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EDITED BY

Lena Maria Lidfors,
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Sweden

REVIEWED BY

Vishal Suthar,
Gujarat Biotechnology University, India
Krisztina Nagy,
University of Hertfordshire, United Kingdom

*CORRESPONDENCE

Jessica A. Pempek
✉ jpempek@purdue.edu

†PRESENT ADDRESS

Jessica A. Pempek,
Department of Animal Sciences, Purdue
University, West Lafayette, IN, United States

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Effect of different genres of music on behavior and milking parameters of dairy cows during milking

Madison P. Pinkerton¹, Zachary England¹, Benjamin A. Wenner¹
and Jessica A. Pempek^{2*†}

¹Department of Animal Sciences, The Ohio State University, Columbus, OH, United States,

²U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), Livestock Behavior
Research Unit, West Lafayette, IN, United States

Compared to other enrichment modalities, relatively few studies have been conducted to evaluate sensory stimulation as environmental enrichment in dairy cows. The aim of this study was to explore the effect of music played in the milking parlor on the behavior and milking parameters of dairy cows during the afternoon milking. Ninety-one Jersey cows were introduced to one of five music treatments, including no music or classical, country, Latin, rock music genres, in the milking parlor over four 5-day periods in a switchback experiment. One music treatment was applied per day. The amount of milk harvested from the afternoon milking and milking duration were recorded for all cows, and average milk flow rate was calculated. Cow behavior at milking cluster attachment was video recorded and assessed for a subset of cows ($n = 38$) by scoring flinch, step, or kick (FSK) responses using a 4-point system based on the direction and height of hind leg movements. The amount of milk harvested increased by 0.5, 0.3, 0.4, and 0.2 kg when classical music was played compared to no music, country, Latin, and rock, respectively. Treatment did not influence milking duration, average milk flow rate, or FSK responses. Future research is needed to explore the possible influence of parlor music on aspects of human behavior and preference for music genres. Other aspects of animal behavior (e.g., temperament, total number of FSK responses) should also be considered in future studies, as well as cows' response to music in other farm environments.

KEYWORDS

animal welfare, behavior, dairy cow, music, productivity

1 Introduction

Environmental enrichment can enhance animal welfare by promoting naturalistic behavior and reducing the incidence of behavioral problems (Newberry, 1995; Ninomiya, 2014). Compared to other enrichment modalities, relatively few studies have been conducted to evaluate sensory stimulation as environmental enrichment in dairy cows

(Mandel et al., 2016). However, some research has investigated the influence of music on milk production and physiology. For example, Lemcke et al. documented an increase in milking frequency when different music genres of similar tempo were played inside an automated milking system compared to no music (Lemcke et al., 2021). Another study reported higher milk yields and lower fecal glucocorticoid metabolite concentrations in dairy cows with constant exposure to classical music compared to limited (i.e., parlor music only) and no music exposure (Erasmus et al., 2023). Still, opportunity exists to explore the potential beneficial effects of different music genres played in the parlor on milk production and efficiency.

Using ethological methods and principles to study of animal welfare is important to understand how animals interact, respond to, and control their environment (Dawkins, 2004). A flinch, step, kick (FSK) response can be a useful tool to assess the behavior of dairy cows using the height and direction of their leg movements (Willis, 1983; Hemsworth et al., 2002; Stewart et al., 2017). For example, high FSK scores have been documented in lactating cows in stressful situations and are indicative of restlessness (Willis, 1983). Sutherland et al. also reported variable FSK behaviors in cows with different temperaments, as indicated by their coping response to an environmental stressor (Sutherland et al., 2012). Further, dairy cows that are fearful of humans take more steps during milking compared to those that are less fearful (Rousing et al., 2004). Thus, FSK responses can be used to better understand how dairy cows are influenced by music played in the milking parlor but have yet to be investigated.

The aim of this study was to explore the effect of music played in the milking parlor on the behavior and milking parameters of dairy cows during the afternoon milking. Music was played consistently in the milking parlor prior to the start of this study, and because previous research has documented that routine deviations can cause stress and negatively impact milk production (Sutherland et al., 2012), we hypothesized that parlor music would improve milking parameters and reduce FSK responses compared to no music.

