The effect of vibrato on response time in determining the pitch relationship of violin tones

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Abstract

This experiment investigates the effect of vibrato on response time in determining the pitch relationship of two successive violin tones. The result may provide insight into many musicians' impression that vibrato can be used to mask inaccurate intonation since the preliminary data indicate that listeners require more time to determine the mean pitch of a vibrato tone.

INTRODUCTION

Since Seashore (1938), numerous experiments have been conducted and studies written on the pitch perception of frequency-modulated sounds. The vast majority of experiments conducted have used synthesized sounds such as sine tones (Hall III, 1986; Shonle and Horan, 1980) and complex tones (d'Allesandro and Castellongo, 1994; Hall III, 1986; Hall et al., 1997; Iwamiya et al., 1983b, 1994). In these studies, there has been a consensus that the pitch perceived is that of the mean. Numerous vocal vibrato studies have been written as well (d'Allesandro and Castellongo, 1994; Prame, 1994, 1997; Sundberg, 1978, 1995). In contrast, not many studies have used real instrumental sounds for pitch determination tasks until recently (Brown and Vaughn, 1996).

In our study, based on previous research at the MIT Media Lab (Brown and Vaughn, 1996), two-interval two-alternative forced choice (2I2AFC) experiments were conducted to investigate the effect of vibrato on response time in determining the pitch relationship of two successive violin tones. Our study differs from the MIT setup in that no pitch shifting of recorded tones was done in order to obtain desired pitches and response times were calculated in two different experiments. We will also discuss our experimental setups and results. All subjects used in this study came from the Peabody Institute of the Johns Hopkins University consisting of ten graduate students, one undergraduate and one faculty member.

I. EXPERIMENTAL SETUP

A. Sound production

All violin sounds used in our listening experiments were recorded in one of the computer music studios at the Peabody Institute. In order to more accurately preserve the timbral change corresponding to a changing pitch on the violin, we carefully recorded a violinist playing the mean frequency of A = 440Hz and at different frequencies of ±3, ±6, ±9, ±15, and +21 cents from the mean without vibrato, using an AKG C414B-ULS microphone at a distance of approximately 6 inches away from the violin. An A = 440Hz vibrato tone was also recorded.

All violin tones were recorded directly onto a DAT and were transferred digitally to the AIFF format for the listening experiment setup, which was created in MSP/Max graphical software synthesis language. Intonation was carefully monitored by having a violinist match digitally produced sine tones at an audio rate of 44.1KHz, 16-bit stereo, heard through headphones placed over one ear while monitoring the accuracy of the pitch played with the other ear. In order to find portions of the recorded violin tones that were stable in fundamental frequency, a phase vocoder algorithm was used (Brown, 1996; George and Smith, 1992).

B. Listening Experiment

In the first 2I2AFC experiment, based on previous research (Brown and Vaughn 1996), listeners were asked to rate the second of two stimulus tones higher or lower in comparison with the first.

In Experiment I, the first stimulus was either a vibrato tone or a non-vibrato tone of A = 440Hz and the second stimulus was always a non-vibrato tone of A = 440Hz or at different frequencies ranging from ±3, ±6, ±9, ±15, and +21 cents from the mean (A = 440Hz). A total of 20 soundfile comparison tests were created in MSP/Max environment, where each comparison test was repeated eight times at random, thus resulting in a total of 160 trials for each subject. Each comparison test consisted of two stimuli, approximately 1 second each in duration, separated by an interstimulus silence tone of 250 milliseconds. Subjects heard all comparison tests through a pair of SONY MDR-7506 Professional headphones which was connected to the built-in DAC of a PowerMac 8500/120.

After hearing each comparison test, the subject was asked to choose as quickly as possible the box on the monitor screen which best described how the second stimulus tone was perceived in relation to the first stimulus tone. These boxes were selected by the subject typing numbered keys ranging 1 to 4 for the choices “definitely lower,” “maybe lower,” “maybe higher,” and “definitely higher” (Brown and Vaughn, 1996). Data collected for each subject consisted of the response choice selected by the subject and the subject’s response time in making the selection measured in milliseconds.

