Practical application of a call feeding station in gestating sows considering agonistic interactions, lesions and learning abilities in group housed sows

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„Die religiöse Ehrfurcht vor dem, was unter uns ist, umfasst natürlich auch die Tierwelt und legt den Menschen die Pflicht auf, die unter ihm stehenden Geschöpfe zu ehren und zu schonen."

Johann Wolfgang von Goethe

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1 Summary

Since 2013, the European Commission has required pregnant sows to be kept in groups. The main problem encountered with group-housed sows is agonistic interactions. This problem even becomes greater if sows are individually fed with electronic feeding systems because sows often compete for access to the station. On the other hand, the advantage of electronic feeding systems is that they enable control over individual feed intake and facilitate the management of group-housed sows. An additional problem in modern housing systems is the few cognitive stimuli. The aim of this thesis was to test whether sows are able to learn in adequate time a trisyllabic name and keep it throughout the whole production cycle. Furthermore was to test whether these problems of agonistic interactions can be reduced by a call feeding station that only allows access to feed after sows had been individually called. The first step (section four) investigated if sows were able to learn an individual cue and verified whether a call feeding station can also be applied to larger groups of sows. In the second step (section five), it was tested whether the call feeding station would reduce agonistic interactions among the sows.

Before the call feeding software was installed, a control phase with a common electronic feeding station was implemented for 30 weeks. The learning procedure was conducted in a small waiting pen. Here, each sow was trained to associate an acoustic signal with a food reward delivered to the feeding station. During the first five days, the sows had free access to the station (classical conditioning). Afterwards, the feeding station was switched to an operant conditioning mode, which continued for 14 days.

In this phase, the sows were allowed to enter the feeder only after their individual acoustic signal was played. Throughout the entire learning phase, the sows were fed twice a day at the feeding station. After a total of 19 days, the sows were moved into a larger waiting area where they were introduced into a group with three more subgroups for 80 days. At this point, the sows only received food after being called by the feeding station in a random order, either once or twice a day according to the experimental treatment.

In section four, we used a total of 62 sows and collected data based on the recordings of the software that controlled the electronic feeding station for each sow. For each day, the proportion of correct responses per sow and day was calculated for both the learning pen and the waiting area. For the analysis, the sows were divided into two different learner groups depending on their experience with the electronic sow feeder: the sows that already knew the electronic feeding station and had to re-learn that they were allowed to enter the feeding station only after they were called (RLS) and the sows that were naive to the electronic feeding station (NLS).

During the first learning trial, the NLS sows (62.75%; Q_1=50.0%; Q_3=100.0%) demonstrated better learning performance compared with the RLS sows (47.5%; Q_1=40.0%; Q_3=58.5%) (N_1=14, N_2=14; Z=-2.4289; p=0.0151). The sows that repeatedly stayed in the learning area had significantly better learning performance than the sows that learned the task for the first time.

However, their learning performance was already sufficiently high during the first learning trial. After six weeks of farrowing and insemination, all of the sows remembered the learning task with partly almost100% correct responses.

In section five, the effects of the call feeding station on the agonistic behaviors of sows in the waiting area are described. With a total of 85 sows, four different feeding modes were tested: feeding once a day with the electronic feeding station and no additional straw as litter (NF1-), feeding once a day with the call feeding station and no additional straw as litter (CF1-), and feeding twice a day with no additional straw as litter (CF2-) or with additional straw in the activity area (CF2+). Agonistic behavior (pushing, fighting, biting, hunting and treating) in front of the feeding station was recorded via video two days before a new subgroup was integrated and lasted for four days. During the observation periods, the sows were scored for wounds and lesions on the body every three weeks as well as two days before and two days after a new subgroup was integrated into the waiting area.

The proportion of agonistic interactions was higher in NF1- compared with CF1- in the morning (06:00 h to 11:00 h) ($p<0.0001$), and in CF1-, a reduced level of agonistic interactions could be observed throughout day. The feeding frequency and the additional presence of straw in the activity area did not affect the proportion of agonistic interactions. Less lesions and wounds were found at the head and the flank because of the call feeding station.

These results led to the conclusion that the sows learned their name, and they remembered their individual acoustic signal even after six weeks of farrowing and insemination.

They were able to generalize the signal in different surroundings, i.e., the learning pen and the waiting area. Furthermore, the results showed that a call feeding station enabled the sows to predict their feeding time, which resulted in a reduction of agnostic interactions. This study contributes to a better understanding of the cognitive abilities of sows and shows possibilities for improving the welfare of sows in farming by reducing agonistic interactions and by integrating a cognitive enrichment component into their daily feeding routine.

2 Zusammenfassung

Seit 2013 ist es durch die Europäische Kommission gesetzlich festgeschrieben, dass Sauen in der Phase der Trächtigkeit in Gruppen gehalten werden müssen. Eines der größten Probleme in der Gruppenhaltung von Sauen sind die agonistischen Interaktionen untereinander, vor allem bei elektronischen Abrufstationen. Hinzu kommt, dass Sauen in diesem Haltungsabschnitt nur mit wenigen kognitiven Reizen konfrontiert werden. Sie werden über elektronische Abrufstationen gefüttert, die den individuellen Futterverbrauch kontrollieren und ein vereinfachtes Management der Herde ermöglichen. Im ersten Schritt dieser Arbeit wurde untersucht, ob Sauen einen individuellen Ton lernen und diesen auch durch die unterschiedlichen Produktionsabschnitte behalten können (Kapitel 4). Des Weiteren wurde untersucht, ob es möglich ist eine Aufrufstation in eine größere Gruppe von Sauen zu integrieren. Darüber hinaus wurde untersucht, ob die agonistischen Interaktionen innerhalb der dynamischen Sauengruppe gesenkt werden konnten (Kapitel 5).

