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Training laboratory-housed non-human primates, part 1: a UK survey

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Abstract

Training using positive reinforcement is increasingly recognised as a valuable tool for the humane and effective management and use of laboratory-housed non-human primates. We utilised a mixed-mode questionnaire to survey use of training and other learning processes (socialisation, habituation and desensitisation) in over half of UK establishments using and breeding primates. The survey demonstrated that there is widespread awareness of training as a refinement technique and appreciation of its diverse benefits, but training is not used as widely or as fully as it might be. This is due to real constraints (principally staff and time and a lack of confidence in ability to train), and perceived constraints (such as a supposed lack of published information on how to train and assessment of the benefits, and an overestimation of the time investment needed). There is also considerable variation between establishments in the purposes of training and techniques used, with a reliance on negative reinforcement in some. We conclude that there is opportunity for refinement of common scientific, veterinary and husbandry procedures (such as blood and urine collection, injection, capture from the group and weighing) through use of positive reinforcement training, especially when combined with appropriate socialisation, habituation and desensitisation. We end this paper with recommendations on best practice, training techniques and staff education.

Keywords: *animal welfare, habituation, positive reinforcement, refinement, socialisation, training*

Introduction

Laboratory-housed non-human primates may experience a range of potential stressors, including capture, cage-change, physical and chemical restraint, injection and venepuncture. Training them to co-operate, using positive reinforcement training (PRT) techniques which reward desired behaviour (see Table 1), is one means of significantly reducing the adverse impact of such procedures upon them, and is recommended as good practice by many legislative and professional guidelines (eg Home Office 1989; International Primatological Society 1989; National Research Council 1998; Laboratory Animal Science Association/Medical Research Council 2004; Medical Research Council 2004). Published literature demonstrates that primates can be trained to co-operate with a wide variety of procedures (see Prescott *et al* 2005a) and that they maintain a high degree of reliability in participating in such events, which is particularly important when working to fixed-time points for sampling (Schapiro 2000; Prescott & Buchanan-Smith 2003). Trained animals show reductions in cortisol levels, stress-related behaviours, stress-related abortions, physical resistance to handling, and fear responses such as fear-grinning, screaming and acute diarrhoea (Elvidge *et al* 1976; Mitchell *et al* 1980; Moseley & Davis 1989; Reinhardt *et al* 1990; Reinhardt 1991, 2003; Luttrell *et al* 1994; Bassett *et al* 2003; McKinley *et al* 2003; Videan *et al* 2005). Training can also enhance the care and well-being of captive primates, for example, by providing a means to reduce abnormal behaviour, enhance positive social interaction and facilitate health inspection and treatment (Laule *et al* 2003).

Refinement techniques that reduce or eliminate adverse effects for animals used in scientific research (Russell & Burch 1959) not only benefit animal welfare, but can also enhance the quality of the research. Suffering in animals can result in physiological responses that are, at least, likely to increase variability in experimental data and, at worst, may invalidate the research; but training can minimise such responses (Schnell & Gerber 1997; Schapiro 2000; Reinhardt 1991, 2003, 2004; Hassimoto *et al* 2004; Lambeth *et al* 2004; Schapiro *et al* 2005). Techniques that reduce sources of variability also have the potential of reducing the number of animals required in a given protocol (Biological Council 1992; Brockway *et al* 1993; Scientific Committee on Animal Health and Welfare 2002).

Training can also have significant benefits for staff by improving the ease, speed and safety with which procedures can be performed (Heath 1989; Bloomsmith 1992; Luttrell

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et al 1994; Reinhardt 1997, 2003; McKinley *et al* 2003; Iliff *et al* 2004). Furthermore, the additional time that staff spend with the primates, and the need for individual recognition and close observation of animal behaviour, means that the trainer develops a relationship with each individual animal, which can be beneficial for animal welfare (eg by reducing the occurrence of abnormal behaviour, or through a reduction of fear of humans and improved ability to cope with routine husbandry procedures (Bayne *et al* 1993; Waitt *et al* 2002; Bassett *et al* 2003; Baker 2004; McKinley 2004; Bourgeois & Brent 2005). This is especially likely to be the case when PRT is used. The building of a primate-trainer bond has also been reported to raise staff morale and lead to positive changes in the attitude of staff to the animals involved (Bayne *et al* 1993; Bloomsmith *et al* 1997; Bayne 2002).

Given the potential benefits of training primates to animals, science and staff, one might expect training to be used in all laboratories that use and breed primates. However, implementing training may be difficult in some cases. Laule *et al* (2003) write that staff may have to work with many animals and populations may change frequently; short notice may be given for research programmes, allowing little time for training of animals; and the research may involve situations where PRT is difficult to implement within restrictions on enrichment options, social interactions, physical activity and food amounts. In addition, there are few opportunities for staff education about training animals, and worries about knowing how to train can have a stalling effect. If solutions can be found to such constraints on use of training, then this could result in significant reductions in animal stress and improvements in animal welfare and, ultimately, better research.

