Refinements of Equipment and Methodology to Reduce Risk during Pole-guided Chair Transfer of Nonhuman Primates

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Neurophysiologic studies of NHP commonly involve their transfer from a housing enclosure to a laboratory by using a mobile chair. This transfer should be performed in a manner that is safe and minimizes stress for both animal and handler. The risk of harm associated with attempting to transfer these animals is increased when they are mature and naïve. We have modified previous chair designs and transfer methodologies to reduce this risk by maintaining a constant barrier between NHP and handler while providing control to the handler to facilitate chairing. Chair modifications were built inhouse, and a commercial, hydraulic lift table was used to dock the primate chair to home cages of different heights. The docking chair method was used with 8 adult, male rhesus macaques. A graduate student transferred the animals without complications. These modifications did not compromise existing features of the chair, they did not require training time in addition to that for the standard chairing method in our facility, and they improved safety. These refinements to a commonly used chair and transfer methodology support rapid habituation, safe transfer and reduced stress for both animal and handler. The refinements we describe mitigate the potential risk of harm during NHP transfers and thus advance animal welfare.

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In some research facilities, NHP are routinely transferred from their living enclosure to a mobile chair for transport to the laboratory. Several methods accomplish this transfer without the need for sedation. One of these methods is the traditional pole-and-collar method,¹ which requires guiding of an animal outside of the cage and into a chair without a physical barrier between the animal and handler. This method has previously been refined to incorporate predominately positive training techniques.¹² This refinement has the potential to improve animal welfare,^{17,18} but we believe that the pole-and-collar method needs to be refined further to improve the safety of both animal and handler and to assure that the collection and quality of scientific data are not compromised. Over an 11-y period, there were 38 reported transfer-related incidents in our facility including escapes (the NHP exits the cage and is not in the handler's control), bites and scratches, equipment-related incidents (such as chair bumps and toppling), and physical near-misses (when an injury was barely avoided). Even after years of training, changes in NHP environment and stress can lead to regression (that is, the return of undesirable behavior from an earlier stage of the training process)¹⁰ and compromise safety. Individual NHP differ with regard to reactive temperaments,^{3,5,6,19} and rhesus macaques can "be quite reactive to novel events."¹⁴ This risk is elevated with impulsive or aggressive males (approximately 5% of males)¹⁴ and NHP that are naïve, large, and adult.

In the current study, our goal was to modify existing chair designs and transfer techniques that have been in use for decades to provide additional safety for both a single handler and the NHP. Our modifications do not compromise the existing

features of a chair or require training time in addition to that for the standard method used in our facility. We here describe simple chair modifications that allow for easy guidance of the animal into the correct position in the chair by using a pole. This modified design maximizes the safety of animal transfer for NHP and requires very little additional training or time from the handler.

Materials and Methods

All procedures were approved by the Queen's University Animal Care Committee and were in full compliance with the Canadian Council on Animal Care guidelines regarding the care and use of laboratory animals. Technician surveys of standard chair training techniques were performed at our institution, and training records were reviewed for comparison with our refined method.

Subjects. The study involved 8 Chinese-origin, male rhesus macaques (*Macaca mulatta*; age, 9 to 14 y; weight, 14 to 17 kg), of which 4 animals had been chair-trained previously by using a closed primate chair (Crist Instruments, Maryland). The remaining 4 had never been chaired before; animal technicians described 2 of these naïve macaques as being particularly reactive, and 1 of the 2 had a unilateral amygdala lesion from a previous study. Animals were selected for this study if they were on a protocol indicating that, in the next year, they would be involved in experiments that required chair transfer (for example, a neurophysiologic study of memory) in a laboratory down the hall from the primate housing rooms.

The health status of NHP in our facility is monitored daily by our animal care staff. Animals are graded from A to D according to their general health: A, the primate appeared bright, alert, and responsive; food was consumed; urine and feces were present in the cage; and behavior was normal; B, the primate showed slightly abnormal responses (quieter, decreased interest

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in the caretaker) or had a small cut or abrasions; C, the animal showed increasingly abnormal responses (for example, ignored caretaker), and D, the primate was in distress and needed immediate attention. All macaques received a grade of A for every day of this study.

Chair training history. Prior to this study, 4 of the animals underwent chair training with an adaptation of the pole-and-collar method. This method is standard in a number of primate research facilities.^{4,8,11,12} NHP were trained in a commercially available closed chair (Crist Instruments, Hagerstown, MD), which from here on will be referred to as the 'standard chair,' because it is standard in our facility. The chair-trained NHP had the same pole training as the naïve NHP did. This pole training is described in Step 1 of the *Chairing Procedure* section of this article.

