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THE EFFECTIVENESS OF VISUAL FEEDBACK SINGING VOCAL TECHNOLOGY IN GREEK ELEMENTARY SCHOOL

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1. ABSTRACT

The main scope of this research is to investigate children's singing voice pitch accuracy and quality. The investigation was led in two elementary schools, mainly on children aging between 6 and 9. We have used common freeware[1] for visual feedback, in order to find out its degree of effectiveness on the improvement of the children's pitch accuracy. The results indicated that through the use of visual feedback singing software and the teacher's help, children are more motivated to sing in tune, to understand the vowel quality, and to learn how to improve their singing.

2. INTRODUCTION

Since the 80's, the music education system in Greece has a rather traditional policy which includes fixed methods for singing pedagogy. According to the National music education curriculum the main axis of cognitive content specified in DEPPS (Cross Curriculum Framework) for Music is threefold: a) performance skills, b) music-making activities and c) evaluation skills. [2]

During our research, we have noticed that Modern Greek elementary schools lack a structured educational proposal for the cultivation of the children's singing voice accuracy and quality. In order to cultivate singing performance at school the music teacher has to solve several problems in classroom: first of all tonal accuracy and then subordinate characteristics such as intensity, breathing, proper articulation, and vocal expression. The students should learn about the acoustic function of their auditory and vocal system and subsequently how to use them during singing. According to Trollinger «as teachers we must have knowledge of the vocal mechanism and vocal pedagogy» [25].

3. SOME ACOUSTIC CUES ON CHILDREN'S PITCH ACCURACY IN SINGING

A better singing education for children should be based on he following two principles a) the acoustic function of their voice, and b) the appropriate acoustic and listening culture (the culture of a child aged from 6 to 9 is directly related to child's cognitive and physical development).

By reviewing the literature of the children's singing skill development we could focus on certain studies that deal with the improvement of pitch accuracy. As a result we gathered data for further investigation on the pitch matching accuracy, speech fundamental accuracy, tonal aptitude and singing achievement {[6], [7],[8],[14],[16],[29]}.

The development of children singing skills can be classified in two categories: *created songs* and *taught songs* [28]. Created songs are the ones used by children in their free play and taught songs are the ones that children learn at school. According to Rutkowski some children are classified as non-singers and others as singers[3] [21]. Rutkowski also proposed a method for developing children's singing voices[4]. Another approach on the classification of singers is proposed by Welch who recommends the Vocal Pitch Matching Development (VPMD) Model [28]. Other researches like Buckton, Goetze, Smale {[2], [5], [23]}, investigate different aspects of children's vocal development like pitch accuracy, vocal range, musicality etc.

It is also very important to take into account the physiological parameters and the registers which affect pitch accuracy. Children's voice is divided into three main registers[5]. Their vocal folds are so weak and

[1] *Singing Coach 5 Pro:* software from Electronic Learning Products invented in 2003 (http://www.singingcoach.com/index.html).

[2] DEPPS and APS of Music, Pedagogical Institute, Athens, 2012 (p. 337 and 349-350

[3] The scale created by Joanne Rutkowski classifies the voices of children in 4 categories: a) Pre-singer, b) Speaking range singer c) Limited range singer d) Initial range singer

[4] In Singing Voice Development Method (SVDM) she has created a nine phrases singing model that the child has to pass to succeed and be a confident singer

[5] The low, middle and high or head register. The low is mainly used for speech and singing. The high is the one to be used by children for "healthy" song. If a child in this age (6-9) uses his low or chest

thin that they cannot pass above F5 or beyond E1 [10]. They also have a small lung size and certain laryngeal cartilage mobility so they can produce a limited pitch range and small phrases [29]. The pedagogical conclusions drawn from the physiology of child-speech have to do with the most important features of the singing sound. For example, the duration and the intensity of a sung vowel are limited, as also the acoustic range of sounds that a child can produce during the singing procedure.

The age is also a factor that can change the efficiency of the voice tonicity {[12], [16], [22]}. On the contrary, gender has no influence on the proper tone of the song [1].

According to Phillips [16] reasons why a child cannot sing properly are specific: a) children don't sing properly when they don't have tonal feedback, b) cannot separate the song from the speech, c) cannot understand the voice of the head (head voice), e) cannot breathe properly, if there is anxiety or other emotional reasons and f) when they have poor posture.