Here we report the results of a survey designed to evaluate the extent to which primates are trained in a range of UK research and breeding establishments, designated under the Animals (Scientific Procedures) Act 1986. The survey was initiated as part of a programme of work on refinement by the Royal Society for the Prevention of Cruelty to Animals (RSPCA) and following discussions with the Universities Federation for Animal Welfare Pharmaceutical Housing and Husbandry Steering Committee (UFAW PHHSC) and the Primate Sub-Committee of the Animal Procedures Committee. The survey also explored socialisation with humans, habituation and desensitisation (see Table 1), since the term 'training' is used colloquially in the UK to refer to these learning processes as well as to the shaping of an animal's behaviour so that it actively responds in a way that is desired by the trainer. These processes have also been reported to improve the well-being of captive primates (Moseley & Davis 1989; Bayne *et al* 1993; Heath 1989; Bloomsmith *et al* 1999; Laule *et al* 2003; Baker 2004).

The key objectives of the survey were:

• to create a database of current knowledge and practice of training, socialisation with humans, habituation and desensitisation;

• to identify good practice;

• to identify obstacles and solutions to further uptake of these processes.

The overall aim was to use the results of the survey to facilitate application of these processes to refine the use and breeding of laboratory-housed primates.

Materials and methods

Between April and December 2004, 15 establishments were visited, comprising six universities, three government establishments or pharmaceutical companies, three contract research organisations (CROs) and three breeding establishments. This represented over half of all designated establishments using primates at that time, and includes most major users. Thirteen establishments housed macaques (rhesus macaque, *Macaca mulatta*; long-tailed macaque, *M. fascicularis*; stump-tailed macaque, *M. arctoides*) and five establishments housed common marmosets (*Callithrix jacchus*).

The survey took the form of a face-to-face interview based on a mixed-mode questionnaire. This allowed for more comprehensive and accurate data collection than is possible with a postal-based survey method. A total of 32 people participated in the survey, including scientists, animal technicians, Named Animal Care and Welfare Officers, Named Veterinary Surgeons and facility managers. Participants had primary responsibility for co-ordinating and conducting the training, socialisation, habituation and desensitisation of the primates, or else had primary responsibility for the welfare of the primates. Fixed and open response questions were used to collect quantitative and qualitative data on training knowledge and practice. The Likert technique (Likert 1932) was used to measure attitudes. The terms in Table 1 were defined and explained before the interview. Preliminary results of the survey for some questions on training only are reported in Prescott *et al* (2005b).

Results and discussion

Incidence of training, socialisation, habituation and desensitisation

Table 2 shows incidence of training, socialisation, habituation and desensitisation, broken down by establishment type. A total of 11 out of 15 establishments train primates, although sometimes using negative reinforcement training (NRT) (see Table 1). Of these 11, six have formal training programmes where records are kept. These are Universities conducting physiological and psychological research where primates are trained to perform tasks to generate data and such training is integral to the research. The other establishments train on an *ad hoc* basis, for some species, groups of animals, and procedures only.

One of the first steps in training animals is to socialise them with humans so that interactions that occur during training can be as stress free as possible. Socialisation with humans also facilitates monitoring of health and welfare without the need to capture animals and remove them from their enclosures. We therefore included socialisation with humans in our definition (which normally refers only to conspecifics;

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Table 1 Definitions of terms used in the survey.

Term	Definition
Training[1]	The shaping of the behaviour of a primate so that it actively responds in a way that is desired by the trainer (eg offers a limb for injection, stands on a weighing scale, waits and allows subordinate individuals to feed uninterrupted).
Socialisation[1, 2]	The process by which a primate learns how to successfully interact with members of its own species and with other species (eg humans) with which it co-habits.
Habituation[1]	The waning of a response as a result of repeated stimulation, but not fatigue. This kind of learning is of importance in familiarising a primate with aspects of the environment to which it is inconvenient for it to react to. It is of value in encouraging primates to ignore non-threatening stimuli (eg the sound of clippers, restraint in a sling, confinement in a transport container).
Desensitisation[1]	Systematically pairing positive reward directly with an uncomfortable or aversive experience or stimulus in order to reduce any associated fear or anxiety response.
Positive reinforcement	Frequency of a behaviour is *increased* because something positive is obtained on its performance (eg food treat, verbal praise, tactile contact).
Negative reinforcement	Frequency of a behaviour is *increased* because something negative is removed on its performance (eg cage squeeze-back mechanism).
Punishment	Frequency of a behaviour is *decreased* because something negative is introduced on its performance (eg verbal command 'No!').

[1] Note that these processes may occur concurrently.
[2] Defined in the Oxford English Dictionary Online as "The process of forming associations or of adapting oneself to them; especially the process whereby an individual acquires the modifications of behaviour and the values necessary for the stability of the social group of which he is or becomes a member."

see Table 1). All 15 establishments felt that primates become familiar with human behaviour as an inevitable consequence of their housing and husbandry in captivity. However four establishments (two CROs and two breeding establishments) have a formal socialisation programme where time is set aside for positive interaction between humans and animals and records are kept. Formal programmes are beneficial to ensure that socialisation with humans does not slip when staff is busy, and the records can be reviewed to check the progress of individual animals and the programme as a whole.

All establishments with the exception of two breeding establishments use habituation, and all, save one breeding establishment and two universities, use desensitisation. These universities felt that their management and use of primates is such that uncomfortable or aversive experiences for the animals are avoided and therefore use of desensitisation is not necessary.

