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PITCH AND RHYTHM STRUCTURES FOR AURAL ATTENTION TRAINING

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Valdis Bernhofs
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Summary of Doctoral dissertation

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**Introduction**

The notion to listen attentively has been known at least since the times of Ancient Greece, and it has always been intriguing for philosophers, poets, musicians and orators. In the acknowledgements of Alexander Gottlieb Baumgartner, a later 18th century German philosopher, and his followers, attentive listening is one of the basic questions of musical aesthetics. Also, in the works of Johann Georg Sulzer and Johann Nikolaus Forkel, the role of attention, regarding listening and performing a musical composition, is stressed multiple times. The aforementioned philosophers are in one mind in their works about one thing: in order to turn the attention to a composition, any musical figure that is noticeable may be used. These can be unexpectedly rapid passages, as well as trills or rhetorical figures. Such efforts to turn the attention and hold the attention are often used in musical compositions and may be indirectly connected with the topic of the dissertation – aural attention training. Upon raising the question about using any particular piece of music for aural training, or any possibilities of transference or adaptation of structure of any particular piece of music, it appears that the question about musical composition’s effect on attention processes in the context of music science has scarcely been looked at. There could be several explanations as to why. First of all, direct references to attention processes in the connection with musical composition are rarely spotted, they are quite scarce and they are rarely followed by any in-depth explanation. Secondly, it is not the direct aim of a musical composition to develop attention processes. Even though aural attention most often is a prerequisite for perception and successful cognitive processing of a composition, it is not meant for aural attention training. Thirdly, in the branch of music science, music and its parameters’ interactions with perception and cognitive processes are rarely researched. This has its explanation – aural attention as a cognitive process is usually considered to be in the fields of other branches of science, including music psychology. Therefore, on the basis of necessity to research music and its parameters’ significance and regularities characteristic of music science (in dissertation – system of pitch and rhythm structures), this work also includes issues of concern from other fields close to music science - music psychology (aural attention research) and music pedagogy (development of the training programme).

Both visual attention and aural attention are selective attention types and components of the attention system. Attention system is an important aspect for human function. Attention is characterised by complex actions, which are influenced by multiple interactions and cooperation between various brain areas. Attention affects the central processes altogether; it is responsible for human’s overall activity, perception and evaluation of information, and
independent planning capability. Therefore, the teachers’ assertion, that there is a need for lasting attention in school, is well-grounded.

In modern neuroscience there is an increased tendency to examine brain activity and its changes caused by variety of factors. Such examinations also point to the fact, that attention, with its multitude of components, is one of the primary brain functions – higher level cerebral cortex activity is possible only if the attention process is fully activated. However, attention processes conceptually and functionally are difficult to separate from other cognitive functions. This serves as evidence for attention as a governing instance, which organises processing of other informative processes in human organism; attention also enables successful learning capabilities in an individual.

Attention disorders can be observed in a variety of education systems and in different tiers of education establishments. Though, it has to be considered, that a child’s attention capabilities in elementary school are not yet stabilised. Practicing pedagogues have observed that, very often, good concentration ability serves as a prerequisite for a successful beginning of music education. And vice versa – latest research in neuropsychology indicates that music has a positive effect on human psyche. Several musical parameters – rhythm, pitch, timbre, dynamics, and register – may affect those centres in the cerebral cortex and in human brain altogether, which are responsible for the activation of the attention system. Variety of literature sources emphasise that the attention capabilities, using variety of acoustic exercises, are possible to train and develop.

Research mentioned in the literature sources reveal, that the two music parameters most often connected with attention capabilities are pitch and rhythm. In multiple sources there are mentions of the connection between these two parameters and activation of attention process; besides, their different localisation in the brain is also stressed. Latest methods in neurophysiology allow for detection of precise neuron activation, if rhythm or pitch information is passed for the reception of an individual. Different attention activation effects can be observed while performing certain excitation or structured acoustical information listening exercises. Therefore, one can express a hypothesis, that, by using select pitch and rhythm structures in a certain manner, it is possible to stimulate definite brain areas, which are also responsible for attention capabilities.

From the types of selective attention (visual, aural, spatial), up until now, the least researched has been aural attention and its connections with certain music parameters. In research practice, there are only a handful of standardised aural attention testing instruments. In this dissertation, in connection with sensory perception’s aural attention process
peculiarities, a training programme for aural attention training has been developed; it is based on a common system of pitch and rhythm structures. The programme includes pitch and rhythm structures, which, while one is being trained to differentiate between these structures, develops both the attention process activation and the sustainability of attention system components. Also taken into account is the congenial component – short-term memory, because memory, already in the period of early attention (arbitrary activation of attention after receiving stimuli), contributes to aural processes. Therefore, the research, carried out within the framework of this dissertation, is aimed at aural attention system and the possible types for its development in the connection with definite pitch and rhythm structures within the framework of unified system of structures.

In order to gain a more detailed definition of the aspects regarding the researched problem, the following questions were asked:
1) what kind of relationship exists between aural attention and the selected music parameters – pitch and rhythm;
2) what kind of relationship exists between unified system of pitch and rhythm structures and aural attention training possibilities;
3) are there any differences between pitch and rhythm structures in the context of aural attention training.

The theoretical ground for these questions warrants necessity to find answers to several additional questions:
1) what characterises attention, which criteria define aural attention process within the attention system;
2) in which way is it possible to define the level of aural attention;
3) in which way acoustic information influences aural attention;
4) what is the role of aural attention in the perception and cognitive processing of pitch and rhythm structures;
5) in which way, using pitch and rhythm structures, would it be possible to train aural attention, and what would be effect of such training.

In the context of the aforementioned scientific interests and relevant problems, the research object, aim, and tasks were defined.

**Research object:** aural attention and the possibilities of its development.
**Aim of the research:** to develop an aural attention training programme, which is based on pitch and rhythm parameters; to assess its effects on the aural attention of 7-8 year old children - music school students.

To realise the aim of the research, the following **objectives** were set forward:

1) to gather the researchers’ knowledge on the subject matter of attention, especially aural attention, as well as the influence of pitch and rhythm parameters on the aural attention process in general;
2) to create a system of structures for two relatively standalone – pitch structure and rhythm structure – subsystems, to create a theoretical basis for the development of the training programme model;
3) to develop governing criteria for the aural attention training programme and to develop a computer-based program
4) to choose appropriate methods for the research and to form adequate criteria for the selection of research subjects;
5) in the connection with the research methods chosen:
   – to choose a standardised, non-verbal aural attention measurement instrument (a test), which is appropriate for the research groups, their age and cultural environment,
   – with the help of a standardised non-verbal aural attention test, test the efficiency of the newly-created pitch and rhythm training programme;
6) to carry out the research – creating the research groups, organising attention training, and registering data;
7) to analyse the findings, interpret them, and to draw the conclusions.

On the basis of the tasks set forward, a research type and method were chosen, the subjects of the research selected, the research executed and data - processed.

**Type of research, design and method:** experimental hybrid research (Geske et al., 2006), where, according to the systematic exploratory research guidelines (Bortz et al, 2006):

  firstly, with a unified system of pitch and rhythm structures, **theory** is established;
  secondly, by developing the aural training programme and its computer version, a **model** is developed;
  and thirdly, using **quantitative research**, the effectiveness of the newly-created training programme is tested.
The research includes 85 respondents, 7-8 years old students of a common education establishment, who, in their day-to-day schooling, along with the usual subjects, also intensively study music (6-8 music lessons per week). Retaining the principle of class divisions, three groups were created. With the help of a standardised attention test AUDIVA, a pre-test was conducted in the pitch group (PG or O₁), rhythm group (RG or O₂) and control group (CG or O₃). Participants of the pitch and rhythm groups, along with their music classes in school, studied the newly-created AUT training programme’s 10 levels. Control group continued their music studies, but did not receive the attention training. At the end of the training, six months after the attention pre-test, an aural attention post-test was performed in the pitch group (PG or O₄), rhythm group (RG or O₅) and control group (CG or O₆).

**Data was obtained** by using a standardised attention control measurement tool AUDIVA. In addition, all data gathered during the execution of the training levels, was gathered and systematised. **Data processing** was done using SPSS version 19.00, program EXCEL, and a program created specifically for this research – AUT – which recorded responses of the subjects during the pitch and rhythm structure differentiating (training) exercises. Data, which was obtained during the training, due to the vast amount, have not been analysed in this dissertation. During the **data analysis**, the following statistical methods were used: method of signed rank comparison, non-parametric test criteria analysis, correlation analysis, factor analysis, as well as calculations of efficiency done both among the groups, and within each group individually.

**Dissertation structure** is formed by an introduction, three chapters, conclusion, list of literature, and appendix. The dissertation includes 28 images and 40 tables. **Chapter one** describes the theoretical basis of the research. It looks at, and explains, the notions and terms used in the research, doing so from both psychological and neurophysiological, as well as music theory standpoint. Here, the knowledge found in the literature about the attention system, aural attention as a type of selective attention, chosen parameter – pitch and rhythm – connection with early attention process, and these parameters’ cognitive processing in the brain, is compared and analysed. Within this chapter, the problematic situations, regarding aural attention process research, are also discussed, as well as possibilities of aural training. **Chapter two** serves for the music parameters’ – pitch and rhythm structures – integration into a common system of structures. The criteria for creating system of structures and the newly-formed terms are explained here, along with selection
principles regarding pitch and rhythm structures and groups of structures – the argumentation for theoretical basis for aural attention training programme. This chapter also deals with the principles of developing the aural training programme. In the conclusion of the chapter there is a description of the newly-formed aural attention programme and its levels. **Chapter three** describes the method of the research and the instrumentation it includes, along with the selection of respondents and the procedure of the research. Within the framework of the research tasks, hypotheses and research questions, the results calculated are reflected here, along with a test of precision regarding instrumentation used, as well as arguments for the efficiency of the aural attention training programme. Within this chapter, the **hypothesis** was confirmed – **structured pitch and rhythm training has considerable effect on aural attention in 7-8 years old students of music school.**

Research’s **theoretical** and **methodology basis** is based on gathered information about **workings of the attention system** (Posner, 2004, Raz, 2004; Eysenck et al., 2010; Zattore, 2004; Posner et al., 1990; Posner et al., 1987; Posner et al., 1971; Zimmermann et al., 2002), **aural attention processes** (Peretz et al., 2007; Trepel, 2008; Stoffier et al., 2005; Karnath et al., 2006; Justus et al., 2002; Krumhansl, 2000; Lane, 1998; Ten Hoopen, 1996; Broadbent, 1954) and **their correlation with memory** (Waongne, 2012; Ruzzoli et al., 2012; Näätänen et al., 2011; Winkler, 2007; Czigler et al., 1996; Dehaene et al., 1991). **pitch and rhythm parameters’ role in activating attention system functions** (Waongne, 2012; Zarate et al., 2012; Winkler, 2007; Näätänen, 2007; Krumhansl, 2000; Gomes et al., 2011; Koelsch et al., 2003; Koelsch et al., 2001; Koelsch et al., 2000; Tervaniemi et al., 2005; Peretz et al., 2007; McDermott et al., 2008; Eitan et al., 2009; Loui et al., 2005; Sussman, 1997), **structuring of pitch and rhythm and their cognitive processing** (Zarate et al., 2012; Lappe et al., 2011; Peretz et al., 2007; Zattore, 2007; McDermott et al., 2008; Justus et al., 2002; Overy et al., 2004; Altenmüller et al., 2007; Altenmüller et al., 2006; Piaget, 1980), as well as the **significance of training regarding development of attention processes** (Lappe et al., 2011; Winkler, 2007; Näätänen, 2007; Rueda et al., 2005; Pozner, 2004; Menning et al., 2000; Tervaniemi et al., 2000).

The knowledge gained during the experiment, both theoretical and empirical, holds significant meaning in the context of multiple branches of musicology – music psychology, music therapy and music pedagogy. The training programme AUT, developed during this research, is, in the field of research practice, a new, non-verbal tool for the development of
aural attention processes. This tool, without any specialised training, may be used by a wide variety of users – music psychologists, music therapists, as well as music pedagogues. The pitch and rhythm training programme, developed within the framework of this dissertation, is based on reciprocal interaction of multiple processes – pitch and rhythm structure perception and cognitive processing, as well as aural attention system components. Systematic and controlled approach, regarding structuring of music parameters, will promote further aural attention research:

- by offering aural training possibilities to different types of educational establishments,
- by developing different training and self-training exercises for people of varying age,
- by promoting research of music structures and aural attention training possibilities in a different cultural environment,
- by developing training programme modules for people with different attention disorders.

