Testing the Efficacy of Various Materials as Sound Barriers

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ABSTRACT

Sound waves are reasonably malleable forces which humans often attempt to control and manipulate in a wide variety of ways. However, at the most basic level, it is very common to want to suppress sound in efforts to contain it. The goal of this experiment was to find out whether a barrier of a basic material suppressed sound at two different distances. The results showed that having a barrier suppressed sound significantly more than having no barrier at both distances, but there was a not a significant difference between the types of barriers that were tested.

1. INTRODUCTION

When living in close quarters to other people, controlling how much noise one is making can be a challenge. Sound can behave in very odd ways, and is often a challenge to contain. However, humans are making noise constantly through desire or circumstance so knowing how to keep sound to one's self is a useful skill. It is for this reason that this investigation explores the question "How do sound barriers of different materials perform at dissipating sound from various distances?" Answers to this can potentially help in maintaining respectful volumes around one's neighbors, and can provide useful knowledge of how to contain sound.

2. MATERIALS AND METHODS

In the experiment a speaker playing a constant F-sharp tone[1] was either subject to a plastic barrier, a steel barrier, or no barrier (control). The plastic barrier was an unsealed plastic tupperware and the steel barrier was a loaf pan on top of a baking sheet. Both barriers were 6 sides of the same material, flush but unsealed to the bottom side. The speaker was also placed at either 8 inches or 12 inches away from the head of the microphone.

The dependent variable of stabilized volume was measured on a scale of decibel full scale (dbfs), which is a negative scale with a maximum value of 0. The scale is measured in this way that it has a 'ceiling' at 0 because this is the point at which audio begins distorting. The value of a sound wave on this scale is highly influenced by gain, which is essentially an amplification parameter. For this experiment, the gain was set to its maximum level so that audio coming in would stay well under 0 dbfs but also so it could be picked up strongly by the microphone.

Initially peak decibel level was going to be used as the dependent variable, however, because the front of a sound wave, or the attack, tends to be slightly stronger than when the wave has stabilized and is constant, there was some unaccounted for variation. Due to this, the dependent variable was changed to the stabilized decibel level.

The speaker used to produce the tone was the Baby Boom Bluetooth Speaker by Altec Lansing. An SM-57, a reasonably common and versatile microphone, was used to measure the stabilized decibel level. The audio software Logic Pro 10 was used to process and output the stabilized decibel level which was then recorded into a data table.

Superfluous sounds were controlled by staying as quiet as possible while collecting data and attempting to conduct the study under optimally silent conditions. Also, volume was controlled by performing tests at a constant volume for the phone and the speaker across trials. Finally, the amount of space sound had to reverberate inside of the the container was controlled by selecting containers of similar volumes. To carry out this analysis, ANOVA tests were performed, at a significance level of .05, using JMP®, Version 13.0, SAS Institute Inc., Cary, NC, 1989-2007. To compare the individual treatments to each other we used Tukey's Honest Significant Difference test.

3. RESULTS AND DISCUSSION

The results from the ANOVA test show that both distance (F(1, 12) = 10.09, p = .008) and material (F(2, 12) = 120.91, $p < .0001$) have an effect on average stabilized decibel level. The averaged stabilized decibel level for the control group was the loudest at -16.17 dbfs, while there was no significant difference in the average stabilized decibel level between the metal and plastic groups (Table 1). Additionally, placing the speaker 8 inches away from the microphone resulted in a significantly louder average stabilized decibel level as compared to 12 inches away.

Table 1. Average stabilized decibel level (in dbfs) for barrier material and distance (standard deviation in parenthesis)

Material	Mean (SD)	Distance	Mean (SD)
Control	-16.17 (2.04) A	8 in	-24.67 (7.97) A
Metal	-30.17 (2.71) B	12 in	-27.56 (7.40) B
Plastic	-32.00 (2.28) B		

[a] Different letters indicate significance differences between those levels at $\alpha = .05$ using Tukey's HSD

There was no significant interaction between distance and material for average stabilized decibel level (F(2, 12) = 1.94 p = .826). However, the treatment with the loudest average stabilized decibel level was the control group that was 8 inches away from the microphone, while the quietest treatment was the plastic group that was 12 inches away (Table 2).