Opportunity for, and feasibility of, use of the learning processes, and in particular training, depends on a number of factors, such as the numbers of animals held, used or bred, staff to animal ratio, age of animals at first use and duration of their use, and group size. We were interested in looking for gross patterns between these factors (Table 3) and use of the training (Table 2). Universities typically have small numbers and groups of animals that are used for research projects lasting many years, and high staff to animal ratios. One might expect these characteristics to facilitate use of training, and this appears to be the case. However, all three CROs surveyed also utilise training, primarily of macaques to enter a transport cage. This finding is encouraging given that CROs hold large numbers of animals, and use large numbers quickly (eg short-term toxicology studies) and at a young age. They do, however, have a relatively high staff to animal ratio, which may assist training.

Breeding establishments may not use training and habituation because they do not conduct many scientific procedures (two breeding establishments conduct a limited amount of research or testing), hold large numbers of animals, sometimes in large groups, and have a relatively low staff to animal ratio. However, there is opportunity for training and habituation of animals in breeding establishments to encourage co-operation with husbandry and veterinary procedures, particularly for breeding animals that are kept for a long time (eg Reinhardt 1990; Luttrell *et al* 1994). One macaque breeding establishment has now begun to train animals to stand for injection.

Five customers of breeding establishments reported that they were keen for them to invest more in socialisation, habituation and training of primates destined for use in research so that the animals are more tractable and less stressed when issued for use, with the consequence that the research can progress more quickly and easily. Moreover, temperament has been found to correlate with training success for rhesus macaques (Coleman *et al* 2005). It should, therefore, be possible for breeding establishments to screen primates to be assigned to research projects in which they will be trained with the goal of obtaining the best candidates for those studies. Socialisation, habituation and

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Table 2 Incidence of training, socialisation, habituation and desensitisation by establishment type.

Learning process	University (n = 6)	Government or pharmaceutical (n = 3)	Contract research (n = 3)	Breeding (n = 3)	Total (n = 15)	Formal programme
Training	6	2	3	0	11	6/11
Socialisation with humans	6	3	3	3	15	4/15
Habituation	6	3	3	1	13	4/13
Desensitisation	4	3	3	2	12	-

Table 3 Characteristics of establishments surveyed.

Characteristic	University (n = 6)	Government or pharmaceutical (n = 3)	Contract research (n = 3)	Breeding (n = 3)
Number of animals held (range)	2-15	148-380	109-678	220-860
Number of animals used per year[1] (range)	0.5-5	15-35	150-654	0-30
Number of animals bred per year[2] (range)	0-1	0-106	n/a	30-400
Mean staff to animal ratio	1:2	1:45	1:20	1:70
Age at first use (range)	3-24 months	3-24 months	12-36 months	18-24 months
Duration of use (range)	3 months - 10 years	3 months - 7 years	1 week - 1 year	15-20 years (breeding), 1 week - 2 years (research)
Group size (range)	1-5	1-30	1-30	1-100

[1] euthanased.
[2] production.

training programmes, in conjunction with temperament testing, are becoming an accepted part of the preparation of laboratory dogs for their life on study (Heath *et al* 2002; Adams *et al* 2004). Dogs that have undergone limited socialisation show greater variation in behaviour (including during mock procedures) compared with dogs that have experienced intensive socialisation (Boxall *et al* 2004).

Decisions about whether to utilise training to refine a particular procedure often depend on a cost-benefit analysis, weighing on the one hand the potential for animal suffering associated with the traditional method and, on the other hand, the likely staff and time investment involved with the training. Different types of establishment may reach different decisions depending on the frequency with which animals undergo the procedure and the method used. For example, the frequency with which blood is taken from macaques ranged from once per lifetime, involving a cage squeeze-back mechanism and/or anaesthesia (most universities and breeding establishments), to up to 24 times in a 48 h or much longer period using manual restraint (CROs). Time before data collection begins is short for CROs (mean = 5 weeks for macaques and 6 weeks for marmosets) in contrast to universities (mean = 36 weeks for macaques) (Table 6). We believe training for co-operation to be a worthwhile investment in the latter case to reduce animal stress and data variability.

Moreover, depending on their respective responsibilities, different types of staff may reach different decisions on the need for animals to be trained. Animal technicians and scientists are the staff most responsible for driving training at the establishments surveyed (Table 4). It is surprising that few establishments identified the Home Office Inspectorate and local ethical review process (ERP) as drivers of animal training, given the responsibilities of the Inspectorate and ERP for reviewing research proposals involving animals, encouraging the widest possible application of the 3Rs and advising on high standards of animal care and welfare (Home Office 2000).

Constraints on training

All establishments believe training can be a refinement. Eleven out of 15 establishments have acknowledged this for over 10 years, and eight for over 15-25 years. Thirteen out of 15 establishments agree that training of primates is a feasible concept for them; one disagrees and one neither agrees nor disagrees – largely because of time constraints. Of the 13 that agree training is feasible, three do not train presently, so there may be opportunity for refinement at these establishments. Furthermore, all of the establishments who do not train identified instances where training would benefit animals and staff, so again there may be opportunity for refinement at these establishments, if they can overcome the constraints they face.

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Table 4 Drivers of training, as described by those surveyed.

Driver	Total (n = 15)
Animal technicians	8
Scientists	6
Veterinarians	4
Scientific literature	3
Needs of the experiment	3
Animal welfare organisations	3
Ethical review process	2
Home Office Inspectorate	2
Legislation	1
Professional guidelines	1
Training specialists	1
Customers of breeding establishments	1
Culture of care	1

Table 5 Constraints on training, as described by those surveyed.

