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FACULDADE DE LETRAS

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Orientadores: Prof.ª Doutora Marina Cláudia Pereira Verga e Afonso Vigário
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Tese especialmente elaborada para obtenção do grau de Doutor no ramo de Linguística, na especialidade de Linguística para Diagnóstico e Intervenção

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Para a minha filha, Beatriz…

"Sim, me leva para sempre, Beatriz…

Me ensina a não andar com os pés no chão.

Para sempre é sempre por um triz…

…

Diz quantos desastres tem na minha mão…

…

Diz se é perigoso a gente ser feliz…"

Chico Buarque e Edu Lobo

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"Se te perguntarem o que vem primeiro, o pé ou o caminho, pensa um segundo, apenas um instante, e depois diz: a pegada dos outros." (*in* O Caminho, Mario Satz e Yara Kono)

Segui pegadas que me fizeram sonhar e concretizar sonhos… em formato de papel com sons e música… caminhos que trilhei, feitos por pessoas e com pessoas numa lista infindável de nomes que espero não esquecer e a quem agradecerei sempre…

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E *"se, por acaso, te perguntarem o que importa mais, o perto ou o longe, espera um bocadinho antes de responderes. Porque se disseres o perto, nunca chegarás muito longe; mas se disseres o longe, pode ser que toda a viagem te pareça perto e agradável de percorrrer."* (*in* O Caminho, Mario Satz e Yara Kono)

Abstract

The relation between music and language has been intensively studied in recent years. Research has revealed that both domains engage similar processing mechanisms, including auditory processing and higher cognitive functions, and recruite partially overlapping brain structures. Furthemore, different authors have shown that linguistic functions can be positively influenced by music training above 4 years old. Music has also been shown to be associated with the promotion of linguistics skills in children with specific pathologies related to language, such as dyslexia, in 7- to 10-year-olds. In this thesis, we conducted four studies on the effect of music training on different aspects of language development. We studied this influence on phonological awareness in children with typical development and speech or language disorder (Studies 1 and 2) and on phonetic and phonological development in the same populations (Studies 3 and 4). In this randomized control study, with a test-training-retest methodology, 49 typically developing children, aged between 3 and 4, were assessed with a phonological awareness test (Study 1) and a phonetic and phonological test (Study 3). These tests were applied before and after a school year with weekly Music Classes (experimental group) or Visual Arts Classes (control group) in kindergarten. Two additional studies with the same methodology were conducted with 16 atypically developing children, aged between 3 and 6. This group included children with phonologically based Speech Sound Disorder (SSD) and / or Developmental Language Disorder (DLD). The goal of investigating this topic in this group of atypical children was to understand music relation with phonological awareness development (Study 2) and phonetic and phonological development (Study 4), and this at stages earlier than those where the beneficial effect of music in language-related skills has already been found. When comparing pre- and post-assessment and irrespective of type of lessons' exposure (music or visual arts), results always showed significant differences in each group, as expected due to general developmental reasons. In Study 1, Music Classes' students outperformed the control group, showing significantly larger differences between the beginning and the end of the lessosns period, indicating that music lessons have influenced phonological awareness, and pointing to a causal relation between music training and phonological awareness as soon as 3 years of age. In Studies 2, 3 and 4 no significant differences were found between groups in the post-assessment moment. This fact may suggest the need of more intensive music training or, in what concerns atypically developing children, a specific music curriculum designed to bridge their linguistic rhythm (and possibly pitch) processing deficits. Globally, this thesis supports the hypothesis that music training may promote language abilities, in particular phonological awareness, in 3-year-olds with typical development, that is prior to the ages that have been previously studied.

Keywords: Language development, phonological awareness, phonetic and phonological development, music training, phonologically based Speech Sound Disorder, Developmental Language Disorder.

Resumo

A relação entre música e linguagem tem sido alvo de diversos estudos ao longo dos últimos anos. Estes estudos têm demonstrado que as duas áreas estão relacionadas, utilizando mecanismos de processamento comuns (incluindo o processamento auditivo e o processamento de funções cognitivas) e recorrendo a estruturas neuronais comuns. Vários autores referem a influência da música em diferentes áreas do desenvolvimento linguístico em crianças com idades superiores a 4 anos, nomeadamente no que diz respeito a competências de consciência fonológica, consciência fonémica, precursores da leitura e capacidade de leitura (em crianças com desenvolvimento típico e com dislexia). De forma a compreender a influência do treino musical no desenvolvimento da consciência fonológica (Estudos 1 e 2) bem como das capacidades fonéticas e fonológicas da criança (Estudos 3 e 4), foi desenhado um estudo com metologia teste-treino-reteste, com randomização de uma amostra e constituição de um grupo com Aulas de Música (grupo experimental) e outro grupo com Aulas de Artes Visuais (grupo de controlo). Esta metodologia incidiu sobre uma população de crianças com desenvolvimento típico (N=49), com 3 anos de idade (Estudos 1 e 3) e sobre uma população com Perturbação de Sons de Fala de base fonológica e / ou Perturbação do Desenvolvimento da Linguagem (N=16), entre os 3 e os 6 anos de idade (Estudos 2 e 4). Todas as crianças foram avaliadas antes e depois do período de intervenção, que decorreu durante um ano escolar, em contexto de Jardim de Infância, com a frequência de uma aula semanal de 45 minutos (Música VS Artes Visuais).

A comparação realizada entre os momentos de avaliação inicial e final revelou diferenças significativas no desenvolvimento das diversas competências, em todos os grupos – melhoria expectável devido ao desenvolvimento da criança resultante apenas do tempo decorrido. No Estudo 1, sobre a influência da música no desenvolvimento da Consciência Fonológica, os alunos de Música obtiveram melhores resultados do que os alunos de Artes Visuais, mostrando uma evolução significativamente maior do que o grupo de controlo no momento da pós-avaliação. Este facto indica que o treino musical influenciou positivamente o desenvolvimento das competências de consciência fonológica, apontando para uma relação de causa-efeito, aos 3 anos de idade. Nos Estudos 2 (influência da música no desenvolvimento da consciência fonológica em crianças com desenvolvimento atípico), 3 (influência da música no desenvolvimento fonético-fonológico em crianças com desenvolvimento típico) e 4 (influência da música no desenvolvimento fonético-fonológico em crianças com desenvolvimento atípico) não foram encontradas diferenças significativas entre os grupos experimentais e de controlo no momento de avaliação final. Este facto pode indicar a necessidade de um treino musical mais intensivo ou, no caso das crianças com desenvolvimento atípico, que compreenda um currículo especificamente desenhado para colmatar as dificuldades ao nível do processamento linguístico e musical.

Esta tese suporta a hipótese de que o treino musical promove o desenvolvimento de capacidades linguísticas, nomeadamente de consciência fonológica, aos 3 anos de idade, numa faixa etária anterior às até aqui estudadas. Este facto poderá ter impacto na criação de programas de promoção da consciência fonológica em contexto de Jardim de Infância, ou na potenciação de estratégias utilizadas pelo educador de infância, no seu dia-a-dia, no sentido de promover o desenvolvimento de competências fundamentais nas aprendizagens subsequentes da leitura e da escrita.

Palavras-chave: Desenvolvimento da linguagem, consciência fonológica, desenvolvimento fonético-fonológico, treino musical, Perturbação de Sons de Fala, Perturbação do Desenvolvimento da Linguagem.

