REST

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WHAT IS REST

- Remote Explosive Scent Tracing
- A system where odors are collected and brought to an animal to assess
- More and more important for screening for cargo and diseases
  - Could be useful for drugs, invasive species, food products
- REST can increase the efficiency of screening- if implemented correctly

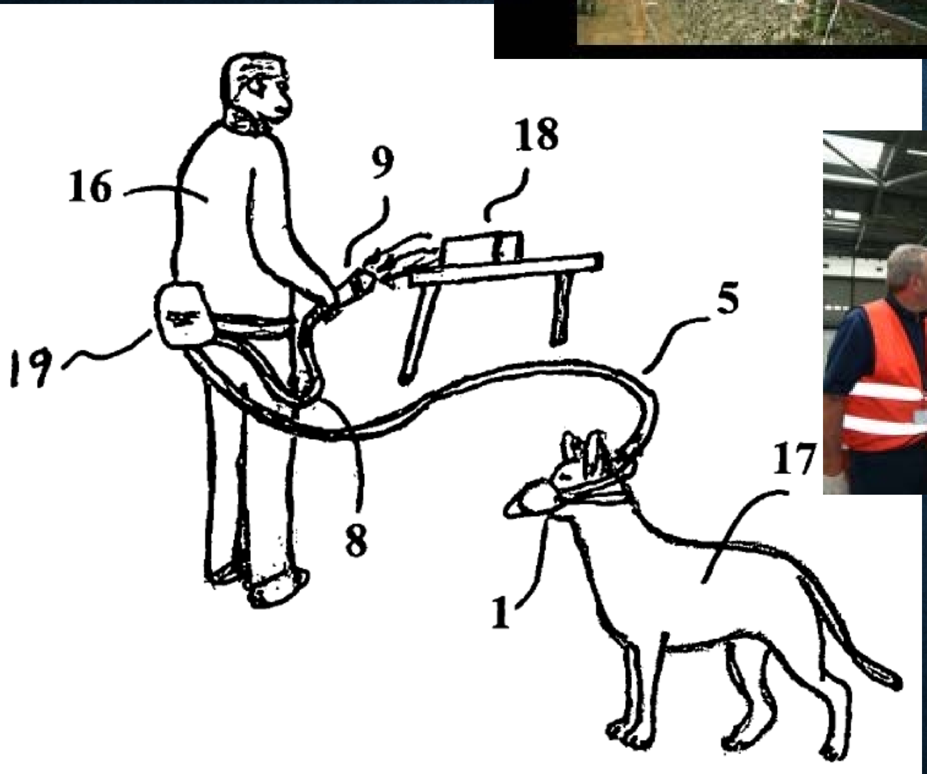
REST IS A COMPLEX SYSTEM

- REST is not just a dog and its trainer: it is a chain of events
- Determination of the target-
  - Vapor or particulates
- Collection of the vapor/particulates
- Storage and transport of the collected odors
- Testing and evaluation of the collected odors
- Interpretation and presentation of the results
- A failure at any of these links renders the results as useless

HISTORY OF REST

- MECHEM originally used for searching RR cars and freight containers
  - Then branched to screen for Land Mines
    - Prompted GICHD to consider using REST
- GICHD sponsored research on the usefulness of REST for landmines and the variables effecting REST
  - Those involved include GICHD, APOPO, NPG, Adee, Rune Fejellanger, Max Jones, Ian & Rebecca McClean and others
- Much of this research highlighted problems in methodology and quality control

