The Nuts & Bolts of Scent Detection

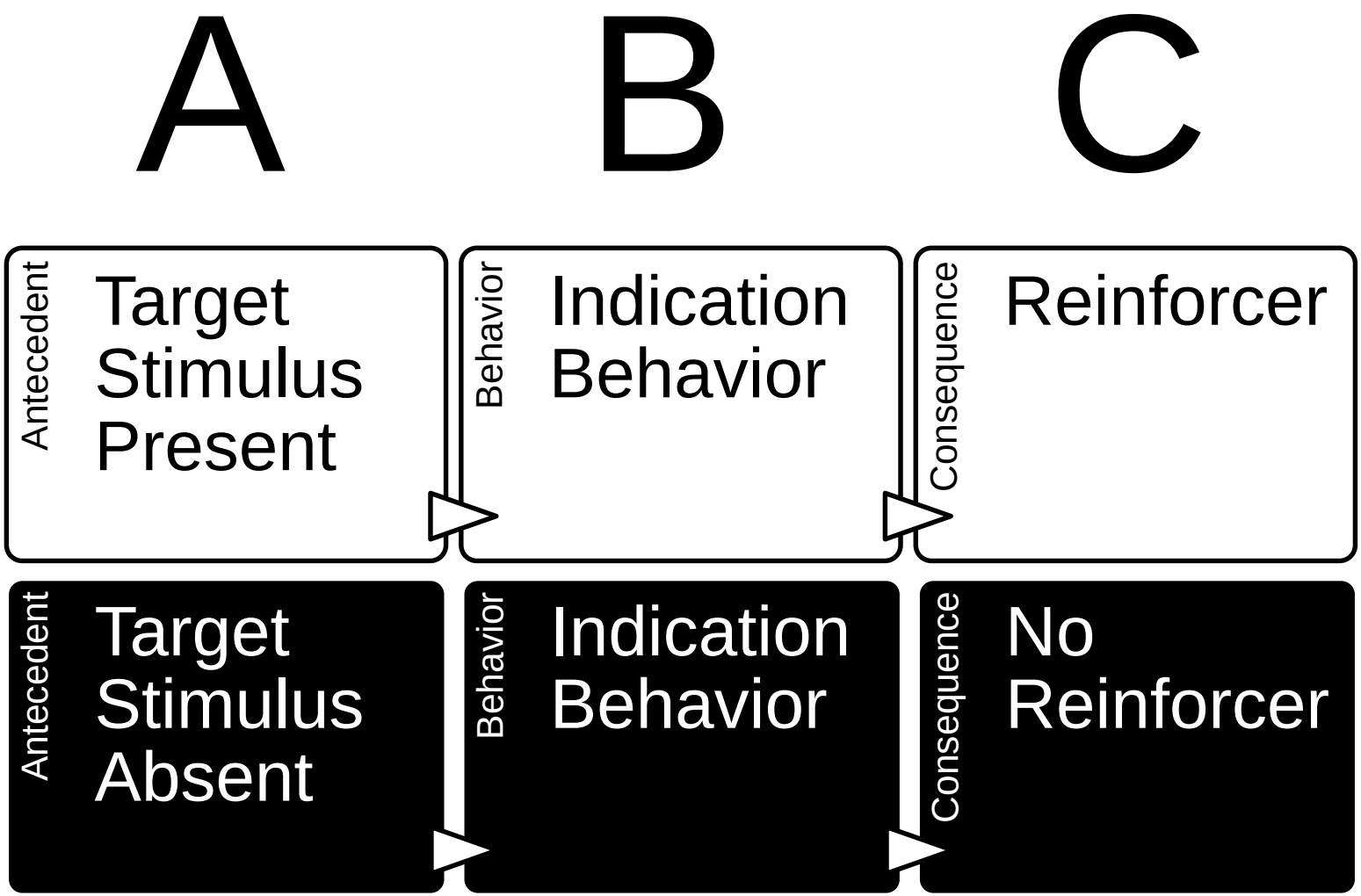
Tim Edwards

Head of Training & Behavioral Research

Learning Objectives

- Describe three factors that influence scent availability
- Design a basic scent-detection training protocol
- Conduct an evaluation of a scent-detection animal
- Describe three challenges associated with scent detection