Table 2. Average stabilized decibel level (in dbfs) based on barrier material and respective distance (standard deviation in parenthesis)

	Distance[a]	
Material	8 in	12 in
Control	-14.33 (0.57)	-18.00 (0.00)
Metal	-29.00 (3.00)	-31.33 (2.31)
Plastic	-30.67 (1.53)	-33.33 (2.31)

4. CONCLUSION

From our results it can be concluded that using plastic or metal as a sound barrier does help to dissipate sound when compared to no material at all. However, there was not a difference found in the amount of sound that each material (metal or plastic) dissipates. The treatments that did the best job of dissipating sound were the plastic container at 8 and 12 inches away from the microphone as well as the metal container at both 8 and 12 inches away from the microphone. All of these treatments dissipated similar amounts of sound, so if one wishes to suppress noise, using these materials could be an option. These findings can be applied to constant sounds emanating from a speaker the at a similar volume as was used in our study.

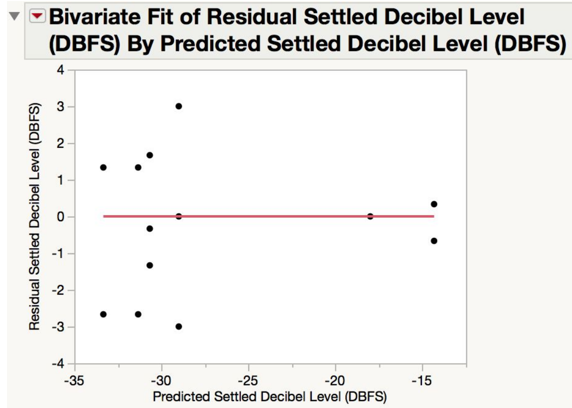
One thing to note is that during the pilot study, a lot more variation was obtained in response between the metal and plastic treatments (-31 dbfs for plastic and -25 dbfs for metal at 8 inches). However, given that the pilot study only required one replication for each treatment in the main study, the data point for metal at 8 in might have been an outlier. This possibly led to the conclusion that fewer replicates were needed to detect a significant difference between those groups than was actually correct, and thus, a significant difference might be found if the study were to be run again with a larger sample size. Additionally, it would be interesting to run this study again to see how using other materials (wood, glass, etc) as a barrier or changing the type of note that was played for the constant tone would affect sound dissipation.

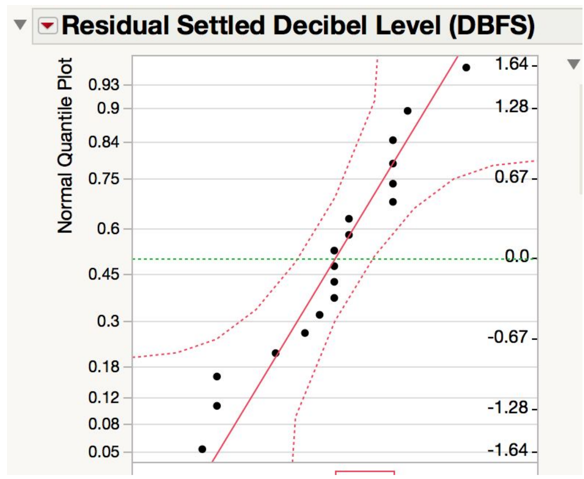
5. REFERENCES

[1] skr33d. "F# / Gb 739.99 Hz Tone For Instrument Tuning." *YouTube*, 20 Feb. 2012. www.youtube.com/watch?v=BcRCzsXVI1M&app=desktop.

6. APPENDIX

Model Assumptions:
Since the points on the normal probability plot of the residuals are roughly clustered along the diagonal, the normality assumptions is not violated. The residuals appear to have similar spread, there could be a slight possiblity of fanning, but the lack of predicted values in the -27 to -20 range means that it cannot be said for certain that the equal variance assumption is violated, but it is likely that it is not violated. Finally, as the treatments were randomly assigned to the experimental units, the independence assumption is not violated.





