A Preliminary Exploration of the Effects of Different Sound Types on the Behavior of Melopsittacus undulates (Budgerigar)

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Abstract: Objective: To explore the effects of different sound types (including different species, frequencies, and volumes on Melopsittacus undulatus singing and approach and avoidance behaviors. Methods: The experimental or test group was set up with different combinations of sound types, frequencies, and volume, and its effects on Melopsittacus undulatus singing and approach and avoidance response were observed. Results: The immediate and sustained effects of noise on Melopsittacus undulatus singing behavior were significantly increased compared to musical tones; under the same volume, high frequency and undulating sounds led to an increase in both immediate and subsequent calls of Melopsittacus undulatus; under the same frequency, a high volume will lead to an increase in the number of tweeting made by Melopsittacus undulatus; a combined increase in frequency and volume will lead to a highly significant increase in the number of tweeting made by Melopsittacus undulatus. An 85dB noise triggers a singing response from Melopsittacus undulatus and produces a clear source avoidance behavior; a frequency of 2048Hz triggers a singing response from Melopsittacus undulatus. Conclusion: This study revealed that noise was more likely to elicit an increase in the number of tweeting made by Melopsittacus undulatus than musical sounds. Loudness volumes of 85dB and above and frequency of 2048Hz and above were more likely to trigger the singing and approach and avoidance response in Melopsittacus undulatus.

1 INTRODUCTION

Prolonged exposure of animals to high levels of noise can lead to effects on their behavioral functions. Apart from the great impact on human life, noise also harms birds living in urban areas. Studies have shown that noise triggers ecological accidents in birds, such as a sharp decrease in species density and community size of more than 50% of birds within 100m of a field road in the Netherlands (Reijnen, Foppen, & Meeuwsen, 1996) In addition, noise is often used as a means of repelling birds in daily life, such as directional sound waves used in airports (Xu,2020) Thus, it is clear that noise can have a great impact on the normal life of birds. Of all aspects of bird functions, communication through singing is extremely affected by noise (Marzluff, Bowman, & Donnelly, 2020). It is mainly reflected in the reduction of the propagation distance of the acoustic signal, interference with the content of the acoustic signal, resulting in the weakening or disappearance of the sound, reduced signal fidelity, and reduced propagation efficiency, thus reducing the possibility of the acoustic signal being received correctly (Barber, Crooks & Frstrup, 2009). The reduced ability to receive and recognize acoustic signals can affect the fertility and fitness of individual birds as well as population size and community composition, and may even jeopardize the entire ecosystem (Slabbekoorn,& Halfwerk, 2009). In this study, we used different types, frequencies, and volumes of sounds and acoustically stimulated Melopsittacus undulatus to observe its calling behavior and approach and avoidance response. The observed indicator of calling behavior is the number of tweets. The number of tweets in approach and avoidance response is one of the monitoring indicators for biological control and human impact on plants and animals (Wu, 2021). The approach and avoidance behavior of Melopsittacus undulatus to high-volume noise may also represent their rejection of this sound, just as humans mostly respond to hearing harsh noise for a long time by actively avoiding a less noisy or noiseless environment. The effect of noise on the effectiveness of singing is mainly reflected in the reduction of the propagation distance of the acoustic signal, interference with the content of the acoustic signal, resulting in the weakening or disappearance of the sound, reduced signal fidelity (Patricelli & Blickley, 2006). And thus reduced propagation efficiency, thus reducing the possibility of the acoustic signal being received correctly (Bee & Swanson, 2007). The reduced ability to receive and recognize acoustic signals can affect the fertility and fitness of individual birds as well as population size and community composition, and may even jeopardize the entire ecosystem (Peris & Pescador, 2003). Therefore, in this study, the number of tweets and the approach and avoidance behavior were used as indicators to observe the stress response of Melopsittacus undulatus after hearing different types of sounds. Based on this indicator observation, the effects of different sound types on its

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behavior were initially explored. This study demonstrates the important influence of urban noise on Melopsittacus undulatus and promotes the study of the ecological conservation of urban birds. In this study, we used different types, frequencies, and volumes of sounds and acoustically stimulated Melopsittacus undulatus to observe its calling behavior and approach and avoidance response. The observed indicator of calling behavior is the number of tweets. The number of tweets in approach and avoidance response is one of the monitoring indicators for biological control and human impact on plants and animals (Yin, Chin-cheng, 2020).

