Final Thesis

Are seals willing to pay for access to artificial kelp and live fish?

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Contents

1 Abstract

Environmental enrichment (EE) is used to improve the wellbeing of animals in human care. One way of testing what resources an animal prefers to have access to, is to make it pay a price. The price is in the form of time or energy spent to get access to the resource. When measuring the motivation of animals it is useful to compare the resource which is to be evaluated to a resource with a known value. Food is often the comparator. The maximum price paid approach measures the highest price an animal is willing to pay for access to a resource. In this study the motivation of a grey seal (*Halichoerus grypus*) for getting access to artificial kelp and live fish was measured. Food was used as the comparator. A large net cage with a weighted entrance and a non-weighted exit gate was used as the test arena. The seal had to enter it by opening the entrance gate which had increasing weights every day, in 10 steps up to 65 kg. The seal was not willing to pay any price for the live fish. The maximum price paid for the food was 60kg, and for the artificial kelp 10kg, i.e. 17% of the maximum price paid for food. The results suggest that neither live fish nor artificial kelp was an attractive EE for this seal. However, the study also shows that spring (reproductive period) is not a good time to test motivation in grey seals.

Keywords: motivation, maximum price paid, environmental enrichment

2 Introduction

The aim with environmental enrichment (EE) is to improve the wellbeing of animals in human care. EE has been widely used by zoos for many years for increasing the frequency of species-specific behaviours (Bashaw *et al.* 2003) and reducing stereotypic behaviours (Hunter et al. 2002, Swaisgood & Shepherdson 2005). Stereotypes are associated with enclosures that lack any or almost any type of stimulation (Shyne 2006). Chamove (1989, in Shyne 2006) defines EE as methods that can alter the expression of natural behaviours in captive animals to become more similar to that of their wild conspecifics. The EE will add ingredients that make the captive habitat more similar to the species' natural habitat, e.g. different floor substrates and climbing opportunities (Swaisgood & Shepherdson 2005). Many studies have used food as EE, e.g. feeding boxes (Amur tigers, Jenny & Schmid 2002), hidden food (leopard cats, Shepherdson *et al.* 1993) and an irregular feeding regime (Mongolian wolves, Kilchenmann 1997 in Jenny & Schmid 2002). Live food has also been used as EE in some studies regarding foraging (Jenny & Schmid 2002) e.g. fishing cat (Shepherdson *et al.* 1993), Sumatran tigers (Bashaw *et al.* 2003), black- footed ferrets (Vargas & Anderson, 1999) and barn owls (Bergan *et al*. 2005).

The welfare of an animal is said to be compromised if the animal is highly motivated to get access to a resource or perform a behaviour, but cannot get access to the resource or perform the behaviour in its enclosure (Olsson *et al*. 2002, Schütz *et al*. 2006). Seals, for example, have responded positively to EE by increasing their behavioural repertoire and decreasing their stereotypic behaviours when offered manipulative objects and being trained (Hunter *et al*. 2002).

A way of knowing what EE the animals prefer is to make them pay a price for access to the EE resources (Cooper & Mason 2000). This approach is often used in animal welfare research (Olsson & Keeling 2002, Warburton & Mason 2003). Measuring the strength of the animals' motivation in this way gives an idea of what the animals value and hence what should be prioritized as additions to their enclosures (Warburton & Mason 2003). The price the animals have to pay is in the form of time or energy spent to get access to a unit of the resource (Houston 1997), e.g. lever pressing, passing through a narrow gap or pushing through a weighted door. These operant tasks are most frequently used since they are simple and automatically measure the cost (Cooper & Mason 2001).

It is useful to compare the resource which is to be evaluated, with a resource of known value (comparator) when measuring motivation in animals. The comparator is often food, since the value of food varies predictably depending on how much the animal has already eaten and the time since the last meal. Then if the motivation to use the EE resource of interest is equal to or higher than the motivation for food when hungry, the resource is said to be very important to the animal (Olsson & Keeling 2002, Kirkden & Pajor 2006).