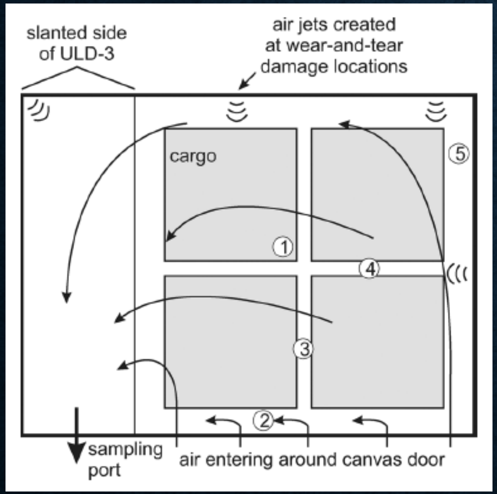
IMAGES OF REST



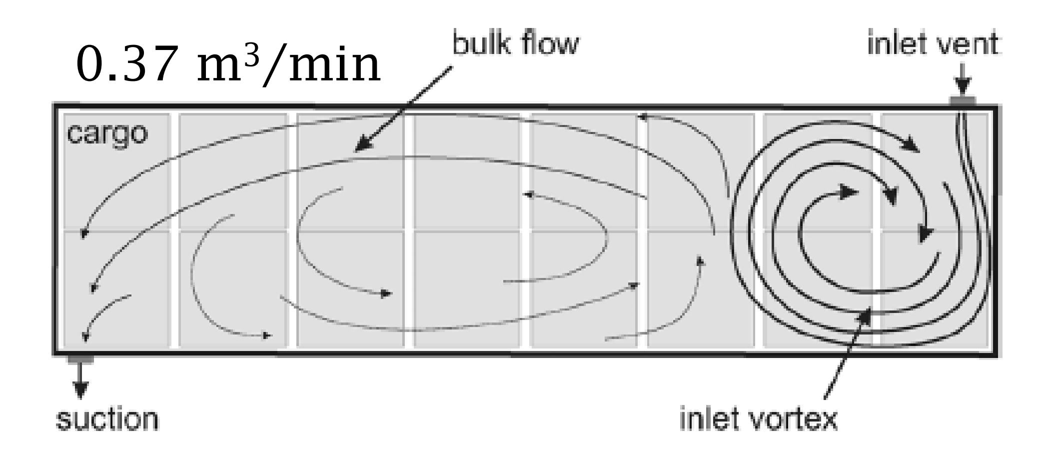
Odor collection

CONTAINERS, SUCTION RATE, AND CIRCULATION

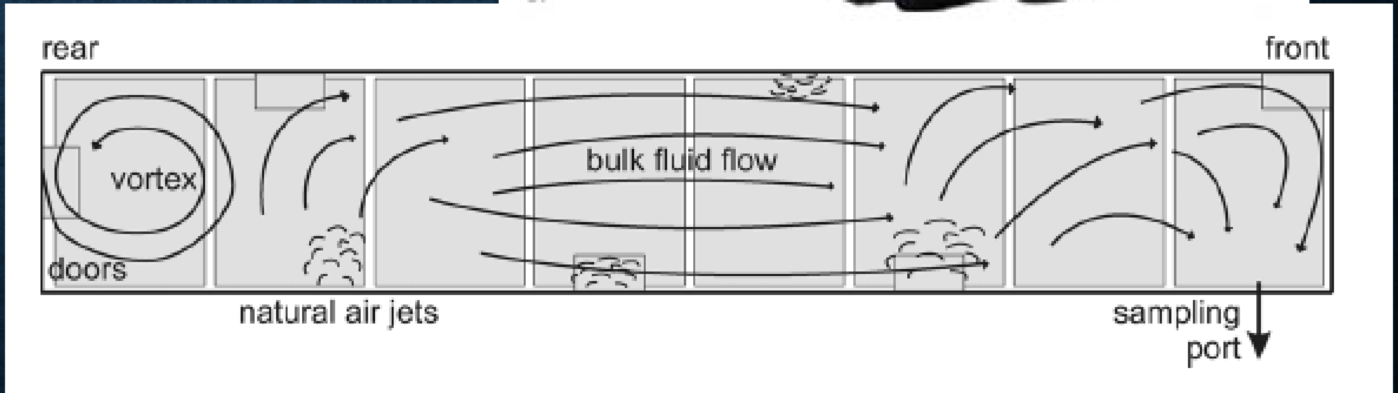
3.8 m^3/min



0.37 m^3/min



3 m^3/minute



Hargather et al 2011

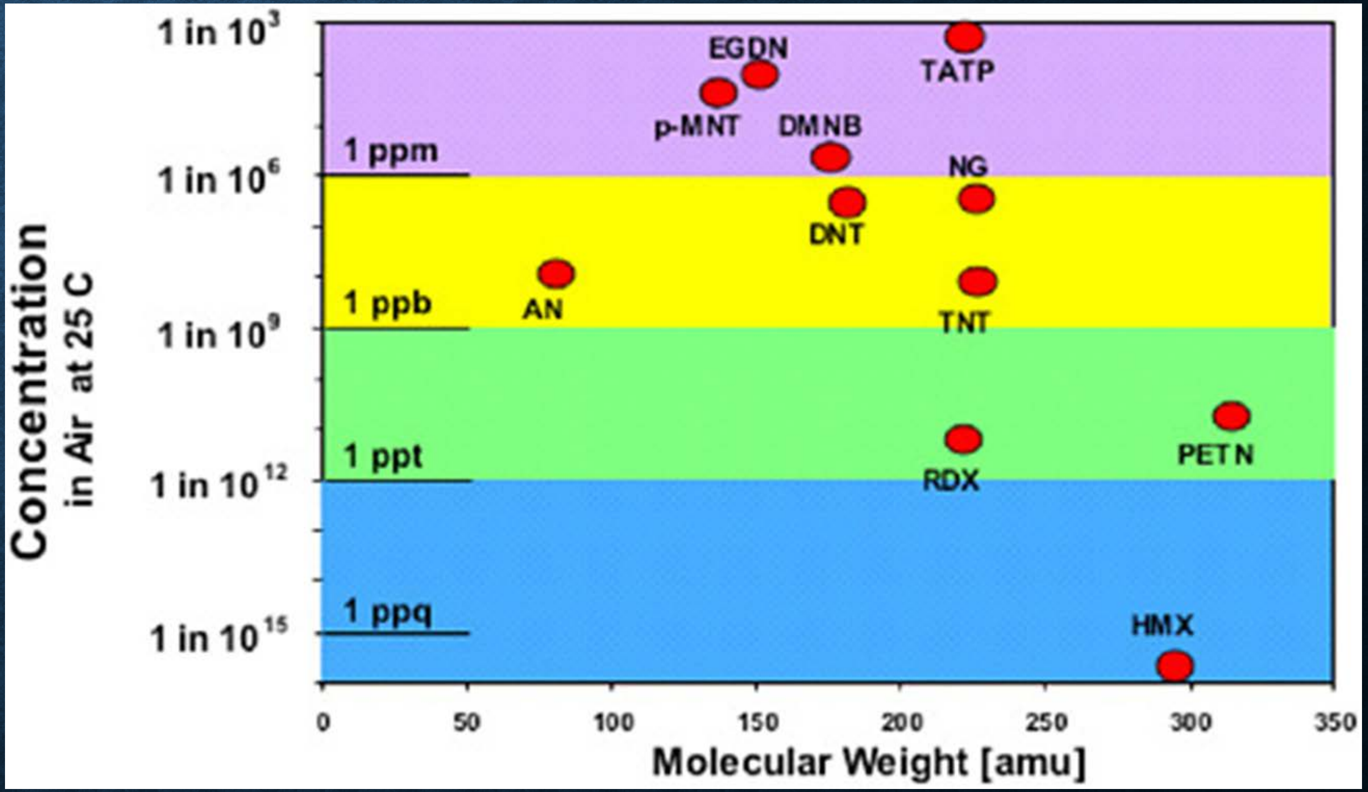
WAYS TO TEST THE DOGS

ODOR COLLECTION

- GIGO- if you can’t collect the odor, all the following stages are irrelevant
- Determine what is your target odor
  - different targets have different collection methods
  - Depends on both the vapor pressure and stickiness of the material
- Caveat- what is good for collection for GC-MS etc. is not necessary good for analysis by the dog.
  - With GC and other devices, the filter and collected material are heated to allow all of the collected material to desorb from the filter
  - The dog can only detect what is already in the headspace of the filter/canister

FIRST QUESTION: WHAT TO COLLECT? VAPOR AND/OR PARTICLES?