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List of Abbreviations and Symbols

AD	Atipically Developing children
APAT	Paediatric Automatic Phonological Analysis Tools
Bac	Backing
Bac PostA	Backing Post-assessment
Bac PreA	Backing Pre-assessment
C	Consonant
C1	First consonant of the syllable
C2	Second consonant of the syllable
ClRed	Cluster Reduction
ClRed PostA	Cluster Reduction Post-assessment
ClRed PreA	Cluster Reduction Pre-assessment
Conf-IRA	Consciência Fonológica – Instrumento de Rastreio e Avaliação
Den	Denasalization
Den PostA	Denasalization Post-assessment
Den PreA	Denasalization Pre-assessment
Dep	Depalatalization
Dep PostA	Depalatalization Post-assessment
Dep PreA	Depalatalization Pre-assessment
Devoicing	Devoing
Dev PostA	Devoicing Post-assessment
Dev PreA	Devoicing Pre-assessment
DLD	Developmental Language Disorder
DyphRed	Dyphthong Reduction
DyphRed PostA	Dyphthong Reduction Post-assessment
DyphRed PreA	Dyphthong Reduction Pre-assessment
ELAN	Early Left Anterior Negativity
EP	European Portuguese
EpRes.CCV	Epenthesis and Ressyllabification in CCV context
EpRes.CCV PostA	Epenthesis and Ressyllabification in CCV context Post-assessment
EpRes.CCV PreA	Epenthesis and Ressyllabification in CCV context Pre-assessment
EpRes.T	Epenthesis and Ressyllabification in CCV and VC contexts

EpRes.T PostA	Epenthesis and Ressyllabification in CCV and VC contexts Post-assessment
EpRes.T PreA	Epenthesis and Ressyllabification in CCV and VC contexts Pre-assessment
EpRes.VC	Epenthesis and Ressyllabification in (C)VC context
EpRes.VC PostA	Epenthesis and Ressyllabification in (C)VC context Post-assessment
EpRes.VC PreA	Epenthesis and Ressyllabification in (C)VC context Pre-assessment
ERAN	Early Right Anterior Negativity
F	Female
FAFA	Ferramentas de Análise Fonológica Automática
FCDel	Final Consonant Deletion
FCDel PostA	Final Consonant Deletion Post-assessment
FCDel PreA	Final Consonant Deletion Pre-assessment
Fdev	Fricative Devoicing
FDev PostA	Fricative Devoicing Post-assessment
FDev PreA	Fricative Devoicing Pre-assessment
Fr	Fronting
Fr PostA	Fronting Post-assessment
Fr PreA	Fronting Pre-assessment
G	Glide
GLiq	Gliding of Liquids
GLiq PostA	Gliding of Liquids Post-assessment
GLiq PreA	Gliding of Liquids Pre-assessment
IFG	Inferior Frontal Gyrus
InMet	Intrassyllabic Metathesis
InMet PostA	Intrassyllabic Metathesis Post-assessment
InMet PreA	Intrassyllabic Metathesis Pre-assessment
M	Male
MC	Music Classes
NVIQ	Nonverbal IQ
OPERA	Overlap, Precision, Emotion, Repetition, Attention
Pal	Palatalization
Pal PostA	Palatalization Post-assessment
Pal PreA	Palatalization Pre-assessment
PATH	Precise Auditory Timing Hypothesis
PCC	Percentage of Correct Consonants

PCP	Percentage of Correct Phonemes
PCV	Percentage of Correct Vowels
PLI	Primary Language Impairment
PT	Planum Temporale
SAMPA	Speech Assessment Methods Phonetic Alphabet
SD	Standard Deviations
SLI	Specific Language Impairment
Sliq	Substitution of Liquids
SLiq PostA	Substitution of Liquids Post-assessment
SLiq PreA	Substitution of Liquids Pre-assessment
SSCLMH	Shared Sound Category Learning Mechanism Hypothesis
SSD	Speech Sound Disorders
STG	Superior Temporal Gyrus
St	Stopping
St PostA	Stopping Post-assessment
St PreA	Stopping Pre-assessment
STS	Superior Temporal Sulcus
SVow	Substitution of Vowels
SVow PostA	Substitution of Vowels Post-assessment
SVow PreA	Substitution of Vowels Pre-assessment
TD	Tipically Developing children
TFF – ALPE	Teste Fonético-Fonológico – Avaliação da Linguagem Pré-Escolar
TL – ALPE	Teste de Linguagem – Avaliação da Linguagem Pré-Escolar
V	Vowel
VAC	Visual Art Classes
WNL	Within Normal Limits
WPPSI-R	Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence— Revised
WSDel	Weak Syllable Deletion
WSDel PostA	Weak Syllable Deletion Post-assessment
WSDel PreA	Weak Syllable Deletion Pre-assessment

Symbols of the International Phonetic Alphabet:

[p]	**p**ai	[l]	**l**ápis
[b]	**b**ola	[ʎ]	coe**lh**o
[t]	**t**acho	[ɾ]	ca**r**acol
[d]	**d**a**d**o	[ʀ]	**r**ato
[k]	**c**asa	[a]	**á**gua
[g]	**g**ato	[ɐ]	**a**migo
[f]	**f**aca	[ɛ]	**é**gua
[v]	**v**ela	[e]	p**ê**ra
[s]	**s**apato	[ɨ]	m**e**nino
[z]	**z**ebra	[i]	**i**lha
[ʃ]	**ch**apéu	[ɔ]	**ó**culos
[ʒ]	**j**anela	[o]	**o**lho
[m]	**m**acaco	[u]	**u**va
[n]	**n**ariz	[j]	pa**i**
[ɲ]	**u**nha	[w]	pa**u**

1 – General Introduction

Music influence on human development has attracted great attention from the scientific community in the last decade, and renewed explorations have emerged on the interaction between areas like musicology, neurology, cognitive sciences, linguistics, and music therapy, among others.

So far, music has proved to influence communicative skills, self-confidence, interpersonal relations among students (Gourgey, 1998), kinesthetic skills (Gilbert, 1981), spatio-temporal skills (Hetland, 2000), cognitive development (Costa-Giomi, 2015; Radocy, LeBlanc, & Boyle, 1990; Schellenberg, 2005; Schellenberg & Weiss, 2013), Intelligence Quotient – IQ (Kaviani, Mirbaha, Pournaseh, & Sagan, 2014; Schellenberg, 2005, 2011), verbal intelligence and executive function (Moreno, Bialystok, et al., 2011), memory (Groussard et al., 2010; Jakobson, Cuddy, & Kilgour, 2003; Roden, Grube, Bongard, & Kreutz, 2014), and second language learning (Lowe, 1995; Sleve & Miyake, 2006).

Concerning language and its association with music, different skills have been studied: phonological awareness (Anvari, Trainor, Woodside, & Levy, 2002; Bolduc, 2009; Degé & Schwarzer, 2011; Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomi, 2011; Lamb & Gregory, 1993; Lathroum, 2011; Moreno, Friesen, & Bialystok, 2011; Patscheke, Degé, & Schwarzer, 2016), phonemic awareness (Anvari et al., 2002; Forgeard, Schlaug, Rosam, Iyengar, & Winner, 2008; Gromko, 2005; Herrera et al., 2011; Lamb & Gregory, 1993; Peynircioglu, Durgunoglu, & Uney-Kusefoglu, 2002; Rubinson, 2009), reading precursors (Anvari et al., 2002; Degé, Kubicek, & Schwarzer, 2015; Degé & Schwarzer, 2012; Woodruff Carr, White-Schwoch, Tierney, Strait, & Kraus, 2014), and reading (Zuk, Andrade, Andrade, Gardiner, & Gaab, 2013). Syntax has also been recently investigated in relation to music (Gordon, Shivers, et al., 2015; Jentschke & Koelsch, 2009; Piro & Ortiz, 2009).

In this thesis, phonological development was the focus of our interest in relation to music, specifically phonological awareness development (Studies 1 and 2) and phonetic-phonological development (Studies 3 and 4). Studies 1 and 3 were developed testing music effects on typically developing children (TD), while studies 2 and 4 aimed to study the same effects on children with atypical development (AD), having speech and/or language disorders – phonologically based Speech Sound Disorders (SSD) and/or Developmental Language Disorders (DLD). The adoption of such terminology is justified in Chapter 3 of the present thesis, in 3.1. section about concepts in music, language and language pathology.

Studying phonological awareness is important because of the role of these skills in predicting literacy. Being defined as the explicit awareness or knowledge of the internal sound structure of spoken words (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Torgesen, Wagner, & Rashotte, 1994), phonological awareness allows the child to be able to subdivide spoken language into words, syllables and phonemes (Lane & Pullen, 2004). Phonological awareness involves perceiving, manipulating, separating, and blending sounds in speech, and is essential to fluent reading and decoding of words (Anthony & Francis, 2005). According to Cardoso & Martins (1991), Goswami (1990) or Öney & Durgunoğlu (1997), this metalinguistics skills are considered a pre-requisite or a predictor of learning of writing and reading.

Phonetic and phonological development wasn't studied so far in relation to music. In our study this was also a point of interest. Phonology can be defined as the knowledge about human languages sound systems and their functioning (Bishop et al., 2017; Odden, 2005). Knowing that SSD are frequently associated with difficulties in phonological awareness development and with future literacy problems (Botting, Simkin, & Conti-Ramsden, 2006; Gillon, 2000; Stackhouse, Wells, Pascoe, & Rees, 2002), made us choose to study this ability, in order to understand if music effect proven so far to some linguistic abilities, was extended to phonetic-phonological skills also. For this reason, after investigating the effect of music training in phonological awareness, we tried to look for music interaction with phonetic and phonological development.