There are four different ways which are recommended for ranking the importance of the resources an animal is willing to pay for. They are elasticity of demand, income elasticity, consumer surplus and maximum price paid (Cooper & Mason 2001, Kirkden *et al*. 2003).

In the elasticity of demand approach, the price of the resources is varied (Cooper & Mason 2001) but the amount of the resource is fixed. Resources with low elasticity are called necessities (e.g. gasoline), while resources with a high elasticity are called luxuries (e.g. wine; Ladewig & Matthews 1996, Mason *et al*. 1998). It is reasoned that if a resource is highly important to an animal, then the animal should be willing to pay more for it, even if the cost increases (Kirkden *et al*. 2003). Two studies that have used this approach are Ladewig & Matthews (1996) and Gunnarsson *et al.* (2000). Ladewig & Matthews (1996) established demand curves (i.e. number of rewards plotted against price, Kirkden in prep) for pigs and tested different commodities like food and straw bedding while Gunnarsson *et al.* (2000) investigated the importance of straw and feathers in laying hens.

In the income elasticity approach, the price is fixed while the income is varied (Cooper & Mason 2001). The importance of the resource is said to be low or high if the income elasticity is greater than 1 or less than 1, respectively (Kirkden *et al*. 2003). One study that used the income elasticity approach is Dawkins (1983) in which she made battery-caged hens put a value on access to litter.

A third way of measuring the importance of a resource is with the consumer surplus, which corresponds to an area under the demand curve i.e. number of rewards plotted against price (Kirkden in prep). It measures the difference between the biggest amount of currency (price) that an animal is willing to pay for a given quantity of a resource and the total price the animal in fact has to pay (Kirkden *et al*. 2003). One study that used this approach was Mason *et al.* (2001) which measured the cost farmed minks were willing to pay for access to EE like a water pool and an alternative nest site.

Finally, the maximum price paid approach measures the highest price an animal is willing to pay for only one visit to the resource (often after a period of deprivation) by increasing the price until the animal stops paying. Maximum price paid can be measured in two different ways: with a long session duration (e.g. the whole light period) or a short session duration (e.g. one hour). The long session imitates the method which is used to obtain the consumer surplus, but with the maximum price paid approach, only one reward per session is allowed and the quantity of the reward may or may not be fixed (Kirkden in prep). Long sessions allow the animal to choose when to pay for the resource during e.g. a whole day, since it may only have a motivation to use this resource at particular times of the day (Widowski & Duncan 2000). A hen, for example, may have a motivation for food several times a day, but motivation for nesting only once at a specific time in the day. Using the short session approach is useful when looking at effects of deprivation or satiation level (Cooper & Appleby 2003, Kirkden in prep). The motivation for the resource is measured at a specific time of day and this may be a disadvantage since it may not be the time the animal is for example the most eager for social contact (Kirkden in prep). One important thing to remember is that although the duration of access to the resource in practice has to be limited, the animal must be given enough time to perform a full bout of the behaviour in question (Olsson & Keeling 2002, Olsson *et al*. 2002).

If additional food is given to the animal outside the experimental session, then the economy is said to be open (Foster *et al*. 1997), whereas if the animal is only given food during the sessions, the economy is closed (Sumpter *et al*. 1999, Hursh 1984). If food is offered too close to the test session, it may affect the maximum price the animal is willing to pay (Hursh 1984).

Two examples of studies that used the maximum price paid approach are Hovland *et al.* (2006), which measured the motivation for social contacts in

silver foxes, and Cooper & Mason (2001) that measured the motivation for different commodities, like toys and a water pool, in farmed mink.

The aim with this study was to measure the motivation of grey (*Halichoerus grypus*) and harbour seals (*Phoca vitulina vitulina*) for getting access to live fish and artificial kelp. Artificial kelp had been offered prior to this study as an *ad lib* EE resource to the seals at Kolmården zoo, but it has never been investigated how much they used it or in what way. However, it was the impression of the trainers that at least some of the seals seemed to like to interact with the artificial kelp, especially the harbour seals (trainer's pers. comm.[1]). The hypothesis was that the seals would be willing to pay for access to the artificial kelp.