Bevor die Software für die Aufrufstation installiert werden konnte, wurden während eines ganzen Produktionszyklus lang Daten unter den Bedingungen einer Abrufstation aufgezeichnet. Diese dienten als Kontrolle (30 Wochen). Das Lernen wurde in einem kleinen Wartebereich separat durchgeführt. Jede Sau erhielt ein individuelles akustisches Signal (einen dreisilbigen „Namen“). Mittels klassischer Konditionierung wurden die Sauen trainiert, den Namen mit einer Belohnung, die in diesem Fall von der Futterstation ausdosiert wurde, zu assoziieren. Sie hatten hierfür freien Zugang zu der Station. Nach fünf Tagen wechselten die Sauen in eine zweite Lernphase, der operanten Konditionierung.

Diese dauerte 14 Tage und die Sauen hatten nur noch Zugang zur Station, wenn sie vorher anhand ihres Namens zur Station gerufen wurden. Nach insgesamt 19 Tagen und einer Trächtigkeitskontrolle wurden die Tiere in den Wartebereich zu drei weiteren Untergruppen umgestallt. Jede Untergruppe umfasste 6 bis 10 Tiere. Auch hier bekamen die Tiere nur noch Futter, wenn sie vorher gerufen wurden. Die Fütterung wurde ein- oder auch zweimal täglich durchgeführt. Dies war abhängig von den Versuchsbedingungen.

In Kapitel 4 waren 62 Sauen in den Versuch integriert. Die erhobenen Daten basierten auf den Aufzeichnungen der Aufrufsoftware. Gespeichert wurden für jeden Tag und jede Sau die insgesamt getätigten Aufrufe und die erfolgreichen Aufrufe. Daraus ließ sich der Prozentsatz der korrekt wahrgenommen Aufrufe pro Tag berechnen. Dies wurde jeweils für die Lernphase und für den Wartebereich berechnet. Die Sauen wurden je nach Erfahrung an der Abrufstation in Lerngruppen eingeteilt: Sauen, die umlernen mussten (RLS), da sie vor dem Versuch schon die Abrufstation kannten, und Sauen, die sowohl gegenüber der Abruf- als auch der Aufrufstation naiv waren (NLS). In der ersten Lerneinheit zeigten die NLS eine bessere Leistung (62.75%; Q_1=50.0%; Q_3=100.0%) im Vergleich zu den Sauen, die umlernen mussten (47.5%; Q_1=40.0%; Q_3= 58.5%) (N_1=14, N_2=14; Z=-2.4289; p=0.0151). Sauen, die zum zweiten Mal oder öfter in den Lernbereich kamen, zeigten signifikant bessere Lernleistungen gegenüber Sauen, die das erste Mal gelernt hatten. Darüber hinaus konnten wir feststellen, dass die Sauen sich an ihren Namen erinnern konnten, auch wenn sie ihn sechs Wochen lang nicht gehört hatten.

In Kapitel 5 wurden vier unterschiedliche Versuchsbehandlungen mit insgesamt 85 Sauen getestet. Als Kontrolle dienten hier die Daten der Abrufstation bei einmaliger Fütterung (NF1-). Für die Aufrufstation gab es drei Varianten:

Aufrufmodus mit einmaliger Fütterung (CF1-), Aufrufmodus mit zweimaliger Fütterung (CF2-) und den Aufrufmodus mit zweimaliger Fütterung und zusätzlichem Stroh im Aktivitätsbereich der Tiere (CF2+). In allen Varianten wurden Verhaltensbeobachtungen innerhalb eines Areals vor der Futterstation durchgeführt (drängeln, kämpfen, beißen, jagen und drohen). Die Videoaufzeichnungen erstreckten sich über einen Zeitraum zwei Tage vor bis zwei Tage nachdem eine neue Untergruppe eingestallt wurde. In einem Abstand von drei Wochen wurden die Sauen auf Wunden und Läsionen untersucht, jeweils zwei Tage bevor und zwei Tage nachdem einen Untergruppe eingestallt wurde.

Der Anteil an agonistischen Interaktionen war deutlich geringer in CF1- als in NF1- (06:00 h bis 11:00 h) ($p>0.0001$) und in CF1- waren die agonistischen Interaktionen während des gesamten Tages insgesamt auf einem sehr niedrigen Niveau. Die Fütterungshäufigkeit und das zusätzliche Stroh im Aktivitätsbereich hatten keinen signifikanten Einfluss auf die agonistischen Interaktionen. Unter den Bedingungen der Aufrufstation wurden weniger Läsionen und Wunden im Bereich des Kopfes und der Flanke verzeichnet.

Aufgrund der vorliegenden Ergebnisse kann mit Gewissheit gesagt werden, dass Sauen in der Lage sind, einen dreisilbigen Namen zu lernen und sich nach sechs Wochen noch an diesen zu erinnern.

Die Sauen konnten weiterhin den Ton in verschiedenen Umgebungen generalisieren. In diesem Fall waren das zwei verschiedene Stallgebäude. Außerdem haben die Sauen gelernt, dass das Warten und das Blockieren vor der Station zu keinem Erfolg mehr führt. Diese Studie trägt zu einem besseren Verständnis der kognitiven Fähigkeiten von Schweinen bei und zeigt Möglichkeiten auf, das Tierwohl zu verbessern, indem agonistische Interaktionen reduziert und eine kognitive angereicherte Haltungsumwelt in die tägliche Fütterungsroutine integriert werden können.