The structure of the newly-created system of structures and computerised training programme AUT allows for easy manipulation of the structure of music, while, at the same time, retaining all the necessary components for the system and training. By defining all of the components of the system of structures, an appropriate climate is created for connecting the aural attention process with other music parameters – harmony, articulation, dynamics and timbre. This will present an opportunity to research, in-depth, the correlation between different music parameters and attention, as well as allow broadening of the user base of the newly-created tool and, consequently, enlarge the possible topics targetable for research in the context of any sub-branch of different sciences.
1. Aural attention and music parameters

1.1. Attention system

A large part of the research is connected with cognitive psychology and cognitive neuroscience (Eysenck et al., 2010:33-202). Research of attention effects mostly focus on sensory system, and explain this system’s interaction with attention. The amount of cognitive research, and the amount of publications regarding such research, has quadrupled when compared with 20th century 60’s. This can be explained by the scientists’ will to explain the prerequisites for cognitive processes, and therefore the attention process itself, as detailed as possible (Posner, 2004:23-26). Research in cognitive processes indicates that attention capabilities are necessary for any cognitive action; therefore, active attention is a prerequisite for cognitive processes.

Attention is a complex action. This complexity comes from the interaction between various brain areas and their reciprocal cooperation. The interaction of different areas affects central processes altogether, is responsible for individual planning (prefrontal cortex), activation (cerebellum and reticular activating system), for reception of information and evaluation association areas, limbic system (Birbaumer et al., 1996).

The activation of the attention system is governed by reticular activating system – RAS. It develops from the sensory pathways’ branches as an aggregation of neurons and their synapses in the reticular formation (formatio reticularis) and the dorsal part of thalamus (thalamus dorsalis) part, it sustains and regulates brain activity. RAS reacts to all sensory information and the neurons of this system are characterized by tonic activity and high chemical sensitivity. RAS includes nuclei of thalamus and they are vital for both state of consciousness and attention. One of the specific parts of thalamus is metathalamus, which is responsible for the transmission of acoustic information, is the medial geniculate body (corpus geniculatum mediale – CGM). CGM is located under the pulvinar and is separated from it by a well-marked circulatory groove, inside the groove there is a subcortical auditory center. CGM is an aggregate of nerve fibres, which relays the information received from receptors to the primary auditory cortex and other areas in the temporal lobe. For certain types of attention, e.g. attention activation focused on a specific excitation, certain non-specific nuclei of thalamus are responsible; they are not directly connected with information processing areas in the cerebral cortex. Among these non-specific nuclei is thalamic reticular
nucleus \((Ncl.\text{reticularis})\), without which the interaction with outside world would be impossible.

Attention, similar to other organic systems, has certain anatomy, regulatory system, and development. (Posner, 2004:3). This characterizes attention as a unified system.

Research of the attention system nowadays is based on the tried and tested three-component theory (Posner et al., 1990; Posner et al., 1987; Posner et al., 1971). Posner introduced the scientific term attentional networking, which could be explained as branching of the attention. This term covers all of the neuralgic connections which are connected with the attention process as a whole. Branching shows a certain degree of independence in a variety of brain areas. At the same time, multiple sub-systems work in a close interaction with each other. Such neuralgic branches can be observed in separate areas in all cerebral cortex, but they do not fully cover it. They have cognitive and emotional tasks, and each of the branches has its specific task within the attention system as a whole. During this process, a development of certain sub-structures may be observed, which points to the fact that the actions of separate branches are controlled by other, higher-level branches. These branches of attention within the system govern sensory, including aural, information and memory processing neuron connection selection and control (Raz, 2004:203-208).

Functionally and anatomically different three attention system components have, in the course of research practice, been termed according to function:

- **alerting function** – ensures activation of attention,
- **orienting function** – ensures positioning of attention towards an event (excitation),
- **executive function** – ensures action of attention in an event which requires decisiveness (reaction). Executive function is also called conflict function – reactions of the attention regarding making a choice between powerful and less powerful excitation.

All three components are considered sub-systems of the attention system and make up the attention system as a whole.

Any excitation can activate attention system. Orientating attention towards one particular type of excitation is called selective attention. With the term selective attention usually one understands selective or focused attention, which is orientated towards an excitation important for the individual, while at the same time blacking out the unnecessary excitation(s). Selective attention shows the ability to isolate a specific event from all the other events and to subject it to a different analysis. It is also orientated to focus attention on one, exercise-relevant excitation and to ignore all of the less-important excitations. In the case of structured selective
attention, one can talk about the persistence of attention or vigilance, which shows the ability to retain attention to one specific task in a given time period.

One of the types of selective attention, along with visual attention, is audial or aural attention. Aural attention allows an individual to quickly and precisely orientate within a space, and to determine source of sound in the surrounding environment. Aural attention mechanism is characterised by a top-down and bottom-up activating process. Top-down process is secured by arbitrary or conscious, towards a task aimed, attention. This way, the margins of perception and reaction activated information processing are broadened; behavioural expression sensitivity is broadened, as well as reduction of latency is achieved. Bottom-up selection process, on the other hand, focuses the brain areas on the incoming acoustic excitation, in order to reach the target set in the behavioural level among other competing excitations (Fritz et al., 2007).

1.2. Research of aural attention processes

Musicology’s close sub-branch, music psychology, looks at both the attention process as a whole and selective aural attention as a prerequisite for listening and attentiveness processes (Justus et al., 2002). Research points to the fact that aural attention, just as the attention system as a whole, can be activated by any excitation (separate sounds) or a combination of excitations (e.g. sequence of three sounds).

Despite the intensity of aural attention research in the last century’s fifties, last century’s cognitive psychology research during 70-80’s mostly dealt with the examination of modality in vision. Aural attention research received less attention. One of the explanations is related to differences in the processing of audial and visual information. According to several researchers, aural information is structured in a more simplistic way: aural excitations, as opposed to visual information (object usually contains the information about colour, shape, content), lack complex hierarchical structure (Neumann et al., 1986:1985-1988).

Aural attention process research nowadays has an ever-increasing tendency. This is promoted by the variety of methods in the modern research, which, including a variety of acoustic stimuli or excitations (e.g. different structures of frequency, timbre, or sound structures) allows to analyse both the early attention (arbitrary activation of attention due to acoustic excitation), and attention-promoted cognitive processes.

For the analysis of the early attention processes, the modern day research, in practice, mostly uses so called sound or sound structure discrimination exercises. While transmitting
acoustic information, the respondent is asked to listen attentively, or, while not paying attention to the information, perform some other task. Nowadays, in order to capture the reactions of aural attention, similar to research in musical cognitive processes, neurophysiological investigative methods, e.g. electroencephalography (EEG), are used.

In research practice, brain’s reaction is occasionally referred to as Event–Related–Potential (ERP); these are human brain response signals to an excitation of a sensory organ, including hearing organ (Näätänen, 2002). Event-Related-Potential also characterises early attention processes. Cerebral cortex, after a hearing organ excitation, can register a potential, which, precisely localised in regard to the activated specific sensory pathway, after a short latent period (after initial excitation: 100-400 ms) is registered in the cerebral cortex. Exogenous components (e.g. sound) approximately after a 100 ms latency period are layered with endogenous attention components (attention’s reaction to excitation). Sections of the curve are designated as positive (P) and negative (N) components. The positive section of the curve, which corresponds to 100 ms reaction time after latent period (P100) and the negative section of the curve with 100 ms reaction time after latent period (N100) in the research are metaphorically compared to an attention switch and represents the spatial attention processes. The positive P100 curve reflects the localised excitation gating process (Luck et al., 2000). Larger amplitude of the positive curve (P100 or P1) points to a more powerful or distinct early attention stage.

The reaction of neural cortex activity towards a single acoustic stimulus is usually characterised by component N1 – approximately 100 ms after receiving the excitation, a negative curve is registered, which occurs in the primary auditory cortex. Activity is mostly registered in the frontal lobe, but as a possible resource for this effect are also mentioned the secondary areas of auditory cortex, transverse temporal gyrus (gyri Heschl: gyri temporales transversi), planum temporale - the cortical area just posterior to the auditory cortex, and the superior temporal gyrus (gyrus temporalis superior) (May et al., 2010). ERP responses, including early responses (positive part of the curve approx. 20-50 ms after receiving excitation, P20-P50) and N1 (approx. 100 ms after receiving excitation), affect attention activation. The negative curve’s N100 or N1 potential points to the precision of the received excitation (Luck et al., 1990). In the experiments with a standard sound (excitation), which is followed by a different signal emitted from similar positions, a distinctly faster reaction was observed, and it is illustrated by increased P100 and N100 potentials in the occipital lobe’s electrodes.
Early attention stage is very much an individualised process; it is considerably affected by the content of the acoustic information; however, reactions of early attention towards recognisable or unrecognisable excitation may be different. Response signals caused by acoustic excitation, regardless of musical education, can be recorded in any individual, and points to aural attention as a universal process. The difference between musicians (individuals with more or less music experience) and non-musicians (individuals who have not studied music or learned to play any music instrument(s)) exists within the quantitative (latent period) and qualitative (amplitude) measures. It can be concluded that components of early attention activation may be influenced by the musical experience of an individual.

To observe the effects connected with early attention activation, usually pitch differentiation exercises are used. Previously, the early attention reactions, which are caused by certain specific excitations as opposed to usual excitations, were discussed. Scientists admit that only acoustic excitation (sound) structures can cause an effect, which in the scientific realm is called Mismatch–Negativity (MMN). MMN effect can be observed not only as a result of standard and specific sound differences, but also as a result of varying length of these specific sounds (Näätänen et al., 1989).

As previously mentioned, early attention is the key towards activation of cognitive processes. All of the incoming excitations are cognitively analysed – the regularity of excitations are analysed in the brain. All of the obtained information is used to activate the attention system in a new way towards the expected signal. If the expected signal differs from the actual excitation, the MMN effect is created (Wacongne, 2012, Sussman, 1997). MMN is a summary of negative components (curves), which can be observed starting from 200 ms after the beginning of latent period. MMN reaction may be observed only in those excitations, which in some way differ from the expected physical context, even if these excitations are being ignored (e.g. an individual is reading a book and attempts to ignore the source of the sound).

By integrating the acoustic excitation offered for the attention in a specific musical context (most often it is a sequence of chords, e.g. five chord cadence with piano timbre) and presenting a change within inner elements (e.g. some chord’s mismatch with the original sequence), with the help of EEG, Early–Right–Anterior–Negativity (ERAN) effect, with the maximum peak of 180–200 ms after receiving the different excitation, can be observed. The highest wave of reaction is most often registered in the frontotemporal lobe (registered with frontal and temporal lobes’ electrodes F8, FT8) (Koelsch et al., 2000:520-541).
Along with MMN and ERAN effects, there are other components connected with early attention activation, for example, P1 and P2 (positive curve with 100 ms and 200 ms latency period respectively), Nd (section of the curve between P2 and P4 waves). The reciprocal differences of these effects among children and adults underline the aspect of experience in the context of early attention. During children’ age, characteristic is P1 activation 70 ms after receiving excitation, negative curve N1 activates 115 ms, but positive P2 – 190 ms after receiving excitation. Curve P1 is much more distinct for children than adults, however, N1 and P2 components are less pronounced in children. Curve Nd, however, separates received excitations from the ignored information. It begins with P2 curve’s decline in adults; for children, possibly, slightly later. Curve Nd is slightly less pronounced in children with attention deficit hyperactivity disorder (ADHD) than in children without attention disorders or adults. Children with attention disorders have difficulty focusing attention on the incoming excitation, therefore, different effects caused by early attention, may be observed (Gomes et al., 2011). Nd activation is concentrated in central frontal lobe, with the peak of 230 ms after receiving excitation. Nd effect is followed by a positive segment of the curve, approximately 410 ms after excitation, with pronounced activation in the frontal lobe (Gomes et al., 2011).

Characterising early attention processes, two effects were advanced – MMN and ERAN. The next subchapter ties these effects with the parameters chosen in the dissertation – pitch and rhythm, and describes these parameters in the connection with early attention activation and acoustic information’s cognitive processing.

1.3. Pitch and rhythm parameters in the context of cognitive processes’ research

The previous two subchapters dealt with both attention system as a whole, and one of the types of selective attention – aural attention, as well as notions about aural attention possibilities and methods were presented. This subchapter deals, in detail, with the activation process of aural attention in the connection with the chosen music parameters – pitch and rhythm. In this subchapter the role of these parameters, both in early attention and cognitive process activation is analysed. This allows for better understanding of the similarities and differences of both of the chosen parameters in the context of cognitive processes.