- It depends on the odor vapor pressure and stickiness
  - Vapor pressure of explosives varies tremendously
  - As does Stickiness of materials
  - Stickiness is as important as vapor pressure
    - The tendency of explosives to stick to walls, packages, clothing, hair, and hands
- This is important when determining the amount of collectable material



STICKINESS AND EQUILIBRIUM

- When does the explosive reach saturation in the atmosphere?
- Griffy (1992): the amount of measured explosive vapor in a room is many magnitudes below the expected amount
- TNT with a surface area of 1cc was placed in a 3*3*2 meter room with an air exchange rate of once per hour. 500 days was calculated for saturation.
  - The amount of TNT on the walls was significant (0.13 ug/m ^{3})
- In practical terms, the amount of explosive in the air is much less than theoretically possible
- Especially true when the container is not air-tight- And they never are.

AIR EXCHANGE RATES IN CONTAINERS

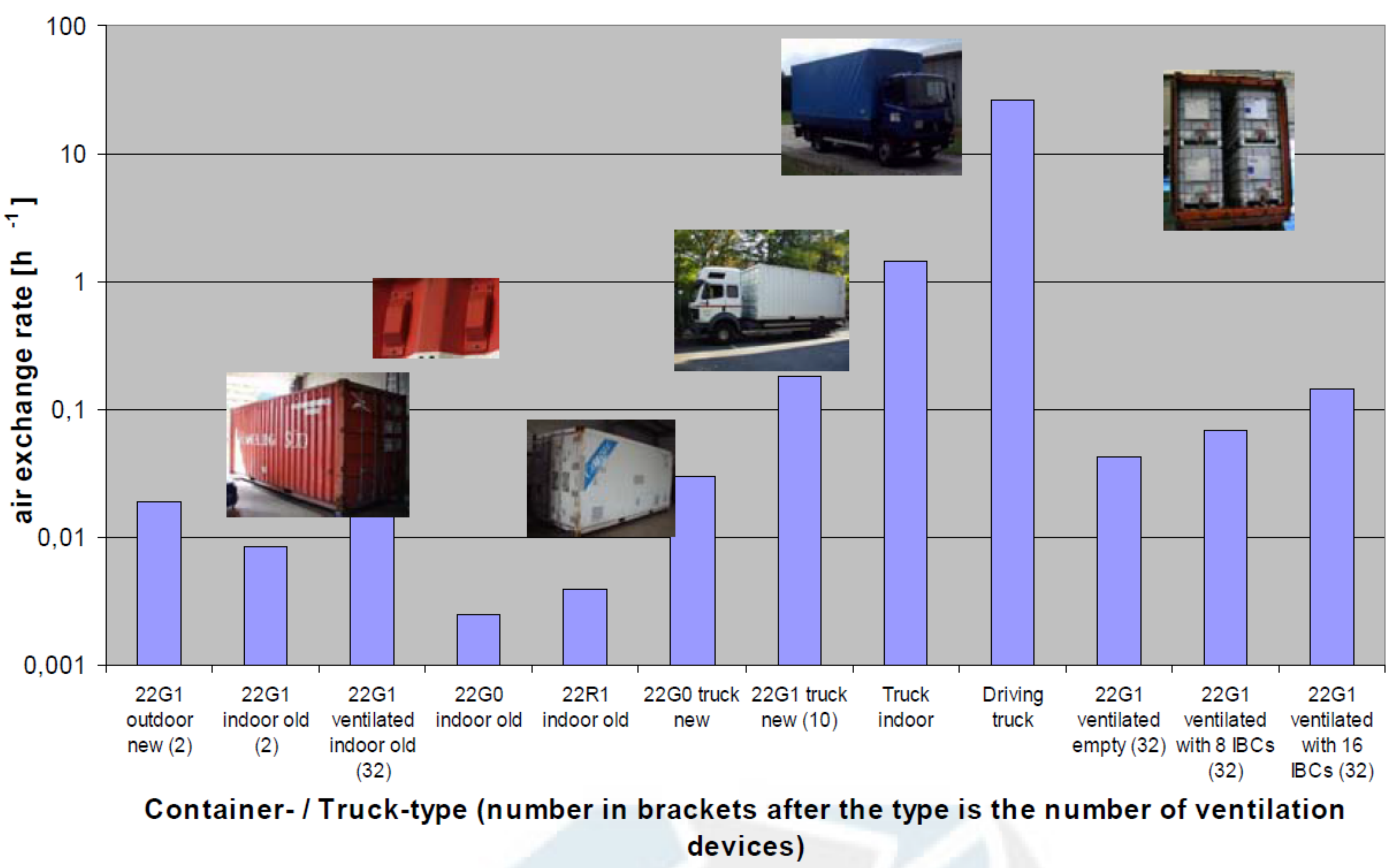


Figure 3: Overview of the air change rates for different containers and trucks

Goedecke, 2008

SOAK TIME: A DEMONSTRATION OF STICKINESS!

TABLE II
NORMALIZED COLLECTED MASS OF VAPOR FOR A 2 MIN SAMPLING PERIOD BEGINNING AT A GIVEN DELAY TIME AFTER A VAPOR INJECTION FOR A 0% FULL CONTAINER

Time delay (minutes)	Normalized collected mass of vapor
0	1.00 ±0.05
2	0.98 ±0.05
5	0.98 ±0.1
10	0.87 ±0.1
15	0.29 ±0.2
20	0.21 ±0.2

From Hargather et al (2011)

As soon as RDX was vaporized it immediately begins to stick to all surfaces.

The more packages in a container, the less odor is available in the air.

PARTICULATES ARE MORE IMPORTANT THAN VAPOR FOR MILITARY EXPLOSIVES

- Many detection devices use the particulates, especially when collection is by wiping.
- Particulates, especially dust, can have non-volatile chemicals stuck to them- and can travel great distances
  - Goss reports that particulates with attached chemicals can even be found in the artic
- Many people maintain that because the VP of explosives is very low, the dog must be detecting the more volatile chemicals correlated with the explosive
  - Dr. Kai Goss, in personal communication, suggests that the dog may inhale dust with the stuck explosives which then dissociate in the mucosa and are detectable by the dog.
  - This bypasses the issue of vapor pressure.

