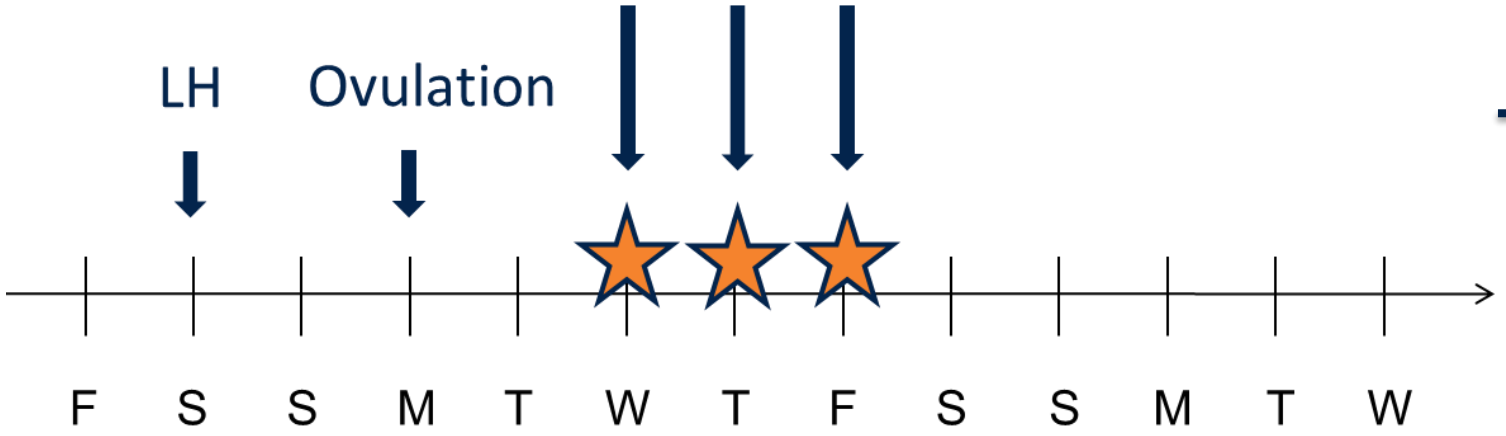
CPS Standard Breeding Practices

- Ovulation timing to confirm peak fertile window
- Standardized Breeding Cycle – Spring 2018

Breeding Cycle – Goal: 3 Matings

Live Cover, TCI, Live Cover/VAI



12 Litters born since April 2018

	Mean Litter size
	8.08 ± 2.99 pups
Conception Rate	**Median Litter size**
100%	9 pups
Semen Type	**Range Litter size**
Fresh	2 – 12 pups

Breeding Program Advancements
Elective C-Sections

- In 2014, CPS replaced Free Whelping with Elective C-sections
- Elective C-sections were chosen with hopes of:
  - ↓ duration of whelping
  - ↓ stress for dam and pups
  - ↑ neonatal survivability
  - ↑ controlled whelping process

Neonatal Survivability = Number of viable pups after 24 hours

Breeding Program Advancements
Retrospective Study: Elective C-Sections

- **CPS Breeding Colony Typical Gestation length**
  - –63 days ± 1 day from LH surge
  - **–61 days ± 1 day from ovulation**

C-section delivery was **significantly faster** (47 ± 11 minutes, n=17) when compared to free whelping (237 ± 66 minutes, n=12), $p < 0.001$.

*Unpublished data

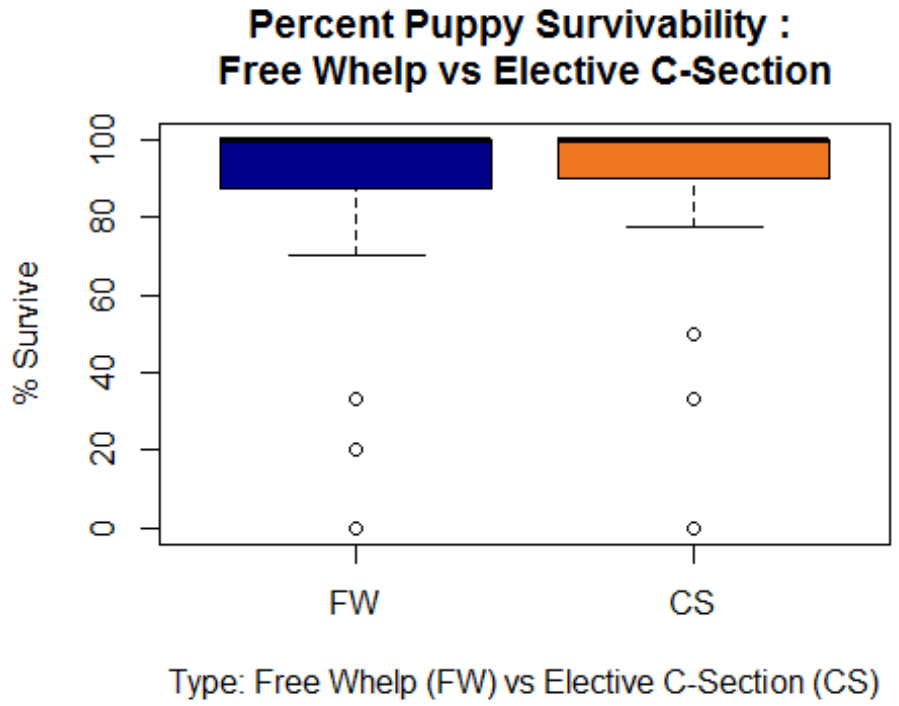
Breeding Program Advancements
Retrospective Study: Elective C-Sections

Puppy Survivability

- **Free Whelp = 27 Litters**
  (includes 4 litters that resulted in emergency C-section)
- **Elective C-Section = 28 Litters**

Puppy survivability **did not significantly differ**

between free whelp and elective C-section, p = 0.68.



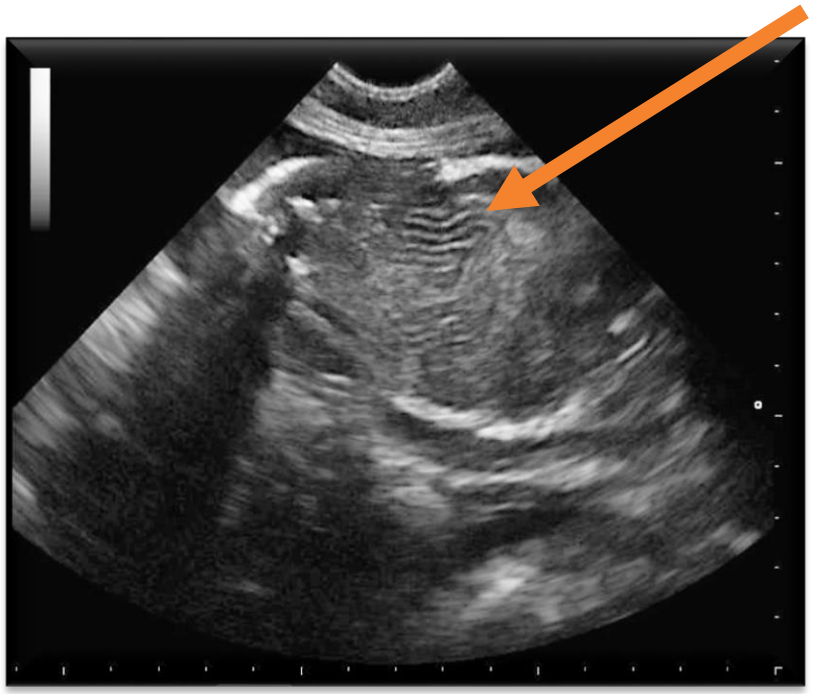
*Unpublished data

HOW TO KNOW WHEN DAM IS READY FOR C-SECTION?

