KEYBOARD AS A STIMULATOR IN TIMBRE RECOGNITION TRAINING

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ABSTRACT

This paper presents the results of a research conducted in a group of Youth Palace in Olsztyn participants. Two different keyboards were used in the experiment to teach how to recognize the timbres of selected musical instruments. Obtained results clearly showed that musical education with the use of keyboards significantly develops timbre hearing of children and youth. The research group performed much better in the tests in comparison with the control group. A danger appearing during this kind of training is the listener getting used to a given timbre (sample). Big part of psychoacoustic research is limited to acoustic stimuli not related to the art of music in a real way, which does not allow the use of this type of research and stimuli in musical didactics. The experiment presented in this paper is based on generating musical sounds that have worked well in education.

KEYWORDS

Children, Digital Technology, Hearing, Musical Education, Teaching

1. INTRODUCTION

Timbre is one of the four sensational characteristics of sounds, next to volume, pitch and duration [Rogala & Łętowski, 2017, p. 331]. Unlike volume, pitch and duration, which can be measured in quite a simple way, timbre of sound is the most complicated and difficult to measure. Timbre is a multifaceted term [Rasch & Plomb, 1999, p. 101; Taraszka-Drożdż, 2016, p. 171], depending on: energy distribution; changes related to the energy distribution over time; spectral characteristics of sound – for example if it is a single sound with a characteristic frequency, if it is audible or not, if it is a noise etc. [Sęk, 2000, p. 18]. The timbre of the sound determines it's auditory image, which can be perceived differently by every listener [Bregman, 1990, pp. 92–93, 336], and can be also treated as an aesthetic feature, as well as be considered by the listener in the context of satisfaction or lack of it [Łętowski, 2002, p. 186].

An attempt to solve the problem of systematization and unification of timbre, can be observed in psychoacoustic research. Numerous independent variables, occurring at the same time, and being hard to measure, became a reason why psychoacoustic studies of sound timbre are limited to artificially generated (synthesized) sounds. In this case the experiments are constantly burdened with a significant limitation: participants are being exposed to stimuli (simple and complex tones, modulated, component tones, pronounced words, noises, elements of scales or harmonic triads) artificially generated by specialistic devices [Miller & Heise, 1950, pp. 637–638; Bregman & Campbell, 1971, pp. 244–249; Bregman et al., 2000, pp. 626–636; Oxenham et al., 2003, p. 1544; Bregman & Woszczyk, 2004, pp. 39–41; Bregman, 2005, pp. 36–37; Parbery-Clark et al., 2009a, p. 14106; Parbery-Clark et al., 2009b, p. 659; Pantev & Herholz, 2011, p. 2152; Parbery-Clark et al., 2012, p. 117; Strait et al., 2012, p. 199; Parbery-Clark et al., 2013, p. 129]. The positive side of it is that the sound material in this case is totally measurable, which allows certain objectivization of the study results. However, on the other hand the research circumstances have little to do with these that normally occur when a person is listening to music. Experiments of this kind, the results of which are very important in acoustics and sound engineering, are unfortunately not very useful in ear training. In the first case the material is described as "acoustic stimuli", while in the second case as "musical sounds" – which from the artistic point of view are not the same thing.

There are few publications written mainly for musicians, so mutual understanding different researchers' needs (i.e. of an acoustician, a psychologist and a musician) seems to be a complex problem. The author of this study tries to look at the timbre analysis from the musical point of view, without detracting from the legitimacy of acousticians' and psychologists' work, because without it, musicians would have no basis for further activity. It means that earlier studies were not conducted on "real" music, but created using suitable generators in a computer and analyzed in a laboratory, which is not a space where a musician can feel free and comfortable. Obtained data confirm that analyses made by other researchers did not concern musical sounds. This shows that there is a wide undiscovered area of knowledge that can be filled with own research. Discussed issue has not been considered in available scientific literature in a way presented in this paper. Observed vulnerability in experiments was the basis to raise following research questions: does the use of popular keyboards' sounds affect the development of timbre memory of children and youth? Can electronic instruments such as keyboards be used to teach acoustic instruments' timbre recognition, by the use of digital sound emulations?