Scent Detection Behavioral Analysis

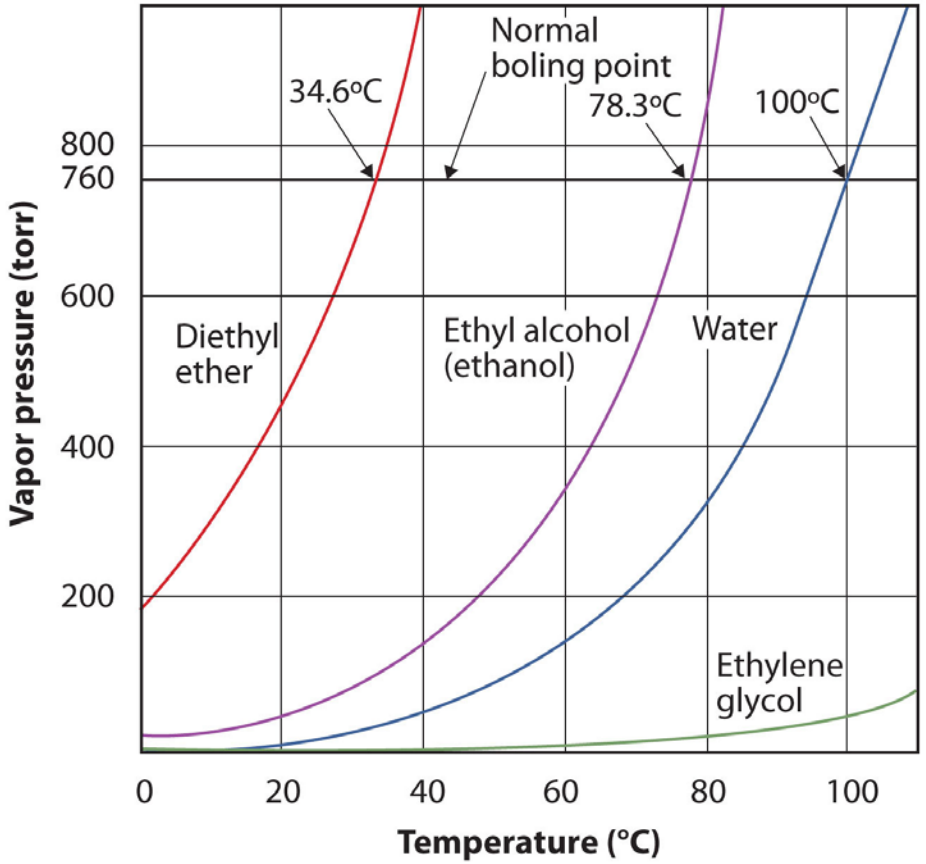


Scent Detection Antecedent

Volatilized Chemical Compounds

Availability depends on:

- Temperature
- Humidity
- Air currents
- Volatility of the compound



Phelan & Webb, 2003

Scent Detection Antecedent

Warning: volatile compounds are difficult to control!

Major issues in scent detection research and operations:

- Cross-contamination – positive sample material contaminating negative sample material
- Handling samples differently can result in introduction of other compounds/cues
- The distribution of volatiles is influenced by environmental factors
- Usually, we cannot detect the presence of the compound

Scent Detection Behavior

Species considerations:

Detection threshold (minimum detectable concentration)

- Behavioral outcome measure, not just a sensor count
- Compound-specific

Other considerations

- Animal care: cost-effectiveness
- Ease of handling
- Trainability: operant conditioning acquisition rates
- Suitability for specific task: physical characteristics, indication response

Scent Detection Behavior

Characteristics of a good indication response:

- Within the animal's repertoire or readily shaped
- Easily identifiable and, ideally, with potential for automated recording
- Response effort too low: high false indication rate
- Response effort too high: high miss rate
- Time-based indications can be adjusted to optimize performance

Scent Detection Consequence

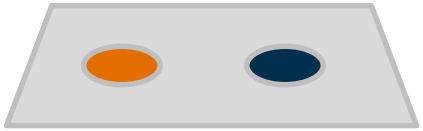
Reinforcer:

- “Marker”: conditioned reinforcer/S^D
- Relevant establishing operation

Scent Detection Basic Training

A basic training progression:

Early



Intermediate

Advanced

Scent Detection Training

Discrete Trial:

1. Detector is presented with discrete units for evaluation
2. Only those indications that occur in the presence of target stimulus are reinforced

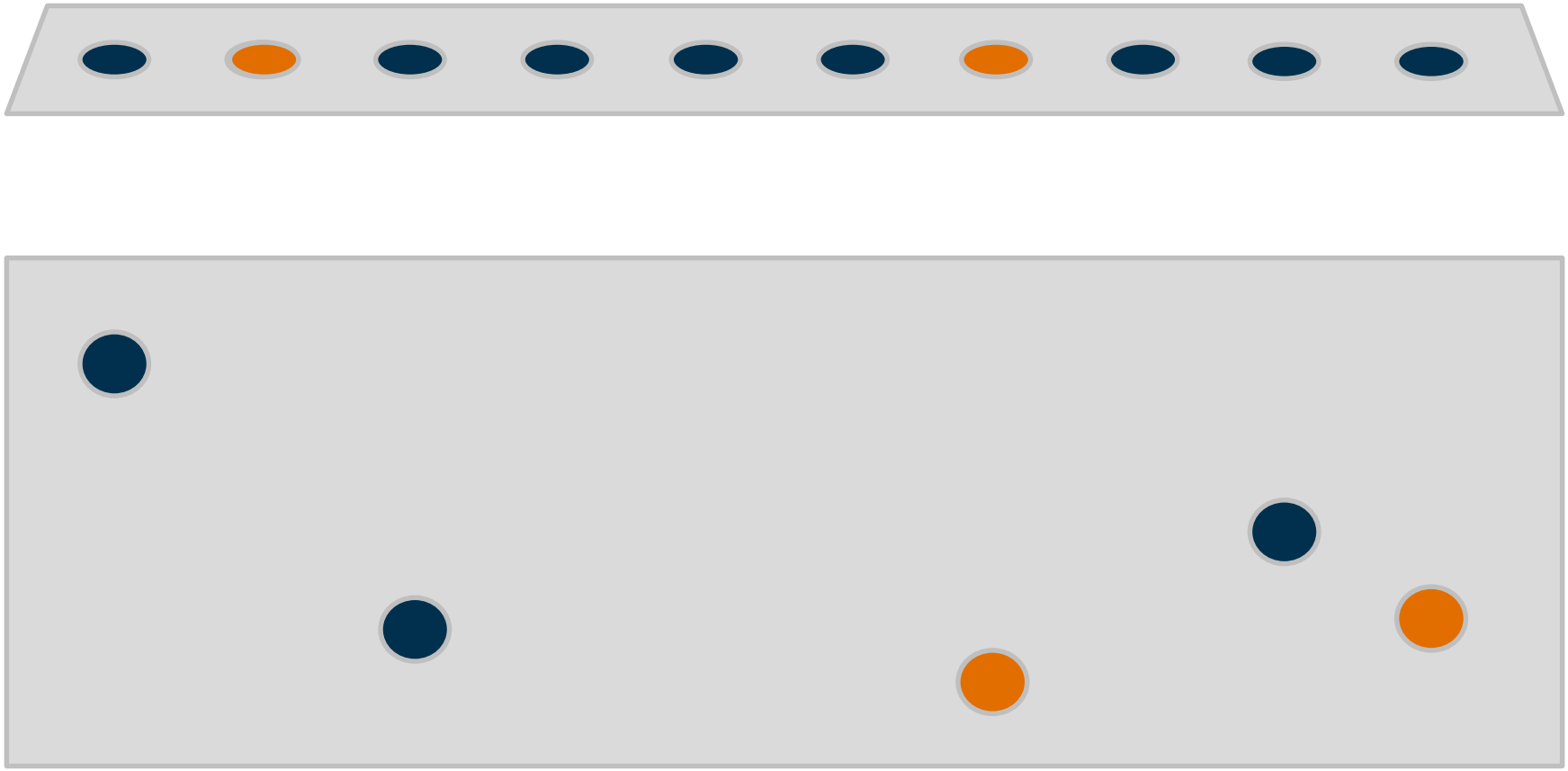
Scent Detection Training

Free Search:

1. Detector can emit indication at any time
2. Only those indications that occur in the presence of (within X cm of) target are reinforced
3. Searching is reinforced by onset of S^D

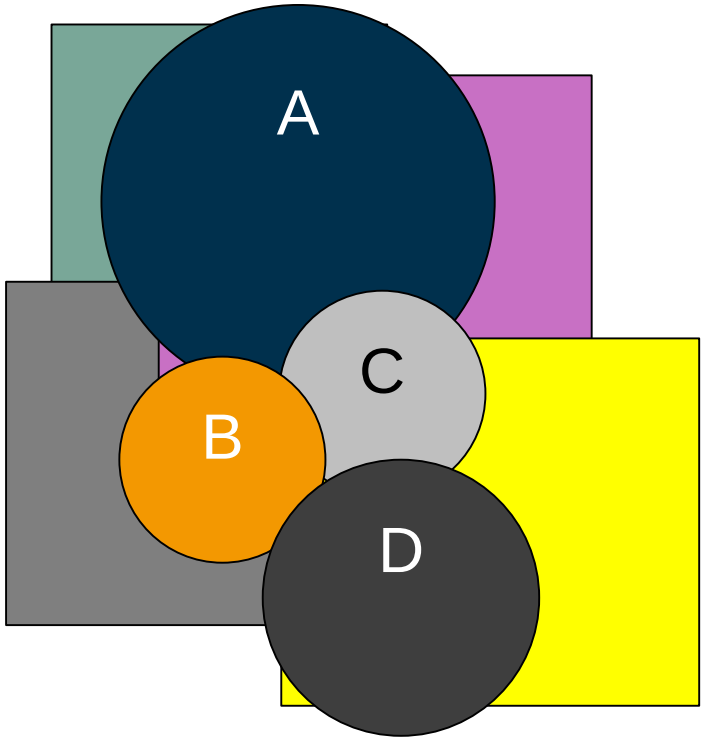
Scent Detection Evaluation

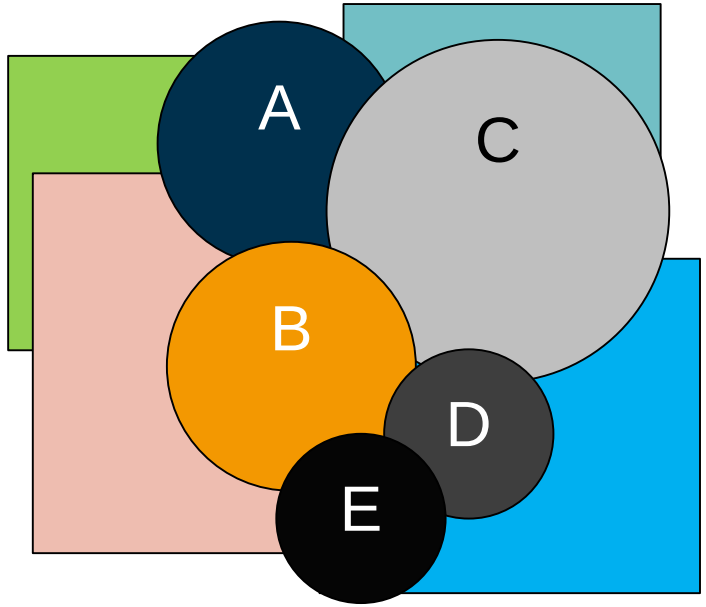
Blind probe:



Scent Detection Complex Targets

Most targets are complex: “bouquets”





Scent Detection Complex Targets

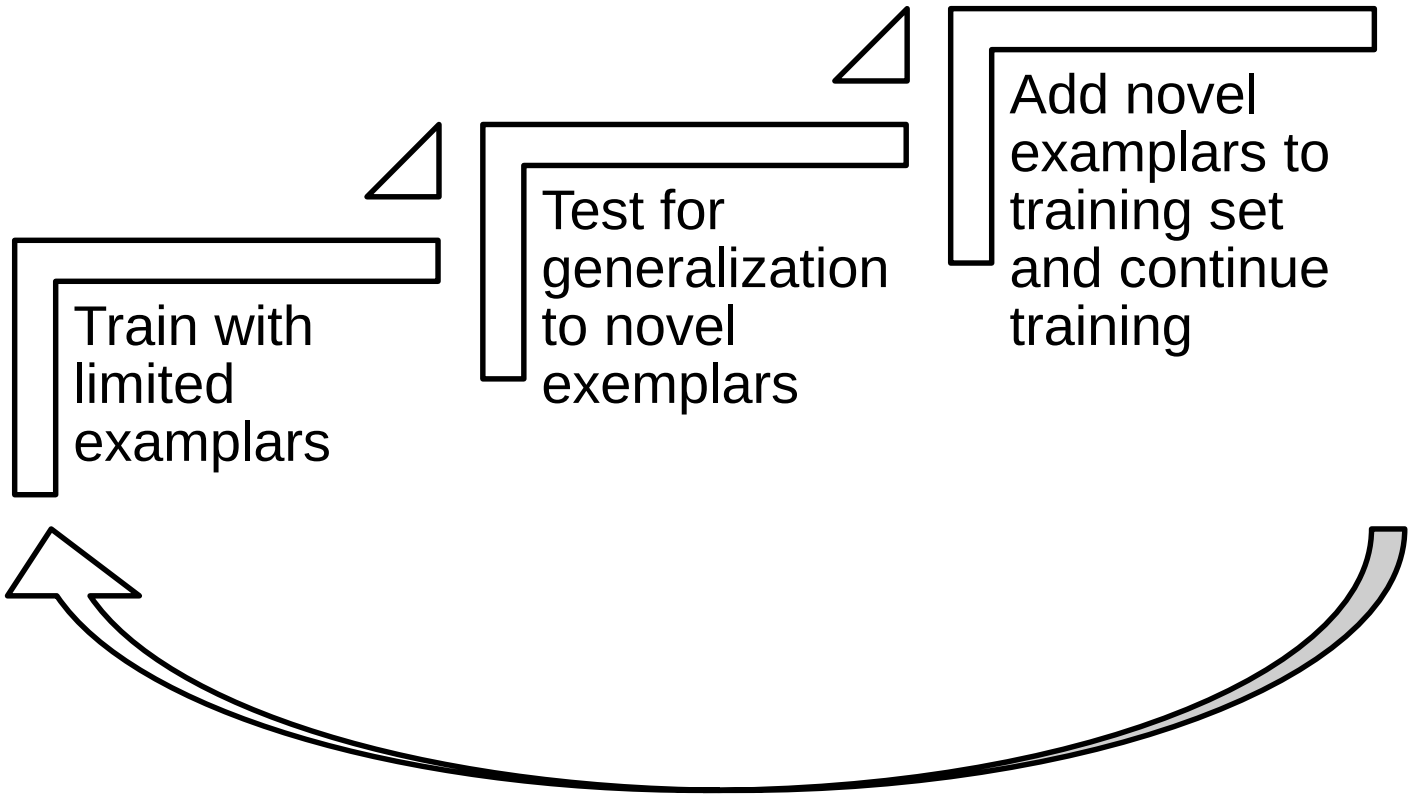
Concept formation

- Herrnstein & Loveland, 1964
- Instances of the S^D are not identical
- Large set of exemplars required before generalization occurs (multiple exemplar training)