Usually students at the age of 6-9 years could gain a much better vocal training, while learning at the same time to speak and write. Further, the teacher must have in mind that the reasons why a child cannot sing properly can be rather psychological, normal organic or environmental [22].

Thus, through vocal training the music teacher could prevent singing problems related to the reasons described above. Teachers have at times suggested comprehensive educational recommendations for improving the children's singing with techniques as suggested by Phillips, Kinney, Baldy, Runfola & Rutkowski, which contain a number of vocal exercises for breathing, vocalization and posture{[16], [12], [1],[20]}.

4. VISUAL FEEDBACK BASED TECHNOLOGIES FOR THE SINGING PEDAGOGY

The last ten years new methods have been developed for analyzing and representing singing aided by computers [3]. In addition, more software have been used for visual feedback which can help singing in tune {[27], [30]}. According to the needs of the new digital school every student can have access to software and hardware for enhancing creative music pedagogy (organ performance, composing music, listening to music, musical toys)[6] [17].

The visual-feedback software technology might help students to correct vocal or tonal mistakes by watching their voices. Software of this category such as *Sing and See*[7], *Singing Coach* and systems like *Singad* [9], *Winsingad* [11], *and Albert* [19], etc. are very progressive in singing education because the whole process is taking place in real-time. These software can help students improve the proper placement of their voice and enable them to see the imaging behavior of the voice, in the larynx, in real-time.

In the table 1, we expose a comparative list of the most common visual feedback singing software and their usability for the amelioration of the children's pitch accuracy:

Some of these software can analyze:

- Pitch accuracy (using the narrow band spectrograms)
- Vowels quality (using the wide-band spectrograms)
- The formants (that can show different characteristics of the vocal tract in the child singing voice)
- Harmonics (that show characteristics of the sound source)
- Vocal quality (loudness, brilliancy, vibrato, formants) in difficult singing patterns, using the LTAS (Long Time Average Spectra)

Most of these software are not "user-friendly" for children at the age of 6 to 9 and many needed guidance by the teacher.

Since now few research projects have been carried out on measuring the pitch accuracy before and after the use of visual feedback software {[15],[18],[27] [30]}.

For the needs of our investigation we have chosen the freeware software *Singing Coach Pro* , ,a very simple and amusing environment for the children as it includes winning 'points' during practice sessions. This particular feature increased excitement and motivation for the children who have taken part to this experiment.

5. METHODOLOGY

Our research took place in two elementary schools in Athens, Greece. The students take music classes for 2 hours per week in the early grades (1st through 3rd) and one hour per week in higher grades (4, 5, and 6th). 30 boys and girls, aging between 6 and 9 years, participated in this study. The recordings were made with an Omni-directional microphone (Rode NT2A) in a computer using an external USB sound card (fast track-400) and the REAPER sequencer[8]. Students were recorded singing a phrase of a Greek traditional children song called: *Let it be said one.* This song belongs to a different category because it uses a "non well-tempered" music scale of the Greek Byzantine Music named Echos[9].

register the vocal range that he exhibits is from A3-C5, but if he uses his head register the vocal range is from G4-G5[9].

[6] Students have to learn new forms of computer literacy that involve both computer technologies to do research and gather information, as well as to perceive computer culture as a terrain which contains texts, spectacles, games and interactive multimedia which contain new literacies.

[7] Sing and See: software from Cantovation Ltd invented in 2004 (http://www.singandsee.com/html)

[8] Reaper: Software from Cockos Incorporated invented in 2005 (http://www.reaper.fm/html).

[9] Most of the Greek traditional songs use this type of scales (modes). This song follows a certain music path that in Byzantine music the

The second recorded song was *Wingfield* by Johannes Brahms which follows the C major scale.
During the experiment three elements were tested:

a) The pitch accuracy in these different songs,
b) The effectiveness of the singing software regarding the pitch accuracy
c) The usability of this particular software

The experiments lasted for 3 weeks. All children were taught how to sing these two songs during their music classes. The first week we recorded children in singing single phrases of these two selected songs; they were given the first note of the song before recording. During the second week they participated in an experimental session where they started to use the visual-feedback software *Singing Coach Pro*. In that way they had the opportunity to see the phrases of the songs in a template (as bars that followed the melody) and also the tempo of the song. Children could see and hear the melody at the same time. This template included the midi version of the two songs in order to give them the ability to listen to the tempo and the melody of the song at the same time as the cursor was moving following the bars. All these children had also in their disposition a private practice time of about 90 minutes divided into two different sessions of 45 minutes each. After this, during the third week all children were re-recorded to see if they made any progress on their singing abilities.