2 EXPERIMENTAL METHODS

Melopsittacus undulatus were housed in groups in closed, quiet, lighted rooms with ambient sound controlled to less than 40 dB. The bird cages were made of iron. The feed was mixed cereals, and sufficient drinking water was ensured. Melopsittacus undulatus was acclimated to the environment in the experimental room for 2 days before the experiment. In this study, Librosa (version 0.9.2), a python third-party library for analyzing audio, was used to extract the frequencies of common noises to make a spectral mass acoustic spectrogram. We selected representative noises based on the low, medium, and high frequency ranges after comparison.

2.1 Testing the effects of musical sounds and noise on the singing behavior

Four groups of musical sounds and one group of high-frequency noise were selected for this experiment, using two juvenile Melopsittacus undulatus in each group. Naturally, birds call less frequently at night, so nighttime (20:00-24:00) was chosen for the experiment.

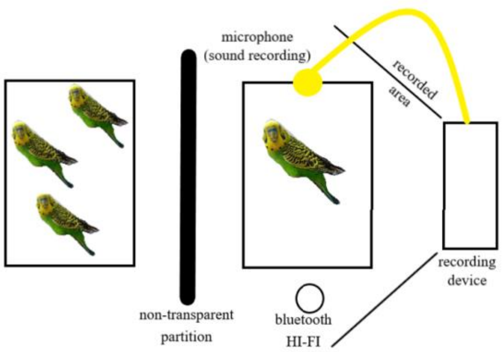

Figure 1 Experimental step of Experiment 1

1) Production of sound material: The first 130 s of the Mozart K.5 were used for sound stimulation. The first 130 s of Mozart K.545 and Mozart K.448 were used for sound stimulation, with the former having a wider range; the first 130 s of Melody of the Night (V) and An der schönen blauen Donau, Walzer, op.314 were used for sound stimulation, with the former having a wider range; the same length of high-frequency noise (electrical noise) was used as the first 130 s of An der schönen blauen Donau, Walzer, op.314. The high-frequency noise (electrical noise) of the same duration was used as a control group. The frequency distribution of each group is shown in Figure 2, and the audio is controlled at 70-80 dB.

(2) The experimental setup was as shown in Figure 1, firstly, the subject was stimulated with an audible clip and the number of tweets was recorded with a counter during this period. After the stimulation, the number of tweets of the subject in the quiet state was recorded for 3 minutes.

(3) The experiment was repeated six times for each group.

2.2 Testing the effect of different volumes of sound on the singing behavior

This experiment was divided into 2 groups, grouped as shown in Table 1, using 3 juvenile Melopsittacus undulatus each, and the night time (20:00-24:00) was chosen for the experiment.

Table 1. Experiment 2 Groupings

Group	Experimental subjects
1 [Low Frequency (128 Hz) + 65 dB	3 juvenile Melopsittacus undulatus
2 [Low frequency (128 Hz) + 85 dB	

Experimental Procedures

1) Python was used to artificially synthesize low-frequency (128Hz) sound for 5 minutes each, and a decibel tester was used to adjust the sound volume during the experiment so that the two groups of experiments reached 65dB and 85dB, respectively.

(2) The experimental setup is shown in Figure 3. The number of tweets in the quiet state was recorded for 5 minutes during the experiment, and then stimulated with different sound segments, and the number of tweets during this period was recorded with a counter.

2.3 Testing the effect of common life noises on the singing behavior

This experiment was divided into seven groups, grouped as shown in Table 1, and three juvenile Melopsittacus undulatus each were used in each group, and the night time (20:00-24:00) was chosen for the experiment.

Table 2 Experiment 3 Groupings

Groups	Experimental subjects
1 (low frequency + 65 dB)	3 juvenile Melopsittacus undulatus
2 (low frequency + 85 dB)	
3 (Mid frequency + 65 dB)	
4 (Mid frequency + 85 dB)	
5 (High frequency + 65 dB)	
6 (high frequency + 85 dB)	

7 (Positive control electrical noise + 85 dB)	

Table 3. Experiment 3 frequency settings

Group	Frequency settings
Low Frequency	Air conditioner cooler sound (approx. 512 Hz)
Medium frequency	Lawn mower sound (approx. 2048 Hz)
High frequency	Electric drill sound (4096-5500 Hz)
Positive control	Electric current sound (approx. 4096 Hz)

Experimental Procedures

1) Python was used to process the selected living noise, four sounds were intercepted for 5 minutes each, and a decibel meter was used to adjust the sound volume during the experiment. The grouping design was based on the frequency and volume results obtained in Experiments 1 and 2, as shown in Tables 3 and 4. The positive control was the high-frequency noise used in experiment 1 with a frequency of about 4096Hz and a volume of 85dB.

