THE PUSH-DOOR FOR MEASURING MOTIVATION IN HENS: AN ADAPTATION AND A CRITICAL DISCUSSION OF THE METHOD

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Abstract *Animal Welfare 2002, **11***: 1-10

*Animals should be given the opportunity to perform behaviours that they are motivated to show if we are to maximise their welfare. Research studies into motivation and appropriate methods of studying it are therefore important. Different factors may need to be taken into consideration depending on the form of the behaviour being studied. Certain commodities, such as a perch for night-time roosting, have a value only if the animal is given full access to them until it has completed the behaviour. For other commodities, such as food and water, the amount can be varied along a continuous scale without affecting the animals' demand for that resource. The commonly used operant techniques generating demand curves are based on the assumption that demand is not affected by the size of the reward (ie how much of the commodity the animal gains access to). As a consequence, these techniques are appropriate only for assessing motivation for resources of which the size can be varied. Resources of the 'all-or-none' type, on the other hand, require a different approach. We discuss different adaptations of the push-door technique as a measure of motivation, and we present results that validate a version with fixed, individually adapted levels of resistance. The method was validated using laying hens (*Gallus gallus domesticus*) tested at different levels of food deprivation and exposed to two series of increasing door resistances. The results show that the level of food-deprivation affects the amount of resistance that is overcome. We conclude that this method could be used to study hens' motivation for commodities of the 'all-or-none' type.*

Keywords: *animal welfare, behaviour, demand, motivation, operant, poultry*

Introduction

Motivation has received much attention in discussions concerning animal welfare, and it has been argued that if an animal cannot perform a behaviour that it is motivated to show, then its welfare will be reduced (Hughes & Duncan 1988; Dawkins 1990; Jensen & Toates 1993; Fraser & Matthews 1997). It is, therefore, important that appropriate and accurate methods to measure motivation are developed. Operant methods, where the animal has to work for access to a resource, have been combined with the consumer-demand approach used in economics to rank resources in terms of how important they are to the animal (Dawkins 1983, 1990).

For certain behaviours, such as perching at night or nesting, the resource that enables the behaviour to be performed will only be meaningful if the hen is given full access to it until the behaviour is completed. As a consequence, the commonly used methods for generating demand functions are not suitable, as they require that the commodity can be bought on repeated occasions and in discrete quantities, and that the size can be varied along a continuous scale. Although a demand curve could be generated for the 'all-or-none' resources mentioned above, by varying the price for access, this would be extremely time-consuming because each session would have to cover an entire night or a complete egg-laying episode. We therefore searched for a method that would provide a valid measure of hens' motivation in these types of situations and, furthermore, that would meet other important considerations, such as being easy to use and avoiding constraints on learning.

Of the previously used operant methods for hens, we selected the push-door, first used by Ian Duncan (see Petherick & Rutter 1990) and further developed by Petherick and Rutter (1990), as a basis for our method. To gain access to a resource, the hen has to exert a certain force to push open the door. The cost of opening the door is varied by varying its resistance. In the original version, weights were added to the door to make it heavier (Duncan & Kite 1987; see also Widowski & Duncan 2000) but, for more accurate control of the resistance, the later version used an electromagnetic force to hold the door closed (Petherick & Rutter 1990). In this later set-up, a computer monitored the size and the duration of the force exerted by the hen pushing against the door, and released the door after a certain amount of work (force x time) had been performed. A hen could thus reach this criterion either with one large push or with a series of smaller pushes at the door. This method was evaluated with birds at two different levels of food deprivation and with food as the resource. It was found that hens took longer to reach the work threshold when they were less food-deprived and so, presumably, less motivated to feed (Petherick & Rutter 1990).