Trying to complement the current knowledge on the topic, we aim to understand the association between music training and language development at 3 years of age, before the ages already studied in TD children, studying phonological awareness development (Study 1) and phonetic and phonological development (Study 3). A population with phonologically based SSD and/or DLD was also studied, aiming to understand music effect on the same language abilities in children with atypical development between 3 and 6 years of age (before the ages already analyzed in studies including children with dyslexia) – studies 2 and 4.

Taking into account the studies known so far, as well as the potential of music in interfering with the development of skills that are so important in child development, we hope to better understand this influence with typical music classes, once a week, in kindergarten context.

To accomplish our goal, in this randomized control study there was a test-training-retest methodology, with a random assignment of children to music classes (experimental group) or visual art classes (control group), trying to control self-selection issues and individual differences pre-existent in both groups – individuals with poor listening abilities would be unlikely to take music lessons, and this could contribute to a positive but not real association between training and linguistic abilities (Schellenberg & Winner, 2011).

Related to the type and periodicity of music training used, it was found that some studies use music-based interventions, specifically designed to promote reading skills (e.g., Bolduc, 2009; Herrera et al., 2011), and have an intensive intervention periodicity, giving multiple classes per day or week (e.g., Degé & Schwarzer, 2011; Herrera et al., 2011; Moreno, Friesen, et al., 2011; Patscheke et al., 2016). In this thesis, we aim to determine if music influences language development, but we also want to see if the kind of intensity of music classes that is likely to be available in kindergartens' everyday lives is sufficient to produce significant improvements in the development of phonology and phonological awareness, since intensive music classes are not common at this age. Specifically, we designed a study with weekly classes of 45 minutes each during a preschool year with no specific activities to promote phonological awareness development – replicating what is typically done and achievable in current Portuguese educational context (for example, there were no specific exercises to work rhymes or word segmentation in syllables with music).

In this thesis, we report the results of two studies conducted on each population group previously mentioned: Typically Developing children – TD; and speech and/or language impaired children, Atypically Developing children – AD. These 4 studies aim to explore possible effects of music on different linguistic skills. The thesis is therefore organized considering the areas under investigation where the potential effect may be found –

Phonological Awareness – Studies 1 and 2; Phonetic-phonological development – Studies 3 and 4.

Since the methodology was very similar in all 4 studies, a general methodology section is presented in Chapter 2 to explain the test-training-retest methodological procedure followed in our 4 studies with TD 3-year-olds and AD speech and/or language disordered 3- to 6-year-olds. Chapter 3 will then present the 2 studies conducted here on phonological awareness assessment in TD children (Study 1) and AD children (Study 2). This chapter is organized as follows. In the background section we present some fundamental concepts related with language and music, an overview of the research already conducted on the topic and some of the major open issues. In section Methodology we briefly recap the methodological details of the studies. The results of each study (Study 1 and Study 2) are presented in section Results and discussed in section Discussion. Finally, the conclusions are given in section Conclusions.

Chapter 4 comprehends Studies 3 and 4, on the phonetic and phonological development in TD children (Study 3) and in AD children (Study 4). The organization of this chapter is similar to that of Chapter 3.

Proving that music can have a positive impact in language development, and specifically in phonological awareness development in preschoolers before 4 years old, may have important implications for early education programs, as music strategies may then possibly be considered as part of an effective plan for promoting academic achievements. The research conducted here thus seems timely and may contribute to the ongoing debate in the educational system on this matter (Gordon, Fehd, & McCandliss, 2015). We discuss this topic in Chapter 5, where we also highlight the major findings of this investigation and point some directions for future investigation.

2 – General Methodology

In this chapter TD and AD populations are described for each study, as well as the procedures and dependent measures used. The design of the experiment is the same for the Studies 1 to 4, as well as the curricula of music and visual art lessons, briefly exposed.

Studies that investigate the relation between music and language have followed two basic approaches. In some work, the variability in linguistic skills is measured without music training, by analyzing individual differences in music aptitude – e.g. Anvari, Trainor, Woodside, & Levy (2002), Degé, Kubicek, & Schwarzer (2015), Degé & Schwarzer (2012), Forgeard, Winner, Norton, & Schlaug (2008), Lamb & Gregory (1993), Lathroum (2011), Peynircioglu, Durgunoglu, & Uney-Kusefoglu (2002), Rubinson (2009), Woodruff Carr, White-Schwoch, Tierney, Strait, & Kraus (2014), Zuk, Andrade, Andrade, Gardiner, & Gaab (2013). These studies may indicate a relationship between music and language, but they do not prove a causal relation effect. For instance, it is possible that effects of self-selection, and environmental or genetic characteristics may influence linguistics skills in people with higher music abilities (whether musicians or not) (Gordon, Fehd, & McCandliss, 2015). On the other hand, some other studies rely on a test-training-retest methodology, being closer to prove a causal relation effect – Degé & Schwarzer (2011), François, Chobert, Besson, & Schön (2013), Herrera, Lorenzo, Defior, Fernandez-Smith, & Costa-Giomi (2011), Moreno et al. (2009), Moreno, Friesen, & Bialystok (2011). With the randomization process, children are randomly distributed to form the experimental and control groups. Groups cannot therefore be organized as a function children's previous aptitude or motivation.

For this reason, data from longitudinal randomized control studies with test-training-retest methods are important to complement the information about linguistic and music aptitude. In our study, we use a test-training-retest methodology in order to explore a causal relation between music and phonological awareness (Studies 1 and 2) and phonetic-phonological development (Studies 3 and 4). Each ability is measured in two different populations: Studies 1 and 3 with TD children with 3 years of age; Studies 2 and 4 with AD children between 3 and 6 years of age. We randomized the samples into an experimental group with

Music Classes (MC) and a control group with Visual Arts Classes (VAC) and assessed the children before and after the training period (music versus alternative training). Besides studying music training influence in these linguistic abilities, we also want to know if such influence may emerge with regular music classes, in kindergartens regular days (once a week, for 45 minutes), during a preschool year, without having a specific design to promote phonological awareness skills.

Phonological awareness development was the only ability measured in two subsequent school years, being the result of the collection of data in a pilot, smaller study and in the larger study conducted in the second year. For this reason, the first study group has a larger sample than the other groups.

2.1. Procedures

Data collection was authorized by Direção-Geral da Educação (DGE) from Portuguese Ministry of Education and Science (Reference 0504200001, 28th July 2015). Parental informed consent was obtained for each child and the data was analyzed anonymously. Children were assessed at the beginning and at the end of the training period (30 classes). All children were assessed in individual sessions at school, in a quiet room, with consent from the parents, the school board, and the teachers. The software SPSS Version 25 and Microsoft Excel 2013 were used for the statistical analysis.

2.2. TD Populations (Studies 1 and 3)

2.2.1. Participants

Subject selection criteria included: monolingual children whose native language was European Portuguese (EP); children aged between 3:0 and 3:11 years old; frequency of 70% of the classes (Patscheke et al., 2016). Children with SSD and/or DLD were not included in this study. Likewise, children with a history of referral to or enrollment in speech-language therapy were excluded, as well as children diagnosed with cognitive disorders or other associated conditions. They came from the same demographical region and shared the same socioeconomic background.

Children assignment to each class was done randomly, at the beginning of the school year, after the recruitment stage using Random.org program. Timestamps proving this randomization are presented below, for each study description.

Study 1

From the initial group of 53 children, 4 were excluded. One child moved to a different kindergarten, 2 children were not Portuguese native speakers, and the other child attended less than 70% of the classes. The dropout rate was 7.54% (4 out of 53 children). The final sample included 49 children (26 female) with a mean age of 3:6 years old. The last 3 children that were excluded still attended the classes, but their data was not collected in the assessment moments. All participants were from 2 different kindergartens in the same city – Aveiro.

The MC group included 25 children (15 female, mean age= 3:5 years old), and the VAC group contained 24 children (12 female, mean age=3:6 years old). Children were randomly assigned to each group. Ramdom.org 1st years' timestamp is 2015-10-15 15:31:12 UTC; and the 2nd years' timestamp is 2016-10-31 16:18:26 UTC.

Study 3

The relationship between music and phonetic-phonological development was studied in the second-year, larger study. 35 children were part of the sample at the beginning of the year, but 4 children were excluded (the same already mentioned in Study 1) – the dropout rate was 11,43%. The final sample included 31 children (20 female) with a mean age of 3:5 years old. All participants were from 2 different kindergartens in the same city – Aveiro.