3 General Introduction

Animal welfare is becoming increasingly important to the larger public and individual consumers during recent years and is currently impacting farming considerably. Agricultural livestock is no longer considered only a means of food production; it also becomes an ethical issue. Additionally, consumer protection and the welfare of farm animals are closely connected with the quality and safety of healthy food (European Union, 2007). EU policies are addressing these public concerns with guidelines and regulations for improved animal husbandry systems, such as pig husbandry regulations. Indeed, animal welfare is not only important for the public but also a central issue for farmers. Animal welfare is now, more than ever, a necessary concern for farmers.

Only appropriately kept animals will be able to achieve the required efficient performance level. Sustained use and profit-earning capacity both depend on the welfare of animals. Moreover, animal welfare is not only good economics but also, and equally important, acknowledges responsibility for living creatures.

In 2013, it became obligatory to keep sows in groups to engage in social behavior at least four weeks after insemination and until one week before parturition (European Commission, 2001; EU Directive 2001/88/EC). Common housing systems for pregnant sows in conventional agriculture are self-closing crates with small static groups or split-yard systems with larger static or dynamic groups (Denhartog et al., 1993; Broom et al., 1995; Durrell et al., 2002).

All systems have advantages and disadvantages and which housing conditions are chosen depends on several factors such as on the size of the reproduction herd, the preferred feeding system and the personal wishes of the farmer (Denhartog et al., 1993).

In the following section, the foraging behavior of sows will be specified, and the problems with electronic feeding systems with group-housed sows will be discussed.

3.1 Natural social behavior of sows in foraging in modern husbandry systems

Pigs are social animals and in nature live in family groups of up to 30 animals (Meyer and Jahn, 2006). Independent of the housing system, a social order within a group of sows exists (Jensen, 1982; Jensen and Wood-Gush, 1984; Remience et al., 2008). Agonistic behavior is always present and is important to build or maintain the social organization of the sows (Puppe et al., 2008). This can also be observed in semi natural environments (Stolba and Wood-Gush, 1989) and in free-ranging sows (Jensen and Wood-Gush, 1984). Puppe et al. (2008) showed that differences in important sociometric measures depended on age and production state. The aggression level decreased with less intensive housing systems, with the possibility of avoiding aggressive situations (Jensen and Wood-Gush, 1984). Adequate space, sufficient feeding places, structural elements and rooting material also reduce agonistic behaviors.

There are several studies on the natural behavior of pigs (Stolba and Wood-Gush, 1989; Wood-Gush et al., 1990; Andersen et al., 2004; Puppe et al., 2008). These authors found that pigs were exploratory animals that spent an appreciable proportion of their time moving between different areas.

In a semi natural environment, Stolba et al. (1989) observed many behaviors related to foraging, such as collecting, carrying, rooting and manipulating food items. This study also found that sows spend more than 50% of their time foraging (21% rooting, 31% grazing), mostly synchronized, with other group members. In a study by Tober (1996), sows spent under free ranging conditions, their active time (82%) engaging in exploratory and foraging behavior. Conventional housing with a mainly barren environment did not allow this species-specific foraging behavior, which can result in an increase in negative social interactions (e.g., agonistic interactions, nosing pen-mates) (Beattie et al., 1996) and can lead to apathy (Arey, 1993) and chronic stress (De Jong et al., 2000).

Currently, sow herds are much larger than they have been in the past. Management problems, which may occur in larger groups, included monitoring the feed intake, health and reproduction of the individual sow (Bressers et al., 1993). The main feeding system in dynamic or larger static groups is the electronic sow feeding system (ESF). The group sizes fed with an ESF depends purely on producer advice, the farmers experience and the size of the reproductive herd. Most producers suggested a range of 50 to 80 sows per feeder (PigTek Europe, 2013; Schauer Agrotronic GmbH, 2013).

The most common type of ESF has an entrance door, which protects the sow from being displaced by others and is designed as a one-way system. All of the animals are equipped with an RFID (Radio Frequency Identification) ear tag transponder. The ESF offers major advantages as a management tool. Depending on the day of gestation, age and weight, a precise feeding ration with different feed compounds can be offered to each animal. Additionally, it is easy to select animals out of the group. The data on the sows can be controlled via computer software, which, in most cases, is compatible with a sow planner and, additionally, a heat detector can be implemented. An ESF can be easily implemented in older stable buildings at relatively low costs (Pik Tek Europe GmbH, 2013).

3.2 Problems with electronic sow feeding systems

The main problems with dynamic groups and ESF are agonistic interactions when introducing new groups to an existing group or when sows are displaced from the area in front of the feeding station during feeding cycles (Jensen et al., 2000; Bates et al., 2003; Anil et al., 2006; Hoy et al., 2007). Dynamic groups are often used for medium-sized or smaller production herds. A dynamic group describes a group of gestating sows in which subgroups with different gestating periods are housed in one pen. Working with production rhythms in piglet production has been the standard for a long time; it combines the economics of labor and barn construction and can also improve animal health. An appropriate rate of production must ensure that marketable piglet lots are produced and that the particularly expensive farrowing places are well used.

With longer production intervals (with fewer groups needed), larger groups are required. Also this thesis was conducted with a dynamic herd of sows consisting of seven subgroups organized in three-week rhythms. Every three weeks, one subgroup (1) was stalled-out for farrowing, one subgroup (2) was simultaneously farrowed, and one subgroup (3) was stalled-out at the insemination center. In addition, one subgroup (4) was stalled-out in the hold area with three other subgroups already present (5, 6, and 7). In a system with static groups, a subgroup passed the hold area and was not stalled-up with the other groups.