2. ASSUMPTIONS AND OBJECTIVE OF THE EXPERIMENT

The objective of the experiment was to examine if the use of various keyboard sounds as a tool during didactic classes influences and stimulates timbre memory of the participants by improving their skills of recognizing the timbres of individual musical instruments in comparison to the control group.

3. SOUND MATERIAL

During the experiment, a teacher was presenting various harmonic and melodic sequences for 10 seconds, each in a pitch scale adequate for a given instrument. These passages were performed by in front of the class participants by the teacher. Each performance was different (no repeating musical structures), so the listeners could not memorize any connections between a melody and a timbre.

All the melodies were played a keyboard, using the sounds chosen by the instructor as the ones, that authentically imitate traditional instruments. In order to verify each participant's familiarity with different instrument timbres, the teacher picked 25 timbres of various acoustic instruments belonging to several instrument families: classical guitar, acoustic guitar, electric guitar, banjo, mandolin, electric bass, double bass, violin, harp, piano, church organ, synthesizer, trumpet, trombone, french horn, tuba, saxophone, transverse flute, oboe, bassoon, clarinet, glockenspiel, music box, tubular bells and carillon.

The chosen articulation (legato) was the same for all the instrument sounds used in the presentation.

4. EQUIPMENT USED DURING THE LISTENING SESSIONS

The research was conducted in the room 312 – the location of the keyboard classes – in the Youth Palace in Olsztyn, Poland. The equipment used in the listening sessions was:

1) *Yamaha PSR-900SX* keyboard, used in the participants' education from September to January.
2) *Korg PA1000* keyboard, used in the classes from February to June.

The loudness level of performed stimuli was set by the researcher before starting the experiment to ensure maximum comfort for every listener participating the listening session. It was set only once, same for every group, approximately 74 phons, and it remained unchanged through the whole study time. Both keyboards belong to the same class of electronic instruments, but were produced by different manufacturers, thanks to which, listener's impressions about electronic simulations of acoustic instrument timbres were different in both cases.

5. LISTENERS AND DATA ON THE RESEARCH GROUP

In the described experiment 2 groups (research and control), each consisting of 25 class participants, were created in a random way [Pilch, 1998, pp. 51, 86–87; Łobocki, 2004], giving a total number of 50 subjects.

Research and control groups were alike, as they both comprised of randomly selected 11 boys and 14 girls aged 7 to 14. None of the subjects had any past experience with music education of any kind.

6. LISTENING SESSIONS

The beginning of the school year in Poland is on September 1st (month marked as I in the Table 1) and the last month of the school year is June (marked as X in the Table 1). The ten-month school period is then followed by two-month summer holidays, when Polish children and young people are not attending any classes. For 10 months, during the school year 2021/2022, all study participants attended weekly, 45-minute lessons in groups of 4. On the first class in September (marked as I in Table 1), before the music education began, first test was per-formed to check knowledge of all the subjects.

Over the course of the study, children and youth being part of the research group participated in training listening sessions in groups of 4, once a week (each Thursday). Subsequent tests of research group subjects' familiarity with instrument timbres were performed on the first Thursday of each month (in accordance with the sched-ule of classes in Youth Palace in Olsztyn).

Children from the control group didn't participate in any training sessions and took in total 4 tests of knowledge: in September (marked as I in Table 2), January (marked as V in Table 2), February (marked as VI in Table 2) and June (marked as X in Table 2), on the first Thursday of each of these months.

7. THE EXPERIMENTAL METHOD

The data obtained in the experiments are subject to mathematical calculations in accordance with statistical requirements. These calculations are made based on study results, which implies that the tests are repeated many times on a large group of subjects in order to get reliable results [Renowski, 1974, p. 6].

This research used a sound source identification method, which relies on recognizing the timbre as a sensational feature that allows recognizing the sound source. In this case the timbre recognition involves assigning it to the respective sound source, or not classifying it if there is no comparable reference timbre in listener's memory [Ozimek, 2002, p. 270].

