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ABSTRACT

Objective: The aim of the study is to conduct an integrative review that will identify effectiveness of Tomatis method as an option for treatment of children with autism spectrum disorder (ASD).

Data Sources: A comprehensive search of meta-analyses and case studies, letters, opinion papers, citations in papers, references, books in English, French and Spanish published during the last 30 years.

Results: A total of 14 articles and 2 books met the inclusion criteria and all were read and analyzed according to an integrative review protocol then categorized. It was observed that there are 6 quantitative studies, 6 with mixed method design and 4 qualitative studies. Almost all of them support Tomatis method (except 1) as an intervention that can help in children with ASD. Even that 1 study that estimated that the positive results were not related to the Tomatis treatment, concluded that the majority of the children in the study demonstrated general improvement in language. A number of studies indicated as a result that children were no longer considered with ASD.

Conclusion: Tomatis method offers interventions that significantly improve the autistic traits in children but more research has to be done, especially randomized control trials that will strengthen the evidence.

Keywords: “Tomatis”, “autism”, “children”, “autistic”, “autisme”, “autistes” and ”enfants”, “autismo”, “ninos”, autistas”.

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1. INTRODUCTION

1.1 Autism

Autism spectrum disorder (ASD) is a group of developmental disabilities that can cause significant social, communication and behavioral challenges (Centers for disease control and prevention, n.d.).

ASD is not only a brain disorder, it a whole body disease that can affect all organs including the brain (Doidge, 2015). Previously it was considered that there were four separate disorders — autism, Asperger's disorder, childhood disintegrative disorder and pervasive developmental disorder (DSM-IV). The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has merged them into one with different levels of symptom severity (APA, 2013). Not every child with autism spectrum disorder looks like others, some are with very mild some with severe symptoms. To be diagnosed with ASD, a child must present many disturbances which co-occur together and among important ones are: deficits in social communication and interaction, in nonverbal communicative behaviours, restricted patterns of behaviour, stereotyped motor movements (echolalia, hands flipping), excessive adherence to routine, fixated interests, hyper or hypo reactivity to sensory inputs and many more (DSM-5 Diagnostic Criteria for ASD, 2013). According to estimates from CDC's Autism and Developmental Disabilities Monitoring Network (2010) - in 2000 the prevalence was about one in 150 children, in 2010, the prevalence has been already one in 68 children (Lake, Perry, & Lunsky, 2014). The most obvious symptoms of ASD emerge between 2 and 3 years of age (Autism Speeks, n.d). According to APA (2013), first symptoms of ASD should occur before the age of 3 years. Screening at age 18 to 24 months may not be reliable or valid (Barton et al.,n.d.). However, Barton et al. (n.d.) add that many authors consider that diagnosis of autism is valid if it is made at the age of 2 years. It is difficult to recognize autism in its beginning (CDC, 2015), it includes delays, unclear diagnosis and several consultations

with healthcare professionals (McMorris, Cox, Hudson, Liu, & Bebko, 2013). Parents often do not receive an accurate diagnosis what would represent a first step in treating autism (Gabriels & Hill, 2002), as diagnosis serves as a base for treatment (Barton, Chlebowski, & Fein, n.d.). Identifying ASD and assessing its manifestations in a child is the most important step to establish a treatment and educational planning for a child with ASD (Gabriels & Hill, 2002, Van Daalen, Kemner, Dietz, Swinkels, Buitelaar, & Van Engeland, 2009). Often, services of an early intervention are not provided without a diagnosis. (Barton et al., n.d.). The American Academy of Pediatrics (Johnson & Myers, 2007) has suggested that children with symptoms of ASD are to be sent for early intervention, without a confirmed diagnosis. Also it is important to understand that early diagnosis gives professionals a possibility to learn about the developmental stages of ASD in the early years (Van Daalen et al., 2009). Once the diagnosis of ASD has been established, it is important for healthcare professionals to direct parents to useful resources.

ASD affects four times more boys than girls (The Editors of Scientific American, 2013). We do not yet know the cause of it. Some think that it may have genetic reasons other attribute it to environmental reasons. Porges thinks that it could be a reaction to stress and trauma happened very early in the child's life (in utero, at birth or in early childhood period) in the form of a strong emotional stress or a physical disruption of the vagal nerve, antibiotics, vaccination (Bridges, 2015).

There are many different approaches used to improve symptoms of ASD: Applied Behavior Analysis (ABA), Cognitive-Behavioral Therapy (CBT), Floortime (Gerritsen, 2010), Picture Exchange Communication System (PECS), Sensory Integration Therapy/Sensory Diets etc. (Chedd & Levine, 2013, Lake et al., 2014), different diet interventions like the GFCF diet (food without casein and gluten), Nambudripad Allergy Elimination Techniques (NAET) for autism - with a hypothesis that major contributors to the development and symptoms of autism include food and nutrient sensitivities (Teitelbaum, Nambudripad, Tyson, Chen, Prince, Moosad & Teitelbaum, 2011), speech therapy, OT special education, sound and music therapies like Tomatis, Samonas, Bérard (Auditory Integration Training) etc. because

generally, therapies that incorporate music could improve social competences, linguistic expression and communication (Wan & Schlaug, 2010). The therapeutic intervention discussed in this paper - the Tomatis method - is one of many possible interventions available to those with ASD (Neysmith-Roy, 2011). Like other mentioned interventions and music therapies, it is not suggested as a cure to ASD, but as a possibly effective therapy that could improve communication skills, physical and motor skills, and social and behavioral skills in children with ASD (Gerritsen, 2010).

1.2 Tomatis Method

"Every man can, if he so desires, become a sculptor of his own brain." (James and Cayal as cited in Demarin, Roje Bedeković, Bosnar Puretić, & Bošnjak Pašić, 2016).

