The annotated bibliography is organized under two topics. The first is stress behaviors and responses in kennelled dogs and the second is the effect of auditory enrichment on these this stress. These sections are each independently organized chronologically.

**Stress Behaviors in Kennelled Dogs**

**Beerda, B., Schilder, M. B. H., van Hooff, Jan. A. R. A. M., & de Vries, H. W. (1997). Manifestations of chronic and acute stress in dogs. *Applied Animal Behaviour Science*, *52*(3–4), 307–319.** [**https://doi.org/10.1016/S0168-1591(96)01131-8**](https://doi.org/10.1016/S0168-1591%2896%2901131-8)

**Summary:** Adverse conditions and environments can lead to reduced welfare in dogs. Stress responses are potential indicators of poor welfare in dogs and this article reviews studies of dogs experiencing stressors to evaluate these responses as indicators of poor welfare. Stress responses are categorized as being behavioural, physiological or immunological. The authors review how dogs show each of these types of stress responses and evaluate these responses for their suitability to measure poor welfare in dogs. Behavioral responses that have been observed and recorded in the literature include increased vocalization frequency and behavioural elements associated with fear and submission which include snout licking, paw lifting and a lowered posture. The performance of thermoregulatory behaviour such as increased salivation, panting and anti-diuresis and the development of stereotypies are other behaviors associated with more severe stress. Dogs experiencing stress have also been shown to display physiological changes. These changes include changes in hypothalamic pituitary adrenal axis which is established by measuring cortisol and sympathetic adrenal medullary axis activity in which cardiovascular activity is measured. Immunological stress responses are not as commonly reported as behavioural or physiological data. In order to accurately detect and assess welfare in dogs using stress responses, these stress responses must be reliably measured. Adaptations to stress indicate reduced welfare so many of the discussed stress indicators need to be validated with respect to chronic stress. The authors conclude that in order to improve stress response interpretation in relation to dogs’ welfare there are multiple strategies to accomplish this. Using already known knowledge on canine stress responses, measuring multiple stress and testing for physiological adaptations to stress are all effective strategies that the authors believe will provide a valid interpretation of stress responses.

**Contribution:** This review article summarizes the scientific literature regarding how dogs show behavioral, physiological and immunological stress responses and it evaluates stress responses regarding their applicability as measures of poor welfare in dogs. It also provides effective strategies for improving the interpretation of stress responses regarding the welfare of dogs. It recommends that additional studies are conducted to investigate acute stress parameters as possible indicators of chronic stress as adaptation may counteract the initial stress response and render parameters of acute stress useless for assessing chronic stress.

**Beerda, B., Schilder, M. B. H., Van Hooff, J. A. R. A. M., De Vries, H. W., & Mol, J. A. (1999). Chronic stress in dogs subjected to social and spatial restriction. I. Behavioral responses. *Physiology & Behavior*, *66*(2), 233–242.** [**https://doi.org/10.1016/S0031-9384(98)00289-3**](https://doi.org/10.1016/S0031-9384%2898%2900289-3)

**Summary:** Poor welfare in dogs is thought to be induced by chronic stress. Reliable methods for measuring stress as well as knowing how it is manifested are necessary. Studies show that changes in a dog’s housing conditions can be stressful, changing their behaviour and physiology without an extreme affect to their well-being. This experiment induced chronic stress in Beagles using social and spatial restriction and behavioral parameters were measured to investigate whether these parameters indicate chronic stress. Fifteen Beagles were exposed to an enriched outdoor housing period in groups for seven weeks followed by a solitary housing period in smaller indoor kennels for six weeks. For ten minutes at a time, behavioral observations were conducted in a continuous manner. Six observation periods per individual per week were obtained during weeks four and five of group housing, and during the first five weeks of individual housing. The frequency and duration of occurrence of the behaviors were then analyzed. It was found that social and spatial restriction was significantly related to changes in the behavior of the dogs by resulting in increased frequency and duration of behaviours that have been previously associated with stress. Indicators of chronic stress may include increased vocalization, low posture, self-grooming, paw lifting, repetitive behavior, and coprophagy. Higher levels of excitement, aggression, and uncertainty can also be present in dogs experiencing chronic stress. These behaviors and patterns can thus potentially identify poor welfare. It was also indicated in the results that female dogs respond more strongly to stressors than male dogs. The authors conclude that their findings from this study may help to identify chronic stress in dogs but their use in other scenarios outside of experimental conditions must be cautious as a specific time frame, dog breed and social and spatial restriction context were used in the experiment.