The standard chair cannot be docked to the home cage because of its fixed height and hinged back door. Therefore, the 4 NHP were trained to exit the home cage on the pole and transfer to into the chair. When an NHP exited the home cage, there was no barrier between the handler and the NHP.

The standard chair had a yoke; once the NHP was transferred to the chair on the pole, the animal had to be trained to lift its head and hold it still. Then the hinged back door was latched, and the neck plate was inserted and fastened. Records indicate that animals would 'turtle,' meaning they would pull their heads down inside of the box chair before the neck plate could be inserted. Holding up the NHP's head required a second handler, who attached a pole to the opposite side of the collar to keep it at a level so that the neck plate could be inserted. In this situation, the risk of the chair being knocked over was increased, thus increasing the risk of harm to the NHP and handlers.

The time needed for each NHP to complete each training step was highly variable. This variability likely resulted from temperament-related differences, which have previously been related to training outcomes.³ Records indicated that as many as 19 training sessions were needed to train an NHP to accept the pole in the home cage and then exit the home cage with full cooperation and as many as 18 additional training sessions for an NHP to voluntarily lift its head within 5 mins of entering the chair. Records indicated that, on several days, an NHP did not want to train and the handlers did not chair the animal.

Husbandry. Animals are housed indoors in standard primate cages (dimensions, 139 cm × 90 cm × 293 cm to 193 cm × 90 cm × 293 cm); 4 of the animals were pair-housed, and the other 4 were housed individually. All cages were equipped with toys, perches, and hanging devices and the floors were covered with wood shavings (Obec's Premium MS, Rip-O-Bec, St Apollinaire, Quebec, Canada), in which treats are hidden daily for foraging. Each animal or pair of animals has access to a smaller transfer cage or 'home cage' (1:1 stainless steel home cage; approximately 90 cm × 90 cm × 90 cm; Allentown Caging, Allentown, PA). Each home cage can be closed off from the larger enclosure by using a sliding door. Before this study, all of the animals were comfortable entering the home cage for treats or fruit and having the handler close and open the sliding door. Six of the animal cages were in one room (4 pair-housed and 2 individual), and the other 2 cages were in a different room with 6 individually housed rhesus macaques. Pairing and primate rooms were unrelated to this study.

Room temperature and humidity were monitored daily and kept at 22 °C and approximately 55%, respectively. Animals were kept on a 12:12-h light:dark cycle and fed a standard diet of high-protein monkey chow (5045 High-Protein Monkey Diet, LabDiet, St Louis, MO) supplemented daily with fruit and vegetables, nuts, and treats. These items were incorporated into

daily enrichment; they were put inside puzzle toys or hidden around the living enclosure for the NHP to find. Four of the 8 NHP were on water control during this study. During chair training, they were given water without restriction, but they had to enter the chair to drink. The chair remained docked to the home cage from 0900 to 1500 (while full-time animal care staff worked in the facility). The amount of water they drank from the bottle on the chair was recorded at 1500 daily to determine whether it needed to be supplemented; the optimal amount was calculated according to the animal's body weight (minimum, 40 mL/kg) and was provided each day in the animal's pen after the completion of training session. NHP that were not on water control were encouraged to enter the chair by baiting with treats. No food restriction was used.

Design of chair. Figure 1 shows a photograph of the docking chair; a closed NHP chair (Crist Instruments) was modified to our specifications. Many primate research facilities use closed chairs, but several types of primate chairs are available, each with benefits and drawbacks that have been discussed previously.¹⁰ We used a commercial, manual, hydraulic lift table (Princess Auto, Ontario, Canada) as a transfer device to bring the chair into the NHP facility and raise it to the height of the cage door. Because the lift table is sturdy, using it reduces the risk associated with equipment incidents or injuries, specifically those related to chair toppling. A detailed diagram of the chair is shown in Figure 2. The chair slides along smooth rails, which are mounted to a base plate that is docked and locked to the home cage. The chair can be pulled away from the cage to allow for poling or can be docked precisely with the home cage door. Once docked, the chair is secured by using 2 heavy-duty rubber tarp straps (Home Depot International, Ontario, Canada) that are inaccessible to the animal and that the handler can install or remove by using one hand. Once the chair is secured, the NHP can be habituated with the chair and enter within for rewards, such as fruit, treats, or water.