Herrnstein, Loveland, & Cable (1976)

Scent Detection Evaluation

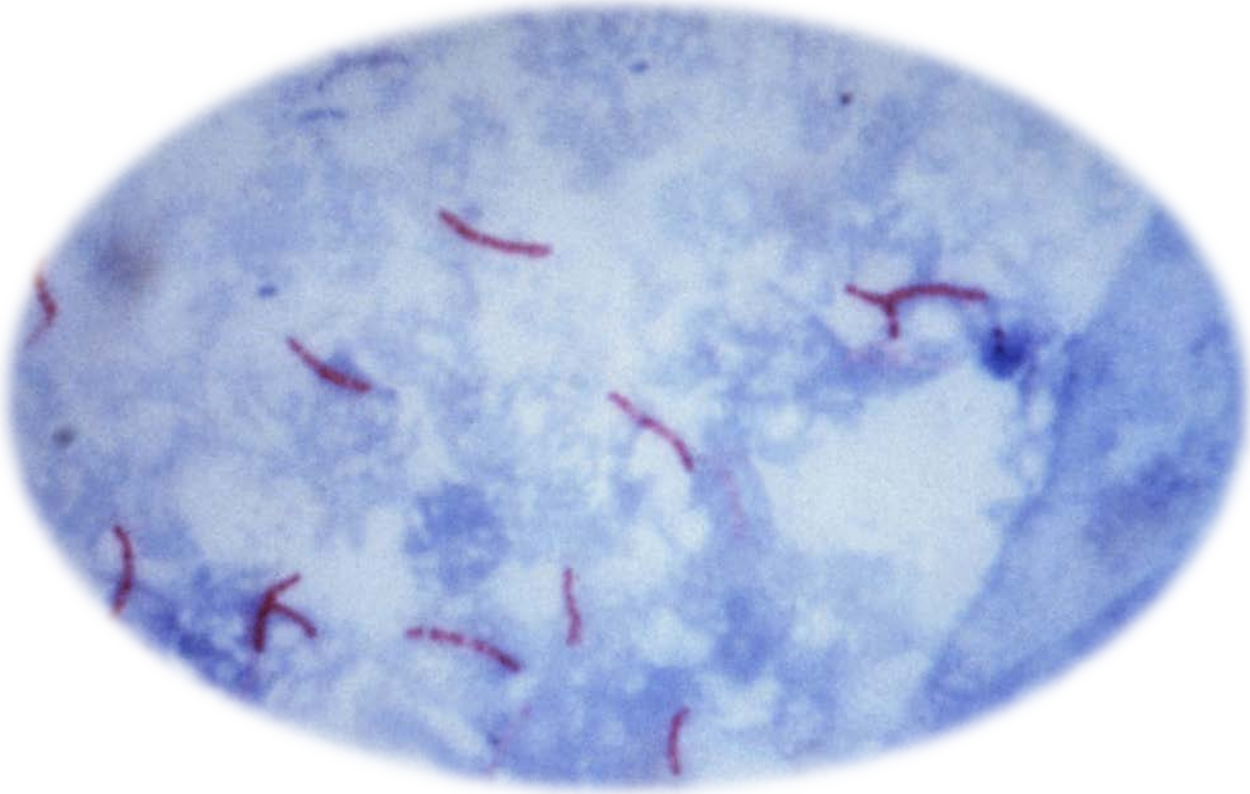
Generalization/blind tests:



Scent Detection Requirements

Confirmed positive samples

- Never reward indication of negative sample
- Challenging with disease detection



