Effective Instrument for Score Reading Skills Assessment
EISTA 2009

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ABSTRACT

In this research effective instrument for score reading skills assessment of the music education students is proposed. New method is based on the subject's gaze registration during simultaneous listening to the music and watching the score. The experimental research was carried out by using eye movement register *Eye Gaze System*, audio player and music sore sheets continuously presented on the computer screen. Recorded trajectory of the gaze on the text of the score revealed relationship between the sounding music and its gaze trace printed on the score. We examined lagging or leading character between sound and watched notes, jumping frequency among staffs of the score assuming priority of the musical material and ability to find implemented mistakes between actual sounds and notes.

Keywords: gaze direction registration, musical score, score reading assessment.

1. INTRODUCTION

The students' skills in "fusion" of sounds and notes representing this sound are essential to many musical study programs: orchestra, band and choir conductors, musicologists, as well as music educators of various levels. While individual score reading skills can be comparatively reliably tested by listening to student's playing the score on the piano, the instrument presented here is able to show precisely the way of following the score – the habit which pedagogues are practically unable to control. This skill is necessary in the process of ensemble, orchestra, band or choir conducting or leading their performing in another way.

Presented research in this paper was designed to develop an objective and effective instrument based on information and communication technologies (ICT) application to assess music students' skills. Proposed method is based on the simultaneous listening to the music and watching the score of the same sheet music changing on the computer screen. Synchronically to this process direction listener's line of sight was registered on the notes sheet and presented for evaluation. Created computer program performed calculations: leading or lagging time between sound and watched notes, watching duration of the gaze staying on particular staff, and reaction to the intentionally prepared erroneous passage.

The instrument which was created in cooperation between Šiauliai University Biomedical Engineering Centre and Art Research Centre enables to investigate a large quantity of students in an initial point of their studies. After a certain period of learning the students can be tested repeatedly and thus their advance in orientation in the score could be assessed.

The research presented in this article, as far as the authors know, has not been carried out earlier. Recording of eye movements were used analyzing and complementing man-machine interaction [3]. Many researches devoted to the eye movement analysis for the perception patterns during reading [5, 6], fine art works observation habits [2, 8, 9], film watching peculiarities [1].

2. THE METHOD OF THE RESEARCH

The experimental research was carried out at Biomedical Engineering Centre (Šiauliai University, Lithuania) using eye movement register *Eye Gaze System* elaborated by enterprise *LC Technologies*.

In the fig. 1 the example of the score page together with eye movement trajectories is presented. The slantwise line and the trajectory meandering around it demonstrate the synchronicity of the gaze direction with sounding music. The deviation of the trajectory at each point to the left means the lagging of the gaze in time; the deviation to the right demonstrates the leading of the gaze in time. The upper curve tracks the jumping and remaining of the gaze on one or another staff.

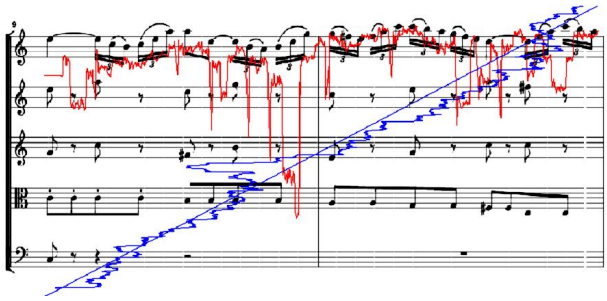

Figure 1. Subject No. 2, score page No. 5, bars 9-10. The upper curve demonstrates the gaze trajectory in the vertical dimension of the score, the slantwise line and the trajectory meandering around it demonstrates the synchronicity of the gaze direction with sounding music.

The research had been carried out mainly by analyzing these schemes obtained from each of research subjects, i. e. in total 72 pages were examined (8 pages of the score traced by 9 subjects of the research). Such parameters as synchronicity with actual time of the sounding music (leading or lagging of the gaze in time), the quantity of staffs encompassed and changes of the gaze in erroneous passage (noticing of the error and gaze reaction to it) were taken into account in the research.

9 music education students from 3rd study year of Faculty of Arts, Šiauliai University took part in the research. Their average age is 21.4 years. 5 students are graduates from conservatoires, 4 students graduated from children music (art) schools. 4 conservatoires graduates studied conducting and score reading before entering the university, others studied neither conducting nor score reading. Students acquired different musical education before entering Šiauliai University: choir conducting (3), singing (1), violin (1), piano (2), accordion (1) and percussion instruments (1) players.