In a study comparing an electronic feeding system with a simultaneous feeding system, Chapinal et al. (2010) found more aggressive interactions in the electronic feeding system than in a simultaneous feeding system with trickle feeding (feeding place ratio 1:1). The aggressive interactions occurred mainly around the feeder when the sows were competing to enter the feeder. In this cited study, however, the sows were not protected from being displaced by other sows during feeding time (Chapinal et al., 2010). The importance of animal protection when implementing an electronic feeding system should not be underestimated. Krause et al. (1997) found more hindquarter injuries in ESF than with synchronized feeding. Simultaneous feeding can avoid or lessen injuries. Remience et al. (2008) concluded that space allowance was an issue for sows kept in groups when fed by ESF. Nevertheless, the benefits of feeding with ESF overcome the negative aspects. Group housing with ESF improves the individual space per animal and thus offers more space for movement (Anil et al., 2006), which is necessary to avoid agonistic behavior (Jensen, 1982).

However, it is still necessary to optimize an electronic sow feeding system to minimize aggression, to prevent sows from being displaced by others and, consequently, to reduce agonistic interactions in front of the feeding station.

3.3 Electronic feeding systems as cognitive enrichment for gestating sows

One field of research on farm animal welfare focuses on the role of the animal's cognitive abilities in their perception of and interaction with their environment. Until now, several studies have focused on the cognitive abilities of farm animals in their discussions on learning and animal welfare (Held et al., 2002; Ernst et al., 2005; Baymann et al., 2007; Broom et al., 2009; Langbein et al., 2009; Broom, 2010). Currently, studies on animal learning are very common. For example, Wredle et al. (2006) trained cows to approach a milking unit in response to acoustic signals, and Langbein et al (2004) trained dwarf goats with a computer-based learning device using drinking water as a reward. Ernst et al. (2005) trained pigs to learn an individual signal and discriminate it from others. What could be the benefits of learning in farm animals? Gestation sows, for example, could benefit much from learning. Despite being housed in groups and with partial access to straw, they did have less positive sensory-motoric stimulation. This can lead to a substantial mental underload for these cognitively powerful animals and can also hinder their sensory-cognitive performance.
Barren environment may even lead sows to abort (worst case) or may lead to a lack of maternal care during the lactation period and fewer weaned piglets (Andersen et al., 2005; Karlen et al., 2007).

The common practice of enriching the environment of pigs is often simple: chains, pieces of wood or smidgens of straw are added to the sow's environment. However, these enrichment tools are often only temporarily attractive. After a few days or even only hours, the sow's interest decreases (Tarou and Bashaw, 2007).

It has already been shown that pigs can learn a signal and discriminate it from others (Ernst et al., 2005; Manteuffel et al., 2010). Subsequently, pigs showed improved wound healing (Ernst et al., 2006). Furthermore, pigs that were fed with a call feeding station were less fearful than pigs without such enrichment (Puppe et al., 2007). A reasonable enrichment tool that benefits the cognitive abilities must not only arouse but also retain the attention and motivation of farm animals (Manteuffel et al., 2009a). Manteuffel et al. (2009a) stated that a useful environmental enrichment "should present objects or situations that act successfully and with a foreseeable rewarding outcome". In addition, cognitive enrichment should define "as the ability to induce a perceptual process for operant learning out of different cues". This may also result in better stable environmental control (Manteuffel et al., 2009a). Bassett and Buchanan-Smith (2007) recommended that positive reinforcement training could improve the control and predictability of the environment and could be used to optimize animal welfare.

Held et al. (2002) stated that cognition can affect production in two ways, "indirectly" and "directly". Production can be affected "indirectly" when cognition or the absence of cognition induces stress and thus places the welfare of the animal in jeopardy.

Production can be affected “directly” when the animal is faced with unsuitable devices, such as nonadapted feeding stations, which lead to less feed intake. Broom (2010) exposed the importance of cognition studies. He found that attitudes toward animals were affected by people’s assessment of the animal’s abilities. If animals are thought to be “stupid” and “unaware”, they would be treated more as an “object” than as an “individual”. Held et al. (2002) defined cognition in their study as “including all mental processes animals use to acquire information about their environment, to store and recall it, and to use it in their decision making.” Altogether, these studies show that the cognitive abilities of farm animals should definitely be considered in the context of animal welfare.

3.4 Objectives of the study

The objective was to reduce the agonistic interactions at the electronic feeding station for gestating sows. With the aid of a call feeding system for gestating sows, it should be possible for the animals to anticipate their access to the feeder and thereby reduce the agonistic interactions in front of the feeding station and the resulting lesions. Furthermore, a call feeding station has the potential to be a cognitive enrichment device (Manteuffel et al., 2009a; Manteuffel et al., 2010).

It was not possible in this thesis to test the direct effects of the call feeding system on the cognitive abilities of sows. Nevertheless, the consequences and possibilities of the call feeding station as a cognitive enrichment tool for gestating sows will be discussed.

Feeding systems that promote the cognitive sensory performance of sows and avoid competitive behavior are currently not tested in practice. Previous research established a call feeding station for gestating sows, with a group of 8 sows under experimental conditions (Manteuffel et al., 2010). For the present study, a common electronic feeding station (INTEC MAC, PigTek Europe GmbH, Schüttdorf, Germany) was modified to be a call feeding station.