Least Squares Means Table

Level	Least Sq Mean	Std Error
12 in,Control	-18.00000	1.1138854
12 in,Metal	-31.33333	1.1138854
12 in,Plastic	-33.33333	1.1138854
8 in,Control	-14.33333	1.1138854
8 in,Metal	-29.00000	1.1138854
8 in,Plastic	-30.66667	1.1138854

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
12 in	-27.55556	0.64310205	-27.556
8 in	-24.66667	0.64310205	-24.667

Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
Control	-16.16667	0.78763594	-16.167
Metal	-30.16667	0.78763594	-30.167
Plastic	-32.00000	0.78763594	-32.000

Summary of Fit

RSquare	0.954597
RSquare Adj	0.935679
Root Mean Square Error	1.929306
Mean of Response	-26.1111
Observations (or Sum Wgts)	18

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	939.11111	187.822	50.4597
Error	12	44.66667	3.722	Prob > F
C. Total	17	983.77778		<.0001*

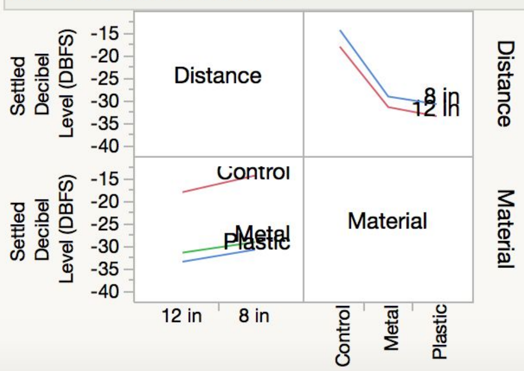
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-26.11111	0.454742	-57.42	<.0001*
Distance[12 in]	-1.444444	0.454742	-3.18	0.0080*
Material[Control]	9.9444444	0.643102	15.46	<.0001*
Material[Metal]	-4.055556	0.643102	-6.31	<.0001*
Distance[12 in]*Material[Control]	-0.388889	0.643102	-0.60	0.5566
Distance[12 in]*Material[Metal]	0.2777778	0.643102	0.43	0.6734

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Distance	1	1	37.55556	10.0896	0.0080*
Material	2	2	900.11111	120.9104	<.0001*
Distance*Material	2	2	1.44444	0.1940	0.8262

Interaction Profiles



LSMeans Differences Student's t

α= 0.050 t= 2.17881

LSMean[i]	Mean[i]-Mean[j] / Std Err Dif / Lower CL Dif / Upper CL Dif	LSMean[j]: 12 in	LSMean[j]: 8 in
12 in	Mean[i]-Mean[j]	0	-2.8889
	Std Err Dif	0	0.90948
	Lower CL Dif	0	-4.8705
	Upper CL Dif	0	-0.9073
8 in	Mean[i]-Mean[j]	2.88889	0
	Std Err Dif	0.90948	0
	Lower CL Dif	0.90729	0
	Upper CL Dif	4.87048	0

Level		Least Sq Mean
8 in	A	-24.66667
12 in	B	-27.55556

Levels not connected by same letter are significantly different.

LSMeans Differences Tukey HSD

α= 0.050 Q= 2.66776

LSMean[i]	Mean[i]-Mean[j] / Std Err Dif / Lower CL Dif / Upper CL Dif	LSMean[j]: Control	LSMean[j]: Metal	LSMean[j]: Plastic
Control	Mean[i]-Mean[j]	0	14	15.8333
	Std Err Dif	0	1.11389	1.11389
	Lower CL Dif	0	11.0284	12.8618
	Upper CL Dif	0	16.9716	18.8049
Metal	Mean[i]-Mean[j]	-14	0	1.83333
	Std Err Dif	1.11389	0	1.11389
	Lower CL Dif	-16.972	0	-1.1382
	Upper CL Dif	-11.028	0	4.80491
Plastic	Mean[i]-Mean[j]	-15.833	-1.8333	0
	Std Err Dif	1.11389	1.11389	0
	Lower CL Dif	-18.805	-4.8049	0
	Upper CL Dif	-12.862	1.13824	0

Level			Least Sq Mean
Control	A		-16.16667
Metal		B	-30.16667
Plastic		B	-32.00000

Levels not connected by same letter are significantly different.