2 Materials and methods

2.1 Animal care and use

This study was conducted with lactating Jersey cows at the Waterman Dairy Center in Columbus, Ohio from November to December 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 this study. All cows at the Waterman Dairy Center were managed in accordance with *The Guide for Care and Use of Agricultural Animals in Research and Teaching*.

2.2 Experimental design and animal management

All lactating cows were housed in a freestall barn and milked twice daily in a double eight herringbone parlor at 0400 and 1600 h. Experimental animals included all cows in the lactating herd ($n = 91$), with an average parity of 2.3 ± 1.3 (mean \pm SD; range 1 to 6), average days in milk of 165.7 ± 101.4 (range 11 to 492), and average milk production of 28.0 ± 6.2 kg/d (range 7.2 to 53.6 kg/d).

Cows were exposed to each of the five music treatments in a switchback experiment. The five treatments were: 1) no music, 2) classical music, 3) country music, 4) Latin music, and 5) rock music. To assess the influence of different genres of music played during the afternoon milking on dairy cow behavior and milking parameters, four music playlists were created, with each playlist composed of one genre of music to impose the corresponding music treatment. Playlists were created using an audio streaming application (Spotify, Stockholm, Sweden), composed of the most popular songs of each music genre. Music was not played in the parlor for the 'no music' treatment group.

This study included four periods of the following: 5 days of data collection, followed by 1 day of non-experimental testing, in which routine milking procedures commenced without data collection (Figure 1); this study started on a Sunday and concluded on a Tuesday. Within each period, treatment order was randomly assigned, with one treatment per day (afternoon milking). During each afternoon milking, no music or the selected playlist played at a constant volume in the parlor. Prior to the beginning of the experiment, the sound level in the parlor during milking was approximately 46.0 decibels (dB), and volume levels remained consistent throughout the study across treatments. Each playlist was approximately 2.5 h long, and the shuffle play feature (i.e., songs were played in a random order) was utilized. If the music playlist concluded prior to the end of milking, a member of the research staff restarted the playlist. During each morning milking, routine milking procedures were followed, void of music treatments or data collection.

2.3 Behavior

A subset of cows ($n = 38$) was selected from the larger lactating herd to assess cows' behavioral response to the attachment of the milking cluster during the afternoon milking. This subset of cows was selected based on the following criteria: 1) >60 days in milk, 2) in their first or second lactation, and 3) continued lactation during the experimental period. Selected cows had an average parity of 1.5 ± 0.5 (mean \pm SD; range 1 to 2), average days in milk of 172.6 ± 50.2 (range 71 to 265), and average milk production of 26.7 ± 5.0 kg/d (range 7.2 to 40.2 kg/d). During attachment of the milking cluster, each cow's behavior was assessed, and a FSK score was given based on their response to this procedure using a 4-point system (Sutherland et al., 2012): score 1 = no hind leg movement, cow may flinch, shiver, or not react at all; score 2 = cow may step or shuffle the hind legs; the hind leg

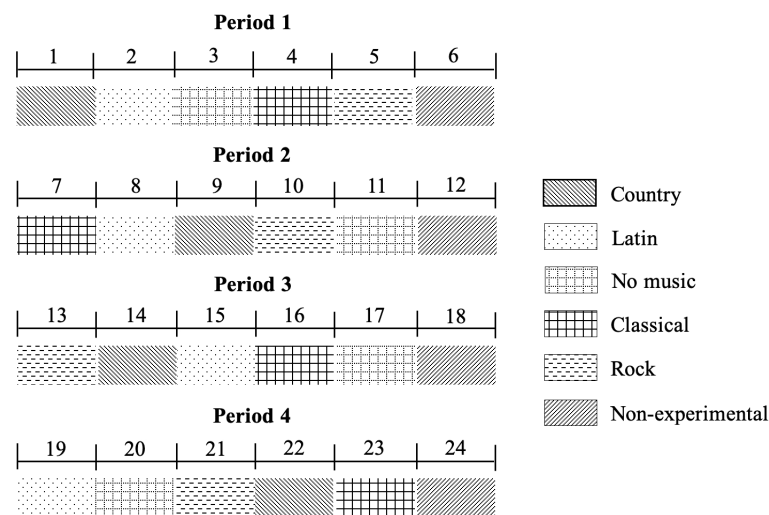


FIGURE 1

Experimental design depicting the 24-d study period. Music treatments (no music, classical, country, Latin, or rock music) were randomly assigned within each period, and one non-experimental day separated each period.

