Canine behaviour and cognition:
evolution, genetics and applications
for breeding and performance

26th – 28th June 2015

Courthouse Hotel, London, UK.

Rapporteur Wrap avec
Les deux rapporteurs:
Dr Dan O'Neill
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Canine Behaviour & Genetics

DISSECTING GENETIC AND NON-GENETIC INFLUENCES ON DOG PERSONALITY

Pamela Wiener

- Defined Personality
  - Individual consistency in behavioural responsiveness to stimuli and situation
  - Distinct behavioural characteristics clustered within different breeds suggest a strong genetic component to personality
  - Also clear evidence for within-breed variation; opportunity for selection .
- Study on the factors influencing personality traits in the Labrador Retriever
  - Heritability estimates for the personality traits ranged from 0 to 0.38.
- Of several physical and environmental factors considered, the "role" of the dog (i.e. working dog, pet, show dog), influenced by both genetic and non-genetic elements, had the strongest association with the personality traits
- Genetic cluster within breed: significantly associated with several personality traits.
- GWAS identified specific regions significantly associated with some traits; largest effect for Trainability.

THE GENETICS OF COMPLEX TRAITS – APPLYING THEORY TO SELECTION ON BEHAVIOUR

Tom Lewis

- Complex traits: under the influence of multiple genes and environmental factors and their interactions
- Effective selection can be achieved without specific knowledge of the location or variants of genes which influence the trait in question.
- Since only genes (not environmental effects) are inherited, and because genes are shared to a predictable degree between relatives, quantitative genetic analysis enables more efficient use of phenotypic and pedigree data to estimate the genetic 'liability' of a trait for each animal in the pedigree.
- Selecting on these 'liabilities' is substantially **more accurate** than selection on phenotype, since non-genetic influences on the phenotype are discounted and the performance of relatives is taken into account.
- By extension, analysis of the genetic liability for multiple traits yields information on how traits are genetically related, and enables the calculation of indices delivering optimal selective efficacy for a series of objectives.
- Such technologies are well-established in livestock production – use more in canine health?

GENETIC EVALUATION OF BEHAVIOUR IN DOGS

Per Arvelius

- Because behavioural traits are heritable and can be changed by breeding, they should be included as an important part of the breeding goal.
- To be effective when selecting breeding animals, good methods for measuring behaviour are essential: objective is better than subjective
- Behavioural data can be collected in many different ways:
  - more or less objective
  - ratings can refer to behaviours displayed in a specific situation or to an overall interpretation indicating the degree of expression of pre-defined traits.
  - Method can be expected to affect the usefulness of the measurements from a breeding perspective.

EBV is more useful for selecting heritable behavior traits than for individual behaviors

MEASURING WORKING DOG PERFORMANCE

Nicola Rooney

To select and breed for optimal working ability requires meaningful and reliable measures of performance: **8-Point Plan**

1. Identify most important aspects of performance
2. Standardise the vocabulary for behaviour
3. Optimise measurement strategy
4. Consider the measurement context
5. Measurement validity and reliability
6. Optimal rater
7. Optimise data collection tool
8. Rater training

Performance assessments in dogs - determining 'good' behavioral measures and phenotypes

Björn Forkman

Types of measure for behavioural traits:

- Behavioural coding e.g. 1 snap/min (+ objective & higher inter-rater reliability, - restrictive)
- Behavioural rating e.g. reject contact (+ overall evaluation, - subjective)
- Adjective rating e.g. courage, curiosity

- Questionnaire tools:
  - Validated
  - Inter-observer reliability and repeatability
  - Compare with other tests e.g. DMA vs. C-BARQ
  - Times studied (validation across populations and time)

Are we truly breeding for what we think we are selecting for e. g . Is C-BARQ fearfulness really the fearfulness that the owner wants to avoid

MIDDLE LATENCY RESPONSE TESTING FOR AUDITORY COGNITION IN CANINES

Peter Scheifele

New ground for Canine Cognitive testing, specifically hearing

- Brainstem Auditory Evoked Response (BAER): measure auditory acuity
- Measure changes in cognitive brain activity in direct response to auditory stimuli
  - Mismatch Negativity (MMN): non-attentive response to an oddball "deviant" tone presented within a series of tones
  - Auditory Middle Latency Response (AMLR)
  - generate responses from the auditory cortex, thalamus and frontal cortex, areas with connections to the hypothalamus, hippocampus and amygdala.

Consider hearing deficits as a possible explanation for 'behaviour' problems.

Need good reference ranges for the data. These do not exist for current tests.

