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The first effect of pitch shift as a function of component spacing

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The paper presents the results of the experiment regarding the influence of the component spacing on the first effect of pitch shift. During the adjustment procedure, the listeners matched the pitch of the three-component complex to the same sensation produced by pure tone. The stimuli were composed of 3rd, 4th and 5th harmonic of 100, 200 or 400 *Hz* shifted up in frequency domain for 30 *Hz*. The level of each component was 50 dB SPL. The subject was presented by a 5 s sample of the test complex and after 500 ms break he had to define the pitch of three-component complex using the matching tone. The results of experiment suggest the pitch shift phenomenon is based on the relative frequency rather than the absolute frequency or the dominant component number.

1 Introduction

Most sound waves produced by human voices or musical instruments have a harmonic structure with the pitch corresponding to the frequency of the fundamental component. However, the perceived pitch does not change when the fundamental is removed. The residual pitch is created by the auditory system on the base of the time structure of the auditory nerve impulses.

Many previous experiments regarding the residue phenomenon focused on the first effect of pitch shift [1, 2]. The obtained results confirm the Schouten theory of residual pitch shift [3], which can be expressed as:

$$\Delta p = \Delta f / n \qquad (1)$$

where: Δp - is the shift of virtual pitch, [Hz]; Δf – is the shift of components of complex sound, [Hz]; n – the number of dominant component

On the basis of these results can be said that the nonlinearity of the hearing system does not influence the formation of residue phenomenon [4]. Thus the conclusion is made that the nonlinear components do not dominate in the creation of the residual pitch.

The paper presents the results of experiment regarding the first effect of pitch shift for the stimuli with the different spacing between the components.

2 The hearing experiment

Five listeners with normal hearing took part in the experiment. The three-component complexes were generated by a computer and passed through the headphone amplifier to the headphones. The stimuli were composed of successive harmonics of the missing fundamental of 100, 200 or 400 Hz, which were equally shifted up in the frequency domain for 30 Hz. For each fundamental the three-component complexes contained 3rd, 4th and 5th (equally shifted up in frequency domain for 30 Hz). The level of the primary tones were constant L_p=50 dB SPL. The spectral level 35 dB SPL of the white noise was used to masked other nonlinear components and it was sufficient to avoid the influence on the pitch perception process. Five series were made for the each listener. Four pitch matches were made in each series. The presentation time was 4 sec., followed by a 0.5 sec. break, and after that, the listeners had to match the pitch of stimuli to the same sensation produced by pure tone. The goal of the research is to define the pitch shift of the residue phenomenon for different fundamental frequency. The presented results were averaged through five listeners.

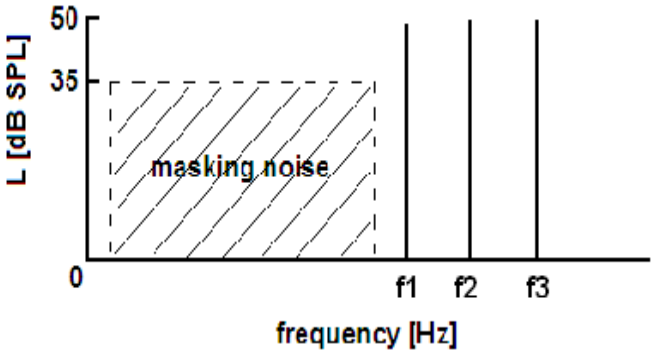

Fig. 1. The Stimuli

3 Result and discussion

The major result of the experiment is that the pitch shift increases along with the component spacing increase. This relation is presented in Fig. 2. The abscissa, component spacing, represents the fundamental frequency of stimuli. The ordinate, Δp, represents the pitch shift of perceived pitch of stimuli. Each point represents 20 pitch matches and the results are averaged through five listeners.

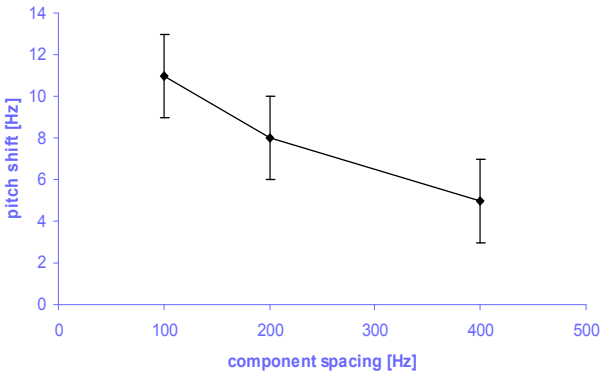

Fig.2 Relationship between the pitch shift and the component spacing

When the component spacing increases the listener were able to perceived the greater pitch shift. It is not obvious when we compare it with the Eq. (1). When we have the same number of the dominant component and the constant value of the shift of the stimuli component, the pitch shift of virtual pitch should be also constant.

In Fig. 2 we can observe the pitch shift depends on the component spacing. When the component spacing increases

the pitch shift decreases. This suggests that the relative frequency, rather than absolute influences the first effect of the pitch shift (Fig. 3). When the component spacing increases the pitch shift of component (relative frequency shift of the component) is less perceived, so the pitch shift of reside component decreases. The previous research also proofed this relationship [5] but suggestion was that the absolute, as well as relative frequency dominates in pitch perception process. The results of this experiment precise that the relative frequency plays the dominant role in the pitch perception process.

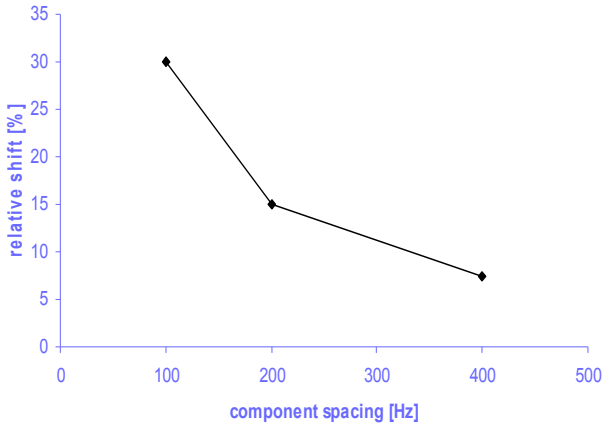

Fig.3 Relationship between the relative frequency shift of the component of the stimuli and the component spacing

5 Conclusion

The conducted research led to conclusion the first effect of pitch shift depends strongly on the component spacing of the stimuli. The increase of the component spacing make the frequency shift of the component of stimuli less perceived and therefore create smallest pitch shift of perceived pitch of the residue.

References

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