6. STATISTIC ANALYSIS

Analysis of the collected data was done using SPSS. The results indicated the presence of three children groups: a) The ones that sang the 2 songs very well in the beginning and their improvement was very slight b) others that sang the 2 songs moderately and ameliorated their pitch accuracy and c) others that sang the 3 songs with a lot of divergence in their notes.

Our discussion will focus on the second group: children that sang the 2 songs moderately in the beginning but ameliorated their pitch after the exercise session (14 children for the first song and 12 children for the second). Our statistics were based on the rms indicator as it is the best indicator for measurements and controls the difference between theoretical rates.

In the first diagram we can see the mean pitch difference among the two songs and in the second the pitch difference rms deviation. As we can conclude from the second diagram the average pitch difference is closer to zero implying that children have improved their pitch accuracy after the use of the software. In the first song, 7 children ameliorated their pitch accuracy by a semitone or less. Five children's pitch amelioration was more than a whole tone and 2 children's amelioration was closer to a whole tone. In the second song only 4 children ameliorated their pitch by a semitone or less, 6 children's amelioration was more than a whole tone and 2 children ameliorated their pitch a bit more than a semitone.

In the first diagram of the first song we can see that the mean pitch difference of 5 children is closer to zero, but the standard deviation for all children ranges from -400 to +300 cents. So, in the first song we have 3 children that their mean pitch difference is very close to zero. In the second song the standard deviation for all children ranges from -800 to +180 approximately and 4 children had a mean pitch deviation closer to zero.

We also used an Independent Samples T-test (Table 2) which helped us check if there was any important statistical difference between the group of the girls and the boys. From the results we can conclude that there is no statistical difference among those two groups before or after the learning process. But we can point out that after the use of the software the results are uniformed (Sig<.05).This indicates that the software learning procedure is very useful in for alleviating any differences between these two groups. The main problem of this statistical analysis was the small number of samples and the number of different groups.

7. DISCUSSION AND FURTHER RESEARCH

According to the results above one can realize that visual feedback did help some of the children and gave them the opportunity to exercise in a more "challenging'' environment. This Visual feedback technology did motivate the children to learn to sing better through a friendly environment which offered them the opportunity to see and analyze the score as well as to learn from their errors with the teachers' help. We have remarked that in the first song (the Greek traditional one) we had better results after the practice than the second one. We can partly conclude the traditional song is 'closer' to the children's ear tuning and for that we had better results after the practice. We have also noticed that age did change the efficiency of children's voice tonicity and also that the girls had better results than the boys.

In the future we will extend our research to more schools with a different background (private schools, multicultural schools, etc.) and we will focus on the particularities of pitch accuracy concerning tuning according to the cultural environment and the educational singing system. We will also measure particular features of children's voices and export results in relation to their age, sex, and social status as well as their inheritance and their feelings and emotions in relation to the song.

In conclusion, through this investigation our main scope is to outline -in a preliminary level - the singing voice profile of children in Greek elementary schools, ameliorate the singing education culture in schools and propose solutions based on computer-based assistance.

interval sizes are: 10-8-12-12-10-8-12.Pa-Vou-Ga-Di-Ke-Zo-Ni'-Pa. For more information [24]

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SOFTWARE	USABILITY FOR THE CHILDREN	Pitch accuracy	Vowel quality	USER INTERFACE FOR CHILDREN	Formants	Articulation	Harmonics	Intensity
Sing and See	✓	✓	✓	Friendly	✓	✗	✓	✓
Singing Coach	✓	✓	✗	Friendly	✗	✗	✗	✗
Melodyne	✗	✓	✓	Not Friendly	✓	✗	✓	✓
Listening Singing Teacher	✓	✓	✗	Friendly	✗	✗	✗	✗
Mac Gamut	✓	✗	✗	Friendly	✗	✗	✗	✗
Match Pitch	✗	✗	✗	Not Friendly	✗	✗	✗	✗
Singing Tutor for Windows	✓	✓	✗	Friendly	✗	✗	✗	✗
Vocal Lab 2.0	✓	✓	✗	Friendly	✗	✗	✗	✗
Voce Vista	✗	✓	✓	Not Friendly	✓	✓	✓	✓
Wavesurfer	✗	✓	✓	Not Friendly	✓	✗	✓	✓
Canta	✓	✗	✗	Friendly	✗	✗	✗	✗