DOG SNIFFING BY PROF SETTLES

FILTERS

- Filters have two important properties- adsorption and desorption.
  - Very efficient filters may trap all the odor but may not release it to the dog.
- The original filter was developed by Mechem and consisted of screening wrapped around a core.
- Other filters were cotton wool, and the current favorite, polystyrene
- The filter must be matched to the target odor
  - The PVC screening may have been effective because it was an efficient dust collector.
- There should be more research into filter design
  - Current filters may not be optimal for explosives detection

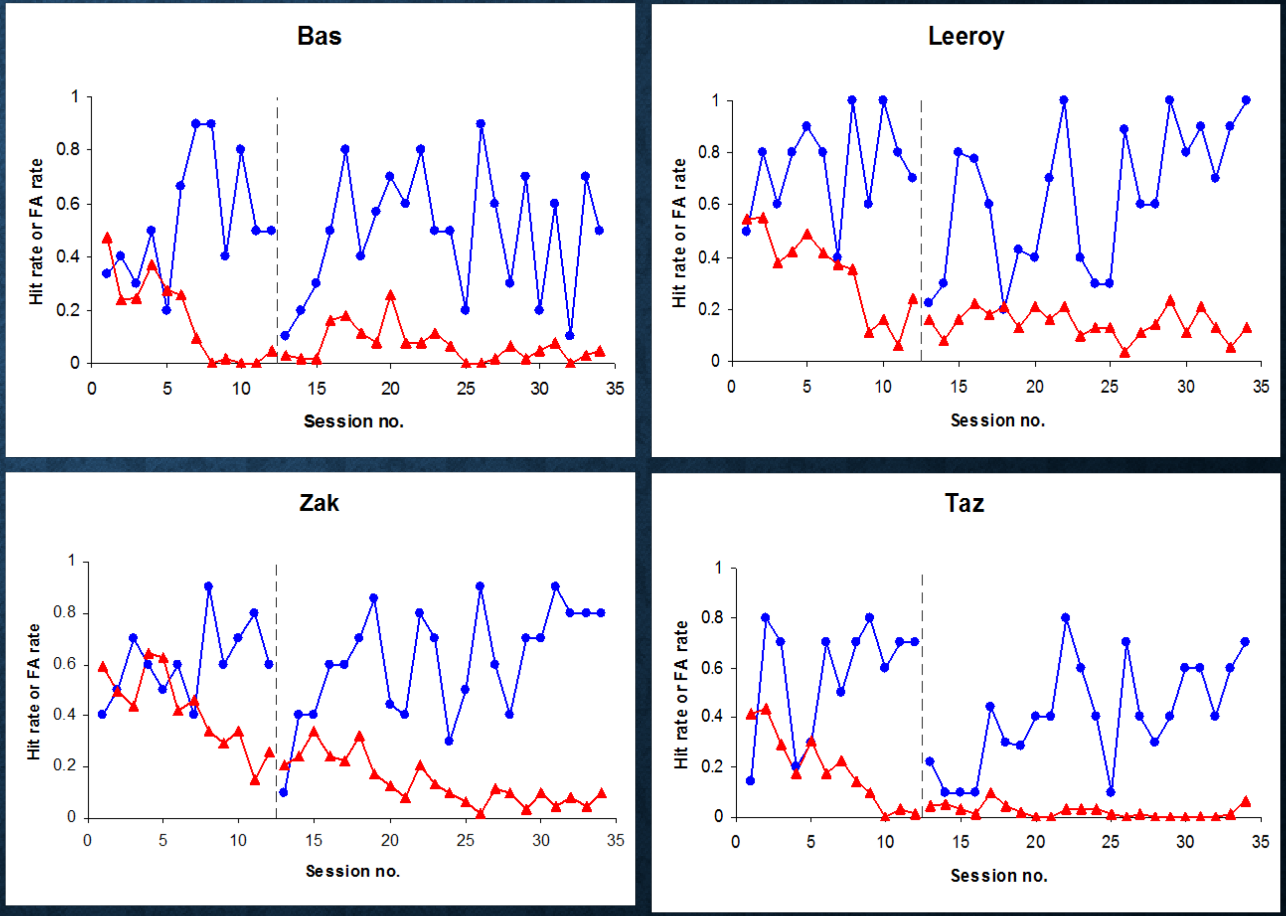
TESTING THE FILTERS

- For us, at this conference, this is the most interesting aspect but very problematic
- Susceptible to all sorts of errors
- Usual methodology is a series of containers with filters, either in a line or on a carousel.
    - Usually there is one target present and several non-target filters.

STIMULUS CONTROL

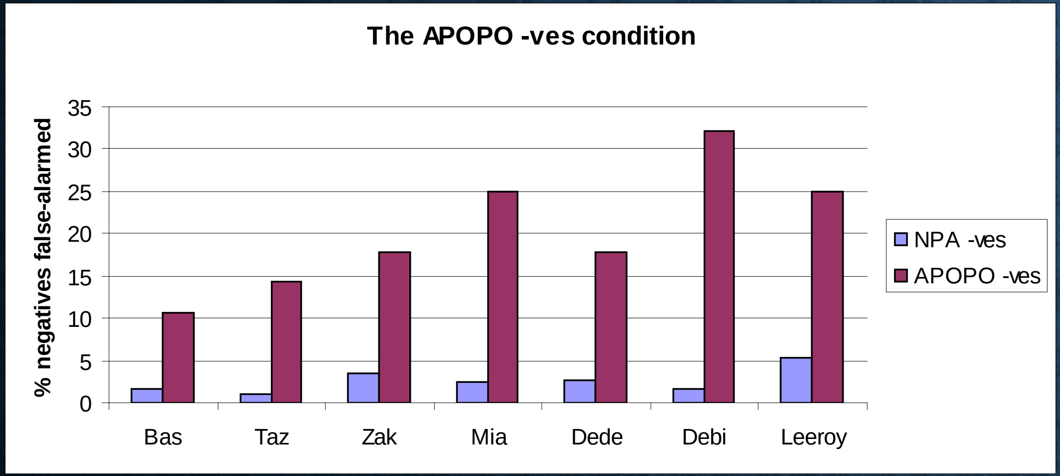
- WE NEED STABLE PERFORMANCE
  - These graphs show an absence of good stimulus control
- To what is the dog responding?
- Inadvertent stimuli can take control!

