

**Effects of Different Genres of Music on Milk Yield, Milking Duration, and
Behavior of Dairy Cows**

Honors Research Thesis

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ABSTRACT

The aim of this crossover study was to explore the effects of different genres of music on cows' milk yield, milking duration, and behavior during milking. Ninety-one Jersey cows were introduced to different genres of music, including Latin, country, classical, rock, and no music (control), in the milking parlor. Cows were exposed to a different genre of music or the control over four 5-day periods, whereby one genre of music was played during each milking. Milk yield and milking time were recorded for all cows. Cows' behavior during milking was video recorded, and later assessed for a subset of cows ($n = 38$) by scoring flinch, step, and kick (FSK) responses during cluster attachment. Milk yield increased ($P < 0.05$) by 0.51 kg, 0.42 kg, 0.32 kg, and 0.23 kg when classical music was played, compared to no music (control) and country, Latin, and rock music genres, respectively. Comparatively, milk yield decreased by 0.19 kg and 0.29 kg when no music was played in the parlor compared to Latin ($P = 0.0304$) or rock ($P = 0.0011$) music, respectively. Statistically significant differences of 9.6 seconds or less in milking time existed when comparing classical music to the control and Latin music, and the control to country and rock ($P < 0.05$). Music did not influence cows' FSK responses during cluster attachment. This study indicates certain genres of music, particularly classical music, increased milk production, which indicates potential benefits to animal welfare and herd profitability over time. Other aspects of behavior, including the total number of FSK responses should be considered during udder washing, cluster attachment, cluster removal, and anti-septic washing in future studies, as well as the cows' response to music played in different environments, such as loose housing and across larger herds.

Key words: behavior; dairy cow; music; productivity

INTRODUCTION

Defining Animal Welfare

Animal welfare is defined as the state of an individual animal as it attempts to cope with the conditions of its environment, existing on a continuum from good to poor (Broom, 1988). The term coping refers to the ability of an animal to maintain mental and physical control, or in other words, it refers to an animal's ability to maintain homeostatic balance (Broom and Johnson, 2019). It is also important to recognize that animal welfare is not something that is given to an animal, but rather refers to the mental and physical state of an individual animal as it experiences the environment in which it lives (Keeling et al., 2011). As a consumer-driven, mandated science, public concerns over animal welfare continue to grow and have become a critical component of food animal production over recent decades. The dairy industry in particular faces increasing scrutiny from consumers and citizens, with welfare concerns related to cows' restricted or limited access to pasture and the outdoors (Schuppli et al., 2014), surplus calf management (Creutzinger et al., 2021), and separating calves from their mothers shortly after birth (Ventura, et al., 2013). Additional concerns relate to the environmental impact of the dairy industry at large, as it attempts to produce food and milk for the world's ever-growing population (von Keyserlingk et al., 2013). Therefore, the need exists to identify ways in which dairy producers can provide opportunities for improvement in their cows' welfare, while maintaining efficiency in their outputs.

Animal Welfare Assessment: The Five Domains Model

The Five Domains Model has been widely adopted as a science-based framework for assessing animal welfare, which recognizes that animals can experience feelings, ranging from negative to positive (Mellor et al., 2020). The domains of this model include (1) Nutrition, (2)

Physical Environment, (3) Health, (4) Behavioral Interactions, and (5) Mental State. Numerous factors in each physical/functional domain generate specific experiences that influence the animal's Mental State, or Domain 5, ultimately resulting in a negative or positive welfare state for the animal (Mellor et al., 2020). This framework can be readily applied in the welfare assessment of animals in human care, including dairy cattle (Mellor and Stafford, 2001).

Domain 1 - Nutrition. The Nutrition Domain considers the nutrient intake of an animal in relation to its needs; an animal that is provided water and feed in sufficient quantity and quality to satisfy its nutritional requirements is more likely to experience a positive Mental State, which might include feelings of satiety or gastrointestinal comfort, ultimately contributing to a positive welfare state (Mellor et al., 2020).

Domain 2 - Physical Environment. Factors that contribute to the living conditions of the animal, including ambient temperature, bedding substrate, air quality, shelter, etc., embody the Physical Environment Domain (Mellor et al., 2020). When the animal's needs are met through the physical environment, the animal may feel positive emotions, including respiratory comfort, physical comfort, thermal comfort, etc., which positively impacts the Domain 5, the Mental State (Mellor et al., 2020).

Evaluating resource-based measures in an animal's physical environment is a key tenant of animal welfare assessment. This includes the animal's auditory, thermal, olfactory, physical, and visual environmental conditions, among others. For dairy cows, the environment within the milking parlor can be quite impactful. Cows typically visit the milking parlor 2 to 3 times per day, for upwards of several minutes, during a typical 305-day lactation. Cows can retain memories of both good and bad experiences, but they tend to retain memories associated with fear; for instance, Dr. Temple Grandin highlighted this association with the milking parlor

environment: “Animals are most likely to develop a fear memory that is associated with the parlor” (Grandin, 1999). Therefore, it is critical that dairy cows have a positive experience in the milking parlor, beginning with their first lactation and all subsequent milkings thereafter .

