Journal of Animal and Veterinary Advances, 4 (4): 441-447, 2005

Using Conditioned Reinforcement as a Way to Make Dairy Cows to Leave an Automatic Milking Unit

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Abstract: Cows milked in an Automatic Milking System (AMS) have to leave the Automatic Milking Unit (AMU) before the next cow can enter. Cows that delay entering or leaving will lower the daily capacity in terms of number of successful milkings. In this study, the effects of a neutral stimuli (NS; acoustic signal) or a conditioned reinforcement (CR; an acoustic signal preceding a light negative reinforcement, such as a flashing light and/or a moving rubber tube on the back of the cow) on dairy cows known for leaving the AMU slowly, i.e., not leaving within 10 sec after the exit gate had opened, was studied. On average it was observed that up to 3 min elapsed before a cow left the AMU after a successful milking without the use of a CR. We found that this time could be substantially reduced by using a CR. Primiparous cows stayed in the AMU after milking between 109 and 125 sec without the CR and after the introduction of the NS or a CR they stayed on average between 12 and 32 sec. The time multiparous cows remained in the AMU after milking terminated was reduced from 178 and 193 sec to 25 and 48 sec when the CR was applied. No long-term effect was seen in multiparous cows receiving only the NS. This indicated that for the effect to be sustained, the acoustic signal had to be paired with a negative reinforcement, such as a CR. Neither the NS nor the CR affected the times for the animals to enter the AMU. Using a conditioned stimuli in an AMS between 100 and 150 minutes daily would be available for additional milkings

Key words: Automatic milking system, exit time, capacity, conditioned stimuli, negative reinforcement

Introduction

Cows milked in an Automatic Milking System (AMS) must visit the Automatic Milking Unit (AMU) a few times per day in order to be milked, preferably doing so on a voluntary basis (Ketelaar-de Lauwere, 1992). Cows are willing to visit the AMU because feed concentrate is dispensed there (Devir *et al.*, 1993 and Prescott *et al.*, 1998). If cows do not come to the AMU by the proper time, they need to be manually brought to the AMU. A good functioning cow traffic is important for the capacity of the milking system (number of successful milkings per day), for the cow and for the herdsman.

Various bottlenecks can be found in the design of a cowshed with an AMSand in the AMS itself, that will influence cow traffic negatively (Stefanowska *et al.*, 1997). For instance, small and awkwardly designed passages to and from the AMU can be an obstacle for smooth running cow traffic. An important bottleneck is in the AMS itself, because only one cow can be milked at the same time in the AMU. The capacity of an AMS may be lowered by the following factors: the cows taking a long time to enter the AMU, the efficiency of the robot during the milking process, cows making non-milking visits, milking failure visitsand cows leaving the AMU slowly. The two factors that depend the most on cow behaviour are the entering and the leaving of the AMU. The entering of the AMU proceeds quickly because the cow expects to get some concentrate there (Stefanowska *et al.*, 1997).

The time required for each cow to enter and leave the AMU has been estimated to be in the order of 15 sec (Frost, 1990). However, Winter (1993) found that the entrance times and exit times were much longer. Prescott (1995) noted that the leaving of the AMU might be postponed as a reaction of the cow to the type of visit and concentrate allotment.

The first milking robots installed in Sweden had been equipped with an electrical cow "reminder" or movement inductor. After the exit gate had opened, the cow had 10 sec to leave the AMU before she received a series of electrical shocks. The Swedish Board of Agriculture disapproved of this method and has banned its use in Sweden. However, there is a problem with cows not leaving the AMU directly after the exit gate has opened and this directly affects the efficiency of the AMS.

Allen *et al.* (1992) found that it was frequently necessary to encourage cows to leave the AMU after milking and Metz-Stefanowska *et al.* (1992) had similar results. Winter (1993) stated that "*Clearly encouraging cows to leave the system will be as important as encouraging re-entry*". This encouraging must use one of the five sense-organs, auditory, visual, olfactory, gustatory and/or cutaneous. The auditory abilities of cattle are well developed, according to Heffner and Heffner (1983) and Albright *et al.* (1966). The visual abilities of dairy cows are limited for colours with shorter wave lengths (blue) (Dabrowska *et al.*, 1981and Hebel *et al.*, 1976 and Soffié *et al.*, 1980). The abilities of cows to taste were for instance studied by Arave *et al.* (1990). The ability to smell (by goats and calves) was tested by Baldwin (1977). The abilities of dairy cows and calves of feeling pain were investigated by Herskin (*et al.*, 2003) and Faulkner and Weary (2000).