The experimental setup is shown in Figure 2. The number of tweets in the quiet state was recorded for 5 minutes in the experiment, and then stimulated with different sound segments, and the number of tweets during 5 minutes of this sound stimulation was recorded with a counter, and the number of tweets during 30 minutes after the end of the stimulation was recorded.

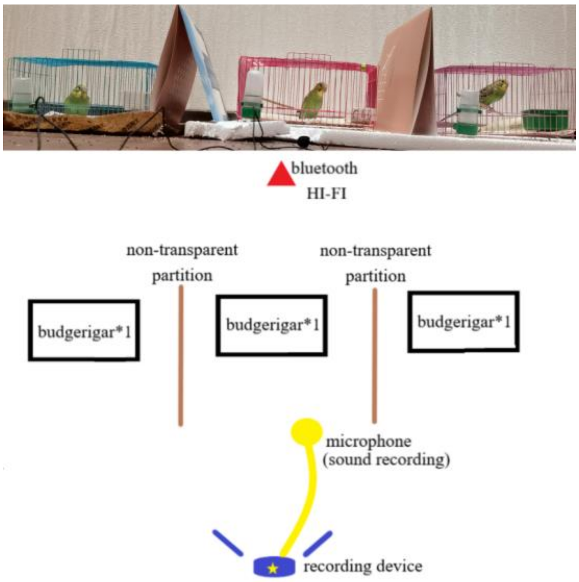

Figure 2 Experimental step of Experiment 2

2.4 Testing the approach and avoidance response of Melopsittacus undulatus to noise

This experiment was divided into 3 groups as shown in Table 3, and 3 Melopsittacus undulatus were used in each group.

Table 4. Experiment 4 groupings

Group	Experimental subjects
1 (positive control + 65 dB)	3 juvenile *Melopsittacus undulatus*
2 (positive control + 75 dB)	3 juvenile *Melopsittacus undulatus*
3 (positive control + 85 dB)	3 juvenile *Melopsittacus undulatus*

Experimental procedures.

1) A 150cm long cage was used as the experimental cage, and the positive control was the high-frequency noise (electrical noise) used in experiment 1, with a frequency of about 4096Hz. A decibel tester was used to adjust the sound volume during the experiment.

2) Melopsittacus undulatus was familiarized with the experimental cage environment for 1 day before the experiment.

The experimental setup is shown in Figure 3. The initial position of Melopsittacus undulatus during the 5-minute quiet phase and the 5-minute sound stimulation phase and its relative movement position every 5 seconds were recorded.

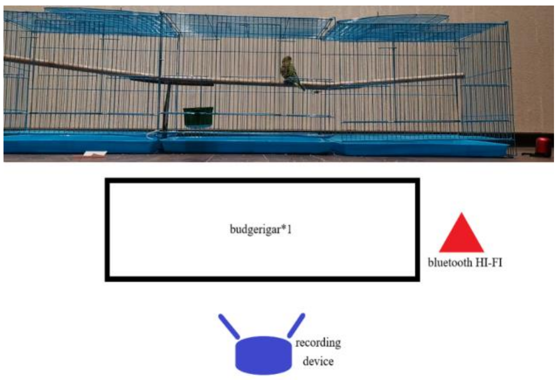

Figure 3. Schematic diagram (bottom) and physical diagram (top) of the experiment 4 setup.

3 RESULTS

3.1 High frequency and undulating sound at the same loudness led to an increase in both immediate and subsequent calls

To observe the effect of frequency on the calling behavior of *Melopsittacus undulatus* and to exclude the interference of the sounds. The experiment was set up to compare the effects of different frequencies of musical sounds and high-frequency noise on the number of tweets made by *Melopsittacus undulatus* at the same volume (70-80 dB) (Figure 4). The experiment started with sound stimulation for 130s and was quiet for 3 min after the end of the stimulation.

The number of *Melopsittacus undulatus* singing increased significantly in the high-frequency noise group during the stimulation compared to the musical sound group. Compared with "Melody of the Night" and "An der schönen blauen Donau, Walzer, op.314", which belonged to the same soothing tone group, the former with high undulation had significantly more calls in the sound stimulation phase than the latter; compared with "Mozart K.545" and "Mozart K.448", which belonged to the similar light and fast tone group, the former with high undulation in the sound stimulation phase had significantly more calls than the latter. The number of tweets was also significantly higher in the former than in the latter.

Sound stimulation in all musical groups increased the number of tweets made by Melopsittacus undulatus, followed by a significant decrease in the number of tweets in the quiet period compared to the stimulation. In contrast, there was no statistically significant difference in the number of tweets during the quiet period in the high-frequency noise group compared to the sound stimulation.