- Ovulation timing performed during estrus-more exact projected DOB
- Progesterone value of <2 ng/ml on day of C-section

  Submit blood samples starting 3 days prior to whelping
- Ultrasound exams to assess fetal maturation

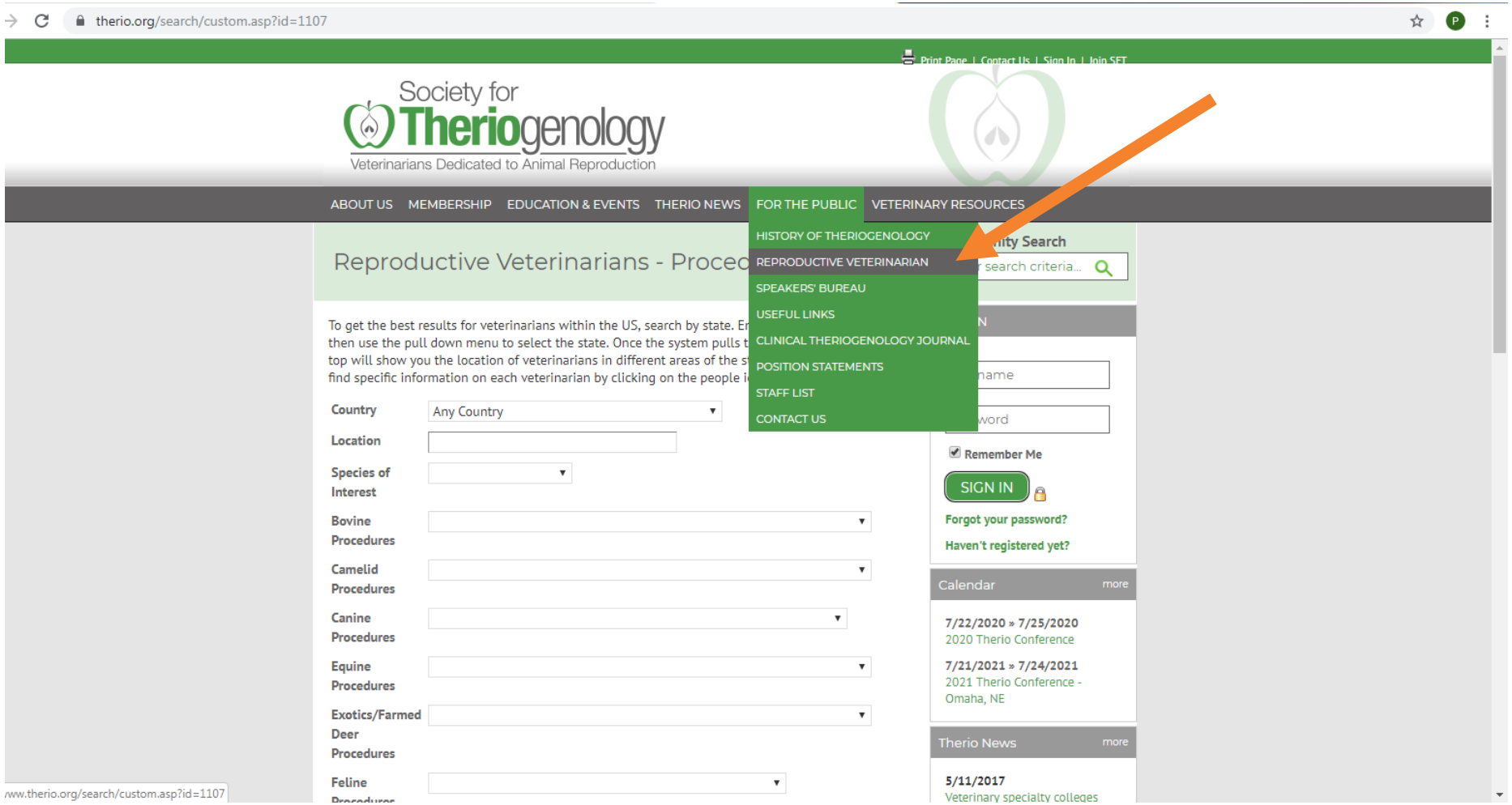
  Perform starting 3 days prior to whelping
  - Fetal Heart rate
    - > 200 beats per minute
  - Fetal maturation
    - Kidneys ~57 days
    - Intestines ~61-62 days
      - » View peristalsis on ultrasound
  - Maternal behaviors
    - Nesting (usually seen overnight when dam is alone)
    - Lack of appetite
    - Decline in body temperature of the dam??



Resources

Society for Theriogenology: "Find a Vet" feature

www.therio.org



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Breeding Program Advancements
Examining Maternal Influences

Maternal influence on puppy health and behavior

- Placenta is a critical organ for fetal morphological and behavioral development, especially brain development
- Identify signatures in placental transcriptome associated with traits of interest
- Placental immunity/inflammation status affects offspring behavior and the level of stress

Environmental signals (nutrient, stress, etc)

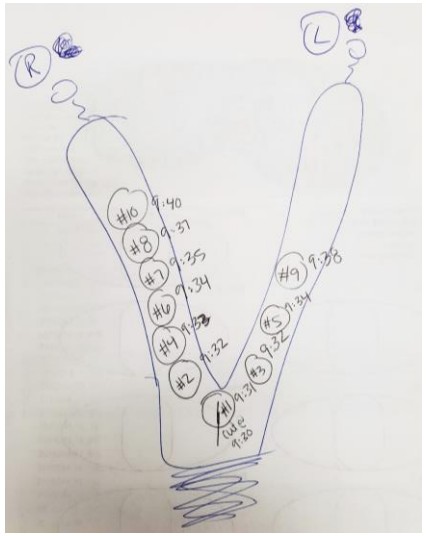
↓

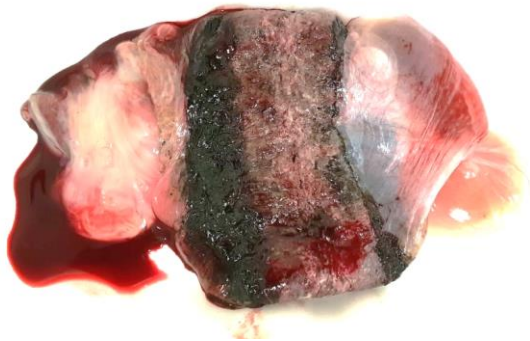
Placenta gene expression and epigenetic profiles

↓

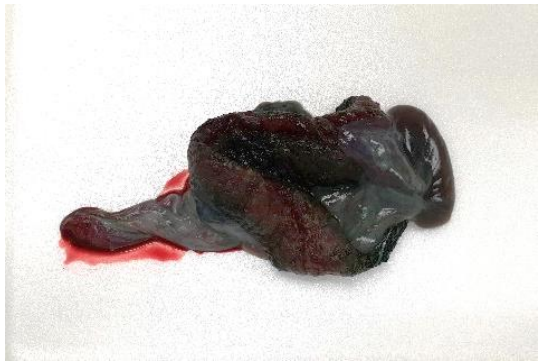
Neurodevelopment and programming

CPS dog placental samples collected on August 17, 2018 from a litter of 10





healthy, 102g



deceased 1-day after birth, 52g

Breeding Program Advancements
Examining Maternal Influences

Puppy APGAR scores
Impact of Elective C-section on pups

Litter DOB:_____

Bitch's Patient Sticker/Info

Color:_____ ID:_____

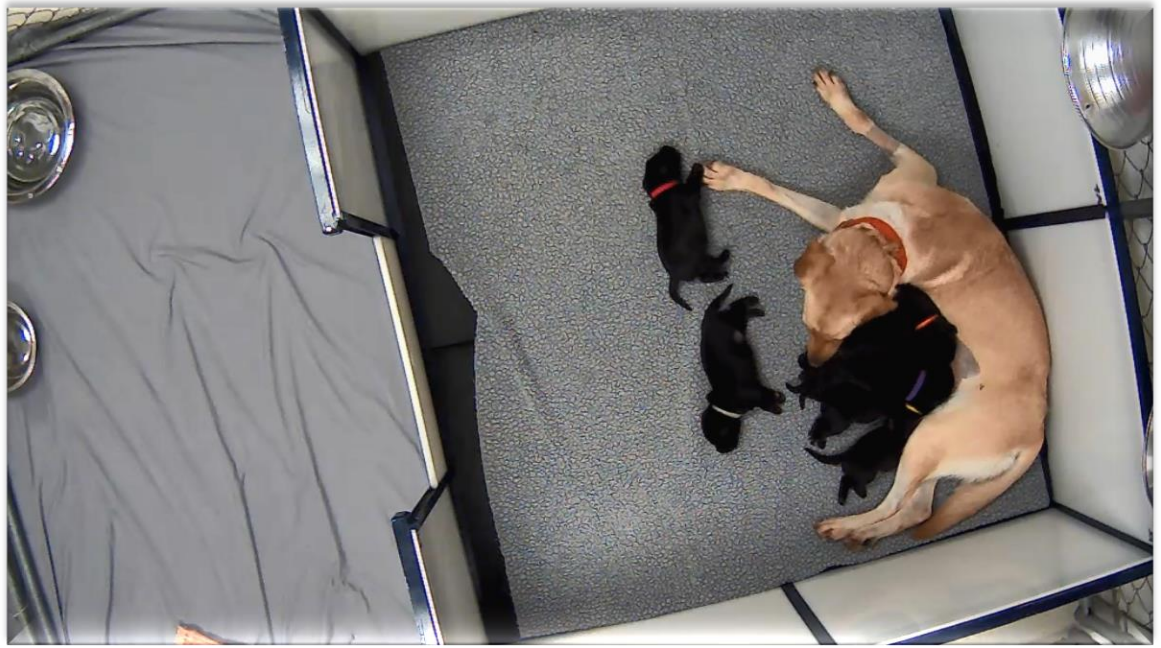
Sex:_____ Wt:_____

PE: Hard and soft palate ☐ Anus ☐ Urogenital ☐ Umbilicus ☐ Auscultation ☐ Abnormalities: _____