Providing a clear discriminative Neutral Stimulus (NS) signalling the onset of a negative reinforcement (Conditioned Reinforcement, CR), should, according to learning theory, minimise the risk of the cows associating the entire AMS with the aversive stimulus (e.g., Domjan and Burkhard, 1986). The objective of this study was to investigate whether a CR with a negative reinforcement could be used to reduce the time required for cows to leave an AMU (exit time) without increasing the entering time.

Materials and Methods

The study was carried out at Bollerup, a commercial farm and agricultural college in Southern Sweden. The experiment started in March 2002 and ended in July 2002. The cows were kept indoors during the entire experiment. No changes were made in the daily management routines.

Animals and Selection of Animals: Two groups of Swedish-Friesian dairy cows were studied, A_0 (primiparous cows) and B_0 (multiparous cows). Assigning the cows into these groups was normal practise on the farm, as decided by the herdsman and not specially arranged for this study. The size of group A_0 varied between 55 and 59 cows and the size of group B_0 varied between 59 and 63 cows. The varying number of cows was also due to normal procedures. Some cows were removed from the groups due to drying off or culling, whereas other cows were added to the groups as soon as they had calved.

In both groups, the cows selected for the study were those that did not leave the AMU directly after a successful milking. Selection criteria were based on data obtained from three consecutive milking visits for cows that were 250 days in lactation or less and who had an average exit time exceeding 10 sec. The number of cows that qualified using these two criteria was 23 in herd A_0 and 36 in herd B_0. The average number of days in lactation at the beginning of the experiment was for group A_0 108 ± 83 and group $B_{0,}$ 112 ± 61.

The cows in group A_0 were further divided *ad* randomly into two subgroups A_1 (11 cows) and A_2 (12 cows); those in group B_0 were also divided *ad* randomly into the two subgroups, B_1 (17 cows) and B_2 (19 cows). There was no difference in exit times between the cows in subgroups A_1 and A_2 or between the cows in subgroups B_1 and B_2.

Housing, Roughage Feeding, Management and Milking: The two dairy cow groups (A_0 and B_0) were housed in the same un-insulated cowshed. A feeding alley separated the two groups from each other. The cubicles in the cowshed were equipped with rubber mats and bedded twice weekly with some fresh straw. There was solid concrete flooring along the cubicles. The floor was cleaned with manure scrapers that operated automatically during the night (between 18:00 h and 06:00 h) every 50 min. During the daytime, the scrapers were turned on manually. Forage was supplied *ad libitum* twice daily, in the morning between 07:00 h and 09:00 h and in the afternoon between 16:00 h and 18:00 h. It was assumed that the variation in feeding time did not affect this study. In both groups, the cows had access to 35 feeding places at the feeding fence and they received the same forage. The cows were milked with Lely Astronaut ® milking robots installed in 1998, one for each group.

Experimental Design:

Description of Treatments:

Treatment 1 –Acoustic Signal : The acoustic signal was identical for all cows and consisted of a "fire alarm" bell. The bell was positioned on the roof of the AMU, about 0.5 meters from the animal's head. The sound of the bell could clearly be heard in the AMU. It could also be heard by cows standing near the AMU. The bell started ringing 10 sec after the exit gate had opened and it stopped ringing 4 sec later. For cows receiving only this treatment, the acoustic signal was a Neutral Stimulus (NS). In Treatments 2 and 3, this signal functioned as a signal for the subsequent negative reinforcement treatment.