We believe that the push-door is a suitable technique for applied research into animal welfare — in particular, for testing hens' motivation for 'all-or-none' resources such as a nest for egg-laying and a perch for night-time roosting, as mentioned above. The principle behind this method is intuitively logical, and it is unlikely to be affected by constraints on learning because not only does it resemble the natural way in which a hen reaches a resource (pushing through undergrowth), but also because the resource is visible to the bird when it performs the response. However, the computer technology required for the set-up used by Petherick and Rutter (1990) makes the method both costly and difficult to use and it can be simplified if the measure of cumulated work is replaced with a measure of maximum effort. This can be achieved by exposing the hen to a series of fixed levels of resistance and determining the maximum force she will push through to gain access to the resource. This maximum force can be regarded as the maximum price the hen is willing to pay and has a counterpart in the economical term 'reservation price' — the price at which the consumer is indifferent to buying or not buying one unit of the good, which depends on how the good is valued (Varian 1990). We also wanted the possibility of adjusting the resistances for each individual. This way, differences in strength and door-opening technique between hens can be corrected for, by basing the resistances used during testing on the previously determined individual maximum capacity for each hen. After these modifications of the method, we found it necessary to validate it using a resource for which the motivation could easily be manipulated (food), before applying it in further experiments with 'all-or-none' types of resources (such as a perch for night-time roosting; see Olsson & Keeling, pp 11–19, this issue). During the validation study, three food-deprivation times were used to obtain different motivation levels.

Materials and methods

Animals

Hens of a commercial hybrid strain (Lohmann Selected Leghorn) were litter-reared with perches. From the age of 16 weeks, they were housed in a group of 30 hens in a pen with access to litter, nests and perches, and maintained on an artificial light regime of 12L : 12D. At 20 weeks of age, twelve hens of similar body weight (1200 ± 50 g) were selected for the experiment and were thereafter kept as a separate group. Hens were 20 weeks old when training started. One bird was excluded because of repeated escape, and three birds were later excluded because they gave up pushing after failing to open the door during training. The remaining eight hens were divided into two groups. Between training and validation of the technique, the birds were used in another experiment, and validation took place at the ages of 50 weeks (first group) or 53 weeks (second group).

Apparatus

The push-door was a swing-door, hinged at the top, and held closed by an electromagnet. The bird could see through the door to the other side and could open it by putting her head through the centre opening and pushing with the front of her wings (Figure 1). The push-door we used was essentially that developed and described by Petherick and Rutter (1990), with the exception that the load-cell holding the door was manually controlled. In order to pass through to the other side of the door, the hen had to push with sufficient force that the metal of the door was pulled away from the electromagnet in the surrounding frame. After this had happened, there was no resistance on the door and the bird could walk through easily. The resistance was manually adjusted before each trial using a mechanical dynamometer applied at a standard point approximately 10 cm below the point where a standing hen would make contact.

Training

The hens were trained and tested in a runway in which the push-door had been positioned in the middle, a start box at one end and a feeder at the other. Each hen was subjected to daily training sessions in which food was available only in the experimental set-up and not in the home pen. In addition to the food consumed during training sessions, each hen was allowed to feed freely for 10 min after each session, by which time the hen would normally stop feeding. She was then returned to the home pen. All hens were weighed at 20 weeks (start of training period) and at 25 weeks (end of training period), and no hen was found to have lost weight.

Hens were first trained to move from the start box to the feeder, where they were allowed to feed briefly. The door was not positioned in the corridor at this stage. Each hen received 10 such trials in quick succession for three consecutive days. Then, the unweighted push-door was placed between the start box and the feeder and the hens were trained for a further five days. On training-day eight, we started to expose the hens to increasing door resistances, decreasing the training to five trials per day. On the first trial of each day, the same resistance was presented as on the last trial of the preceding day, and then on subsequent trials the resistance was increased. Initially, the daily increase was 0.5 N. From day 14 and onwards, this was increased to 1 N per day.

Figure 1 **The push-door.**

Failure to open the door was defined either as when the hen had tried for 7 min but had not managed to pass through, or as when she had made no attempts for 3 min. When a bird had failed, the experimenter opened the push-door and allowed the bird to reach the feeder. The bird was then given two trials at 20 per cent of the resistance she had just failed to open before finishing the session. We found that a hen's performance was considerably affected by the experience of a failure. When a bird was presented with a resistance 0.5 N lower than the one at which she had failed the preceding day, she responded with fewer door-push attempts and usually gave up without managing to open the door. The same also occurred when the resistance was decreased by a further 0.5 N two days after failing. After experiencing this with the four first birds in training, we adjusted the training method in order to encourage the hens to continue responding. Consequently, for the remaining four hens, on the day following a failure, the hen again received 20 per cent of the failed resistance for the first trial and then 40 per cent for trials two to four. On the second day after failing, the resistances were 40, 60, 80 and 85 per cent, and, on the third day, 85, 90, 95 and 100 per cent of the failed resistance, respectively, for trials one to four. We found that, despite this, three out of four birds never again reached the level at which they had first failed to open the door. To obtain a measure that was comparable for all birds, we used the first maximum resistance — the resistance in the trial preceding the first failure — as a measure of each hen's individual capacity or willingness to push the door. These values, all measured at the standard point on the door, ranged between 8.5 N and 11.5 N for different birds.