As we know, in music there is interaction between variety of parameters – pitch, rhythm, harmony, facture, dynamics, articulation, tempo etc. For closer analysis, in this research, two of these parameters were chosen: pitch and rhythm, because these parameters are most often mentioned in the literature sources as the main aspects of the perception of music, which can
directly activate the attention system (McDermott et al., 2008; Peretz et al., 2007; Krumhansl, 2000). The usage of the term *parameter*, regarding pitch and rhythm, is found in both the research of music psychological processes (Eitan et al., 2009; Eitan et al., 2006), and the modern day music analysis (Ценова, 2007; Холопова, 2006; Назаикинский, 1988). The aforementioned term also best describes the usage of pitch and rhythm in this – aural attention - research. Within the framework of this research, pitch and rhythm do not carry the functions of music-descriptive attributes. They are viewed as two indicators of perception, which interact with aural attention components.

In this research, *pitch* describes those sound characteristics, which have absolute frequency (height) and which allow sounds to be ordered in a gradually arranged scale (Randel, 1978). The pitch has been divided into three registers: low – medium – high. The notion of *rhythm* in this research is designated towards the inclusion of certain time arrangement methods meant to organise acoustic material, which, upon forming certain rhythm groups, are organised into structures.

To underline rhythm’s ability to structure, here is an additional explanation of this term, which has been borrowed from the knowledge of cognitive psychology: rhythm is a structured cognitive representation, which is made of sound objects within a (defined) time period. With rhythm, acoustic impulses in time are acknowledged. With the help of rhythm, these units are grouped, and this, in turn, allows registering of acoustic material in a certain time frame, juxtaposing objective and subjective time, as well as allowing for evaluation and saving the sounds in the memory (Stoffer, 2005:451; Bruhn, 2000:41-56).

The parameter of rhythm carries the crucial role of structuring the acoustic material within this research, and this process occurs on the level of perception, attention and memory. In the process of perceiving rhythm structures, usually one of the main components of rhythm is added – *pulse*.

On the level of perception, rhythm can activate pulsation by itself. But pulse is mostly a relatively subjective term – it is created only during the moment of acoustic structure perception and is subject to individual and cultural environment differences (Finscher, 1998:259; Parncutt, 1994:453; Riemann, 1967). As pointed out by Schulze, rhythm, in conjunction with external pulse, helps to develop the perception of time within music (Schulze, 2005:451). This is important to recognise, and it encourages the inclusion of pulse within the system of rhythm structures.
1.3.1. Pitch and rhythm in the research of early attention processes

Pitch and rhythm are the two primary music parameters, which, along with other parameters – harmony and timbre - can most directly cause the activation of early attention and cognitive processing of the received information (McDermott et al., 2008; Krumhansl, 2000). The interaction of these cognitive processes, during the moment of receiving information, is secured by several different areas in the cerebral cortex.

Both in the process of pitch parameter perception and specific sound differentiating exercises, on the level of perception, a considerable role is played by right and left hemisphere’s Heschl's gyri (gyri temporales transversi) (Mathys et al., 2010), by primary auditory cortex, and by second auditory cortical field in the brain (Tramo et al., 2005). As Koelsch notes, accurate perception of pitch is a prerequisite for cognitive processing of melody, harmony and phonology aspects in the context of both language and music (Koelsch et al., 2001).

As concluded in the majority with music perception and cognitive processing connected research, both musicians and non-musicians are sensitive to even slight changes of pitch and length. The level of sensitivity in an individual might differ (Krumhansl, 2000).

There is a conception that aural attention considerably affects the sensory processing of acoustic excitation in the tonotopic (localisation of pitch) primary auditory cortex. During dichotic ERP research using varying pitch (500, 1000, 2000, 4000 Hz), where the length of each sound was 800 ms, the activation of early attention was observed already 70-80 ms after receiving excitation (Alcaini et al., 1995). This might be explained by rapid activation of early attention response mechanism immediately after receiving excitation. Being in an environment of acoustic excitations, the attention switch allows to focus attention on one specific acoustic excitation – possibly important flow of information - while, at the same time, ignoring less important excitations (Näätänen, 2007; Koelsch et al., 2001).

To observe MMN effect, respondents mostly have to pay attention to so called pitch standards, with which the respondent is introduced beforehand. Episodically standard sound monotony is mixed with sounds which differ from standard sounds. These different sounds, in research, are called deviants. Henceforth, describing acoustic excitation differentiation exercises, the terms standard and deviant sounds are used.

A prerequisite for observing the MMN effect is the central aural system’s ability to form representations of acoustic excitations (Näätänen, 2007). The amounts of pitches, as well as the portions of standard and deviate sounds, are changed during experiments. In order to observe MMN effect, it is necessary to create multiple sequences of sound. In the research
practice mostly 2-3 sequences are used, creating groups of acoustic excitations (Näätänen et al., 2011). The difference between standard and deviant sounds causes the brain to react with negative amplitude approx. 100 till 200 ms after receiving the excitation, with distinct activity in primary auditory cortex (Winkler, 2007) and central frontal lobe (Winkler, 2007; Sussman et al., 1997). Frontal lobe plays a special part in attention’s orientation (focusing) control (Näätänen, 2007).

$MMN$ effect can be caused by so-called primary acoustic parameters – pitch and timbre differences, differences in sound’s length, as well as the spatial aspects of sound – direction of sound (Winkler, 2007). Naatanen, in the meta-analysis of early attention processes, notes, that early attention’s characterising component – $MMN$ – can also be caused by the dynamics of sound, the structure of excitation itself, the inner organisation principles of a structure, pauses between the structures or even one millisecond pause within a structure (Näätänen, 2007). The latent period of $MMN$ effect increases, if the pitch or rhythm differentiation process becomes more difficult. Larger amplitude of curve is usual, if the exercise – sound differentiation process – becomes easier. Experiments of sound differentiation show that, while attention is clearly focused on the flow in one ear, the amplitude of the $MMN$ curve lessens. It shows that the attention resources required for the process of listening to one flow is greater than that when listening with both ears (Sussman, 1997).

Early attention activation in the process of pitch and rhythm perception is closely intertwined with memory. French scientists point out that important meaning for information circulation process is possessed by both the thalamic structures in the brain, and short-term memory, which scientists call memory trace. As researchers point out, short-term sensory memory, in this process, is a projection field of sent and received signals (Wacongne, 2012). Researchers say that, precisely because of this projection, the reaction effect $MMN$ is created. Sound differentiation experiments, performed by Wacongne and her colleagues, once again confirm the paradigm, set forward by ethology, psychology and neuroscience, about the peculiarities of brain mechanisms regarding the processes of information perception and early processing. The brain is not only a mechanism, which passively processes incoming signal, but already in the process of perception is able to form a mechanism, which characterises being ahead of an event (Dehaene et al., 1991). Sensory short-term memory’s connection with early attention processes is also described by other researchers (Näätänen et al., 2011; Winkler, 2007; Sussman et al.1997). Multiple researchers point to a special type of sensory memory for hearing – echoic memory (a component of short-term auditory sensory memory, which allows to copy small amount of information and keep it in the memory for a short
period of time), with approximately 10 second capacity for youths (Näätänen et al., 2011; May et al., 2010; Winkler, 2007). Sensory memory is elastic regarding changes.

In the MMN research practice, the difference between musician and non-musicians groups regarding sound differentiating tasks is often discussed. Tervaniemi and colleagues point out that musicians perform sound differentiating exercises more precisely than non-musicians (Tervaniemi et al., 2005). This was observed also while analysing other – N2 (negative curve with latent period of 200 ms after receiving excitation) and P3 (positive curve with latent period of 300 ms after receiving excitation) effects. For the musician group, the amplitude was larger than for non-musician group. Musician group had shorter MMN effect’s latent period. This shows musician ability to react to sound differences faster and more precise. Tervaniemi notes that also other effects – including early attention switch (N1) – characterises the difference between groups and their musical experience (Tervaniemi et al., 2005). Latest research indicate that music training allows to perform tasks, where gradual interval size and pitch register change occurs, more precisely. Musicians could faster and more precisely react to differences in intervals not connected with each other, if the interval reciprocal differences were within 75 – 150 cents (corresponds to almost a tone to one and a half tone). Increasing the reciprocal differences of intervals (up to 175 cents, which corresponds to almost a whole tone), consequently increased the reaction speed. Non-musician group’s results were considerably different. Researchers conclude that sensitivity for differentiation in musicians is more pronounced than in non-musicians (Zarate et al., 2012).

MMN effect is closely connected with ERAN effect. Both effects characterise early attention activation level. The similarities of both effects are marked by polarity, time dispersion and sensitivity to new and unexpected acoustic excitation (Koelsch, 2003). Both effects are connected to activation during the process of complex music structure processing. Koelsch explains ERAN effect as a negative curve of music syntax mismatch (Koelsch et al., 2003). ERAN effect is usually followed by late negative curves (N5), which reflect the process of harmony integration processing in the brain (Koelsch et al., 2000).

Majority of research about the processes of music structure perception and cognitive processing in human brain are connected with examination of adult persons. German scientist Koelsch, pointing to insufficient research of this process regarding children, conducted research and concluded that already at five years of age, the processes of pitch structure cognitive processing reflect the major-minor system’s syntax peculiarities characteristic of European cultures. For example ERAN effect, which points to mismatch between the real sound and the expected, is expressed with a larger amplitude, if a Neapolitan hexachord was
the final chord in a sequence of five chords (not the third in a standard sequence). The effect, caused by this mismatch, scientist explains with the misplacement of Neapolitan hexachord in a diatonic music sequence – for the listener such a chord is unexpected already at the early attention stage (Koelsch et al., 2003; Koelsch et al., 2001).

With the help of *ERAN* effect, it is also possible to describe **age and gender differences** in the sound differentiating exercises. *ERAN* effect in the research points to gender differences – for males, this effect is more pronounced in the right hemisphere, but for females it can be observed in both hemispheres (Koelsch, 2003). In the process of processing chord sequence, distinct *ERAN* effect for boys can be observed in the left hemisphere, but for girls – in both hemispheres. Researchers note that for children (more distinctly - boys) left hemisphere dominates regarding music structure processing. For children, *ERAN* effect has been observed in the lateral inferior gyrus (*gyrus frontalis inferior lateralis*). For adults this area is involved in language syntax processing (Koelsch, 2003). Differences between boys and girls were observed during dichotic listening. Six till nine year old boys could perform language sound exercises spoken into their left ear with less precision than girls of the same age (Moulden, 2000).

During his research, Koelsch found that, for adult males, *ERAN* effect mostly activates in right hemisphere. For boys it mostly lateralises in the left hemisphere. No differences between women and girls were observed during this research (Koelsch, 2003). A Neapolitan hexachord at the end of the sequence caused *ERAN* effect already 200 ms after receiving the excitation and reached its maximum expression with a latent period of 352 ms (F4 electrode, frontal lobe). 400 ms after the excitation *ERAN* effect was continued via negative curve (N5), which reached its maximum value 550 ms after receiving acoustic excitation. Despite there being amplitude differences between 5 and 9 years old children, statistically significant differences were not observed (Koelsch, 2003). It can be concluded that, similar to adults, in children, during the sound differentiating exercises, two curves tied to early attention activation can be observed – *ERAN* or music syntax’s *MMN*, as well as late negativity (N5).

What differs is the magnitude of these effects in one or the other brain hemisphere. This points to both five year old children integration in a certain music system, and early attention activation differences between children and adults in the process of music structure cognitive processing.
1.3.2. Pitch and rhythm cognitive processing

The cognitive processing of pitch and rhythm mostly occurs in the lateral prefrontal gyrus (gyrus preafronatlis lateralis) (Loui et al., 2009; Justus et al., 2002). Research in brain dysfunction shows that the determination of intervals is connected with activation in the left hemisphere, but the melodic lines (voice leading) are processed in the right hemisphere (McDermott et al., 2008; Justus et al., 2002). The processing of intervals is supported by posterior auditory cortex and intraparietal sulcus (sulcus intraparietalis). Responsible for the differentiation of more complex sounds is the planum temporale (planum temporale) (Zarate et al., 2012). Research shows that varying pitch of different registers activate primary auditory cortex, primarily in the right hemisphere. One of the assertions, which emphasises the right hemisphere’s lead role in processing pitch, points out, that auditory processing centres in the left hemisphere are better at adapting to processing of rapidly changing wide range excitations. Such description is characteristic of acoustic excitations created by human speech. The right hemisphere, though, is able to better process the so-called narrow line excitations, which are created by melodies in sound structures (Zattore, 2007).

Different mechanisms characterise pitch structure or excitation group processing. Processing of sound groups is a higher cognitive process, which requires interaction of auditory cortex with frontal lobe, as well as activation of memory mechanisms (Zatorre, 2007; Brown et al., 2007:59-69). Researchers point out that a structured sequence of pitch is perceived, recognised or decoded on the basis of the reciprocal relations of sounds within the structure (Parsons, 2004:247-268). This means that separate pitches are saved, sequentially, in the memory as separate units and then the following pitches are perceives within the process of comparison. Researchers show that during the process of pitch structure processing, the so-called tonal working memory function is activated.