The experimental method for the research group:

1) All the timbre recognition tests were conducted in the very beginning of the first class of each month, and the duration of the test was approximately 7 minutes – remaining time (approximately 38 minutes) were being used according to the curriculum to teach children how to play popular music on a keyboard.
2) On every one of the weekly classes, there was a training listening session held, also lasting around 7 minutes.
3) If the test and a training session were about to happen on the same day, the knowledge test was conducted for the first 7 minutes, then the pupils participated in a training listening session for another 7 minutes.
4) Remaining time (around 30 minutes on the days of the test, and 38 minutes on the other days) was used to implement the classes' curriculum (teaching how to play popular music on keyboard), and it was not connected with the described research.

The experimental method for the control group:

1) The timbre recognition tests were conducted 4 times throughout the research, in the very beginning of the class, the duration of the test was approximately 7 minutes.
2) Remaining time (about 37 minutes) was used to implement the classes' curriculum, focusing only on teaching how to play keyboard.

The duration of the experiment was defined without excessive attention – in a way, that in researcher's opinion, allowed the participants to be introduced to, learn and memorize new timbres of musical instruments. It can be assumed, that longer training session time would cause the timbre recognition skills to grow faster,

which would translate into better results, however the study was conducted during the time of traditional classes (with no extra time for research), additionally, so it should not overly modify or shorten the time of the keyboard lesson itself. The Keyboard class curriculum needed to be fully realized during the lessons so certain time restrictions were put on the experiment to make sure that it does not affect the children learning to play electronic keyboards. This form of conducting experiments was chosen by the author as he was sure, that the children will be participating the classes weekly, throughout the school year.

Timbre recognition testing method:

The teacher was randomly choosing timbres from the previously prepared 25 sound collection, and playing an improvised (unplanned) melody for maximum of 10 seconds. Then the subjects had the same time of 10 seconds to write down the name of recognized instrument on an empty sheet of paper. This sequence was repeated 25 times until all the timbres were presented. In order to avoid "wild guessing" the answers, the test was not a test of choice – not knowing the right answer resulted in lack of it. When the test was over, the teacher collected all the participants' papers and reviewed them later (after the class ended) [Pilch, 1998, pp. 51, 86–87; Konarzewski, 2000, p. 138].

8. RESULTS

Data presented in Table 1 shows the percentage of correct responses (understood as the accurate identification of the sound's timbre) given by all 25 study participants in the research group. Table 1 presents each subject's progress with regard to timbre recognition in context of the number of months spent on training. It shows all the test results obtained throughout the study (from September to June). There were 25 instruments, therefore correct recognition of one equals (and is listed as) 4%, of two equals 8%, of three equals 12% etc.

Table 1. Data presenting the percentage of correct responses given by the subjects in the research group