The music group contained 16 children (10 female, mean age=3:4 years old), and the visual arts group included 15 children (10 female, mean age = 3:6 years old). Ramdom.org timestamp is 2016-10-31 16:18:26 UTC.

2.2.2. Dependent measures

Study 1

Pre- and post-assessment included phonological awareness skills, assessed with Conf-IRA – Consciência Fonológica, Instrumento de Rastreio e Avaliação (Alves, Castro, & Correia, 2009). Conf-IRA is a phonological awareness test that comprises 18 tasks evaluating lexical, syllabic, intra-syllabic and phonemic awareness in words and pseudowords with all syllabic structures existing in EP. In this study, considering children's ages, 11 tasks were applied:

1. Lexical awareness (sentence segmentation into words) – the child sees a picture and listens to a sentence, which (s)he has to segment into different words using his/her fingers, with each finger pointing a word: "A/Joana/pinta/o/livro";

2. Syllabification of words – the child sees a picture and listens to a word which (s)he has to segment into syllables, using his/her fingers, with each finger pointing a syllable: "ga/lo";

3. Syllabification of pseudowords – the child listens to a pseudo-word which (s)he has to segment it into syllables, using his/her fingers, with each finger pointing a syllable: "lo/fa";

4. Combining syllables into Words – the child listens to two or three syllables, each of which presented with a one second interval; at the end (s)he has to put the syllables together to guess the word: "ba + li + za = baliza";

5. Combining syllables into Pseudowords – the child listens to two or three syllables, each of which presented with a one second interval; at the end (s)he has to create a new non-existing word: "tú + fa + ro = túfaro";

6. Final syllable omission – the child looks to a picture and listens to a word that turns into a different word when (s)he omits the last syllable: "nota – ta = nó";

7. Initial syllable omission – the child sees a picture and listens to a word that turns into a different word when (s)he omits the first syllable: "sapato – sa = pato";

8. Syllable inversion – after the child sees a picture and listens to a two-syllable word, (s)he has to change the order of the syllables and identify a new word: "avô - vôa";

9. Rhyme identification – this is a task of multiple-choice items with pictures, where then the child has to choose which of three words rhymes with the first one presented – in this task, metrical rhyme coincides with the syllabic rhyme of the last syllable of the word: "coraç**ão**" rhymes with "gato, colher, or c**ão**");

10. First phoneme identification – the child has to identify which of three words does not begin with the same sound as the others: "pilha, **f**ilha, pena";

11. Last phoneme identification – the child has to identify which of three words does not end with the same sound as the others: "pont**e**, choco, ponto".

Seven of the tasks of ConF-IRA were excluded prior to children assessment, since they were considered to difficult at 3 years of age – in European Portugues (EP) segmental awareness is practically absent in pre-school years (Henriques, 2008; Paulino, 2009; Veloso, 2003). These were the tasks that were not applied: 1) intrasyllabic analysis (syllable segmentation in onset and rhyme), segmentation of 2) words and 3) pseudowords in phonemes, combining phonemes into 4) words and 5) pseudowords, 6) deleting first phoneme from a word to form a different one and 7) word stress identification.

Study 3

Children's assessment of phonetic-phonological skills was realized in individual sessions, at the beginning and at the end of the school year, with Teste Fonético-Fonológico – Avaliação da Linguagem na Criança Pré-Escolar (TFF - ALPE, Mendes, Afonso, Lousada, & Andrade, 2013). This is test comprises 69 pictures of words that include all the sounds in different word and syllable positions possible in EP (Lousada, Mendes, Valente, & Hall, 2012). The child sees pictures in a small book, and names the images one by one.

After the application of TFF-ALPE, the data were analyzed with Paediatric Automatic Phonological Analysis Tools (APAT, Saraiva, Lousada, & Jesus, 2017), an automatic tool that comprehends the analysis of the segment and the syllable – Ferramentas para Análise Fonológica Automática (FAFA Version 1.3.00). With this tool it was possible to obtain the measures listed below: Percentage of Correct Consonants (PCC) score, Percentage of

Correct Vowels (PCV) score and Percentage of Correct Phonemes (PCP) score. The segmental analysis also comprises the occurrence of the following phonological processes: stopping, fronting, backing, depalatalization, palatalization, devoicing, devoicing of fricatives, substitution of liquids, gliding of liquids, substitution of vowels and denazalisation. In the syllabic analysis some processes were also analyzed: final consonant deletion, weak syllable deletion, cluster reduction, intra-syllabic metathesis, reduction of diphthongs, epenthesis and resyllabification (two additional processes analyzed).

2.3. AD Populations (Studies 2 and 4)

2.3.1. Participants

For Studies 2 (on Phonological Awareness) and 4 (on Phonetic-phonological development) we collected our sample in the same two kindergartens, in Aveiro. These studies were developed in a single school year, with the children referred to us by the teachers as having speech and/or language disorders.

Subject selection had inclusion and exclusion factors. The inclusion criteria were as follows: monolingual children whose native language was EP; children aged between 3:0 and 5:11 years old; frequency of 70% of the classes (Patscheke et al., 2016). Children were referenced by the kindergarten teachers as having a speech and/or language disorder that was not associated with any known biomedical condition. They came from the same demographical region and shared the same socioeconomic background. The exclusion criteria were related to the absence of an associated condition (children with autism, deafness, or other biomedical known condition). Nonverbal IQ (NVIQ) was also assessed with the Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence—Revised (WPPSI-R) (Wechsler, 2003) by a trained psychologist, in order to include children whose NVIQ was a minimum score of 80 points (Bishop, 2014). A language assessment was done to every children in an individual session, with the Teste de Linguagem - Avaliação da Linguagem Pré-Escolar (TL - ALPE), a standardized receptive and expressive language test (Mendes, Afonso, Lousada, & Andrade, 2014), and TFF-

ALPE (Mendes et al., 2013) in order to confirm the presence of a DLD or a phonological based SSD.

Timestamps proving the randomization process done after the recruitment stage are presented below, in each study description.

Studies 2 and 4

All children participated in both studies.

From the initial 22 children that integrated the sample, 6 dropped out for several reasons: 1 moved to a different school, 1 quit due to demotivation, 2 were below rate 80 in the NVIQ assessment, and 2 did not match the inclusion criteria, having no speech and/or language disorder. The last 4 children went to the music or visual arts classes during the school year, but the final assessment data was not collected and analyzed. The dropout rate was 27,27% and the final sample was composed by 16 children (5 female) with the mean age 4:9, and different linguistic profiles: 11/16 children have a phonological based SSD with no impairment found in linguistic receptive and expressive levels assessed with TL-ALPE; 5/11 children have a DLD. (Table 1). The experimental group (MC - with music classes) was composed by 8 children (1 female, mean age= 5:1, NVIQ from 80 to 118), and the control group (VAC - with visual arts classes) had 8 children (3 female, mean age=4:6, NVIQ from 83 to 105). Ramdom.org timestamp is 2016-10-31 16:37:44 UTC.

Table 1: Characteristics of participants: gender, age, non-verbal intelligence (NVIQ) (standard score), receptive language (raw score), expressive language (raw score) and intervention group.

Code	Gender	Age (months)	NVIQ (Mean = 97,13 SD= 10,82)	Receptive Language	Expressive Language	PCC Score	Intervention Group
1	M	41	90	-2SD	-2SD	47,94%	MC
2	F	36	98	WNL	-1,5SD	64,43%	VAC
3	M	42	100	WNL	WNL	55,67%	MC
4	M	44	86	-2SD	-2SD	66,49%	VAC
5	M	52	83	WNL	WNL	80,93%	VAC
6	M	71	80	WNL	WNL	88,14%	MC
7	F	68	118	WNL	WNL	92,78%	MC
8	M	71	90	WNL	WNL	73,20%	MC
9	F	59	102	WNL	WNL	68,04%	VAC
10	F	65	101	WNL	WNL	60,82%	VAC
11	F	66	104	-2SD	-2SD	94,33%	VAC
12	M	37	102	WNL	WNL	36,08%	VAC
13	M	60	105	WNL	WNL	34,02%	MC
14	M	69	115	WNL	WNL	71,65%	MC
15	M	71	91	-2SD	-3SD	79,90%	VAC
16	M	66	89	WNL	WNL	77,84%	MC
Mean (SD)		57,38 (13,18)	97,13 (10,82)				

Note: WNL - Within Normal Limits; MC – Music Classes; VAC – Visual Arts Classes

2.3.2. Dependent measures

Study 2

The effect of music training in phonological awareness in speech and/or language disordered 3- to 6-year-olds, was measured with the assessment of these skills prior and after the training period. This assessment was made with Conf-IRA (Alves et al., 2009), also used in Study 1, and previously described.