REGIONAL BRAIN ACTIVITY IN AWAKE UNRESTRAINED DOGS

Peter Cook

- Functional magnetic resonance imaging (fMRI): foundational tool of human cognitive neuroscience
- Animals, until recently, required anesthesia and restraints.
- Dogs, however, are readily trained to the MRI environment.
  - Not allowed to move, Novel environment, Enclosed, Elevated, loud
- Overcome: Positive re-inforcement and 2-4 months training
- Reported multiple tests showing associations between stimuli and regional brain activation
  - Validation; simple reward prediction task (hotdog)
  - Odours: olfactory bulb & caudate activation indicative of reward associated with familiar human scent)
  - Facial recognition: fusiform part of brain
  - Impulse control (Go/No go): pre-motor cortex and frontal cortex associated with successful inhibit

Aims to develop a brain map: functional atlas

THE CONTRIBUTION OF NUCLEAR MEDICINE IN THE RESEARCH OF CANINE BEHAVIOUR DISORDERS

Kathelijne Peremans

- Molecular imaging modalities:
  - Brain Single Photon Emission Computed Tomography (SPECT)
  - Positron Emission Tomography (PET)
  - Brain perfusion and metabolism (glucose consumption) are related to neuronal function
- Investigation of the
  - neurobiological base of brain (dys)function
  - diagnostic tool
  - evaluate psychopharmaceuticals
- Image pathophysiology

  Impulsive aggression: reduced frontal cortex but increased limbic activity

  Anxiety: reduced serotonin receptors

  Aging brain

  Psychopharmaceuticals: Cipramil / SSRI

DOMESTIC DOG EVOLUTION AND GENES UNDER SELECTION IN THE DOG GENOME

Robert Wayne

- Wolves and dogs have an admixed ancestry.
- Clade A/ grouping 1: majority of dog sequences have a single point origin
- First domestication : ~ 36, 000 years ago
- East-Asia (mitochondrial variation) vs Europe (fossil/ skull evidence)
- Two models of breeding:
  - 1. Like evolves Like
  - 2. A single mutation gets passed around many breeds e.g. dwarfism
- Genetic bottlenecks
  - During domestication
  - During bred creation/ re-creation

Process of intensive selection in recent years has increased Mendelian recessive disease genes

COMPLEX GENETICS IN THE DOMESTIC DOG

Heidi Parker

- Dogs are a model for human genetic research
  - High commonality of environment
  - Susceptible to similar diseases that affect humans
  - Genetic x Environmental interactions
  - Dogs have discreet and effectively closed populations
- Examples of both morphology and disease studies using canine mapping methodologies
  - Body size: 7 mutations accounted for 86% variation
  - SCC: **kitlg** - first example of a deleterious gene being actively selected because of desired phenotype
  - Histyiocytic sarcoma: 1 in 5 BMD get HS, different haplotypes between European and US populations

When studying a 'breed' in genetic studies, is a breed truly a single breed or multiple distinct sub-types ??

THE GENETICS OF CANINE OLFACTION

Francis Galibert

- Dogs are known for their exquisite sense of olfaction
- Olfaction comprises:
  - Nose: Detector
  - Brain: Analyser
- Olfactory epithelium: GSD: 200cm2 vs Human: 5 cm2
- Intact OR genes: Dog 856 vs Human 391
- Combinatorial code: Real life is mixed odours and almost unlimited combinations
- Can learn to smell: genotype vs experience??
- High level of polymorphisms leading to AA changes
  - Functional?
  - Cluster within breeds: differing ability and selection pressure
- Limitation: Good transcriptomic data

Little money for olfaction research: not perceived as a major medical problem but it is important for dogs

Nature and nurture – how different environmental conditions interact with the behaviour of the maturing dog

ERIK WILSSON

- Working dogs: training usually starts when the dogs have reached the age of 10-15 months.
- Mostly selected using some type of behaviour test.
- Tests usually performed when behaviour is expected to be stable (about one year).
- Most heritabilities: 10-30%. So 70-90% of observed phenotypic variation is non-genetic.
- These environmental effects may come from the prenatal and the postnatal environment.
- Postnatal effects can be divided by period:
  - Neonatal (1-2 weeks) : rats – early human handling reduces later stress. Mother licking plus size of pup impacts behaviour but no effect of litter size.
  - Transitional
  - Socialisation. Weaning - inhibited bite & nibbling (female punished 75% more than males)
  - Juvenile period: Training sessions & No. host families are associated with success. Host family characteristics important for success.

Genes set up the dog and environment enables expression.