Table 1. Comparative table of visual feedback software

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
pitch_difference_before	Boy	4	-36,4292	206,94600	103,47300
	Girl	10	113,5141	153,86084	48,65507
pitch_difference_after	Boy	4	-30,8758	126,37002	63,18501
	Girl	10	16,4112	93,15492	29,45817

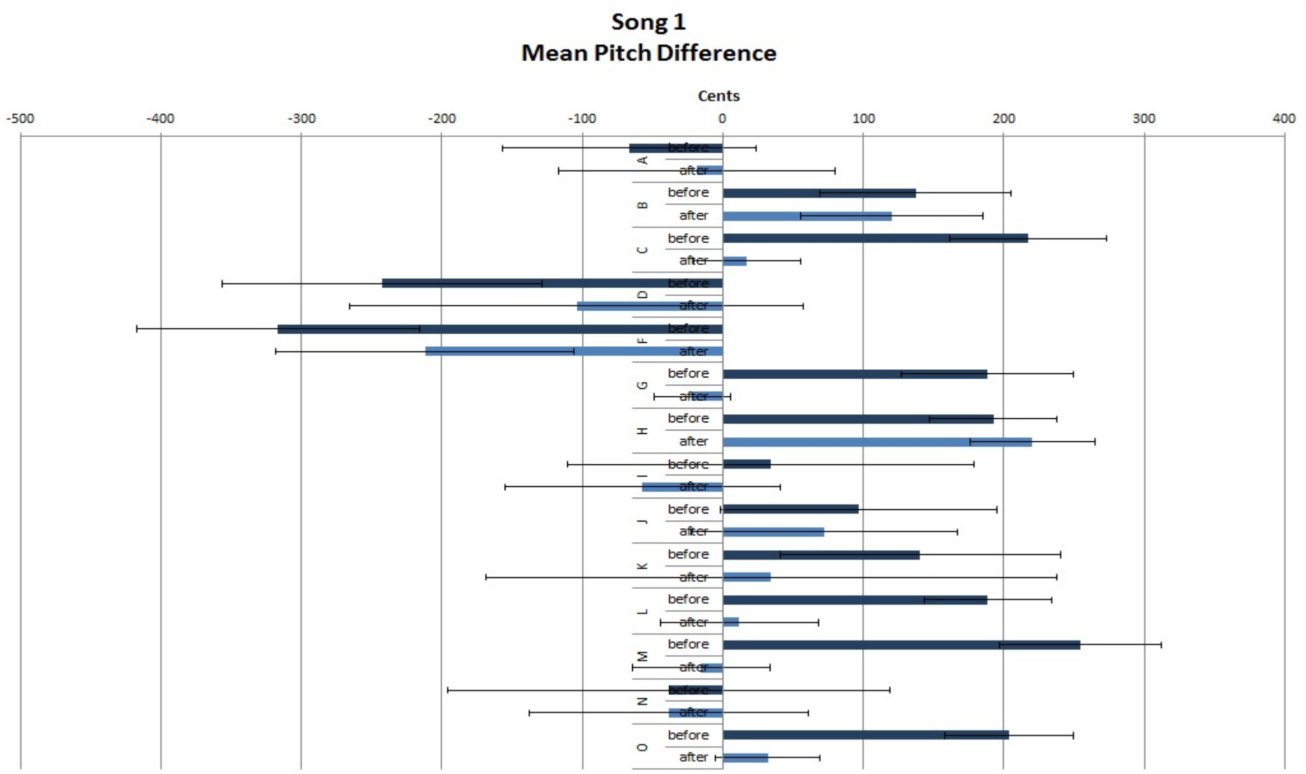