	0	1	2	Score: 5 min	30 min	2 hrs
Mucous Membrane color	Cyanotic	pale	pink			
Heart Rate	<180 bpm	180-220 bpm	>220 bpm			
Respiratory effort/rate	No crying/ <6 rpm	Mild crying/ 6-15 rpm	Crying/ >15 rpm			
Reflex irritability	Absent	Feeble reaction (grimace)	Vigorous Reaction (grimace/vocalization)			
Mobility, muscle tone	Flaccid	Some tone in extremeties	Active Movements			
Suckling (scored as -, +, ++)						
Rooting (scored as -, +, ++)						

Score: 7-10= No distress; 4-6=Moderate distress; 0-3= severe distress Totals: _____ _____

R. Wilborn, Auburn University



Behavioral interactions between dam and pups during postnatal period

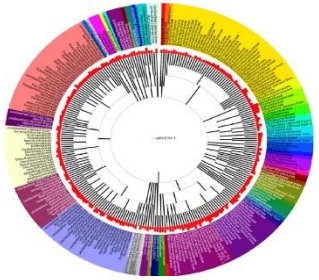
Referencing Bray *et al. (2017)* study

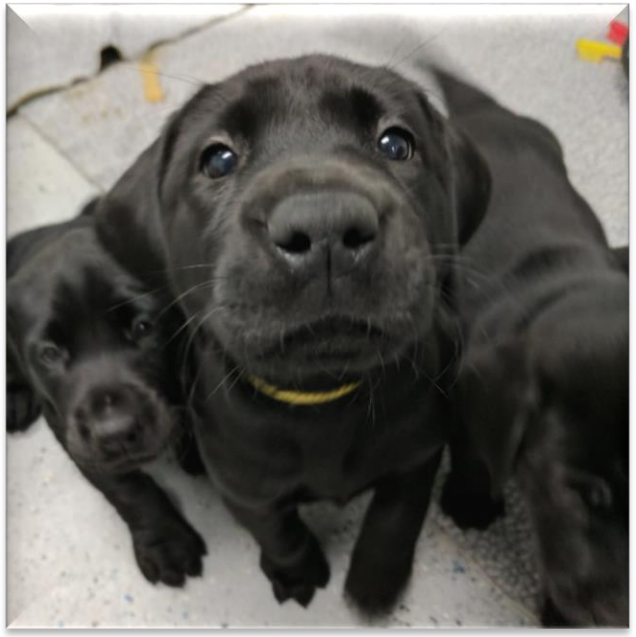
Breeding Program Advancements
Understanding Gut-Brain Axis

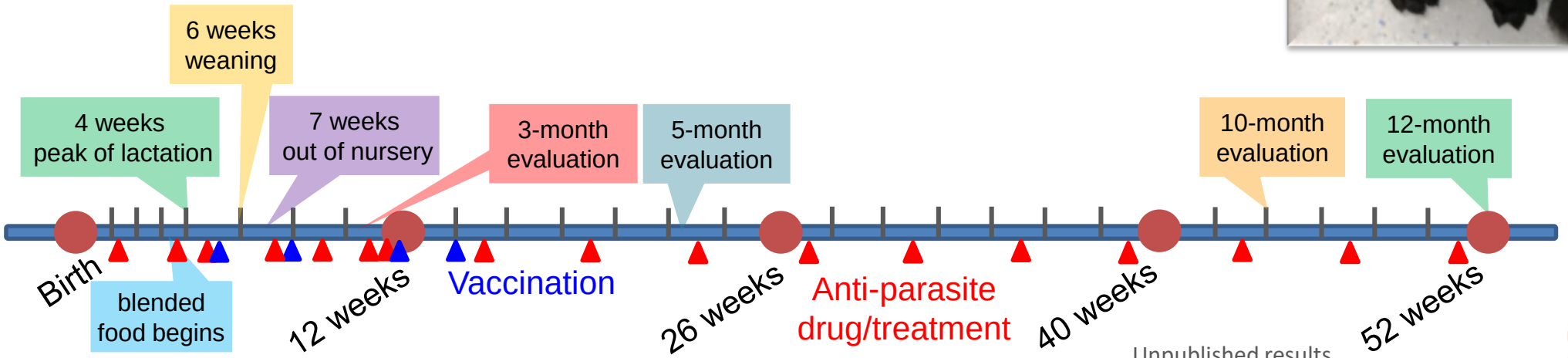
Gut microbiome and behavior – the microbiome-gut brain axis

Drs. Xu Wang & Gloria Wang,
Genomics Laboratory, AUCVM

Whole-genome sequencing
100 million reads per sample







Unpublished results

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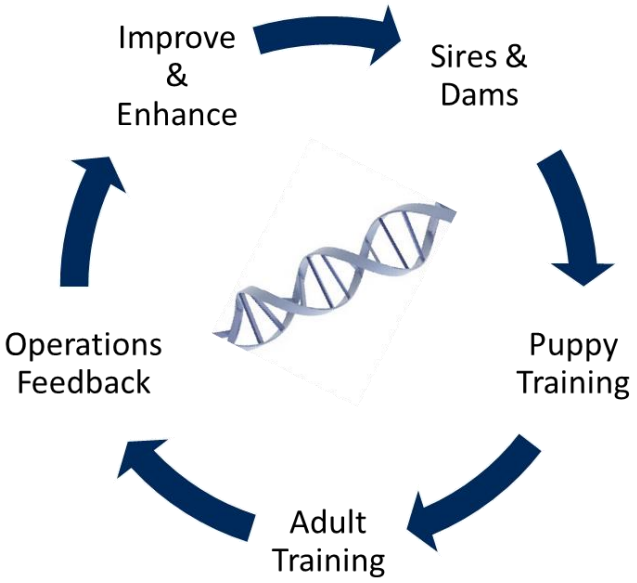
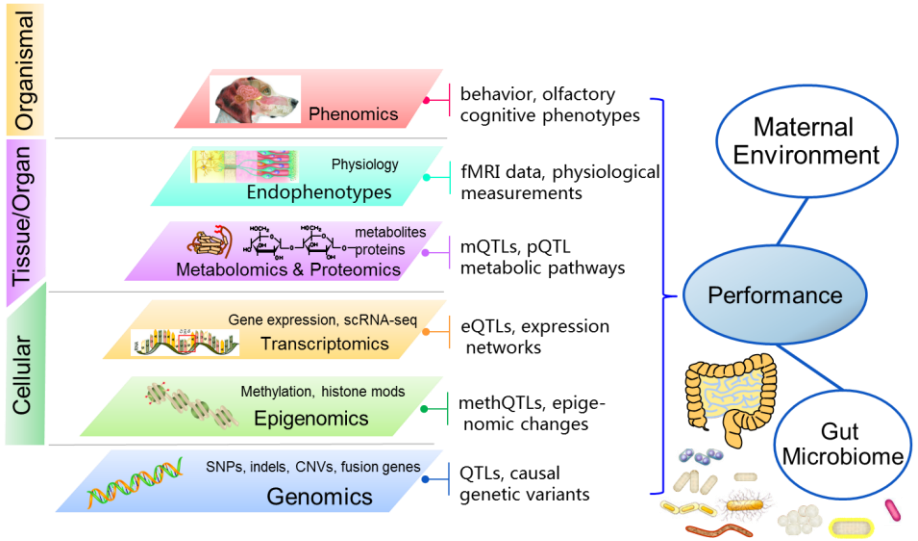
Breeding Program Advancements