**Contribution:** The findings from this study indicate through the measurement of many different parameters that social and spatial restriction induced an array of changes in the spontaneous and stimulated behavior of the dogs. The authors concluded that the resulting behavior will not be specific to a state of chronic stress, and it will be of limited use for the assessment of stress outside an experimental setting. The findings may help to identify chronic stress, but their extrapolation to field situations should be exercised with caution.

**Hiby, E., Rooney, N., & Bradshaw, J. (2006). Behavioural and physiological responses of dogs entering re-homing kennels. *Physiology & Behavior*, *89*(3), 385–391.** [**https://doi.org/10.1016/j.physbeh.2006.07.012**](https://doi.org/10.1016/j.physbeh.2006.07.012)

**Summary:** Measuring the welfare of dogs is a relatively understudied area. Research has recently focused on the use of physiology in welfare assessment, usually through cortisol levels. When examining cortisol as a measure of stress, behavior must also be observed as cortisol is produced from any arousal. Using admission to a rescue centre as a naturally occurring stressor, the authors investigated the effectiveness of welfare measures for domestic dogs. Kennels have been shown to lead to elevated cortisol/creatinine ratios (C/C) levels in dogs. The authors examined the relationship between history and a dog's stress response as the extent of this response is likely to be affected by the dogs' past experience. This study monitored behaviour patterns and urinary C/C in 26 dogs, on days one, two, three, five, seven and ten following admission to the kennel. Dogs were categorised into two different history categories; dogs from a home and strays/returns. The change in C/C over time was different for the two groups of dogs with different levels of habituation to the kennel environment indicating that using urinary C/C as a measure of welfare in dogs was successful. The behavior patterns that changed significantly were an increased frequency of drinking and time spent grooming and decreased time spent panting and paw lifting. C/C did not decrease consistently throughout the study and these changes in behaviour therefore do not definitively indicate a change in long-term stress but could be helpful to communicate short-term stress. The authors therefore conclude that the relationship between C/C and activity is complex and requires further evaluation. They also indicate that further studies regarding the welfare of kennelled dogs should use multiple parameters, as no single one has been found effective alone.

**Contribution:** This study compared physiological and behavioural measures for the assessment of the welfare of dogs in a shelter situation. The relationship between C/C and behavior is complex and warrants further investigation before C/C can be considered as a reliable indicator of welfare in this species. The authors concluded that studies of the welfare of domestic dogs in kennel environments should continue to use multiple parameters, as no single welfare parameter has yet been found to be effective alone, as consistent with previous findings.

**Effect on Auditory Enrichment on Stress Behaviors**

**Wells, D. L., Graham, L., & Hepper, P. G. (2002). The influence of auditory stimulation on the behavior of dogs housed in a rescue shelter. *Animal Welfare*, *11*(4), 385–393.**

**Summary:** Housing is provided for many stray, abandoned and homeless dogs by shelters, but these conditions and the environment itself can be stressful. Auditory enrichment has been studied in many species and studies have found changes in the behavior and physiology of animals exposed to auditory stimulation. The effect of auditory stimulation on the behavior of dogs housed in animal rescue shelters has not yet been investigated. The influence of five types of auditory stimulation which include human conversation, classical music, heavy metal music, pop music and a control, as well as the length of exposure to each condition, on the behavior of sheltered dogs was examined in this study. 50 dogs were exposed to each type of auditory stimulation for four hours with a period of one day between conditions. Each day, a new condition was presented. During the four hours, the dogs’ position in their kennels, their activity, and their vocalization were recorded using a scan sampling technique at ten-minute intervals for each of the five conditions. The results of these three separate aspects of behavior indicated that the dogs’ activity and vocalization were both significantly related to the auditory stimulation but that the length of exposure to the auditory stimulation had no effect on either. Classical music being played resulted in dogs spending more time resting and less time standing as well as spending the most time quiet when compared to all other conditions. These results suggest that classical music results in activities and behaviors suggesting relaxation. Additionally, heavy metal music resulted in more time spent barking. The authors therefore conclude that the type of auditory stimulation that kennelled dogs are exposed to significantly influences their welfare and that their welfare can therefore be enhanced using certain types of auditory stimulation, notably classical music.