Treatment 2 – Moving Flexible Tube: A small flexible plastic tube about 0.3 m long and 0.5 cm in diameter was positioned horizontally along the roof of the AMU when the entrance gate of the AMU was open and positioned vertically when this gate was closed. Thus, the cows could enter the AMU without being disturbed by the tube and they were also prevented from chewing on it. The tube touched the cow on either her right or left side, depending on her position in the AMU. The tube touched the cow the entire time she was in the AMU. The acoustic signal was followed by a negative reinforcement in this treatment when the cow in the AMU needed to be encouraged to leave, by blowing pressurised air through the tube so that it made random movements (Conditioned Reinforcement, CR). The cows could easily avoid the moving tube by exiting the AMU. Treatment 2 was turned on 14 sec after the exit gate of the AMU had opened and turned off 8 sec later.

Treatment 3 – Flexible Tube and Flashing Light: The negative reinforcement here, after the acoustic signal, consisted of two parts, a plastic tube identical to the one described above (Treatment 2 – moving flexible tube) and a light, that when turned on flashed brightly with a frequency of 1 Hz. The light hung from the roof of the AMU above the feeding trough. Here, the CR was variable because the acoustic signal was followed either by the tube making random movements or the light flashing, or by a combination of both the tube and light. A randomiser was used to select one of the three reinforcement options. Treatment 3 was turned on 14 sec after the exit gate of the AMU had opened and turned off 8 sec later.

Experimental Protocol: Data was collected during 3 different periods in 2002. Period 1 started on March 7th, Period 2 started on May 3rd and Period 3 started on May 18th. In Period 1 the selection of cows took place. The length of the respective periods is given below.

Period 1: Reference period and selection of cows

The data from Period 1 was used for selecting cows with the number of days in lactation not exceeding 250 days and with AMU exit times exceeding 10 sec, Fig 1.

Period 2: Study of the effect at introduction of the neutral stimuli (NS) and Conditioned Reinforcement (CR) treatments.

One day before Period 2 started, a signal (Treatment 1) and Conditioned Reinforcement equipment (Treatment 2) were installed in the AMU for the primiparous cows and a signal (Treatment 1) and Conditioned Reinforcement with variable consequences equipment (Treatment 3) were installed in the AMU for multiparous cows. The neutral signal and Conditioned Reinforcement treatments began on day 1 of period 2. Three consecutive milking visits were observed for all the cows in all four subgroups. Cows had to visit the AMU one time when the warning system was actually triggered, i.e., they remained in the AMU for at least 10 sec after the exit gate of the AMU had opened. It was not important what kind of visit it was (milking visit, failed milking visit or unqualified visit).

Period 3: Long-term effect of the Neutral Stimuli and Conditioned Reinforcement

The period started when the treatments had been operational for 18 days. Data from three consecutive milking visits were observed for each animal.

Equipment, Data Collection and Behavioural Observations: Both AMUs were monitored continuously with a videocamera B/W(Elmo

TSR-482) and a Panasonic 6040 time lapse video recorder. Decoding of the videotapes was carried out using The Observer Video-Pro® version 4.1 software (The Observer, 2002. Reference manual version 4.1). A special method was developed in order to be able to identify the cows in the AMU when the videotapes were scored.

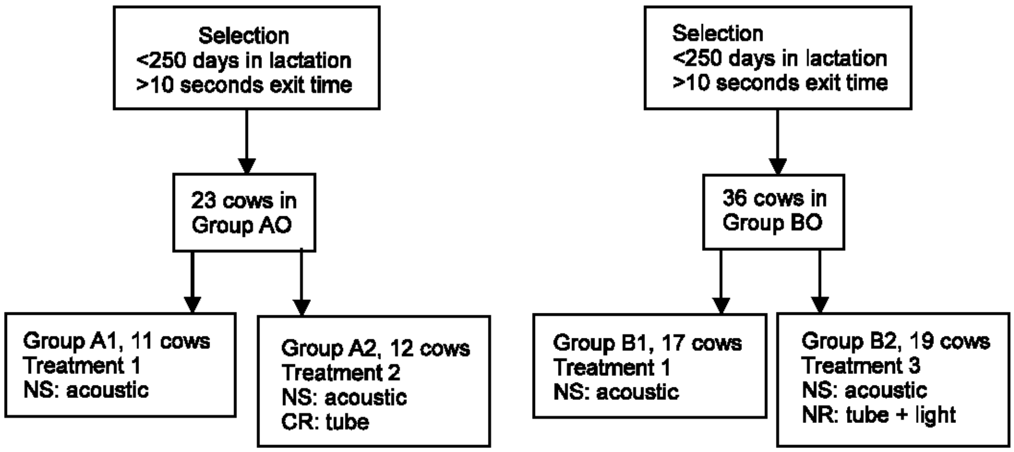

Fig. 1: Selection criteria and group division into A, primiparous cows, and B, multiparous cows