Enhancing Domestic Production of Detector Dogs





Strategic Partners

BROAD INSTITUTE

HUDSONALPHA INSTITUTE FOR BIOTECHNOLOGY

Future

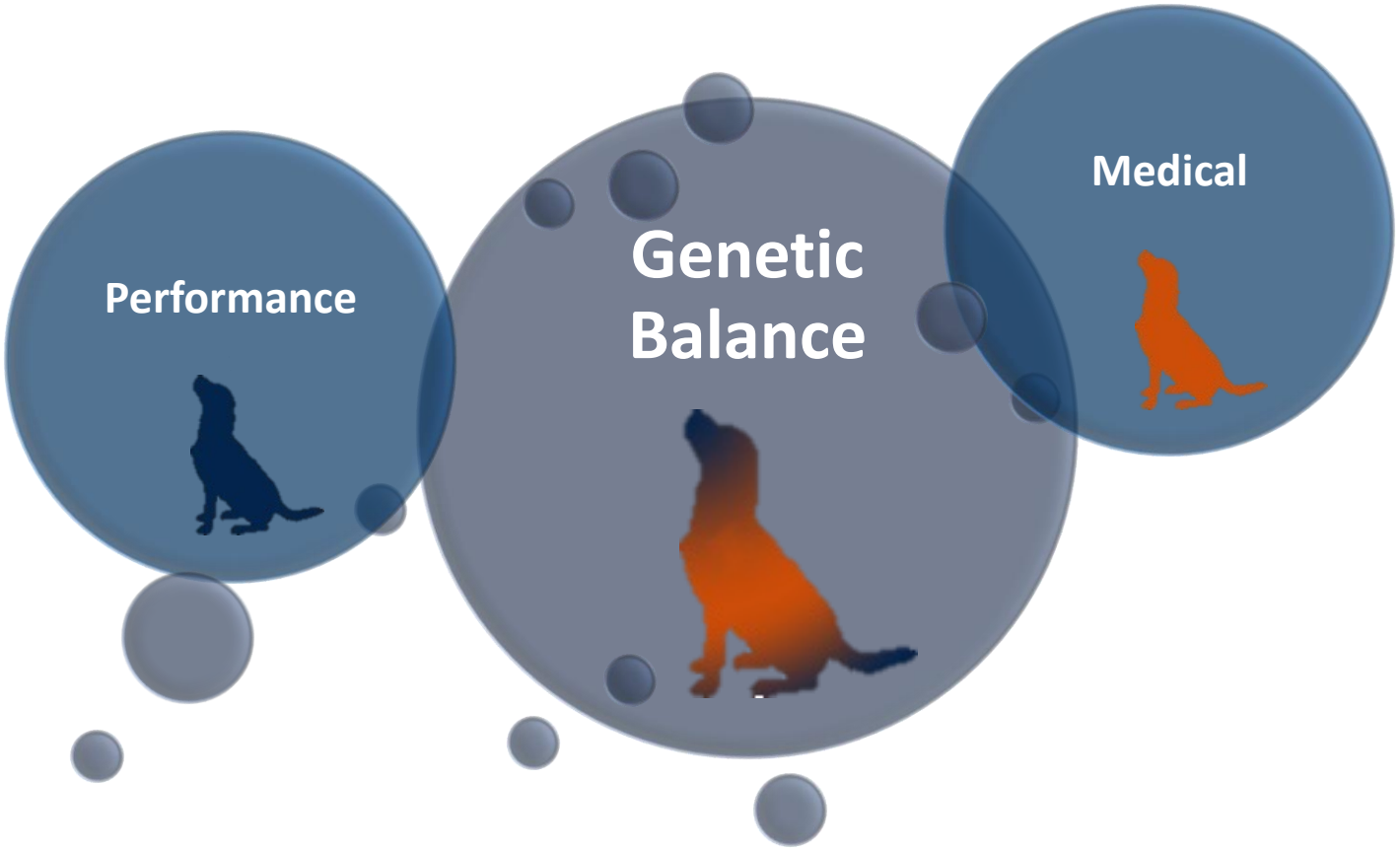
Conception rate of last 55 Breeding Cycles	11 not pregnant→ 9 used Frozen semen
80 %	

Average age of 1st estrus	Average time between estrus
17.4 months ± 8.69	7.47 months ± 1.61

Why so old? Like gymnasts? →
Solution: Examine genetics, pedigree, and various body systems.

Why trouble with Frozen?
Solution: Continue to use TCI for inseminations → then immediately Live Cover with a vasectomized male for each mating

CPS Breeder Requirements



Behavioral Characteristics of the Auburn Dog™

I. Overview of behavioral assessments; what we've done and what we've learned

II. Current and future directions in assessing, identifying, and breeding for improved behavior

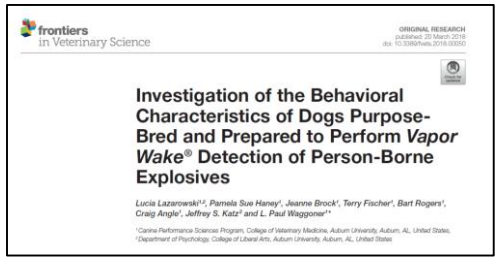
Background

What is the Auburn Dog™ Behavioral Phenotype?

Retrospective analysis of CPS behavior evaluations

N=157 between 2014-2016

3, 6, 10, 12 mo


frontiers in Veterinary Science

ORIGINAL RESEARCH

Investigation of the Behavioral Characteristics of Dogs Purpose-Bred and Prepared to Perform *Vapor Wake*® Detection of Person-Borne Explosives

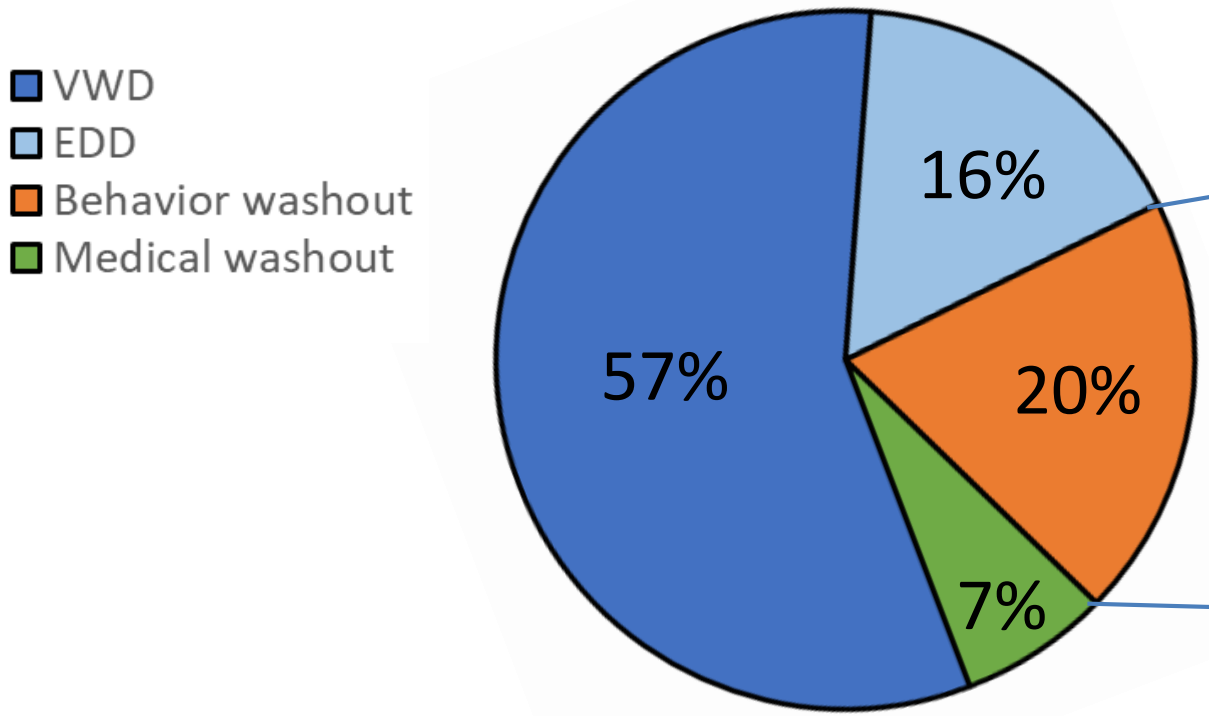
Performance	Retrieve
	Hunt
	Focus
	Possession
	Independence
	Work effort
	Air scenting
Environmental Soundness	Surfaces
	People
	Clutter
	Startles
Trainability	Overall