Constraint	Do train (n = 15)	Do not train, have tried (n = 2)	Do not train, have not tried (n = 15)	Total (n = 15)
Paucity of information on how to train	3	1	2	6
Lack of staff	1	1	3	5
Perceived time investment	2	-	1	3
Lack of time before data collection	2	-	1	3
Lack of assessment of benefits	-	1	2	3
Lack of confidence in ability to train	2	-	1	3
Possible effects on animal health	1	-	-	1
Concern about staff health and safety	-	-	1	1
Concern about effects on scientific validity	-	-	-	-
Concern about effect on animal behaviour	-	-	-	-

Reported constraints on training are shown in Table 5; there are both real and perceived constraints. For example, five establishments, including one that trains, cite lack of staff as a constraint, and some establishments reportedly lack time before data collection begins and/or confidence in their ability to train. In addition, establishments report a paucity of information on how to train and reliable assessment of the benefits, and some overestimate the time investment involved in training. Arguably, the problem is not lack of published information on these points, but lack of knowledge about where to find it (see Prescott *et al* 2005a).

CROs (mean = 5 weeks for macaques and 6 weeks for marmosets) in contrast to universities (mean = 36 weeks for macaques) (Table 6). In addition, CROs have larger and more batches of animals per year. These factors make training programmes at CROs more resource intensive. Moreover, CROs use younger animals sourced from overseas breeding establishments. Habituation, desensitisation and training were reported as being difficult with young animals if they are poorly socialised with humans because they become easily stressed and will not take food. However, macaques at CROs can be, and are, trained, especially during long-term studies, where studies are staggered, or where the animals are imported well in advance of studies to be held as stock and then used sequentially. Establishments reported variation in the speed with which animals acclimatised following relocation and transport such that their temperament and behaviour were suitable for training; more than 4 weeks was reported as necessary in some cases. Breeding in-house and frequent and timely communication between breeders/suppliers and users of primates will help facilitate acclimatisation, socialisation, habituation and training.

Resources reported as required in order for establishments to begin to train or to expand existing training programmes are shown in Table 7. These map quite closely to the constraints reported in Table 5. The second part of this paper aims to help facilitate use of training by improving access to some of these resources (see Prescott *et al* 2005a).

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Table 6 Source and arrivals of animals at establishment surveyed.

	Macaques (n =13)			Marmosets (n = 5)			
	University	**Government or pharmaceutical**	**Contract research**	**Breeding university**		**Government or pharmaceutical**	**Contract reserarch**	**breeding**
Source of animals								
Bred in-house[1]	1	2	-	2	-	3	-	1
UK breeding establishment	5	-	-	-	-	-	1	-
Overseas breeding establishment	-	-	3	-	-	-	-	-
Arrivals from external establishments								
Size of batch	2-4 (mean = 2.4)	-	4-60 (mean = 31)	-	-	-	10-52	-
Number of batches per year	0-1 (mean = 1)	-	3-12 (mean = 6.3)	-	-	-	3	-
Age on arrival (months)	18-36 (mean = 22.8)	-	12-36 (mean = 18)	-	-	-	14-18	-
Length of acclimatisation period before study begins (weeks)	24-48 (mean = 36)	-	3-8 (mean = 5.2)	-	-	-	6	-

[1] Breeding stock may be occasionally supplemented with new animals to increase genetic diversity.

Table 7 Resource requirements for training, as described by those surveyed.

Resource	Total (n = 15)
Audio-visual materials on how to train effectively	6
Written guidance on how to train effectively	6
In person demonstration of training practice	6
More staff	6
More time before studies begin	5
Access to a primate behaviour specialist	5
Wider access to reference material	5
Dedicated staff-training course with practical component	5
More money	3
Face-to-face discussion with experts	2
Secure database on training	1

Purposes of training

The purposes for which establishments wish to train and what they train for presently are shown in Table 8. Establishments would like to train macaques for injection, venepuncture and topical application, and marmosets for restraint and urine sampling, because the animals often undergo these procedures. There are published papers available for these procedures and others, many with training protocols (see Prescott *et al* 2005a). Furthermore, some establishments already train for these purposes. This illustrates that there is a need for better communication between establishments for sharing of information on refinement techniques.

For instance, we are aware of 10 published papers on training macaques to voluntarily offer a limb for venepuncture. Reinhardt (2003) has shown a two-fold increase in serum cortisol with the traditional manual restraint method, and no increase in serum cortisol with an alternative trained method using a combination of PRT and NRT. The initial time investment in training (mean = 38 minutes per animal) quickly pays off in a safe handling procedure that no longer requires a second person to control the animal while the blood sample is taken. Laule *et al* (2003) give a protocol that utilises PRT only and does not feature the cage squeeze-back mechanism utilised in Reinhardt's protocol.

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Table 8 Purposes of training, as described by those surveyed.

