

**BAR-ILAN UNIVERSITY**

**Scientific Definition of "Kol Havara"**

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Submitted in partial fulfillment of the requirement for  
the Master's Degree in the School of Education,  
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Ramat Gan, Israel

2015

## Abstract

A special mitzvah in Rosh-Hashana is to hear the shofar sound. As written by Maimonides (Shofar, Sukka and Lulav laws a, a): "It is a biblical commandment to hear the sound of the shofar on Rosh Hashannah as it says "it is a day of blowing the horn unto you" (Numbers 29, 1) ". The Mishnah (Rosh-Hashana 3, 5) determines that in order to fulfill the mitzvah, one has to hear the actual blow of the horn, termed "kol shofar" and not "kol havara". Therefore, if one hears "kol havara" i.e. from a blower inside a pit, he does not accomplish the mitzvah. The Rishonim and the Poskim did not explain the term "kol havara" and how can it be differentiated whether the sound heard is "kol shofar" or "kol havara". Likewise, the term "kol havara" is implicated in additional halachic subjects, such as hearing mitzvahs via modern tools i.e. amplifier and hearing aid.

Our aim in this research is to try to establish, for the first time, by using scientific tools, what is considered "kol shofar" and what is considered "kol havara". For this purpose, experiments were conducted in an acoustic room, which resembles a cave or a pit with an echo. The sound of the shofar (like every musical instrument), has a base frequency (20) and additional harmonies. When hearing the sound of the shofar, the base frequency and many additional harmonies of this frequency, are heard simultaneously.

The conclusion of this research is that "kol havara" can be defined as the case in which disrupting interference of the base frequency occurs, in a way that this frequency is nearly concealed, but the other harmonies are not decreased (relatively). [Figure 1](#) depicts an analysis of one of the shofar recordings. The base frequency of this shofar blast was 470 Hz. In the upper graph the base frequency is seen with the additional accompanying harmonies, while in the lower graph the base frequency is nearly diminished in the shofar sound heard outside the cave/room.

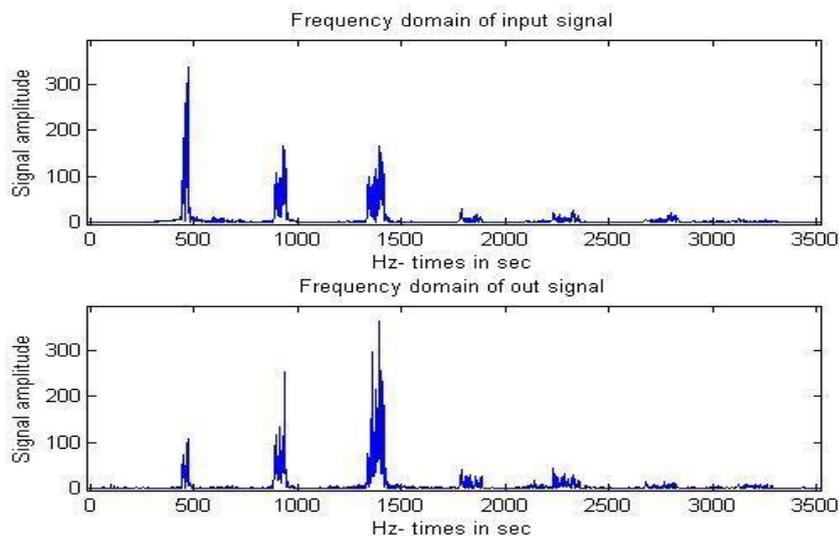


Figure : 1 A graph showing the frequencies of the shofar blowing recorded in the experiment. In the upper panel, the recording was adjacent to the shofar. It can be seen that the base frequency has a high signal amplitude while when recording outside the room (shown in the lower panel) the amplitude of this frequency is decreased significantly by approximately 75% (from 320 to 80). Simultaneously, the first and the second harmonics' amplitude increased, conserving the total energy.