Domain 3 - Health. The Health Domain reflects diseases, injuries, physiological impairments, etc. of the animal, with a positive health status contributing to a positive Mental State and the comfort of being in good health (Mellor et al., 2020). The cow’s productivity during lactation, frequently measured by milk yield, is often utilized as an animal-based measure to assess the animal’s Health Domain. Milk yield can be impacted by a variety of factors that contribute to an animal’s health. Metabolic diseases, including milk fever and ketosis, can influence milk yield; milk fever negatively affects milk production in the 4-6 week period after calving, and the negative effects of ketosis on milk yield can be observed 2-4 weeks prior to clinical signs and diagnosis (Rajala-Schultz, Gröhn, and McCulloch, 1999b). In addition, mastitis, an infection of the mammary gland, can also significantly influence milk yield (Rajala-Schultz et al., 1999a). Other health issues, such as foot and leg disorders (e.g., lameness) are also associated with milk production losses (Rajala-Schultz, Gröhn, and McCulloch, 1999b). Other factors, including negative handling interactions with dairy producers, can influence milk yield as well (Hemsworth et al., 2000).

Milking duration is another measure that can be used to assess dairy cattle welfare, as a longer milking duration can be an indication of disturbed milk let down or the inhibition of milk ejection (reviewed by Bruckmaier, 2005). The hormone oxytocin plays an important role in milk ejection. However, the actions of oxytocin can be inhibited by adrenaline, which is secreted mainly from the adrenal medulla during excitatory experiences, including those that induce fear or distress (Jorgensen and Kleen, 1968). Therefore, a longer milking duration may indicate

distress (or a negative Mental State) during milking. This is supported by previous research documenting increased cortisol concentrations, an indicator of stress, in dairy cows during milkings that had disturbed milk ejection, as a result of cows being milked in unfamiliar surroundings (reviewed by Bruckmaier, 2005). Thus, a longer milking duration could be reflective of a disturbed milk ejection. Milking duration can also be reflective of the health and endocrine function of the animal, with a reduced or absent release of oxytocin from the pituitary gland resulting in disturbed milk ejections (reviewed by Bruckmaier, 2005).

Domain 4 - Behavioral Interactions. The last physical domain is the Behavioral Interactions Domain, which considers interactions between animals (e.g., playing, nurturing young, sexual activity), human-animal interactions (**HAI**), and interactions between an animal and its environment (e.g., making decisions, exploring the environment) (Mellor et al., 2020). The HAI component is a relatively new and important addition to this Model, considering factors such as the aptitude and attitude of animal caretakers towards their animals, as well as their animal handling skills, and the potential impact on the animals (Mellor et al., 2020). Positive HAI promotes animal welfare and results in animals that are calmer, more confident, and easier to manage (Mellor et al., 2020).

Behavioral interactions during milking can be assessed in dairy cows using flinch, step, kick responses (**FSK**) (Willis, 1983; Hemsworth et al., 2002). Measuring FSK responses can provide insight into the Mental State of the cow via the Behavioral Interactions Domain; for example, restlessness, indicated by a high FSK response, has been previously documented in stressful situations (Willis, 1983). Cows with different temperaments, designated by their coping style to an environmental stressor, have also been found to have differences in their FSK responses (Sutherland, Rogers & Verkerk, 2012); an animal with a more effective coping

mechanism is more likely to adapt to changing conditions in its environment, and therefore have better welfare. For dairy cows, the milking parlor represents an environment with a high level of HAI; the impacts of HAI are considered within the assessment of the Behavior Domain. For example, dairy cattle that are more fearful of humans step more during milking compared to dairy cattle that are less fearful of humans (Rousing et al., 2004). Thus, assessing FSK responses can be used to better understand animal welfare in the milking parlor environment.

Influence of Music on Aspects of Animal Welfare

There is no shortage of research investigating the relationships between animals and music. For example, one investigation into the influence of music on pregnant sows showed that classical music from Vivaldi improved sows' welfare, with sows displaying fewer stereotypic and agonistic behaviors directed towards the animal caretaker (Flávia et al., 2017). These sows also spent more time resting when classical music was played. However, the current literature is lacking in similar studies investigating the relationship between music and dairy cattle, and these investigations provide conflicting associations between music and milk production (Lemcke, Ebinghaus, & Knierim, 2021). For example, one study conducted on a dairy farm with an automated milking system (AMS) found that music attracted cows to the AMS, as they chose to be milked more frequently during the periods in which music was playing inside the AMS, compared to when it was not playing (Lemcke, Ebinghaus, & Knierim, 2021). While this study did not find an increase in milk yield during the music treatment periods, music was selected on the basis of having similar tempos, creating a playlist composed of multiple genres and simply observing the cows preference for music versus no music (Lemcke, Ebinghaus, & Knierim, 2021). Thus, although this previous research suggests evidence that music positively influences

cows, the addition of different genres of music might further clarify the association between genre of music and milk yield.