Validation

Over a three-week period, hens were deprived of food for periods of 0 h, 12 h or 24 h. The same duration of deprivation was applied for four consecutive days, during which time the hens were exposed to increasing resistances, with one trial per hen per day being conducted. The resistances were individually adapted to each hen, being 25, 50, 75 and 100 per cent of the individual's maximum capacity. Hens in Group 1 ($n = 4$) were tested according to a schedule of increasing deprivation times, starting with 0 h food deprivation. Hens in Group 2 ($n = 4$) were tested with decreasing deprivation times, starting with 24 h deprivation. All hens were exposed to all combinations of deprivations and resistances in a balanced design in which each hen acted as her own control. The hens were tested in the same runway and using the same procedure as during training, except that they were presented with the same sequence of increasing resistances irrespective of earlier failures. Parameters recorded were time to first contact with door, number of pushes, and time to pass through the door.

Statistical analysis

Comparisons were made between food-deprivation durations of 0 h and 12 h, and between 12 h and 24 h. The maximum resistances at which the door was opened were analysed using pairwise comparisons between deprivation times. The behavioural variables were compared between food deprivation times within resistance in pairwise comparisons, using a Wilcoxon matched pairs signed rank test corrected for multiple comparisons (Holm 1979). Data are presented as median [interquartile range].

Results

Hens opened significantly heavier doors at higher levels of food deprivation. After 24 h of food deprivation, the resistance that was overcome was significantly larger than after 12 h (100 [75–100] versus 62.5 [50–75]% of individual maximum; $W = 0.0$; $P = 0.022$), which in turn was significantly larger than after 0 h of deprivation (62.5 [50–75] versus 12.5 [0–43.75]% of individual maximum; $W = 0.0$; $P = 0.036$).

The latency to make contact with the door was shorter when hens were food-deprived than when they were non-deprived, mainly because of the fact that many non-deprived hens did not try to open the door. There were no differences in the latency between deprivation times of 12 h and 24 h (Figure 2, filled bars). The latency to open the door (Figure 2, open bars) also reflects the low number of non-deprived hens pushing open the door. Deprived hens made significantly more attempts than non-deprived hens to open the door at resistances of 75 per cent (8.5 [5.5–14] versus 0 [0–0], respectively; $W = 0.0$; $P = 0.04$) and 100 per cent (7.5 [4.2–26] versus 0 [0–0.75], respectively; $W = 1.0$; $P = 0.042$) of individual maximum, but no differences were seen at lower resistances. No differences in the number of attempts to open the door were found between hens tested after 12 h and after 24 h of deprivation.

When the birds were not food deprived, there was a difference between the two groups of birds depending on the order of testing. Of the birds in Group 1, which experienced the non-deprived situation first, all opened the door at a resistance of 25 per cent of individual maximum, and at least one bird made attempts at all levels of resistance when not deprived.