According to our research results, it is possible to define scientifically (by examination of the recording frequencies) when the sound heard is considered "kol shofar" and when it is considered "kol havara". Additionally, using this definition we can explain some of the disagreements in the Talmud. Likewise, this definition has many implications regarding modern instruments used nowadays such as hearing aid and telephones (fix and cellular). A controversy is found between the Achronim if the sound heard by these instruments is "kol havara" or a real sound. According to the principle that we suggest it can be examined in a scientific way for each instrument if it matches the conditions of the shofar sound (preserving the base frequency and identical ratios between the base frequency and the harmonics) or it is defined as "kol havara".

We will now summarize the various chapters of this work:

The first chapter presents the scientific background for the research. First, we will explain in this chapter what sound waves are and how they are analyzed in time domain and frequency domain. We will discuss unique phenomena of sound waves in musical instruments, echo and additional cases (such as speech) and explain the interference phenomena in these waves. Following, we will present the telephone system and its development, and conclude the consequences of possible disruptive interferences in telephone signals. The human hearing system will also be explained.

The second chapter constitutes the Halachic background of this work. The chapter discusses the basis of "kol havara" rule presented in the Mishna of the blower of a shofar from a pit, its validity and the conditions for its existence. We will discuss the definition "kol havara" in relation to "kol shofar" and the exact meaning of the concept "kol havara". We will describe the Rishonim's debate about the ruling for "kol havara" in a pit and in other places where "kol havara" is relevant. The last paragraph in the chapter deals with a case of hearing partial valid tekiah, while not hearing the rest of the blast or hearing it as "kol havara".

The third chapter deals with the usage of scientific tools for Halacha purposes. First, we discuss the hearing mitzvah in our era using modern technology - the definition of deaf and the utilization of hearing aid, as well as fulfillment of hearing mitzvah by loudspeaker and telephone. Secondly, we will discuss the relationship between Tora and science in general and the possibility of using scientific tools for ruling in Halachic doubts.

The fourth chapter presents the tools used for the experiments, both the physical tools (acoustic room, shofar, recording systems) and the computer-based analysis tools (Matlab software). We will discuss the research methods, how the "kol shofar" can be analyzed, how the "kol havara" may be analyzed and the analysis of the combination of both sounds.

In the fifth chapter, the three experiments carried out, will be described. The first (and main) experiment, which was executed in an acoustic room several times, with many repeats, is the transmission of "kol shofar" and its recording in the room and outside. We will analyze the results of the experiments to obtain a criterion (influenced by spectral capacity) for what is "kol shofar" solely, and for what is "kol havara" (partially or completely) and what a criterion for distinguishing between the two. As part of this experiment, we will confirm that our criterion to "kol havara" is indeed valid in hearing tests, and that it can be established that there is a difference (in hearing) between "kol shofar" and "kol havara". The second experiment deals with the production of disrupting interferences in the telephone system in an artificial way (in digital communication). In this experiment, we will show how a signal frequency can be omitted from the source signal, by digital tools, using Matlab software. Additionally, in the third experiment we will examine (theoretically) the conditions in which a disrupting interference might be generated in the telephone system.

In the sixth chapter we will analyze the results of the various experiments in the fifth chapter and conclude about "kol havara" and the criterion of disrupting interference which causes "kol havara". According to this principle, we will explain debates of Rishonim in the definition of "kol havara", in rules of a shofar blast in a pit and in the length of hearing shofar required (when part of the blast is improper). Likewise, according to the conclusions in the definition of "kol havara", we will discuss the use of technological devices for hearing mitzvahs (telephone, cellular phone, etc), and their relevance for the definition of "kol havara" as determined by the results of the experiments. We will summarize the experiment, its results and its consequences and confirm in which cases a disrupting interference of the shofar sound from the cave may occur, in order to find a case of "kol havara" in the modern world.