Month / Children	I Sep.	II Oct.	III Nov.	IV Dec.	V Jan.	VI Feb.	VII Mar.	VIII Apr.	IX May	X Jun.
	in %									
1	4.0	28.0	48.0	60.0	84.0	24.0	36.0	52.0	68.0	84.0
2	0.0	16.0	32.0	48.0	64.0	12.0	28.0	40.0	54.0	72.0
3	8.0	20.0	36.0	56.0	76.0	24.0	36.0	52.0	68.0	84.0
4	8.0	20.0	40.0	60.0	80.0	24.0	36.0	56.0	72.0	88.0
5	12.0	32.0	60.0	80.0	92.0	32.0	44.0	60.0	76.0	92.0
6	4.0	16.0	36.0	52.0	72.0	16.0	32.0	44.0	64.0	84.0
7	8.0	20.0	48.0	64.0	80.0	16.0	28.0	44.0	68.0	88.0
8	16.0	40.0	72.0	96.0	100.0	36.0	48.0	66.0	80.0	96.0
9	8.0	32.0	52.0	68.0	92.0	28.0	44.0	62.0	80.0	92.0
10	0.0	12.0	28.0	40.0	60.0	8.0	20.0	36.0	56.0	68.0
11	8.0	16.0	32.0	52.0	72.0	20.0	36.0	52.0	68.0	88.0
12	0.0	8.0	28.0	48.0	68.0	12.0	28.0	44.0	60.0	76.0
13	4.0	16.0	32.0	60.0	84.0	24.0	40.0	56.0	72.0	88.0
14	0.0	8.0	20.0	44.0	68.0	16.0	32.0	48.0	64.0	84.0
15	0.0	12.0	40.0	64.0	84.0	20.0	36.0	56.0	72.0	88.0
16	8.0	16.0	36.0	56.0	76.0	16.0	28.0	48.0	64.0	80.0
17	16.0	32.0	60.0	84.0	100.0	36.0	48.0	66.0	84.0	100.0
18	0.0	8.0	24.0	48.0	64.0	12.0	24.0	40.0	56.0	72.0
19	12.0	28.0	52.0	76.0	96.0	32.0	48.0	64.0	84.0	96.0
20	0.0	8.0	20.0	44.0	60.0	8.0	16.0	32.0	48.0	64.0
21	4.0	8.0	24.0	52.0	68.0	12.0	28.0	40.0	60.0	76.0
22	4.0	16.0	32.0	52.0	72.0	16.0	28.0	44.0	64.0	80.0
23	0.0	20.0	36.0	60.0	76.0	20.0	32.0	48.0	64.0	84.0
24	0.0	16.0	36.0	52.0	76.0	16.0	32.0	48.0	64.0	84.0
25	8.0	24.0	48.0	64.0	84.0	20.0	36.0	52.0	68.0	88.0
Average	5.3	18.9	38.9	59.2	77.9	20.0	33.76	50.00	67.1	83.8

In white columns in Table 1 it can be observed, that from September to January there was a very intensive timbre memory development. The digital keyboard used to present and teach timbres of individual instruments

was Yamaha PSR-900SX. Results analysis reveals clear growth of the average number of correct answers given by respondents on monthly tests, in two cases reaching even 100%. When comparing results from January and September, the average improvement equals 72,6%.

The gray columns in Table 1 (from February till June) present the educational use of the second electronic keyboard – Korg PA1000. In this case there is also visible, significant development of timbre memory, which occurred within five months since the implementation of this new instrument, resulting in 100% of correct answers given by one of the subjects in the instrument timbre recognition test. By comparing average results obtained in June and February, a conclusion may be made, that among the study participants, correct recognition of chosen timbres increased by an average of 63,8%.

Data presented in Table 2 shows the percentage of correct responses obtained in the control group, which did not take part in training listening sessions every week. This group of 25 pupils went through the test only four times, in September, January, February and June. Comparing both tables, it can be observed that in the control group there was no growth of the instrument timbre recognition skills. Results presented in Table 2 oscillate within the range of statistical error and are not significant. Presented data shows that timbre education in the experimental group occurs very quickly, which cannot be observed in the control group.

Table 2. Data presenting the percentage of correct responses given by the subjects in the control group

Month / Children	I Sep.	V Jan.	VI Feb.	X Jun.
	in %			
1	4.0	4.0	4.0	4.0
2	4.0	8.0	4.0	4.0
3	12.0	12.0	4.0	4.0
4	8.0	4.0	0.0	4.0
5	0.0	0.0	0.0	0.0
6	16.0	16.0	12.0	12.0
7	4.0	0.0	4.0	0.0
8	0.0	4.0	0.0	4.0
9	0.0	0.0	0.0	0.0
10	8.0	8.0	4.0	4.0
11	12.0	12.0	12.0	12.0
12	4.0	4.0	4.0	4.0
13	0.0	4.0	4.0	0.0
14	0.0	0.0	0.0	0.0
15	16.0	16.0	12.0	12.0
16	8.0	4.0	4.0	8.0
17	4.0	4.0	4.0	4.0
18	0.0	0.0	0.0	0.0
19	4.0	4.0	0.0	4.0
20	8.0	8.0	12.0	12.0
21	4.0	8.0	8.0	8.0
22	8.0	12.0	8.0	12.0
23	0.0	0.0	0.0	0.0
24	8.0	12.0	8.0	12.0
25	0.0	0.0	0.0	0.0
Average	5.3	5.8	4.3	5.0

Table 3 shows each subject's progress. Presented data was calculated based on the arithmetic mean of all correct answers given by the respondents. In case of the white columns it is each participant's mean from September to January (using the Yamaha PSR-900SX keyboard), while in case of the gray columns it is each pupil's mean from February to June (using Korg PA1000). Average is an arithmetic mean of the calculated progress of all the individuals together during the periods of using the sounds of two different keyboards in the timbre training.