While experimenting with the comparison of two pitches, activation was observed in the right side of the frontal lobe. Similar observations have been recorded while comparing two pitch phrases – activation was observed in the cerebral cortex and infra-cortical (infracorticalis) areas, mostly in the right inferior part of frontal lobe. In both cases, the step principle, or sound comparison in chronological order, was observed. The only difference is in the workload of working memory. During the research, differences regarding the reaction speed and amount of mistakes made were also observed – processing of a broader structure requires longer reaction time, but longer reaction time lessens the amount of mistakes. The process of differentiating between separate sounds is characterised by faster reaction but larger amount of mistakes (Zattore, 1994).
Several authors point out that the activation of frontal lobe is tied to a successful execution of an exercise (Zattore, 2004; Perry et al. 1993). While following a sound sequence, during the experiments, asymmetric activation of posterior frontal lobe and dorsolateral (dorsolateralis) prefrontal cortex was observed, which points to functional differences between cognitive processes and tonal working memory. It is possible that right posterior areas of frontal lobe process pitch information, but dorsolateral areas of prefrontal cortex provide significant support for the process of tone comparison and are therefore connected with the activation of tonal working memory (Perry et al., 1993).

In research, it has been noted multiple times, that secondary auditory cortical field is also significant in the cognitive processing of pitch structures. While examining sound differentiating processes, scientists have observed activation in the right hemisphere auditory cortex’s secondary area and superior temporal gyrus (gyrus temporalis superior) at moments, when a longer sequence of pitches is presented. In similar experiments – memorising and differentiating pitches in a sequence of 3–7 pitches, therefore also involving working memory processes – activation of both hemispheres was observed in posterior superior temporal gyrus (gyrus temporalis superior posterior) bilaterally, supramarginal gyrus (supramarginalis) bilaterally (with a distinct dominance in the right side), premotor cortex bilaterally with a distinct dominance in the right side, as well as in the right hemisphere’s upper parietal lobe (Binder et al., 1997).

The aforementioned information points to differences in the processing of separate sounds and sound structures: in the perception and processing of sound structures, a significant role is possessed by tonal working memory, which supports the ability to hear the structure as a whole and define its separate structural elements. The knowledge from the research points to interaction between tonal working memory and aural attention processes. A significant meaning, during the process of perception, is carried by the layout of structure within a scale – the functional relations of sounds, as well as the tonal centre of structure, or a support tone, helps to perceive the structure as a whole. Judging by the aforementioned information, it can be concluded, that the processing of pitch structures occurs at multiple levels – starting from the examination of interval reciprocal relations and up to semantic processing of a pitch phrase, where a significant role is played by the length of a sound and, therefore, the rhythm parameter.

The perception and processing of rhythm structures activates basal ganglia (ganglia basalia), cerebellum (cerebellum), motor and premotor cortex, as well as supplementary motor area, which is located in the cortex (cortex motorum supplementarum) of the brain. As
shown by the research of the *MMN* effect, these areas are also possible to activate during aural, including sound differentiation, exercises (Lappe et al., 2011). Lappe and colleagues conclude that previously prevailing perception about the *MMN* effect, caused by rhythm structure training, dominating in the left hemisphere, is disputable. The *MMN* effect, caused during exercises, where differentiating between the length of rhythms occurs, has been observed in both hemispheres, including in the right – hemisphere connected with processing pitch. This points to the specific role of primary auditory cortex during the processing of acoustic excitation, regardless of the physical properties of excitation (Lappe et al., 2011).

Research in brain dysfunction also shows that localised processing of rhythm structures is also possible without the presence of melodic structural elements (Peretz et al., 2007:255). This shows the independence of rhythm structure neural processing within the cognitive system. Even if the rhythm structure has a certain pitch, the processing of acoustic information can be considered as processing two separate components with interaction regarding activation of other centres.

The neural representation of rhythm is possible to localise. It has been recorded in research that the dominating hemisphere for rhythm processing is the left hemisphere; however, processing can also occur as a bilateral neural process. Simple, regular, previously met rhythm structures are processed within the frontal lobe in the left hemisphere (corresponds to area 6 within Brodman’s cytoarchitectural organization, BA 6), parietal lobe (*lobus parietalis*), and the anterior lobe of cerebellum (*anterior cerebellum*). The processing of unknown and more elaborate rhythm structures occurs in the right hemisphere’s frontal area and the anterior part of the frontal lobe. In the processing also involved are both hemispheres’ parietal lobe centres and the posterior lobe of cerebellum (*posterior cerebellum*) (Sakai et al, 1999).

The most important areas for rhythm structure processing are parietal lobe and prefrontal cortex with specific activation in inferior parietal lobule (*inferior parietal*) and in both hemispheres’ prefrontal cortex areas. Activation of the aforementioned regions is connected with increased attention towards the aspect of time in music, and with the activation of the working memory functions for the perception and processing of the duration of sounds (Peretz et al., 2007:247-268).

Cerebellum plays a special role in processing rhythm structures. Exactly in this region, in correlation with the aspect of time in the acoustic stimulus, the perception and reproduction of the subtle micro-motoric nuances occurs. Powerful activation of cerebellum is undoubtedly tied to motoric actions. While processing rhythm structures, the activation of cerebellum may
be partly connected to motoric actions. Mostly, it supports cognitive processes during the moment of time structure processing. While differentiating rhythm, tempo and articulation, cerebellum activation is more pronounced in non-musicians. When differentiating the duration of sounds, its activation is more pronounced in musician group. This shows the role of cerebellum in processing the duration aspects of sounds and considerable differences between musicians and non-musicians. It is possible that musicians perceive changes in the duration of sound as new information, as opposed to metre, tempo and articulation, hence the differences in cognitive actions. Non-musicians, however, do not see the extension of acoustic material as new information, as opposed to other elements. It is important to recognise the multifunctionalism of cerebellum regarding processing of rhythm structures (Peretz et al., 2007:247-268).

For quite a long time, elements of rhythm and metre were considered as mutually complementary. Patel, together with other scientists, (Patel et al., 1997) with the help of PET method, observed brain activation during periods, when sounds were played in regular or irregular structure. During the research, the activation of the left Broca’s area (gyrus frontalis inferior of the brain's left hemisphere) was recorded, and it points to the connection of metro-rhythm structures with speech processing areas in the brain (Patel et al., 1997:243-299).

The principles of both pitch and rhythm content decoding are notions subject to musical cultures and are developed by the musical experience. Exactly because of the aspect different musical experiences, scientists are encouraged to set forward specific prerequisites for forming respondent groups for research of both pitch and rhythm cognitive structuring principles. Separation of groups is important, because as a result of intensive musical training, the anatomical structures of the brain are able to change form. Processing of acoustic information, as a result of neural plasticity, obtains different processing mechanisms in that respondent group, whose musical experience has developed on the basis of musical training (Altenmüller et al., 2007:121-142).
1.4. Aural training efficiency

Despite the fact that differentiation of sounds as a whole is an individual process, due to aural differentiation training, MMN components change significantly (Lappe et al., 2011; Winkler, 2007; Menning et al., 2000). Lappe notes that the differences of musical training during the stage of early attention may be characterised precisely via MMN components (Lappe et al. 2011).

Naatanen, while analysing the efficiency of MMN research, points to the effects of three day training in sound differentiating, by using, during the training, a complex – structures of excitations of varying duration and timbre (Näätänen, 2007). Other scientists also admit that the effect of the training is increased by the physical properties of sound. During experiments with sinusoidal sounds and sounds of pronounced timbre, a clearly shorter MMN effect’s latent period and larger amplitude was observed with so-called harmonic sounds – sounds, which are perceived with a distinct timbre. This shows that the process of early attention activation is affected positively by neural decoding of sound properties, opposite to the opinion that extra workload during the process of perception also delays the activation of early attention (Tervaniemi et al., 2000).

As noted by Koelsch, as a result of musical training, processing of more complex tasks of sound differentiation occurs not only in the highest cognitive level, but also on the levels of early attention and short-term memory processes (Koelsch et al., 1999). Positive changes during sound differentiation exercises point towards the development of early attention processes. In respondents, who could not distinguish between incoming excitations, MMN effect was not observed. After respondents had learned the skills of sound differentiation, MMN effect could be observed. Naatanen notes that the effect of the training is largely determined by the content of the experiment and the physical properties of sound (Näätänen, 2007).

Gottselig and colleagues, by using two different deviating sound structures (more easy and less easy distinguishable from standard structures), trained each of the groups for six minutes. MMN effect was observed only in the group which had been trained with more easy recognisable sound structures. MMN activation, for this group, was observed bilaterally in temporal superior gyrus (gyrus temporalis superior) with the left hemisphere dominating both before and after the training. MMN activity in the right hemisphere was observed only after the training (Gottselig et al., 2004). Gottselig’s research serves as the basis for statement about the effect of the excitation’s content on the processes of early attention – the difference
between standard and deviating structures is created only if the individual is able to perceive this difference and if the memory capacity of the individual is sufficient.

Several authors describe the sustained effect of the training during the training and within a certain timeframe after the training. Menning acknowledges that a significant training effect regarding the tasks of sound differentiation can be observed already after the first week of training. After a short breakthrough at the start of the training, a little, but persistent improvement of the results follows. Both the N1 (reacting to standard excitation – 1000 Hz) and MMN (reacting to deviant sounds within a structure – 1005, 1010, 1050 Hz) curve amplitudes had a tendency to increase. Shortly after the training, the stability of results was observed – there were no deviations from the measurements taken immediately after the end of previous training session. Three weeks later, decrease of amplitude was observed, but the results differed, positively, from the measurements taken before training (Menning et al., 2000). This shows the possible positive effect resulting from regular training.

The effect of training regarding pitch and rhythm structures may be observed in groups with varying musical experience. Mathys and colleagues note that the effect of training can be observed in both musicians and non-musicians. The group of researchers concluded that during sound differentiation exercises, human sensitivity towards differences in the content of the perceived information can be observed. These abilities are possessed by any human, because they are provided by neural processes in the cerebral cortex – activity in Heschl’s convolutions in the right hemisphere (auditory cortex) and left hemisphere’s auditory cortical field, which is responsible for the precision of differentiation. As a result of the training, the activity within the aforementioned areas is increased, regardless of any previous musical experience (Mathys et al., 2010). Other authors also report on changes within neural activity resulting from training. Lappe and colleagues have observed neural plasticity changes in respondents, non-musicians, who, during intensive sensor-motoric aural training, learned certain rhythm structures. MMN and P2 curves of respondents involved in active training were significantly different from those of other responders, who were passively observing the training group. Researchers concluded that the inclusion of rhythm groups in regular training (in research – 8 training lessons) can develop the neural activity of non-musicians in the process of metro-rhythm structure processing (Lappe et al., 2011).

Significant differences between musicians and non-musicians may be observed in experiments, where the differentiation of sounds occurs within one structure (differentiation of interval differences or change of melodic movement). As noted by Fujikoka, during the tasks of differentiating between separate pitches, a similarity between musicians and non-
musicians may be observed. However, in the tasks connected with interval and melodic motion differentiation within a certain structure, more pronounced $MMN$ effect can be observed strictly in the musician group (Fujioka et al., 2004). The researcher notes that musical training and being musically gifted can positively influence differentiation of more complex components, but that musical training does not influence arbitrary early attention reactions towards differentiation of separate pitches within a structure. Therefore, the Japanese scientist confirms a previously advanced assumption about similarities (in early attention activation) and differences within the process of perception and processing of acoustic information between musicians and non-musicians.

1.5. Description of aural attention training methods

When the initial work on this research for dissertation had begun, it was found that aural training methods for children of schooling age are not available without clinical context. One of the possible explanations may be connected with the therapeutic use of aural training – aural training is most often used to treat symptoms of a psychological process, including attention deficit hyperactivity disorder (ADHD).

Attention training, as a type of therapy, has mostly been researched regarding its clinical aspect. Aural training is often used for rehabilitation in patients with brain trauma or other neurologic disorders (Rohling et al., 2009), for cognitive training (Wells, 2009), as well as for reducing restlessness and social anxiety (Papageorgiou et al., 2000). It is not uncommon for attention training to be a part of depression (Siegle et al., 2007), melancholy (Cavanagh et al., 2000) and hallucination (Valmaggia et al., 2007) treatments. Several authors have observed that the dynamics of attention development is a side effect of some other, e.g. meditation, training (Slagter et al., 2007; Tang et al., 2007). This shows the connection between attention and other cognitive and emotional processes in clinical context.

