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Mine Detection Rats: Effects of Repeated Extinction on Detection Accuracy

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output raster map for each degree of operational difficulty. For example, the overall surface with a low degree of difficulty is directly read into the output raster. This kind of information may be significant for decision-makers and operators, especially in financial terms. With further work, in fact, this model offers the possibility to estimate the financial implications of their operational choices.

Conclusion

The resulting map is a good starting point for decision-makers and operators to refine their evaluation of the degree of operational difficulty and improve efficiency in their work. However, this tool is intended as a guide, and real-world political or economic factors may lead to or prevent demining activities in a way that may disagree with the tool. In addition, deminers should be aware that modification of one parameter could affect the outputs of the model significantly.

See endnotes page 67.

Figure 6. Parameters provided to users at the execution of the model.
Figure courtesy of the authors.

The mine detection rats in Mozambique work on training fields and actual minefields (operational sites). The training field comprises several 100 sq m, 200 sq m and 400 sq m boxes indicated by ropes along each side. Between zero and four deactivate- ed landmines are buried within each box. The rats are attached to a rope (via a harness held by two handles on either side of the box). The rats walk across the box they are searching. When an indication response (pausing and digging) occurs within 1 m of a landmine, the trainer clicks to signal reinforcement and food is delivered.

When the rats are used operationally, the location of mines (and other explosive remnants of war) is unknown prior to clearance operations. Therefore, knowing whether an indication response is correct (i.e., within 1 m of a mine) or incorrect is impossible. To avoid the possibility of reinforcing incorrect responses and thereby potentially reducing the rat’s subsequent detection accuracy, no reinforcers are delivered when the rats are used operationally.

In technical terms, the rats work under extinc- tion (no reinforcement) conditions when used operationally and under differential reinforcement (food reinforcement for correct responses, no reinforcement for incorrect re- sponses) conditions during training. Extinc- tion inevitably weakens previously reinforced responses.18 For this reason, the rats rotate between the training field and the operational site. The rationale for this arrangement is that reinforcement of correct responses on the training field will sufficiently strength- en such behavior to compensate for the re- sponse-weakening effects of extinction at the operational site. The rats’ performance at the operational site strongly suggests that this is the case, but we have not systematically eval- uated the extinction effects, though studies of

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by Amanda Mahoney, Amy Durgin, Alan Poling (Western Michigan University, APOPO), Bart Weetjens, Christophe Cox, Tass Teweida, TeKimiti Gilbert (APOPO)

This article describes the performance of Giant African Pouched Rats where reinforcement (reward) or extinction (no reward) conditions affected landmine identification. Accuracy deteriorated quickly in the absence of reinforcement, suggesting that reinforcement is essential.

See endnotes page 67.

Figure 7. The mine detection rats (left) are shown in the experimental setup with one trainer and one instructor.

All photos and figures courtesy of the authors.

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are under way. In an effort to gain information of value to maximize the effectiveness of APOPO’s MDR team, the present study evaluated the effects of extinction on the detection accuracy of five rats performing under controlled conditions that allowed for accurate assessment of their performance.

Setting, Subjects and Materials
Trials took place in Morogoro, Tanzania on the APOPO training field, which contains approximately 1,200 landmines buried in a fenced 283,279.95 sq m site. In the portion of the training field used, one mine was buried in a marked 100 sq m box. Some of the boxes in APOPO’s training field have markings to indicate landmine locations and some do not. The boxes without markings were used in the present study to provide blind testing conditions, under which the trainers were unaware of mine locations. The tests used six boxes, each containing just the one mine. Each test took an average of 17.8 minutes with a range in time of 8 to 25 minutes. Five rats participated in this test. Each rat had recently passed a blind test in which it located each of eight unmarked mines in a 400 sq m area with no more than one false alarm. The rats were distributed between two trainer units, each unit comprised two trainers and one notetaker. The notetakers were APOPO minefield supervisors. APOPO certified all trainers and selected them because they demonstrated good adherence to standard operating procedures. Materials included clickers to signal availability of the food rewards, data sheets, a banana (the food reinforcer) and mine detection training box materials.

Training box materials consisted of measuring tape stretched along one side of the box and a rope that stretched across the box between the two trainers and guided the rat as it walked in the box. The rats were attached to the rope via a harness and lead cord and could walk back and forth along the rope. The trainers held two measuring tapes between them. One end of each tape was attached to the rat’s harness at zero. Thus, the exact location of the rat’s indications could be determined through the coordinates of the measuring tape value in the trainer’s hand and the measuring tape value at the trainer’s feet. After the rat walked down the rope in one direction, the trainers took a 0.5 m step forward and the rat walked in the opposite direction across the box. In all tests, the rats were allowed to traverse the rope only once before they were moved forward.