One of the greatest discoveries in neuroscience is neuroplasticity of the brain. The brain can make new neural pathways, re-connect, modify and reorganize to adapt to new situations – because it is plastic. What was not functioning in the brain now we know that it can be stimulated and rewaken (Bridges, 2015). Music is a powerful stimulus for neuroplasticity and balances the brain's electrical activity (Demarin et al., 2016). It is shown by brain scan studies that neurons fire in unity to music in perfect synchrony and that is the reason why music can affect the rhythms of the brain (Doidge, 2015).
A lot of data speaks in favor of the exposure of pregnant women and newborns to music which promotes brain development and the inner ear of a child (Demarin et al., 2016). Music itself is healing. Proven benefits of brain stimulation by music are in multiple areas, it improves cognitive, social, physical and emotional domains (Kunstler & Daly; Lindbaek; Molnar-Szakacs, Wang, Laugeson, Overy, Wu, & Piggot; Simpson & Keen as cited in De Vries, Beck, Stacey, Winslow, & Meines, 2015). The impact upon children with ASD is no different. The most significant link between music and performance improvement or changes in neuropsychological activity has been demonstrated in Campbell's studies involving Mozart's music from which the theory of The Mozart Effect emerged (Demarin et al., 2016). It is undeniable,

as Campbell (2005) states, that the rhythms, melodies and high frequencies of Mozart's music inspire creative and motivational areas of the brain. Campbell based his discovery on the works of a French doctor Alfred Tomatis, who hypothesized that the lack of sound stimulation or abnormal stimulation in utero and/or early childhood can cause aberrant behaviours and delayed or disabling communication skills (Doidge, 2015).

Tomatis believed that many children with ASD cannot tune to frequencies of human speech because, as he believed, autistic children have under-developed inner ears that can be retrained through intensive sound therapy (Ruben, 2006) and music presented at different frequencies helps the ear, promotes healing and the development of the brain (Tomatis, 1991).

Tomatis formulated three laws, known as the Tomatis Effect:

Law 1: The voice only contains the harmonics that the ear can perceive

Law 2: If you give the possibility to the ear to correctly hear the distorted frequencies of sound that are not well heard, these are instantaneously and unconsciously restored into the voice.

Law 3: The imposed audition sufficiently maintained over time results in permanently modifying the audition and phonation (Tatum et al., 2004).

The Tomatis Effect describes the connection between the voice, the ear and the brain and was accepted by the French Academy of Science in 1957 (Davis, 2005).

Tomatis demonstrated that listening to some filtered sounds, especially filtered sounds of child’s mother and Mozart music have an effect on the brain, enhance listening, speaking skills, and emotional and mental awareness (AbediKoupaeia, Poushanehb, Zade Mohammadi, & Siampour 2013). Auditory stimulation is performed by listening to music (Mozart and Gregorian Chants) mother's voice recording and someone’s own voice through an active vocal work, processed and filtered through an electronic device (Gerritsen, 2010). The device allows the music of Mozart and other sounds to be supplied through air and bone conduction, through headphones equipped with a vibrator that transmits sound to the auditory cortex via bone conduction (Gerritsen, 2010). Blocks of sessions (Intensives) are separated by three to eight week periods allowing the integration of the impact of each Intensive into everyday experiences (Neysmith-Roy, 2011).

Music and mother voice recording had been filtered to bring out the high frequencies in order to re-awake the brain's potential to listen and to stimulate the brain's desire to communicate (Madaule, 2003; Ruben, 2006). Tomatis describes autism as the deepest example of "excluded" listening or the autism is the purest form of "non-listening" (Madaule, 1989, Ruben, 2006). Through sound and music the Tomatis method simulates the main phases of the child's listening and communication development, but it is very important to start with the stimulation of children with ASD as early as possible and to persevere in it (Madaule, 2003). Mozart is naturally very rich in high frequencies and because of the high frequency properties, Dr. Tomatis found the music of Mozart to be the best suited for stimulating the brain (Ruben, 2006). Tomatis found that listening to Gregorian chants increased sense of physical and emotional balance and that Mozart's music filtered to a particular frequencies trained the brain to discriminate those frequencies thus restoring listening deficiencies, improving speaking and attention skills (Campbell, 2012). Chanting in many traditions restores inner harmony, slowing down the heart rate, decreasing blood pressure and breathing (Wieder, 2004). Tomatis noted that Gregorian chants contain all frequencies of human voice but not produced by mouth but by bones and using them (Wieder, 2004), he artificially imposed relaxing system on listener (Davis, 2004) There are many and varied applications for the Tomatis Method. it is also attributed to combating depression, helping people learn foreign languages, helping to develop better public speaking skills (Ruben, 2006), improve attention (Tatum et al., 2004), etc. Based on his clinical practice, Dr. Tomatis has considerably evaluated his method of auditory stimulation and estimated that it appreciably improves the quality of life in for about 60% of children with ASD; of those who do benefit, about 50% show a quick positive response (Neysmith-Roy, 2011), the other 40% do not respond to the standard Tomatis Auditory stimulation (Gerritsen, 2010). As with other treatment interventions, there are no tests to determine weather a person with ASD will or will not respond to Tomatis therapy (Gerritsen, 2010).

2. METHODS

This integrative review of the literature aims to gather and analyze the available scientific evidence produced on the effectiveness of the Tomatis method in children with ASD that will contribute to the development of knowledge on the issue. Since the integrative review is the broadest type of research reviews it is well suited for the topic explored and will include many sources which will help in reviewing the evidence (Broome as cited by Whittemore & Knafl, 2005) and enhance holistic understanding of the topic of interest (Whittemore & Knafl, 2005).

The Integrative Review will be presented in six stages: Guiding questions, Search strategy and sampling of data, Data collection and extraction, Critical analysis of the studies included, Discussion of results and Presentation of the integrative review (Tavares de Souza, Dias de Silva, & De Carvalho, 2010).

2.1 GUIDING QUESTIONS

The evidence within the literature will be critically reviewed in order to answer the following guiding questions:

- What has been published in the last thirty years on effectiveness of the Tomatis method in children with ASD and
- Is there any evidence that the Tomatis Method is an effective treatment option for ASD.

2.2 SEARCH STRATEGY AND SAMPLING THE DATA

The first step of the search strategy was to search for primary sources: meta-analyses and case studies and secondary sources: letters, opinion papers, citations in papers, references, books to be reviewed in the databases listed below.

The Keywords used in the search strategy were: “autism” AND/OR “autistic children” AND “Tomatis”. Search in French was performed by using Keywords: “Tomatis” AND “autisme” OR “autistes” and ”enfants” and in Spanish “Tomatis” AND “autismo” AND “ninos”.

When keywords: “Tomatis” and “children” and “autism” are entered into the search box, we expect that the articles we are interested in will be retrieved.