Study 4

In this study, we aimed to understand the relationship between music and phonetic-phonological development in the disordered population. TFF-ALPE was applied and the segmental and syllabic productions were analyzed with FAFA (Saraiva et al., 2017), described in Study 3 section for dependent measures.

2.4. Design (Studies 1 to 4)

Aiming to study the association between music and language development, these 4 studies were designed with the same general structure.

A first-year pilot study included a smaller group of 3-year-olds typically developed, and the assessment of the phonological awareness skills only (Study 1). Given that the pilot study led to no changes in the design of the study, the results obtained for this group were included in Study 1, which therefore contains the data collected in two successive school years. Apart from that, all the studies followed the same methodological procedures (Figure 1).

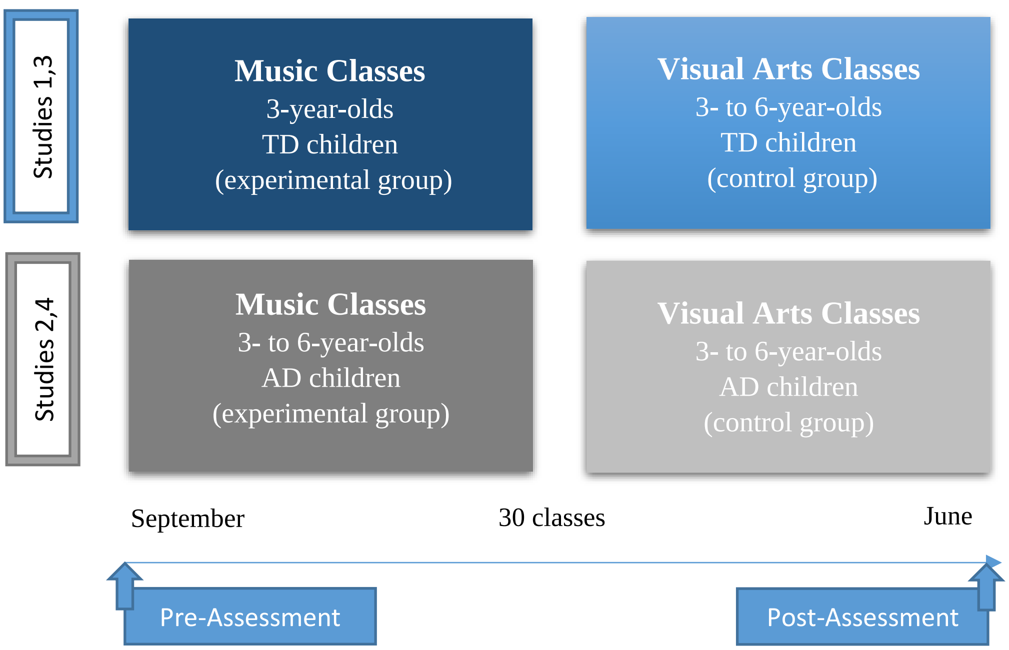


Figure 1: Timeline for the assessment and training sessions in Studies 1 to 4 in each school year.

All children were assessed in the beginning of the school year. Then, they were trained for a school year, corresponding to 30 classes that occurred once a week for 45 minutes. MC and VAC groups were balanced in number of participants. The programs were implemented by trained teachers. The same two teachers were training children in music and visual arts classes. In the first year, both were blind with respect to the research goals. For personal reasons, both teachers in the first year had to quit this research at the end of the school year. In the second year, two different trained teachers gave the classes, following the same methodology. One of them was blind with respect to the research goals, the second was the author of this thesis. These four instructors had substantial experience in working with young children.

Children in each class (experimental and control groups) were recruited from eight different classes in two kindergartens, and both participating kindergartens had one music and one visual arts group – this aimed to control for the work done by each kindergarten teacher and to rule out kindergarten effects. The children did not receive other music or visual arts lessons during this period.

The training programs were matched in duration, themes (e.g., autumn, winter, animals, Disney) and materials (all materials were used for both classes: autumn leaves, balloons, journal, rolls of toilet paper, among others).

In the present study, a number of procedures were introduced to control for external variables:

1. Kindergarten teachers and parents were blind with respect to the aim of the study, which is positive in controlling parental and teachers' expectations and possible influence in working the skills under assessment;

2. Only one of the 4 teachers giving the music and visual arts classes was aware of the research goals, whereas the remaining 3 were blind with respect to the aim of the study;

3. Also, children had no other forms of music and visual arts classes during the experimental period – making it safe to draw conclusions about the training and its effects on phonological development;

4. for the evaluation process, and in order to ensure inter-judge reliability, an external therapist blind with respect to the aim of the study transcripted a percentage of the children in the 4 studies: in Study 1, 12.24% (N=6) of the sample was transcripted, in study 3, 12,90% (N=4) of the sample was transcripted, in studies 2 and 4 12,5% (N=2) of the sample was submitted to the same procedure. This speech and language therapist also listened to the recordings of the application of Conf-IRA and TFF-ALPE in a sample of children (randomly selected) and made the phonetic transcription of the data and the scoring of the tests. Inter-judge reliability was analyzed through the percentage of accordance between the two therapists. These results are present in the Results section of this thesis.

2.5. Classes Curriculum

2.5.1. Music Lessons (Studies 1 to 4)

In the music lessons children were trained for 45 minutes, once a week, in a quiet room that offered good conditions for the different tasks. A typical session comprised a short welcome (a good morning song, a short talk), a variety of exercises and a farewell song. The musical work contained activities of listening to and exploring songs from varying genres and styles, joint singing without the lyrics (most of the time), joint drumming, melodic and rhythmic exercises based on Musical Learning Theory (Gordon, 2000a, 2000b), playful familiarization with intervals in occidental music and music using Greek musical modes, improvisation, pitch, intensity, timbre and rhythmic discrimination exercises, pitch, intensity, timbre and rhythmic production exercises, and moving/dancing along with classical music, and included live instruments or their own voice, familiarization with different instruments, instrument discrimination exercises, playing with their own body and objects of their day life (e.g. autumn leaves, toys, journals, balloons, rolls of toilet paper). The planning of music lessons is included in this document as supplementary material. According to Rodrigues, Rodrigues, Pereira, Rodrigues and Lopes (2016) using chants (melodies without the words) and songs (melodies with the words) is important, but using chants with syllables like pa-pa-pa or lai-lai-lai is crucial, since it makes it easier to the child and to the adult to pay attention to the musical aspects, and not to the semantic domain of the vocalizations.

2.5.2. Visual Arts Lessons (Studies 1 to 4)

In the visual art lessons children were also trained for 45 minutes, once a week, in a quiet room that offered good conditions for the different tasks. Here, Visual Arts classes comprehended a great variety of arts, including painting (famous artists and everyday life painting), cinema, architecture, and sculpture. A typical session comprised a short welcome (a good morning movement or statue, a short talk), a variety of exercises and a farewell moment. Exercises included the visualization of a small presentation projected on the classroom wall about the life and work of an artist, talks about famous artists, their lives and work, and the colors, shapes, and materials they used, as well as the manipulation of different painting materials (e.g., pencils, pens, brushes, hands, gouaches, pastel pencils), and modeling materials (e.g., journal with glue, plasticine, clay), drawing or constructing with usual and unusual materials (e.g., pencils, glitter, salt, autumn leaves, journals, balloons, rolls of toilet paper). The planning of visual arts lessons is included in this document as supplementary material.

3 – Music effects on Phonological Awareness

3.1. Literature review

Concepts in music, language and language pathology

In this study, we use few basic concepts for which some clarification might be useful, like language, music, or notions in the area of language pathology (Language Disorder, Developmental Language Disorder, Speech Sound Disorder and Dyslexia) – some of them are exclusive from one of the areas, others are shared between music and language fields. These definitions try to make it clear what we are studying and why. Through concepts of language and music it is possible to find obvious similarities that might be crucial to understand the relationship between both areas, although it is only a starting point.

According to the American-Speech-Language-Hearing Association (1982), language is a complex and dynamic system which is composed of conventional symbols that are used for thought and communication, having different modes of use. Language exists within historical, cultural and social contexts and is organized in areas under different rules in each language (phonologic, morphologic, syntactic, semantic and pragmatic). The interaction of biological, cognitive, psychosocial and environmental factors determines language acquisition, which use requires the understanding of associated nonverbal cues, motivation and social rules (American Speech-Language-Hearing Association, 1982). Language acquisition involves inducing structure from environmental input (McMullen & Saffran, 2004). By being exposed to the speech sounds and interactional contexts were they are used, the child develops language in a quick way that does not need formal instruction (Sim-Sim, 2017).