- Dogs in service
  - VaporWake®
  - Standard EDD
- Dogs unsuitable for service (washouts)

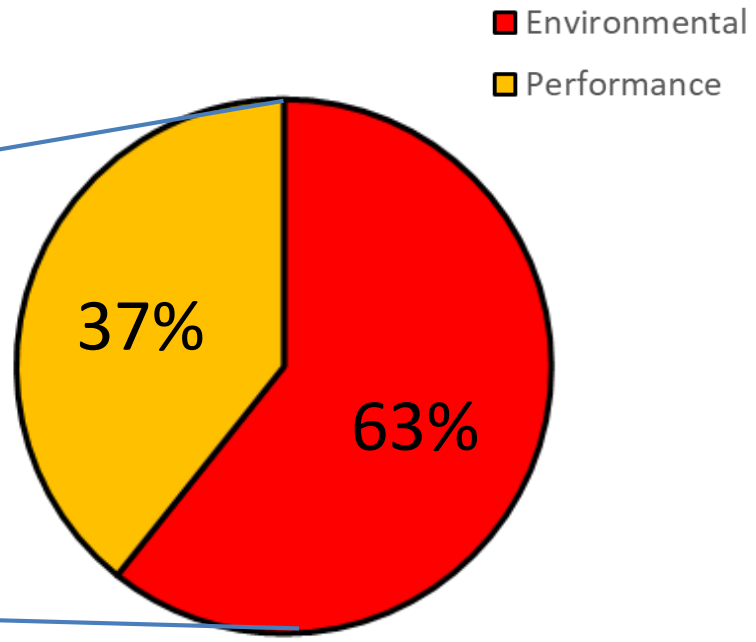
Results

Outcomes 2014-2016

N=157



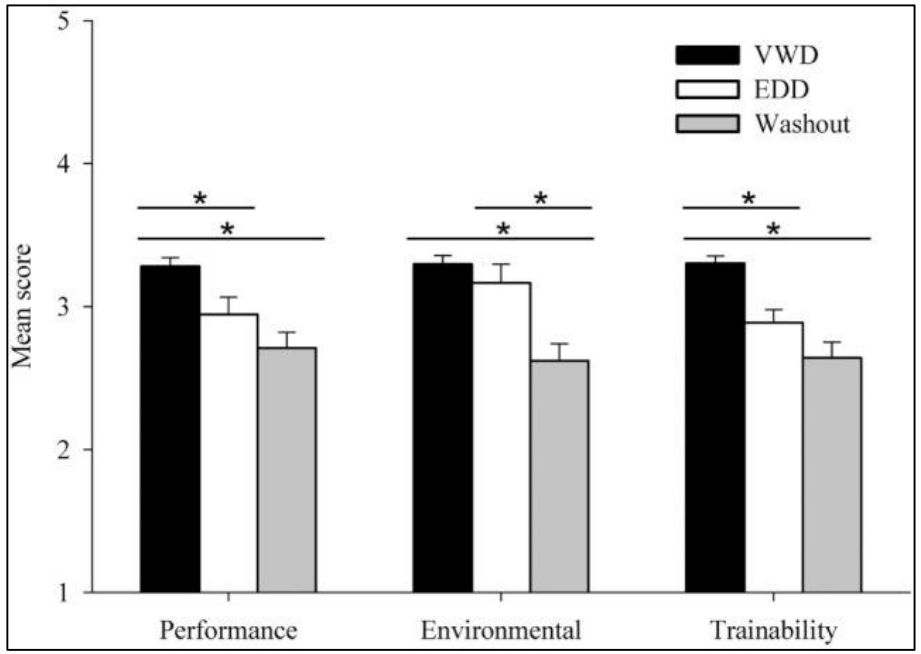
Behavioral issues



Results

- Distinct behavioral differences between **VaporWake™**, **EDD**, and **Washout** dogs
  - Performance-related traits differentiated VWD from EDDs, not ES
  - Environmental soundness greatest factor for serviceably as a working dog

- Service-quality dogs not necessarily reflect breeding quality

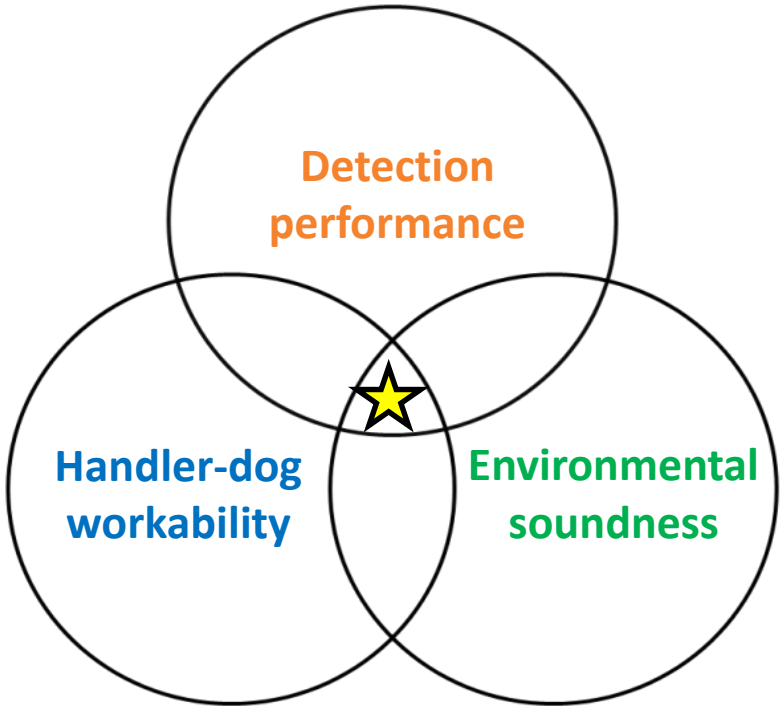


Lazarowski et al. (2018)

Breeder Requirements

CPS Breeder Behavioral Requirements

- Excellent hunt and air-scenting
- Deference for searching vs. social interaction with people
  - Balance between independence and trainability
- Focused, persistent, and composed when faced with difficult challenges
- Resilience in extreme work environments



Takeaways

- Refine definitions/measurement to gain better resolution of important traits
- Early prediction
- Improve environmental soundness
- Genetic vs. environmental

Approaches

I. Improve behavioral assessments

II. Emphasis on early development

I. Refinement of Behavior Evaluations

Incorporation of cognitive assessments

frontiers in Veterinary Science

ORIGINAL RESEARCH
published: 04 October 2018
doi: 10.3389/fvets.2018.00236

Enhanced Selection of Assistance and Explosive Detection Dogs Using Cognitive Measures

Evan L. MacLean[1,2]* and Brian Hare[3,4]

[1] School of Anthropology, University of Arizona, Tucson, AZ, United States, [2] Department of Psychology, University of Arizona, Tucson, AZ, United States, [3] Evolutionary Anthropology, Duke University, Durham, NC, United States, [4] Center for Cognitive Neuroscience, Duke University, Durham, NC, United States

Cognitive testing

N= 81 @ 3, 6, and 11 mo

Cognitive Domain	Sub-domain	Test
Social	Communication	Gesture following
		Help solicitation
	Empathy	Emotion contagion
Physical	Reasoning	Causal cues
	Spatial navigation	Barrier detour
	Object permanence	Spatial transpositions
General	Executive Functions	Working memory
		Self control
		Attention
	Motivation	Persistence
		Emotion regulation

Duke University Dog Cognition Test Battery

Behavior evaluations

Performance	Retrieve
	Hunt
	Focus
	Possession
	Independence
	Work effort
	Air scenting
Environmental Soundness	Surfaces
	People
	Clutter
	Startles
Trainability	Overall

Final outcome:

☑ Success

☒ Washout

Canine Performance Sciences

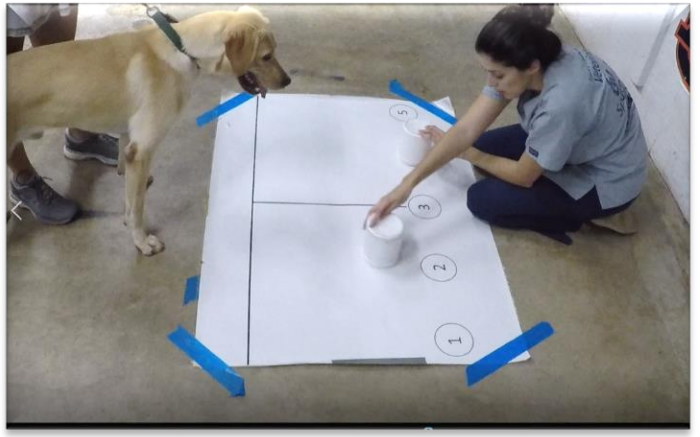
I. Refinement of Behavior Evaluations: Cognitive assessments