Inclusion and exclusion criteria

Inclusion:

1. Timeframe: from 1987 to 2017
2. The sample: children with the ASD, age group: from 2-21.
3. Intervention researched has to be Tomatis method
4. Data should be presented in English, French or Spanish language
5. The types of research design are: meta-analyses, randomized control trials, cross-over trials, case-control, letters, opinion papers, case reports, books and other grey literature.

Exclusion:

1.Other sound-based interventions, other music therapies or other Mozart music therapies

2. Other medical conditions and psychological disorders

Table 1

File Index Ref	Data Base used	Search Terms used	Number of articles
1.1	Cochrane	Autism and children and autism and Tomatis	1
1.2.	CINAHL	Autistic children and autism and Tomatis	1
1.3	MEDLINE PubMed	Autistic children and autism and Tomatis	4
1.4	Lilacs	Ninos autistas and autismo and Tomatis	0
1.5	WEB of Science	Autistic children and autism and Tomatis	8
1.6	Scopus	Autistic children and autism and Tomatis	8
1.7	Google Scholar	Autistic children or enfants and autistes and Tomatis	8
1.8	OVID through UCLAN library	Autistic children and	34

1.9	Discovery	Tomatis Autistic children and autism and Tomatis	14
2.0	Willey Online Library	Tomatis Autistic children and autism and Tomatis	3
2.1	Proquest Medical Library	Tomatis Autistic children and autism and Tomatis	16
2.2	Reference lists	Tomatis Autistic children and autism and Tomatis	9
2.3	Tomatis Association website	Tomatis Autistic children and autism and Tomatis	5
2.4	Other		4
	TOTAL		115

The literature search identified 113 papers and 2 books. Several articles were also obtained by scrutinising the reference lists of key articles or reviews relating to Tomatis method. After the title/abstract screening, 34 publications were obtained for detailed evaluation. 1 article was sent by e-mail by the author upon the request. After detailed evaluation all sources that did not meet the criteria of relating specifically to Tomatis method and autistic children were excluded. From the final 16 papers and 3 books we excluded brief clinical vignettes and anecdotal stories.
The remaining 16 studies form the basis of this review: 6 of them are quantitative, 6 are mixed method designs and 4 of them are qualitative ones.

2.3 DATA COLLECTION AND EXTRACTION

The selected studies are analyzed and submitted into a table (Table 2.) which provides information on:

a. Author(s)
b. Year of publication
c. Original title

d. Origin/country of origin

e. Study Design and Measurement instrument

f. Aims/purpose of the study

g. Intervention type / Intervention duration

h. Study population and sample size (number and age)

i. Outcomes

2.4 CRITICAL ANALYSIS OF THE STUDIES INCLUDED

Studies are ranked according to the type of evidence (Angelieri, 2013) (Table 3).

- Level 1: evidence resulting from systematic reviews and meta-analysis
- Level 2: evidence from randomized control trials
- Level 3: evidence from non-randomized control trials
- Level 4: evidence from cohort studies
- Level 5: evidence from case-control
- Level 6: evidence from case-series
- Level 7: evidence from case reports, individual case studies, single descriptive or qualitative study, biography
- Level 8: evidence based on opinions of specialists
- Level 9: animals / in vitro studies

At this stage, studies are being evaluated in order to interpret the results of the research, to carry out a comparison with theoretical knowledge and to establish conclusions and possible implications.

Level 1 Evidence – Quantitative design, Meta-analyses and systematic reviews

1. Gerritsen (2009) conducted a meta-analysis and systematically assessed 35 research studies on the impact of Tomatis method on different disorders, among many - ASD. Gerritsen (2009) has reviewed 7 small scale research projects on the impact of Tomatis method in children with ASD: Neysmith-Roy (2001), Schiedeck (2000), Vervoort et al. (2007), Corbett et al. (2008), Spaggiari (1995), Tatum et al. (2004) and Nel (2005). The results indicated the improvement of social, linguistic and psychological skills in all studies, except Corbett et al. (2008). Corbet et al. (2008) did not show any

statistically significant difference between the Tomatis and Placebo group. It is highly possible that the Placebo group was contaminated with cross-over design, (Gerritsen, 2009) but as well, since it contains Mozart's music which can result in Mozart effect it is questionable whether this can be considered as a placebo.
Also Gerritsen (2009) reinterpreted the results of Corbett et al. (2008) and showed that by changing methodology from quantitative to qualitative, results changed in favour of Tomatis method in terms of positive behaviour changes in children with ASD who benefited from Tomatis method to a certain extent.

2. Gerritsen (2010) critically reviewed studies that investigated the effects of Tomatis method in children with ASD - very shortly: Neysmith-Roy (2001) and Vervoort et al. (2007) and in more details: Corbett et al. (2008). According to Gerritsen (2010), Neysmith-Roy (2201) and Vervoort et al. (2007) showed significant improvements in behavior in children with ASD and objectively reported positive outcomes.
Corbett et al. (2008) according to Gerritsen (2010) did not show a statistically significant difference in the language skills between Tomatis treatment and Placebo because the sample size very small and too heterogeneous to be analyzed as a group. A cross-over design was also inappropriate to measure the impact of an intervention, after the treatment has been completed, because Tomatis first/Placebo second measured the sum of the Placebo Effect plus the Extended Tomatis Effect and the second phase was no longer a true Placebo. Gerritsen (2010) considered that Corbett et al. (2008) failed to report the results of the behavioral assessments that were included in the data collection, though the original objective of the research was to assess the impact of the Tomatis therapy on both communication and behaviour deficits. Gerritsen stated that Corbett et al. (2008) only reported the results on expressive and receptive language skills. When Expressive and Receptive Vocabulary Data were analyzed as a group, no significant differences between Tomatis and Placebo Group were detected. When analyzed as 11 individual case studies, as Gerritsen (2010) suggested, data pointed that six out of 11 subjects showed significant Improvements after 90 hours of Tomatis Therapy. Gerritsen (2010) advocated that further research needed to be

carried out, properly designed to further investigate the effect of Tomatis therapy on children with ASD. In particular, cross-over designs should be avoided because Tomatis therapy has or could have an extended effect and continues after completion of the intervention period (Gerritsen, 2010).