The purpose of giving live fish to the seals was to investigate if foraging was a part of their natural behaviour repertoire that they wanted to be able to perform. Live fish had never before been given to these seals so it was very interesting to see how they would react to and interact with the live fish. The hypothesis was that the seals would be willing to pay for access to live fish.

3 Material and methods

3.1 Animals

One female Baltic grey seal, Liivi, and one male harbour seal, Marcus, were used in this study. Liivi was born in 1994 in the wild and Marcus was born in 1992, also in the wild. They were both rescued as orphans, and brought to Kolmården for rehabilitation. They were housed in the Brådjupet, the pinniped exhibit at Kolmården zoo, which has a maximum depth of 9 meters and a water volume of 2.5 million litres. The enclosure is outdoor and the temperature in the water follows the season. Although the trials were carried out in the winter, the water temperature never went below 0˚C, and no ice was formed on the surface. During the trials there were two other grey seals and two other harbour seals in the enclosure. They were all fed twice a day with a varying mixture of thawed herring, capelin and mackerel and every second day they received vitamin and mineral supplements.

The live fish used in the trials were eels (*Anguilla anguilla*), burbot (*Lota lota*), pike (*Esox lucius*), perch (*Perca fluviatilis*), flounder (*Pleuronectes limanda*), whitefish (*Coregonus lavaretus*) and sculpin (*Triglopsis quadricornis*) that were caught in Bråviken by a professional fisherman. The fish were housed outside in a 4x4x0.5m fish tub, which was borrowed from the Swedish Board of Fisheries. Since these trials were carried out in the middle of the winter, the tub was partly covered with Styrofoam

[1] Sunna Edberg, Dolphinarium at Kolmården zoo, Sweden.

boards, and this, together with a piglet heat lamp, prevented the water from freezing.

3.2 Experimental setup

A large cylindrical net cage was used as the test arena (Figure 1). It was approximately 4m high and had a diameter of 4m. Three rings of Ø50mm PEM hose constituted the "skeleton" of the cage. Several holes were drilled in the two lower rings to allow them to be filled with water and sink. The top ring was air-filled to make it float. A 210/24 net with 8mm knot-less mesh was used. It was tied to the hoses using cable ties. Three vertical 5x5cm wooden beams were attached to the bottom and top PEM rings to stretch out the net. The roof net of the cage was lifted by a big buoy, approximately 70cm in diameter, to make it easier for the seals to breathe while inside the arena.

Attached to the upper PEM ring there was an entrance and exit gate arrangement. The curved gates were made of polypropylene and the entrance gate had a float, which could be filled with a controlled amount of air, thereby pressing it against the roof of the entrance box (Figure 2). In order to get inside the cage, the seal had to press down this gate, and the buoyancy of it determined the "price" (Figure 3). The net cage was anchored to the bottom of the seal enclosure in order to keep the entrance gate float submerged and prevent the seal from lifting the cage instead of pressing down the float. Air was blown into the float via a plastic hose, and the buoyancy was measured with a scale. A small bridge extending from the pool side to the centre of the cage roof made it possible to change the buoyancy and to carry out the initial training of the seals to enter the cage. Outside the sessions the entrance gate was blocked by a plywood door to prevent any seal from entering the cage.

The exit door also had a float, but only a small one; just enough to keep the gate closed. It could easily be opened, but only from the inside of the cage.

The artificial kelp was made of a thick cellulose felt (Vira fabric, which is used in the paper industry for drying paper pulp), which was cut into several 4m lengths, each approximately 15cm wide. These fabric lengths were attached to wooden bars, approximately 150cm long and 5cm thick, arranging them into two straight curtains. The wooden bars floated on the surface of the cage, and the curtain almost reached the bottom of it.

A camera (Canon, G10 Hi) was used to record the behaviour of the seals through an underwater acrylic panel during the trials.