Table 3. Data presenting mean progress in the field of correct recognition of selected instrument timbres, of every participant. The table also includes the collective data calculated as an arithmetic mean of all the results

Children (research group)	Progress (in %)	Progress (in %)
1	80.0	60.0
2	64.0	60.0
3	68.0	60.0
4	72.0	64.0
5	80.0	60.0
6	68.0	68.0
7	72.0	72.0
8	84.0	60.0
9	84.0	64.0
10	60.0	60.0
11	64.0	68.0
12	68.0	64.0
13	80.0	64.0
14	68.0	68.0
15	84.0	68.0
16	68.0	64.0
17	84.0	64.0
18	64.0	60.0
19	84.0	64.0
20	60.0	56.0
21	64.0	64.0
22	68.0	64.0
23	76.0	64.0
24	76.0	68.0
25	76.0	68.0
Average	72.6	63.8

9. DISCUSSION OF RESULTS

A big problem for the subjects in the first phase of the experiment was to recognize the timbres within such instrument groups as:
– carillon, tubular bells,
– music box, carillon,
– oboe, bassoon, clarinet,
– electric bass, double bass, tuba,
– banjo, mandolin,
– classical guitar, acoustic guitar,
– trumpet, trombone, french horn, tuba, saxophone.

In each of the above cases it can be observed that instruments within the groups have very similar timbres. This shows that most of the participants' mistakes were related to recognition of instruments sounding alike, which often were presented in the same or similar pitch scale. Obtained data clearly depicts the problems in the area of timbre recognition that occur in this group of subjects at this educational level, thanks to which, it is clear what are the musical education aspects that need particular attention. Piano, violin, church organ and synthesizer sound very characteristically, so there were not any big timbre similarities, hence much smaller number of participants' mistakes in this instrument group (in comparison to previously listed groups).

Another problem that has been noticed, refers to Table 1, where the same instrument sounds (timbres under the same name) were presented, with only variable being an electronic keyboard model (gray color). In this case, it can be seen that the use of different sounding samples – played using Korg PA1000 – caused a great decrease in specific instruments' timbre recognition skills (even though the training sessions were repeated weekly). This data clearly depicts participants getting used to previously presented instrument timbres, despite the fact that when using Yamaha PSR-900SX, the teacher used different samples of the same instrument (from

a library pre-stored in instrument's memory). Changing the electronic instrument (source of the samples) to a different one resulted in a significant change in sound which caused some mistakes in recognizing timbres of certain instruments by the study participants. However, it is worth mentioning that the number of correctly recognized instrument timbres did not drop to the pre-experiment level for any one of the subjects, which proves that the intend-ed development of timbre recognition skills was observed to some extent.

10. CONCLUSION

The results of conducted experiments show that keyboards can be very good stimulators and can properly stimulate the development of timbre recognition and processing for children and youth. Digital emulation of acoustic instrument timbres in contemporary keyboards is getting better and better, thanks to which electronic keyboards can be successfully used as a didactic tool helping to teach children and youth how to identify the timbres of acoustic instruments. At the same time the experiment proved the relevance of using keyboards in musical education involving timbre hearing stimulation.

Conclusions that arise after the results analysis clearly indicate that the traditional ear training relying on the sound of piano allows students to learn how to recognize intervals, scales, keys, chord qualities etc., but causes problems with correct recognition of different instrument timbres. The use of keyboards on didactic classes may significantly reduce this problem. Extending school classes with new electronic instruments causes the development of timbre identification skills of the students, which shows that it is worth considering to implement new technologies in classes, as it contributes to the development of important auditory competences used in further musical work.

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