In summary, Experiment 1 demonstrated that under the same conditions of volume, high frequency, and undulating sound had a significant and sustained effect on the song behavior of *Melopsittacus undulatus*, especially the high-frequency noise (about 4096Hz).

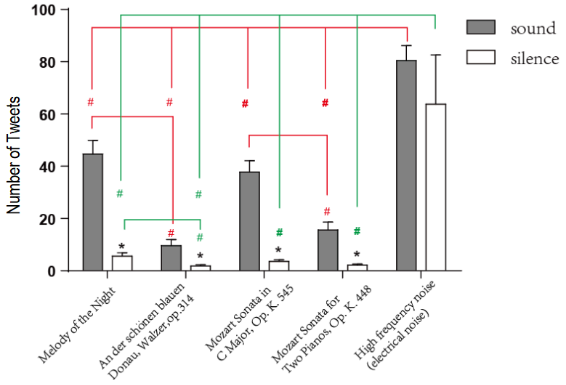

Figure 4. High frequency and undulating sound at the same volume lead to an increase in both immediate and subsequent singing in Melopsittacus undulates.

3.2 At the same low frequency, louder sounds lead to an increase in the number of Melopsittacus undulatus singing

To observe the effect of volume on the song behavior of Melopsittacus undulatus and to exclude the effect caused by frequency. Experiment 2 compared the effect of different volumes on the number of Melopsittacus undulatus calls at the same low frequency (128Hz) (Figure 5). The experiment started with 5 minutes of silence, and after the end of silence was stimulated for 5 minutes with a low-frequency sound (128Hz) of low volume (65dB) or high volume (85dB).

The number of tweets during the stimulus phase was significantly greater than during the previous quiet period when the 85dB sound was played ($p<0.05$). However, there was no significant difference in the number of tweets during the stimulation phase and the previous quiet period when the 65dB sound was played. Melopsittacus undulatus in the 85dB group had a significantly higher number of tweets during stimulation compared to the 65dB group during sound stimulation ($p<0.001$).

In conclusion, the effect of 85 dB sound on the singing behavior of Melopsittacus undulatus was more significant than that of 65 dB sound.

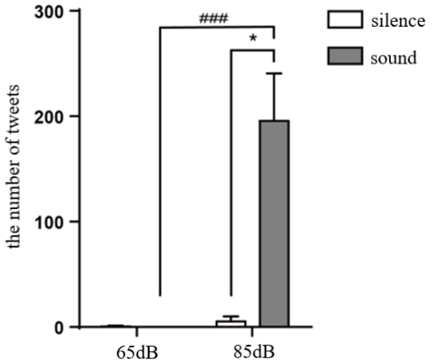

Figure 5. Volume at the same low frequency (128 Hz) leads to an increase in the number of tweets made by Melopsittacus undulatus.

3.3 Frequency and volume collectively affect the singing behavior of Melopsittacus undulatus

In this study, it was demonstrated in experiment 1 that the noise of frequency around 4096Hz significantly affects the song behavior of Melopsittacus undulatus, and in experiment 2, it was demonstrated that the sound volume can also have a significant effect on Melopsittacus undulatus when it reaches 85dB under low-frequency conditions. Since all living sounds are formed by the combination of frequency and volume, to further understand the specific effects of sound on calling behavior, Experiment 3 was set up to compare the effects of representative living noises with different volumes and frequencies on the number of tweets of Melopsittacus undulatus. The effect of different volumes and frequencies on the number of tweets (Figure 6). The experiment started with 5 minutes of silence and ended with 5 minutes of sound stimulation. In this study, various permutations of 65dB and 85dB with low frequency (air conditioner chiller sound, about 512Hz), medium frequency (lawn mower sound, about 2048Hz), and high frequency (electric drill sound, 4096-5500Hz) were tested, and 85dB of high-frequency noise (about 4096Hz) served as a positive control (Figure 6A).

A comparison of the effects produced by sound volume at the same frequency showed that there was a significant difference in the number of Melopsittacus undulatus calls during the sound stimulation phase between the 65dB and 85dB group at medium frequency, and the number of Melopsittacus undulatus calls was significantly higher in the 85dB group at a medium frequency than in the 65dB group. The number of Melopsittacus undulatus calls was significantly higher in the 85dB group than in the 65dB group ($p<0.01$). In the high-frequency condition, the effect of 85dB on the number of Melopsittacus undulatus singing during sound stimulation was higher than that of the 65dB group although the difference was not statistically significant.