In the research practice, certain training methods can be found which influence the development of attention system’s branching (Berger et al., 2000:3-5), however, these methods are mostly based on the development of the visual attention system. In the modern research practice there exist certain systematised methods, which are aimed at aural attention training. The developed methods are mostly targeted at children with ADHD.

For determining the attention capabilities, in research practice, usually a test method is used. Certain tests, such as AUDIVA (Aufmerksamkeitstester) or Continuous Attention Performance Test (CAPT) include sound stimulators or sound structures, which are meant for
examination of aural attention reactions. Developers of both tests point out that these tests are suited for repeated measurements and that they also possess training function. The specifics of this dissertation dictate that the most appropriate test for this research is the non-verbal AUDIVA test, where the acoustic stimulators are piano sounds.

Summing up the knowledge from this chapter, it can be concluded that:

1) activated attention is a prerequisite for cognitive processes. Attention capabilities are necessary to perform any cognitive action – attention is inseparable from other perception and cognition processes;

2) the process of attention is connected with the interaction of several subsystems – activation, orientation, and executive functions interact almost simultaneously: subsystems of attention have close reciprocal connection;

3) aural attention – a type of selective attention within attention system, same as the attention system as a whole, may be activated by any acoustic excitation – separate sounds or an aggregate of sound;

4) special role in the activation of attention and cognitive processes is carried by the early attention stage, which is described as an individual process, and it is significantly influenced by the content of the acoustic information;

5) in literature sources, pitch and rhythm are the most often mentioned parameters which can directly activate attention system. Pitch and rhythm parameters have different localisation of cognitive processing in the cerebral cortex and other brain structures;

6) for the analysis of attention processes, in modern day research practice, mostly acoustic excitation or structured excitation (pitch and rhythm structures) differentiation exercises are used. Only structured information can activate attention processes, causing specific effects, which in literature sources are called MMN and ERAN, and which characterise both the activation of early attention and the cognitive processing of acoustic information in the brain;
7) attention process in the acoustic excitation differentiation exercises is closely connected with sensory short-term memory. A special type of sensory memory – echoic memory, has a capacity limit, which in youth is limited to 10 seconds;

8) attention disability is one of the problematic issues in school, therefore it is important to examine in which way definite pitch and rhythm structures, in correlation with attention functions, are able to influence and develop aural attention system as a whole;

9) attention system, along with aural attention, can be subject to training – the effect of attention training is primarily determined by the content, intensity and regularity of training;

10) at the same time, it has to be concluded that no methods aimed at aural training are available without clinical context. Pitch and rhythm parameters regarding their connection with the possibilities of training aural attention processes, have scarcely been researched.
2. The development of structure system and training programme model

The content of the second chapter of the dissertation mostly corresponds with the framework of explorative research, which serves as a basis for three main points of the research: first, a theory is developed, from which subsequently both the model and the hypothesis is developed. (Bortz et al, 2006).

In the beginning, the notion of *structure* in the context of the newly-created system of structures is explained (subchapter 2.1.). In subchapter 2.2., a theory is set forward about the pitch and rhythm information structuring and its inclusion in a unified system of structures. The principles of creating a system of structures as such are explained in four subchapters. (2.2.1. – 2.2.4.) Subchapter 2.2.5. reflects on the principles of selection and arrangement regarding pitch structures, using the newly-created system of structures developed during the dissertation as a basis. Subchapter 2.2.6. reveals the principles of selection and arrangement regarding rhythm structures within the framework of the newly-created system of structures. On the basis of the system of structures, it’s theoretical and computer-based model, aimed at 7-8 years old children, is developed – pitch and rhythm training programme’s AUT 2nd version (subchapter 2.3).

2.1. The notion of structure in the context of research

Within the framework of this research, the notion of structure is closely connected with aural attention process – a structure does not have any artistic value, it has a certain function assigned to it – relevant or irrelevant pitch and rhythm excitations group in the differentiation exercises. The size of a structure, corresponding to previously described peculiarities of the attention process, is completely determined by the capacity of the short-term memory.

2.2. The system of pitch and rhythm structures

In order to research the chosen music parameters’ – pitch and rhythm – effects on aural attention, during the research, a **new system of structures** has been developed. At the core of the system of structures is the practical and theoretical knowledge on the principles of development of systems of structures, on the peculiarities of aural attention, on the processes of cognitive processing of pitch and rhythm structural elements. The system of structures is unified – its core principles can be applied to both the rhythm and pitch parameters.
2.2.1. Description of the system of structures

At the basis of the system is a structure (S). Structures differ and can vary infinitely. One or more structures may become a training structure (T), and from this moment the chosen structures determine the rules of unifying these and other structures. Closest to the training structures is structure group A (A) – the structural phases of this group is an organic continuation of training structures.

Structure group A is similar to training structures, but at the same time – does not include training structures within itself. With the broadening of the structural phases within structure group A, an increasing tendency to distance from the training structures becomes more apparent – structure group A transforms into structure group B (B). The structural phases of the new structure group retract from the point zero (S0P) of training structures and structural elements (SE), they become larger and more liberal. Similarity with the controlling structural elements is retained only on the level of development tendencies – new structures within one structure phase have a similar direction of development to that of a training structure, or a notion of repetition of two incomplete structures. At the same time, structure group B retains the principle initiated by structure group A – to create a structure that is similar to the training structure, but is not identical with it, within one structure phase. Structure group B develops this principle further - structure phases include not only structures similar to training structures, but also structures identical to training structures. Integration of structural elements alien to training structures with the training structure itself has the aim to activate the attention system and all of its subsystems on all levels. Structure group C (C) appears as a new structure group for perception. Its basis is the unification of multiple structures with factors of acoustic influence (AF). Structure group C is aimed at disregarding the structural elements alien to a training structure, while offering for perception a new, additional, layer of acoustic elements. The size of structure phases within structure group C is smaller than that of structure phases of group B. At the same time, the amount of identical training structures within one structure phase is increased.

2.2.2. Principles of the development and organisation of system of structures

In the research the word structure (S) is designated for a sequence of pitch or rhythm symbols, which correspond to one time interval (TI) or three seconds of time (TI=3 seconds (s)). Each structure includes two, time-wise, identical parts (TI=1.5s+1.5s). Both parts of a full structure may be identical, similar or different.
For the system of structures to be used as a tool for attention training, three selected and mutually exclusive full structures are named **training structures** (T or T1, T2, T3). A training structure corresponds to one TI (T=TI) and both of its parts are identical. As an example, pitch and rhythm training structures within the system of structures reflected in the dissertation, are as follows (Image 2.2:1):

![Image 2.2:1 Pitch and rhythm training structures (T1, T2, T3)](image)

When obtaining the control function, the corresponding structure interacts with other structures in the context of a broader presentation or **structure phase (SP)**. Structure phase is made of two or more mutually exclusive, similar, or identical structures. The task of structure phases is to create new – comparative information layer: their separate segments within one incomplete or complete structure may be identical or similar to training structures.

The reciprocal opposition of training structures, as well as their varying combinations with other structures included in phases or groups create two-level relationship, which within the framework of the system are called horizontal and vertical levels of complexity. **Horizontal level of complexity** can be attributed to the time period or length of a structure phase, which is gradually increased and, therefore, affects sustained aural attention (vigilance) during the process of acoustic information perception. The second level of complexity is **vertical complexity**. It characterises the content of a structure – the relationships between the elements included in a phase and the stable, unchanging training structures. The level of vertical complexity affects the activation of attention, as well as focusing the attention on different, mutually similar and exclusive acoustic excitations.
2.2.3. Training structures and other structures

Training structures may exist only when other structures exist. Only by setting training structures in opposition with other structures it is possible for training structures to realise their functions. To describe the variety of elements of intonation or rhythm within other structures, it was necessary to perform grouping of structural elements within the system. As a result, a new term, structure group (SGR), was created. During the research, three structure groups have been created – A, B, and C. The qualitative content (intonation/rhythm) included in each structure phase is characterised by the choice of material and arrangement properties specific for this group, as well as relations between stable training structures and variable free structures. The development of a structure group – a display of the vertical complexity level – is connected to obeying some definite principles within one structure group: the belonging of a structure phase to any particular group is characterised by relations between free structures and training structures. Therefore:

- structure group A is similar in content to T;
- structure group B content-wise is distanced from T;
- structure group C includes related T elements, but is supplemented with new acoustic factors thereby creating new excitations during the process of attention activation.

2.2.4. Complexity of structure groups

The complexity of system of structures describes the relations between training structures and structure groups’ structure phases; therefore, the level of complexity may differ. Upon the inclusion of multiple training structures in a unified system, the complexity level changes. The criteria for determining the level of complexity of a system of structures, on the levels of both perception and attention, are connected with two-way relations of training structures and structure phases on a horizontal and vertical level. The relations between structural elements included in the control structures and the structural elements included in structure phases determine, whether horizontal or vertical complexity level is low, medium, or high. The overall level of complexity has a tendency to increase if there are less structure pauses within a structure row (SR), and if structure phase elements, which are identical or similar to training structures, repeat.

**Horizontal complexity** is determined by two criteria:
1) what is the amount of structural elements in a structure phase, what is the variety of full structures (Sp) within one structure phase;
2) what is the size of a structure in terms of time intervals (TI).

Broader structure phases, which unite several, mutually exclusive structural elements, have higher horizontal complexity.

**Vertical complexity** is determined by two criteria:
1) Structure phase relations with training structure, that is, how pronounced is the correlation of relevant (T) and irrelevant full structure (Sp) acoustic excitations within one structure phase;
2) how many layers are in one structure phase. Structure phase may be layered with one or two (with additional acoustic factors) levels.

Higher vertical complexity level is characteristic of structure-wise longer structure phase, which includes multiple full structures (Sp) identical or similar to training structure, and is layered in two levels.

For characterising the mutual relations of structure groups and training structures, several criteria were formed, which characterise the level of similarity within these relations. The mutual relations of structure groups and training structures can be characterised in seven levels of similarity. These levels are split in three divisions of relations.

**First division of relations** (similarity levels I–III) is characterised by similarities within incomplete training structure. First three levels are characteristic of all three structure groups.

**Second division of relations** (similarity levels IV–VI) is characterised by structure similarities within a full training structure. Similarities may occur within one or two TIs.

**Third division of relations** (similarity level VII) is characterised by only one level and it describes the similarity of the structure (within a structure phase) with a full training structure (T). Both types of acoustic information differ with only one structural element – a pause within structure phase.

On the level of perception, horizontal and vertical complexity can be **high, medium or low**.

**High complexity level** is characteristic of structure group C, because:
- structure phase has two layers,
- both layers include mutually exclusive structural elements,
- structure phases include similarity levels of all three groups.
Medium complexity level is characteristic of structure group B, because:

- structure phases have been developed within 8 – 20 time intervals (24s – 60s),
- structure phases include multiple mutually exclusive structural elements,
- structure phases include similarity levels of two groups.

Low complexity level is characteristic of structure group A, because:

- structure phases have been developed within 2 – 10 time intervals (6s – 30s),
- structure phases include structural elements characteristic of training structures,
- structure phases include certain first and second group’s similarity levels.

2.2.5. Pitch structures in the newly-created system of structures

The selection of pitch structures is based on the music theoretical knowledge about pitch-descriptive properties, as well as on neuropsychology based knowledge about the peculiarities of pitch structure perception and cognitive processing.

Pitch structures are included in the newly-created system of structures and for their description all of the previously described components of a system of structures are used.

2.2.5.1. Description of the pitch training structures

At the basis of pitch system of structures are three arbitrarily chosen pitch structures (T), which, as a result of selection, have obtained the functions of a training structure.

Pitch training structures are developed in a unified tempo-metric writing – structural elements are played with identical time interval and each corresponds to 0.5 seconds or one-sixth of TI.

Despite the point zero being the same for all three T, their differences are created by the directions of their development:

- T1 descending step of a perfect fourth,
- T2 gamut-type motif ascending via whole-tones,
- T3 gamut-type motif descending via whole-tones.
2.2.5.2. Description of pitch structure groups

Pitch structure phases are split into three structure groups.

**Structure group A** is made of 10 structure phases, which regarding structural elements, continues the progression ways characteristic of training structures (repetition, voice leading, range). Their size corresponds to 2 – 10 time intervals. Group A structure phases have a low level of complexity. The common properties of the group’s structure phases are:

- Perfect interval relations with S0P;
- The range of the structure phase does not exceed two t8 intervals, therefore, it does not create significant contrasts in pitch;
- structure phases are based on diatonic scale;
- structure phases retain gamut-type motion, in their voice leading gradually are introduced perfect intervals, consonance (fifths and sixths) scale descriptive augmented intervals (A7 – A9);
- structure phases include structures, which are similar to incomplete structures within a training structure on the standard (similarity level I) or transposed pitch (similarity level III). Some structures also include full structures similar to training structures (similarity level V), however, it is not characteristic of the whole group;
- the amount of similarity levels and their repetition contained within the group has a tendency to grow.