	Macaques (n = 13)		Marmosets (n = 5)	
Purpose	**Already train**	**Would like to train**	**Already train**	**Would like to train**
Scientific procedures				
Venepuncture	2	2	-	1
Injection	-	6	-	-
Urine sampling	-	1	1	2
Saliva sampling	-	-	-	-
Faecal sampling	-	1	-	-
Topical application	1	2	1	-
Restraint	6 (chair)	1	-	3
Oral administration	2	-	-	2
Generation of data on cognitive tasks				
Touch screen	2	-	1	-
Lever press	1	-	1	-
Joystick	1	-	-	-
Eye tracking	1	-	-	-
Finger press	1	-	-	-
Husbandry procedures				
Weighing	9	1	1	2
Shifting location	9	-	1	1
Collar cleaning	-	-	-	1
Capture	9	1	-	2
Separation	3	-	-	1
Station	-	2	-	3
Cooperative feeding	-	1	-	1
Health procedures				
Palpation	-	1	-	2
Stethoscope	-	-	-	2
Joint manipulation	1 (hand)	-	-	2
Infant care	-	-	-	2
Mouth inspection/teeth cleaning	-	1	-	3
Temperature	-	1	-	2
Ultrasound	-	-	-	2
X-ray	-	-	-	-

With regard to husbandry procedures, nine establishments train their macaques for co-operation with capture, shifting location and weighing. This involves using a combination of PRT and NRT to train animals to enter a transport cage or, in two cases, a primate chair. Once trained, animals can be caught swiftly and without undue distress (Reinhardt 1992), which can then facilitate veterinary and breeding management, husbandry and research. Use of training for this purpose in the UK is in contrast to a 1989 United States census conducted at the National Institutes of Health which reported that "only 9% of (56) scientists interviewed currently train their animals to enter transport cages" (Bayne 1989, cited in Reinhardt 1991). The frequency with which macaques are captured varies from five times per day (CRO) to once every 6 months (University) depending on the purpose of capture (eg weighing or procedures), age of the animal and individual study requirements.

Few establishments train marmosets (2/5) compared with macaques (9/13) yet staff members have a high desire to train marmosets, particularly for husbandry and health procedures. Marmosets may be trained less because of their small size, such that they can be easily handled and therefore present less of a danger to personnel. In addition, fewer marmosets may be trained because of other considerations, for example, compared to macaques, marmoset colonies are often larger, marmosets have shorter life spans,

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Table 9 Responsibilities for training (n = 15), as described by those surveyed.

	Responsible for determining the need to train primates	Responsible for training primates
Junior animal technician	10	12
Senior animal technician	12	7
Scientist	8	8
Veterinarian	5	-
Ethical review process	3	-
Customer of breeding establishment	2	

Table 10 Techniques used to train, as described by those surveyed.

Technique used	Total (n = 15)
Positive and negative reinforcement	9
Negative reinforcement only	3
Food or water management	4
Positive reinforcement only	2
Negative punishment[1]	2
Positive punishment[2]	1
Clicker training	-

[1] Frequency of a behaviour is decreased because something pleasant is removed on its performance.
[2] Frequency of a behaviour is decreased because something unpleasant is introduced on its performance.

and large series of blood samples cannot be taken from the same individual (Buchanan-Smith *et al* 2003a, b). However, there is growing evidence that marmosets can be trained to co-operate in a range of tasks, using only PRT and with no need for food or water management (eg McKinley *et al* 2003; Scott *et al* 2003; Smith *et al* 2004). The typical tasks include training to co-operate in scientific procedures and tests of cognitive ability, and to facilitate husbandry and veterinary procedures (see Prescott *et al* 2005a). For example, marmosets have been trained to stand on a balance for in home-cage weighing and to urinate into a collection vial on request (McKinley *et al* 2003). One advantage of this training is that it avoids the need for capture and restraint, which can be stressful for primates (Reinhardt *et al* 1990, 1995; National Research Council 1998; Sauceda & Schmidt 2000).

Only one establishment of the five housing marmosets has trained its marmosets for in home-cage weighing. At the remainder, marmosets are caught for weighing (one per week to once per month) or scientific procedures (daily or less frequently), either by chasing them into a nest box or by hand using a gauntlet or surgical glove. Although some animals, if exposed often enough to capture and restraint, appear to acquiesce and/or tolerate this practice, there are physiological data which demonstrate that restraint can remain stressful for marmosets and macaques even when the animals are habituated to the procedure over a long period (Mann 1991; Morrow-Tesch *et al* 1993; Schnell & Gerber 1997); this can have implications for the data obtained from such animals.

Training practice and staff education

Junior and senior animal technicians and scientists are the individuals most commonly responsible for determining the need to train primates and for conducting training of the animals (Table 9). Regarding techniques used to train, there are a variety of schedules of behaviour modification (see Table 1). Positive reinforcement is generally considered the most humane of these options (Laule 1999; Laule *et al* 2003; Pryor 2002). It involves voluntary co-operation for pleasurable reward, rather than coercion via the threat of a negative event or experience, and therefore gives the animal greater control over the interaction, which is a desirable scenario for the well-being of captive animals (Weiss 1968). Nine out of 15 establishments use both positive and negative reinforcement, sometimes in the context of the same procedure, and three establishments use negative reinforcement only (see Table 10), which is a cause for concern. No establishments used clicker-training. We recommend that training methods should be based on positive reinforcement and that negative reinforcement should only be used when positive alternatives have been shown to be ineffective. If NRT must be used (eg for training aversive procedures), it should be used in combination with PRT (McKinley 2004).

The most common positive reinforcers are verbal praise and food (Table 11), although the efficacy of verbal praise as a reinforcer has not been shown. Preferred foods can be highly motivating, but foods used for training need to be counted in the nutritional content of the diet (Scott 1990) and junk food should be avoided. The most common

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Table 11 Reinforcers and punishments used to train, as described by those surveyed.