This and the next slides contain data collected by Max Jones and his colleagues in an attempt to develop a REST system for landmine detection.



SOURCES OF VARIATION OF STIMULUS CONTROL

The effect of different locations of preparation on false alarm rate

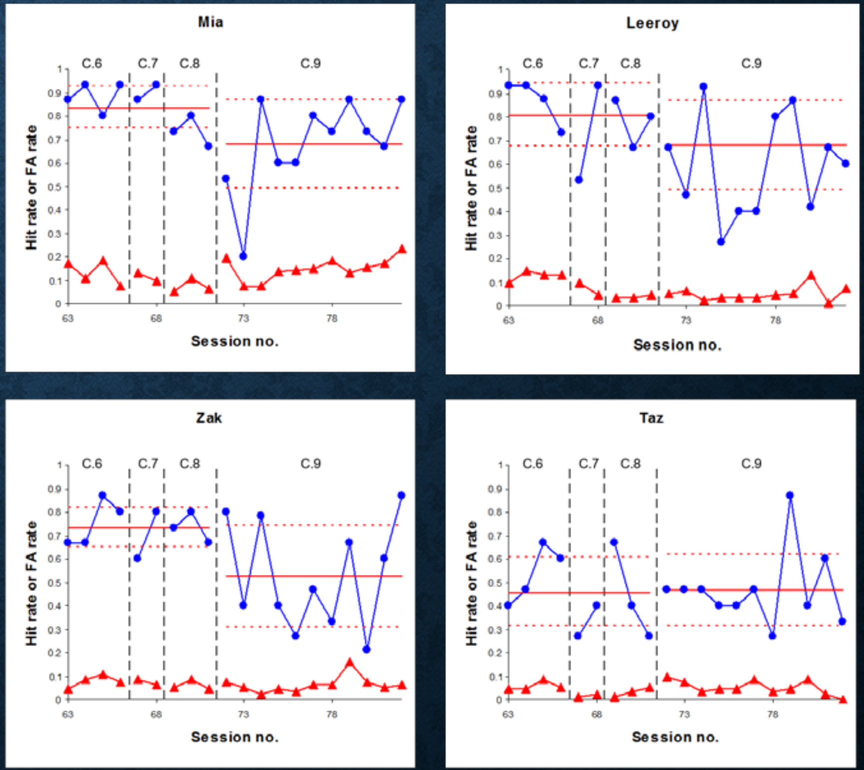


When both positive and negative stimuli were prepared in the same room there was an increase in the number of false positive responses

Either due to contamination or different ambient odors

Latex gloves were changed more frequently when preparing S+ filters

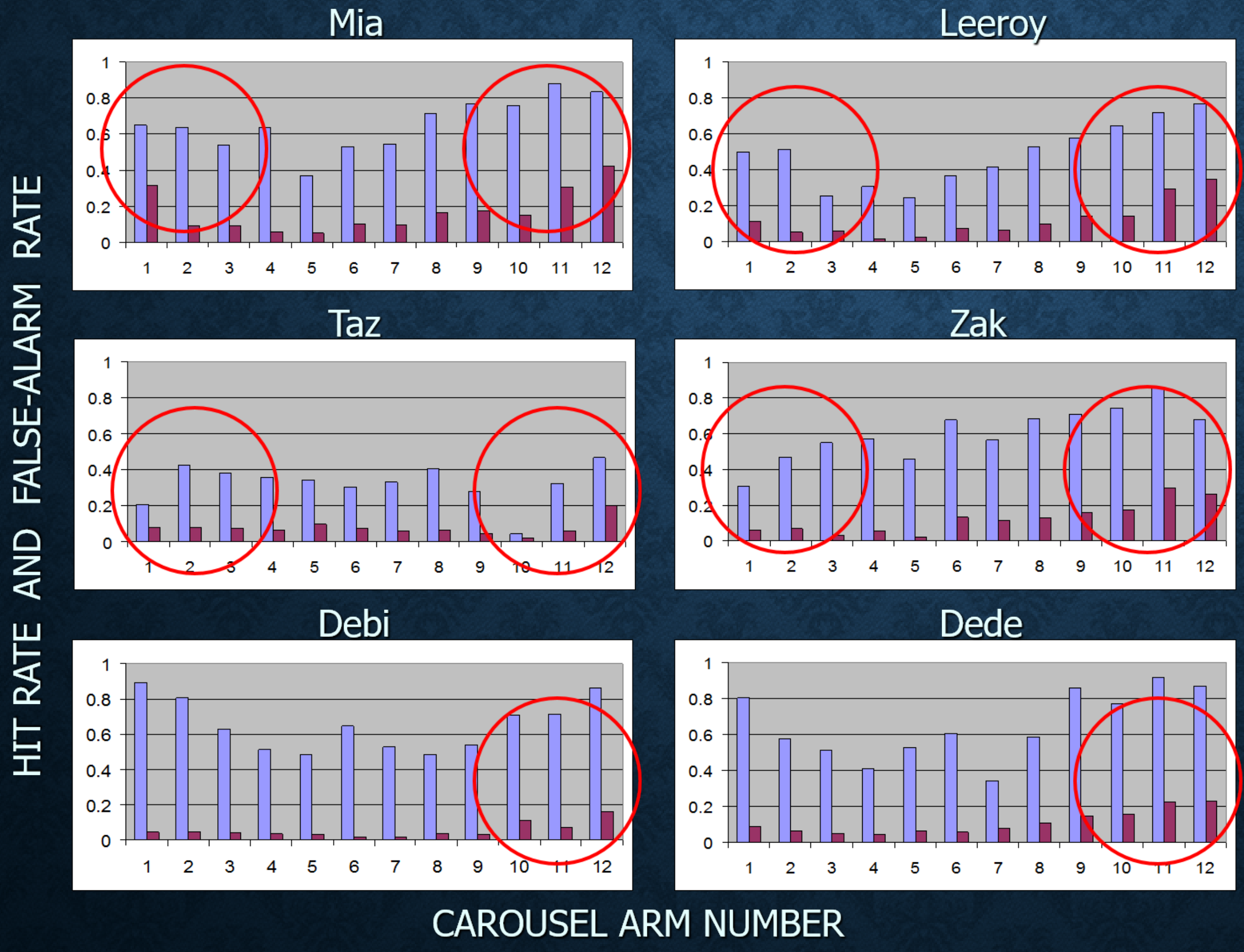
AT C9 switched to plastic gloves and accuracy decreased



