What do detection dogs know and how do we know they know it?

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Tullverket


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Model

	+/present in real world	**-/absent in real world**
+/present in dog’s opinion	**A**	B – false positive
-/absent in dog’s opinion	C – false negative	D

False positive rate = B/(B + D) – ***specific tests maximize the ability to ID ‘blanks’ or true negatives*** [D/(B + D)]

False negative rate = C/(A + C) – ***sensitive tests maximize the ability to ID a target substance*** [A/(A + C)]

- Most training and certification programs permit some false positives and/or negatives.

- So……How many target odors and how many blanks will you need for any given # of acceptable false positives and false negatives, given the calculated false positive or false negative rate?

Example:

- Constraint 1: The minimum criterion for passing is:
  - false positive error rate less than or equal to 10% ($\alpha \leq 0.10$)
  - false negative error rate of less than or equal to 5% ($\beta \leq 0.05$).

- Constraint 2: The dog can pass with:
  - 2 false positive errors ($\delta = 2$) and
  - 1 false negative error ($\Upsilon = 1$)

- What is the minimum test design that meets all of these criteria simultaneously?

- I. False positive constraint combination: The false positive error rate is less than or equal to 10% ($\alpha = 0.10$) and the dog can make 2 false positive errors ($\delta = 2$) and still pass the test.

- Let Θ = the number of opportunities to make a false positive error during the test.

- To meet the first constraint we require:
- $\delta / \Theta \leq \alpha$
- $[2 / \Theta] \leq 0.1$
- $\Theta = 2 / 0.1 =$ 20 empty boxes. If you tolerate only a 5% ($\alpha = 0.05$) false positive rate, you would need 40 empty boxes

- II. False negative constraint calculation: The false negative error rate is less than or equal to 5% ($\beta \leq 0.05$), and the dog can make 1 false negative error ($\Upsilon = 1$) and still pass.

- Let Ω = the number of opportunities to make a false negative error during the test.

- To meet the second constraint we require:
- $\Upsilon / \Omega \leq \beta$
- $[1 / \Omega] \leq 0.05$
- $\Omega = 1 / 0.05 =$ 20 boxes with target substance

- The minimally acceptable test design is 40 boxes (20 empty and 20 with target) with target locations randomly assigned on each iteration of the test.

- Using these statistical concepts in truly randomized, blinded test will enhance any program and provide true accuracy and reliability measures for dogs.

General model – if you decide on or know 2 of the variables, you solve for the third

False positives:

- false positive error rate </= α
- false positive errors allowed = δ
- number of opportunities to make a false positive error during the test = Θ
- $\delta / \Theta \leq \alpha$

Put your tolerance for false positive error rate here (eg, 5%/0.05)

Put # test containers here

Put # false positives errors allowed here

False negatives:

- false negative error rate of less than or equal to β
- false negative errors allowed $= \Upsilon$
- number of opportunities to make a false negative error during the test $= \Omega$
- $\Upsilon / \Omega \leq \beta$

