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Automated chair-training of rhesus macaques

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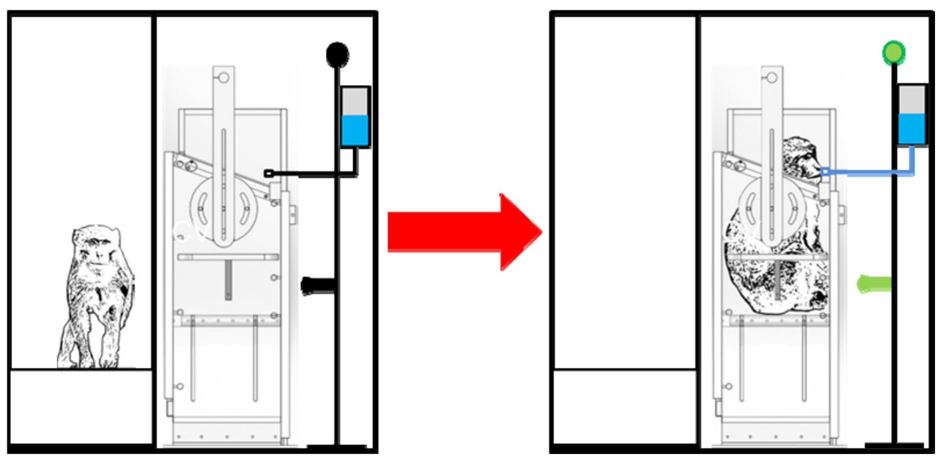
HIGHLIGHTS

- Working with macaques requires that they be trained to enter a primate chair.
- We developed a “smart chair” that responds to the animal and trains it to enter without humans in the room.
- The animals learned to enter the chairs within a few sessions, and this method was best for an animal with a behavioral pathology.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Neuroscience research on non-human primates usually requires the animals to sit in a chair. To do this, typically monkeys are fitted with collars and trained to enter the chairs using either a pole, leash and jump cage. Animals may initially show resistance and risk injury. We have developed an automated chair-training method that minimizes restraints to ease the animals into their chairs.
New method: We developed a method to automatically train animals to enter a primate chair and stick out their heads for neckplate placement. To do this, we fitted the chairs with Arduino microcontrollers coupled to a water-reward system and touch- and proximity sensors.
Results and comparison with existing methods: We found that the animals responded well to the chair, partially entering the chair within hours, sitting inside the chair within days and allowing us to manually introduce a door and neck plate, all within 14–21 sessions. Although each session could last many hours, automation meant that actual training person-hours could be as little as half an hour per day. The biggest advantage was that animals showed little resistance to entering the chair, compared to monkeys trained by leash pulling.

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Conclusions: This automated chair-training method can take longer than the standard collar-and-leash approach, but multiple macaques can be trained in parallel with fewer person-hours. It is also a promising method for animal-use refinement and in our case, it was the only effective training approach for an animal suffering from a behavioral pathology.

1. Introduction

Non-human primates are the best animal model for studying the neural mechanisms of high-level and cognitive behaviors because their brains are so similar to our own. However, this similarity brings its own complications: these smart social animals can be difficult to persuade into performing unnatural tasks. Monkeys show a wide range of temperaments and may develop pathologic and self-injurious behaviors in response to experimental requirements (Novak et al., 1998; Bellanca and Crockett, 2002). This is a problem because the success of research depends on earning the animals' cooperation with the least amount of distress. One example of a necessary but counterintuitive task is chair training: requiring an animal to submit itself into an enclosed space, outside the safe familiarity of its home cage. Historically, chair training required using a pole or a leash to transfer the primate into the chair. This process is invariably met with resistance by naïve animals (Mattsson et al., 1976; Robbins et al., 1986). Within our community of non-human primate investigators, the most common way to adapt them is to use a squeeze-cage mechanism to confine the animal, hook the animal's collar to a pole or leash while providing some reward, then using gentle but firm pressure to get the animal into the chair or jump-cage. Once in the chair, the animal is given abundant liquid and fruit rewards. Over time, the great majority of animals acclimatize to the chair and enter it willingly.