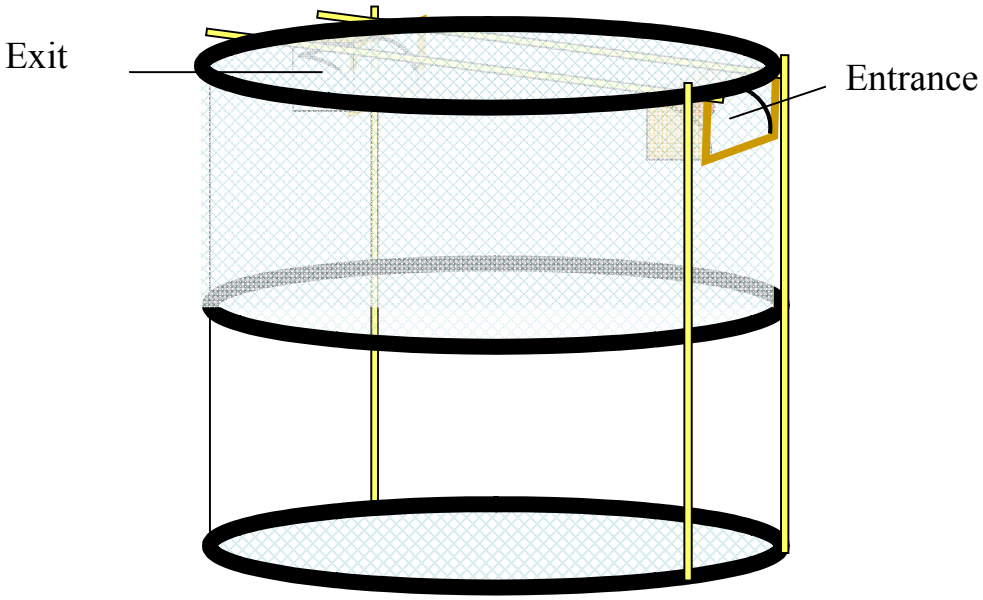

Figure 1. The net cage with the entrance gate in the upper right corner and the exit gate opposite to it.

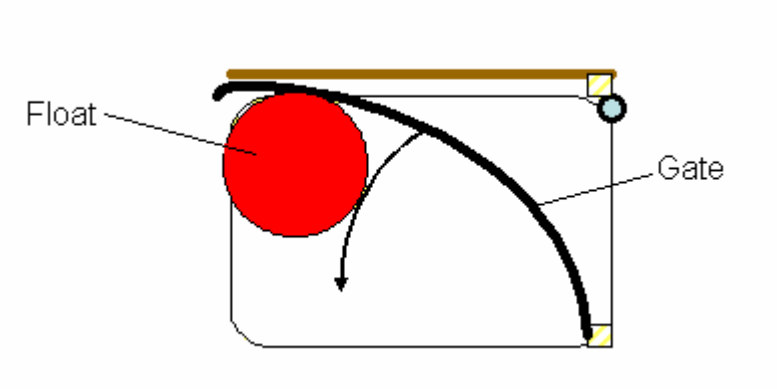

Figure 2. The entrance gate with the float.

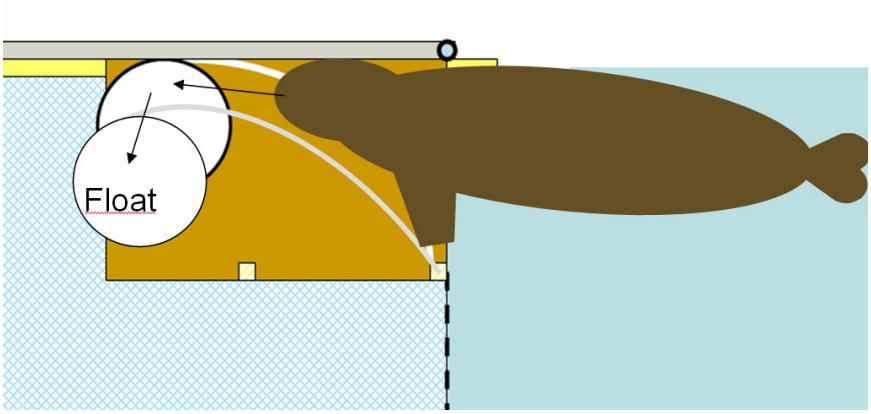

Figure 3. Shows how a seal had to open the entrance gate.