Reinforcer/punishment	Macaques (n = 13)	Marmosets (n = 5)
Positive reinforcement		
Verbal praise	6	3
Food[1]	7	1
Tactile contact with humans (petting)	5	-
Fluid[2]	3	1
Contact with conspecifics	3	-
Negative reinforcement		
Cage squeeze-back mechanism	9	-
Sight of net	5	2
Chasing by human	3	1
Presence of human in front or back, or inside, of home enclosure[3]	2	2
Loud, stern voice	1	2
Noise from banging on enclosure fittings	2	-
Movement of human limbs or hands	-	2
Rattling of keys	-	1
Tap on restraint chair	1	-
Positive punishment		
Verbal command 'No!'	1	-
Squirt of water	-	1 (when fighting)
Negative punishment		
Time out from reward	2	1

[1] Fresh fruit, dried fruit, vegetables, seeds, nuts, pulses, cereals, primate treats, banana flavoured pellets, chocolate, sweets, rice paper for macaques; rusk, marshmallow for marmosets.
[2] Ribena® for macaques; banana milkshake for marmosets.
[3] Although reported as a negative reinforcer, human presence can have a positive or negative effect on animal welfare depending on the actions of the human.

negative reinforcers are use of a cage squeeze-back mechanism to encourage animals to come to the front of a cage and to be restrained, sight of a net and chasing by humans, all of which can be avoided with PRT. Establishments should create an inventory of all current interactions with primates and move to a PRT-based system of interaction where possible.

There is little consistency in the provision of educational opportunities for learning about training primates. Staff development at seven establishments does not include information about training primates, whereas at seven others this information is included as part of on-the-job training (Table 12). Members of staff learn how to train primates most often through word of mouth. At only two establishments have staff attended a dedicated course on training animals. However, 14 establishments indicated that they would be willing to fund attendance on a UK course of this kind.

Generally up to four staff members per establishment are involved in training the animals, although usually there is one main trainer. Animals are trained singly, in pairs or in groups, in sessions ranging from < 15 minutes to over 2 hours (depending on the purpose of training). Differences in the ease of training were reported for animals of different age, sex, temperament, species, source, past experience, and in different group sizes and housing types. In addition, establishments reported a number of ways to improve the efficiency of training programmes. Although these are subjective reports, UFAW PHHSC funded research is underway to identify ways to optimise the time investment involved and make training more effective including, among other things, the effect of animal age, sex and temperament on the time investment required for training with positive reinforcement (Bowell *et al* 2004).

Costs and benefits of training

Costs and benefits of training reported by those establishments that train are given in Table 13. Generally speaking, the largest cost of training is the initial time investment in educating staff and implementing the behaviour modification process. However, there is every indication that this investment will be recouped within a short period, and that it is more than outweighed by the benefits to primates, staff

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Table 12 Training practice and staff education, as described by those surveyed.

	Total (n = 15)
Does staff development include training of primates? If so, how?	
No	7
On-the-job training	7
Attendance on a dedicated course	2
Modular training under A(SP)A	1
IAT course	1
Visits to other establishments	1
What resources are used to train people to train primates?	
Word of mouth (colleagues)	10
Scientific literature	3
Attendance on a dedicated course	2
Attendance at scientific meetings	1
Professional guidelines	-
Advice from a training specialist	-
Advice from HO inspector	-
If there was a UK course on training primates, who should attend?	
Animal technicians	8
Senior animal technicians	7
All staff working with primates	5
Veterinarians	2
Scientists	1
Number of primates in a training session	
1	10
2	5
3-6	6
7-30	1
Number of trainers involved[1]	
1	4
2-4	6
5-12	1
Length of training session (minutes)	
< 15	5
15-120	2
> 120	6
Have you encountered any differences in the ease of training?	
Sex	5
Temperament	3
Group size	2
Source	2
Species	1
Age	1
Housing	1
Past experience of the animal	1
Have you identified any ways of improving the success and efficiency of your training programme? (open question)	
Different reinforcers for individual animals according to their preference	1
Formal training for trainers	1
Some animals work better after feeding - they are less distracted, frustrated and aggressive	1
Trainers with a good awareness of primate behaviour	1
Good communication between trainers	1
Adapted cages, chairs and jackets to make them more comfortable for the animals	1
Pair housing – animals are more relaxed	1
Begin socialisation with humans early in life	1
Begin training early in life with young animals	1
Change task manipulanda* in order to keep the animals' attention	1
Water management with water under complete control	1

[1] Usually there is one main trainer. * Manipulanda: objects that are manipulated by the primate's hands.

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Table 13 Costs and benefits of training (n = 11), as described by those surveyed.

	Costs	Benefits
To primates	Hunger or thirst when food or water management is used (1). Distress when negative reinforcement is used (1).	Less stress for the animals (11). Enrichment through greater mental stimulation and control (4). More satisfactory human-animal interaction (animal well-being) (3). Reduced opportunity for injury during procedure (1).
To staff	Time investment (3). Emotional upset when familiar animals are euthanased (1). Money for staff training courses (1).	Less stress for staff (4). Increased staff morale (3). Improved efficiency of procedure (3). Reduced concern over health and safety of staff (3).
To science	Time investment (1).	Better quality data (7). Able to use animals for longer (2). More data per animal (2). Reduction in number of animals used (1).

Table 14 Importance of socialisation with humans, habituation and desensitisation, as described by those surveyed.