Cows were identified by means of a tag that they carried on their neck collar. As soon as a cow had entered the AMU, the tag was identified and data (date, time and cow number) was saved in the AMS's management system. This data could later be retrieved with the Dfquery software (NEDAP®). After filtering and reorganising in Matlab®, this data was merged into an existing ODF-file (Observer Data File). When a videotape was scored, the number of the cow present in the AMU would appear in the event log of the observation module of The Observer. During the experiment, the time lapse video recorders were synchronised with the AMS's management system.

From the video material, the duration of the following activities were calculated: Entrance time, that is, the time it took a cow to enter an AMU, is defined as the time between the opening and closing of the entrance gate of the AMU behind the cow, when a cow was waiting at the front of the AMU. When a cow came to the AMU directly from the lying area, the entrance time was defined as being the time between when she was in a specific position and the closing of the entrance gate. This position was when her head was in the same place had the entrance gate been closed.

Total exit time, that is, the time it took a cow to leave the AMU. It started as soon as the exit gate of the AMU began to open and stopped when the exit gate started to close.

The total exit time was divided into the following sub-activities:

a) Eating time, the time a cow spent with her head in the feeding trough, while the exit gate was open.
b) Blocking time, the time another cow prevented the cow in the AMU from leaving.
c) Half-way out time, the time a cow was standing "half-way" out of the AMU (exit gate could not be closed).
d) "Just standing" in the AMU (without eating), this includes only standing and other activities taking place during standing, for instance, licking parts of the AMU.

Type of Amu Visit: In the AMU, data was collected for each cow visiting. The data used were: the number of visits each cow made to the AMU and the type of visit (milking visit, failed milking visit and unqualified visit). Data from 3 consecutive days per period were used for data analysis.

Daily Concentrate Allocation: The management system calculates for each cow an appropriate daily concentrate ration corresponding to her milk yield, that is, her lactation status. The concentrates are only given in the AMU. The amount of concentrate per visit is not constant, since the management system takes into consideration the milking interval, the expected milk yield and the lactation status. However, some cows do not eat all the concentrate given to them. This residue is left for the next cow entering the AMU. It was not technically feasible to determine the amount of concentrate residues. An attempt was made to film the AMU feeding trough in order to evaluate if concentrate was left behind or not. This was not possible without making substantial structural changes in the AMU, such as, removing the roof, installing additional light and cleaning the feed trough regularly. Therefore, it was decided not to include the desired concentrate portion or the actual amount of concentrate per milking (because it would not be exact) nor residues (because it was not possible to determine them) in the statistical analyses.

Statistical Analyses: The averages observed for entrance time and total exit time, consisting of eating (concentrate) time, blocking time, time half-way-out time for other activities in standing position, were determined for each cow. The data from each cow were used in the comparison between subgroups and between periods. This was done using the Wilcoxon two-sample test and the Wilcoxon signed rank test, respectively. The same procedures were used to compare visiting types between subgroups and between periods. The ranking analysis was used since the data was not normally distributed. The statistical analyses were performed with the Statistical Analysis System (SAS) software (Sas Institute Inc., 1994).

Results and Discussion

Milking Visits for Subgroups A_1 and A_2: No statistical differences between subgroups or periods could be found using ($P<\alpha/n$) with $\alpha=0.05$ and n=9 (number of statistical tests performed), (Table 1 and 2).

Daily Concentrate Allocation: There were no significant differences in the assigned concentrate rations between subgroups (A_1 compared with A_2 and B_1 compared with B_2) or between periods. However, the concentrate ration tended to decrease from the start of the experiment to the end. This was due to the management system adjusting the individual cow ration according to the advancing lactation status, i.e., decreasing milk yield over time.