is lifted <20 cm; score 3 = the cow may step or kick forward with the hind legs; the hind leg is lifted >20 cm; score 4 = the cow uses a hind leg to kick backwards. Four video cameras (Panasonic HC-V180 Full HD camcorders, Osaka, Japan) were installed above the milking stalls in the parlor; each camera was able to view four milking stalls or four cows during milking. Information collected by the AfiMilk system (e.g., cow order, milking stall number) was used to identify the individual cows on the video. To assess the influence of music treatment on the cow's behavioral response to cluster attachment, videos were watched continuously by one trained observer (MP), and a FSK score was assigned for each cow during cluster attachment at the beginning of the afternoon milking(s).

2.4 Milking parameters

The amount of milk harvested and milking duration were automatically recorded (AfiMilk, Kibbutz Afikim, Israel) for each afternoon milking; milking duration began when the milking cluster was manually attached and ended when the unit automatically detached. Temperature (°C) and relative humidity (%) were recorded from 1600 to 1900 h at the Columbus station of the Ohio Agricultural Research and Development Center, located 0.5 km from the Waterman Dairy Center. The temperature-humidity index (THI) was calculated as: $(1.8T + 32) - [(0.55 - 0.0055RH) \times (1.8T - 26)]$, where T is the air temperature in °C and RH is relative humidity in % (NRC (National Research Council), 1971).

2.5 Statistical analysis

Behavior and milking parameter data were manually entered into Microsoft Excel (Microsoft Corp., Redmond, WA) and checked for errors and completeness; data from the morning milking were not

collected and, therefore, not included in the analysis. Two cows were diagnosed with mastitis during the experimental period and were excluded from all analyses due to the likely confounding influence of mastitis on both milking parameters (Rajala-Schultz et al., 1999) and behavior (Mainau et al., 2022). Average milk flow rate was calculated by dividing the total milk harvested during the afternoon milking by total milking duration. Continuous variables (the amount of milk harvested, milking duration, average milk flow rate) were analyzed using a linear mixed-effects model (PROC MIXED in SAS version 9.4; SAS Institute Inc., Cary, NC), and *post hoc* multiple pairwise comparisons were performed using Tukey-Kramer's adjustment to avoid inflation of type I error rate. An ordinal logistic regression model (PROC GLIMMIX), using a cumulative logit link function, was used to determine the association between FSK scores and different music treatments; contrasts were made between treatments using the ESTIMATE statement of PROC GLIMMIX. All models included the fixed effects of treatment, sequence, period, parity, days in milk categorized by quartiles (<130 days, 130 to 177 days, 178 to 211 days, >212 days), and THI, with cow within sequence included as a random effect. Because the order of treatments (sequences) was randomized across cows, we included cow (sequence) as a random effect to account for their individual response within a sequence. We included sequence (i.e., randomized treatment order) as a fixed effect to ensure that no single treatment was systematically advantaged or disadvantaged by its position in the sequence. The amount of milk harvested was also included as a covariate in the model for milking duration. Statistical significance was declared at a level of $P < 0.05$.

3 Results

3.1 Behavior

The average FSK score was 1.8 ± 0.7 (mean \pm SD; range 1 to 3). Overall, cows' behavioral response during cluster attachment was

minimal; 33.5% (229/683) of cows received a FSK score of 1, 48.6% (332/683) received a FSK score of 2, and 17.8% (112/683) received a FSK score of 3. No significant differences in FSK scores were observed in response to the different music treatments (Table 1). FSK scores were not influenced by days in milk, parity, period, or THI.

3.2 Milking parameters

Milking parameter results are summarized in Table 1. The amount of milk harvested increased ($P < 0.01$) by 0.5, 0.3, 0.4, and 0.2 kg per afternoon milking when classical music was played compared to no music, country, Latin, and rock music, respectively (Figure 2). The amount of milk harvested also increased ($P < 0.01$) by 0.3 kg per afternoon milking when country and rock versus no music was played in the parlor (Figure 2). No significant differences in the amount of milk harvested were observed between Latin music compared to country or no music, as well as rock music compared to country or Latin music (Figure 2). Milking duration averaged 5.0 ± 1.3 min (mean \pm SD; range: 2.3 to 10.4 min). However, no significant differences in milking duration were observed between treatments (Table 1). Average milk flow rate was 2.9 ± 0.7 kg/min (mean \pm SD; range: 0.9 to 5.5 kg/min), and no significant differences were observed between treatments. Temperature and relative humidity from 1600 to 1900 h averaged $6.8 \pm 4.5^\circ\text{C}$ (mean \pm SD; range: -3.1 – 15.3°C) and $64.8 \pm 15.8\%$ (mean \pm SD; range: 39.4–99.3%), respectively. THI averaged 51.5 ± 3.6 (mean \pm SD; range: 44.3–58.8).