The first study of this thesis asked (1) whether it is possible for reproductive sows to learn an individual acoustic cue and discriminate it from others, can this be transferred to the gestation area with other sows in a dynamic group and will they be able to obtain their feed when they hear the acoustic sound over an automatic feeding system. The second question was (2) whether the sows could remember their names over such a period and how long did it take to obtain 100 % of their daily feed amount. These questions are the focus of the first paper, chapter four: *Learning performance of gestating sows when called to the feeder.*

In a second study, it is tested whether (3) call feeding results in reduced agonistic interactions between the sows and thereby of lesions. In addition, it was investigated (4) whether there are differences between different feeding frequencies (one-time vs. two-time feeding) and (5) whether additional straw in the activity area has any effect.
These questions are the focus of the second paper, chapter five: *Individual calling to the feeding station can reduce agonistic interactions and lesions in group-housed sows.*

4 Learning performance of gestating sows when called to the feeder

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Abstract

A call feeding station in which sows learn to be allowed to enter a feeding station only after being called by an individual acoustic signal has been shown to reduce agonistic interactions in front of the feeding station. Here, we tested important prerequisites for integration of a call feeding station in common husbandry practice of group-housed sows. In particular we tested whether the learning task was accepted by the animals in a reasonable time, whether sows which already knew a feeding station would perform different from sows naive towards any feeding station, whether sows would remember their individual acoustic call after returning from farrowing and service period an whether feeding frequency in the gestation pen would affect learning performance. A total of 62 sows involved in this experiment. 22 of those sows did not have any practice with a feeding station before the experiments (NLS= new learning sows) and 40 sows were already accustomed to a conventional feeding station and had to adapt to the new task of the call feeding station (RLS = relearning sows). Subgroups of sows were trained in a learning pen for 19 days and then integrated into a larger group of sows in the gestation pen where they were fed either once or twice a day by a call feeding station.

During training the proportion of correct responses in both groups increased (RLS: r_s= 0.6247; $p = 0.0169$; NLS: $r_s = 0.6169$; $p = 0.0188$). NLS showed a higher learning performance compared to RLS sows (median: 62.75% vs. 47.5% correct responses).

In the gestation pen learning success of sows which had learned the call feeding task for the first time still increased throughout the gestating period of 80 days ($r_s = 0.5426$; $p < 0.0001$) but showed a steady course of correct responses of 100% in sows which returned into the gestation pen for a second time or even more often. After six weeks of farrowing and service period in which sows did not hear their individual call both NLS and RLS sows remembered it to 100% in median. Across the whole stay in the gestation pen, calling the animals to feed once a day resulted in a slightly better learning performance than twice a day ($N_1 = 80$, $N_2 = 80$; $Z = 3.6297$, $p < 0.0003$). Our results suggest that with respect to the learning ability of sows the prerequisites for implementation a call feeding station in the normal production process are given.

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5 Individual calling to the feeding station can reduce agonistic interactions and lesions in group housed sows

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Abstract

In this study we used a new call feeding station which enables sows to learn that they have access to feed only after an individual acoustic signal was given. We tested whether this call feeding station is able to reduce agonistic interactions between sows and whether effects of call feeding can further be improved by enrichment. A total of 85 gestating sows were kept in a dynamic group in a large waiting area (207 m²) equipped with littered laying areas and an outdoor run. During a control treatment sows were fed with a normal electronic feeding station once a day (NF1-). Before testing the call feeding station sows had been conditioned for an acoustic signal (a trisyllabic “name”) and learned that they are allowed to enter the feeding station only after their name was called. With the call feeding station sows were fed either once (CF1-) or twice a day (CF2-). In addition we tested for effects of further enrichment such as straw in the activity area (CF2+).

Agonistic behaviours and number of sows were observed by video in continuous recording from 06:00 to 18:00 in an area (4 x 3.25 m) in front of the feeding station in periods of four days (NF1-: 7 periods, CF1-: 5 periods, CF2-: 3 periods, CF2+: 4 periods) and analysed using mixed models. During each observation period sows were scored for wounds and body lesions at different body parts. From 06:00 h to 11:00 h the proportion of agonistic interactions was much higher in the feeding mode NF1- compared to CF1- (feeding mode x time of day: $p < 0.001$) and in CF1- agonistic interactions were on a low level throughout the whole feeding cycle. The feeding frequency and the additional presence of straw in the activity area did not affect the proportion of agonistic interactions (all $p > 0.05$). The results on the number of sows in front of the feeding station mirrored the findings for agonistic interactions. In NF1- more sows were involved in agonistic interactions compared to CF1- (83.1 ± 12.9 % vs. 61.5 ± 19.6 %; $p = 0.005$) but there was no difference between the CF treatments. The number of severe lesions was higher at the head ($p = 0.004$), the shoulders ($p = 0.042$), the flank ($p = 0.002$), but not at the hindquarter ($p > 0.05$) in NF1- compared to CF1-. The results suggest that signalizing the feeding time individually increases the predictability for access to the feeding station and, consequently, reduces competition between sows.

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6 General Discussion

This study aimed to test whether a modified call feeding station could be implemented in the practice of piglet production. In particular, the study focused on the learning performance of sows and the effects of the call feeding station on agonistic behavior when feeding. The interrogation was based not only on learning and whether the sows were able to connect a stimulus with a reward but rather whether the pigs were able to use a tool to their benefit by their cognitive abilities, which punctuates the controversial theme of animal welfare. Hence, there were many indications that a call feeding system has a positive effect on the sow's welfare. The following section discusses the impact of a call feeding station on the social behavior of sows, the learning performance of sows with the call feeding station, and the possible practical application of a call feeding station as a cognitive enrichment tool.

6.1 Impact of call feeding on the behavior of gestating sows

The main problems with group housing gestating sows are agonistic interactions with individual feeding and electronic feeding systems. This problem resulted from the regulation of access to the feeder by the social status connected with agonistic interactions (Broom et al., 1995; Marchant et al., 1995; Anil et al., 2006; Manteuffel et al., 2010). Furthermore, the agonistic interactions increased because of the inability of each sow to foresee the time to access the feeder (Durrell et al., 2002).