Both Gerritsen's systematic reviews (2009, 2010) analyse and evaluate original Corbett et al. (2008) in depth, regarding the conduct of the research and its reporting transparently assessing all the strengths and weaknesses of the Corbett's investigation (2008).

Level 2 Evidence – Quantitative design, Randomized control trials

1. Corbett, Shikman, & Ferrer (2008) aimed to determine the effects of Tomatis method on language skills in children with ASD using randomized, double-blind, placebo-controlled, crossover design. Corbett et al. (2008) resumed that the results in the study reflect a lack of improvement in language using the Tomatis Method for children with ASD. Participants in the study were heterogeneous, considering their age, language skills and different IQ levels. While one group had received Mozart music and Gregorian chants with amplified high frequencies with both: air and bone conduction (Tomatis method) first (90 hours) and then placebo treatment (90 hours), the other group - had received an intervention with Mozart's music and Gregorian chants without the modulation of frequencies and without the bone conduction (placebo) and the music was not processed through the Electronic Ear.
So called placebo intervention in this study represents an intervention well known and documented the Mozart effect and Corbett et al. (2008) should have acknowledged it and should have offered a different form of intervention to the placebo group, in a form of a white noise, which would reduce a possible influence on participants. Because it is unclear if the results reported were caused by the Tomatis method or by Mozart Effect intervention or both, or if they would have occurred anyway. Mozart's effect has also been observed with a positive effect to communication, speech, reading and writing skills (Campbell, 1997; 2005).
In the authors' opinion, the results of this research cannot confirm that Tomatis method is efficient, in terms of language skills improvement, because the language improvement is not related only to Tomatis group but to placebo

group (Mozart Effect) as well. A cross-over design in this study is the most controversial, because both groups had actually received two different interventions – Tomatis stimulation and Mozart Effect stimulation, and both interventions might have led to significant improvements in majority of children, which might be directly related to interventions themselves rather than, as the author interprets, are unrelated to the interventions received and are independent of them. Rauscher et al. (1993) found out that the short exposure to Mozart's music produces short-term increases in spatial reasoning abilities and long-term effects in cognitive abilities (Shellenberg, 2001; Jenkins, 2001).

Also when interpreting research results it is also important to evaluate the size of the sample. Larger sample sizes would give results with increased precision and better statistical strength. If the sample size is as small as 11 participants, the results will probably not be statistically significant. Therefore, small sample sizes should not be used to make broad conclusions. This study has substantial weaknesses of a study design and interpretation of results.

2. AbediKoupaeia et al. (2013) aimed to investigate the effects of Tomatis method in reducing the autistic symptoms in children using randomized controlled trial. 34 children aged from 4-8 years were randomly assigned and equally divided into experimental and control groups. We cannot confirm, because the authors were not giving the information whether all children in experimental group wore headphones that were equipped with air and bone conduction. It remained equally unclear because it was not explained in the study what sort of music participants had been listening through 30 sessions / 60 hours of the program: were they listening only to Mozart music or both Mozart and Gregorian chants that represent the core of the Tomatis method along with filtered mother voice recording? Also the information was missing if the music was modulated or not in terms of high frequency enhancement which is also specific to Tomatis method. The Listener Profile was made for each participant and served as the basis for choosing the most adequate among different categories of classical music albums. Descriptions concerning Listener Profile test and description of music materials chosen are not included in the description of methods. Comparing

the results of the two groups – experimental and control, the research showed that the Tomatis sound therapy could reduce autistic symptoms, increase social interaction, communication, and reduce stereotypical movements according to the Gilliam Autism Rating Scale (G.A.R.S.) questionnaire, performed before and after the intervention as a measurement tool in this study. Since the study did not explain whether all the parameters of the Tomatis method were performed: filtering (music modulation obtained through the electronic ear that attenuates low frequencies and amplifies higher frequencies), headphones with an attached bone conductor permitting the sounds to be heard through bone vibration as well as the usual air conduction, it is difficult to say with certainty whether there is an evidence of Tomatis effect or Mozart effect. AbediKoupaeia et al. (2013) acknowledge only following limitations of their study: parents' unwillingness to respond to questions during tests and geographical limitation of this study. Since methods are not clearly described the experiment cannot be replicated independently. The study is flawed by weaknesses of reporting therefore conclusions are based on insufficient data.

Level 6 Evidence – Quantitative studies, Case series

1. Davis (2005) aimed to investigate changes in 100 children with ASD, after 60 hours of Tomatis method in 12 areas of consideration: Interpersonal growth; Listening and speech; Academic Achievement, Thinking, Learning; Attention; Behaviour; Intrapersonal Growth to know and express Self; Movement, Sports and Rhythms, Musical and Vocal Skills; Relaxation; Creativity; Reading, Writing, Spelling; Well being. The Parents rated each of the area before and after treatment from their point of view. Some of the areas where changes occurred were highly rated (Interpersonal Growth 87%, Listening and Speech 85%, 81% in Academic Achievement, Thinking, Learning, 80% in Attention, 79% in Behavior, 69% in Intrapersonal Growth to Know and Express Self, 66% in Movement, Sports, and Rhythm, etc.) and some of them lower (Well-being 20%). It is significant that in every area of consideration the changes were evident. All parents saw some level of improvement as a result of the Tomatis intervention. The research was conducted in a Tomatis centre where children with various disorders come

only for Tomatis therapy so sampling criteria are not described. There is no indication of how long the research has been conducted, it is not indicated if participants were randomly selected and we do not have information if the parents were informed about the research (Informed Consent). It is said that every parents filled the forms before ("Abilities to be Improved" form) and after the 60 hours of intervention ("Abilities improved" form) regardless of whether or not the research has being carried out. It was reported that participants were exposed to 60 hours of a basic Tomatis programme, but it is not described what a basic programme is. The weakness of this study is a lack of transparency in reporting. Also it is possible that the results are biased or that the criteria of improvement differ from parent to parent.