3.3 Training

The gate arrangement was put in the pool several months prior to the experiments. The gates were fixed in an open position to let the seals get used to swimming in and out of them. When the net cage was installed, the two seals Liivi and Markus were trained to enter and exit the cage, using operant conditioning techniques (Ramirez 1999). During this training the entrance gate was kept open so the trainer could guide them into the cage using a target (a buoy on a long pole; see Ramirez 1999). Inside the cage the seals were rewarded with dead fish and were allowed to swim around *ad lib*. The same procedure with the target was used when guiding the seals out of the cage and outside they were rewarded again with fish. During all the training sessions there were two or three other seals outside the cage that seemed interested in the cage, but none of them tried to get inside. The training was done in the morning and in the afternoon at the seals' normal feeding times.

In total there were twelve training sessions with both Liivi and Marcus. Marcus only learned to enter the cage with the gate wide open and therefore could not be used in the experiment. This may have been because Liivi hindered him from making further progress. Liivi, however, learned to both enter and exit the cage in just two sessions; and in the eighth, eleventh and twelfth training sessions the entrance gate was filled with air to test her capacity to open it. The weights were 20, 30 and 45kg, respectively. She managed 20 and 30kg, but not 45kg. On all the other training sessions there was no resistance in the gate, and on almost all of these sessions, thawed food fish were thrown in the cage for her to eat.

One eel was introduced to Liivi before the experimental trials since she had never before experienced live fish. She did not, however, respond well to it and wanted nothing to do with it. A while after the experimental trial some other live fish were introduced to her again, but she did not respond well to them either and therefore the trials with live fish had to be aborted.

3.4 Experimental trials

In this study dead fish i.e. herring, which are part of the normal daily food, were used as the comparator. The maximum price paid approach was chosen because it shows in a simple way what resources the animal want to have access to by increasing the price stepwise until the animal ceases to pay. An open economy was used during the comparator trials and a closed economy during the trials with the artificial kelp. This was because the seals were given free food after the comparator sessions, but were not allowed free access to the artificial kelp after these sessions. The seals were allowed one visit per day into the cage, with increasing entrance weights every day. Both resources were presented inside the net cage. This way of measuring motivation for EE has as far as I know never been done before with seals.

The experimental trials with Liivi began the day after the last training session. All test sessions were carried out in the afternoon, at approximately 3pm, in order to have a fixed hunger level. This was approximately six hours after the morning feeding, when she got about half of her daily 3kg food ration. Before a comparator session started, approximately 1kg of fish was put inside the cage, the camera was rigged and the entrance gate float was filled with the correct amount of air, which was verified by the scale. Then the outer door was opened and Liivi was allowed to enter when she liked. There was a time limit of approximately 20 minutes before the outer door was closed again. Liivi, however, often entered the cage within only a few minutes after the door was opened. She got an additional approximately 1kg of fish 5-10 minutes after the comparator sessions because the trainers had to prevent her from stealing food from the other seals when they were fed after the trials.

The buoyancy increase schedule was 0, 10, 20, 30, 40, 45, 50, 55, 60 and 65kg. The first day there was 0 kg buoyancy and the second day 10kg and so on. The first set of trials was done with dead fish as the comparator, and the following trials were done with the artificial kelp.

3.5 Statistical analysis

The maximum price paid for artificial kelp was presented as a percentage of the willingness to pay for the dead fish.

4 Results

All trials were carried out between February 16th and March 23rd. There was a short break of five days (from March 3rd to 8th) between the comparator trials and the trials with the artificial kelp because of the introduction of live fish to Liivi. There was a longer break of 10 days (from March 13th to 23rd) between

the two last sessions (10 and 20kg) with the artificial kelp. This was due to Liivi and another female grey seal giving birth (in Liivi's case a stillborn), and because of this they had to be disturbed as little as possible during the first week.