**Contribution:** The findings from this study suggest that the behavior of sheltered dogs is influenced by the type of auditory stimulation that they are exposed to, with classical music having a relaxing effect on activity and behavior. The effect of auditory stimulation on the behavior of kennelled dogs had been unknown and this study examined whether enriching the environment of sheltered dogs through auditory stimulation would have a positive effect on their behavior and therefore, their welfare.

**Kogan, L. R., Schoenfeld-Tacher, R., & Simon, A. A. (2012). Behavioral effects of auditory stimulation on kenneled dogs. *Journal of Veterinary Behavior*, *7*(5), 268–275.** [**https://doi.org/10.1016/j.jveb.2011.11.002**](https://doi.org/10.1016/j.jveb.2011.11.002)

**Summary:** The kennel environment can be very stressful for dogs and this stress can impact individual health and lifespan when this stress is continuous. Sensory stimulation, a category of environmental enrichment, includes auditory stimulation and is a method for stress reduction that is being investigated for use in kennels This article examined how the behavior of kennelled dogs is affected by auditory enrichment. This study used classical, heavy metal, specifically designed classical, and no music (control) to investigate the effect of auditory enrichment on aspects of dog behavior. Over four months, 117 dogs were presented three music or control conditions daily which were randomized and tested each day for 45 minutes each, followed by 15 minutes of silence. Every five minutes, instantaneous sampling was used to record the dogs’ behaviors where the number of times the dog performed the behavior in each category was recorded. Sleeping or not sleeping was recorded for activity, silent or not silent was recorded for vocalization and shaking or not shaking was recorded for body movement. Each of the three aspects of behavior was significantly influenced by auditory stimulation. Compared to other conditions, classical music resulted in more time sleeping and less time vocalizing while heavy metal increased body shaking. The effects of classical music are suggestive of relaxation and conversely, the effects of heavy metal are suggestive of nervousness. Additionally, there was not a significant difference in resultant behavior influenced by the specifically designed classical music for any of the behavior categories. The authors conclude that auditory stimulation can affect the behavior of kennelled dogs and specifically, playing classical music in the shelter can reduce stress that is induced by this environment.

**Contribution:** The findings from this study suggest that auditory stimulation can affect kennelled dogs’ behaviors and stress levels, and therefore, can be used to enhance the welfare of shelter dogs. This study furthered the only previously published study that investigated the effect of music on dogs. Some of the findings were replicated including that classical music promoted more restful behaviors that might be associated with a reduced stress level.

**Bowman, A., Dowell, F. J., & Evans, N. P. (2015). ‘Four seasons’ in an animal rescue centre; classical music reduces environmental stress in kennelled dogs. *Physiology & Behavior*, *143*, 70–82.** [**https://doi.org/10.1016/j.physbeh.2015.02.035**](https://doi.org/10.1016/j.physbeh.2015.02.035)

**Summary:** Kennel environments present many stressors for dogs which can be both short-term and long-term. The resulting stress from exposure to these stressors can not only negatively affect dogs’ health, but also their chance of being rehomed due to behavioral changes. Environmental enrichment, and music specifically, has been used in other species to minimize stress. Music as a form of auditory enrichment for kennelled dogs has also been studied but in these experiments the duration of auditory stimulation as well as the length of the trial were limited. When exposed to classical music, a change in the dogs’ behavior has previously been reported, increasing the amount of time spent sleeping and reducing the amount of barking. This study tested whether playing classical music to kennelled dogs in a shelter environment would reduce their stress, as measured both physiologically and psychologically. The authors investigated changes in heart rate variability (HRV), salivary cortisol and behaviour of 50 dogs living in a shelter in response to seven days of exposure to classical music. They also investigated whether the response to stress was influenced by other factors. Dogs were exposed to two consecutive seven day treatments of silence and classical music using a cross-over design in which two groups had the opposite order of treatments. Data for HRV, using heart rate monitors, salivary cortisol, and behavioral observations, using scan sampling, were collected.

The findings indicate that dogs display reduced signs of physiological and psychological stress in response to auditory stimulation demonstrated by HRV and behavioural data. Classical music is likely an appropriate enrichment technique for reducing stress in kennelled dogs. Additionally, dogs became habituated to the calming effects of music the second day of exposure and music for reducing stress may be more effective in males than females.