Few studies have investigated the influence of different genres of music on milk production. One student in the Alfred University Honors Program investigated the effects of one music genre (e.g., classical) in an AMS on dairy cow productivity. During the periods that classical music was played, there was a significant increase in the number of cows that entered the AMS, and the authors found a positive association between classical music and individual cow milk yield. However, the total milk yield throughout the duration of the study was not significantly different between the music and control (no music) treatment groups (Kenison, 2016). Another study investigated the effects of Latin, rock, and African percussion music on aspects of dairy cattle welfare and found significant differences in milk yield between treatment groups: on the 60th day of the trial, the average milk yield for cows in the African percussion and rock treatment groups were significantly lower compared to the control (no music) treatment group (Donghai et al., 2018).

Additional outcome variables that have not been considered in previous studies with regard to music and dairy cattle welfare are milking duration and behavior for individual cows. Milking duration is not only an important factor to consider for animal welfare, but also for the dairy producer, as milking duration can impact the overall milking routine and production efficiencies. A shorter milking duration might be apparent in animals that are calmer and not in distress; cows may let down their milk more quickly without interruption; and have reduced residual milk. Therefore, identifying a genre of music that is associated with reduced milking duration might be one consideration to improve both efficiency in the milking parlor and dairy cattle welfare. The influence of music in the milking parlor environment on cow behavior has

also not been reported in the literature; therefore, our study included a behavioral assessment to assess the impact of different genres of music on dairy cattle behavior during milking.

Objective and Hypothesis

The objective of this study was to explore the effects of different genres of music on dairy cows' milk yield, milking duration, and behavior during milking. We hypothesized that country music would increase milk yield and reduce FSK responses and milking duration, compared to classical, Latin, rock, or no music played during milking.

MATERIALS AND METHODS

Farm, Animals, and Management

This study was conducted with lactating Jersey cows at the Waterman Dairy Center from November 28 to December 20, 2021, in accordance with the guidelines set forth by The Ohio State University Institutional Animal Care and Use Committee (Protocol no. 2021A00000089). This farm was selected based on its proximity to The Ohio State University and their willingness to participate in the study. Experimental cows (i.e., those included in statistical analysis; n=91 cows) included those in the lactating herd with an average parity of 2.3 ± 1.3 (mean \pm SD; range 1 to 6), average DIM of 165.7 ± 101.4 (range 11 to 492), and average milk production of $14.0 \text{ kg} \pm 3.1 \text{ kg}$ (range 3.6 kg to 26.9 kg).

Cows were housed in a loose housing system and milked twice daily. For both morning and afternoon milkings, cows were moved from the freestall barn at approximately 0400 and 1600 h for routine cleaning by farm personnel. Cows were then moved into the milking parlor at approximately 0435 and 1635 h, and milking began approximately 10 min later. Cows are

milked in a DeLeval, double-eight herringbone parlor; the first four cows are handled by one individual, and the last four cows are handled by another individual.

Per the Waterman Dairy Center's standard operating procedure for milking, each individual cow receives pre-dip treatment (e.g., 0.5% iodine solution) and are then hand-stripped. The cows' teats are then wiped off with a cloth, and the milking cluster is attached. Once the unit detaches automatically, each cow is checked to ensure complete milking, and a post-milking disinfectant (e.g., 1% iodine solution), which also contains skin conditioners, is applied. This process is repeated for the entirety of the herd, and milking generally concludes at approximately 0630 and 1830 h.

Experimental Design and Treatments

All lactating cows were subjected to each of 5 music treatments in a crossover study design. The 5 treatments were: 1) Control (no music) 2) country, 3) Latin, 4) classical, and 5) rock music genres. To assess the influence of different genres of music played during milking on dairy cow behavior and productivity, four music playlists were created, with each playlist representing one treatment group and composed of one genre of music, including rock, country, classical, and Latin music. The control treatment group did not have any music playing within the parlor environment. The pieces of music that composed each playlist were selected from the top charts for each music genre. There could have been overlap between the playlist representing the country music genre and the music that is typically played in the parlor and barn environments on the farm. Each playlist was approximately 2 to 3 h long, and the shuffle play feature (i.e., songs were played in a random order each time) was utilized. In the event that the music playlist concluded prior to the end of milking, a member of the research staff (MP) would start the playlist again.

The experimental period included four replicates of the following: five days of data collection, followed by one non-experimental testing or washout day. Within each replicate, treatment order was randomly assigned (**Table 1**). During each afternoon milking session of the trial, the selected playlist (or control) played at a constant volume in the parlor. Prior to the beginning of this experiment, the sound level during milking sessions was approximately 46.0 decibels (dB), and dB levels remained consistent throughout the trial. Music was limited elsewhere on the farm.