4.1 Comparator trials

The comparator trials showed that Liivi was prepared to work for the fish. She managed to get through the gate load from 0 to 20 kg without any apparent effort, but when weighted with 60 kg of buoyancy, she had to work hard to get through the gate: she did not manage to pass through the gate until her 16th attempt, after nearly 20 minutes. When the buoyancy was increased to 65 kg, she failed to get through the gate. Hence 60 kg was her maximum price paid for food (Figure 3).

Inside the net cage she swam directly down to the bottom and ate her fish and then swam almost directly out of the net cage again after all the fish were consumed.

4.2 Artificial kelp

Liivi's maximum price paid for the artificial kelp was 10kg (Figure 3). When inside the cage, she did not interact with the kelp at all, but just swam around for a while and then left the cage through the exit gate.

The maximum price paid for artificial kelp was hence 17% of the maximum price paid for food.

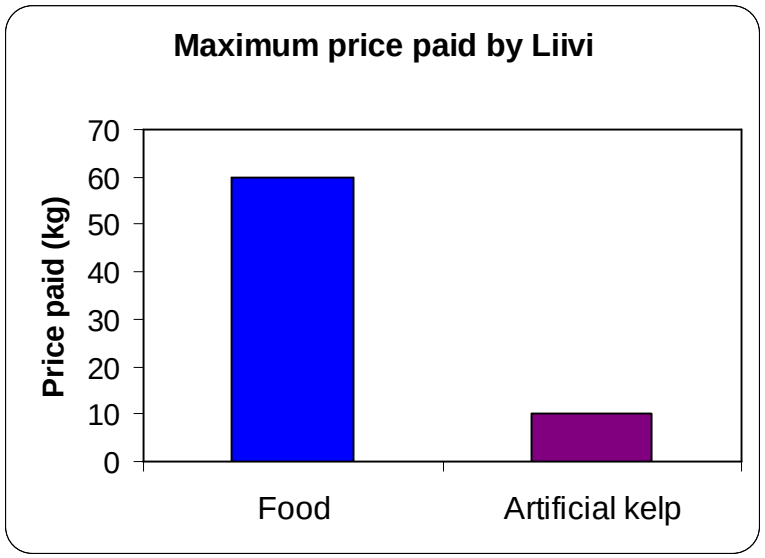

Figure 3. The maximum price the grey seal Liivi was willing to pay for food and artificial kelp, respectively.

5 Discussion

Liivi was willing to pay 60kg for food (dead fish). She was food deprived for approximately 6 hours and was tested at a time when she would normally have received her second feed of the day. Both the deprivation period and her expectancy of food at this time would have contributed to her level of feeding motivation, and it is probable that the strength of her motivation to enter the cage for fish was moderate. During the training and comparator trials she was always very eager to enter the net cage, even though during training there was sometimes no food inside. She worked in a deliberate and focused way to open the entrance gate and at the four heaviest weights, 45, 50, 55 and 60kg, she made several attempts to open it before she managed to do so. Olsson *et al* (2002) found that hens that were food deprived opened heavier doors and made more attempts to do so. Schütz *et al* (2006) also found that lactating cows walked longer distances for food when food deprived.

The fact that she was given about 1kg of free food approximately 5-10 minutes after the sessions could have had a negative effect on her motivation to enter the cage (Hursh 1984). To avoid this, there should be a delay from the experimental session until the free access (e.g. of 30-90 minutes: Kirkden, in prep). To test whether the short delay in this study reduced Liivi's motivation it would be necessary to run a trial in which she was not given free food directly after the sessions. Timberlake *et al.* (1987) found that rats' motivation to work for access to food was not affected when they got free food 30min or more after one trial.

Liivi's eagerness to enter the cage was expected because of her fondness for food, but in future trials with Liivi it would be interesting to test different deprivation levels since her maximum price paid should increase with food deprivation time. Another aspect to consider in future studies is that the fish she was given in this study were very fat and that could have affected the maximum price paid because she maybe needed more than 6 hours to digest the breakfast fish to be really hungry in the afternoon.