Total Exit Times for Subgroups A_1 and A_2: For the Primiparous cows during Period 1 (reference period) there was no statistical differences in total exit time between A_1 and A_2, (Table 3). After the installation of the signal and the

Table 1: Type of visit (mean±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup A_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup A_2 (Treatment 2, CR: acoustic signal and moving flexible tube).

	Period								
	1			2			3		
	Reference period			Introduction effect			Long term effect		
Subgroup	Milking	Failed	Unqualified	Milking	Failed	Unqualified	Milking	Failed	Unqualified
A_1	2.1±0.2	0.3±0.1	0.6±0.3	2.2±0.2	0.5±0.3	0.5±0.2	2.2±0.2	0.6±0.4	0.7±0.3
A_2	1.9±0.2	0.3±0.2	0.3±0.1	1.9±0.2	0.5±0.2	1.0±0.2	1.8±0.1	0.5±0.2	0.6±0.2

Table 2: Type of visit (mean±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup B_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup B_2 (Treatment 3, CR: acoustic signal and (ad randomly) either moving flexible tube, flashing lamp or a combination of tube and light)

	Period 1			Period 2			Period 3		
	Reference period			Introduction effect			Long term effect		
Subgroup	Milking	Failed	Unqualified	Milking	Failed	Unqualified	Milking	Failed	Unqualified
B_1	1.9±0.2	0.1±0.1	0.3±0.1	1.7±0.1	0.3±0.2	0.9±0.3	1.7±0.1	0.2±0.1	0.3±0.1
B_2	1.9±0.1	0.0±0.0	0.1±0.1	1.9±0.1	0.1±0.1	0.8±0.1	1.9±0.1	0.1±0.1	0.5±0.5

Table 3: Total exit times in sec (mean±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup A_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup A_2 (Treatment 2, CR: acoustic signal and moving flexible tube).

	Period 1		Period 2		Period 3	
Subgroup	Reference period		Introduction effect		Long term effect	
A_1	109^{ax}	±20	12^{bx}	±1	16^{bx}	±6
A_2	125^{ax}	±37	32^{bx}	±13	16^{bx}	±5

Means in the same row without a common superscript (^{ab}) differ significantly ($P<\alpha/n$) with $\alpha=0.05$ and n=9 (No. statistical tests performed) Means in the same column without a common superscript (^{x}) differ significantly ($P<\alpha/n$) with $\alpha=0.05$ and n = 9 (No. statistical tests performed)

Table 4: Total exit times in sec (mean±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup B_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup B_2 (Treatment 3, CR: acoustic signal and (ad randomly) either moving flexible tube, flashing lamp or a combination of tube and light)

	Period 1		Period 2		Period 3	
Subgroup	Reference period		Introduction effect		Long term effect	
B_1	178^{ax}	±27	63^{bx}	±17	185^{abx}	±56
B_2	193^{ax}	±38	25^{by}	±8	48^{bx}	±12

Means in the same row without a common superscript (^{ab}) differ significantly ($P<\alpha/n$) with $\alpha=0.05$ and n=9 (No. statistical tests performed) Means in the same column without a common superscript (^{xy}) differ significantly ($P<\alpha/n$) with $\alpha=0.05$ and n = 9 (No. statistical tests performed)

conditioning stimuli at the start of Period 2, the exit times decreased significantly for the cows in both subgroups with 109 sec to 12 sec for A_1, (SEQARABIC) and 125 to 32 sec for A_2, (Table 3).

Seqarabic: There was no statistical difference for the total exit time for either subgroup between Period 2 and 3. The NS/acoustic signal itself led to the the same reduction in exit time as did the CR/acoustic signal plus reminder in the form of the moving flexible tube (Treatment 2).

Total Exit Times for Subgroup B_1 and B_2: The multiparous cows in B_1 and B_2 did not show statistical differences in exit times during Period 1, (Table 4). The total exit time was 178 sec for the cows in B_1 and 193 sec for those in B_2, (Table 4). After installation of the reminder at the start of Period 2, the exit times decreased from 178 sec to 63 sec for B_1 and from 193 sec to 25 sec for B_2 (Table 4). For both subgroups, this reduction in total exit time was significant. During Period 3, the cows in B_1 (acoustic warning) returned to the same exit time as noted previously in Period 1.
The cows in B_2 had a shorter total exit time during Period 2 than those in B_1 did, which was significantly different. There were no statistical differences in the total exit time between the subgroups during Period 3.