The target is never isolated- context effect

MORE VARIABLES

<u>The carousel arm number</u>.
More responses at start and end of carousel

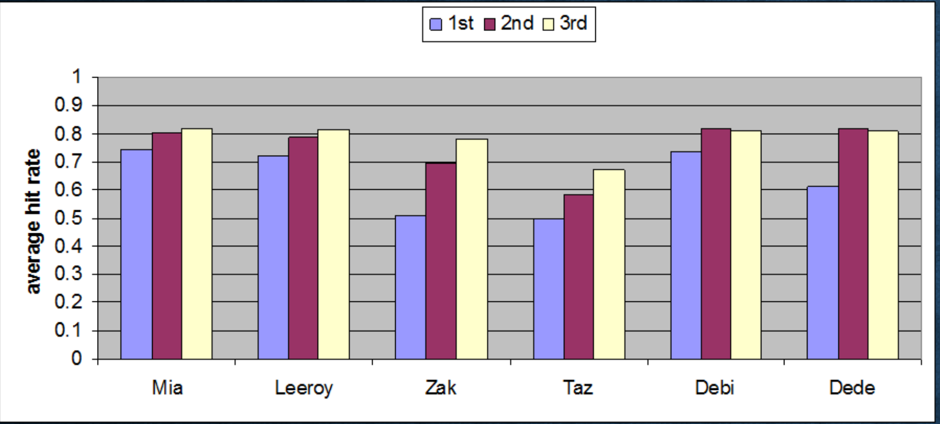


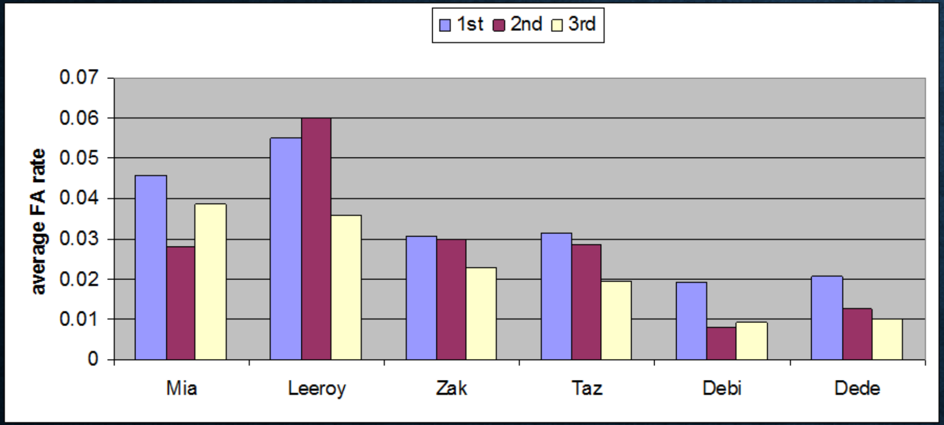
Expectation of the dog!

STILL MORE VARIABLES

The order of testing of the dogs:

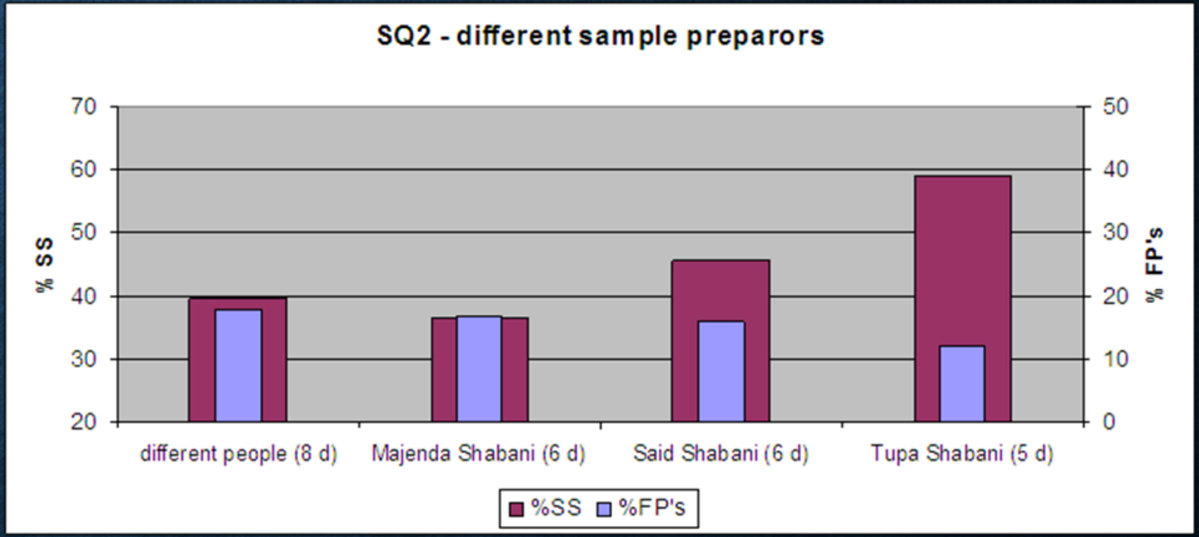
Repeating the same lineup showed that the third dog did better than the first





Who prepared the samples

There were serious individual differences!