Milk Yield and Milking Duration

As each dairy cow entered the milking parlor, the AfiMilk® system identified individual cows and automatically recorded their milk yield (measured in pounds) and milking duration (measured in minutes) for each milking. Milking duration started when the milking cluster was manually applied to the teats and ended when the unit automatically detached from the udder at the end of milking. At the conclusion of each day, data for individual cows' milk yield and milking duration was accessed through the AfiMilk system and recorded for each PM milking session of the trial.

Behavioral Observations During Milking

A subset of cows ($n = 38$) was selected from the larger lactating herd to assess the behavioral responses to the attachment of the milking cluster during the PM milking. Experimental cows were selected based on the following inclusion criteria: 1) >61 DIM, 2) in their second or third lactation, and 3) continued lactation during the experimental period. The experimental cows in the subset had an average parity of 1.5 ± 0.50 (mean \pm SD; range 1 to 2), average DIM of 172.55 ± 50.15 (range 71 to 265), and average milk production of $13.37 \text{ kg} \pm$

2.49 kg (range 3.59 kg to 20.09 kg). Behavior was assessed by scoring each cow's FSK response (**Table 2**) during milking.

Four video cameras (Panasonic HC-V180 Full HD camcorders) attached to tripods were installed above the milking stalls in the parlor; each camera was able to view four milking stalls and thus, four cows per frame. Information collected by the AfiMilk® system (e.g., cow order, milking stall number) was used to identify the individual cows on the video. Videos were watched continuously by one observer (MP). To assess the influence of music treatment on the cow's behavioral response during milking, FSK scores (**Table 2**) were assigned for each cow at the beginning of each milking.

Statistical Analysis

Two cows were diagnosed with mastitis during the experimental period and were thus excluded from all analyses due to the possible confounding influence of mastitis on the outcome variables. Continuous variables (milk yield and milking duration) were analyzed using a linear mixed-effects model (PROC MIXED, SAS; Version 9.4; SAS Institute Inc., Cary, NC), and behavior (FSK scores) was analyzed using an ordinal logistic regression model (PROC GLIMMIX, SAS). All three models included the fixed effects of music treatment, period (1 to 4), parity (1 to 6), and days in milk (DIM), with cow within sequence included in the model as a random effect. Statistical significance was declared at a level of $P < 0.05$.

RESULTS

Milk Yield

Results for milk yield are summarized in **Figure 1**. Milk yield increased ($P < 0.01$) by 0.51 kg, 0.42 kg, 0.32 kg, and 0.23 kg when classical music was played in the parlor, compared

to no music (control) and country, Latin, and rock music genres, respectively. Comparatively, milk yield decreased by 0.19 kg and 0.29 kg when no music was played in the parlor compared to Latin ($P = 0.0304$) or rock ($P = 0.0011$) music, respectively. Milk yield also decreased ($P = 0.03$) by 0.01 kg per milking when country music was played compared to rock music. There were no differences observed in milk yield ($P > 0.10$) between control and country music, country and Latin music, and Latin and rock music treatment groups. Period did not significantly influence milk yield ($P = 0.51$).

Milking Duration

Milking duration increased ($P < 0.05$) by 9.6 seconds and 6.0 seconds when cows were exposed to classical music in the parlor compared to the control and Latin music, respectively. Milking time decreased ($P < 0.05$) by approximately 6.6 seconds when no music was played, compared to country and rock music. There were no differences in milking duration between classical compared to country and rock music treatment groups, between Latin compared to the control (no music), country, and rock music treatment groups, or between country and rock music treatment groups. These results are summarized in **Table 3**. Period did not significantly influence milking duration ($P = 0.51$).

Behavior

Music treatment did not influence cow behavior, measured by FSK score, during milking (**Table 4**). In other words, cows had similar FSK responses regardless of the type of music (or no music) played in the milking parlor environment. The average FSK score was 1.84 ± 0.70 (mean \pm SD; range 1 to 3). The behavior scores were not influenced by period, DIM, or parity.

DISCUSSION

This aim of this study was to investigate the effects of different genres of music played during milking on dairy cows' milk yield, milking duration, and behavior, within the framework of the Five Domains Model for animal welfare assessment (Mellor et al., 2020). Aspects of dairy cows' environment (e.g., the milking parlor) was manipulated through the addition of different auditory stimuli in the form of different genres of music. The cows' responses to the 5 different music treatments were assessed by quantifying changes in milk yield, milking duration, and behavior, assessing factors within the Health and Behavioral Interactions Domains. These factors contribute to the cows' Mental State and overall welfare status. Since the focal point of this study was the milking parlor environment, the Nutritional Domain was not independently assessed, although it remains a critical part of animal welfare assessment.