Certainly, single feeding in cubicle pens would avoid agonistic interactions, but with growing production herds, it is more economical to feed the sows via computer controlled feeding systems. The production model of dynamic groups is certainly lowered because of much larger production herds and large static groups that are fed with an electronic feeding system. Incidentally, Strawford et al. (2008) found no much difference in agonistic behavior between static and dynamic groups after mixing. The average time of aggressive encounters at mixing was shorter in the dynamic pen, probably induced by more space. Additionally, the aggression levels were similar, despite the dynamic group regrouping every 5 weeks. However, management factors such as space, available feed and roughage, group size, pen structure, and animal handling, might have an impact on agonistic behavior. A call feeding station might bring more calmness in the group.

By the strength of the ascertained data, it showed that competition for access to the feeding station could be reduced using the call feeding station compared with a common electronic feeding station. This was indicated by a reduction in agonistic interactions and also in the number of sows involved in the agonistic interactions. A further positive effect was the lower proportion of sows with lesions and wounds in the regions of the head and the flank. Different studies have proven that the process of grouping and feeding with electronic feeding stations induces stress in the lower ranked sows (Arey and Edwards, 1998; de Jong et al., 2000). With the call feeding station standing and waiting in front of the feeder was no longer successful for the sows. The call feeding station allowed the sows to anticipate the time they get access to the feeder.

Especially for young sows, it was easier to get access to the feeder and to avoid the *“danger area”* in front of the feeding station. Unfortunately, this perception arose during the trial and no data were available and based only on subject feeling. It might be appeared that for these particular sows, possible stress related to accessing the feeder could be reduced.

6.2 Learning behavior

The sows were trained to associate the individual acoustic signal with the feeding station, or to be more precise, with food rewarded on the basis of classical and operant conditioning. Classical conditioning or “Pavlovian conditioning” is a case of associative learning “the formation of some sort of mental connection between representations of two stimuli.” (Shettleworth, 2010).

The “name” or signal that was played during the training phase while the sows were feeding in the station was initially a neutral stimulus. In association with the given food, the name was changed to a conditioned stimulus. The food was given in the feeding station; simultaneously, the signal was played (conditioned response). Subsequently, after five days, the software changed the regulation of the call feeding station into the operant or instrumental conditioning mode. Now, sows had to learn about the consequences of their behavior. The signal was played first, and the respective animal had to go to the feeding station to get access to food. This kind of associative learning is a very simple form of learning.

Simple forms of operant learning are already common in farm animal housing, such as an electronic feeding station for pigs where pigs have to learn to enter a feeding box with a normally locked door to get food, automated milking units where cows have to learn to enter a box to be milked, and nipple drinkers for different kind of animals, where they have to learn the functionality of delivery. All types of animals have to learn the functionality of such devices with operant learning.

Understanding a call feeding system from an animal's point of view could be compared with the farmer who is calling his cows to the milking unit. Similarly, pigs, horses and dogs know it is their feeding time when they hear a signal, such as the rattle of a feed hopper, which they associate with the feeding routine. Often the animals become nervous in anticipation of receiving food. The sows had no trouble learning this operant conditioning process of the call feeding system. They heard "their own noise" and knew it was their time to feed.

In the past, many studies have shown different forms of pig learning. Pigs are able to learn from others if food is involved. Held et al. (2000) showed that naive dominant pigs were able to learn from pre-trained subordinate pigs where food was hidden, instead of searching themselves when foraging. Additionally, pigs have a good memory. They are able to remember good feeding sites in the wild. This implies that pigs have well-developed spatial learning and memory abilities.

Mendl et al. (1997) found that young male pigs used their memory rather than food related cues to retrieve food hidden in one of ten areas in a test arena. In our study, sows had good memory abilities, too. In the second learning phase, the sows were called from the first day and had correct responses of over 80%. With more housing periods, they had more than 90% correct responses. It was even possible to call the sows out of insemination within the building toward the learning area, although they had not been called for six weeks.

In the previous study of Manteuffel et al. (2010), all of the sows were naive regarding the electronic feeding station (normal and call feeding station) and learning the criterion was reached at 8.4 days (definition of learning criterion = 80% correct responses) with calling six times daily. In our study, the correct responses after 7 days were steadily above 60%, approximately with calling two times daily. Initially, calling six times would improved learning efficiency, but this also led to a remarkable increase in fights, most likely because of higher feeding motivation resulting from smaller feed rations, and thus to repeated encounters. Thus, calling frequency was reduced to twice a day for the experiments. In addition, the lower number of calls also better matched the practicality for common piglet production, and two calls were more realistic than six calls. In common piglet productions, there are more animals in one group (up to 60 animals). The time for sow management would be difficult to fit into one day, especially if periods of rest were integrated for the sows.

The relearning sows might have confounded the effects concerning learning performance, too. These sows had to learn that waiting in front of the feeder no longer succeeded.

This waiting behavior is the most common problem with electronic feeders for gestating sows (Bates et al., 2003; Anil et al., 2006). When fed with electronic feeders, high-ranking sows obstruct access to the feeder and other sows have to wait for their turn. The high-ranking sows defend their position with major implications for their own (and others) health. Therefore, their social status has the main influence on their behavior (Puppe et al., 2008; Hoy et al., 2009).

There occurred serious problems during the study with the call feeding software at the beginning of the first learning session. These breakdowns of the software and/or network led to forgotten or deleted animals, failure related to the feeding periods and allocation of new names, etc. Not only data were lost because the call feeding mode had been switched to normal feeding mode. This concerned almost all subgroups in the first learning phase.
The problems with the software were immediately and extensively optimized during the time of data collection, but the first learning sessions were particularly affected. Due to this fact the learning success of the animals was most likely affected.