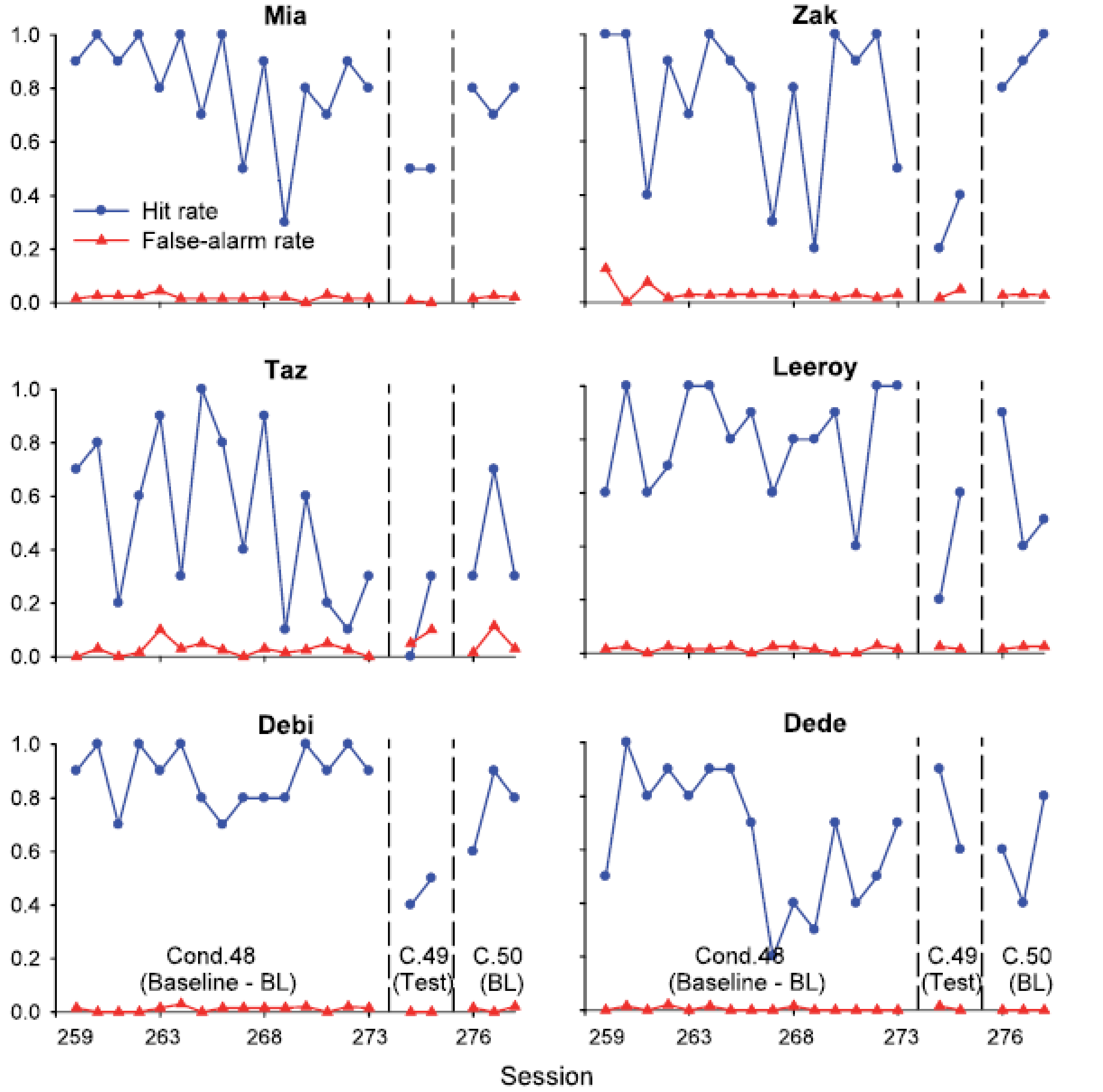


EFFECT OF DOUBLE BLIND ON ACCURACY

the lab assistant would anticipate the "sit" of the dog and click early. When the test was blind the assistant could not anticipate and required a full sit

You need objective criteria for the response

FIGURE 18 | Hit rates and false alarm rates for each dog in each session of the condition preceding the first blind test (Condition 48), during the blind test (Condition 49), and the condition following the blind test (Condition 50).



PROBLEMS OF MEMORY

- Dogs can rapidly learn and remember new odors
  - No one has tested the limits of olfactory memory in the dog
  - Rats can easily learn 80 odors and remember them for weeks
  - No reason to expect dogs to be different
- But they can also learn new and easier cues to solve the problem
  - Whatever gives most reinforcement with least effort.
  - The problem solving is dynamic

WORKING MEMORY

- We can usually remember seven items- the magic number 7 plus or minus 2.
- L. Brooke April et al (2013) did an experiment on working memory in rats- in a single session
    - A simple paradigm.
        - Go to a dish that contains odor A. Then present two dishes, one with A and one with B. The rat is reinforced only for going to B.
        - Then present three dishes, A, B, and C. The rat is reinforced only for going to C.
        - The rat can remember up to72 odors in one session.
        - This suggests that when negative controls are reused the dog already knows not to respond to them
            - **Therefore in designs, each probe should only be used once** (as was done by Schoon et al.)

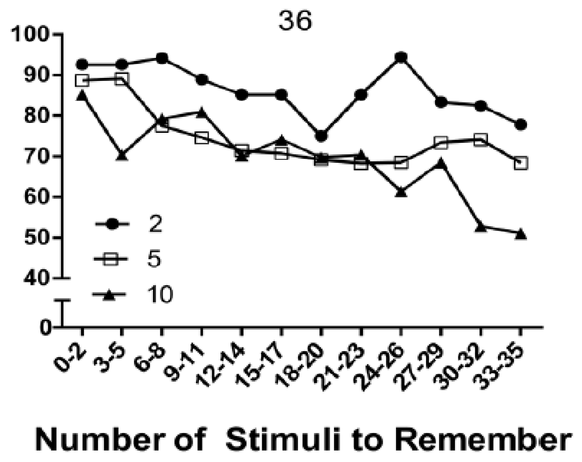


Figure 3.
Percent correct in Experiment 1 as a function of the number of stimuli to remember. Panels depict within session accuracy for conditions involving 12 (top panel), 24 (middle panel), and 36 stimuli (bottom panel). Black circles represent the 2 comparison (comp) choice arrangement, white squares for 5 choices, and black triangles for 10 choices.