Data were recorded on graph paper that depicted the box measurements. Each test box was displayed as a grid comprised of 0.5 m x 0.5 m squares. Shaded gray squares corresponded to the mine locations. The indication response was scratching the ground for any length of time within 1 m of the landmine. Upon a rat indication, the trainer informed the notetaker, who recorded the location of the response and whether or not the trainer should sound a click and deliver food to the rat. In the reinforcement condition, the trainer was instructed to sound a click and deliver food (i.e., provide a reinforcer or reward) each time an indication response within 1 m of a mine was emitted. Reinforcers were never provided in the extinction condition.

Experimental Design
A multiple baseline with reversal design evaluated detection accuracy under reinforcement and extinction conditions. In a multiple baseline design, different subjects are initially exposed to the conditions of interest on different days. This design demonstrates that the changes observed when conditions change are the result of the change in conditions and not the result of some other factor (e.g., weather conditions, day of the week, time of exposure to a condition). A reversal design calls for returning to a prior condition, which in this case was the reinforcement condition. Thus, all of the rats were exposed to a reinforcement condition, then extinction, reinforcement and finally extinction.

Performance
When performance remained at 100% accuracy under the reinforcement condition over at least four consecutive days, the extinction condition began. Since there was only one mine per box, if the rat found it, the detection accuracy was 100%; if it did not indicate a mine, the detection accuracy was 0%. The rat worked under the extinction condition until detection accuracy fell to 0% for at least two consecutive days. This sequence was then repeated.

All rats worked in one box per day, and sessions were conducted up to five days per week. Sessions were not conducted on weekends, holidays or days with heavy rain. Data recorded each day for each rat were the location of indicators, the number of hits (indication responses within 1 m of a mine), the number of false alarms (indication responses further than 1 m from a mine) and the number of misses (mines with no indication response within 1 m).

Results
In this condition, when an indication response occurred within 1 m of a mine, the trainer produced a click sound using a handheld clicker. If the rat began to approach the trainer within 3 seconds of the click, which usually occurred, the trainer delivered food. If the rat did not approach the trainer within 3 seconds of the click, the trainer did not present food. If a rat walked over a mine without indicating, the trainer continued clearing the rest of the box. Each rat searched each area of the box only once.

Extinction Condition: Extinction sessions were the same as reinforcement sessions, with the exception that neither a click nor food was presented following either correct or incorrect identification responses. Second Reinforcement and Second Extinction Conditions: The second reinforcement condition, which was identical to the first reinforcement condition, occurred after the first extinction condition. The second extinction condition was the same as the first one and was the last condition arranged for each rat. Figure 1 shows the number of days that each rat was exposed to each experimental condition.

Independent-observer Agreement. A second observer independently collected data during 21.5% of sessions. The second observer agreed with the primary data collector on 98.1% of rat indications.

Figure 1 shows that overall, the rats’ accuracy in detecting landmines was high during the first reinforcement condition and quickly declined when extinction was introduced. Accuracy remained inconsistent and relatively low after reinforcement was again arranged but eventually reached a high level. The rats’ accuracy again declined even more rapidly when extinction was introduced a second time. For this reason, these rats will not be used in actual future detection operations.

Few false alarms (incorrect identification responses) occurred under any condition, and the number of false alarms per session did not consistently differ under reinforcement and extinction conditions. None of the rats emitted more than three false alarms on any given day, and an individual rat typically emitted zero or one false alarm each day.

Discussion
This study evaluated the performance of APOPO’s MDRs under reinforcement and extinction conditions and found that, in general, the rats demonstrated high accuracy and stable performance after sufficient expo-
sures to the reinforcement condition and vari-
able but substantially lower accuracy during the re-
tinction condition. There was a high carry-
over from the reinforcement condition in that performance remained variable after the rein-
tinction condition was reinstated. Sometimes several reinforcement sessions were necessary for performance to recover to 100% accuracy.

In operational settings, the rat does not receive reinforcements, because it is un-
known where mines lay and, consequently, whether the rat’s indications are correct (i.e., within 1 m of a mine) while searching. The study’s aim was to determine how many days an MDDB rat can work on a minefield, without re-
ward, before performance degrades. Under the conditions of the present study, this period was conclusively shown to be quite short. The rat’s accuracy in detecting mines fell, on average, after 3.1 days of exposure to extinc-
tion, although their false alarm rates did not change systematically. Furthermore, recovery of the asymptotic accuracy level following extinc-
tion took up to nine days.