	Macaques (13)			Marmosets (5)		
	Low	Medium	High	Low	Medium	High
For primate well-being						
Socialisation with humans	-	1	10	-	-	5
Habituation	1	1	9	1	-	3
Desensitisation	1	1	5	1	-	4
For use of primates						
Socialisation with humans	-	-	10	-	-	4
Habituation	1	-	11	1	-	3
Desensitisation	1	2	7	1	1	3

and science in terms of improved animal welfare, facilitated management and reduction in the variability of research data (Table 13; Thurston 1992 cited in Desmond & Laule 1994; Schnell & Gerber 1997; McKinley *et al* 2003; Savastano *et al* 2003; Schapiro *et al* 2003; Reinhardt 2003). No costs to primates were reported from training with PRT.

Unfortunately there is a lack of objective quantification of both costs and benefits of training by establishments, but such data are increasingly available in the scientific literature (see Prescott & Buchanan-Smith 2003). Five establishments commented that well-socialised and trained animals yield more and/or better quality data relative to untrained animals which could lead to reduction in the number of animals used, although they had not attempted to quantify this. Training programmes should be implemented and executed in such a way that the results (benefits, costs and effectiveness) can be quantitatively measured. This enables the progress of the programme to be monitored and can help justify to senior management the time investment involved.

Only two of the 11 establishments that train have published details of their use of training, and it is very rare for methods of training to be included in the methods section of mainstream science journals. Establishments should share information on training attempts (failures and successes) by documenting and publishing their work and by visiting other establishments. This will help identification and implementation of humane training methods and hence refinement. Where possible, publications should include details of the training techniques, protocols, cues and rewards, housing and husbandry, time investment, effectiveness and potential for reduction of animal numbers.

Socialisation with humans, habituation and desensitisation

Table 14 shows the importance of socialisation with humans, habituation and desensitisation as rated by participants in the survey. These processes underpin and complement training efforts (Scott 1991; Laule *et al* 1996; Laule 1999; McKinley *et al* 2003), and were most often rated as being of 'high' importance, both for primate well-being and for efficient use of primates. The majority of participants felt that these processes resulted in calmer, less fearful animals, experimental data from which are likely to be more consistent and meaningful.

Macaques and marmosets are most often socialised with humans by animal technicians interacting positively with the primates around routine husbandry throughout the animals' lives (Table 15). However, four macaque and three

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Table 15 Socialisation with humans, as described by those surveyed.

	Macaques (n = 13)	Marmosets (n = 5)
Responsible for socialising primates with humans		
Animal technician	10	4
Senior animal technician	6	5
Scientist	4	1
Veterinarian	-	-
Time when socialisation is conducted		
Routine husbandry	10	4
Routine husbandry and dedicated session	4	3
Number of dedicated sessions per week	1 - 7 (mean = 5)	7 (mean = 7)
Length of each session (minutes)	5 - 60 (mean = 35)	5 - 60 (mean = 27)
Kind of human animal interaction involved		-
Feeding	8	5
Play	6	2
Grooming	6	1
Location where socialisation takes place		
Home enclosure	10	5
Indoor play area	1	-
Outdoor enclosure	1	-
Other	1 (restraint chair)	-
Do staff members go into the animal's enclosures?		
Yes	3	3
No	7	2
Typical group size during interaction	1 – 30 (mean = 5)	2 – 100 (mean = 12)

Table 16 Purposes of, and responsibilities for, habituation and desensitisation, as described by those surveyed.

	Habituation		Desensitisation	
Purpose	**Macaques (n = 13)**	**Marmosets (n = 5)**	**Macaques (n = 13)**	**Marmosets (n = 5)**
Scientific procedures				
Restraint in chair	7	-	2	-
Venepuncture	2	-	1	3
Oral gavage	1	-	2	1
Oral capsule	1	-	1	-
Injection	1	-	1	-
Jacket	1	-	-	-
Cage squeeze-back mechanism	1	-	-	-
Mask for inhalation	1	-	-	-
Nasal administration	1	-	1	1
Procedure room	1	-	-	-
Generation of data on cognitive tasks				
Neck bar on chair	3	-	-	-
Testing room	2	-	1	-
Arm sleeve	2	-	-	-
Head fixation	1	-	-	-
Electrodes on skin	1	-	1	-
Novel manipulanda	1	-	-	-
Touch screen	1	-	-	-
Husbandry and health procedures				
Transport box	4	-	-	-
Weighing	-	1	-	2
Swap infants for hand rearing	-	1	-	-
Other				
Human visitors	-	-	-	2
Handling	-	1	-	1
Responsiblity for habituation				
Animal technician	7	-	6	4
Senior animal technician	2	1	3	3
Scientist	4	1	3	-
Veterinarian	2	-	1	-
Are records kept?				
Yes	5	1	2	1
No	4	-	5	3

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marmoset units have dedicated socialisation sessions in addition to routine husbandry, which involve technicians feeding, playing with and/or grooming the animals for, on average, around 30 minutes five to seven days per week. If the health status of the animals is known and they are free from zoonotic disease, dedicated sessions take place within the animals' home enclosures. Health and safety concerns such as bites and scratches are classified as occupational hazards.

