

# A method for a acoustical comparison of the Hammered Dulcimer

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## Introduction

Often musical instrument makers need to compare instruments in terms of sound quality. In addition to the sound spectrum of the produced tone, the decay time of the excited note is also a main quality parameter for the hammered dulcimer [1]. To provide a reproducible excitation, an artificial drum mechanism is used.



Fig. 1: Typical Styrian Dulcimer (diatonic)

## Exciting a Dulcimer

In general, the Styrian Dulcimer (see Fig. 1) is played using a special set of drumstick or hammer. Mostly the heads of the wooden hammers have one side covered with leather (or similar material) to soften the surface. This gives the musician the possibility to change the characteristic of the produced sound [1, 2]. For all analysis described in this paper, the hard side of the hammer was used.

## Parameters of variety

For comparing the sound and decay rate of the initiated note, the excitation has to be as reproducible as possible. In fact, a musician will not be able to strike the hammer in the exact same way [3]. Fig. 2 illustrates the main parameters of variation in excitation, where:

- $\varphi$  is the angle of strike,
- $\alpha$  describes a possible tilt in the rotation of the hammer,
- $\beta$  is the variance of the hammer angle different from 90 degrees in relation to the strings,
- $X_{pos}$  defines the variation in the distance measured between beater and bridge,
- $Y_{pos}$  is the strike position in relation to the center of the set of strings,
- $F$  is the striking force, and
- $v$  the striking velocity.

Because of the round shape of the hammer-head, a variation of the angles  $\varphi$ ,  $\beta$  and the  $Y$  position will excite the strings differently. Hitting the string at a different  $X$  position will influence the excited vibration modes of the string [4].

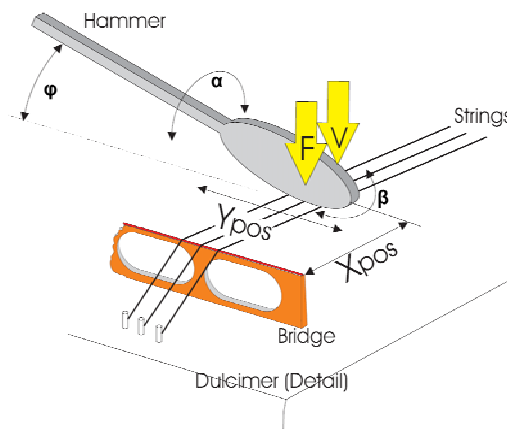


Fig. 2: Parameters of variety

As long as the instrument is assumed as a linear system, a variation of the striking force will affect only the produced power of sound and the decay time. Practical tests, made using recordings in an anechoic chamber showed clear variations in sound spectra and decay time depending on the parameters of variation.

## Artificial excitation mechanism

According to the aforementioned possible variations of striking parameters, an electro mechanical system to provide reproducibility has been designed (Fig. 3).

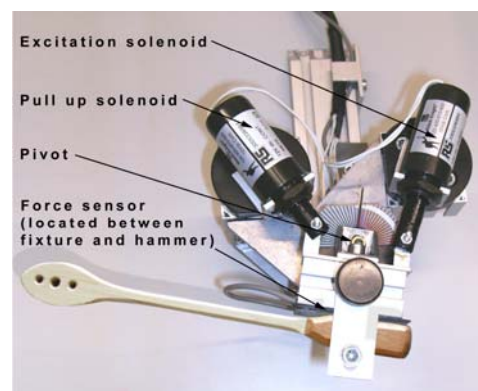


Fig. 3: The mechanical excitation mechanism

The artificial excitation mechanism (AEM) consists of two solenoids connected to a hammer fixture and a computer interface. Software controls the audio recording, as well the movement of the hammer. To provide a free vibration of the string after a strike, as well as a non chattering excitation, the hammer has to be pulled up immediately after the first string-to-hammer contact. A force sensor, located between the hammer and the fixture, triggers the software to send a "pull-up" request.

After using the AEM, the excitation was proved to be reproducible by recording 10 excitations at 3 notes each, and

comparing the sound-data. The differences in sound-level are below 1 dB, and a comparison of the sound spectra show negligible variations. This highly reproducible sound-production simplifies the calculation of the decay time.

## Sound data analysis

To provide comparable sound data for analyzing, all recordings were done inside an anechoic chamber. The instrument sits on an optical table where also a heavy yet movable stand for carrying the AEM is also mounted. The sound was captured using a ROGA<sup>TM</sup> RG50 instrumentation microphone positioned one meter in distance above the dulcimer center. A PCB<sup>TM</sup> signal conditioner and charge amplifier (Model 482A22) is directly connected to a PC-soundcard. The total recording time was limited to 15 seconds each strike.