Exit Times Divided in Sub-activities for Cow Subgroups A_1 and A_2: The total exit time has been divided into the sub-activities eating time, blocking time, "half way out" time and the activity "just standing", (Table 5 and 6). For cows in subgroups A_1 and A_2, no statistical significant differences could be found either between periods or between subgroups. However, the cows in A_1 showed a tendency to decrease their eating time from 65 sec during Period 1 to 2 sec during Period 2 (P=0.02), cows in A_2 showed the same tendency, with 45 sec during Period 1 and 8 sec during Period 2 (P=0.06), (Table 5)Table 5). The cows in A_2 experienced longer blocking times during Period 1 (46 sec) than during Periods 2 (2 sec), P=0.06 and 3 (0 sec), P=0.03, (Table 5). The cows in A_1 showed a tendency to decrease the activity "just standing" during Period 2 (8 sec) and Period 3 (9 sec), respectively, as compared to Period 1 (17 sec), P=0.01 and P=0.02 between Periods1and 2 and Periods 1 and 3, respectively, (Table 5). Cows in A_2 showed a similar trend between Periods 1 (25 sec) and 3 (8 sec), P=0.01, (REF Table 5).

Exit Times Divided in Sub-activities for Cow Subgroups B_1 and B_2: The total exit time has been divided into the sub-activities eating time, blocking time, "half way out" time and the activity "just standing", for cows in B_1 and B_2, (SEQARABIC). The sub-activity eating decreased significantly for both subgroups between Periods 1 and 2 and this effect remained during Period 3, (Table 6). Cows in B_1 and B_2 were less prone to blocking during Period 2 and 3 then during Period 1, (Table 6). Cows in B_2 showed a tendency to spend less time standing halfway out during Period 2 (6 sec) than during Period 1 (27 sec), P=0.08, Table 6. Cows in B_1 showed a tendency to spend a much longer time half way out of the AMU during Period 3 (132 sec) than during Period 1 (38 sec), P=0.07. The sub-activity "just standing" decreased significantly between Periods 1 and 2 from 34 sec during Period 1 to 19 sec during Period 2 for the cows in B_1 and tended to decrease between Periods 1 and 3, 34 and 23 sec , respectively, P=0.01. Cows in B_2 showed a tendency to decrease their "just standing" time between Periods 1 (30 sec) and 2 (13 sec), P=0.02; this tendency remained during Period 3 (15 sec), as compared to Period 1, P=0.04.

Entrance Time for Cows in Subgroup A_1, A_2, B_1 and B_2: The effect of the conditioned stimuli on the time required for cows to enter the AMU was also studied. The results showed that the entrance time, (Table 7 and 8) did not change significantly, except for the cows in B_2, this subgroup was 2 sec faster entering the AMU during Period 3 (14 sec) than during Period 1 and 2 (12 sec), P=0.005.
The results of this investigation showed that the total exit times from an AMU can be drastically decreased by using Conditioned Reinforcement (CR), without jeopardizing an increase in the AMU entrance time. It was observed that without the negative reinforcement, the exit times for cows with a delayed exit, were between 109 and 125 sec for 1st parity cows and between 178 and 193 sec for cows in their second lactation or higher. This was comparable to the findings of Mottram *et al.* (1994), who found that more than 50 % of the cows milked in an AMS lingered on average 198 sec in the AMU after a completed milking event. They concluded that the throughput of the milking system could better be improved by reducing the time cows lingered in the AMU than by increasing the speed of teat cup attachment. In another study, Mottram *et al.* (1995) found that in 9 % of the milking visits, the cows remained in the AMU for more then 5 min after a completed milking event. It was noted by Metz-Stefanowska *et al.* (1992) that 38 % of the cows stayed in the AMU after milking and had to be pushed out. They could find no significant relationship between lingering in the AMU and the number of voluntary milking visits or between lingering and the concentrate ration.
For the cows I n subgroups A_1 and A_2, the exit time decreased by afactor between 4 and 9. The effect obtained during

Table 6: Time required in sec (mean±SE) for eating, blocking, half-way out and "just standing" during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup B_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup B_2 (Treatment 3, CR: acoustic signal and (ad randomly) either moving flexible tube, flashing lamp or a combination of tube and light).