The result of this study shows that artificial kelp was not an attractive EE for the grey seal Liivi, but because only one seal was participating in the experiment, the result cannot be applied to every grey seal. The fact that maximum price paid for artificial kelp was much lower than the maximum price paid for food indicates that motivation for artificial kelp was low. There may be several reasons why Liivi was not interested in interacting with the artificial kelp and hence did not want to pay so much for it. One reason might be that she had come into heat after giving birth to her stillborn pup half way through the trials with artificial kelp. As a result, she appeared to have lost interest in almost everything except the male grey seal (trainers, pers. comm.[2]). A second reason, although less likely, may be that she did not like to

[2] Sunna Edberg, Dolphinarium at Kolmården zoo, Sweden.

be inside the cage since we had introduced the eel to her shortly before starting the kelp trials. When inside the cage with the eel, she ignored it after shortly nipping it at the tail fin, and when we put some dead fish into the cage while the eel was inside she just swim down and picked up the dead fish and swam out with them again to eat them. A third reason could be just the opposite, that she had forgotten what to expect in the cage during the break after her delivery, and hence was not willing to pay a higher price for an unknown reward. Maybe she should have been allowed to swim inside a few times for free before the artificial kelp test sessions were initiated. It would have been better not to have started the trial with the artificial kelp until her reproductive period was completely over. The long break between 10kg and 20kg might also have devalued the artificial kelp since she did not experience a steady increase of the price like she did in the comparator trial. A fourth reason could be that the artificial kelp was an unattractive EE for Liivi and thus only worth 10kg to her.

In order to properly test the motivation for live fish, it is important to find out what live fish these seals might prefer, and in what months they can be obtained. Liivi, a rehabilitated orphan, had never been given the opportunity to chase or eat live fish, and may have needed some time to get used to this. It is shown in the wild that most grey seals steal fish, e.g. whitefish, herring and salmon, from gillnets if they get the opportunity (Fjälling 2006). Also their reproductive seasons in the spring should be avoided. Preferably also the seals should be trained to be separated so they can be tested individually, to avoid social factors from interfering.

5.1 Conclusion

The hypothesis that seals were willing to pay for access to artificial kelp could not be rejected. Liivi paid 10kg, but the motivation was weak. She was not willing to pay any price for live fish. Circumstances outside the experiments indicate, however, that the results were not reliable, mostly connected to the fact that the experiments coincided with the reproductive season of this species.

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7 References

Bashaw MJ, Bloomsmith MA, Marr MJ & Maple TL (2003) To hunt or not to hunt? A feeding enrichment experiment with captive large felids. Zoo biology 22, 189-198.

Bergan JF, Ro P, Ro D & Knudsen EI (2005) Hunting increases adaptive auditory map plasticity in adult barn owls. The journal of neuroscience 25, 9816-9820.

Chamove A (1989) Environmental enrichment: a review. Animal technology 40, 155-78.

Cooper JJ & Appleby MC (2003) The value of environmental resources to domestic hens: a comparison of the work-rate for food and for nests as a function of time. Animal welfare 12, 39-52.

Cooper JJ & Mason GJ (2000) Increasing costs of access to resources cause re-scheduling of behaviour in American mink (*Mustela vison*): implications for the assessment of behavioural priorities. Applied animal behaviour science 66, 135-151.

Cooper JJ & Mason GJ (2001) The use of operant technology to measure behavioural priorities in captive animals. Behaviour research methods, instruments, & computers 33, 427-434.

Dawkins MS (1983) Battery hens name their price: consumer demand theory and the measurement of ethological "needs". Animal Behaviour 31, 1195-1205.

Fjälling A (2006) The conflict between grey seals (*Halichoerus grypus*) and the Baltic coastal fisheries- new methods for the assessment and reduction of catch losses and gear damage. Dissertation No. 1006. Linköping University, studies in science and technology.

Foster TM, Blackman KA & Temple W (1997) Open versus closed economies: performance of domestic hens under fixed-ratio schedules. Journal of the experimental analysis of behaviour 67, 67-89.