However, it is notable that almost all of the sows learned the new call and increased their learning performance despite these severe problems. At the end of the first learning sessions, the software was in a steady state. Apparently, the sows were not affected by these failures during the second learning session (after they were farrowed and inseminated).

6.3 Call feeding as cognitive enrichment?

This study did not allow for the investigation of the effects of cognitive skills in gestating sows, but one of the central questions in recent studies was how cognitive enrichment can affect animal well-being and, thus, productivity. Additionally, which enrichment tools were suitable?

Meehan and Mench (2007) criticized many of the enrichment devices that, for example, used foraging materials that did not include the integration of suitable challenges, which activate the cognitive skills of animals. In the wild, animals are frequently confronted with challenges and problems that they must cope with to survive and thrive (Curtis and Stricklin, 1991; Boissy et al., 2007a; Broom, 2010). Indeed, animals should have the opportunity to be active participants in their environment and be offered possibilities to modify their own behavior (Meehan and Mench, 2007). Concerning this requirements, cognitive challenges should be appropriately considered. Problem solving in the wild is a natural process, while enrichment for animals in captivity is often not included (Meehan and Mench, 2007). In comparison to other enrichment tools, a call feeding station will never lose the interest of the sows because of alternating calling order and varying feeding times. Due to this animals have to be constantly attentive. According to Manteuffel (2010), call feeding has the potential to provide “cognitive enrichment”. This results from different challenges the sows have to deal with: First, the sows have to detect a discriminatory stimulus (name) affected by their motivation to feed.

Second, the adaptation of their own behavior is required to gain access to the feeding station and, thus, to the reward (food) and finally to complete control over the process (Manteuffel et al., 2010). Control over their housing environment has a close connection to animal welfare; it is the knowledge of the consequences of their actions (Manteuffel et al., 2009b). Obtaining control of the environment is usually related with an increase in predictability (Bassett and Buchanan-Smith, 2007; Manteuffel et al., 2009a). Sows fed with a call feeding system have the opportunity to control their environment in the form of predictable access to the feeding station. They can predict that they are going to be fed when they are called, and they also know that no call means no food.

In addition to it, animal welfare is strongly related to the mental states of animals (Dawkins, 1990). By anticipation of positive stimuli, such as access to feed, neurophysiologic systems related to positive emotions are activated (Imfeld-Mueller et al., 2011). Boissy et al. (2007b) found that feelings involved some cognitive ability to establish temporal and instrumental prospects and stated the following: “These cognitive abilities allow anticipation or prediction of events whereas emotional responses involve coping with the situation.” This may indicate how housing facilities encroached on their mental state and also offer advice for management procedures that appreciate their cognitive capacities to minimize stress and improve welfare (Mendl et al., 2010).

6.4 The call feeding station and practical application

With the aid of the Leibnitz Institute for farm animal behavior in Dummerstorf (FBN), it was possible to install the call feeding system in a reproduction herd. The FBN had already tested the call feeding system with the same technical design but only with a maximum of eight animals in one barn. In our experiment, two different buildings were electronically connected with each other using wireless LAN, which was necessary because the waiting area was located in a separate building. Only one computer network system was installed for the complete production system. This had not been tested before and contributed to the initial problems. By the modern standards of sow keeping, it would not be necessary to link different buildings together.

With the electronic feeding system from PIG TEK, it is common to link different reproduction groups in one network. The sows learned their name in the learning pen and could transfer this name to the waiting area. The sows showed that they could generalize the signal in another environment, and no difficulties occurred during the cyclic relocations, which are common in practical farm management routines.

It was noted that almost all of the sows learned their names. There was only one sow that did not learn her call. Unfortunately, it was not possible to identify the reason. It was speculated that the animal was having hearing problems or was even deaf.

Based on the flexibility of the software used, it was possible to integrate this sow into the normal feeding cycle. She received her feed (normal feeding mode) during a time gap, which could be programmed with the software. To be flexible in the feeding procedure is an important aspect to implement a call feeding station in practice, if efficient animals will not learn the tone. With respect to the possible benefits of the practice, Fiedler et al. (2005) found that fattening pigs had better meat quality in an enriched environment. Additionally, Ernst et al. (2006) found positive effects on the immune system and health when fattening pigs were fed with a call feeding station. Thus, the call feeding station as a cognitive enrichment device can possibly improve well-being, health and production, and thus, it seems possible that the additional economic benefits of improved health, improved performance and eventually more reared piglets can be realized.

Call feeding also may facilitate the management of sows, especially in larger groups. While working in the stables, it was my personal impression that the handling of sows with the call feeding station was easier compared with a normal electronic feeding station. For example, the training at the feeding station of young sows, which is time consuming because of the crowd of sows in front of the common electronic feeding station, is not necessary anymore. In addition, it was possible to call a sow “right now” to receive medical treatment, but it has yet to be clarified whether medication had a negative influence on learning behavior.

After the call feeding station was installed and the sows learned their names, the entrance door was no longer blocked by high-ranking sows. Therefore, it may also be possible to integrate the training procedure into the waiting area. Consequently, a separate learning pen, as used in this study and mostly in practice, might not be necessary, which, in return, would provide an excellent economic management advantage.

The duration of the handling of sows that were called once a day to the feeder, the “inter-feed time” (i.e., the time from the first call until a sow entered the feeding station and received feed and the next sow was called), was in the range of approximately 13 minutes. The time from the first call until the sow was recognized by the antenna and passed the trough into the feeding station was approximately 1.5 min. This resulted in a mean duration of stay at the feeding station of 11.5 min, which is exactly the same duration found by Hoy et al. (2007) for a conventional electronic feeding station.