4 Discussion

4.1 Behavior

Behavior, as measured by FSK responses at the time of milking cluster attachment, was similar across music treatment groups. One possible explanation for this may be the ordinal scoring system that was used in this study. Cows were not observed kicking backwards when the milking cluster was applied, i.e., no cows received a FSK score of 4, and the main behavioral difference was whether a cow lifted her hind leg and how high it was lifted. The lack of high FSK scores may indicate that cows across treatments were experiencing

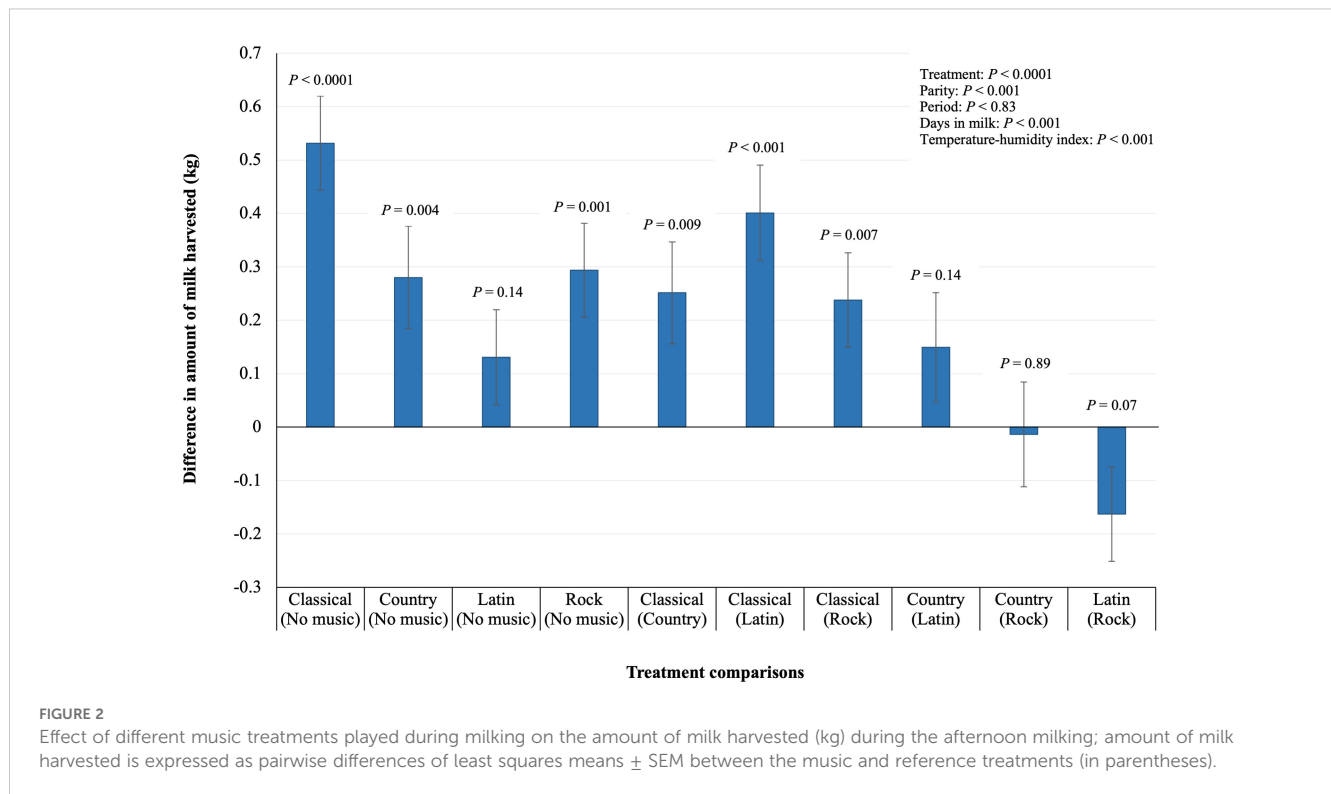
low arousal and stress in the milking parlor (Willis, 1983) due to familiarity with this environment, as well as frequent handling and human-animal interaction. Our behavior results are similar to Sutherland et al. who reported a mean FSK score of 1.5 for multiparous cows in a familiar environment. However, higher FSK scores (e.g., 2.2 to 2.8) at the time of milking cluster attachment have been reported for first-lactation heifers during the first week of lactation (Sutherland et al., 2012). Future studies could consider the frequency of steps or hind leg movements for the duration of milking, which could be used as a more sensitive indicator of cow comfort. Further, although music treatment did not influence FSK response, sensory stimulation as environmental enrichment might influence other behaviors (e.g., anxiety-related behaviors, how readily cows approach the milking parlor, social behavior, etc.) that were not measured in this study. For instance, Uetake et al. investigated the influence of music on dairy cows' voluntary approach to an automated milking system and reported an increase in the number of cows that occupied the holding area when classical music was played compared to no music (Uetake et al., 1997). Additionally, piglets exposed to classical versus no music post-weaning had increased play behavior, an indicator of a positive affective state (de Jonge et al., 2008). Although the relationship between FSK score and milking parameters was not investigated in the current study, others have found a negative correlation between FSK score and milk yield in heifers during one and six weeks of lactation, but no significant correlations were observed between FSK score and milking duration or milk flow rate (Sutherland and Dowling, 2014).