Gunnarsson S, Matthews LR, Foster TM & Temple W (2000) The demand for straw and feathers as litter substrates by laying hens. Applied animal behaviour science 65, 321-330.

Houston AI (1997) Demand curves and welfare. Animal behaviour 53, 983-990.

Hovland AL, Mason G, Bøe KE, Steinheim G & Bakken M (2006) Evaluation of the 'maximum price paid' as an index of motivational strength for farmed silver foxes (*Vulpes vulpes*). Applied animal behaviour science 100, 258-279.

Hunter SA, Bay MS, Martin ML & Hatfield JS (2002) Behavioural effects of environmental enrichment on harbour seals (*Phoca vitulina concolor*) and gray seals (*Halichoerus grypus*). Zoo biology 21, 375-387.

Hursh SR (1984) Behavioral economics. Journal of the experimental analysis of behaviour 42, 435-452.

Jenny S & Schmid H (2002) Effect of feeding boxes on behaviour of stereotyping Amur tigers (*Panthera tigris altaica*) in the Zurich zoo, Zurich, Switzerland. Zoo biology 21, 573-584.

Kilchenmann M (1997) Das Laufverhalten der Mongolischen Wölfe (*Canis lupus chanco*) im zoo Zürich: stereosypie oder evoluierte strategie? Master's thesis, University of Zurich, Zurich, Switzerland.

Kirkden R (In prep) Economic measures of motivational strength: what they are and what they can do

Kirkden RD & Pajor EA (2006) Motivation for group housing in gestating sows. Animal welfare 15, 119-130.

Kirkden RD, Edwards JSS & Broom DM (2003) A theoretical comparison of the consumer surplus and the elasticities of demand as measures of motivational strength. Animal behaviour 65, 157-178.

Ladewig J & Matthews LR (1996) The role of operant conditioning in animal welfare research. Acta Agric. Scand. Sect. A. Animal Sci. 27, 64-68.
Mason G, McFarland D & Garner (1998) A demanding task: using economic techniques to assess animal priorities. Animal behaviour 55, 1071-1075.

Mason GJ, Cooper JJ & Clarebrough C (2001) Frustrations of fur-farmed mink. Nature 410, 35-36.

Olsson IAS & Keeling LJ (2002) The push-door for measuring motivation in hens: laying hens are motivated to perch at night. Animal welfare 11, 11-19.

Olsson IAS, Keeling LJ & McAdie TM (2002) The push-door for measuring motivation in hens: an adaptation and a critical discussion of the method. Animal welfare 11, 1-10.

Ramirez K (1999) Animal training- successful animal management through positive reinforcement. Shedd- the world's aquarium. USA.

Shepherdson DJ, Carlstead K, Mellen JD & Seidensticker J (1993) The influence of food presentation on the behaviour of small cats in confined environments. Zoo biology 12, 203-216.

Shyne A (2006) Meta-analytic review of the effects of enrichment on stereotypic behaviour in zoo mammals. Zoo biology 0, 1-21.

Schütz K, Davison D & Matthews L (2006) Do different levels of moderate feed deprivation in dairy cows affect feeding motivation? Applied animal behaviour science 101, 253-263.

Sumpter CE, Temple W & Foster TM (1999) The effects of differing response types and price manipulations on demand measures. Journal of the experimental analysis of behaviour 1, 329-354.

Swasigood RR & Shepherdson DJ (2005) Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? Zoo biology 24, 499-518.

Timberlake W, Gawley DJ & Lucas GA (1987) Time horizons in rats foraging for food in temporally separated patches. Journal of experimental psychology: animal behaviour processes 13, 302-309.

Vargas A & Anderson SH (1999) Effects of experience and cage enrichment on predatory skills of black-footed ferrets (*Mustela nigripes*). Journal of mammalogy 80, 263-269.

Warburton H & Mason G (2003) Is out of sight out of mind? The effects of resource cues on motivation in mink, *Mustela vison*. Animal behaviour 65, 755-762.

Widowski TM & Duncan IJH (2000) Working for a dustbath: are hens increasing pleasure rather than reducing suffering? Applied animal behaviour science 68, 39-53.