A comparison of the effects produced by the sound frequency with the same volume showed that when the volume was 65 dB, there was no significant difference in the number of tweets between the low-frequency and mid-frequency groups, but the number of tweets in the high-frequency group increased significantly compared to the low-frequency group (p<0.01); when the volume was 85dB, the middle frequency, high frequency, and high-frequency noise (85dB) groups were significantly increased compared with the low frequency (p<0.01).

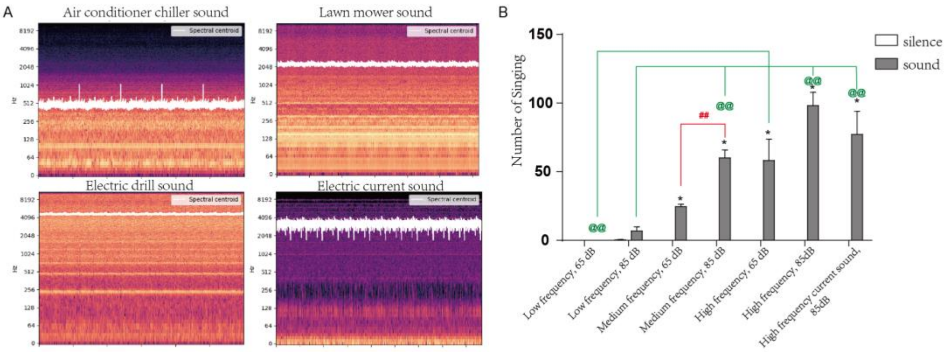

Figure 6. Effect of living noise with different frequencies and volumes on the number of Melopsittacus undulatus calls.

3.4 Noise volume reaches a certain threshold (85dB) and triggers the approach and avoidance response of Melopsittacus undulatus

To further observe the effect of noise on Melopsittacus undulatus behavior, the approach and avoidance response was also observed in this study. In this study, we observed which volume was sufficient to trigger the approach and avoidance response of Melopsittacus undulatus under the same frequency (high-frequency noise), medium volume (75dB), and high volume (85dB).

As shown in the results of Figure 7, Melopsittacus undulatus showed significantly more approach and avoidance response to high volume (85dB) noise compared to low volume and medium volume. There was no significant difference between low volume and medium loudness. This experiment demonstrates that high-volume noise of 85dB and above negatively affects Melopsittacus undulatus, which tries to avoid high-volume noise.

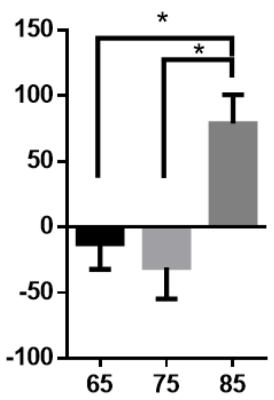

Figure 7. No significant difference in the effect of the sound of different loudness at the same frequency on the Melopsittacus undulatus approach and avoidance response.

4 CONCLUSIONS AND DISCUSSION

4.1 Conclusions

The following conclusions were made from this study.

1) Noise significantly increases both immediate and sustained effects on Melopsittacus undulatus calling behavior compared to musical sounds.

2) High frequency and undulating sounds at the same volume lead to an increase in both immediate and subsequent calls of Melopsittacus undulatus.

3) A sound with a high volume at the same frequency will lead to an increase in the number of Melopsittacus undulatus singing.

4) An increase in frequency and volume together will lead to a significant increase in the number of Melopsittacus undulatus calls.

5) A volume of 85dB triggers a singing response from Melopsittacus undulatus and a significant avoidance of the sound source.

6) The frequency reached 2048Hz triggered the singing response of Melopsittacus undulatus.

4.2 Discussions

Prospective research directions

Despite the findings of this study that high frequency, high volume, and undulating noise have immediate and sustained effects on the song behavior of *Melopsittacus undulatus* and cause *Melopsittacus undulatus* to produce approach and avoidance behavior, there are many questions worth exploring based on the present study. For instance, the purposes of calling in *Melopsittacus undulatus* include courtship, foraging, etc. Does acoustic stimulation affect the information or emotions it conveys through calling? How do the frequency, volume, and height of sound affect *Melopsittacus undulatus* calling behavior? Does noise affect *Melopsittacus undulatus* physiological indicators and long-term health? Can the responses and further inferences of *Melopsittacus undulatus* in this study be generalized and applied to other urban birds? Future studies on these aspects will help to further understand the effects of noise on *Melopsittacus undulatus* and other urban birds.

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