2. Torres de Carella (n.d.), aimed to investigate if Tomatis method could reduce echolalia (immediate or delayed repetition of what has been heard) in children with ASD. Echolalia is a very common stereotype in children with ASD. Echolalia represents the phase in acquiring and learning language in children with ASD.
Research design is quantitative descriptive and the aim is to describe the opinion of the participants on the impact of Tomatis method on echolalia in children with ASD. The Standardized Questionnaire with 12 questions was prepared for parents of children with ASD who present echolalia. From 51 distributed, only 8 questionnaires were returned are accepted for the research. Tomatis Intervention varied from 62 hours (25% of participants) to 110 hours (50% of participants). 100% children presented echolalia before the treatment. 37% of parents reported improvement in echolalia. Generally, during the Tomatis intervention many other interventions are being undertaken at the same time and the improvement cannot be exclusively attributed to the Tomatis method. 8 questionnaires represent a very small sample to draw any conclusion and results are not statistically significant. The other weakness of this study is unequal duration of the programme that children were exposed to, authors did not report which programmes were included in Tomatis intervention.

Level 7 Evidence

a) - Mixed Method Design, Individual cases study

1. Six boys with severe ASD (aged 4 to 11 years) received the Tomatls Method stimulation with the aim to assist them in behavioural changes (Neysmith-Roy, 2001).

Participants were referred to Tomatis Centre for the study. All parents of the children with ASD (diagnosed according to APA and WHO criteria, 1994) were beforehand informed about the possibility that the children might not benefit from the treatment and made an informed decision about their participation signing the Informed Consent Form which described the study in details. The study did not include a control group because of the ethical reasons (withhold of the treatment) and because of the differences of each of the boys.

Twenty-minute video samples were registered for each boy, every time they completed one intensive of the Tomatis programme. After a year, all tapes were randomized and evaluated by educated evaluators who did not know about the treatment program nor about the children. Each participant's videos were rated by the two research assistants and the scores were averaged. Children's Autism Rating Scale (CARS) is measured at the beginning and end of treatment. Participants were followed and treated individually.

At the end of each intensive a progress interview was conducted with the parents. Three (50%) boys showed positive changes in behavior after the treatment. From a developmental point of view the changes occurred in pre-linguistic areas for 5 out of 6 boys that are considered as prerequisites for verbal communication.

Children who showed a change in behavior were 6 years or younger at the beginning of treatment. The author suggests that Tomatis method could be useful in managing pre-linguistic behavior and thus help prepare children to adopt the basic skills needed to develop language and learning.

One boy was no longer considered autistic, two boys showed mild symptoms of ASD and three boys remained within the severely autistic range. For some of the children the Tomatis Method was not their first encounter with Tomatis method and one boy simultaneously was under Tomatis treatments. These research results suggest that it would be useful to evaluate the effects of the Tomatis Method on children with ASD in a research environment where

experimental conditions can be more rigorous.
Given the small sample size, conclusions. Neysmith-Roy research gave us some useful indications for further investigations regarding the conduct of the research on Tomatis method in children with ASD transparently assessing all the strengths and weaknesses of the study.

2. Vervoort et al. (2007) aimed to study whether Tomatis Method can reduce neurological dysfunctions in children with ASD in a form of the Qualitative Case Study, using measurement tools: Auditory Evoked Potential technique, EEG Brain Mapping and Tomatis Listening Test System. During the intervention period none other interventions was applied. The observed time of intervention with the Tomatis method differed from case to case (in a range from 6 months to 5 years). The comparison of each of the four cases was with itself (before and after the treatment). All four children exhibited great changes and improvements during and after interventions with filtered and non-filtered Mozart music and Gregorian chants, and filtered mother voice recordings. Vervoort et al. (2007) underlined that those four cases represented a small selection of many successfully treated cases.
Such a small sample (4) may compromise the conclusions of the study and can prevent extrapolation of the results. On the other hand this study took a lot of time with extensive and intensive treatments because of the severity of the cases. Certainly a bigger sample would impose some practical and technical obstacles but larger samples sizes can lead to statistically significant differences that can contribute to evidence-based practice.

b) - Mixed Method Design, Single case studies,

1. Tatum et al. (2004) aimed to investigate whether synergistic benefits exists from the simultaneous combination of Tomatis method with a speech therapy.
Tatum et al. (2004) presented the case of a 14-year-old girl diagnosed with ASD, not verbal. Before starting with the Tomatis method, only speech therapy intervention was applied from her age of 4. In spite of 10 years of speech therapy, she pronounced only few syllables Ba, Da, Ma. The girl was evaluated prior to the start with Tomatis Method (Pre-test “Abilities to be

Improved” Form), during the intervention (Daily Observation Form) and after each intensive (Post-test “Abilities Improved” Form).
After the first intensive of 30-hour of Tomatis method without any additional speech therapy, parents reported increasing awareness of listening, independence, motivation, and desire to communicate. She was calmer, more tolerant, less irritable, sleeping better, and no longer too sensitive to the sounds. Besides, she verbalized more.
During the second intensive, the Lindamood® Phoneme Sequencing Program (LiPS) was introduced and integrated into the Tomatis method. 30 minutes of audio vocal active microphone work with LiPS content followed by 30 minutes of passive listening for three weekly sessions over ten months, totaling about 120 hours.
From nonverbal, she has had a significant improvement in communication, attention, understanding, socialization, skills of everyday life and learning in general. This case also has showed that older children as well as younger children can benefit a lot from Tomatis programme because stimulation to the brain comes through the ears. The combination of Tomatis training, speech therapy, oral motor work, and her motivation to learn and practice new sounds and words have dramatically affected her speech. Although the aim of this study was to demonstrate the synergistic effect of speech therapy together with Tomatis method, the results of this study show that Tomatis is generally effective as a treatment for children with ASD. The speech therapy alone for 10 years has not made great progress as the Tomatis method contributed through 150 hours of passive and active work program.
Tomatis protocol is two hours of Tomatis Listening per day for 30 hours, with four-week break in between, and then another 30-hour intensive of Tomatis. This case demonstrate the usual situation In a real word where we cannot observe positive changes of Tomatis Method isolated from other social influences or educational interventions. Further investigation should be done to more precisely determine the effect of combining more interventions for children with ASD.

2. Nel (2005) aimed to identify the effect of Tomatis Method on psychological well-being and communication skills in a 14-years old boy with

Asperger's syndrome (one of levels of symptom severity of ASD according to DSM-5). Mixed method design is used in a single case study. Qualitative data were obtained through semi-structured interview before and after intervention, quantitative data through Projective drawing and Profile of Mood States (POMS). Tomatis programme consisted of 75 hours of filtered music, mother's voice recording and active vocal work over 6 months in three intensives. Results indicated improvement in Interpersonal Communication and psychological well-being. A scientific contribution of this case study (Nel, 2005) is in its holistic approach and empirical value.