## Segmentation of sound data

For a consistent decay rate processing, the time domain signal has to be trimmed at a specific level of amplitude (red lines in Fig. 4). The total length of the trimmed sound data becomes dependant on the decay rate, but will be independent of the total recording time and position of attack after recording start (see blue colored signal in Fig. 4).

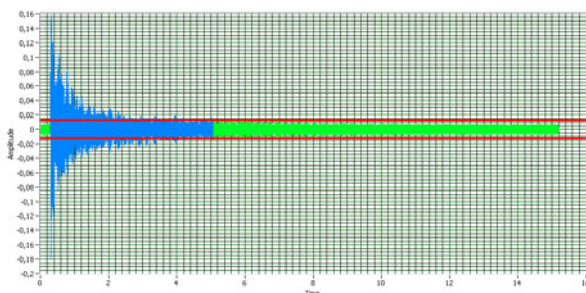


Fig. 4: Captured time domain signal, red: trim levels, blue: trimmed signal, green: cut signal

## Calculation of decay rate

Because the design of the hammered dulcimer, the strings are strongly coupled to the slotted bridge and soundboard. David Peterson assumed in his paper [3], that this may be one reason, why the double decay rate, which can normally be observed at instruments with more than one string per note (e.g. piano), can not be found in hammered dulcimers. This fact simplifies the calculation of the decay rate.

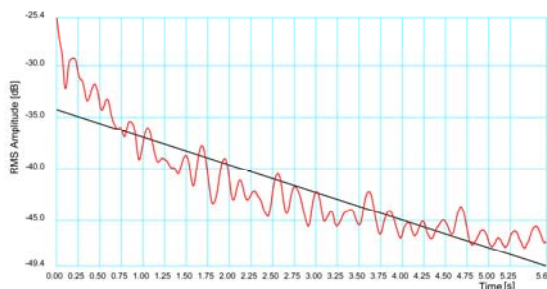


Fig. 5: Decay graph, red: RMS amplitude, black: least square fitted linier approximation

After calculating the envelope of the time signal (see red curve in Fig. 5) the method of least squares is used to fit the

decay rate curve (black line in Fig. 5). The gradient value can now be used to compare the decay rates of different notes of one instrument and also for a comparison of different models of dulcimers.

## Conclusion

The artificial excitation mechanism proved to excite the instrument more consistently (therefore more reproducibly) than a musician. The standard deviation of the measured decay rates of 5 human excitations (1,23) in comparison to 5 computer controlled excitations (0,12) showed a factor of about 10 in difference (see Fig. 6).

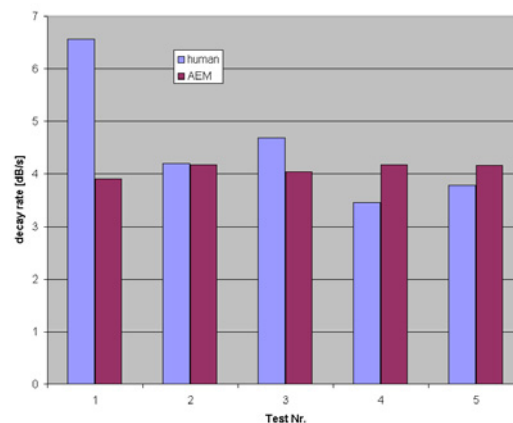


Fig. 6: Comparison of decay rates of one note excited by a musician (blue) and the artificial excitation mechanism (red), 5 times each

Due to thermal effects inside the solenoids and electronics, some variances in the striking force are not negligible. The accuracy of the AEM could be improved by using the force sensor not only as a trigger, but also to normalize the recorded sound signal by the measured striking force.

## References

- [1] D. Peterson, T. Rossing, G. Canfield, "Acoustics of the hammered dulcimer, its history, and recent developments", Acoustical Society of America: Journal of the Acoustical Society of America (JASA). P.3002 (1994)
- [2] D. Peterson, "String vibrations in hammered dulcimers", Acoustical Society of America: Journal of the Acoustical Society of America (JASA). P.3002 (1994)
- [3] D. Peterson, " Hammer/String Interaction and String Modes in the Hammered Dulcimer ", Société française d'acoustique: Proceedings of the International Symposium of Musical Acoustics, ISMA SFA, P.532-538 (1995)
- [4] H. Fleischer, H. Fastl, "Beiträge zur Vibro- und Psychoakustik - Schwingung und Schall eines Hackbretts", ISBN: 1430-936X, Germany, P.55ff (2004)