**Contribution:** The findings of this study add to the literature relating to enrichment of the kennel environment, suggesting that classical music is an appropriate enrichment technique with the ability to considerably reduce the stress experienced by dogs a shelter. This finding is consistent with that of previous studies and additionally shows that dogs become habituated to the calming effects of music as soon as the second day of exposure and that the effects of music as an environmental enrichment tool may be more pronounced in males.

**Brayley, C., & Montrose, V. T. (2016). The effects of audiobooks on the behaviour of dogs at a rehoming kennels. *Applied Animal Behaviour Science*, *174*, 111–115.** [**https://doi.org/10.1016/j.applanim.2015.11.008**](https://doi.org/10.1016/j.applanim.2015.11.008)

**Summary:** Dogs can be kennelled for numerous reasons and this environment presents many possible sources of stress. Behavioral problems, chronic stress, and poor welfare can each potentially be caused by continued exposure to stressors in the kennel and this can also affect dogs being rehomed. A specific form of sensory environmental enrichment is auditory stimulation, and this is studied hoping to enhance the welfare of kennelled dogs. Research has found classical music to be effective in reducing stress, but other forms of auditory enrichment have yet to be investigated. This study thus investigated the behavioral effects of audiobooks as a form of auditory enrichment on kennelled dogs and compared the effects to other forms of auditory enrichment. One of five auditory conditions of audiobook, classical, pop, psychoacoustically designed dog music, and no auditory control, were presented to 31 dogs once per day for two hours. Using instantaneous scan-sampling according to an ethogram, the dogs’ behavior was recorded every five minutes. The results demonstrate that audiobooks have a significant effect on the dogs’ behavior which is relevant as activity is often used to recognize stress in shelter dogs. In response to the audiobook condition, they were found to spend less time sitting and standing and more time resting and sleeping. There were also lower levels of barking and walking, except when compared to the control. Overall, audiobooks resulted in increased levels of resting behaviors. These findings suggest that in a kennel environment, the presentation of audiobooks has the potential to be more effective in reducing stress and increasing relaxation than the other conditions that were implemented, including classical music. Audiobooks therefore can likely be used as an effective auditory enrichment tool that is easy to use and inexpensive for reducing stress and improving welfare in the shelter environment for kennelled dogs.

**Contribution:** The findings from this study suggest that audiobooks can serve as a form of auditory enrichment to have a beneficial effect on the behavior of kennelled dogs. The results suggest more positive effects upon dog behavior even compared to classical music, which has been proven in other studies to be the most effective form of auditory enrichment in kennel environments.

**Bowman, A., Dowell, F. J., & Evans, N. P. (2017). The effect of different genres of music on the stress levels of kennelled dogs. *Physiology & Behavior*, *171*, 207–215.** [**https://doi.org/10.1016/j.physbeh.2017.01.024**](https://doi.org/10.1016/j.physbeh.2017.01.024)

**Summary:** Dogs can be kennelled under different contexts and this environment can present many stressors. Dogs in shelters can stay in kennels for long periods of time and this can lead to the development of chronic stress which can impact dogs’ physical and mental wellbeing, as well as their likelihood of being rehomed. The use of auditory enrichment, notably music, to minimize stress in kennelled dogs has found that classical music has a significant effect for reducing stress, but habituation to this positive effect occurs quickly. This study aimed to determine if the previously observed beneficial effects on stress behaviors in dogs using classical music as auditory enrichment could be extended by exposing dogs to multiple music genres to reduce the onset of habituation. This experiment involved 38 dogs being exposed to one of five genres of music (soft rock, motown, pop, reggae and classical), each day, for five days and a silent control two days before and two days after auditory enrichment. Physiological responses were measured by heart rate variability (HRV) and urinary cortisol and behavioral responses were measured by behavioral data. The results demonstrate that exposure to any genre induced more time lying down and less time standing up and more barking was observed when music stopped. Both soft rock and reggae indicated reduced stress from increased HRV compared to the other genres. The beneficial physiological and behavioral changes that were observed suggest that auditory enrichment in the form of music can potentially reduce stress in kennel environments, consistent with previous studies. The authors also conclude that the reduction in stress caused by music was constant throughout the exposure, suggesting that the effect of habituation is reduced by increasing the presented types of auditory enrichment.

**Contribution:** The findings from this study suggest that auditory enrichment causes positive behavioral and physiological changes in kennelled dogs, as demonstrated in previous studies. Different genres, particularly soft rock and reggae were associated with decreases in stress and importantly, a variety of music minimizes the extent of habituation to auditory enrichment that has been observed in previous studies. These findings reinforce those of previous studies regarding auditory stimulation as an effective enrichment tool and demonstrate the requirement to identify the form of audio most suited to most dogs at a given time.