Independent Samples Test

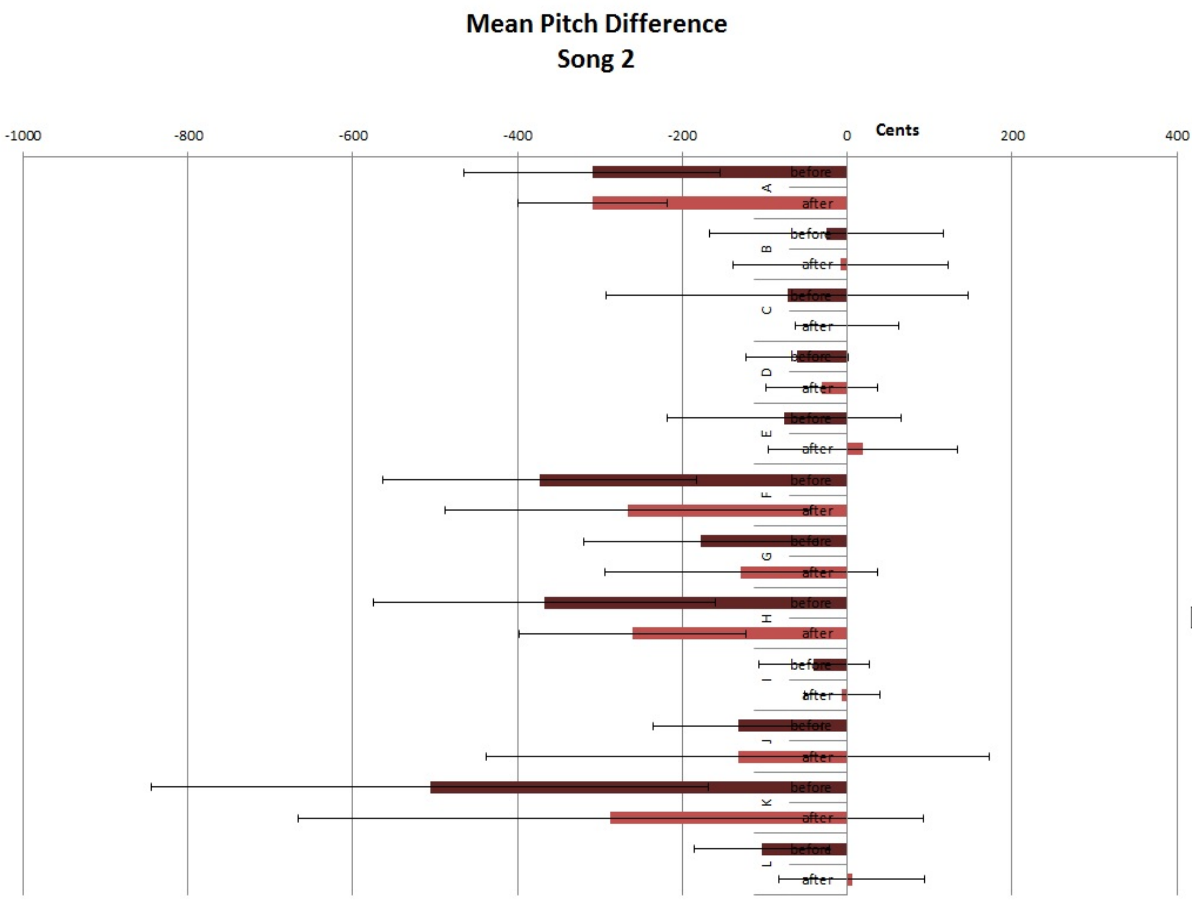
		Levene's Test for Equality of Variances		t-test for Equality of Means
		F	Sig.	t
pitch_difference_before	Equal variances assumed	,450	,515	-1,502
	Equal variances not assumed			-1,311
pitch_difference_after	Equal variances assumed	,445	,517	-,780
	Equal variances not assumed			-,678