**Structure group B** is made of 10 pitch structure phases, which, in their structural elements, are significantly different from the progression methods of training structures. Their size corresponds to 8 – 20 time intervals and in the whole system it is the longest structure phase group. Group B structure phases have a medium level of complexity and are responsible for the following common properties of structure phases:

- the beginning of structure phase may be in any relation to S0P;
- the range of structure phase exceeds two t8 intervals, thereby creating significant pitch contrasts within one structure phase;
- structure phases include steps to any simple or compound intervals - characteristic of voice leading are large steps and nearness of larger intervals;
- characteristic of structure phases are diminished (dm) and augmented (au) intervals;
- structure phases include chromatic motion;
structure phases have a tendency to distance from the original scale: they also distance from S0P;
structure phases include parts of S, which are similar or identical to incomplete T – mutual differences exist on the level of chromatic semitones;
structure phases include 2 to 15 similar and identical full training structures – mutual differences with T exist on the level of chromatic semitones.

Structure group C is made of six pitch structure phases and it is comparatively the smallest structure group. Group’s structure phases retain the size of structure groups which are characteristic of B – they are made of 8 - 18 time intervals; however, in terms of structural elements, it considerably differs from B. By unifying multiple acoustic factors, structure phases are layered in two levels. Taking into account the peculiarities of perception, the second level is considered to be not only additional background sounds or noises, but also dynamic gradations, reverberation effects of a sound, and changes in timbre – all types of so-called acoustic disturbance factors, which affect both perception and aural attention. C group’s structure phases have a high level of complexity and for complete perception require a high degree of attention perseverence.
C group’s structure phases’ pitch level has a tendency to return to the progression principles characteristic of training structures - range is narrowed, voice leading gets smoother, the amount of chromatic sequences lessens.
Common tendencies are as follows:
• any interval relations to S0P are possible, but relations with perfect intervals are dominating;
• the range of phase structure in both directions regarding S0P does not exceed t8 interval;
• structure phases have some notions of scale;
• structure phases include any simple interval steps in voice leading – characteristic of voice leading are relatively small steps;
• nearness of perfect intervals within structure phases;
• structure phases are layered in two levels of perception – characteristic of them are both pitch background and noises, and rapid changes of dynamic gradation and timbre;
• structure phases have a tendency to distance from T similar incomplete S – they have a tendency to assimilate full identical T;
• structure phase includes a new structural element – pause. Pause becomes the only sign of difference between Sp and T (structure phase C6).
2.2.6. Rhythm structures in the newly-created system of structures

The selection of rhythm structures is based on music theoretical knowledge about metre-rhythm descriptive characteristics, as well as on neuropsychology based knowledge regarding the peculiarities of meter/rhythm structure perception and cognitive processing. Rhythm structures have been included in the newly-created system of structures and for their description all of the system’s components have been used. Within the system of structures, in correlation with the peculiarities of rhythm structure perception (Grahn et al., 2007, Krumhansl, 2000), an additional structure component has been added – pulse (P) and one unit of pulse corresponds to one-sixth of TI.

2.2.6.1. Description of rhythm training structures

At the core of the rhythm system of structures are three, by the author arbitrarily chosen, rhythm structures (S), which in the research have gained the properties of a training structure (T).

Rhythm training structures are timbre-wise identical, but they have been created without any specified pitch. Structural elements have been distributed with identical time spaces between them and each corresponds to 0.5 seconds or one-sixth of TI.

The point zero for all three T is different and these differences are characterised by their relations to pulse:
- T1 pulse beat division in two rhythm units identical in duration,
- T2 pulse beat division in two rhythm units with the first unit being dotted,
- T3 pulse beat division in two rhythm units with the second unit being dotted.

The size of one full T corresponds to one time interval (3 seconds) and includes six structural elements (6 x 0.5 seconds).

The elements of rhythm training structure are synchronised with regular pulsation in the background. Background pulsation helps to perceive the structure as a whole, therefore, it is not considered to be an additional layer – additional workload in the process of acoustic information perception and processing.
2.2.6.2. Description of rhythm structure groups

The content of rhythm training structures determines the structure phase’s affiliation with one of the rhythm structure groups (SGR).

Rhythm structure groups are characterised by the following criteria of horizontal and vertical complexity:

- the size of a structure phase in terms of time intervals (length of structure phase),
- within S0P included structural element relations to pulse (P),
- the regularity of background pulsation,
- the content of a structure – the complexity of rhythm groups regarding pulse,
- similarity level and the count of its repetition within one structure phase,
- the amount of layers.

Rhythm structure phases don not have a definite pitch – structural elements are timbre-wise identical. They are evenly layered with identical time spaces and each corresponds to 0.5 seconds.

Rhythm structure phases have been divided into three structure groups.

**Structure group A** is made of 10 structure phases, which, in terms of structural elements, continue the progression principles characteristic of training structures. Their size corresponds to 2 – 10 time intervals. A group’s structure phases have a low level of complexity.

The common properties of group’s structure phases are as follows:

- structure phases developed with a background of regular pulse;
- structural phase differences with T are expressed only at the beginning of structure;
- the arrangement of rhythm in T considerably differs from the rest of the rhythm material.

**Structure group B** is made of 10 rhythm structure phases, which, in terms of structural elements, significantly differ from the progression principles in training structures. Their size corresponds to 8–20 time intervals and it is the group with longest structure phases.

B group’s structure phases have a medium level of complexity and it is formed by the following common properties of structure phases:

- structure phases developed with a background of varying pulse;
- differences with T are expressed in the whole structure;
- within the flow of the structure there have also been included rhythm structural elements similar to those in T, however, they differ in details.
Structure group C is made of 6 rhythm structure phases and it is comparatively the smallest structure group. Group’s structure phases retain the size characteristic of B structure group – they are made of 8 – 18 time intervals, but, in terms of structural elements, it significantly differs from structure group B. Unifying multiple acoustic factors, structure phases are layered in two levels. Taking into account the peculiarities of perceptions, the second level is considered to be not only an additional background of rhythm sounds or noises, but also gradation of dynamics, sound reverberation effects, and changes in timbre – all of the acoustic disturbance factors, which can influence both perception and attention processes as a whole.

C group’s structure phases have a high level of complexity and for the processing of their content a prolonged, sustained attention is required.

C group’s structure phases’ level of pitch has a tendency to return to the progression principles characteristic of training structures.

Common tendencies of this group are as follows:

- the background pulsation contains interruptions;
- within the common flow of structure phases there have also been included formations quite similar to the rhythm in T;
- structure phases contain disturbing side effects – sounds of noise, dynamic contrasts, timbral and spatial-acoustic effects.
2.3. Pitch and rhythm aural attention training programme (AUT)

2.3.1. Structure of the aural attention training programme AUT

The primary task of this training programme is to train aural attention, while, to achieve this result, activating short-term memory processes for the perception and differentiation of pitch and rhythm structures. The programme, within the framework of this dissertation, is meant for 7-8 years old children.

Training programme includes pitch and rhythm differentiation exercises and it has been developed by following the principle of gradualness: exercises, in a definite order, contain variable acoustic information, with factors of acoustic influence included, and gradually increased time given for doing exercises.

Training structures with irregular repetitions both separately and within structure phases have been laid out in ten training exercises, which in the research have been named attention development levels (ATL)

Attention development levels are characterised by the following properties:
- they include acoustic information – system components T, SF, SP, P;
- they include one, two or three different training structures (T);
- they contain different amounts of structure lines;
- they set forward different requirements regarding aural attention activation and perseverance;

Crucial part of attention and perception criterion is the tendency of complexity, which is determined by proportional relations of training structures, structure groups and structure pauses within one ATL. The summary of all ATLs has been given in the table (Table 2.3:1).

As can be seen in the table, first three ATLs are marked by relatively large volume of T (18–21%) and pauses (SF) (23–14%). Gradually, in the form of new acoustic information, are being included with T similar structure group’s A structure phases. They imitate separate parts of T or create similarities with a T’s full structure. Starting with ATL 3 acoustic information is being included, which on its own contains not only structures similar to T, but also structures identical to them. The differentiation of these structures requires steady attention for a longer period of time (up to 20 TI or one minute). While increasing the amount of structure phases in structure group B within one ATL (starting with ATL 4), and with a new structure group appearing (structure group C starting from ATL5), the amount of
repetition of T, and its related – A structure group’s structure phases, decreases. Such asymmetry of proportions presents more intensive so-called relevant excitement count (relevant are not only T, but also those parts of structure phases, which include with T structure identical structures) and, therefore, the attention’s sensitivity towards the amount of acoustic excitation is heightened. Last three ATLs, lessening the amount of pauses and including broadened B and C structure groups’ structure phases following one another, achieve high level of complexity. They are aimed at aural attention development within a longer timeframe – up to 10 minutes within one ATL.

Table 2.3:1 Tendency of complexity within all ATLs (%)

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>SP</th>
<th>Description of tendency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATL 1</td>
<td>21</td>
<td>57</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>Training structure (T) and structure pause (SP) dominate, a contraposition for low vertical and horizontal complexity level structure phases (A)</td>
</tr>
<tr>
<td>ATL 2</td>
<td>18</td>
<td>69</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>Reduction of the amount of low complexity level structure phases (A), inclusion of medium complexity level structure phases (B)</td>
</tr>
<tr>
<td>ATL 3</td>
<td>21</td>
<td>46</td>
<td>19</td>
<td>0</td>
<td>14</td>
<td>Increasing the amount of medium complexity level structure phases (B), lessening the amount of structure phases (SP), reduction of separately layered Ts</td>
</tr>
<tr>
<td>ATL 4</td>
<td>13</td>
<td>50</td>
<td>30</td>
<td>0</td>
<td>7</td>
<td>Inclusion of high complexity level structure phase (C)</td>
</tr>
<tr>
<td>ATL 5</td>
<td>13</td>
<td>47</td>
<td>30</td>
<td>6</td>
<td>4</td>
<td>Inclusion of high complexity level structure phase (C)</td>
</tr>
<tr>
<td>ATL 6</td>
<td>16</td>
<td>40</td>
<td>32</td>
<td>5</td>
<td>6</td>
<td>Inclusion of high complexity level structure phase (C)</td>
</tr>
<tr>
<td>ATL 7</td>
<td>9</td>
<td>28</td>
<td>46</td>
<td>9</td>
<td>8</td>
<td>Inclusion of high complexity level structure phase (C)</td>
</tr>
<tr>
<td>ATL 8</td>
<td>9</td>
<td>19</td>
<td>48</td>
<td>17</td>
<td>7</td>
<td>Increasing the amount of high complexity level structure phases, lessening the amount of low complexity level structure phases</td>
</tr>
<tr>
<td>ATL 9</td>
<td>6</td>
<td>12</td>
<td>47</td>
<td>27</td>
<td>7</td>
<td>Increasing the amount of high complexity level structure phases, lessening the amount of low complexity level structure phases</td>
</tr>
<tr>
<td>ATL 10</td>
<td>7</td>
<td>15</td>
<td>43</td>
<td>28</td>
<td>7</td>
<td>Increasing the amount of high complexity level structure phases, lessening the amount of low complexity level structure phases</td>
</tr>
</tbody>
</table>
2.3.2. Development of the aural attention training programme’s computer program version (AUT version 2)

Aural attention training programme’s (AUT) 1. and 2. computer versions have been developed in cooperation with master’s student Rūdolfs Kreicbergs from University of Latvia, Faculty of Computing. First version was used during the pilot stage of the research to find out, what kind of improvements or fixes are to be done in the future, as well as to determine the critical values used for proceeding from one training level to another.

AUT version 2 has been developed to be used by multiple test leaders (trainers) – it also includes views for participants of tests. To launch the program, the JAR file needs to be executed. Program automatically, from the folder files, reads all of the previously inserted data. In order for program to work, all of the data is needed, but if any file is missing or is incorrectly formatted, program records it into the log file and halts its operation. This way, errors can be found and corrected quickly.

When starting to work with the program, first, the main menu is opened. (Image 2.3:1). Here, the user can either choose between either trainer or participant, filter participants (to find any participant easier), add a trainer, add and edit participant data. If a participant has been previously assigned for rhythm or pitch training, the user may select the appropriate one (or any one of them, if the chosen participant is just a test participant).

Image 2.3:1 AUT version 2 user interface
Trainers are registered only for error-fixing purposes – when adding a trainer, a name and surname has to be provided (Image 2.3:2).