A passage (first 16 bars) from 2nd part of J. S. Bach's Violin Concerto No. 1 in A Minor was used in the research. The duration of the passage is 2 min. 21 sec. The score consists of 5 staffs: solo violin, 1st violins, 2nd violins, violas and *continuo* (cellos and double basses in one staff but without figures indicating harpsichord's chords traditional for Baroque orchestral style). On the whole the passage covers 8 pages, one score system per page. The time signature is 4/4, tempo – *Andante* (quarter = 60, or eighth = 120 – the main pulse unit is eighth note). The texture is predominantly homophonic. Interaction between solo violin and is minimal: initial 4 bars filled with by orchestral chords with bass line which carries restrained thematic material of *ritornelli*. In further development the soloist accepts the role of leading voice which interchanges with orchestral episodes repeating primary material in bars 7-8 and 15-16. Such score graphics causes fairly clear tasks for score readers: it is necessary to catch the entries of soloist and transfer the attention to the appropriate places of the orchestra, firstly bass line and also vertical chords of violins and violas. Thus there are three textural layers in this score: 1) embossed line of solo violin, 2) comparatively less prominent but thematically important bass line and 3) rhythmically mostly equable chords of the middle voices. The tempo is slow therefore the research subjects did not need especially high skills of score reading in order to encompass at least main voices of the score. Students were not informed about the musical passage in advance and it was unfamiliar for all of them. The score pages in computer's screen changed while sounding of the last fourth of the last measure. In order to attract listeners' attention and prepare them for the beginning of playing music one bar length rhythmical entrance was used.

The most intriguing element of the research was deliberately erroneous passage in solo violin part. The detection of wrong notes was studied in [7]. It was placed in bar 13 and lasted for two fourths, the first half of this bar (Figures 2 and 3). The reflection of the noticed mistake in gaze registration diagram should show the peculiarities of eyes movements in comparison with general way of score reading and thus enable to indicate the skills of the students in following the score.

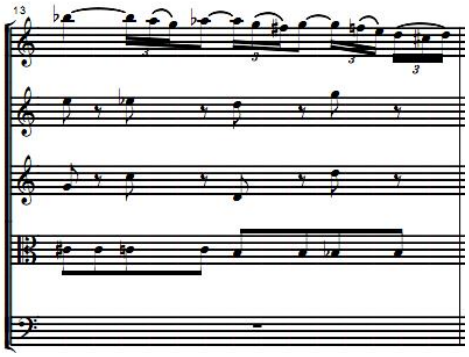

Figure 2. The original text of the J. S. Bach's Concerto for Violin No. 1, 2nd movement, bar 13.

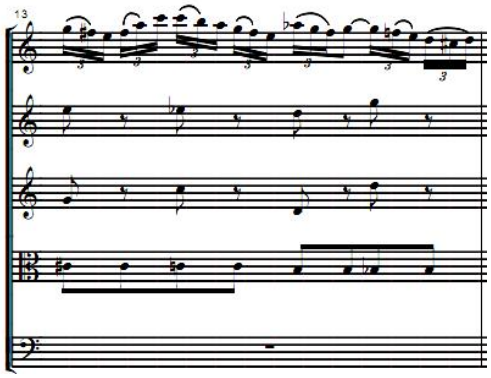

Figure 3. The erroneous version of the J. S. Bach's Concerto for Violin No. 1, 2nd movement, bar 13. This version was presented for students in order to identify their ability to notice the erroneous passage by analyzing eyes movements.

3. THE RESULTS OF THE RESEARCH

The general analysis of the data revealed that in this research music education students' gaze peculiarities correspond with those of the earlier research which was carried out in May 2008 [4]. Although the slow tempo and small quantity of staffs (5) made up favorable conditions for gaze to encompass the whole score, it was revealed that subjects more often encompassed only limited quantity of staffs. Part of the students concentrated their gaze on solo violin part neglecting staffs of the orchestra.

Figure 4 shows time leading (+Δt) or lagging (-Δt) average meanings and standard deviations of all 9 students (they are numbered from 1 to 9). Small squares indicate average time

leading or lagging meanings during the experiment. The height of the column indicates standard deviations. The last column indicates average leading or lagging and standard deviation meanings obtained by summing the results of the whole experiment.