At establishments where habituation takes place, it is animal technicians that are responsible for it (Table 16). Sometimes records are kept as part of a daybook. Habituation is generally not used for marmosets, although at one breeding establishment these animals are habituated to handling, weighing and swapping of infants for rotational hand-rearing. At seven establishments macaques are habituated to restraint in a 'primate chair' and a few other establishments habituate macaques to a variety of other stimuli and situations. There is, however, a lack of consistency between establishments, which is difficult to understand given that habituation is relatively low cost and easy to implement. For example, only one of the 13 establishments using macaques requires that animals be habituated to a transport container before national or international transport. This is done by placing an identical container in their home enclosure several weeks prior to transport (Swallow *et al* 2005; Wolfensohn & Honess 2005).

Habituation to procedures typically involves introducing the animals to increasing degrees of restraint and/or stimulus complexity gradually over a period of days. For example, in the case of a macaque used in an inhalation study, the animal might first be habituated to restraint in a primate chair. This may involve placing the chair in the animal's home enclosure for a few days, so that he/she has the opportunity to explore the apparatus and become familiar with it. The animal is then restrained in the chair for short periods of time (minutes to hours), the length of which are gradually increased, say over one week, to that required for the study. Next the animal is habituated to a face mask while sitting in the chair, then the mask with positive pressure, then aerosol delivery through the mask, and finally aerosol delivery of the test substance. The intention is that by introducing the animal to successive approximations of the procedures, day 1 of study is likely to be less stressful for the animal and the data obtained more reliable.

Some establishments desensitise primates to a variety of uncomfortable or aversive procedures, equipment and situations, usually by providing food rewards during or afterwards (Table 16). However, overall incidence of desensitisation is low, and there is little consistency in its use between establishments and species. Again, it is most often technicians who are responsible for desensitising primates.

Conclusion and animal welfare implications

The survey demonstrates that there is widespread awareness in the UK research community of training as a refinement and appreciation of its diverse benefits, but training is not used as widely or as fully as it might be. This is due to real constraints (principally a lack of staff and time and a lack of confidence in ability to train), but also perceived constraints, which can be overcome by information sharing and education (such as a supposed lack of published information on how to train and assessment of the benefits, and an overestimation of the time investment needed). It is clear, then, that there is opportunity for refinement of common scientific, veterinary and husbandry procedures (such as blood and urine collection, injection, capture from the group and weighing) through use of positive reinforcement training, especially when combined with appropriate socialisation with humans, habituation and desensitisation.

In order to take advantage of this opportunity for refinement, facility managers and principal investigators must ensure appropriate staff levels and sufficient time for training before studies begin, and consider how they can best support their staff to work with co-operative, trained animals rather than resisting, fearful ones. In addition, published information and guidance on training must be made more readily available to all those who use primates in research and testing. To assist establishments in achieving these goals, part 2 of this paper (Prescott *et al* 2005a) includes a tabulated literature review of primate training, a detailed sample training protocol, and guidance on developing and implementing a training programme based on PRT, including resource and personnel requirements.

Recommendations

- The possibility of training primates to co-operate with scientific, veterinary and husbandry procedures as a less stressful alternative to traditional methods should always be considered when planning a research project and re-assessed during the life of the project.
- Regulators (eg UK Home Office Inspectors and local ethical review processes) should take an active role in promoting use of training as a proven refinement.
- Facility managers and principal investigators should be receptive to animal technicians who identify a need for training and should support them in this regard.
- Primate behaviour and animal training specialists should take the lead in making published information on training primates more widely available and in challenging misconceptions about the resource implications of training.
- From the standpoint of animal welfare, training methods should be based on positive reinforcement (reward). Negative reinforcement should only be used when positive alternatives have been shown to be ineffective. If NRT must be used (eg for training aversive procedures, or when very little training time is available), it should be used in combination with PRT.
- Establishments should create an inventory of all current interactions with primates and move to a PRT-based system of interaction.
- Training programmes should be planned carefully. Advice on application of learning processes should be sought from a primate behaviour and/or animal training specialist.

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• Facility managers and principal investigators should ensure appropriate staff levels for training programmes to be carried out optimally (eg by reorganising daily work routines).

• Facility managers and principal investigators should ensure sufficient time for training before studies begin (eg by breeding in-house, or importing animals well in advance of studies and holding them as stock).

• There should be more frequent and timely communication and co-ordination between breeders and users of primates so that animals can be better prepared for the challenges of life in a laboratory environment and for the specific procedures that they are used for.

• As a first step to training, animals should be socialised with humans and habituated to accept food treats from the hands of staff as part of a formal socialisation programme.

• Habituation and desensitisation should be used more widely, particularly in the early phases of training programmes. By making stimuli less fearful or stressful, these processes can increase the animal's willingness to cooperate with training and thereby achieve training goals more quickly.

• Training programmes should be implemented and executed in such a way that the results (benefits, costs and effectiveness) can be quantitatively measured. The progress of the programme should be monitored as this can help justify to senior management the time investment involved.

• Establishments should share information on training attempts (failures and successes) by documenting and publishing their work and by visiting other establishments. Where possible publications should include details of the training techniques, protocols, cues and rewards, housing and husbandry, time investment, effectiveness and potential for improved validity of scientific findings and reduction of animal numbers.

• All staff, including management, should appreciate that the provision of consistent socialisation, habituation and training is as important as all other husbandry activity.

• All animal care staff (including veterinarians and principal investigators) should be trained in order to ensure that all of their actions make a positive and consistent contribution towards any socialisation, habituation or training programme. Failure to do so can result in unintentional reinforcement of undesirable behaviour, causing misunderstanding and frustration for both primates and staff members. Such training should include guidance on using operant conditioning and interpreting primate behaviour.

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