Music, "one of the oldest and most basic sociocognitive domains of the human species" (Jentschke, Koelsch, & Friederici, 2005, p. 232), is very often defined as a language itself, having a finite number of elements (notes and figures) that are combined according to grammatical rules, organized in hierarchical structures (Jentschke et al., 2005), generating an infinite number of meaningful utterances (Lerdhal & Jackendoff, 1983). Through human evolution, music has proven its' role in communication, group coordination, and social cohesion (Jentschke et al., 2005). The process of learning musical structure happens, like in language, through everyday exposure to music, without formal music training. Like in language development, the child shows sensitivity to some music features (implicit knowledge) and some others have to be learned (Anvari et al., 2002). In music perception, defined as the ability of perceiving and processing rhythm, pitch, or melody, which unfold over time (Hodges & Sebald, 2010; Krumhansl, 2010), the child is initially able to detect the overall music contour of a musical phrase and only after that, like in language development, (s)he perceives smaller units, such as differences between two pitches.

Music classes allow many possible methodologies. In this thesis, Edwin Gordon's Musical Learning Theory was the major inspiration. Here, the musical sessions aim to create a musical environment that gives the child the chance to listen, explore and build his/her musical vocabulary, using mostly his/her body, voice and movement to emphasize tonal and rhythmic development (with songs and chants – songs without the words, and their tonal and rhythmic patterns) (Rodrigues et al., 2016). Teachers' role is to prepare a good and varied environment, prone for the child to learn autonomously to create and improvise – rhythmic and tonal patterns make part of the set stage created by the teacher in order to proportionate the context were the child listen, comprehend, create, improvise and build its' musical knowledge. Building this musical vocabulary, as well as executing rhythmic and tonal patterns, is expected to make it easier to learn how to read and wright musical notation in school classes of formal musical education (Gordon, 2005).

Duration, intensity and pitch are used as linguistic prosodic elements (Cutler, Dahan, & van Donselaar, 1997) that are also fundamental parameters in music. Rhythm refers to temporal or durational characteristics (Hodges & Sebald, 2010); pitch is associated with a tone being perceived as high or low (Radocy et al., 1990) and corresponds to the perceptual cue of fundamental frequency manipulation; and melody is a succession of musical tones that requires the integration of both pitch and rhythm (Radocy et al., 1990). Pitch patterns exist in language as a sequence of continuous and curvilinear contours, while in music they correspond to sequences of notes (Bidelman, Gandour, & Krishnan, 2011). In both areas, intensity describes nuances in sound volume (Bolduc & Lefebvre, 2012) oscillating between loud, moderate and soft intensities (Flohr, 2003). Specifically in language, intensity is usually associated with prominence that tends to be located at utterance-final position (Nespor & Vogel, 2007). This is a salient clue used in utterance edges, as well as final lengthening, initial strengthening, and major pitch changes that point the presence of edge tones and pitch accents (Gussenhoven, 2015). These prosodic factors play an important role in the development of early linguistic segmentation abilities (Butler & Frota, 2018), being crucial in language perception and comprehension, speech production and language acquisition (Vigário, 2010). According to the prosodic phonology there is a finit number of prosodic domains hierarchicaly organized – segmental, entonational and prominence processes may depend on the organization of those phonological units (Nespor & Vogel, 2007; Vigário, 2010). Entonational phenomena, crucial on language development, are related with this prosodic structure (Gussenhoven, 2015). In a process known as prosodic bootstrapping, prosodic cues (stress, prominence and rhythm properties), intonation and prosodic boundaries help the infant to segment the speech signal, contributing to establish linguistic categories (Frota, Cruz, Matos, & Vigário, 2009).

All the common characteristics in language and music already described help us in understanding why music and language, although being different systems, have so much in common and may interact in child typical and atypical development.

Trying to reflect more closely language characteristics on child development in normal and abnormal conditions, turning the terminology closer to the reality in educational, clinical and investigation contexts, vocabulary in language pathology has changed in the last years.

The term *Primary Language Impairment* (PLI), describes a language disorder regardless of cause (Bellair, Clark, & Lynham, 2014), having no medical condition associated (Boyle, McCartney, Forbes, & O'Hare, 2007). The term *Specific Language Impairment* (SLI) is defined as a multifactorial disorder that can be caused by the combined influence of environmental and genetic risk factors (Bishop, 2009). This term, previously used to "refer to children whose language development is not following the usual course, despite typical development in other areas" (Bishop et al., 2017, p. 1068), became controversial because it did not reflect clinical realities.

Considering that the lack of agreement about criteria and terminology affects access to services as well as research and practice, Bishop and colleagues (2017) designed a study using an online Delphi method to address issues on terminology. This iterative process leads a panel of experts to rate a set of statements on these issues. These statements were then revised and rated again to a final result. With the feedback of this second round, the authors prepared a final set of statements, with the percentage of agreement and supplementary comments from the panel. Adopting terminology that is not novel, Bishop et al. (2017) propose the consistent use of some terms. The adoption of these terms will require big changes in the way people work. Considering that these changes are a fundamental step in language pathology research, and also aiming to contribute to the consistency in this field, in what follows we choose to adopt the terminology proposed in Bishopet al. (2017) in speech and language disorders terminology.

The term ‘language disorder’ is used for subjects whose profile includes language problems in middle childhood and beyond, causing functional impairment in everyday life (Bishop et al., 2017). When associated with differentiating conditions, where a biomedical diagnosis has a language disorder among others, it is recommended that it is referred as a ‘language disorder associated with X’, where X can be a neuro-sensorial hearing loss, a brain injury, Down Syndrome, among other conditions. *Developmental Language Disorder* (DLD) is then used to describe language impairment when it is not related with a known differentiation condition. In this case the term ‘developmental’ is used because the disorder emerges in the course of development, not being acquired or secondary to a biomedical diagnose (Bishop et al., 2017).

In our study, we will use the term *Developmental Language Disorder* instead of *Specific Language Impairment* or *Primary Language Impairment* along the lines of the recommendations of this international panel of experts. According to Bishop and colleagues (2017) DLD is a heterogeneous category that includes a wide range of problems. For this reason, clinicians and researchers may look for the main areas for intervention and decide to focus their attention in one specific area, getting a more homogeneous sample to study.

When the child has phonological problems that are not accompanied by other language problems, the criteria for a DLD are not met, having a good prognosis, often responding well to specialist intervention (Bishop et al., 2017). According to Bishop et al (2017), in this case, the child should be diagnosed with a Speech Sound Disorder (SSD) which can be related with a production that has motor or physical origin, involve misarticulations, or be phonologically based, in which case the problem is in the organization of speech sounds into categories.

In our thesis, we have 16 children with SSD or DLD: 5/16 have DLD and 11/16 children have a phonologically based SSD, with no impairment in the other linguistic areas.

If for many years, dyslexia and SLI (now DLD) were seen like different disorders being usually considered different disorders that co-occurred frequently (Catts, Adlof, Hogan, & Weismer, 2005), now some autohrs consider that they are manifestations of the same problem, in different stages or degrees of severity (Bishop & Snowling, 2004; Tallal, Allard, Miller, & Curtiss, 1997).

Dyslexia, also known as Specific Learning Disorder (American Psychiatric Association, 2013) or Specific Reading Disability, is characterized by specific learning difficulties in literacy, when normal intelligence and schooling are maintained (World Federation of Neurology, 1968). This common developmental disorder has a big impact on a child's education and psychosocial outcome (Bishop & Snowling, 2004; Clegg, Hollis, Mawhood, & Rutter, 2005), and leads to difficulties at school as well as through adulthood (Lyon, 1998).

Children with DLD are at risk of academic failure (Durkin, Conti-Ramsden, & Simkin, 2012), behavior and psychiatric problems (Conti-Ramsden, Mok, Pickles, & Durkin, 2013; Snowling, Bishop, Stothard, Chipchase, & Kaplan, 2006), unemployment or economic disadvantage (Parsons, Schoon, Rush, & Law, 2011).

Retrospective studies show that children diagnosed with dyslexia had, most of the times, previous language development difficulties (Snowling, Bishop, & Stothard, 2000). Similarly, children with SLI frequently have later reading difficulties (Tallal et al., 1997). According to Snowling and colleagues (2000) the reading problems observed in SLI and dyslexic children have the same causes, being related to core phonological skills, differing in the severity of the difficulties experienced before reading acquisition.