Joint attention

Social bias

Inhibitory control

Problem-solving



Behavioral flexibility

Persistence

Attention/Memory

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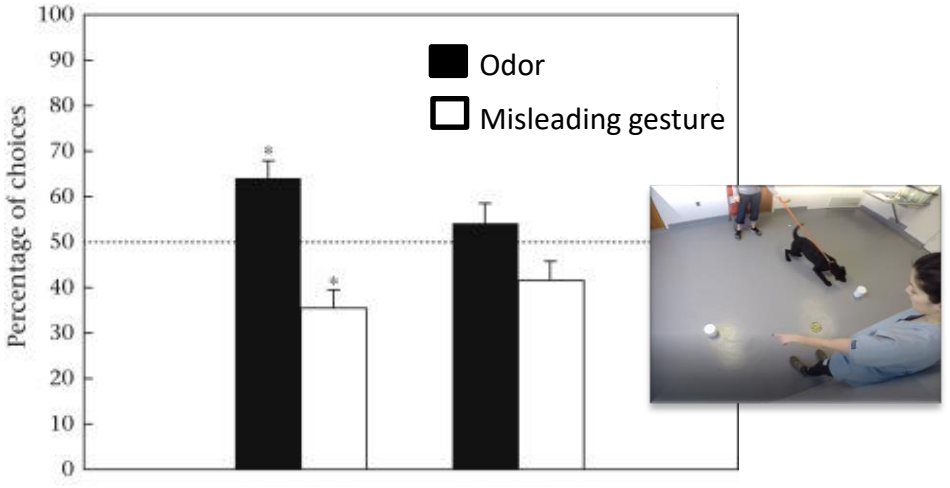
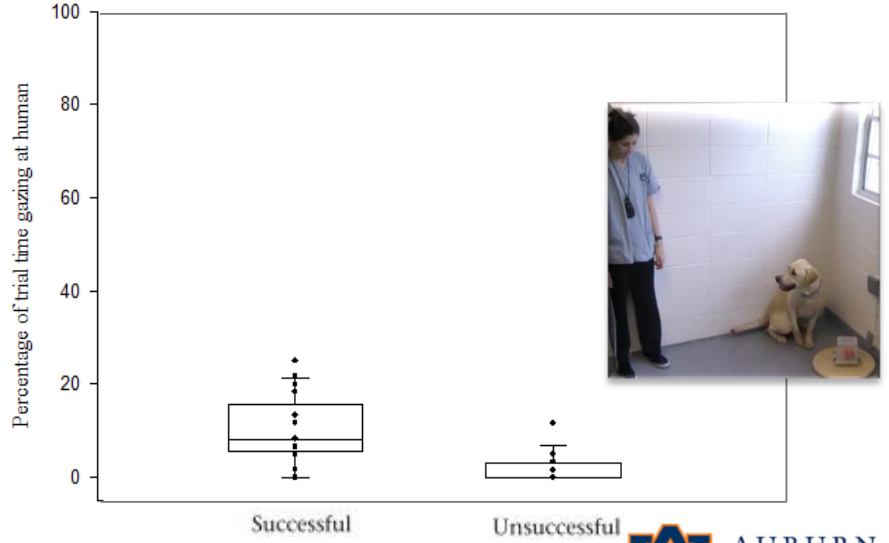
I. Refinement of Behavior Evaluations: cognitive assessments

1) **Relationships between cognitive abilities, behavioral evaluations, and outcome**
   - Problem-solving speed
   - Accuracy success
   - Attention
   - Cognitive flexibility
   - Persistence/motivation
   - Social sensitivity*
   - Arousal

2) **Early indicators of future success**
   - Evident as early as 3 months

Lazarowski et al. (2019) *Animal Behaviour*





I. Refinement of Behavior Evaluations: cognitive assessments

1) **Relationships between cognitive performance, behavioral evaluations, and outcome**
   - Problem-solving speed
   - Accuracy success
   - Attention
   - Cognitive flexibility
   - Persistence/motivation
   - Social sensitivity*
   - Arousal

2) **Early indicators of future success**
   - Evident as early as 3 months

Takeaways

Cognitive domains underlie important detection dog characteristics

- **More objective and reliable**
- **Validate existing measures**
- **Complementary**

I. Refinement of Behavior Evaluations: cognitive assessments

The role of arousal in problem solving and performance

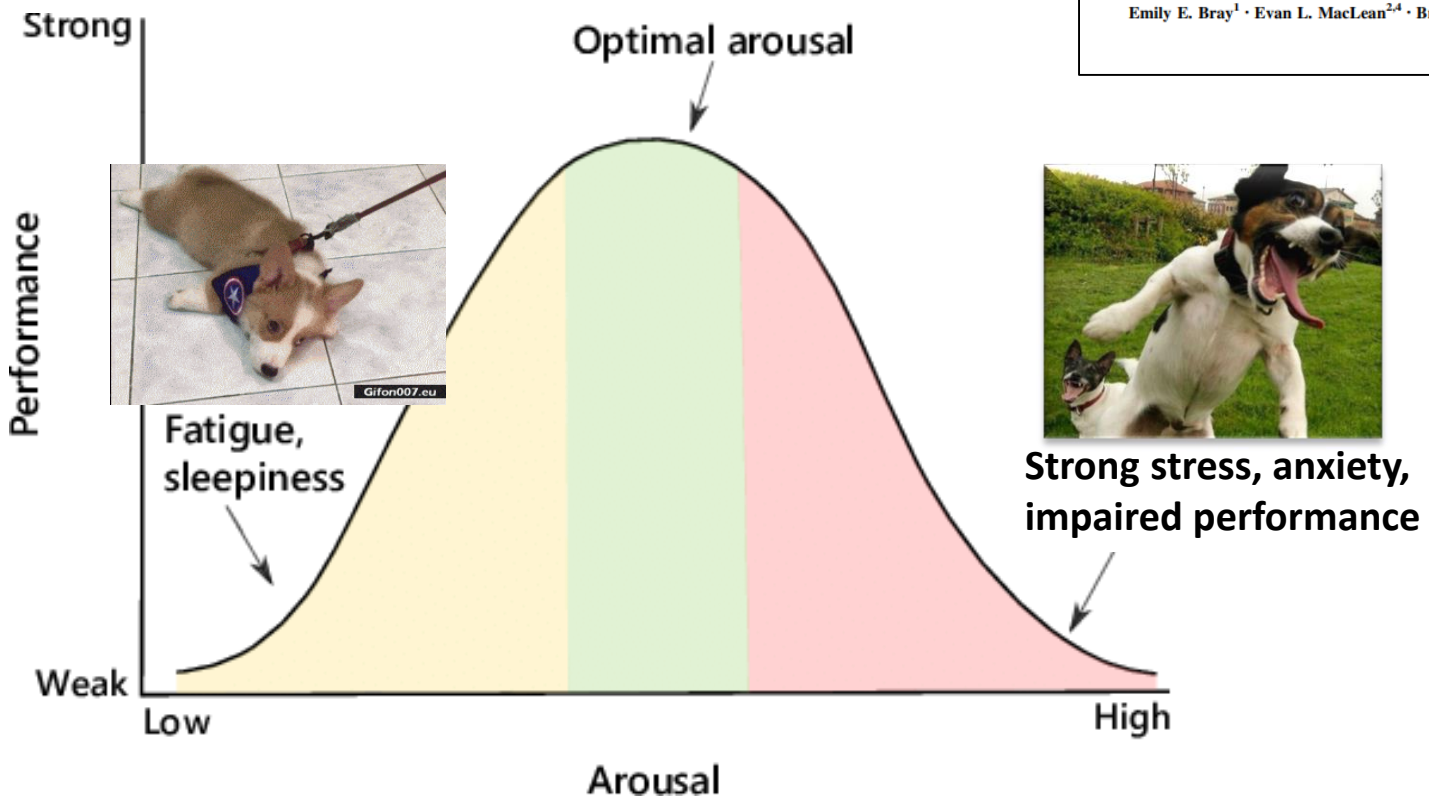
Anim Cogn (2015) 18:1317–1329
DOI 10.1007/s10071-015-0901-1