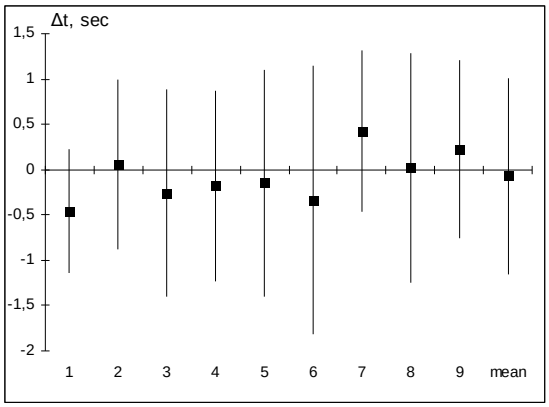

Figure 4. Time leading or lagging and standard deviations average meanings attained during the experiment. Vertical axis indicates measuring in seconds, figures on the horizontal axis – numbers of subject.

The leading-lagging peculiarities are different for various students, but the consistent pattern was revealed that the subject who's gaze most significantly lead the real time following the score restricted the vertical aspect with minimal quantity of the staffs (sometimes even one). In other words better synchronicity in horizontal axis was achieved at the expense of quantity of staffs watched vertically.

For the more pictorial presentation of the results obtained during experimental session, the diagrams for every subject are presented in figure 5. The height of the bars shows the percentage (vertical axis) of gaze staying at one of 5 staffs (their numbers are on the horizontal axis) comparing with the duration of the whole experiment. It is obvious, for instance, that the subject No. 1 had concentrated his gaze on the second staff. This shows the attachment to the part of the first violin which in this particular case is not predominant (mostly performs the upper voice of the equally rhythmic harmonic complex). Quite opposite result can be seen in subject's 5 diagram: the attention is mostly paid to the solo violins part (1st staff), a little less concentration can be seen on basses part (5th staff) which perform the most important thematic material among all orchestral voices, and the parts of orchestral violins and violas (middle staffs) are just slightly touched by the gaze.