Although this study did not control for the influence of music on human behavior, perhaps the presence (or absence) of music, as well as the genre, impacted dairy farm employees' behavior and animal handling. Moregaonkar et al. reported that, in addition to increasing milk production in dairy cows, Indian instrumental music improved employees' work efficiency in the milking parlor (Sutherland and Dowling, 2014). Additional evidence in the human literature suggests that the absence of music in the workplace results in lower quality-of-work and reduced positive affect (Lesiuk, 2005). Although this warrants further investigation, perhaps dairy farm employees experienced fewer positive emotions and/or were less efficient when no music was played in the milking parlor (compared to classical, Latin, and rock music), which could have influenced animal handling and milking parameters. Additionally, other

TABLE 1 Effect of different genres of music played in the milking parlor during the afternoon milking on average milk flow rate (kg/min), the amount of milk harvested (kg), milking duration (min), and flinch, step, kick score; variables are expressed as least squares means \pm SEM.

Variable	Music treatment					SEM	P-value
	No music	Classical	Country	Latin	Rock		
Average milk flow rate, kg/min	2.8	2.9	2.9	2.8	2.8	0.04	0.15
Milk harvested, kg	13.5 ^c	14.0 ^a	13.8 ^b	13.6 ^{bc}	13.8 ^b	0.13	<0.001
Milking duration, min	5.0	5.1	5.0	5.1	5.1	0.06	0.23
Flinch, step, kick score, 1 to 4	1.8	1.8	1.8	1.9	1.9	0.7	0.60

^{a-c}Means within a row without a common superscript differ ($P < 0.01$).



studies with human subjects have documented that lyrical music negatively influenced attention and concentration compared to non-lyrical music (Shih et al., 2012). Classical was the only non-lyrical music genre in this study and could have increased attention and concentration among dairy farm employees during milking, leading to more positive animal handling experiences. However, this, too, requires further investigation, and we encourage future work in this area to determine the possible association between music, animal handling, and dairy cow welfare.

4.2 Milking parameters

Classical music increased the amount of milk harvested during the afternoon milking compared to no music and country, Latin, and rock music. Classical music is highly orchestrated and organized in tempo, pitch, and tonality (Lemmer, 2008). Because of this, we speculate that classical music could have been perceived as comforting or more relaxing from the cow's perspective compared to other music genres or no music. It is also possible that music with faster tempo markings may have caused a startle response and perhaps interrupted milk let-down and ejection, reducing the amount of milk harvested (Bruckmaier, 2005). However, this warrants further investigation.