**Amaya, V., Descovich, K., Paterson, M. B. A., & Phillips, C. J. C. (2020). Effects of music pitch and tempo on the behaviour of kennelled dogs. *Animals, 11*(1), 10.** [**https://doi.org/10.3390/ani11010010**](https://doi.org/10.3390/ani11010010)

**Summary:** Dogs live in confinement for various reasons and these environments can be stressful. Behavioral issues and poor welfare can be caused by this increased stress. Behavioral arousal is characterized by increased alertness and sensory sensitivity and behavioral observations are therefore a useful tool to assess stress. Auditory enrichment is a widely used form of sensory environmental enrichment for reducing stress and music is commonly chosen as an auditory stimulus. The aim of this study was to investigate whether characteristics of music such as pitch and tempo affect arousal-related behaviors in dogs by exposing kennelled dogs to musical tracks modified for high pitch, low pitch, fast tempo, and slow tempo, as well as white noise and a control. Ten piano music songs were modified for pitch and the six treatments of four different treatment-song combinations, white noise, and control were presented to ten dogs daily, for ten minutes each over ten days. The ten days was divided into two blocks of five days with a two-day gap in between to avoid habituation. Cameras were used to record the dogs and behavior was coded by an observer using a standardized ethogram. The low pitch tracks seemed to influence behavioral changes which increased alertness, indicated by aroused tail movements. These tracks also resulted in less resting behaviors and more behaviors that indicate alertness. These results are suggestive that dogs were less relaxed and more alert when low-pitch music was played when compared to the other treatments. The increased alertness could be associated with Morton’s motivations-structural rules, where low frequency vocalizations signal aggression, leading to increased vigilance. The authors suggest that further studies to examine the effect of music characteristics on arousal-related behaviors could include more dogs, more breed diversity and various behaviours, and increase the length of the treatment period.

**Contribution:** The findings from this study suggest that the music characteristic of low pitch appears to produce changes in behavior by increasing the alertness of dogs, indicating behavioral arousal, a key component of the stress response. Auditory enrichment has been shown to reduce arousal-related behaviors in dogs in previous studies, but it was not clear whether specific characteristics of music such as pitch and tempo produce these effects. This study thus advanced knowledge in the field, providing evidence for the effect of low pitch music on stress behavior in kennelled dogs.

**Lindig, A. M., McGreevy, P. D., & Crean, A. J. (2020). Musical dogs: A review of the influence of auditory enrichment on canine health and behavior. *Animals*, *10*(1), 127.** [**https://doi.org/10.3390/ani10010127**](https://doi.org/10.3390/ani10010127)

**Summary:** This article summarizes and provides and overview of the current scientific literature of the use of music therapy and exposure in dogs. This paper is therefore helpful in influencing and educating future applications of this promising tool in regard to canine health and welfare. Music therapy in animals has been investigated in other companion animal species but in dogs especially and has been found to produce several potential benefits. A systematic review was conducted examining the therapeutic effects of music on dogs. Articles were identified through Web of Science and PubMed, screened by title and abstract and a final dataset of nine articles was used. This review provides strong evidence that exposure to music affects dog behavior, specifying that classical music was reported to have a calming influence in a stressful environment. No additional benefit has been observed from any music purposely designed for relaxing dogs. Classical music was associated with dogs spending more time sitting or lying down, resting and sleeping, and less time vocalizing and standing. The use of classical music to enrich environments in which animals are confined or under stress is an inexpensive and easy to implement form of enrichment that offers potentially considerable benefits for animal behavior, health and welfare. Music therapy’s benefits in canine shelters are likely to be much greater than what is known to date as interest in its use is growing. The authors indicate that to advance the knowledge of this field, future studies can be conducted using specific targeted populations, interventions and response measures. This study also explains the importance of individuals’ and species’ preferences for specific music and being mindful in avoiding habituation to the enrichment.

**Contribution:** This review article summarizes the scientific literature in the emerging domain of the influence of auditory enrichment, specifically music, on canine health and behavior. It also acknowledges that this field is relatively under-researched, requiring further studies to answer precise research questions. As a systematic review, this article is also an excellent resource for finding other related articles, especially primary literature, related to the influence of music therapy as a behavioral enrichment tool in dogs.