3. Pralong, Espinosa, & Trigo (2014) in their single case study aimed to investigate if the Tomatis Method could reduce autistic traits and improve reading and writing skills in 8 years old boy with ASD. Mixed method design is used. Qualitative data were obtained through observation and analysis of reactions of the boy and quantitative data from measuring anxiety with SCAS (Spence Children's Anxiety Scale) and hyperactivity level (Vanderbilt Assessment Scale, NIOCHQ, 2010). A focus group was also carried out with relatives of the child, with the theme: "Strategies that parents use to confront the crises of their children with ASD". After 4 intensives (9 months and 120 hours) and the use of the Tooballo® (active voice work) 5-10 minutes every day during those 9 months, the child achieved a remarkable level of maturation, a decrease in anxiety levels, but no significant changes in attention and hyperactivity. In the academic part there were advances in the process of literacy. There were significant behavioral changes such as: making more of eye-contact, more sensitive and could externalize his interests, imitated others, had a sense of humor, new behaviours which are not generally present in children with autism. Also more open to unpredictable changes and was seeking contact with his peers. In the same time Risperidon, medication that he was using prior to the Tomatis method was stopped without any side effects or aggravation of his state.

4. Davies & Smith (2016) aimed to investigate whether Tomatis Method could help 18-year-old boy with Asperger disorder (ASD) who suffered from behaviour problems (outbursts of anger and violence, obsessive-compulsive

disorder, anxiety), sleeping problems, eyesight problems, motor problems and diarrhea. Before and after each of 4 intensives, the boy was assessed through mixed method design. Qualitative data were obtained through interviews and observations and quantitative through Tomatis Listening Tests (TLTS). TLTS is a measuring instrument used to determine the listening curve and listening distortion and it enables monitoring of changes and planning for the next programme. The programmes were made from filtered Mozart's music and Gregorian chants. Recordings of filtered mother voice and active vocal work has not been introduced into programmes. There were improvements in his behaviour regarding obsessive-compulsive disorder, he was overall calmer, his sleep and a bowel movement were better, improvements were noted in a posture and motor skills as well. After the Tomatis intervention some other interventions were applied concerning his eyesight and gross motor problems. Davies & Smith (2016) considered that the Tomatis therapy was more effective because it was used in combination with other interventions. This single case study has not been found searching through electronic database and it has not been published in peer-review journals. It has been identified on Tomatis professional organisation website therefore it is of a lower-level of evidence than previous single case studies.

c) – Qualitative design, Biography

Ruben (2010) presented personal experience story, a real autism success story of her daughter Ashley who was diagnosed with ASD and completely recovered from it. In a book (Ruben, 2010) we follow a life experience from the time her daughter was diagnosed until she got well and completely out of ASD. A girl from her early days did not have a good body posture and was floppy and quite clumsy. When older, did not show the interest in playing with others, did not know how to feed herself, ate only few different food. She was always alone watching the same video over and over again and did not show any affection. Her speech and communication delayed. When diagnosed with ASD, she was 22 months old. Lot of interventions were introduced in child's every day activities: GFCF diet, speech therapy, Floor Time, Occupational Therapy. Tomatis method together with sensory integration were applied during about 1,5 year in 6 intensives.

Already after the first intensive, a girl started to eat new food and to talk more spontaneously. During the second intensive, mother voice recording and active vocal work (babbles) were introduced, echolalia appeared as well as her coordination and motor planning improved. After her third intensive, a girl started to talk, sing and express herself. After the fourth intensive she was three years old and she had more balance and coordination, spoke spontaneously, hugged and showed her affection, only year and half beforehand she was still nonverbal. After her 5th intensive, a girl was retested and the results showed a normal child's development. 6th intensive brought further improvement in her body – not only promoted her speech but liberated her from typical repetitive mannerisms (hand flapping and toe walking). As Doidge (2015) said, ASD is much more than a brain disorder, it is a whole body disease and affects all organs including the brain.

On her 4th birthday, Ashley stopped with GFCF diet and all other early interventions. Her gut was healing and she no longer suffered from a leaky gut.

When she entered 1st grade of the Montessori school, she wrote: " When I was little Mosart made me special because I had Autisum and could not talk but now I can talk thanks to Mosart. Autisum is when You can't talk. Mosart is what takes away your Autisum."

Ashley went through all possible Tomatis interventions: filtered Mozart's music and Gregorian chants, filtered mother voice recordings and active vocal work. She was certainly among those 60% (Gerritsen, 2010, Neysmith-Roy, 2011) or 80% of children with ASD (Madaule, 1998) who benefited Tomatis method.

Level 8 Evidence – Qualitative design, Opinions of Specialists

1) Madaule (1998) has been working for 40 years with children with ASD. He observed that many of children with ASD had normal development and then started to present at about the same age (around18 months) symptoms of ASD. So he started to investigate and to collect immunization data for all those children and the data directly links the appearance of ASD with administration of vaccines. According to him this might be the reason why children tend to regress at the same age. The Tomatis programme of neuro-auditory stimulation for children with ASD usually takes from 150 to 200 hours

over 6 to 12 months. Is Tomatis method helpful for all children with ASD? Madaule has confirmed that results vary from a child to child, but the overall progress has been observed in 80% of cases, and even more, 80-90% is observed regarding development of pre-linguistic skills. The age of children is also very important for the successful treatment with Tomatis method: those who start when they are 2-3 years old, their results could be fantastic, for those from 4-6 years results are often very good, for older than 6 years the results tend not to be so good, but it is very individual. Madaule noted also that if the child has lost the ability to talk it has a better prognosis with Tomatis stimulation than one who has never talked. Filtering out the lower frequencies from mother voice recording simulate the hearing sounds in the womb (intrauterine hearing, also called a sonic birth). Madaule presented two cases of boys in ASD: Timmy and Sean. Both were nonverbal when they came to the Madaule's Centre and both made great progress in their motor skills, communication and attention. Timmy, an autistic 3,5 years old boy, nonverbal, affectionate but disconnected and locked inside, after 1st intensive and 30 hours of Tomatis program (15 days, 2 hours a day) exhibited motor skills improvements, became more present, more interactive and responding to other children. After his second intensive, a month after the 1st, the improvement from the 1st intensive was maintained and he further improved in spontaneous speech, drawing, attention span etc. He continued to come to the centre every 6 months for years and his progress continued. At 10, he was much better but still some works needed to be done concerning his writing and speaking, but he was definitely different child than he was at the beginning of the Tomatis method. Sean, 7 years old boy with the help of Tomatis method made a transit in 110 hours from very severe to a moderate form of ASD. After the 2nd intensive he started to use home device LiFT for the training at home programmed with 20 hours of music and sounds to suit to Sean's individual needs. After his third intensive in the Centre he made a lot of progress but he needs to continue with Tomatis method until his adolescent age in order to build and improve his vocabulary.