Milk Yield

The Health Domain was assessed by measuring milk yield for individual cows. Different genres of music, particularly classical music, increased milk yield, which indicates potential benefits to animal welfare and herd profitability. Increases in milk yield were also observed when Latin and rock music were played in the milking parlor compared to the control (no music). Further, milk yield was higher when cows were exposed to rock compared to country music. These increases in milk production were also biologically significant; based on the results of this study, playing classical music in the parlor environment (compared to the control or no music) can possibly increase milk production by approximately 1 kg per cow per day. This significant increase in milk yield indicates that the animal is in good health and her output has not been impaired by factors including negative handling interactions. This suggests she has a positive Mental State, which includes the comfort of good health and function and being at ease. In addition, this increase in milk yield over the cow's lactation could be quite substantial; at the

current price of approximately \$4.00 per gallon of milk, each cow could produce an additional \$313 over the course of her 305- day lactation. Therefore, producers may improve the profitability of their herd, while concurrently improving animal welfare.

The results of this study do not confirm our original hypothesis, which was that country music would increase milk yield, compared to other genres of music and the control. Prior to this research study, country music was played somewhat regularly in the milking parlor environment. Many animals habituate to their environmental conditions, and deviations are known to induce stress (Sutherland et al., 2012). Thus, it was assumed that country music would be more familiar to dairy cows and, therefore, be the music treatment that resulted in the highest milk yield. However, it is possible that the slower tempo of classical music compared to the other genres was more comforting and relaxing to the cows, increasing milk let-down and ejection. Music with increased tempo might have startled the animals and interrupted their milk let-down, leading to lower yields.

Comparing our results to other studies is somewhat difficult, due to the differences in music genres and the type of milking parlor. Nevertheless, our results seem to confer with those of Kenison (2016) in that classical music also increased milk yield; however, that study was conducted on a farm with an AMS and Holstein cattle and, therefore, the similar results could be attributed to other confounding factors (i.e., influence of humans, breed of cow, choice in milking times) rather than the treatment itself. In contrast, our results conflict with Donghai and colleagues (2018) as this study found that no music played in the parlor resulted in greater milk yields. These conflicting results highlight the need to continue this line of research in order to further clarify the relationships between genre of music, milking parameters, and their

implications in the assessment of animal welfare, as well as to expand applicability to parlor designs more commonly used on larger dairies in the United States.

Milking Duration

Although differences in milking time were observed between some music genres, it is unlikely that these differences would impact milking procedures. For instance, the greatest time difference observed when comparing music treatment groups was 0.16 minutes (or 9.6 seconds). Reducing the amount of time that the milking cluster is attached to the teats is beneficial for the health and integrity of the teats (Besier, Lind & Bruckmaier, 2016). Although it is unlikely that this small difference impacted the cow negatively, this could be investigated further. It is difficult to discern the milking duration results, as a cow that is producing a greater milk yield (a positive indicator of animal welfare) might simply require a longer duration to empty her udder. In contrast, a longer milking duration might also indicate disturbed milk let down (a negative indicator of animal welfare). Adrenaline and cortisol have been associated with disturbed milk let down, as a result of cows experiencing fear during stressful events (Jorgensen and Kleen, 1968; reviewed by Bruckmaier, 2005). The classical music treatment resulted in the greatest milk yield increase, with no negative behavioral responses, which could be an indication that the increase in milking duration was a consequence of the greater milk yield, as opposed to inhibited milk let down, therefore suggesting a positive Mental State Domain.

Behavior

Behavior, as measured by FSK responses, was not different between music treatment groups. One possible explanation for this lack of observed difference is the scoring system that was utilized in the current study. Among all the behavioral assessments, no cows were assigned a score of 4 (on a 4-point scale), meaning there were no observations of cows that kicked

backwards upon the application of the milking cluster. Therefore, the main difference between behavioral scores was whether the cow lifted its hind legs and how high their legs were lifted. Further, this scoring system did not consider the frequency of steps or hind leg movements. While some cows only shuffled their hind legs once or twice, other cows shuffled their legs for the duration of the milking cluster attachment; however, using the FSK scoring system, they received the same behavioral score due to lifting their legs the same height. For the cows that only shuffled their legs once or twice, this could indicate that she is calmer as a result of the music genre, or that she is unbothered by the music and is merely reacting to a stimulus other than the milking cluster (i.e., flies, another cow, etc.). For the cows that shuffled much more frequently, this could indicate they are more startled by a particular genre. There is likely a different Mental State associated with each of these two categories of behaviors, with cows that infrequently step more likely to be calm, relaxed, or confident, than cows that are frequently lifting and shuffling their legs, and might be more stressed, anxious, or startled. Therefore, future behavioral assessments should consider the frequency of feet shuffling in addition to the height.