In support of our results, Erasmus et al. reported that exposing cows to constant classical music for 28 d increased milk yield compared to limited or no exposure to classical music (Erasmus et al., 2023). Furthermore, higher milk yields were also observed when Indian instrumental music was played during milking in alternating months for 1 yr by Moregaonkar et al. (2006)

(Sutherland and Dowling, 2014). There is also evidence in other food animal species that suggests classical music enhances health and performance (Gvoryahu et al., 1989; Li et al., 2020). For example, pigs exposed to classical music for 60 d had a stronger immune response (e.g., higher levels of immunoglobulin G, interleukin-2, interferon gamma) compared to those exposed to mechanical noise or the control (Li et al., 2020). Classical music has also been reported to significantly increase body weight in 8-week-old chicks versus control chicks that were not exposed to music (Gvoryahu et al., 1989). Given this potential, the use of classical music to enhance health and performance should continue to be considered and studied in dairy cows, as well as other species.

In addition to the genre, it is important to consider how the duration of exposure and sound level of the music affects the animals, as well. In this study, cows were exposed to a different music treatment daily across each period. In comparison, the duration of exposure to the music treatment(s) across previous studies varied, with studies investigating days [4 and 6 d; Lemcke et al. (2021)] to weeks [28 d; Erasmus et al. (2023)] to months [69 d; Uetake et al. (1997)]. It is possible that, if cows were exposed to the same music treatment for a longer period, the effects on the amount of milk harvested would have been maintained. Another possibility is that cows would have habituated to the music treatment over time and the amount of milk harvested may have returned to initial levels. The sound level of the music in the milking parlor in the current study was 46 dB. There is some evidence in dairy cows that suggests sound levels of 80 dB increased anxiety-related behaviors and heart rate and reduced feed intake, and if sound levels reached or exceeded 100 dB, blood glucose levels and leukocytosis also increased (Li et al., 2020). Similarly, dairy cows acutely exposed to

85 dB of a pink noise stimulus showed increased arousal, avoidance, and sympathetic activation, compared to 65 dB (Johns et al., 2017).

While many factors can influence milking efficiency, duration of unit attachment and individual cow performance characteristics are particularly important. There was no evidence to suggest significant differences in milking duration or average milk flow rate among music treatments in this study. It is difficult to entirely discern the milking duration results, as a cow that is producing more milk (as observed in response to the classical music treatment) might simply require a longer duration to complete milking. In contrast, a longer milking duration might also indicate disturbed milk let down (Szentléleki et al., 2015). Future studies could consider the use of a lactometer to assess milk flow parameters and further evaluate the effect of music treatment on milking duration and average milk flow rate. Additionally, milking duration and average milk flow rate were influenced by days in milk and parity in our study, which has been reported by others (Sandrucci et al., 2007). Other factors, such as pre-milking procedures (Sandrucci et al., 2007) and end-of-milking flow settings (Stewart et al., 2002), can also affect milk flow traits and may have a larger impact than the auditory environment.

When interpreting the results of this study, a limitation to consider is the study design and lack of a contemporary control group. Although a 'no music' treatment group was included, it was imposed on different days than the genres of music, and explanations for the observed differences beyond the cow level cannot be discounted. Additionally, the study design did not include a habituation period, whereby cows could adapt to the different treatments before experimental measures were taken, and carry-over effects between genres are possible. Perhaps, different milking technicians were present over the course of the study, and it is possible that their response to the music treatment influenced animal handling. Further, although we did not observe any differences across period, we did not record management-based changes, such as diet modifications, which could have impacted milking parameters. Another possible limitation to consider is the lack of data from the morning milking session(s), which could have been used to assess other milking parameters, such as completeness of milking. Finally, because Spotify-generated playlists were used for this study (i.e., the authors did not select the individual pieces of music), variability in the tempo, mood, etc. might have been present across the pieces of music within each genre.

In conclusion, different genres of music, particularly classical music, increased the amount of milk harvested during the afternoon milking. However, music did not influence milking duration, average milk flow rate, or cows' FSK responses during milking cluster attachment. Future research is needed to explore the influence of different music genres on factors beyond the cow level, such as changes in human behavior, animal handling, or employee preference for a particular genre(s). Future research should also investigate the effects of different genres of music on Holstein cattle behavior, productivity, and temperament, as well as on commercial operations and in other farm environments, such as loose housing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The animal study was approved by The Ohio State University Institutional Animal Care and Use Committee. The study was conducted in accordance with the local legislation and institutional requirements.

Author contributions

MP: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. ZE: Conceptualization, Data curation, Investigation, Project administration, Supervision, Writing – review & editing. BW: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Writing – review & editing. JP: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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