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Amanda Mahoney  
*APOPO*

Amy Durgin  
*APOPO*

Alan Poling  
*APOPO*

Bart Weetjens  
*APOPO*

Christophe Cox  
*APOPO*

*See next page for additional authors*

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Mine Detection Rats: Effects of Repeated Extinction on Detection Accuracy

Authors
Amanda Mahoney, Amy Durgin, Alan Poling, Bart Weetjens, Christophe Cox, Tess Tewelde, and Tekimiti Gilbert

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Mine Detection Rats: Effects of Repeated Extinction on Detection Accuracy

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.

As a result of almost 30 years of war, landmines are a devastating problem in Mozambique. According to a United Nations’ report, an estimated 20 people step on landmines every month in Mozambique and, due in part to lack of adequate health care, 40% of those people die. Since the mid-1990s, efforts have been made to clear Mozambique of landmines, but millions are believed to still contaminate the country. Anti-Personnel Landmine Detection Project (APLDP) started using Giant African Pouched Rats (Cryptoprocta ferox) for landmine detection in Mozambique in 2007. Details on how the rats are trained and used operationally are provided elsewhere. In brief, the rats are trained through operant conditioning in which food reinforcement (reward) appropriate indication responses (i.e., those that occur within 1 m of a mine). Incorrect indication responses are not reinforced. Training begins in a controlled laboratory setting and proceeds through a series of steps to a large training field.

An early evaluation conducted in 2005 in which seven rats searched 20,234.28 sq m of land in Mozambique indicated that their detection rate by the rats. Such findings suggest that pouched rats are accurately in detecting landmines and, as a result, they are used operationally in Mozambique.

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 detectable landmines are buried within each box. The rats are attached to a rope (via a harness) held by two handlers 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 the 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 extinction (no reinforcement) conditions when used operationally and under differential reinforcement (food reinforcement for correct responses, no reinforcement for incorrect responses) conditions during training. Extinction inevitably weakens previously reinforced responses. 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 strengthen such behavior to compensate for the response 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 evaluated the extinction effects, though studies.
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 contained approximately 1,210 landmines buried in a fenced 283,279 sq m area. 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 repeatedly 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 teams; each team 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 by 0.5 m squares. Shaded gray squares corresponded to the mine locations. The indication response was scraping 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.

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 conditions 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 indications, 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

Figure 1 shows the percentage of hits per day by individual rats during reinforcement and extinction conditions. Because each box had one mine, accuracy was either 0% or 100%. During the initial reinforcement condition, the rats identified all mines except for a single mine missed by Njali in the third session.

In general, because accuracy was 100% on the first day, the rats did not appear to learn from the use of the same six boxes. The trainers may have learned the location of the mines, and at some point they may not have been operating under blind conditions. However, a second observer was present and systematically 20% of the sessions ensured that procedures were followed as written and that there was agreement in recording.

When extinction was introduced, accuracy declined for four of the five rats within three sessions. Enda’s performance did not fall until the seventh session but remained at 0% for six of the next seven sessions. Typically, the rats continued emitting an indication response over the mine on some days during extinction, but failed to indicate on about as many days as they indicated. Upon return to the reinforcement condition, detection accuracy for Toyota remained variable for six days while performance for Mar remained at 0% for eight out of nine days before improving to the initial reinforcement-condition level. Performance for Njali and Bila recovered to 100% accuracy in two days, and Enda’s performance improved to this level after three days. Upon return to extinction, responding fell within two to four days for all rats. Performance again took several days to recover to prior reinforcement levels for Enda and Mar, although the performance of Bila, Toyota and Njali recovered in zero to two days.

Figure 2 summarizes findings across the five rats. This figure clearly shows that overall the rats’ accuracy in detecting landmines was high during the first reinforcement condition and quickly declined when extinction was arranged. Accuracy remained inconsistent and relative 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-
The rats' accuracy in detecting mines fell, on average, after 3.1 days of exposure to extinction, although their false alarm rates did not change systematically. Furthermore, recovery of the asymptotic accuracy level following extinction took up to nine days.

To maximize experimental control, the present study only used 100 sq m boxes containing a single mine. In operational demining in Mozambique, the overall density of landmines is substantially lower. For example, in one study in which the rat was located in a 93,400 sq m area, which yielded an average of 0.04 mines per 100 sq m area, although in some cases a rat made one or more runs in a small area. The effects of extinction on the performance of MDRs under such conditions, where target density is highly variable but low overall, remain to be determined. Of course, performance in extinction depends on a number of environmental variables. These variables seemingly would include the number of environmental variables. These variables are likely to include mine types, size, and shape, as well as the presence of other obstacles such as vegetation, rocks, and soil conditions. The rats' performance in detecting mines fell, on average, after 3.1 days of exposure to extinction, although their false alarm rates did not change systematically. Furthermore, recovery of the asymptotic accuracy level following extinction took up to nine days.

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