ORIGINAL PAPER

Increasing arousal enhances inhibitory control in calm but not excitable dogs

Emily E. Bray[1] · Evan L. MacLean[2,4] · Brian A. Hare[2,3]

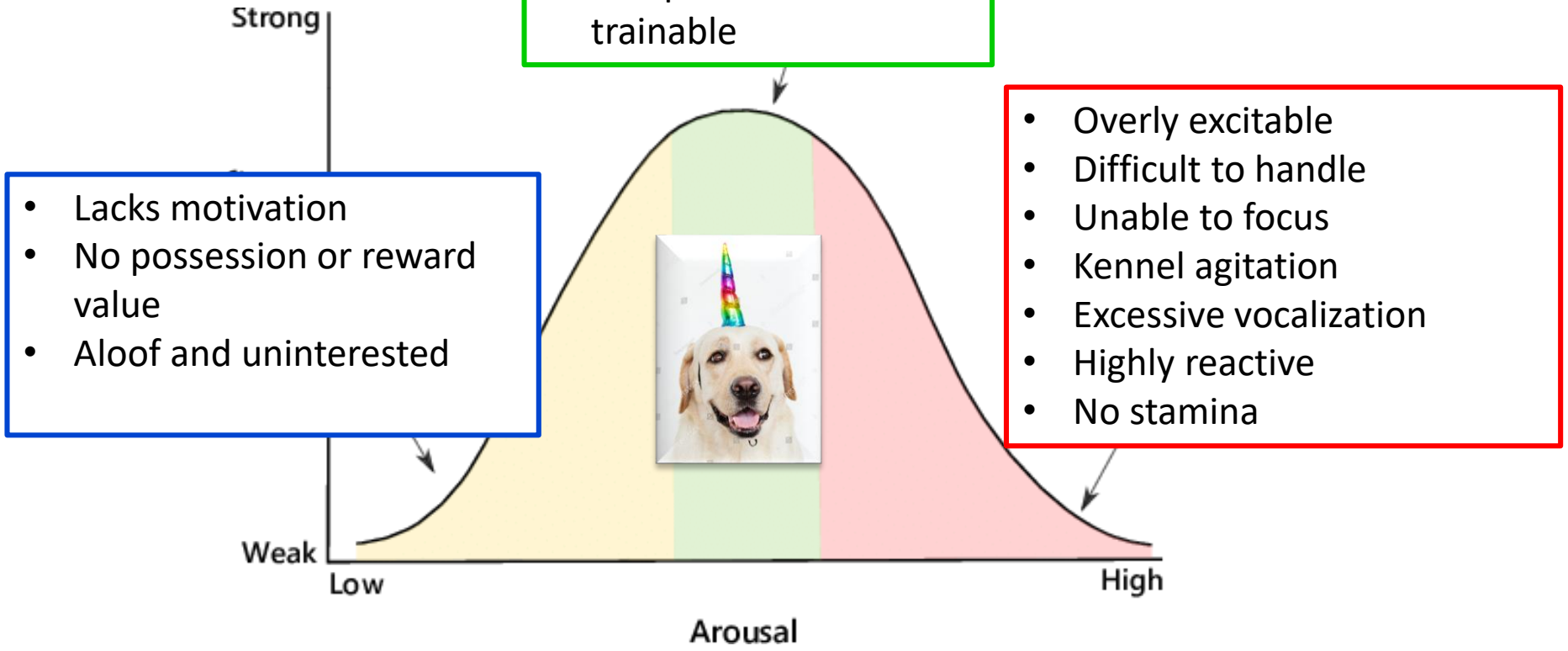
Yerkes-Dodson law



Strong stress, anxiety, impaired performance

I. Refinement of Behavior Evaluations

- Strong motivation
- Focused energy
- Manageable
- Independent but trainable

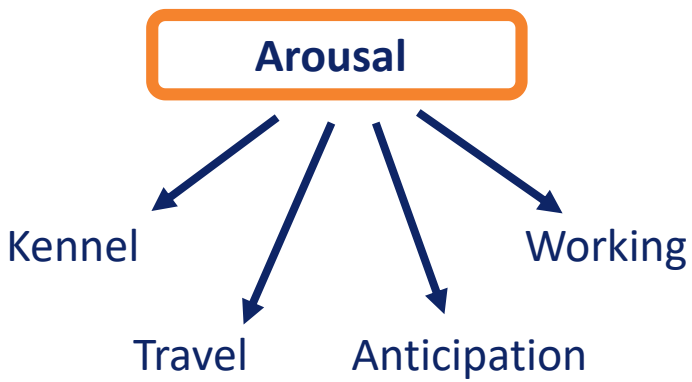


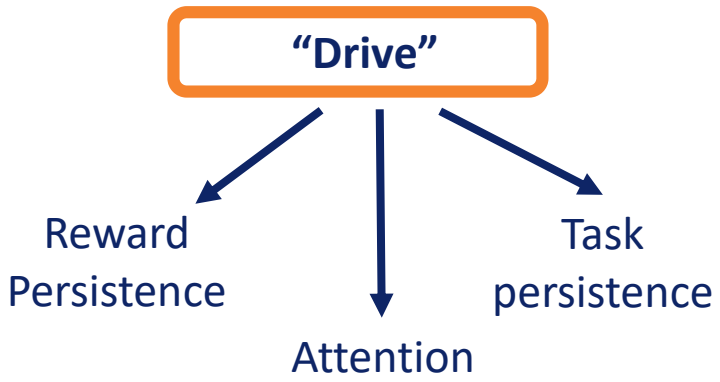
- Lacks motivation
- No possession or reward value
- Aloof and uninterested

- Overly excitable
- Difficult to handle
- Unable to focus
- Kennel agitation
- Excessive vocalization
- Highly reactive
- No stamina

I. Refinement of Behavior Evaluations

Behavior Evaluations, 2.0



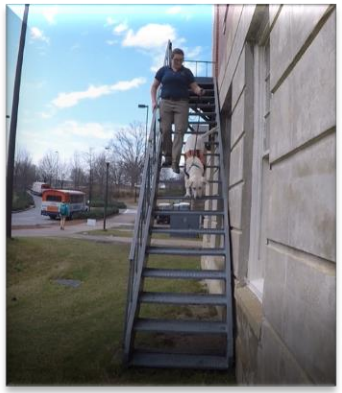


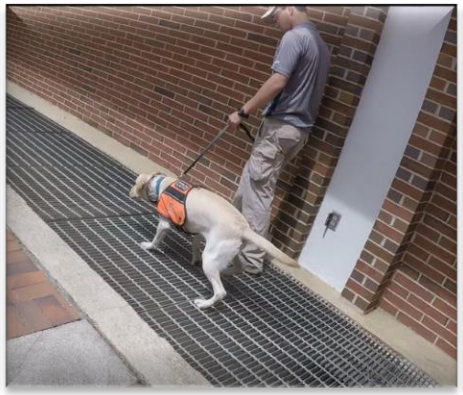
Handler-dependent ← Balance → Too independent

I. Refinement of Behavior Evaluations

Behavior Evaluations, 2.0

- Adoption of ***The Behavior Checklist*** (Dr. James Serpell, U Penn) for environmental soundness measures
  - Standardized and validated
  - Can be used for genetic analysis with Estimated Breeding Values (EBVs)