Another possible factor that might have had a larger influence on behavior is the variation in herd milking time. For instance, the time that it took to complete milking was variable from day to day, with differences observed of up to 75 minutes. Depending on the experience of the milking staff and other circumstances, including screening for and treating cases of mastitis, some cows had to wait several minutes in their milking stall before the milking cluster was attached. There is typically a systematic order in which the cows enter the milking parlor (Soffié, Thinés & De Marneffe, 1976), and thus some of the cows might consistently wait longer to be milked than others. This day-to-day variability in delayed time to cluster attachment once cows were in the milking stall, in addition to increased duration of herd milking time, could have

influenced FSK responses, with cows that had to wait extended periods of time on some of the experimental days experiencing feelings of anxiousness or discomfort, which are negative affects associated with the Mental State Domain. These factors may have had a larger influence on the cow's behavior compared to the exposure to different genres of music in the parlor environment.

The milking parlor staff also likely influenced the cows' behavior. Some of the staff members had been working at Waterman Dairy Center for a longer period of time and were more experienced; these workers typically applied the milking cluster more quickly and correctly on the first try. On the other hand, some workers were new or still in training, and these individuals took longer to apply the milking cluster and sometimes had to try several times before attaching the unit correctly. The animal handling skills were also variable between employees, with some being gentler in their application of the milking cluster than others. Per the farm's milking procedure, the step immediately preceding milking cluster attachment was to wipe the pre-dip off of the teats using a cloth. It was observed that sometimes this was done more vigorously by some personnel compared to others, which could have influenced the outcome of the next step, the attachment of the cluster. These factors likely influenced the cows' behavior, and possibly contributed to a negative Mental State, including feelings of fear or discomfort. This further emphasizes the need to consider human attitudes and HAI during animal welfare assessment, especially for dairy cattle, to ultimately promote positive handling experiences for animals.

An additional factor that should be considered is the sound level within the milking parlor environment because of the milking machinery. This study was limited in its ability to adjust the volume of the music in the parlor, to align with management practices at Waterman Dairy Center, and to be mindful of the cows' enhanced sense of hearing and the possibility of causing auditory discomfort. This is an important consideration because even without the addition of

music, the milking parlor can be a loud environment. The music only adds to the baseline of noise, created by the sounds of other cows, the employees, and the milking machinery in particular. Therefore, it is important to add music that promotes a positive Mental State, to not add to these potentially startling auditory stimuli. Although classical music increased milk yield, indicating its potential benefit to dairy cow welfare, the impact that the sound of the machinery has on the cows cannot be disregarded. Further, Waterman Dairy Center has a double-eight herringbone milking parlor, which is ideal for smaller dairy operations. However, many dairy facilities are larger in size or use other milking systems, including rotary parlors or AMS systems, which might increase the sound level in the milking parlor environment, due to increased herd size or different complexities of machinery. Most farms in the United States also milk Holsteins, which have different patterns in behavior during lactation, compared to Jersey cows (Munksgaard et al., 2020). Therefore, future studies investigating the effects of baseline noise in the milking parlor, as well as whether varying the volume of music is capable of mitigating any found effects, is warranted, as is investigating the influence of different genres of music on Holstein cows during milking. Evaluating behavior during other routine procedures, including udder washing, cluster removal, and anti-septic washing using FSK scores or other behavioral metrics should also be considered for future studies.

CONCLUSIONS

This study indicates different genres of music, particularly classical music, increased milk yield, which indicates potential benefits to animal welfare and herd profitability over time. Although differences in milking duration were observed between some music genres, it is unlikely that these small differences (e.g., less than 10 seconds) have an impact on overall

milking duration. Future studies could consider using a lactometer to assess milk flow parameters and further evaluate the observed differences in milking duration between music treatment genres. Music did not affect cows' FSK responses during cluster attachment; the total number of FSK responses could be considered during udder washing, cluster attachment, cluster removal, and anti-septic washing or the number of steps cows take during milking in future studies. Future research should also investigate the effects of different genres of music on Holstein cattle during milking, as well as on larger farms and in other environments, such as loose housing.