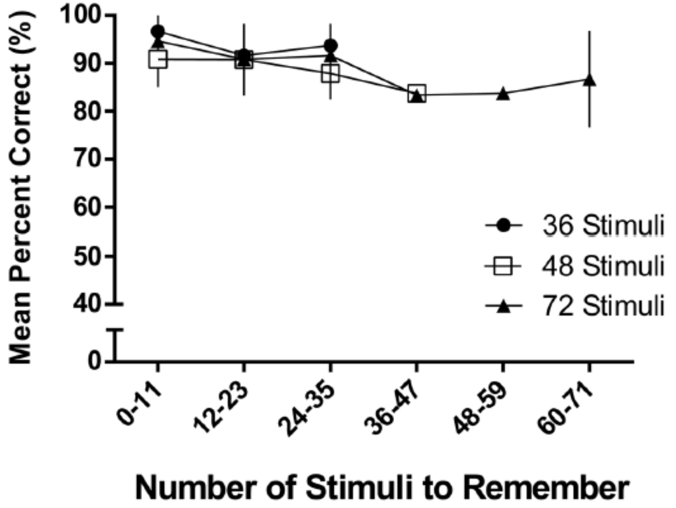


Figure 5.
Mean percent correct in Experiment 2 shown as a function of the number of stimuli to remember (bins of 12 trials). Black circles show performance on 36-stimulus sessions, 48-stimulus conditions are shown as white squares, and 72-stimulus conditions are shown as black triangles. Error bars represent SEM.

EXAMPLE OF LEARNING THE FILTERS IN A CANCER STUDY

- Walczak et al (2012)
- Trained dogs to respond to cancer odor
- Criterion II: dog chooses 1 filter sample out of all sniffed samples without any False positives.
    - The probability of correct indications by chance when all 5 stands in the lineup had been sniffed was 20%.

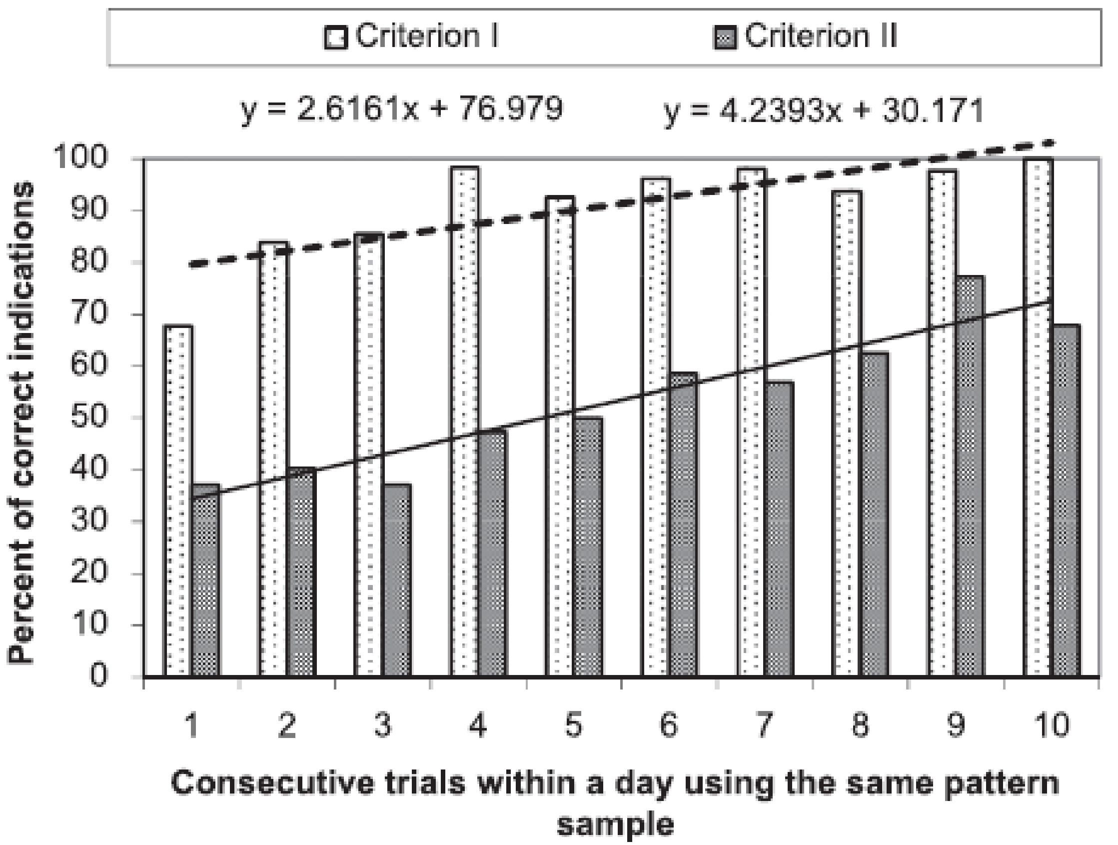


Figure 8 Percentage of correct indications in consecutive trials within a day using the same pattern sample.

PROBLEMS OF REINFORCEMENT

- Dogs work for reinforcement
- When the filter identity is unknown, it should not be reinforced
- Necessary to use known positive and known negative filters
  - But how many and of what types?
  - And how do you prepare the filters? Should they be very similar to the unnkowns?
  - We found that what is important is the difficulty of detection, not the filter identify
- The more known positives, the fewer unknowns can be checked
- Too few known positives and the dog will not perform well
- The answer to this balancing act requires extensive research to optimize the performance

REST VERSUS FREE-RUNNING

- The problem of stimulus control in REST and FREE-RUNNING is similar
  - But they are more critical in the rest paradigm
- Disadvantages of REST:
  - There is no gradient for the dog to follow
  - The total amount of target material available to the dog is usually less then collected by sniffing
  - The dog has less time to habituate to the ambient odors
  - The dog has to make an immediate decision at each filter
  - **The possibility of error at any stage of the REST process is greater**
  - **THUS REST is more challenging**
- On the other hand, it is much easier to continually calibrate the dog's performance by presenting positive and negative controls
- The dogs work in a controlled environment and expend less energy running around
- The search time for inspecting cargo is significantly shorter

CONCLUSIONS

- If you want to use REST, you have to understand its benefits and limitations
- A lot of research and development is still needed
- Some important variables are
    - Vapor pressure and stickiness of the target
    - Particulates versus vapor
    - Stimulus control
    - Memory
    - reinforcement

QUESTIONS?

Thank You

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