Image 2.3:2 Data window for training leader

Information on every participant is saved – ID, name, surname, date of birth and gender (this determines the requirements for passing a training level), type of test (each participant is trained with either pitch or rhythm program) (Image 2.3:3). If the new participant is only a tester, his/her results will be saved in a different folder.

Image 2.3:3 Data window for participant

Within main menu, upon choosing pitch or rhythm program, the main menu of the test is opened. It is the same for both test types. First, the training structures, which will be included into the corresponding ATL, are selected (Image 2.3:4).
For the sake of error correction and testing, a *Phrases* button was also added, allowing to listen to any phrase – this functionality is used to reduce mistakes during the training process. Upon clicking *Phrase T1*, *Phrase T2* and *Phrase T3*, the corresponding training structures - T1, T2 and T3 – will be played. No additional menus open upon clicking these buttons (Image 2.3:5). Similar to version one, version 2 offers the possibility to also perform preview tests. By pressing any of these buttons, the test’s menu will open.

In the window of test relevant structures a countdown in milliseconds is added, this way the action, after the previous event has ended, is registered. Shortest allowed time for reaction, after the last structural element of the relevant structure is played, is 0 ms, maximum – 499 ms. After playing a training structure, an automatic response window appears, which evaluates respondent’s answer – *correct* or *wrong*, as well as shows the response time after receiving excitation (ms). On the left side of the window, the time remaining until the end of the training can be seen. (Image 2.3:6).
In AUT version 2 there is a participant’s results window, which is shown to the participant after completing the training. For the sake of simplicity, six drawings were created (6 for boys and 6 of girls), which visually characterise the evaluation in six grades. Last two figures on the right side show negative evaluation (Image 2.3:7).

For transitioning from one training level to the next, the following calculation was applied:

$$ R = A - \frac{10 \cdot X}{T} $$

where

$ R $ is the total score, $ A $ – correct answers (%), $ 10 $ – penalty coefficient for additional clicks – reacting to irrelevant excitations, $ X $ – the amount of mistakes, $ T $ – completion time (seconds).

All actions of a respondent are recorded and automatically registered in the log file. Full results window includes multiple structure codes, which allow grouping the obtained results for further analysis. Lines are coloured for easier reading of results. All of the data obtained during training are possible to group according to vertical complexity criteria.
At the end of the chapter, it can be **concluded** that:

1) judging by music parameter – pitch and rhythm – differences in cognitive processing, two standalone training programmes with 10 levels (ATL) were created. However, both of them are based on unified, common principles of the system of structures. Both training programmes have been created while by observing the complexity criteria of the system of structures, each on ten levels with increasing intensity of aural attention training (5 – 10 min.).

2) From the theoretical model of the training programme, the computer model has been developed – AUT version 2. The program is based on Java platform; therefore, it can be used by a broad user base. The computer program has a distinct visual look and it is easy to use. All output data has a high code quality. With the help of the training program, attention system components may be registered – reactions of attention activation, perseverance of the attention regarding standard and deviant pitch and rhythm structures. Program automatically registers and groups all of the input data, presenting the opportunity to perform detailed analysis on pitch and rhythm parameter possible interaction with the components of aural attention system.
3. Research regarding the efficiency of the pitch and rhythm aural training programme

3.1. Research aim and objectives

The aim of the empirical quantitative research is to verify the hypothesis, set forward in the qualitative research, about the effectiveness of the newly created training programme AUT v.2 in 7-8 years old children studying at music school.

3.2. Description of the empirical basis

Within the framework of the research, two criteria for inclusion were set forward:

1) Participant of a research group on a daily basis, along with the usual subjects in school, also studies multiple music subjects and is involved in a musical collective;

2) Participant of a research group is a first or second grade student, that is, 7-8 years of age;

85 respondents took part in the research (N=85). 68 students or 80% of respondents at the start of the research were only 7 years old, 17 students or 20% of respondents were 8 years old. From all of the respondents, 35 or 41.2% were boys, but 50 or 58.8% - girls. All of the Riga Dome Choir School 1st and 2nd grade students, who were of 7-8 years of age at the start of the research, took part.

While retaining the class division as much as possible¹, three research groups were created: pitch group (PG (n=30)), rhythm group (RG (n=30)) and control group (CG (n=25)). All of the respondents continued their standard education process during the research, but respondents of two groups – SG and RG – had a chance to participate in aural attention training, in addition to their usual music classes.²

The division of respondents, according to their age and gender, within the research groups, are as follows:

¹ Retaining the division of classes was a factor of great importance for organising the work with training programme: training occurred during lessons and during one lesson 4-5 students individually took part in the training. Treniņgrupas maiņa bija iespējama pēc treniņa pirmā līmeņa apguves, ja to vēlējās respondents.
² Upon the request of CG participants (and their parents), these respondents, at the end of the research, also had the possibility to study 6 of the programme’s training levels.
PG group had 30 respondents, from which 29 or 42.6% from the total amount of respondents were 7 years old, but 1 or 5.9% from the total amount of respondents was 8 years old. 11 or 31.4% from the total amount of respondents were boys.

RG group contained 30 respondents, from which 21 or 30.9% from the total amount of respondents were 7 years old, but 9 or 52.9% – 8 years old. 14 or 40% from the total amount of respondents were boys.
CG group had 25 respondents, 18 or 26.5% were 7 years old, but 7 or 41.2% from the total amount of responders were 8 years old. 10 or 28.6% from the total amount of respondents were boys.
Data was collected from January 2012 to May 2012.
3.3. Variables of the research

The variables of the research come from the standardised aural attention measurement tool AUDIVA. Research set forward three criteria, six indicators and thirteen characteristics, which describe the aural attention measurements at the start and at the end of the research (Table 3.3:1).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicators</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention activity (K1)</td>
<td>Tonic and phase activation state of the attention (R1.1.)</td>
<td>Standard deviation: reaction time to the relevant acoustic excitation (P1.1.1.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation: reaction time to the relevant visual excitation (P1.1.2.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median: reaction time to the relevant acoustic excitation (P1.1.3.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median: reaction time to the relevant visual excitation (P1.1.4.)</td>
</tr>
<tr>
<td>Selectiveness and persistence of</td>
<td>Relative level of concentration (R2.1.)</td>
<td>Absolute ignored relevant acoustic excitations (P.2.1.1.)</td>
</tr>
<tr>
<td>the attention (K2)</td>
<td>Relative level of focusing the attention (R2.2.)</td>
<td>Absolute irrelevant acoustic excitation (P.2.2.1.)</td>
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<tr>
<td></td>
<td>Vigilance (R2.3.)</td>
<td>Relative relevant acoustic excitations (P2.3.1.)</td>
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<td>Absolute relevant acoustic excitations (P.2.3.2.)</td>
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<td>Relative errors of the acoustic excitations (P2.3.3.)</td>
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<td>Absolute errors of the acoustic excitations (P2.3.4.)</td>
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<tr>
<td>Division of the attention (K3)</td>
<td>Relative level of divided attention (R.3.1.)</td>
<td>Absolute errors regarding relevant visual excitations (P3.1.1.)</td>
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<td>Interaction of the excitations of the attention (R3.2.)</td>
<td>Relative relevant visual excitations (P3.2.1.)</td>
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<td></td>
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<td>Absolute relevant visual excitations (P3.2.2.)</td>
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</table>

Table 3.3:1 Criteria, indicators and characteristics of the research
3.4. Research method

For gathering the research data, a standardised aural attention tool, in Germany developed and adapted *Aural and divided attention testing tool* or AU DIVA, *ADT 3000, ver. 42* was used, with the help of which the aural attention measurements at the beginning and the end of the research were taken. At the time of the research, AU DIVA tool had not been adapted for Latvian population; therefore, all of the results are only relevant for the research groups. *AU DIVA* test is a non-verbal tool, aimed at children who are 4 to 8 years of age. With the help of the aural test, it is possible to determine *four aural attention components*:

1) overall state of consciousness (*alertness*);
2) the state of the focused or selective attention;
3) attention persistence or vigilance;
4) divided attention, which is measured by including an extra visual excitation source during the test (a light bulb in the machine).

**Level of the attention** is determined by three components:

1) aural attention activity;
2) aural attention selectiveness and persistence;
3) division of the attention.

During the processing of the obtained data, statistics from the research groups, regarding the aural attention parameters and characteristics at the beginning of the research and the changes within them during five months while taking (or not taking) part in the training programme, were calculated.

Data processing uses *One–Sample Kolmogorov–Smirnov Test*, to determine the data division accordance with standard division within each group.

Using *Mann–Whitney* test, a selection rank comparison between two independent selections was done – for training groups (each separately) and control group, determining the research groups’ significance of the mutual differences at the beginning and the end of the research.

Using *Wilcoxon Signed Ranks* non-parametric test, the significance of differences, within each research group (between two interconnected groups) at the beginning and the end of the research, was determined.

Using the *Pearson product-moment correlation coefficient* method, it was determined,
whether significant correlation, between characteristics within each research group at the beginning and the end of the research, exists.

Using the method of *Factor Analysis*, the group of characteristics was measured, determining the mutual connections and existing correlations between the characteristics at both the beginning and the end of the research.

For determining the effect size, the *Cohen’s d* is used.

All data has been calculated with the help of SPSS ver. 19.00. Full corpus of the primary data can be found in the appendix. Information on statistics, which is relevant for the dissertation, in the tables and drawings, has been translated in Latvian.

All of the tests use the significance value *p*=.05.

### 3.5. Research process

The research was conducted in three stages. During first and third stage, data gathering was performed, using measurement tool AUDIVA, in all three groups. During stage two, two of the research groups (PG and RG) took part in the newly-created training programme AUT v.2. The approbation of the programme occurred from January 2012 to May 2012.

### 3.6. Results analysis, interpretation, and conclusions

The results of the quantitative research and the performed analysis allow arriving at the following conclusions:

1. Results of the aural attention research correspond with the acknowledgements of other authors regarding the problematic issues with attention during schooling age and point out the considerable aural attention gradation differences within both one group and one educational establishment. The results of the research also confirm the assertions, previously advanced by the author of this work, about there being no reasonable link between musical talent and attention problem issues: **also in 7-8 years old children, who study music subjects on a daily basis, a significant difference in attention activity, persistence and division can be observed.**
2. During the analysis of the literature sources, it was concluded, that until now there had not been a unified methodology for aural attention training without clinical context. Despite aural attention’s ability to be subject to training already from elementary school age, and pitch and rhythm parameters having a significant role in the training process, until this point, pitch and rhythm structure ties with aural attention processes and possibilities to train these processes have been scarcely researched.

3. By creating a systemic approach to aural attention training, within the framework of qualitative research, the pitch and rhythm aural attention training programme’s theoretical model and training programme’s computer version was developed. Within empirical quantitative research, it has been proven, that structured pitch and rhythm training significantly influences aural attention in 7-8 years old children studying in music school. Marked differences at the end of the research were observed between experiment groups – pitch and rhythm group and the control group. At the end of the research, pitch group had significant improvement in aural attention indicators (P1.1.1. (p=.014) and P1.1.3. (p=.005)). Maximally significant improvement can be observed in indicators, which, in rhythm group’s respondents, characterise the aural attention precision (P1.1.1. (p=.000)) and aural attention perseverance (P2.1.1. (p=.001), P2.3.1.(p=.001), P2.3.2. (p=.001)). Both experiment groups, unlike the control group, during the repeated measure displayed significant to maximally significant improvements in two criteria: aural attention activity and aural attention perseverance.

4. As described in literature sources, aural attention training is tied to two music parameters - pitch and rhythm. While developing the content for the training programme, both parameters are mostly not divided. In this research, pitch and rhythm made up two different branches of the training programme, therefore, quantitative research included two experimental – pitch and rhythm – groups, and the influence of both parameters on the aural attention was tested. Results of repeated measure show considerable differences between the experimental groups regarding almost every characteristic of the selective attention perseverance. Those results of the rhythm group’s respondents, which characterise the perseverance of selective attention, at the end of the research significantly, positively differed from the indicators of the pitch group’s respondents (Mann-Whitney test, P2.1.1. (p=.048), P2.3.3. (p=.036), P2.3.4. (p=.036)) (P2.3.1. (p=.048)). The differences in the experiment groups are also stressed via the effect indicators (Cohen’s d). Medium effect (P1.1.1. (d=.51), P2.3.2. (d=.53) and P2.3.4.
and large effect \((d=.77)\) characterise rhythm group respondents’ indicators regarding the components of attention activity and selective attention perseverance, however, the pitch group shows medium effect \((d=.97)\) only in the attention activity indicator. Therefore, the necessity to create two experiment groups, and separately research pitch and rhythm music parameter and hearing component interconnections has been proven.