IWDBA

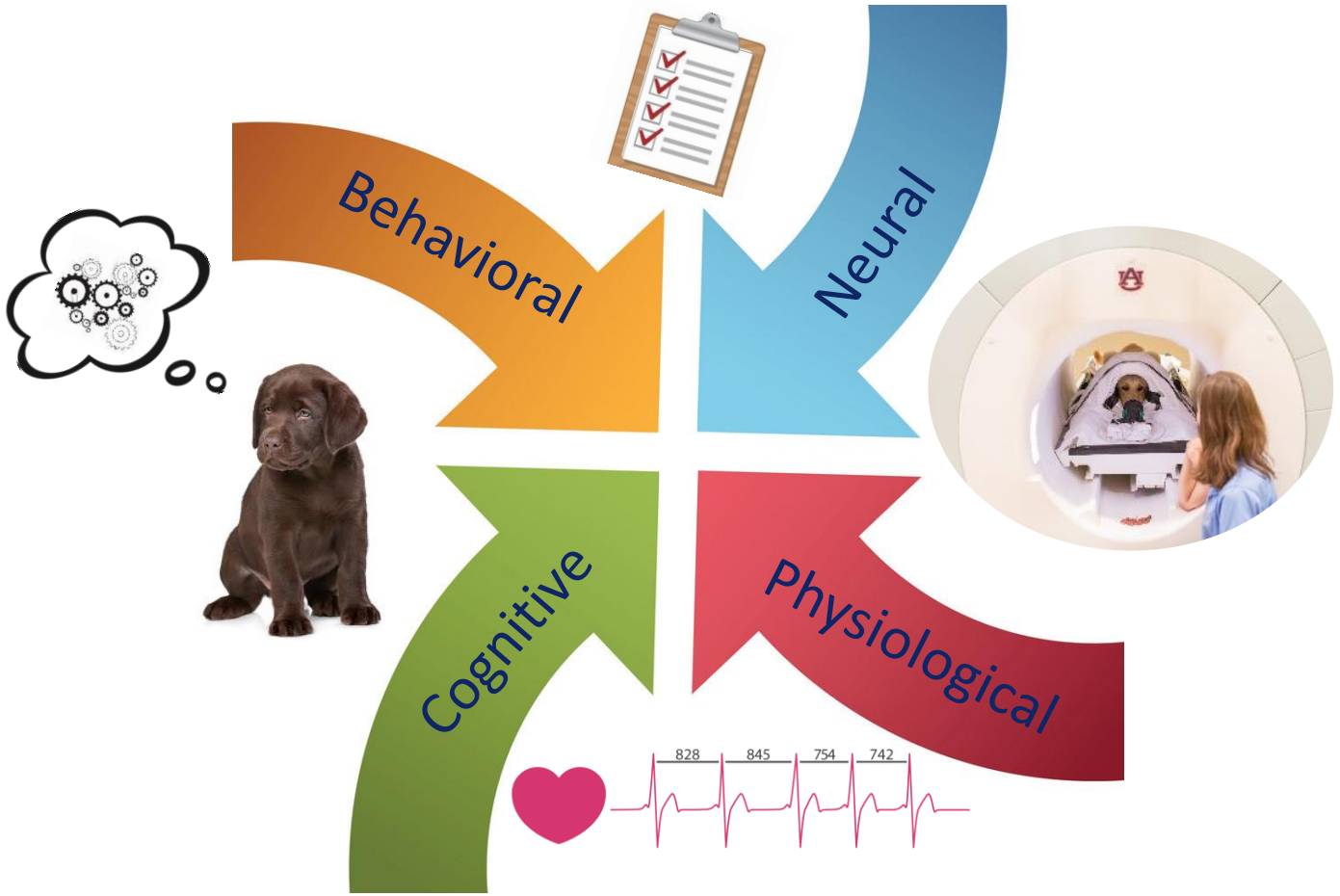
1 - Behavior Checklist (BCL) Scoring System

- **BCL General Overview**
- BCL Form Downloads
- Definitions (Download Page ~ Alt. Languages)
- > 1 - Anxious in Unfamiliar Situations
- > 2 - Fear of Noises
- > 3 - Fear of Novel Objects
- > 4 - Fear of Underfootings
- > 5 - Fear of Dogs
- > 6 - Fear of Stairs
- > 7 - Fear of Traffic
- > 8 - Separation Anxiety
- > 9 - Hyper-Attachment
- > 10 - Fear of Strangers
- > 11 - Body Handling Concern
- > 12 - Retreats when Reached for
- > 13 - Harness Sensitivity

Guiding Eyes for the Blind

The Seeing Eye®

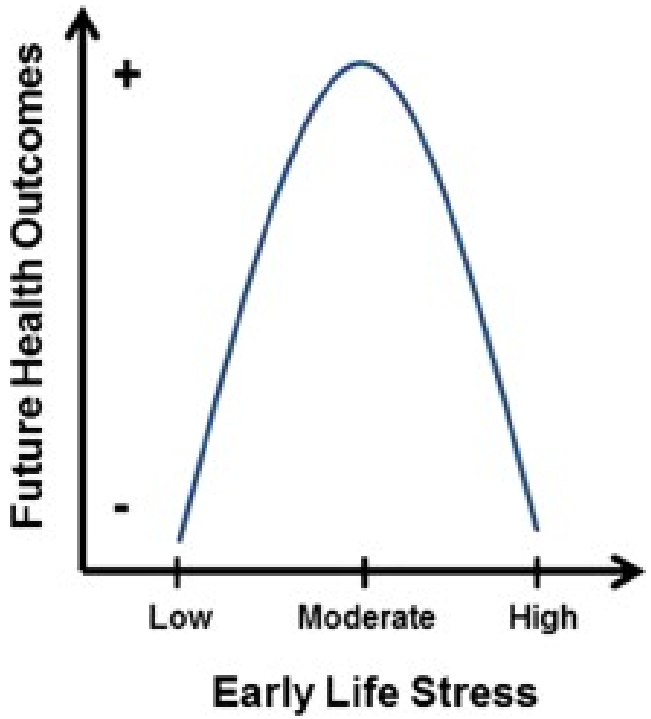
Validation with other measures



II. Emphasis on Early Development

The role of Early Life Stress (ELS)

- Chronic or severe ELS can be traumatic
- Mild-moderate ELS:
    - Promotes resilience
    - Enhances problem-solving abilities
    - Self-regulation of arousal
    - “Stress inoculation”

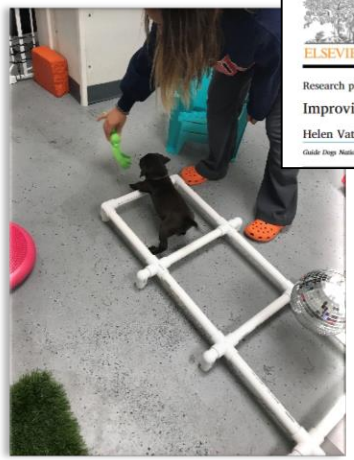


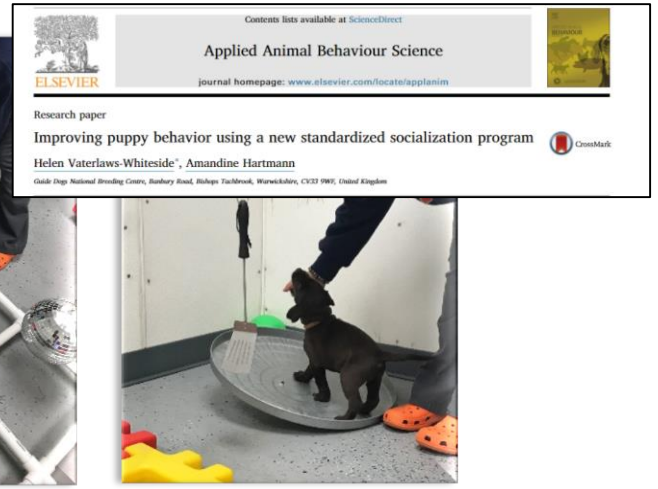
II. Emphasis on Early Development

Enhanced early socialization

- Introduction of “small challenges”:
  - Brief separations
  - Individual enhanced socialization
  - Multi-sensory stimulation

- Maternal interactions
  - Population specificity?





Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Research paper

Improving puppy behavior using a new standardized socialization program

Helen Vaterlaws-Whiteside*, Amandine Hartmann

PNAS

Effects of maternal investment, temperament, and cognition on guide dog success

Emily E. Bray[a,b,1], Mary D. Sammel[c], Dorothy L. Cheney[d,1], James A. Serpell[e], and Robert M. Seyfarth[a]

Contributed by Dorothy L. Cheney, June 21, 2017 (sent for review April 3, 2017; reviewed by Sarah Marshall-Pescini and Karen J. Parker)

Credit: Courtesy of The Seeing Eye; Bray et al. (2017)

PUBLIC HEALTH

Coddled Puppies Make Poor Guide Dogs, Study Suggests

August 7, 2017 · 3:44 PM ET

Heard on All Things Considered

Remaining Questions and Current/Future Directions

- Link between high performance-reactivity?
  - Biological underpinnings of sensitivity to rewards/aversives
- Influence of genetics and behavior
  - Maternal influences and epigenetics
  - Gut/brain/behavior axis

Cognitive parameters of scent detection

- Learning capacity
- Memory duration and capacity
- Limits of detection
  - Threshold, generalization

Thank You

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Breeding program support

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Canine Performance Sciences

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Canine Performance Sciences

Advancing the Mobile Sensor Technology