Activity	Subgroup	Period 1 Reference period		Period 2 Introduction effect		Period 3 Long term effect	
Eating	B_1	$60^{a\,x}$	±16	$3^{b\,x}$	±2	$12^{b\,x}$	±8
	B_2	$81^{a\,x}$	±22	$6^{b\,x}$	±4	$11^{b\,x}$	±5
Blocking	B_1	$45^{a\,x}$	±19	$17^{b\,x}$	±16	$18^{b\,x}$	±14
	B_2	$54^{a\,x}$	±37	$1^{b\,x}$	±1	$1^{b\,x}$	±1
Half-way out	B_1	$38^{a\,x}$	±16	$24^{a\,x}$	±8	$132^{a\,x}$	±56
	B_2	$27^{a\,x}$	±14	$6^{a\,x}$	±3	$21^{a\,x}$	±12
"just standing"	B_1	$34^{a\,x}$	±5	$19^{b\,x}$	±4	$23^{ab\,x}$	±5
	B_2	$30^{a\,x}$	±7	$13^{a\,x}$	±2	$15^{a\,x}$	±3

Means in the same row without a common superscript (^{a}) differ significantly ($P<\alpha/n$) with α=0.05 and n=9
(No. statistical tests performed)
Means in the same column (within an activity) without a common superscript (^{x}) differ significantly ($P<\alpha/n$) with α=0.05 and n =9 (No. statistical tests performed)

Table 7: Entrance time in sec (mean±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup A_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup A_2 (Treatment 2, CR: acoustic signal and moving flexible tube)

	Period 1		Period 2		Period 3	
Subgroup	Reference period		Introduction effect		Long term effect	
A_1	$8^{a\,x}$	±1	$10^{a\,x}$	±2	$6^{a\,x}$	±1
A_2	$12^{a\,x}$	±3	$16^{a\,x}$	±3	$15^{a\,x}$	±6

Means in the same row without a common superscript (^{a}) differ significantly ($P<\alpha/n$) with α=0.05 and n=9
(No. statistical tests performed)
Means in the same column without a common superscript (^{x}) differ significantly ($P<\alpha/n$) with α=0.05 and n = 9
(No. statistical tests performed)

(No. statistical tests performed) the Period 2 (Introduction period) did not diminish during Period 3, that is, the negative reinforcement had a long term effect. For these two subgroups no difference between Treatment 1 (NS: only acoustic signal) and Treatment 2 (CR: acoustic signal + moving tube) could be detected. This means that the acoustic signal, which was meant to be a Neutral Stimulus (NS), seemed to have an effect after all. The cows in subgroup B_1 (NS: only acoustic signal) had an exit time during Period 3 similar to the one they had in Period 1. This meant that the effect of the acoustic signal had disappeared. Thus, in order to obtain a long term effect, it appeared that

Table 8: Entrance time in sec (mean ±SE) during Period 1 (Reference period), Period 2 (Introduction effect) and Period 3 (Long term effect) for cows in subgroup B_1 (Treatment 1, NS: acoustic signal) and for cows in subgroup B_2 (Treatment 3, CR: acoustic signal and (ad randomly) either moving flexible tube, flashing lamp or a combination of tube and light).