Scent Detection Requirements

Comparable negative samples

- Otherwise, behavior can come under the control of other stimuli

Scent Detection Requirements

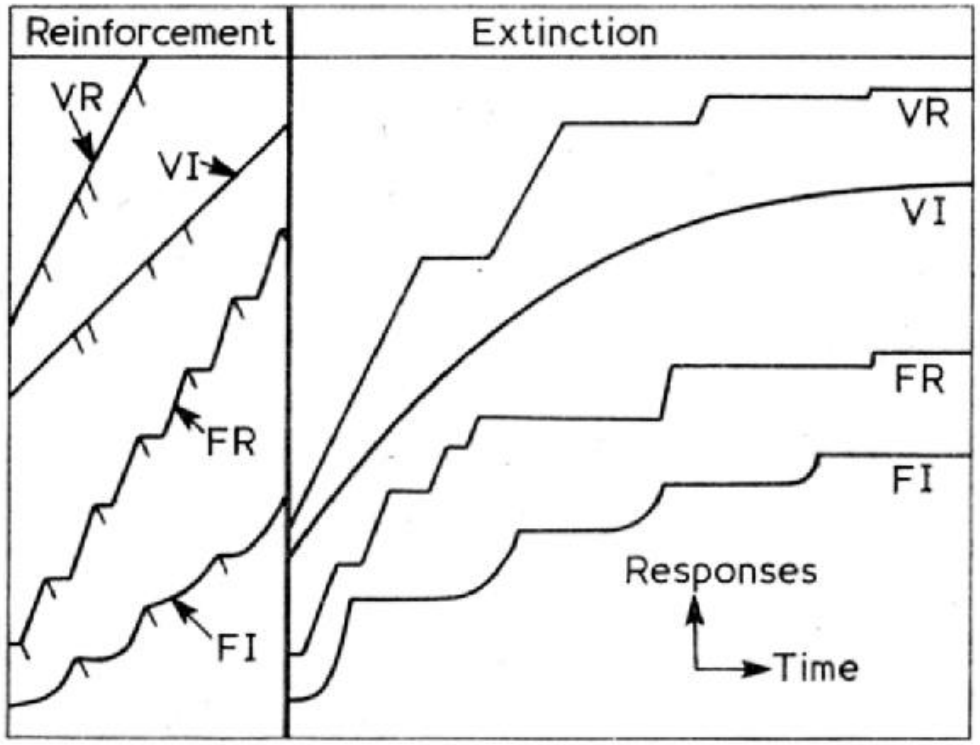
Large number of sample sources

- Many samples from the same “mother sample” doesn’t count

Scent Detection Requirements

Intermittent reinforcement

- Resistance to extinction
- Evaluation of blind and otherwise unknown samples



Reynolds, 1968

Scent Detection Requirements

Blind evaluation

- Trainer not informed of sample location/status

Das lesende und rechnende Pferd mit seinem Lehrer HERRN VON OSTEN (Berlin.)

Scent Detection Requirements

Confirmed positive and negative samples for evaluation

		Condition (as determined by "Gold standard")		
		Condition Positive	Condition Negative	
Test Outcome	Test Outcome Positive	**True Positive**	**False Positive** (Type I error)	**Positive predictive value** = Σ True Positive / Σ Test Outcome Positive
	Test Outcome Negative	**False Negative** (Type II error)	**True Negative**	Negative predictive value = Σ True Negative / Σ Test Outcome Negative
		Sensitivity = Σ True Positive / Σ Condition Positive	Specificity = Σ True Negative / Σ Condition Negative	

Scent Detection Requirements

SOP and QA

- Critical to stability/reliability
- Critical for sample preparation and handling

Scent Detection Going Operational

Market research:

- What is the current solution, if any, and why is your scent detection product superior?
- What does it take to get integrated into the existing framework?

Industry expertise:

- Develop deep understanding of the relevant technology and processes
- Establish yourself as an industry expert

Scent Detection Examples

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Scent Detection References

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