2) Gilmor & Madaule (1989) observed that children with ASD react more emotionally expressive, laughing and crying, especially towards their

mothers after they have been stimulated with filtered mother voice recording. Nonverbal children with ASD start to produce sounds and screams, eye contact and attention span improve, repetitive body movement and aggressive behavior decrease. Intensity and duration of periods of autistic social withdrawal diminish and children with ASD start to establish contacts with other children.

3) Madaule (2003) observed that self-stimulating behaviour in children with ASD: hand flapping, spinning and rocking is an attempt to stimulate vestibular system which is in charge of body movements, gravity, balance, coordination and body-image and it needs to be stimulated because it is poorly functioning. Watching the same video, listening the same song and repeating the same phrase is an attempt of self-regulation to energise the brain. Tomatis method acts on both, auditory (voice control) and vestibular systems (body awareness).

The core listening program for children with ASD starts with 2 intensives with a month break in between with only passive listening to music, wearing headphones 15 days in a row, 2 hours per day. Primarily they listen to Mozart's music and when possible filtered mother voice recordings. When a child is ready, during following intensives, months or year later, the child starts with an active vocal work. 50-75% of children with ASD coming to Madaule's centre experience better understanding, communication and simultaneous speech.

Madaule (1989, 2003, Gilmor & Madaule, 1998) presented his long professional experience in form of a personal letter, an article and a book which are of lower evidence comparing to previous studies from the higher level of evidence but his opinion gave us possibility of better understanding of the method itself, a procedure of implementing Tomatis programme and possible outcomes. He is the most experienced living expert in this field and he learned about Tomatis method from dr. Tomatis 50 years ago and was treated from dyslexia by dr. Tomatis himself when he was a young boy in France (Madaule, 1994, Doidge, 2015). In this integrative review he has been represented by 3 studies, experts' opinions (lowest level of evidence) because

of valuable number of cases of ASD that he has treated, he is indispensable source of evidence for Tomatis method.

2.5 DISCUSSION OF RESULTS

Date of publication:

16 researched studies were predominantly published during 2000 except two oldest, published in 1989 (Gilmor & Madaule) and 1998 (Madaule). The most recent was published in 2016 (Davies & Smith).

Authors:

2 authors (Gerritsen, 2009, 2010, Gilmor & Madaule Madaule, 1989, Madaule, 1998, 2003) published more than 1 study, others 1.

Country of origin:

Studies were conducted in 9 countries through out the world: Belgium, Canada, Ecuador, Iran, Mexico, Puerto Rico, South Africa (SAR), United Kingdom, United States of America (USA). USA (4) and Canada (4) being leading countries.

Designs:

Quantitative design (6): Meta-analyses and systematic reviews (2), Randomized control trials (2), Case series (2*);*

Mixed Method Design (6): Individual cases studies (2), Single Case Studies (4)

Qualitative (4): Biography (1), Experience of Specialists (3)

Measurement instruments:

Choice of measurement instruments depended of design and purposes of particular study.

In Quantitative research various measuring tools were used, ranging from scales relative to autism degree to different psychological evaluation, semi-structured interviews etc.

1 study - The Gilliam Autism Rating Scale (GARS), pre- and post-questionnaire

1 study - Children's Autism Rating Scale (CARS)

1 study - The Autism Diagnostic Observation Schedule-Generic (ADOS-G)

The Stanford-Binet Intelligence Scale-Fourth Edition (SB4), IQ, The Peabody Picture Vocabulary Test-Third Edition (PPVT-III), The Expressive One Word Vocabulary Test (EOWVT).
1 study - The Profile of Mood States (POMS), The Draw-a-Person (DAP), The Draw-a-Tree (DAT),
1 study -The Spence Children's Anxiety Scale (SCAS), Vanderbilt test for hyperactivity;
2 studies - Pre- and Post- assessment ("Abilities-to-be Improved" form, "Abilities Improved" form).
1 study - Electroencephalogram (EEG) and Auditory Evoked potentials (AEP).
Only 4 studies used the Tomatis Listening Test (Davies & Smith, 2016, Davis, 2005, Neysmith-Roy, 2001, Vervoort, 2007, which belongs exclusively to the Tomatis method and helps to identify listening potential providing information on voice quality, language acquisition, learning ability and many more. 2 systematic reviews and 3 experiences of specialists are excluded from analysis.
Qualitative measurement tools used were: Client Case History, Interview, Observation, Daily observation, Open-ended questions, video.

I**ntervention:**

More than a half of studies (9) specifically mentioned usage of both interventions, passive (Filtered Mozart music and Gregorian chant, including mother voice recording) and active phase (Audio vocal work), 4 used Mozart music and Gregorian chants with bone and air conduction and 1 (AbediKoupaeia et al., 2013) did not specify what kind of classical music was applied in the research, 2 systematic reviews (Gerritsen, 2009, 2010) were excluded from this evaluation because they are not specifically assigned to the music programme. It was observed that all 4 quantitative and 2 mixed method studies used only Mozart music and Gregorian chant, without filtered Mother Voice Recording and active vocal work. 1 of them used additional programme which is not part of Tomatis method (Tatum et al., 2004).

Intervention duration:

5 studies are excluded: 2 systematic reviews (Gerritsen, 2009, 2010) and 3 experiences of specialists (Gilmor & Madaule, 1989, Madaule, 1998, 2003). Intervention duration varied from study to study, in a range from 2

intensives (60 hours) to 37 intensives (Vervoort, 2007). An intensive usually corresponds to 30 hours (15 days, 2 hours) but it is not always a case.