The chair-training method has been recently improved in two significant ways: (1) by refining the pole-and-collar method through the use of positive reinforcement training techniques (McMillan et al., 2014) and (2) through the use of desensitization, positive and negative reinforcement training to persuade the animals into a box-style chair, good for animals previously deemed unfit for traditional pole and collar techniques (Bliss-Moreau et al., 2013). Our project advances the latter approach, by using a box-chair design while substituting person-hours with an automated reward system. Our initial motivation was to train an animal with self-biting, stress-coping behavior using a gentler approach, while still keeping an efficient workflow.

We trained two male macaques, to enter their chairs without poles or leashes, using reinforcement delivered by an automated Arduino-based system. Arduinos are cheap and flexible microcontroller boards, programmed using simple open-source software, which can be interfaced with different types of sensors and motors. This system obviated collars, and the number of automated training sessions required to get the monkey in the chair, with a neckplate on, was not much higher than the number of sessions required by all-human training. Our goals were to reduce the number of person-hours required during initial training and to provide an alternative to monkeys with behavioral problems. Based on the animals' disposition to approach the chair and investigators during training, the automated system was less stressful to the animals, more precise in its reward timing, and unmatched in its "patience" with anxious animals.

2. Materials and methods

All procedures conformed to USDA and NIH guidelines and were approved by the Harvard Medical School Institutional Animal Care and Use Committee. This article conforms to the Animal Research: Reporting In Vivo Experiments (ARRIVE) Guidelines.

2.1. Subjects and training history

Both animals were adult male rhesus macaques (*Macaca mulatta*), monkey R (8 year-old, 13 kg) and monkey G (4 year-old, 5 kg). They were each pair-housed with other monkeys in standard primate caging at Harvard Medical School, under a 12-h light/dark cycle with ad lib. access to chow. Water and fruits were available during experimental sessions.

Monkey R arrived with a history of abnormal and self-injurious behaviors, including hair-pulling and arm-biting. Both animals were acclimatized for 2 weeks. Monkey R was collared with a rubber-lined chain and a five-inch extension with an O-loop at the end for the leash. Monkey R began under our standard training, which is as follows: first, we teach them clicker lessons (associating the sound of a click with reward), and then use the clicker to reinforce desired behaviors, such as moving to the front of the cage. At this point, we familiarize the animals to the leash, using the cage's squeeze apparatus to bring them closer to the front and touching their collar loops with a small hook, all while providing reward. Animals are acclimatized to the squeeze by confining them to the front for several minutes. After they learn to sit calmly while being confined, we get them used to being touched with the small hook by putting it close to their collar loop. Usually, animals resist to being touched with the hook, batting it away or showing fear grimaces. However, they gradually show less resistance as this action is followed by fruit and liquid rewards. The great majority of monkeys "graduate" to leash training, where we attach the leash and let them move around their cage while providing gentle but firm resistance to guide them within the cage and into the chair. However, before graduating to leash training, monkey R reactivated his self-injurious behavior, biting himself at the sight of the hook, and we transferred him to the new training protocol. Monkey G was never collared or leash-trained, only clicker-trained.

2.2. Primate chairs

The primate chairs consisted of a polycarbonate primary box enclosure (13 inches × 13 inches × 36 inches, width × length × height) mounted on a wheeled aluminum platform (17 inches × 19 inches × 9 inches, $w \times l \times h$, Fig. 1A). This is the same type of chair used for all training approaches (leash, pole and automated). The top of the primary box had a fixed front neck plate and a removable back neck plate. The back of the chair had a guillotine-style door, and the floor of the chair was an aluminum perch that permitted the animal to achieve solid footing while letting waste pass onto a bottom tray. The top of the chair had a removable clear cover that could be snapped into place using metal pins, to prevent escape before the neck plate was inserted. The chairs were built on-site. The chairs were attached securely to the housing cage using 1-inch-wide nylon webbing straps with feed-through buckles (McMaster-Carr). To permit free movement of the chair door, we attached acrylic spacers to the back of the chair, forming a 5-inch-long "tunnel" between the cage door and chair entrance. We cut 4–5 holes in the chair to permit attachment of our touch sensor