REFERENCES

- Besier, J., Lind, O., & Bruckmaier, R. M. 2016. Dynamics of teat-end vacuum during machine milking: types, causes and impacts on teat condition and udder health-a literature review. *Journal of Applied Animal Research* 44(1):263-272.
- Broom, D. M. 1988. The scientific assessment of animal welfare. *Applied Animal Behaviour Science* 20: 5-19.
- Broom, D.M. & Johnson, K.G. (2019). Adaptation, Regulation, Sentience and Brain Control. In: Stress and Animal Welfare. *Animal Welfare*, vol 19. Springer, Cham.
Doi: https://doi.org/10.1007/978-3-030-32153-6_2.
- Reviewed by Bruckmaier, R.M. 2005. Normal and disturbed milk ejection in dairy cows. *Domestic Animal Endocrinology* 29(2): 268-273.
- Creutzinger, K. et al. 2021. Perspectives on the management of surplus dairy calves in the United States and Canada. *Frontiers in Veterinary Science* 8, article 661453.
- Donghai, W. et al. 2018. Effects of Latin, rock and African percussion music on protein and energy metabolism in cow. *Meteorological and Environmental Research* 9(2): 87-91.
- Flávia, S. et al. 2017. Effect of auditory enrichment (music) in pregnant sows welfare. *Journal of the Brazilian Association of Agricultural Engineering* 37(2): 215-225.
- Grandin, T. 1999. Reducing fear improves milk production. *Hoard's Dairyman*: 684.
- Hemsworth, P.H. et al. 2000. Relationships between human-animal interactions and productivity of commercial dairy cows. *Journal of Animal Science* 78(11): 2821-2831.
- Hemsworth, P.H. et al. 2002. The effects of cognitive behavioral intervention on the attitude and behavior of stockpersons and the behavior and productivity of commercial dairy cows. *Journal of Animal Science* 80: 68-78.

Jorgensen, N.A. & Kleen, E.J. 1968. Milk production. *SDSU Extension Fact Sheets*. 1337.

https://openprairie.sdstate.edu/extension_fact/1337.

Keeling, L.J., Rushen, J., & Duncan, I.J.H. (2011). Understanding animal welfare. In M.C.

Appleby, J.A. Mench, I.A.S. Olsson, B.O. Hughes (Eds.). *Animal Welfare* (No. Ed. 2, pp.

13-26). Wallingford, UK: CABI. Doi: [10.1079/9781845936594.0013](https://doi.org/10.1079/9781845936594.0013).

Kenison, L. 2016. The effects of classical music on dairy cattle. Alfred University Honors

Thesis.

Lemcke, M.C., Ebinghaus, A., & Knierim, U. 2021. Impact of music played in an automatic

milking system on cows' milk yield and behavior—A Pilot Study. *Dairy* 2:73-78.

Mellor, D. J. et al. 2020. The 2020 five domains model: including human-animal interactions in

assessments of animal welfare. *Animals* 10(10), 1870.

Mellor, D.J. & Stafford, K.J. 2001. Integrating practical, regulatory and ethical strategies for

enhancing farm animal welfare. *Australian Veterinary Journal* 79 (11): 762-768.

Munksgaard, L. et al. 2020. Changes to steps, lying, and eating behavior during lactation in

Jersey and Holstein cows and the relationship to feed intake, yield, and weight. *Journal of*

Dairy Science 103(5): 4643-4653.

Rajala-Schultz, P. J. et al. 1999a. Effects of clinical mastitis on milk yield in dairy cows. *Journal*

of Dairy Science 82(6):1213-20.

Rajala-Schultz, P.J., Gröhn, Y.T. & McCulloch, C.E. 1999b. Effects of milk fever, ketosis, and

lameness on milk yield in dairy cows. *Journal of Dairy Science* 82(2): 288-294.

Rousing, T. et al. 2004. Stepping and kicking behaviour during milking in relation to response in

human-animal interaction test and clinical health in loose housed dairy cows. *Livestock*

Production Science 88:1-8.

- Schuppli, C. A. et al. 2014. Access to pasture for dairy cows: Responses from an online engagement. *Journal of Animal Science* 92: 5185-7725.
- Soffié, M., Thinés, G. & De Marneffe, G. 1976. Relation between milking order and dominance value in a group of dairy cows. *Applied Animal Ethology* 2(3): 271-276.
- Sutherland, M. A., Rogers, A. R., & Verkerk, G. A. 2012. The effect of temperament and responsiveness towards humans on the behavior, physiology, and milk production of multi-parous dairy cows in a familiar and novel milking environment. *Physiology & Behavior* 107 (3): 329-337.
- Ventura, B. A. et al. 2013. Views on contentious practices in dairy farming: the case of early cow-calf separation. *Journal of Dairy Science* 96 (9): 6105-6116.
- von Keyserlingk, M.A.G. et al. 2013. Invited review: Sustainability of the US dairy industry. *Journal of Dairy Science* 96(9): 5405-5425.
- Willis, G. L. 1983. A possible relationship between the flinch, step and kick response and milk yield in lactating cows. *Applied Animal Ethology* 10: 287-290.