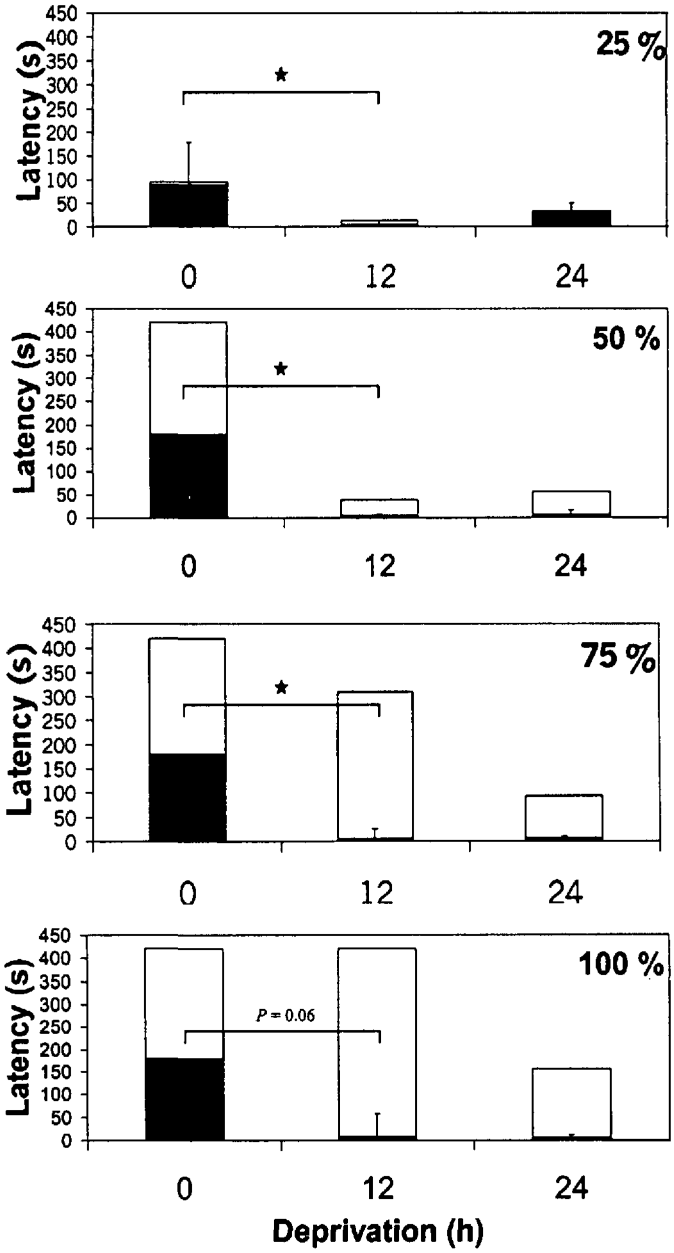

Figure 2 Latency to first contact with the door (filled bars) and latency to open the door (open bars) after 0 h, 12 h and 24 h of food deprivation and at resistances of 25, 50, 75 and 100 per cent of individual maximum capacity (median and interquartile range). Note that when the interquartile range is equal to the median, no error bars are printed. Significance stars indicate differences in latency to contact with the door at $P < 0.05$.

Of the birds in Group 2, which experienced the food-deprived situation first, only one made an attempt to open the door at 25 per cent resistance when tested in the non-deprived condition. At higher resistances, none of the birds in this group even tried to open the door when not food-deprived, and so all scored the maximum latency.

Discussion

This experiment verifies a methodology for using a modified version of a push-door, based on the maximum resistance that is overcome in order to gain access to a resource and taking into account the birds' individual capacity. This technique is useful for studying motivation for commodities of the 'all-or-none' type, such as a nest or a perch, for which the conventional methods of generating demand curves are time-consuming and difficult to apply.

The push-door with fixed resistance levels

During training, it was clear that food-deprived hens were motivated to open weighted doors in order to gain access to food. During the subsequent validation of the method, when we recorded the maximum resistance level at which each hen opened the door, we found that hens opened heavier doors when they were food-deprived for longer periods. They also opened the door after shorter latencies and at heavier resistances, and made more attempts to open it, when they were food-deprived than when they were not. These results confirm that this modification of the push-door method is valid for measuring motivation in hens. Of the recorded variables, the maximum force used to open the door — that is, the maximum price paid for access to food — seems to provide the best measure of motivation because it distinguishes not only between the deprived and the non-deprived state but also between the different levels of deprivation.