In the last years, research has investigated the relation between linguistic and musical abilities in dyslexic children, since these children show difficulties in tasks that involve accurate rapid naming, as well as in musical rhythmic activities – because of this, rhythm and rapid skills may need a bigger attention in musical training with children with dyslexia (Overy, Nicolson, Fawcett, & Clarke, 2003).

Knowing that dyslexic children may have also some constraints in musical skills, and since it seems to exist a clear relation between dyslexia and DLD (prior to learning to read and write) made us choose to look for music effects in children with DLD. Then we can investigate this relation in an earlier stage of language pathology.

Phonological Awareness – definition, role and relationship with music

Studying the influence of music on the development of phonological awareness is of particular interest because of the role of phonological awareness on subsequent language related abilities, such as reading and writing. Phonological awareness, “the conscious sensitivity to the sound structure of language” (Herrera et al., 2011, p. 69), can be defined as the explicit awareness of the sound structure of words in oral language (Freitas, Alves, & Costa, 2007; Sim-Sim, 2006; Wagner et al., 1997), referring to the understanding, detection, and manipulation of a language sound system (Freitas et al, 2007, Patscheke, Degé & Schwarzer, 2016, Sim-Sim, 2006). This individual sensitivity to the sound structure of language includes the ability to analyze and manipulate language at the word level (large phonological unit) and at the phoneme level (small phonological unit) (Patscheke et al., 2016). Phonemic awareness ability refers to the sensitivity to the sound of the smallest pronounceable units of the fonological component – usually referred to in the literature of this area as *phonemes* (Herrera et al., 2011).

Besides phonemic awareness, there is also the intra-syllabic awareness, which refers to the ability to manipulate sound sequences larger than the phoneme, but smaller than the syllable: the onset and the syllable rhyme (Afonso, 2015; Sim-Sim, 2006).

Phonological awareness tasks include: isolating individual words from the speech flow (Patscheke et al., 2016), rhymes evocation (Rios, 2009; Santos, 2012), identifying words that rhyme, blending syllables (combining syllables into word or pseudowords), syllabification of words or pseudowords, counting the syllables within a word, identifying words that have a common syllable (Lathroum, 2011), the segmentation of syllables into onset and rhyme (Alves et al., 2009; Rios, 2009), blending sounds (combining sounds into words or pseudowords) (Lathroum, 2011), sound segmentation, elision, or matching (Yopp, 1992), correcting speech errors, or discriminating words in terms of a different sound (Lathroum, 2011). The child must recognize these linguistic sound categories in spite of variations in pitch, tempo, speaker, and context (Anvari et al., 2002).

Some authors (e.g., Alves et al., 2009; Rios, 2009) consider the word awareness is part of phonological awareness, as the word is also a phonological constituent, which is part of the phonological hierarchical organization and a domain of phonological rules (Afonso, 2015). In this way, tasks like finding words in a sentence or segmenting phrases into words, may also be included in the phonological awareness assessment (Afonso, 2015; Alves et al., 2009).

During kindergarten, children develop phonological awareness skills, although some aspects seem to be acquired informally, when comparing and discriminating words that sound similar (Lathroum, 2011). According to Lane & Pullen (2004), rhyming is one of the first skills acquired. Children show early ability to identify words that sound similar or different before they are able to manipulate sounds in words. However, this easily acquired ability might refer only to *metrical* rhyme. Metrical rhyme involve similarities between two words from the stressed vowel or diphthong to the end of the word (Afonso, 2015). Identifying words that rhyme has been considered the easiest operation among phonological awareness tasks, emerging in 3- to 3:6-year-olds, and gradually developing until children reach age 5 (Rios, 2009; Santos, 2012). However, development is different if we consider *syllabic* rhyme.

Syllabic rhyme awareness refers to the identification of the components (nuclei and coda) inside the syllable itself (Afonso, 2015; Sim-Sim, 2006). Detecting this type of rhyme is more difficult than identifying metrical rhyme (Barrera & Maluf, 2003). In her sample, Afonso (2015) found that only 0.9% of children in the 1st grade (at age 6) successfully performed this task.

Children can also blend sounds to form words before they segment words into phonemes – the developmental sequence seems to progress from the perception of larger sound chunks to smaller units of sounds (Anthony & Francis, 2005). Authors like Lathroum (2011) consider that the developmental sequence begins with children’s ability to recognize larger units, like words, proceeding to their ability to analyze syllables and then phonemes. However, Afonso (2015) found that only 18% of pre-school 5 years old children of her sample were able to identify the unit ‘word’ within a phrase, and the phrase segmentation task is considered difficult for EP-speaking children at these ages (Antunes, 2013; Cardoso, 2011). This difficulty may also depend on the prosodic status of the word, since EP-speaking children are better in segmenting stressed functional words compared to unstressed (Cardoso, 2011). According to Cardoso (2011) children at school age are better than preschoolers in word awareness tasks, showing that alphabetization plays a crucial role in this ability. These results may suggest that children will only identify word boundaries clearly when they learn how to separate them in reading and writing, with blank spaces (Basseti, 2005; Chaney, 1989).

The ability to omit syllables in words has been tested in preschoolers between 4:8 and 6 years old by Carvalho (2012), in a pilot study of Conf-IRA (Alves et al., 2009). The results for these ages show a mean score of 1.69 / 5 for initial syllable omission, and 1.23 for last syllable omission. Afonso (2015) showed that 66.8% of the children at the 1st grade (6-year-olds) and 97.7% of the children in the 3rd grade (8-year-olds) did this task successfully. Syllable inversion has been tested with Conf-IRA (Alves et al., 2009), in 4:8- to 6-year-olds by Carvalho (2012), who found a mean score of 0.38 / 4.

Phonemic awareness tasks seem to be the most difficult operations for pre-school children, since at this age they seem not to be able to count phonemes within a word or identify a word final sound (Peynircioglu, Durgunoglu & Uney-Kusefoglu, 2002), showing limited ability to manipulate individual sounds in words (Lathroum, 2011).

All the data presented attest that in EP segmental awareness is very difficult in pre-school years, corroborating Henriques (2008), Paulino (2009) and Veloso (2003), information that lead us to exclude some tasks in phonological awareness assessment in Studies 1 and 3, as it was already mentioned in the section about methodological procedures.

Mastering phonological awareness skills is of key importance in writing and reading acquisition, since transforming print symbolic information into linguistic mental representations is based on children’s prior language experience, in particular, their attention to the components of words (Gordon, Fehd & McCandliss, 2015; Wright &

Jacobs, 2003), and their ability to recognize and manipulate the phonological segments of spoken words (Peynircioglu et al., 2002).

Neural mechanisms responsible for phonological awareness can also explain individual differences on literacy learning (Schlaggar & McCandliss, 2007). Children's understanding of how the written symbols map onto the sounds that form a word is better when the child has fully developed phonological awareness abilities, and auditory sensitivity to the spoken phonemic units is an advantage for learning the orthographic to phonological mapping system, being considered a pre-requisite to reading (Goswami, 1990) or a predictor of this subsequent ability (Cardoso & Martins, 1991; Öney & Durgunoğlu, 1997).

In the last years the relation between music and phonological awareness has been studied, as we will se later in this chapter, trying to better understand the relationship between both areas, as well as the reasons why this relation exists.

Common structures in music and language

Music and language are highly structured systems, to which we are exposed in our everyday life (Jentschke et al., 2005) – both consist of auditory stimuli, are generically structured, deliver messages (Lehrdahl & Jackendoff, 1983) and may use the same vocal apparatus in the production level (Anvari et al., 2002). There is also a parallel in terms of spoken / sung and written representations of both areas. Spoken / sung stimuli are always composed by a limited number of units and structures, being possible to identify a phonological area since both involve combining a small number of elements (phonemes VS notes and figures) to create an unlimited number of productions. Like in syntax in music there are also rules responsible for generating an unlimited number of phrases or utterances that are meaningful (Anvari et al., 2002; Degé & Schwarzer, 2011; Lehrdahl & Jackendoff, 1983). Related to the written representations, music and language are also parallel, since they both have a written code mapped directly onto sounds (Moreno, Bialystok, et al., 2011).