Figure 1. Effect of different music genres played during milking on milk yield (kg); treatments in parentheses indicate the referent genre for each comparison

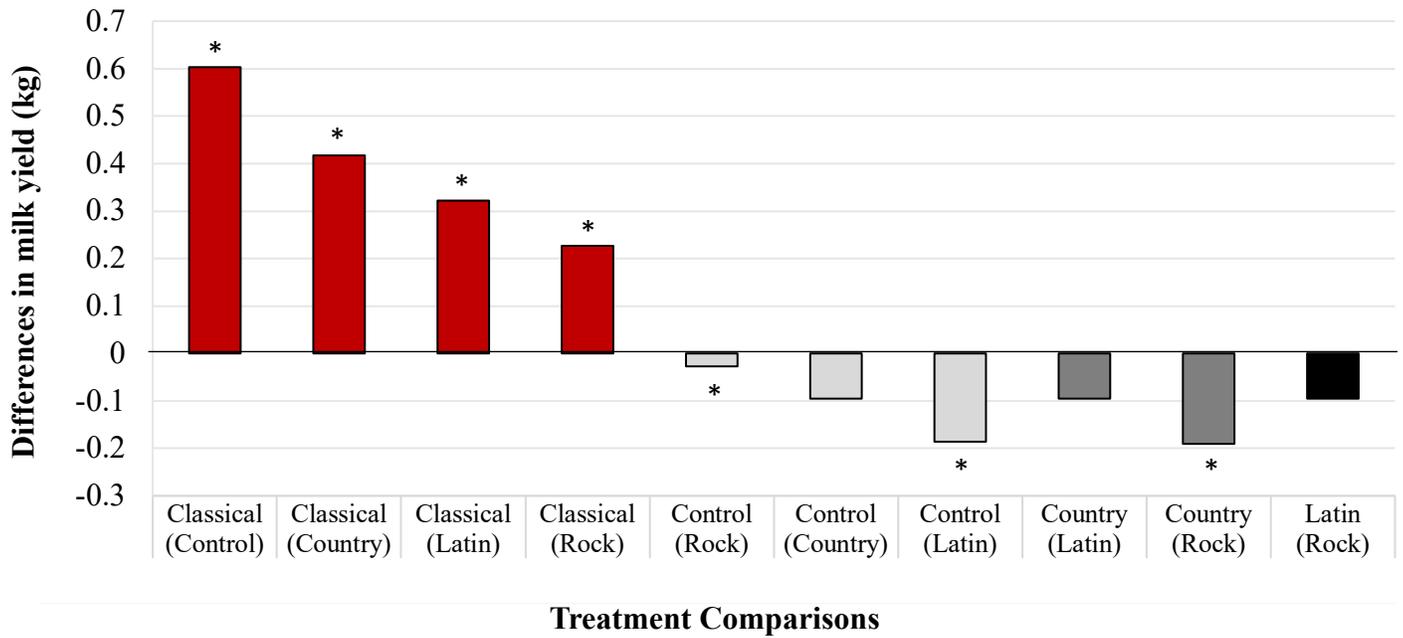


Table 1. The different genres of music or the control that cows were exposed to in the current experiment over four 5-day periods, whereby one genre of music was played during each milking

Replicate	Day 1	Day 2	Day 3	Day 4	Day 5
1	Country	Latin	Control	Classical	Rock
2	Classical	Latin	Country	Rock	Control
3	Rock	Country	Latin	Classical	Control
4	Latin	Control	Rock	Country	Classical

Table 2. Description of the flinch, kick, and step (**FSK**) behavioral responses assessed during milking on lactating dairy cows

Score	Score Description*
1	No hind foot movement, cow may flinch, shiver, or not react at all
2	Cow may step or shuffle the hind legs; the hind leg is lifted <20cm
3	The cow may step or kick forward with the hind legs; the hind leg is lifted >20cm
4	The cow uses a hind leg to kick backwards

*Scoring system adapted from Sutherland et al. (2012)

Table 3. Effect of music genres played during milking on milking duration (seconds); milking duration is expressed as differences of least squares means \pm SEM between the music treatment and referent genres

Treatment	Referent	Duration (sec)	SEM	P-value
Classical	Control	9.6	2.8	0.0007
Classical	Country	2.4	2.8	0.34
Classical	Latin	6.0	2.8	0.034
Classical	Rock	2.4	2.8	0.37
Control	Country	-6.6	2.7	0.02
Control	Latin	-3.6	2.7	0.21
Control	Rock	-6.6	2.7	0.01
Country	Latin	3.0	2.7	0.24
Country	Rock	0.00	2.8	0.95
Latin	Rock	-3.6	2.8	0.22

Table 4. Effect of different music genres on the flinch, kick, and step (FSK) behavioral responses of cows during milking

Treatment	Referent	OR*	95% CI	P-value
Classical	Control	0.93	0.64 to 1.35	0.71
Country	Control	0.94	0.61 to 1.43	0.76
Latin	Control	0.81	0.51 to 1.28	0.37
Rock	Control	0.74	0.49 to 1.23	0.16
Classical	Rock	1.25	0.67 to 1.46	0.24
Country	Rock	1.26	0.78 to 1.70	0.31
Latin	Rock	1.09	0.86 to 1.83	0.68
Classical	Country	1.00	0.80 to 1.67	0.98
Latin	Country	1.16	0.73 to 1.63	0.44
Classical	Latin	1.15	0.81 to 1.97	0.48

*Odds ratios reflect the odds of a lower FSK score