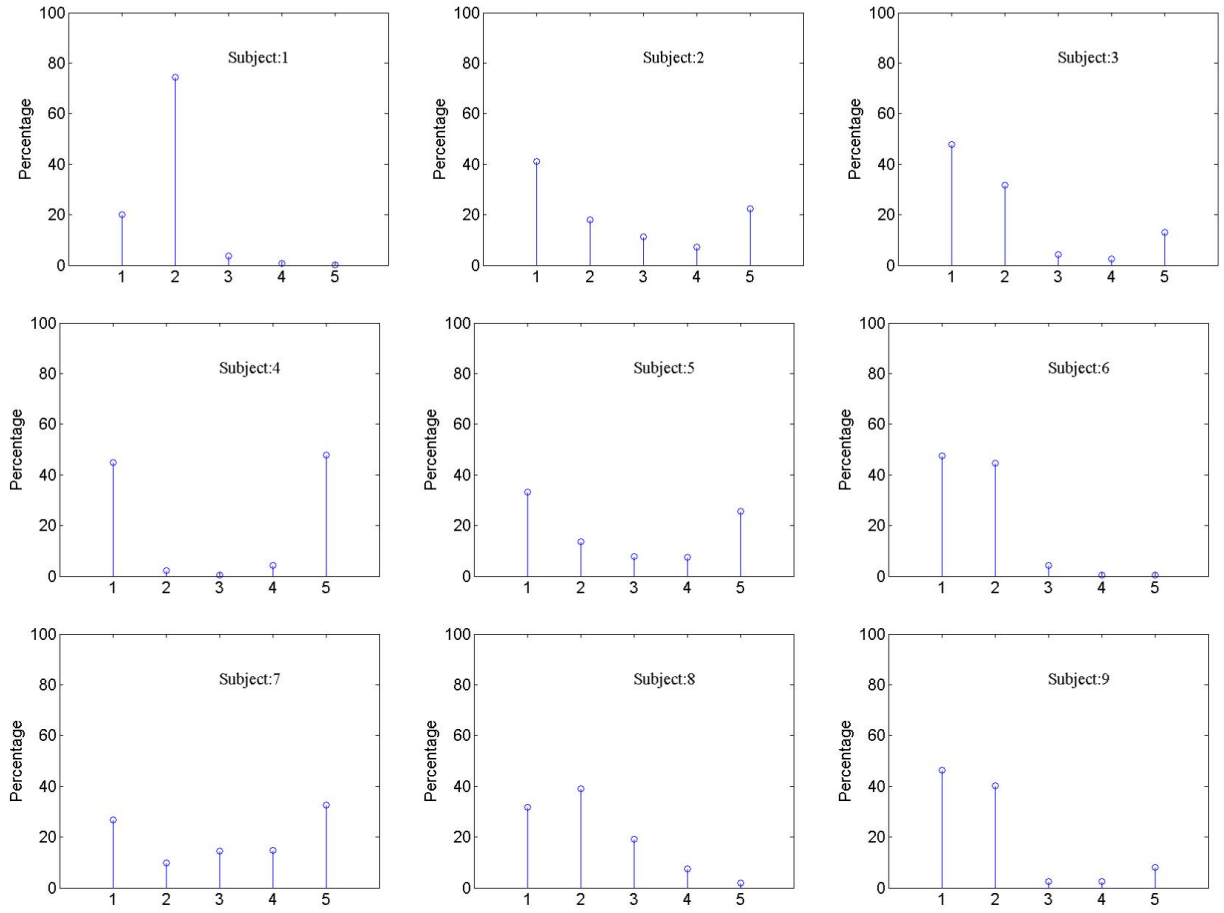

Figure 5. Duration of the time of gaze staying on each of 5 staffs of the score for each subject in percentage comparing with the whole time of the experiment.

The main attention was paid to the gaze reaction to the error in bar 13. It was observed that the subjects who noticed the error immediately lost the synchronicity with actual music time and began to search in one or other way for the reason of discrepancy between notes and sound. They had returned to the synchronic gaze-sound relationship after different time span presumably depending on each of them individual skills (the range is between the end of the 13th and the middle of 14th bars). But 3 of 9 subjects revealed very little evidence of embarrassment or did not reveal at all. Therefore it can be presumed that these students' score reading skills are very superficial and they did not notice the error or at least there reaction to it and confusion was not as strong as others'. In Figures 6 and 7 both cases are presented.