To maximize experimental control, the present study only used 100 sq m boxes con-
taining a single mine. In operational demining in Moramgbe, the overall density of land-
mines is substantially lower. For example, in one study the target was located in a 93,400 sq m area, which yields an average of 0.04 mines per 100 sq m box, although in some cases a rat made one or two misses in a small area. The effects of extinction on the performance of MDDB under such conditions, where target density is highly variable but low overall, remain to be determined. Of course, performance in extinction depends on a num-
ber of environmental variables. These var-
iables seemingly would include the number of responses emitted without reinforcement and the manner in which reinforcement was ar-
 ranged prior to extinction.

Future research in this area might inves-
tigate the effects of training with intermit-
tent reinforcement, which is well-known to promote accurate performance under extinct-
ion. Though APOPO has not yet evaluated this methodology, it has used intermittent re-
forcement, with trainers rewarding 85% of indications. APOPO plans to study intermit-
tent reinforcement and evaluate optimal pa-
rapters and effectiveness.

APOPO is currently investigating the util-
ity of exposure to reinforcement conditions, prior to or following the extinction condi-
tion. The success of this procedure depends largely upon how well the rats discriminate between training (reinforcement) and opera-
tional (extinction) conditions.

These tests were conducted for experi-
mental purposes to provide relevant informa-
tion to APOPO management. Prior research conducted under operational conditions indi-
cates that APOPO rats are accurate in detect-
ing landmines under the conditions arranged in Moramgbe.10 APOPO draws upon several means of reinforcement delivery: in opera-
tional conditions: frequent quality control checks, data collected regularly on individ-
ual rat performance and ample opportuni-
ty for reinforcement on the nearby training field. How the rats would perform under other conditions, for example, if they worked for longer periods each day or in areas with differ-
ent landmine concentrations, is speculative. The present data strongly suggest, however, that their accuracy would decline significantly if they worked for periods during which several indi-
ation responses occurred and were not reinforced. This study and previous ones provide a research base that informs APOPO’s operating procedures in a way that optimally operates procedures and ensures the rat’s performance is maintained at high levels under operational settings.

APOPO’s primary goal is using poched rats effectively and efficiently for humanitarian purposes, not conducting scent detection re-
search. Such research, however, is the best way to find out and for that reason is given high priority by the organization. Conducting such research uses personnel, time and financial re-
sources that could go directly toward mine clearance or land release. Therefore, we attempt to choose research topics carefully and to design studies in a way that minimizes cost. Small-N research strategies characteristic of behavioral analysis have proven especially valuable in this regard, and we recommend them to the human-
itarian demining community.22

See endnotes page 67

Endnotes

1. The Need for Collaboration Between Ordinance Manufacturers and UXO Clean-up Personnel, Imber [from page 10]
2. The Vietnamese refer to the Vietnam War as the “American War. “Viet-
ober 2011.
5. One example of this categorization in the United States can be seen in the Occupational Safety and Health Association’s guidelines for UXO technicians. OSHA requires American-employed UXO technicians to complete a 40-hour Hazardous Waste course and subsequent eight-hour refresher course to work at UXO clearance sites.
6. HERO standards are designed to limit the potential for electromagnetic radiation to adversely affect munitions and electro-explosive devices. High electromagnetic environments can be produced by mod-
9. “Estimates for the Total Number of IDPs for all of Sudan.” International Dis-
tober 2011.
11. The Ordnance Disposal Office began its operations in EI Fasher in 2005 and became an integral component of UNAMID in 2008. It works in di-
rect support of UNAMID priorities to create a safe environment for the civilian population in Darfur. More information can be found at http://
ifar.org.
12. Sudan’s National Mine Action Authority (NMAA) was established through Presidential Decree No. 299 in December 2005 and adopted the Sudan Mine Action Bill in 2010. In 2012, NMAC and UNAMID ODO signed a letter of cooperation, and NMAC started establishing offices in Darfur. More information can be found at http://smaa.org.
13. International Mine Action Standards Mine Risk Education Best Prac-
ber 2011.
15. “Key Facts and Figures for Sudan with a Focus on Darfur.” Relief Web.
17. Traditional community leaders
18. When discovering the use of UXO as school bells out of economic neces-
sity, UNAMID ODO responded by including school bells as part of the risk education materials.
20. Grenade Blast Kills 25 in Turkey, Reitman [from page 13]