During training, we observed that birds did not try as hard to open the door after they had failed to open it once. We therefore changed the methodology to make sure that birds were given an appropriate positive experience of the door after failure. Despite this, we found that the turning point at which the hens would no longer open the door occurred at lower and lower resistances upon consecutive failures during training. It is unlikely that the hens became exhausted, as they were tested only once a day, so this implies that there was another reason why they stopped responding. It has been suggested that failure to obtain reinforcement can result in frustration, which is aversive (Amsel 1958, 1962). Animals commonly learn to make responses that result in the avoidance of aversive stimuli (Chance 1999), and it could be argued that in this experiment the hens were reducing their frustration by avoiding attempts to obtain reinforcement (door opening). If this is the reason that the birds stopped opening the door after their initial failure, then it is suggested that future experiments of this type use a variable schedule of reinforcement during training in order to prevent the total extinction of door-opening behaviour after a failure. It is also possible that the hens learnt that the observer would open the door if they did not and so the door-opening response was not required after failure. Nevertheless, during the validation study several months after training, five out of eight birds reached the first turning point again, despite failing to do so during training. This indicates that the lack of attempts to open the door after initial failure was a transitory and reversible phenomenon. However, the possibility that hens were stronger at 50 weeks of age (validation) than at 20 (training) cannot be ruled out in the absence of other measures of hen strength. Despite the findings of decreased responding after failure, the results indicate that it was indeed appropriate to use the turning point at which birds first stopped responding as the individual maximum. A further observation was that during validation, many birds made no attempt to open the door when they were not food-deprived, and this was particularly noticeable for the group tested with decreasing deprivation levels. According to the theory mentioned earlier, this could reflect the fact that deprived birds who had experienced frustration as a result of not being able to reach the food were less likely to attempt to push through the door, so avoiding the frustration that they now possibly associated with the door. Therefore, they were unlikely to attempt to open the door after experiencing failure. However, birds that had not been deprived when they failed to open the door had not experienced frustration and were therefore much more likely to attempt to open the door after previous unsuccessful attempts. Alternatively, birds that were first tested when they were non-deprived may have been attracted to push at the door despite a low motivation to feed because of its novelty during the first days of testing. Birds that had experienced the test when they were more deprived tried to open the door only when they were motivated to feed.

Different applications of the push-door technique

The main advantage of the push-door is that it uses a method that is intuitively logical and is relatively natural to the hen. By pushing through a door, the hen gains access to the resource that she can see through the door. This response resembles pushing through dense undergrowth, which is the way in which a hen under natural circumstances would gain access to various types of desirable resources such as nest sites or places to roost. As such, this operant behaviour would not be expected to be associated with any particular type of resource or to be subject to any constraints on learning (see Matthews & Ladewig 1994; Mason *et al* 1998; Sherwin & Nicol 1998).

However, not all designs of the push-door make use of this natural response. The original model, where the door swung freely and its resistance was increased by adding weights, gave way slowly and offered continuous resistance until the hen had passed through it, very much as low branches or dense grass would do (Duncan & Kite 1987). In fact, because the weights were attached to the door, the resistance actually increased as the hen lifted it up to push through it. It was because of this increasing resistance at the same door-weight that Petherick and Rutter (1990) developed the computerised push-door version. This door remains securely locked until the hen has performed the required amount of work and then suddenly opens with no resistance at all. In this respect, it functions more like a conventional fixed-response schedule of reinforcement, where no reinforcement is given until the response requirements are fulfilled. Their door does, however, maintain some of its 'natural' properties in that the reinforcer is visible and is available by pushing through the door. The push-door has also been used in strictly conventional reinforcement experiments, where the hens are required to respond with repeated pushes on a door that never opens but where the reinforcer is given in a dispenser after a set number of responses. It has been shown that such door-pushing can replace key-pecking, which is the most common operant response for birds (Sumpter *et al* 1995). However, although the door-push as a response may have an advantage in that it avoids the association with feeding, this application cannot be expected to be perceived by the hen as any more natural than the traditional key-peck apparatus. In our adaptation of the push-door with magnetic resistances at fixed levels, we have tried to retain the advantage of the door as a natural behavioural response while aiming for a more exact control of the resistance. However, our application still has the disadvantage that the door opens rather suddenly once the hen gives a push strong enough to break the magnetic field. The continuous and consistent resistance that is desirable could be achieved by extending the magnetic contact along a slide, so that the door maintains the same resistance as the bird pushes through it.

We used fixed resistance levels that were individually adapted to each hen's capacity, which was identified during training. This allows the actual experiment to be carried out during a short and standardised period, which is an improvement on the original push-door concept where the weight is increased during the test period until the animal stops responding. The original methodology resulted in experiments of highly variable durations for different birds; for instance, Widowski and Duncan (2000) found that a range of 6–29 sessions were needed to determine the resistance at which a hen stopped responding. Although the training becomes more elaborate in that it requires estimates of each individual's capacity to be determined, the number of days needed to establish the individual maximum can be greatly reduced if massed trials (ie a series of trials repeated each day) are used during training.