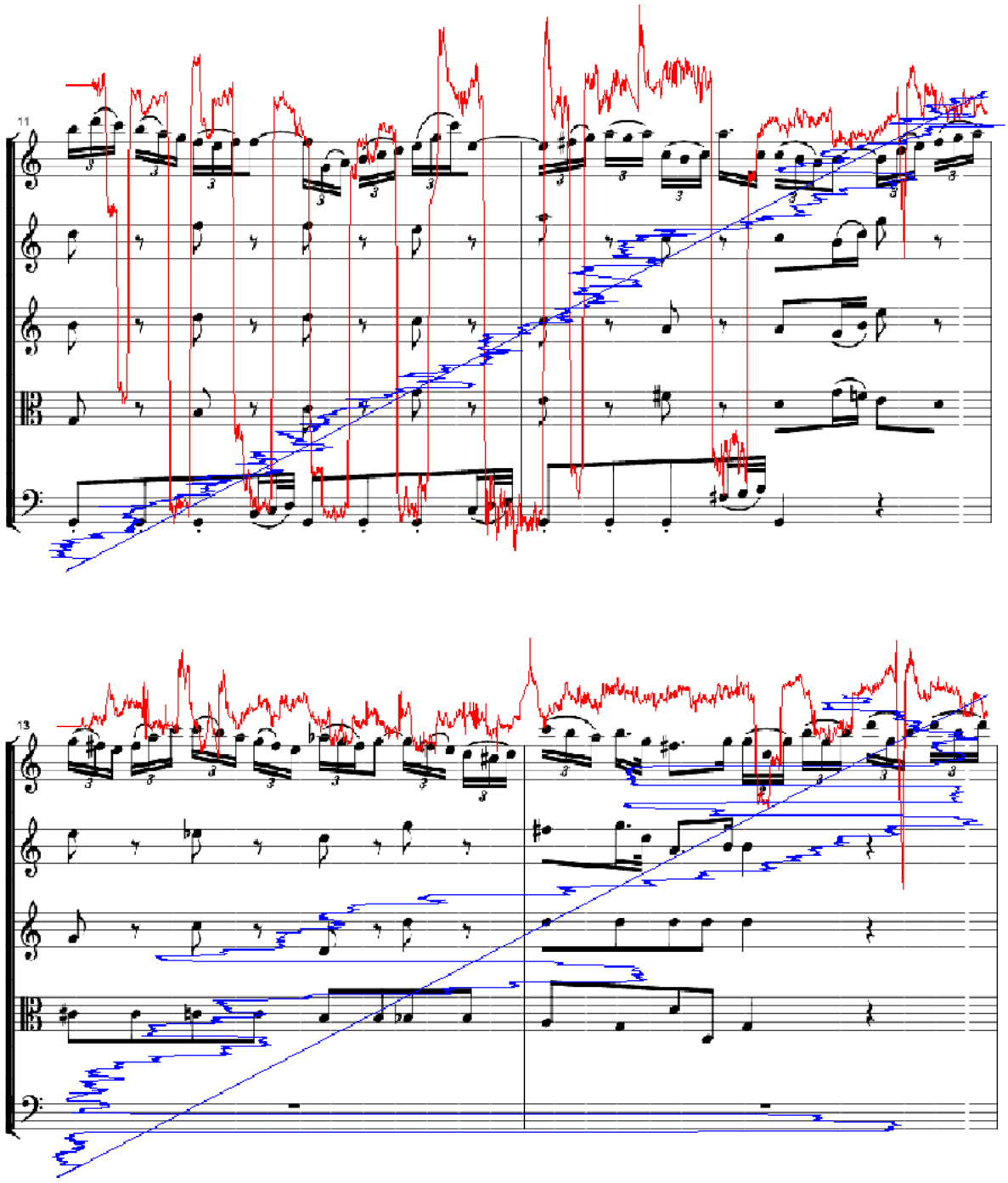

Figure 6. Subject No. 5, score pages No. 6-7, bars 11-14. The immediate subject's reaction to the erroneous passage: the encompassing of the whole score in bars 11-12 is replaced with concentrating of solo violin's staff in bars 13-14 (upper curve); the synchronicity with real sound in bars 13-14 is lost and returns to the synchronic trace not earlier than in the middle of the bar 14 (the slantwise line and the trajectory meandering around it).