In Figure 2, the chair topper (c) is fixed only on the left side (i), leaving a gap big enough for the handler to maneuver a pole from the right side and front of the chair. The chair topper extends over the front of the chair and back to the home cage, thus preventing escapes above the chair when it is docked. The chair topper has a thin rectangular opening at the top, so that the back plate can slide through it when the back plate is placed from above. The chair is equipped with a collar guide (a), which is a set of metal extrusions machined inhouse; the aluminum NHP collars (Primate Products, Immokalee, FL) slide between these extrusions. The collar guide is bent upward into a ramp so that the NHP collar doesn't have to be at any particular angle to enter. We put a horizontal bar at the front of the collar guide (b) so that the pole can be hooked onto it and temporarily secure the NHP's collar to the chair. Once the animal is secure, the handler can insert the sliding back plate (g) and a locking collar plate (not shown) to restrain the back of the collar.

We replaced the hinged door of the standard chair with a sliding back plate (g) to secure the back of the chair. The back plate is placed from above and through the thin rectangular opening in the chair topper. Depending on the handler's height, a step ladder may be required for placing the back plate during animal transfer from a top home cage. The back plate is useful because it can be raised to the desired level to allow for injection or examination, without exposing the animal's entire body. This modification can simplify access to an animal's limb and thus reduce the risk associated with barrier-free handling.

If a particular animal holding room cannot accommodate a hydraulic lift table, the chair can be adapted to an alternative

Figure 1. The docking chair.

base for transfer. A platform cart with secure brakes or locking wheels (for example, Folding Aluminum Platform Cart [Changzhou Vtuvia Technology, Jiangsu, China]) can be used to provide a fixed-height base that is portable and that can be folded for convenient storage. Carts should be modified to include a bench clamp (j; for example, EZSMART 6 in. Bench Clamp [Home Depot International]) or other device to prevent the base plate from sliding when force is applied. Before purchasing this type of fixed-height base, handlers should confirm that it aligns with the bottom of the home cage from which the animal will be transferred and that it conforms to the laboratory setup. For example, in our facility, the fasteners that hook the base plate onto the bottom home cage would have to be 14.5 cm above the floor. In addition, once the animal is in the chair, it should be at the correct height for recording in the neurophysiology rig or behavioral system in use. We recommend the use of fixed-height bases only for bottom home cages, because taller bases with a higher center of mass are more likely to topple if a collision were to occur between rooms.

Chairing procedure. Step 1: pole training. The animals are trained to accept the pole in the cage. The top third of the pole is put into the home cage; as soon as the NHP moves toward it, the handler rewards the animal (with fruit or treats) and introduces the verbal command 'pole.' Some NHP are more curious than others and approach the pole as soon as it is placed in the cage; others avoid it initially and become interested after they receive treats. Once the animal learns to approach the pole, rewards are provided only when the NHP gets closer to the pole than it did during the previous session. For the next phase of this training step, rewards are only provided when the NHP gets close enough to the pole that its collar touches. Once the NHP is comfortable touching its collar to the pole, the handler hooks

the pole onto the collar. The first time that this step is achieved can be frightening for a naïve NHP, the handler should wait until the NHP on the pole is calm. As soon as the NHP is calm, it receives a big reward (their favorite treats or a whole piece of fruit), and the collar is released from the pole. Once the NHP is comfortable on the pole for a few sessions, the handler gently moves the NHP a couple of steps backward and forward in the home cage before providing a reward. This phase gets the NHP used to the kind of pole manipulation that they will experience during chair transfer. The training time required for pole training varies with each animal, animals required between 14 and 34 training sessions in our facility. This kind of shaping of behavior and incremental exposure to new steps in the training process facilitates a cooperative relationship with the NHP.

Step 2: preparing the chair. Initially, NHP are habituated to the chair for several days by securing the chair to the home cage and leaving it to be explored by the animals. The home cage door is opened, and the chair back plate is removed to allow the NHP to enter for water and treats. Once the NHP is habituated to the chair, the handler may prepare to shift the NHP into the chair. The lift table is elevated, and the arms of the base plate are fastened to the bottom of home cage. The chair is pushed away from the home cage along the smooth rails, and the back plate of the chair is removed and set aside. The door on the home cage is opened to the first notch, creating enough room to allow for poling but maintaining a barrier between handler and NHP. The animal's collar is attached to the pole, and the handler pushes the chair toward the home cage and secures it with tarp straps (Figure 3).

Step 3: chairing. With the chair secured to the home cage, the home cage door (which was opened to the first notch) is unlatched and opened completely. Using the pole, the handler guides the animal's collar into the collar guide. Once the collar is in the collar guide, the handler latches the pole onto the horizontal bar at the front of the collar guide, thus securing the collar to the chair. The handler then slides the back plate into the chair from above and through the narrow opening in the topper. The NHP is now enclosed in the chair. For additional security, the back of the collar is locked with a collar plate; the NHP is then offered fruit and treats. The pole is removed from the NHP collar and chair, the lift table is lowered, and the animal is ready for transfer to the lab. Once in the lab, the chair topper can be removed.