CANINE OPIOID RECEPTOR GENE POLYMORPHISM AND BEHAVIOUR ASSOCIATIONS

Enikő Kubinyi

- Described 2 aims of research:
  - Aim 1 : Use dogs as a model for human disease.
  - Aim 2: Dog welfare
- The mu-opioid receptor (MOR): responds specifically to endogenous and exogenous opioids.
- Humans: SNPS in protein-coding region of the MOR gene involved in mediating complex behaviours including social bonds, addiction, and mood disorders.
- A total of 120 purebred dogs and 24 wolves were genotyped
- Questionnaire data were available for 114 dogs
- Behavioural test data were available for 118 dogs.
- SNP-Associations found for
  - Inattention factor
  - Reaction to the separation from the owner

EXPLORING FUTURE POSSIBILITIES FOR STUDIES IN CANINE ANXIETY DISORDERS

Niwako Ogata

- Anxiety disorders: clinical behavior problems such as aggression, compulsive disorders and separation anxiety
- Unlike human research, epidemiological data in veterinary behavior medicine is scarce
  - Human: Anxiety: 18.8% prevalence with 22.8% classed as severe
  - Caseload data: 83-91% of clinical behavior cases
- Study: canine compulsive disorders in genetically predisposed breeds.
  - Flank/blanket sucking in Dobermans: Chromosome 7 locus susceptibility to CCD
- Advised to explore beyond clinical signs and describe ENDOPHENOTYPE
    - Physical/medical
    - Neuroanatomical: e.g. total brain and grey matter higher in CCD
    - Neurochemistiry e.g. serotonin receptor abnormality in OCD
    - Neurocircuitry

USING BREED SPLITS TO EXPLORE THE GENOMICS OF CANINE WORKING BEHAVIOUR

Claire Wade

- Selective sweeps: genomic signatures of human or natural intervention in animal fitness.
- The predominant feature of a selective sweep is that there is a long region in the DNA that has little remaining variation in the cohort of animals under selection.
- Concentrated analyses within single dog breeds that have been subjected either to a formalised breed split, or to very different selective pressures.
  - Labrador Retriever
    - Chromosome 25: Not well characterised for function for dogs. Mouse; obesity, cold sensitivity, reflexes, lethargy, co-ordination, hypo-activity
    - Validated in separate C-BARQ population: associated with energy score
  - Australian Kelpie
    - Chromosome 3: Dog: Cerebellar abiotrophy. Mouse: Fear conditioning, Nociception, Gait, Pupillary reflex, nystagmus, Anxiety response.
    - Australian outback covered in spiky plants

We are often selecting for unknown adaptive traits

Canine anxiety genetics: challenges of phenotyping complex traits

Katriina Tiira

- Dogs are promising genetic animal model for human psychiatric disorders:
- Vet behavioral science can learn from human psychiatry diagnosis, personality research and genetic research.
  - Sample size: collaboration
  - Selecting good controls
  - Dimensional phenotype – mild vs severe
- High correlation between questionnaire and behavioral test results (use both)
- Phenotype – co-morbidity
- Choice of breed: breed heritability varies
- Environmental effects:
  - Fearful dogs: poorer maternal care, less socialized in early life, less daily exercise
  - Noise phobic dogs: less daily exercise, sterilized, older

Metabolomics tells what is happening right now vs. Genetics tells what might happen

Collaboration unlocks success

Rapporteur Wrap: key conference messages: 1

1. **Single accepted standard nomenclature**
   - Personality vs. behaviour traits vs temperament vs behaviour
   - Hierarchical web: parent-child terms e.g. VeNom Coding
2. **Agreed validated measurement systems**
   - Repository
   - Forum to discuss and share
   - PCA & FA: what are we measuring??
3. **Multi-disciplinary: experts from many fields**
   - Translational medicine: impact
   - Effectiveness
   - Funding
   - Larger sample sizes

Rapporteur Wrap: key conference messages: 2

4. **International comparisons:** breeds are not breeds (are breeds and breed sub-groups really functional species)
5. **Decide why we are doing the research**
   - Dog welfare vs therapy vs basic science vs translational.
   - Impact aims: for the dog, for man, for science
   - Prioritisation of the project aims (state these).
6. **EBV: Individuals vs populations**
7. **Use appropriate techniques: genetic, statistical**
8. **The power of good data and linking databases**
9. **Need good epidemiology integrated into behaviour research programmes**
10. **This event has been brilliant: need another one?**

Complexity is not a vice but an opportunity

We hope you all enjoyed

Dog Behaviour and Genetics

We look forward to seeing you at the next one.