	Period 1		Period 2		Period 3	
Subgroup	Reference period		Introduction effect		Long term effect	
B_1	$8^{a\,x}$	±1	$8^{a\,x}$	±1	$12^{a\,x}$	±3
B_2	$14^{a\,x}$	±7	$12^{ab\,x}$	±2	$12^{b\,x}$	±2

Means in the same row without a common superscript (^{ab}) differ significantly ($P<\alpha/n$) with α=0.05 and n=9
(No. statistical tests performed)
Means in the same column without a common superscript (^{x}) differ significantly ($P<\alpha/n$) with α=0.05 and n = 9

the signal had to be coupled with a negative reinforcement, since the cows seemed to habituate to only an acoustic signal. The cows in B_2, (CR: acoustic signal + random reinforcement), did not show a habituation effect. This meant that the effect of the conditioned stimuli was still present during period 3.
The stress responses during milking in a conventional and an automatic milking system in dairy cows have been compared by Hopster *et al.* (2002). In their study, the AMS was provided with an electrical movement inductor to remind cows to leave the AMU after they had finished milking. It was concluded that automatic milking and conventional milking are equally acceptable, if only considering the welfare of the dairy cows during milking (Hopster *et al.*, 2002). Oostra and Sällvik (2000) investigated exit times for dairy cows milked in an AMS equipped with an identical electrical movement inductor. Their results showed that 90-95 % of the cows left the AMU before the first electrical induction was given. Another possible method of improving cow flow trough the AMU is to offer the cows a reward outside the AMU. This can be in the form of concentrate or forage. It has been shown that feeding concentrate in the exit area led the cows to exit the AMU more rapidly than when they were not fed in the exit area, regardless of whether or not the animals had been fed in the AMU (Prescott, 1995). Another study showed that cows increase their exit time when they are fed concentrate in the AMU and fed forage in the exit area (Winter, 1993). A backside to this "luring method" was that the cows paid fewer visits to the concentrate feeder and more feed was left (Ketelaar-de Lauwere, 1999).
Using concentrate to motivate cows to move towards a specific part of the system appears to be possible (Ketelaar-de Lauwere *et al.*, 1999 and Prescott, 1995), but to make them leave a specific part may be more difficult (Winter, 1993). A potential risk with providing concentrate directly after the AMU is that instead cows may linger around the concentrate dispenser and thus increase the risk that they block the exit possibilities of the cow in the AMU. Negative reinforcement might from that point of view have a better effect, since cows leave the AMU more rapidly without "traffic congestions" developing in the close vicinity of the exit area.
The aversive stimuli used to move the animals should not be so strong so that the cows will hesitate to return to or enter the AMU. Lamb (1976) noted that if cows have an undesirable experience in a certain area, they are unwilling to return to that area in the future. This was not the case in the present study. No negative effect on entrance time or on AMU utilization could be detected with the aversive stimuli used here. This investigation was carried out on a commercial farm. This meant that the cows were not studied under fully controlled and consistent circumstances. Although the day-to-day routines were kept as constant as possible, it could not be prevented that cows were added to the groups studied and some were removed. The possibility cannot entirely be disregard that this might have had an effect on the results. Especially activities such as blocking and standing half-way out of the AMS may have been influenced when new cows were introduced into the group or when other cows were removed.
This study showed that the exit time could be reduced by 100-150 sec when an effective warning and reminder system was installed. If 20 cows in an AMS-herd could be stimulated to leave the AMU 100-150 sec faster for each milking visit, this would increase the available time for additional milking visits by 100-150 min per day. With an average AMS-occupation time of 10 min, this would mean that 10-15 extra milkings per day could be performed.

Conclusions

From this study it was concluded that: It can take on average up to 3 min for a cow to leave the AMU after milking in an AMS. The time needed to leave the AMU could be reduced substantially by installing Conditioned Stimuli with a light negative reinforcement. The negative reinforcement used in the present study did not appear to affect the cows negatively since the time needed for the animals to enter AMU was not changed. There would be time for 10-15 more milkings per day if a conditioned stimuli system was installed.

Acknowledgements

The authors would like to acknowledge Thomas Permerup, Lely Sverige AB for his kind help with the installation of the cow reminder system. The Bollerup Estate is thanked for allowing us to carry out this test on their farm, using their facilities and animals. We would like to express our gratitude to Uno Eliasson, Peter Andersson and Annika Sällvik for helping with changing the videotapes. We also would like to thank Lely Sverige AB and Lely Nederland for providing the necessary equipment, software and financial resources. We would further like to thank the Swedish Farmers' Foundation for Agricultural Research and the South of Sweden Agricultural Research Programme for financial support.

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