Results

Identification of potential risks in the standard chairing procedure and how they were addressed through our transfer methodology are provided in Figure 4.

All 8 NHP (4 naïve and 4 standard-chaired) were chaired using this docking chair transfer method. The steps that were unique to this chairing method (steps 2 and 3) required 4 training sessions and 1 to 4 training sessions, respectively. Each chair-training session took less than 20 min, and there was only one training session each day. Only one trainer was required for chair transfer of the animal, and no sedation was used.

Daily reporting by trainers and animal care staff indicated a reduction in signs of distress among NHP during chairing. Specifically, 4 animals showed increased willingness to engage, and the 2 reactive NHP showed fewer stereotypies and self-injurious behaviors, such as pacing and self-directed biting,¹⁵ during chairing. No regression occurred during the study period. Persons conducting chair transfer can experience distress during the process,¹⁰ but the 2 trainers involved in this study independently noted that they did not experience distress because there was no barrier-free handling.

Figure 2. Schematics of the docking chair: (a) ramped collar guide, (b) horizontal bar, (c) chair topper, (d) smooth rails, (e) base plate, (f) table-lowering control lever, (g) sliding back plate, (h) fasteners that hook the base plate onto the bottom of the home cage, (i) chair topper connection (on one side only), and (j) bench clamp to further secure base plate to lift table.

Data on incidents reported in our facility during an 11-y period (May 2006 through April 2016) showed that there were no periods of 13 mo in which no incidents occurred. Transfer-related incidents included 6 escapes (the NHP exited the cage and was not in the handler's control), 7 bites, 14 scratches, 7 equipment injuries (such as bumps on a chair or chair toppling), and 4 near-misses (when an injury was barely avoided). In comparison, the current study took place over a 13-mo period, and no incidents occurred.

The probability of no incidents occurring over a 13-mo period was calculated using the yearly recorded incidents, with a mean of 4 and a standard deviation (σ) of 2.2361. The sample standard deviation was 2.1484 at $n = 1.0833$, yielding a 91.7% chance that the sample mean would fall within 1.86 standard

deviations of the mean (that is, 1 or more incidents would occur). Therefore, the probability of no incidents occurring over 13 mo was 8.23%. It is important to consider that other factors may have influenced this percentage, including (but not limited to) the experience and skill of the trainers, the temperament of the primates transferred, the number of primates transferred, and the number of times that each primate was transferred. No procedural changes occurred other than the transfer equipment and methodology refinements described.

Discussion

We present a simple technique for safely moving an NHP from its cage and into a primate chair. This method maintains

Figure 3. Steps taken to chair a NHP. (A) Chair baseplate is docked and locked to the cage and the chair is slide to an initial position far from cage to allow for polling. (B) After the animal is poled, the chair is pushed forward along the smooth rails. (C) The chair is in the transfer position and can be secured to cage with rubber tarp straps (D) The NHP is guided into the collar guide using pole.

a barrier between the trainer and the animal to maximize the safety of both. Direct transfer and release of NHP eliminates the manipulation of animals outside the home cage, a situation that can be stressful for the handler and the animal. Appendix A of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes ETS No.123 states that “nonhuman primates dislike being handled and are stressed by it.”⁷ Similarly, an international survey of NHP facilities found that in many laboratories “the person conducting chair restraint training experienced distress during the process.”¹⁰ Therefore we believe that our method will have a positive effect on wellbeing, beyond physical safety, by eliminating stressful situations for trainers and NHP.

The few institutions that have reported internal incidents allow for contextualization of our results. A large regional primate research center in the United States provided yearly estimates of internal incident rates of 44 to 65 NHP-associated injuries during a 5-y period of observation (261 incidents in total over 5 y).^{2,13} NHP-inflicted scratches and bites had the highest 5-y incidence rates, together accounting for 51.7% of reported incidents. Trainers with more than 20 h of animal contact weekly were 3 to 4 times more likely to report an incident than were part-time workers. Of all reported injuries, 33% occurred in persons hired less than 6 mo previously. Additional data analysis indicated that under-reporting of work-related injuries was high. In addition, incident logs at another institution showed a total of 86 reported incidents in 1 y. Of these incidents, 20 (23%) were scratches, cuts, or lacerations and 11 (13%) were bites from NHP.⁹ These reports indicated to us that barrier-free handling was a prominent risk at multiple institutions. It is important to consider the cause of

internal incidents in standard NHP facilities to identify specific risks for which targeted prevention programs and improved procedures may be beneficial.