There are a number of other methodological and interpretational problems in demand studies and, whichever method is chosen, there will always be weak points (Sherwin & Nicol 1998). We suggest that the method described here is suitable for assessing motivation for commodities such as nesting or night-time perching, where completion of the behavioural sequence is important for the value of the resource. Methods in which the animal pays an 'entrance fee' to gain unlimited access to a resource have been criticised because if the cost increases, the animal can respond by rescheduling its behaviour to fewer but longer bouts, and so the total use will be little affected (Mason *et al* 1998). However, this criticism is valid only for resources and circumstances where such rescheduling is possible. This is not the case with resources of the 'all-or-none' type, such as a nest for egg-laying, a partner for mating or a perch for roosting (see Olsson & Keeling, pp 11–19, this issue), for which we suggest that methods with an entrance fee are particularly suitable.

Conclusions and animal welfare implications

The adaptation of the push-door technique described here, which uses fixed resistance levels (cf 'reservation price'), is a simplified version of an operant technique for measuring motivation in hens. This version requires less complex technology and so should facilitate experimentation outside the laboratory. A further advantage is that the method is intuitively logical and easy to explain — an important aspect, as the relevance of welfare research is ultimately determined by whether the results and their welfare implications can be communicated to people who can implement the results in practice.

Acknowledgements

The authors wish to thank Catherine Sumpter, Barry Hughes and Lindsay Matthews for help with planning the study, Hans Gustavsson and Bengt Edwinsson for technical assistance and John Öhrvik for statistical advice. Thanks to Tina Widowski, Stefan Gunnarsson and two anonymous referees for comments on earlier versions of the manuscript. The study was funded by The Swedish Council for Forestry and Agricultural Research.

References

Amsel A 1958 The role of frustrative nonreward in continuous reward situations. *Psychological Bulletin 55*: 102-119

Amsel A 1962 Frustrative nonreward in partial reinforcement and discrimination learning: some recent history and theoretical extension. *Psychological Review 69*: 306-328

Chance P 1999 *Learning and Behavior*. Brooks/Cole Publishing Company: Pacific Grove, USA

Dawkins M S 1983 Battery hens name their price: consumer demand theory and the measurement of ethological needs. *Animal Behaviour 31*: 1195-1205

Dawkins M S 1990 From an animal's point of view: motivation, fitness and animal welfare. *Behavioural and Brain Sciences 13*: 1-161

Duncan I J H and Kite V G 1987 Some investigations into motivation in the domestic fowl. *Applied Animal Behaviour Science 18*: 387-388

Fraser D and Matthews L R 1997 Preference and motivation testing. In: Appleby M C and Hughes B O (eds) *Animal Welfare*. CAB International: Wallingford, Oxon, UK

Holm S 1979 A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics 6*: 65-70

Hughes B O and Duncan I J H 1988 The notion of ethological 'need', models of motivation and animal welfare. *Animal Behaviour 36*: 1696-1707

Jensen P and Toates F M 1993 Who needs "behavioural needs"? Motivational aspects of the needs of animals. *Applied Animal Behaviour Science 37*: 161-181

Mason G, McFarland D and Garner J 1998 A demanding task: using economic techniques to assess animal priorities. *Animal Behaviour 55*: 1071-1075

Matthews L R and Ladewig J 1994 Environmental requirements of pigs measured by behavioural demand functions. *Animal Behaviour 47*: 713-719

Olsson I A S and Keeling L J 2001 The push-door for measuring motivation in hens: laying hens are motivated to perch at night. *Animal Welfare 11*: 11-19

Petherick J C and Rutter S M 1990 Quantifying motivation using a computer-controlled push-door. *Applied Animal Behaviour Science 27*: 159-167

Sherwin C M and Nicol C J 1998 A demanding task: using economic techniques to assess animal priorities. A reply to Mason *et al*. *Animal Behaviour 55*: 1079-1081

Sumpter C E, Foster M and Temple W 1995 Predicting and scaling hens' preferences for topographically different responses. *Journal of the Experimental Analysis of Behaviour 63*: 151-163

Varian H R 1990 *Intermediate Microeconomics. A Modern Approach*. W W Norton & Company: New York, USA

Widowski T M and Duncan I J H 2000 Working for a dustbath: are hens increasing pleasure rather than relieving suffering? *Applied Animal Behaviour Science 68*: 39-53