For a feeding cycle of 12 hours and one feeding per sow per day, this would result in approximately 55 sows that could be fed by a call feeding station. With a stay of approximately 11.5 min at the conventional feeding station, it would be possible to feed 62 sows presuming the sows would immediately enter the feeding station one after the other. Thus, with a call feeding station, the number of sows that could be fed would be reduced by approximately 11%. However, in practice, there are already highly efficient producers who keep 45 to 55 animals per feeder. In this case, no losses would appear in the productivity per animal unit.

6.5 Conclusions and perspectives

The results of these studies show that it is possible to implement the call feeding system in a reproductive herd of sows. A call feeding station is likely to improve the sows' welfare by reducing the amount of agonistic interactions in front of the feeding station and, consequently, by reducing lesions due to fighting. In addition, a call feeding station might serve as a source of cognitive enrichment for the sows. Farmers may profit from a call feeding station because of the improved health of their sows, and furthermore, the management of sow herds may be facilitated, for example, by reducing the effort to familiarize young sows with a feeding station. It is hoped that in the future the call feeding station will become an integral part of modern and sophisticated housing conditions in means of precision livestock farming that aims to integrate and support the cognitive abilities of sows.

The results of these studies also indicate further possible applications for call feeding. Sows were able to transfer their understanding of their individual acoustic signal from the learning pen to the waiting area located in another stable. This may indicate that they are able to generalize the meaning of the signal independent of the surrounding environment. This generalization was also supported by two accidental events that happened during the experiments: Because of a defective loudspeaker, I once called a sow with my voice and the sow went to the feeder to obtain the food.

Another example was observed when a sow was accidentally called while she was still in the insemination center where the call feeding station was not installed but nonetheless she heard the tone from the learning pen, which was in the same building. After hearing the calling, the sow turned and went immediately to the feeding station. If sows really are able to generalize their signals, it might be possible to use an additional conditioned response for other practices like move to another pen or stable.

Nonetheless, there still are open questions. It would be interesting to test whether the call feeding station had positive effects on the auditory attentiveness of sows leading to a higher attentiveness in the farrowing pen, which might result in a reduction of crushed piglets. The current economic situation for piglet producers is characterized by increasing costs and reduced operating margins. Benefits from a call feeding station, such as reduced veterinarian costs and/or increased productivity due to lower piglet losses, would further increase the acceptance of call feeding stations by farmers.

Understanding and using the cognitive abilities of farm animals may also have an effect on animal welfare in a broader context. Kirkwood and Hubrecht (2001) stated that “the level of priority and resource given to the care of organisms is influenced by beliefs and understanding about their capacities for conscious awareness”. Although this study did not test for possible states of conscious awareness, it nevertheless showed considerable learning and memory capacity in sows.

Following Broom (2010), who stated that animals that were classified as unaware and stupid would be observed more as objects than as individuals, the findings of this thesis may contribute to the treatment of sows and other farm animals as individuals rather than as objects. Thus, this thesis could make a substantial contribution to improve the central problem of electronic feeding systems and, consequently, improve the animal's well being.

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8 Curriculum Vitae

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TEILNAHME AN KONGRESSEN UND VERÖFFENTLICHUNGEN

Journal of Animal Science (JAS) (accepted 23.Juli 2012)

Individual calling to the feeding station can reduce agonistic interactions and lesions in group housed sows

DGS- Das Magazin für Geflügelwirtschaft und Schweineproduktion

Putenmast: Was bringt ein Außenklimabereich?

Freiburger Tierschutztagung

Beitrag zur „Aktuelle Arbeiten zur artgemäßen Tierhaltung 2010“. 42. Tagung Angewandte Ethologie bei Nutztieren der DVG, KTBL-Schrift 482

Thema: Können mit einer Aufrufstation für Wartesauen agonistische Interaktionen gesenkt werden?

The 33th ISAE conference

03.-07.2010, Uppsala, Sweden

Vortrag zum Thema: Do sows learn their names?

Vortragstagung der Gesellschaft der Förderer und Freunde für Geflügel- und Kleintierforschung e.V. (GdFuF) am 21.04.2009

Vortrag: Entwicklung einer „Aufruffütterung“ für Sauen

World Poultry Congress

29.06.-04.07.2008, Brisbane Australien

Vortrag zum Thema: Inquiries to a turkey house with roofed outside run and different stocking densities

Tagung der DVG- Fachgruppe “Tierschutz”

21.-22.02.2008, Nürtingen

Vortrag zum Thema: Pferdehaltungssysteme in der niedersächsischen Pferdehaltung unter dem Aspekt der Tiergerechtheit

9 Erklärung an Eides statt

Hiermit erkläre ich an Eides statt, dass ich die vorliegende Arbeit selbstständig und ohne fremde Hilfe verfasst habe. Es wurden keine anderen als die in der Arbeit angegebenen Quellen und Hilfsmittel benutzt. Die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen sind als solche kenntlich gemacht.

I declare under penalty of perjury that this thesis is my own work entirely and has been written without any help from other people. I used only the sources mentioned and included all the citations correctly both in word or content.

Datum/Date Unterschrift des Antragsstellers/Signature of the applicant

10 Erklärung über bestehende Vorstrafen und anhängige Ermittlungsverfahren

Hiermit erkläre ich, dass ich weder vorbestraft bin noch dass gegen mich Ermittlungsverfahren anhängig sind.

I hereby declare that I have no criminal record and that no preliminary investigations are pending against me.

Datum/Date Unterschrift des Antragsstellers/Signature of the applicant

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