5. The results of Wilcoxon’s test in the repeated measurement showed significant to maximally significant changes only in those groups, which participated in the aural attention training. At the same time, here the differences between experiment groups can also be observed: summary resultative indicators are higher for the group, which participated in the rhythm training programme – group’s resultative indicators, which are connected with every characteristic of selective attention persistence, at the end of the research had maximally significant improvement \((P2.1.1. \ (p=.000), \ P2.2.1. \ (p=.001), \ P2.3.1. \ (p=.000), \ P2.3.2. \ (p=.000), \ P2.3.3. \ (p=.001), \ P2.3.4. \ (p=.001)).\) Respondents of the pitch group, at the end of the research, showed significantly different results in the components of selective attention perseverance \((P1.1.3. \ (p=.017), \ (P2.2.1. \ (p=.014)).\) Significant and maximally significant changes in the experiment groups reveal the effect of the newly-created pitch and rhythm training programme.

6. The differences between experiment groups and the control group are evidenced by measuring the effectiveness (Cohen’s \(d\)). Within both experiment groups, unlike the control group, at the end of the research, medium and large effect was observed. Large effect characterises pitch group’s aural attention reaction time and the precision of the answer of the reaction: pitch group’s respondents, as a result of the training, displayed shorter reaction time and higher precision of execution \((P1.1.1. \ (d=.81), \ P1.1.3. \ (d=.94)).\) Large effect characterises rhythm group’s attention activity and the persistence of the selective attention. \((P1.1.1. \ (d=1.22), \ P2.1.1. \ (d=.81), \ P2.3.2. \ (d=.81))\) – as a result of training, respondents of the rhythm group displayed higher precision of answers and more pronounced evenness regarding their reactions. Medium effect characterises rhythm group’s attention activity \((P1.1.3. \ (d=.59).\) Large and medium effect also characterises attention activity’s and selective attention persistence’s peculiarities (both of which have also been included in the training programme). The effect, observed in all of the aural attention components, displays the effectiveness of the pitch and rhythm aural attention training programme.
7. At the end of the research, within the groups involved in the training, an interaction of aural attention components, which was not characteristic of control group, was observed. Pitch group’s results point towards correlations between the precision of reactions and shorter reaction times, and characterise positive changes in attention activity criteria (Pearson’s product-moment correlation, \( r = -0.361, p = 0.05 \)). Correlation between relevant aural answer precision and the amount of absolute relevant aural answers (\( r = 0.466, p = 0.01 \)) points to the interaction between work precision’s and quantitative indicators (amount of correct answers). Correlations between the precision of relevant aural answers and the amount of absolute irrelevant aural answers (\( r = -0.557, p = 0.001 \)) characterise the evenness during the task’s execution. More even work, however, negatively interacts with the amount of correct answers (\( r = -0.466, p = 0.01 \)). The work of pitch group’s respondents, as a result of the training, has become steadier, but it is characterised by slower pace of execution. In the rhythm group, a positive correlation has been observed between both the precision of aural and visual answers (\( r = 0.40, p = 0.028 \)), and the precision of visual answers and the amount of aural mistakes. It is concluded that, while the amount of aural mistakes is being reduced, the precision of divided attention is increasing (in correlation analysis – the time diapason for the reactions of visual answers is reduced, \( r = -0.42, p = 0.021 \)). Characteristic of both groups involved in the training is a similar correlation of such indications, where clearly the criteria of aural attention activity, and criteria of selective aural attention perseverance interact, however, different are both the characteristics’ pairs and the significance of the correlations between them. **This points to the inclusion of two different music parameters – pitch and rhythm - in unified aural attention training, and describes the different connections these parameters have with aural attention components.**

8. At the end of the research, the attention component characteristics subjected to attention training definitely layer together: with the amount of mistakes reducing, not only the amount of correct answers increases, but also the answer’s reaction time diapason towards the relevant aural excitation lessens. The results of factor analysis point towards similar layers of characteristics in the experiment groups: at the end of the research, in both experiment groups, the layering of characteristics descriptive of attention division within one factor was not observed. In control group, however, there is interaction of characteristics, which describe both aural and visual attention. **The layering of characteristics, descriptive of aural attention activity and persistence of selective aural attention, in both experiment groups, points to the effect of the aural attention training.**
Conclusion

The aim of the doctoral dissertation was to create a new tool – aural attention training programme, and to verify the effectiveness of this programme in the chosen target group. The results of the empirical research analysis points to the effectiveness of the training programme within the target group regarding the dynamics of development in multiple attention functions – activation and alertness. While advancing towards the research goal, gradually all of the tasks set forward in the dissertation were completed. By doing studies of literature sources, as well as executing the practical research, the answers to the dissertation’s questions, and the consequentially asked additional questions, have been found.

As a result of the analysis of literature sources, answers regarding the research possibilities of attention, and especially aural attention system, have been found. The literature sources, having been analysed, offered knowledge on attention as a system with substructures being engaged in a tight reciprocal interaction – functions, which are responsible for attention activation, alertness and the execution of any task. Within the theoretical chapter, it was concluded, that attention has a significant role in executing the highest level cognitive, therefore mind’s, actions. This allows proposing a generalisation of the attention’s role: attention is an intermediary between perception and cognition, which operates within the interaction of multiple system components. One of the types of attention is aural attention, which belongs to the attention system as a whole.

While describing the research methods of attention, it was concluded, that in the modern research, using the investigative methods of neurophysiology, both the early attention processes, and the role of selective attention in activating cognitive processes, have been researched. The acknowledgements of the research offered answers to questions regarding attention as individualised process, and its development possibilities outside of clinical context.

By choosing two music parameters – pitch and rhythm – as the possible excitations for aural attention system, their role in the process of both aural attention and cognitive processing of music structures, was established.

Aural attention may be activated in different ways via separate excitations, or, via grouped or structured acoustic information. The knowledge of literature sources offered answers to the questions about the role of structured pitch and rhythm information regarding the activation of aural attention processes. This knowledge promoted the creation of a system of structures for both of the selected music parameters. The newly-created system of structures includes components, which interact with the functions of aural attention. In the context of the
dissertation, the system of structures is considered to be a theoretical base for another – also newly-created tool – pitch and rhythm aural attention training programme.

At the core of training programme’s development has been the knowledge gained from literature about the changes of aural attention process resulting from training. As pointed out by sources, a significant requirement for creating training methods is their content and usage. At the same time, it had to be concluded, that so far no methods had been available outside of clinical context. The majority of aural attention tests and training programmes are based on the inclusion of word sounds or language semantics. It was concluded that there is a lack of systemic approach regarding the research of interaction between music structures and attention processes. This promoted the development of training programme for two independent music parameters – pitch and rhythm, and to verify, within the quantitative research, the effectiveness of this training programme in the chosen target group – 7-8 years old children attending music school.

The choice of music school as the educational establishment was purposeful. Literature sources emphasize, that music lessons can also influence the attention and concentration abilities. At the same time, it has to be concluded, that also in this dissertation the previous observations of the author have been confirmed: attention problems of varying nature exist also in musically gifted children, which have multiple music lessons per week. This acknowledgement is, perhaps, explained by the typical road to success and results characteristic of music education. Attention training, on the other hand, is not considered to be a primary target of music education.

The results of the empirical research set the attention to the topicality of the problem in the context of aural attention research and the daily life in school. They offer valuable knowledge on both the effectiveness of the training and the differences of pitch and rhythm in the context of aural attention training.

The gathered corpus of theoretical and practical knowledge allows for the execution of one of the most important tasks set forward in the dissertation – by way of the analysis of results, and their interpretation, to enumerate the main conclusions of the dissertation:

- The knowledge found in literature sources, regarding the role of activated aural attention in supporting cognitive processes, has also been confirmed in a practical research – good aural attention abilities are necessary to react to acoustic excitations, and to be able to differentiate these structure groups among other, irrelevant structured excitations.
• Good attention capabilities are often a prerequisite for beginning schooling process. At the same time, it has to be concluded, that attention capabilities, when beginning schooling, have not yet stabilised. The primary aim of music education lessons is not the development of attention capabilities. This has also been proven by the results of this research’s analysis – also in 7–8 years old children, who study music subjects on daily basis, considerable differences may be observed regarding the activity, perseverance and division of the attention.

• When developing the theory – a unified system of structures for pitch and rhythm parameters, it was possible to create a suitable platform for connecting certain components of the system of structure with aural attention processes, and to include these interacting components in the aural training model.

• When developing the model – aural attention training programme, with two standalone branches (pitch and rhythm), it was possible to separately research the influence of pitch and rhythm parameters on the functions of aural attention, as well as to perform similarity and differentiation analysis.

• Empirical research’s results confirm the acknowledgement, known within research practice, about early attention as an individualised process. Measurements of attention activation at the beginning and the end of the research point to significant differences among respondents both within the borders of one group and within comparison of multiple groups. Reaction time to acoustic excitation is characterised by a broad range of results, also within one group. This directs one’s attention to the dissimilarity of attention processes within respondents from one group or class, and promotes the creation of varying approaches for developing aural attention processes.

• Structured pitch and rhythm information activates the attention system, however, the activation and persistence of this effect differs. This has been proven by the disparate results of the effect’s analysis in both – pitch and rhythm – groups. As a possible explanation obtained from literature: pitch and rhythm parameters not only have discrepant localisation of cognitive processing in the cerebral cortex and other brain
structures, but they also cause discrepant effects in the process of early attention activation.

- The knowledge obtained during training programme effectiveness analysis points to the elasticity of the most important aural attention components – activation and alertness function - during structured and level-based acoustic training. This is based on the results of repeated measures, which show significant to maximally significant improvement in two criteria: aural attention activity and aural attention persistence.

- Using level-based computerised aural attention training programme in practice opens up possibilities for new type of effective aural attention training in schools, and in music psychology and therapy.

Looking at the main conclusions, it can be said, that the dissertation answers all of the questions set forward in the beginning. By performing the research tasks and confirming the hypothesis, it can be assumed, that the aim of the research has been achieved – a pitch and rhythm aural attention training programme has been created, and its effect on the aural attention of 7-8 years old children studying in music school has been measured.

At the same time, it can be concluded, that the knowledge and results gained by undertaking and completing the dissertation offer much broader possibilities for future analyses. As previously mentioned, the research of the newly-created training tool’s effectiveness was based on results, which were obtained with the help of standardised tool AUDIVA. However, during the execution of all 10 levels of the training program AUT v.2, massive amounts of valuable results were obtained, which require prolonged and careful further analysis in the framework of some other research. The results of this analysis will allow obtaining knowledge on the effectiveness of separate levels of the newly-created training programme, and the connections separate components of the system of pitch and rhythm structures have with both aural attention and aural memory processes. Continued research, using the current results’ base, will offer the chance to discuss the inclusion of aural attention training programme, either as its full version or separate modules, in the routines of pedagogues and psychologists in a wide variety and different types of educational establishments.
Theoretical aspects of the dissertation and the results of the research have been approved in several international scientific conferences and seminars:

**Presentation** System of pitch and rhythm patterns to promote aural attention abilities in 7- and 8-year-old children, International Conference on Cognitive and Behavioural Psychology in Singapore organised by the Global Science and Technology Forum; Singapore, 13-14 February 2012.

**Research seminar** for psychologists: AURAL ATTENTION: functions, disorder, training possibilities, Universitas Pelita Harapan in Jakarta; presentation and seminar leader; Jakarta, 17 February 2012.

**Presentation** Audiālās uzmanības pētniecība: problēmas nostādne un situācijas raksturojums (Aural attention research: formulation of issues and profile of the situation), 6th International Scientific Conference Mūzikas zinātne šodien: pastāvīgais un mainīgais (Music Science Today: The Permanent and the Changeable); Daugavpils, 6 May 2011.

**Poster presentation** The influence of a system of pitch and rhythm patterns on the promotion of aural attention abilities of elementary school pupils, IX Annual Auditory Perception, Cognition and Action Meeting in St. Louis, USA; St. Louis, 18 November 2010.

**Presentation** Neiropsiholoģiskie aspekti mūzikas pedagoģijā (Neurological aspects of music pedagogy), Aktualitātes mūzikas pedagoģijā (Current Topics in Music Pedagogy) conference organised by the Jāzeps Vītols Latvian Academy of Music; Riga, 22 May 2010.

**Presentation** Pētījums par melodijas un ritma struktūr sistēmas ietekmi uz audiālās uzmanības attīstību (A study of the influence of melody and rhythm structure systems on the development of aural attention), VII International Conference Mūsdienu mākslu terapija – teorija un prakse (Contemporary Art Therapy: Theory and Practice); Cēsis, 17-19 July 2009.
The theoretical aspects of the research and intermediate and final results have been published in scientific issues:


Bibliography