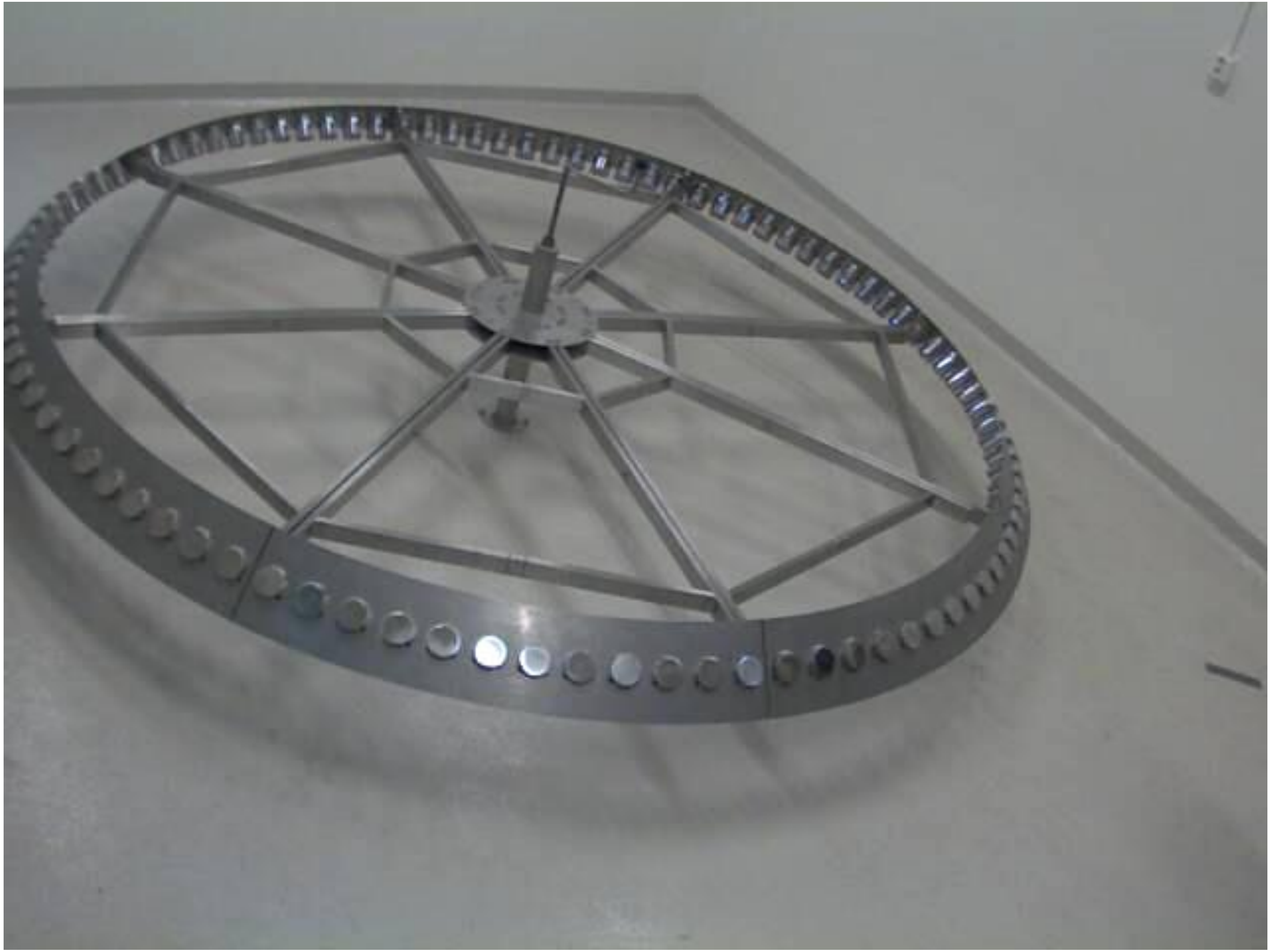
Put your tolerance for false negative error rate here (eg, 5%/0.05)

Put # test containers here

Put # false negatives errors allowed here

Design

- 96 slot wheel
- Stainless steel design and containers food-grade stainless steel jars
- Industrial dishwasher – containers used once; apparatus cleaned each use
- 3 internal standards
- 13 non-target compounds plus empty containers (container odor, only)
- 11 target compounds (some newly being trained and added incrementally over 17 trials)
- Randomized container assignment using a random number table
- Randomized location of wheel by spinning
- Randomized start quadrant
- One way glass
- 2 way radio
- Completely double blinded – separate tasks/people and handler signal as only indication, with tester blind to any info except the start quadrant and handler signal



The probability (*P*) of choosing *K* correct bins (containing targets) from *N* total bins of which only *K* are *targets* and the rest are non-target substances or blanks is given by (*C* = # of combinations):

$$P(N,K) = \frac{1}{C(N,K)}$$

where,

$$C(N,K) = \frac{N!}{(N-K)!\,K!}$$

For 3 targets in a total of 96 bins:

$$C(96,3) = \frac{96!}{(93!)3!} = 142,880$$

$$P(96,3) = \frac{1}{142880} = 6.99888 \times 10^{-5}$$

Conclusions – what this type of study can offer operational people:

- The use of such statistical designs, and the infrastructure that makes them possible, tells us what dogs know, what they don’t know and where we need improvement. These studies also tell us about which dogs are learning and how fast they do so (and so…perhaps who to breed).

- Such designs teach handlers to watch and understand their dogs.

- Such designs give organizations confidence that their teams perform as demanded and promised, while identifying weaknesses to be addressed.

- The implementation of this type of strategy can keep us all safer, and allow handlers to do there jobs better, with maximal credibility.

Acknowledgments

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- The study was conducted in Sweden and the facility was built at one of the Swedish Customs facilities.
- The study was done using Norwegian Customs dogs and handlers, and the expertise or both sets of these team members is gratefully acknowledged.
- All participants – including the handlers – were fully vested in this research, asked questions, reviewed designs, shared concerns and their needs, and were ideal collaboration partners.