The calculated probability that no incident would occur during the 13-mo period of the current study may be affected by factors beyond the scope of our analysis. One of these factors is trainer experience. The introduction of new trainers in 2011 and 2014 seemed to coincide with an increase in incidents during the 11-y baseline period. The current study involved both a new trainer and an experienced trainer. This experienced trainer was associated with the 11-y baseline period. Therefore, trainer experience was likely not a factor in incident reduction. The number of NHP transferred can be expected to affect the probability of an incident occurring. However, although many NHP were transferred during the baseline period, likely fewer than 8 NHP were chair trained simultaneously and transferred within any consecutive 13 mo of the baseline period, given that most NHP experiments in our facility are conducted cage-side. Therefore, the average number of incidents during the baseline period would be expected to be lower than during the current study. The individual temperament of each primate can affect the probability of an incident occurring. Of the 8 animals involved in our study, 2 were described as being particularly reactive, which is uncommon in our facility. If reactive temperaments are associated with an increased number of incidents or regression, we would expect that more incidents or regression would occur during this study than during the baseline period, but this was not the case.

An international survey of NHP facilities states that 2 of the most challenging steps in preparing a naïve NHP for chair restraint within the academic and government sectors are

	Areas of risk in standard chairing procedures	How we mitigate this risk
Chairing	Any pole or leash manipulation of NHP outside of the cage carries a risk of incident. Transferring the NHP from the home cage to the chair requires guiding the animal out of the cage, across the floor, and into the chair.	The docking transfer method does not require any manipulation outside of the cage. The NHP can be guided directly into the chair from the home cage.
Moving	The base of the chair is light, and the chair may topple, particularly during initial chairing of a large uncooperative NHP.	The hydraulic lift table (to which the base plate is mounted) is extremely sturdy, thus eliminating the risk of toppling.
Accessing	The hinged back door must be open to access an animal's limbs. A potential risk of incident is present when there is no medium between the trainer and the animal.	A sliding back plate is used instead of a back door. The plate can be raised to any desired level to allow access to the animal through a small window.
Releasing	Once the yoke is released, the animal can forcefully exit the chair and could get loose or overpower an inexperienced handler.	The chair is docked to the home cage before the NHP is released. When the animal exists the chair, it is already caged, thus preventing any opportunity for contact with or escape of NHP.

Figure 4. A sample of potential risks identified in an analysis of a standard chairing procedure and how our novel transfer method mitigates those risks.

removing the NHP from the cage and having the NHP poke its head through the top of the chair and keep it there.¹⁰ Our method eliminates removal of the NHP from the cage, and the NHP slides into a collar guide as it enters the chair instead of having to stick its head up and hold it still for yoking. Existing methods, such as the Auto Chair,¹⁶ also eliminate removal of the NHP from the cage. The Auto Chair docks the chair to an adapter on the home cage and automates water delivery. It accomplishes this goal by using an electronic reward system that releases water once a capacitive touch sensor detects the animal. The reward system is manually programmed using a microcontroller. Our chair topper holds a standard primate water bottle that delivers water only when the primate lifts its head and drinks; water delivery does not need to be automated electronically for this training step.

A limitation of our methodology is that the chair is more complex and expensive (due to the cost of the rails, base, and collar guide) than is a commercially available chair if a facility does not already have one that is not in use. Another limitation is that our chair takes up twice much floor space and is heavier than a standard chair, so it can be cumbersome to steer or push onto elevated weighing scales. Alternative bases such as platform carts can be used to reduce the space needed and to improve the mobility of the chair. However, without flexibility in the height of the chair, trainers lose the ability to transfer NHP from both top and bottom home cages and to lift the NHP to the correct height for the laboratory setup (for example, for the NHP to reach a joystick or touch screen). Taller bases that are less cumbersome to steer and push over uneven surfaces may not be sufficiently sturdy and may topple if a collision occurs when moving between the housing room and lab. It should be emphasized that most of these equipment and methodology refinements could also apply to facilities using other chair types, such as the open chair. Eliminating barrier-free handling, using a sturdy base, and docking could improve safety for many people working in research.

In summary, the novel equipment modifications and chairing methodology that we present enables the safe and timely transfer of NHP into a primate chair. These modifications allow handlers to work with larger animals with very little additional training and maximizes their comfort and security. Given these features, we propose that our refined chair is a practical and useful means of animal transfer and facilitates safe, ethical research with NHP.

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