In Experiment II, subjects were again asked to compare two tones and determine if the second tone was higher or lower in pitch than the first. This time, the order of stimuli was reversed: the first stimulus was always a non-vibrato tone (A = 440Hz and at ±3, ±6, ±9, ±15, and +21 cents from the mean), and the second stimulus was either a vibrato tone or a non-vibrato tone (A = 440Hz). The order in which the tests in both Experiments I and II were presented to subjects was random.

II. RESULTS

Results from Experiment I confirm the MIT study findings that the choice of the first stimulus (A = 440Hz, vibrato or non-vibrato) does not significantly affect subjects’ ability to compare the stimuli. This was also the case for Experiment II in that there were no appreciable differences (see Figure 1). After comparing the response times in the first experiment, no appreciable differences of the response times based on the choice of the first stimulus were found. However, in comparing the response times from the second experiment, we found that subjects took longer when the second tone was a vibrato tone (see Figure 2). Paired-difference t-tests showed that in Experiment I, there is no difference in the response time whether the first tone is vibrato or non-vibrato ($t = 0.01$, $2p = 0.992$). On the other hand, in Experiment II, there is such a difference ($t = 2.55$, $2p = 0.027$).

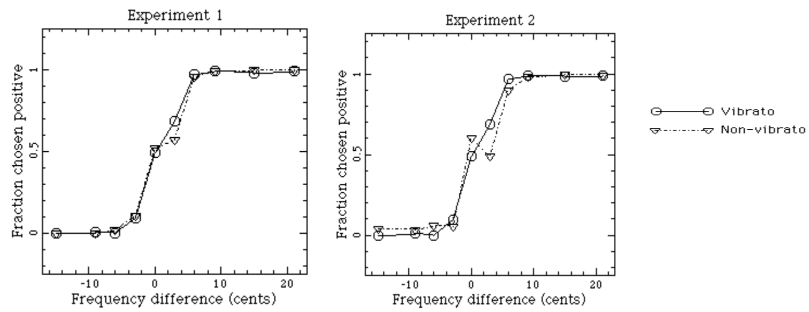

Figure 1. Fraction of responses “higher” plotted against target pitch.

	Experiment I		Experiment II	
	vibrato	non-vibrato	vibrato	non-vibrato
S1	1992.1875	2061.9375	1982.0000	1963.3125
S2	1746.1250	1640.0000	1912.0625	1957.8750
S3	1554.9375	1737.4375	2022.4375	1729.6250
S4	1111.2500	1006.5000	1337.8861	919.6420
S5	1731.0000	1600.5000	2301.1875	1496.0625
S6	2084.2500	2043.3750	1906.3750	1748.1875
S7	1015.6250	1073.6250	700.7500	632.6875
S8	1022.8125	1023.4375	748.0625	747.4375
S9	1783.8125	1787.9375	2037.2500	1961.0000
S10	3693.0000	3624.2500	2587.4375	2458.0625
S11	2135.9375	2284.1875	2556.6250	2605.5000
S12	1585.7500	1576.9375	2013.5625	1721.2500

Figure 2. The mean response times (ms) of each subject

III. CONCLUSION

In both experiments, we observed no difference in subjects’ ability to accurately determine the relative pitch of the two stimuli based on the presence or absence of the vibrato tone. We believe this is because the one-second length of the vibrato tone is more than enough for subjects to be able to resolve the tone to its mean pitch. However, in Experiment II, subjects took more time to determine the pitch of the vibrato tone than the non-vibrato tone. We did not observe this difference in Experiment I. We suspect that in Experiment I, it was irrelevant if there was a vibrato tone present, since the second tone was always straight and the subjects were therefore never pushed to quickly determine the pitch of a vibrato tone. The results from Experiment II, however, seem to indicate that when the vibrato tone was presented as the second stimulus, subjects could not identify the pitch as quickly. This result may explain the commonly held belief among musicians that vibrato can be used to mask poor intonation. In other words, vibrato allows performers more time to adjust their intonation before an audience can detect the mean pitch.

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