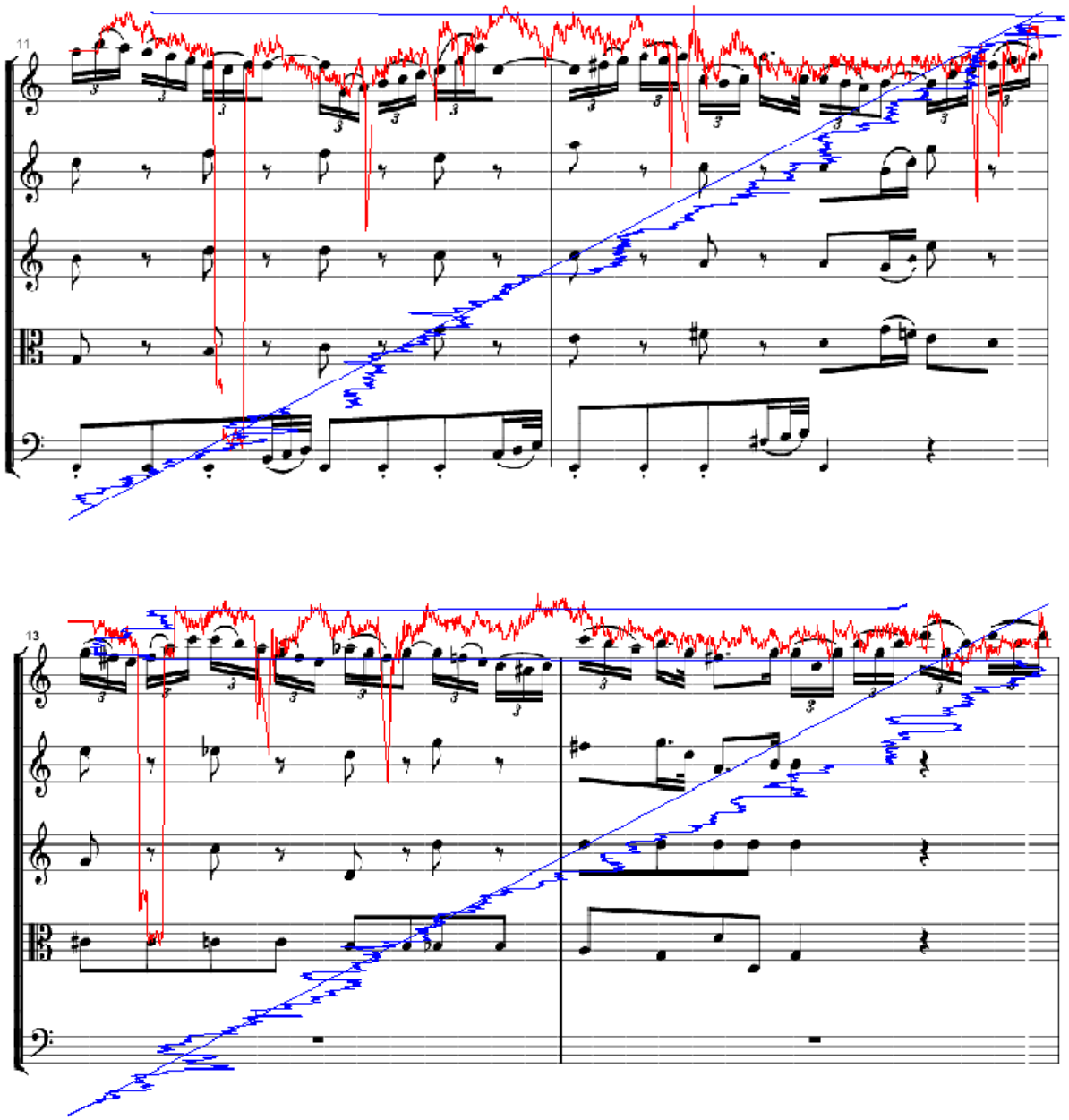

Figure 7. Subject No. 9, score pages No. 6-7, bars 11-14. Gaze is mostly concentrated on the solo violin's part (upper curve), the synchronicity with the real music time is constant (the slantwise line and the trajectory meandering around it); there are no obvious significant changes in erroneous passage presumably because of not noticing the error.

4. DISCUSSION

While tracing the sheet music, the gaze should in average slightly lead the actual sounding time point. The conductor must know in advance the sounds which are going to appear, anticipate the forthcoming acoustic result and control it with his/her ear. During this research the task for subject to imagine themselves as conductors had not been set, but it could be foreseen that music education, conducting etc. students should have demonstrated appropriate professional skills in this particular situation. The results obtained demonstrate the level of skills of eyes orientation in music score. However with the help of this research it is impossible to identify the level of students' ear for music development, in other words, it cannot be checked how much they are capable to correlate the altitude of notes written in the score with correspondent actual sounds.

Indications of time leading–lagging reveal themselves in new aspect if we compare them with the other criteria of the research: eye movements in the score paying attention to one or another staff striving to cover the vertical dimension. In this aspect the differences are sufficiently high. Correlating with the

leading–lagging results it can be stated that the subject who traced one or two staffs for the better part of time and did not regard other staffs, comparatively easily lead the actually sounding time, while students who encompassed deeper layers of the score more often lagged. Therefore it is obvious that the musicians who deal with scores in their work need to combine both dimensions of orientation in the score: the horizontal aspect (tracing the notes in sheet music a little leading the actual sound) and the vertical aspect (ability to notice the layers of the texture in the totality of the staffs).

5. CONCLUSIONS

1. The proposed method is based on the analysis of the trajectory of eye movements on the text of the score which allows us to identify the consistent patterns of relationship between the sounding music and recorded notes of this music.
2. Three parameters were taken into account in this relationship: lagging or leading between sound and notes; jumping and staying time on a certain staff(s); the gaze reaction to the discrepancy between actual sound and wrong notes.
3. Students with higher skills show better synchronicity between sound and notes (slight leading), mostly keeping gaze on the staffs with the main musical material, and obvious reaction to the wrong notes.
4. It was noticed that students who most significantly kept the synchronicity between sound and notes concentrated on the minimal quantity of the staffs (sometimes even one).
5. It was noticed that the reaction to the erroneous passage lead to the loosing of the synchronicity between sound and notes. Six students of nine clearly showed mentioned reaction.
6. The implemented instrument revealed that ICT technologies allow to assess students' skills objectively, in a short period of time and with small workload for a teacher.

6. REFERENCES

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