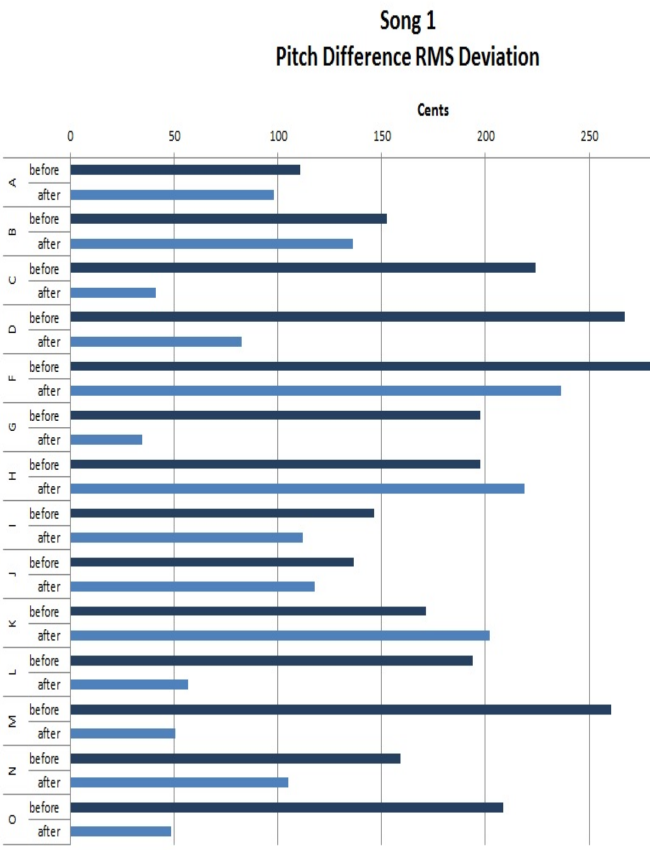
Independent Samples Test

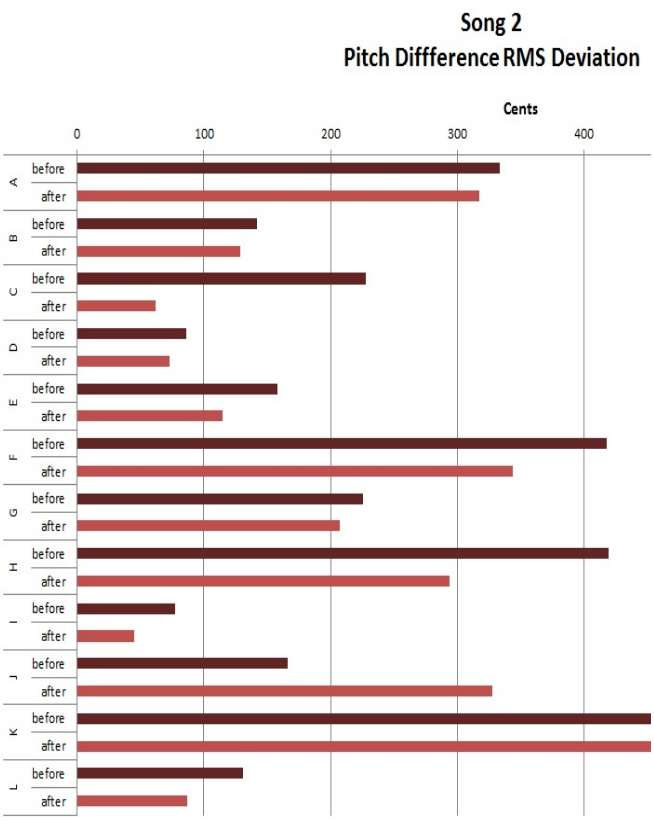
		t-test for Equality of Means		
		df	Sig. (2-tailed)	Mean Difference
pitch_difference_before	Equal variances assumed	12	,159	-149,94338
	Equal variances not assumed	4,402	,254	-149,94338
pitch_difference_after	Equal variances assumed	12	,450	-47,28700
	Equal variances not assumed	4,377	,532	-47,28700

Table 2. Independent Samples T-test


Song 1
Mean Pitch Difference
Cents
-500
-400
-300
-200
-100
0
100
200
300
400
A
B
C
D
F
G
H
I
J
K
L
M
N
O
before
after


Mean Pitch Difference
Song 2
Cents
-1000
-800
-600
-400
-200
0
200
400
A
B
C
D
E
F
G
H
I
J
K
L
before
after


Song 1
Pitch Difference RMS Deviation
Cents
0
50
100
150
200
250
A
B
C
D
F
G
H
I
J
K
L
M
N
O
before
after


Song 2
Pitch Diffference RMS Deviation
Cents
0
100
200
300
400
A
B
C
D
E
F
G
H
I
J
K
L
before
after