Aims and purposes:

3 studies aimed to investigate if Tomatis method can reduce ASD symptoms, 1 if it can reduce echolalia in children with ASD, 1 study investigated the effects of the Tomatis Method on language skills in children with ASD, 1 study aimed to investigate the effect of Tomatis method in the area of change in academic achievement thinking, learning, attention, behavior, creativity, interpersonal growth, intrapersonal growth to know and express self, well-being, listening and speech, reading, writing, and spelling, movement, sports, and rhythm, musical and vocal skills, and relaxation. 1 investigated the effect of Tomatis Method on the psychological wellbeing and communication. 1 investigated synergistic benefits from the simultaneous combination of Tomatis method with a speech therapy. 1 investigated if Tomatis Method can reduce neurological dysfunctions. Other 7 studies are represented by 2 systematic reviews, 3 opinions of specialist (1 did not state aims or purpose and 1 is a biography).

Participants sample:

The number and age of participants vary from study to study, 5 studies have 1 participant and the biggest sample is 100 participants in 1 study. The majority of studies had small group designs.

The youngest participants were 2 years old and the oldest 21. Majority of participants were boys.

Outcomes:

All studies reported similar results: reducing symptoms and stereotypical movements, increasing social interaction and verbal communication, improvements in speech (and echolalia), emotional and attention enhancement. Even a study (Corbett et al. 2008), that estimated that the positive results were not related to the Tomatis treatment, concluded that the majority of the children in the study demonstrated general improvement in language. A number of studies indicated as a result that children were no longer considered with ASD.

2.6 PRESENTATION OF INTEGRATIVE REVIEW

2.6.1 Limitation:

This integrative review has identified 16 studies that reviewed and evaluated the effectiveness of Tomatis method in children with ASD.

We encountered in various studies different names under which the Tomatis method has been evaluated and practiced: Tomatis Method, Listening therapy (Madaule, 1994) Tomatis Program (Davis, 2005) Audio-Psycho-Phonology (Vervoort, 2007).

The methodological quality of studies in general was adequate although some deficiencies were detected, particularly in aspects related to a cross-over design and a interpretation of results (Corbett et al. 2008), related to poor and insufficient data (AbediKoupaeia et al., 2013) and generally a very small sample in majority of studies which made results not statistically significant. Only 1 study obtained informed consent thus maintaining ethical standards.

All studies showed that Tomatis method through it's different forms of interventions, Mozart music and Gregorian chants, filtered mother voice and active vocal work can contribute in reducing symptoms of ASD and it can improve language development, verbal communication, attention span, socially acceptable behaviours, social skills and emotional understanding. Introduction of the active vocal work depends of the age and linguistic maturation of the child, consequently nonverbal children are limited only to passive phase of listening (Madaule 1998, Vervoort, 2007).

Most of studies based their investigation on a duration between 60 and 120 minutes of programmes. Evaluating cases of serious forms of ASD and studies in which the intervention lasted for several years we can conclude that 60 or 120 hours of Tomatis method may be insufficient for some children.

The severity of ASD and the age might have an impact to the effectiveness of Tomatis method. In general, researchers and authors represented in this integrative study consider that for children with ASD who start early enough with the Tomatis neuro-auditory stimulation very good results may be expected in overall functioning (Madaule, 1998, Neysmith – Roy, 2001, Vervoort, 2007). The only thing to remember is that Neuro (brain) plasticity has a lot to offer to children with ASD (Bridges, 2015).

2.6.2 Recommendation:

Most of studies were focused on communication skills and speech in ASD because a lack of communication skills is the main feature of ASD. Some researchers presume that about 30-50% of all children with ASD never develop speech (Tager-Flusber as cited in Goh, Whitaker, Feldman, Cull, Hoyte, Algermissen, … Peterson, 2013) and remaining 50-70% develop some verbal speech, others claim that 80% can learn to talk (The Editors of Scientific Mind, 2013). The problem of talking in children with ASD is very important and should change the perspective of the need for early intervention. The Interagency Autism Coordinating Committee has set the priority to develop more effective procedures for children with ASD with the aim of achieving functional speech in 90% of school children (Goh et al., 2013). The use of Tomatis method in children with ASD from early years on a regular base might bring desired speech changes. Several studies presented long duration interventions (more than a year) in nonverbal children with very positive therapeutic outcomes (Madaule, 1998, Vervoort 2007, Ruben, 2010). Doidge (as cited in Madaule, 1994) says that human brain is neoplastic and its circles are very dynamic and change rapidly in response to activity and experience. Research outcomes in this integrated review show that the Tomatis method can play a very important role and fill the hole in the current situation where we find ourselves helpless with outdated and inefective measures and protocols in front of growing numbers of children with ASD. Tomatis method is not a new intervention, it has been in practice for more than 50 years but it is still developing and evolving. A number of children with ASD increases and represents a challenge for all the society, in every country of the world. Neuroscience gives us new evidences and shows us that

auditive neurostimulation, in this case the Tomatis method, can significantly improve the general condition of children with ASD if not completely resolve it. Change is certainly happening but for severely impaired children with ASD so much change is necessary that sometimes parents do not recognize it or the slow pace with which this change occurs is not what they expect to happen (Davis,2004). Change might not happen at the end of only 60 hours of listening program. The road leading to a change is a long process and children sometimes need a few years to reach their goal (Davis, 2004).

That is the reason why we need more evidence-based research which will support the 50 years of successful experience. From the moment dr. Tomatis passed away in 2001, his method has undergone through several innovation cycles driven by geographical and technological differences. We encountered in various studies different names under which the Tomatis method has been evaluated and practiced: Tomatis Method, Listening therapy (Madaule, 1994) Tomatis Program (Davis, 2005) Audio-Psycho-Phonology (Vervoort, 2007).

The overall advancement in technology has also affected the Tomatis method's equipment, so today there are small, portable devices with pre-recorded music that allow therapy to be run outside the Tomatis Centres, which certainly makes easier for parents to organize everyday's life when every minute is so precious and children are burdened with numerous interventions and obligations.

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Flow chart

Figure 1