While the relevant units are different, the basic learning processes may be similar (Saffran, Johnson, Aslin & Newport, 1999) – learning both sound systems requires extracting a small number of categories that are meaningful from a sequence of acoustically variable signals

(Degé & Schwarzer, 2011). The ability to perceive sounds in relation to one another is present in both language and music, which according to Lathroum (2011) may point to parallel auditory processing mechanisms. As it has been referred earlier in this document, musical and linguistic systems can be learned in an casual / informal manner, and from this environmental passive exposure the human brain can extract the regularities of these systems – this implicit knowledge will influence perception and performance (Jentschke et al., 2005).

Durational and pitch modifications present in language (as prosodic elements) and in music (in rhythm and melody) are used to mark group boundaries. In music processing, in order to organize sound sequences into relevant patterns, listeners use metric, rhythmic, melodic, and harmonic information – there are larger and smaller pitch and rhythmic units, organized in hierarchical structures (Krumhansl, 2000; Radocy, LeBlanc & Boyle 1990). In language, segmenting and processing the speech signal involves the use of word stress, phrasal prominence and rhythmic patterns, tones and intonation, as well as duration patterns and pauses. These elements can also play a crucial role in language development in the identification of significant categories and category groupings, organized in hierarchical structures (Bion, Benavides-Varela & Nespor, 2011; Frota, Cruz, Matos & Vigário, 2016).

According to Patel and Iversen (2007, p.370), “pitch is a highly structured aspect of music and is also used to convey linguistic information”. Music and language feature a rhythmic organization, marking group boundaries in similar ways using pitch movements and durational modifications. This implies a cross-domain sensitivity to these cues, which starts early in life (Jusczyk & Krumhansl, 1993), and at least an input processing mechanism in infants tuned to linguistic prosodic information (Höhle, 2009). Prosody has a fundamental role in language acquisition, development and comprehension, as well as in the organization of sound material (Langus, Marchetto, Bion, & Nespor, 2012).

Prosodic development is then considered important in this relationship between music and language, since linguistic prosodic elements (duration, intensity and pitch - Cutler, Dahan, & van Donselaar, 1997) are also present in music. In this way, musical training might help developing prosodic abilities, interfering with language development.

In the brain, neuroimaging studies found significant anatomical and functional differences between musicians and non-musicians (Gaser & Schlaug, 2003; Hyde et al., 2009; Schlaug, Jäncke, Huang, Staiger, & Steinmetz, 1995), showing that in musicians, music and language are processed in the same areas in both hemispheres (Lathroum, 2011; Platel et al., 1997; Zatorre & Schönwiesner, 2011), revealing a significant overlap in activation patterns (Peretz & Zatorre, 2005).

Music processing activate regions in both hemispheres, with an asymmetry for pitch-based processing, in the right side of the brain (Peretz & Zatorre, 2005). In speech, both perception and production may invoke an overlapping of neural structures that may work independently or in tandem (Skoe & Kraus, 2012). These common neural systems include the posterior portion of the left and right superior temporal gyrus (STG) and superior temporal sulcus (STS), as well as the left inferior frontal gyrus (IFG – Broca's area) (Lathroum, 2011).

Music impact on brain plasticity also affects the subcortical encoding of linguistic pitch patterns (Wong, Skoe, Russo, Dees, & Kraus, 2007), specifically the auditory brainstem, which role is fundamental in the processing of all sounds that enter the cochlea, making it an obligatory structure both in speech and music (Bidelman et al., 2011; Skoe & Kraus, 2012). According to Strait, Hornickel, & Kraus (2011) human auditory brainstem responses are enhanced, and this subcortical development of regularly-occurring speech is related to a better performance in tasks like reading or speaking under optimal conditions and not-optimal listening conditions – this process is driven by top-down cortical modulation of subcortical responses. Because of this, music aptitude and literacy abilities should have a positive correlation with subcortical enhancement of speech cues, since there may be shared subcortical resources for speech and music (Peretz & Zatorre, 2005) enhancing how music is represented in the brainstem (Wong et al., 2007).

The corticofugal system seems to be crucial in this process, serving as a mediator in the communication between subcortical structures and high-order cognitive processes in order to tune other behaviourally-relevant signals (Peretz & Zatorre, 2005). This top-down corticofugal processes may interact with permanent and temporary bottom-up and local processes, shaping subcortical function (Skoe & Kraus, 2012).

But music effect goes beyond the auditory system onto the dorsal and ventral pathways, which role is primordial in language acquisition (Hickok & Poeppel, 2007; Scott & Wise, 2004) – in language, the ventral stream (largely bilaterally organized and involving structures in the superior and middle portions of the temporal lobe) is responsible for processing speech signals for comprehension, and the dorsal stream (left-hemisphere dominant and involving structures in the posterior frontal lobe and the posterior dorsal-most aspect of the temporal lobe and parietal operculum) is responsible for mapping acoustic speech signals to the articulatory networks in the frontal lobe (Hickok & Poeppel, 2007) and may have also an auditory-motor integration role (Scott & Johnsrude, 2003; Wise et al., 2001).

A sensorimotor interface exists in an area in the Sylvian fissure at the parieto-temporal boundary (area Spt) in the posterior region of the dorsal stream. This area is located in the Planum Temporale (PT), associated with speech processing, but also activated with various acoustic signals, like tone sequences, music or spatial signals, and non-acoustic signals, like visual speech, sign-languages or visual motion. According to Hickok and Poeppel (2007), this may mean that PT region (in the dorsal pathway) receives various acoustic and non-acoustic information, linking speech, tones, music, environmental sounds and visual speech to the vocal tract gestures.

Specific neuroanatomical structures appear to be common to the perception of musical and speech sounds specifically when talking about phonological awareness (Tervaniemi, 2006; Warrier et al., 2009). Hemispheric specialization seems to be a result of the processing of acoustic characteristics of the signal – despite the auditory stimuli is musical or speech signal, the auditory system perceives rapidly-occurring temporal or spectral information from either signal in similar ways, and this might be one of the reasons for a possible overlap in brain structures (Lathroum, 2011): in the right hemisphere, the rapid temporal processing occurs, as well as the perception of specific aspects of speech, like prosody (Platel et al., 1997; Zatorre & Schönwiesner, 2011); and in the left hemisphere, the fine spectral processing occurs, including rhythm in music, phonemic discrimination, and rhyme judgments in speech (Zatorre & Schönwiesner, 2011).

These domain-general abilities, that exist in both music and speech processing, may build the basis for the connection between the two areas (Degé et al., 2015). According to Peretz and Zatorre (2005) music and language processing cannot be completely modular (meaning that one should be immune to the other), but this does not imply that they are processed by a common core of mechanisms. It is possible that separable components compete for general attention or memory, and that learning music experience improves executive function, influencing a variety of cognitive domains.

Music influence in language development – possible explanations

The fact that music and language share the same auditory domain, the organization of discrete perceptual elements into structured sequences (Patel, 2003), the need for segmentation both sequences in smaller units (Lathroum, 2011), and common processing mechanisms (McMullen & Saffran, 2004; Patel, 2008) may help to understand the relationship between language sound categories and musical sound categories (Degé & Schwarzer, 2011).

Domain transfer effects may or may not implicate a direct interaction, although recent research points to the mediation of executive functions, domain-general attentional or corticofugal inluences (Skoe & Kraus, 2012). Anvari et al. (2002) suggest that skills in music perception are related to auditory and cognitive mechanisms beyond those tapped by phonological awareness, pointing to a domain-general effect of music in language.

According to Peynircioglu et al. (2002), in child development, experiencing and acquiring a certain spoken language influences phonological awareness skills. For example, when comparing phonological differences between similar words to learn their meanings, the child must be able to compare sounds between words, developing phonological sensitivity in this learning process. The authors claim that if this happens, some different auditory experiences may also enhance phonological awareness skills – if music and speech processing involves similar skills in sound discrimination, temporal sequencing, attention, and working memory, getting the child exposed not only to speech, but also to music, may help developing auditory skills that might contribute to better speech perception and enhanced phonological awareness (Lathroum, 2011).

Music perception requires the ability to listen to musical stimuli making comparisons between perceived sounds, as well as predicting subsequent sounds (Lathroum, 2011). According to Koelsch (2009) music perception involves acoustic analysis, auditory memory, auditory scene analysis, as well as processing of musical syntax and semantics that depend on complex brain functions. Most of the music perception abilities may enhance music listening skills, and then improve speech perception, promoting some aspects of speech processing mechanism (Corrigall, Schellenberg, & Misura, 2013). In both speech and music, children must discriminate and process sounds that are extracted from perceived acoustic signals varying over time. Auditory temporal processing, important in both areas, is key, for instance, to children's discrimination of similar-sounding consonants, which is essential in phonological awareness and reading and writing learning (Lathroum, 2011).

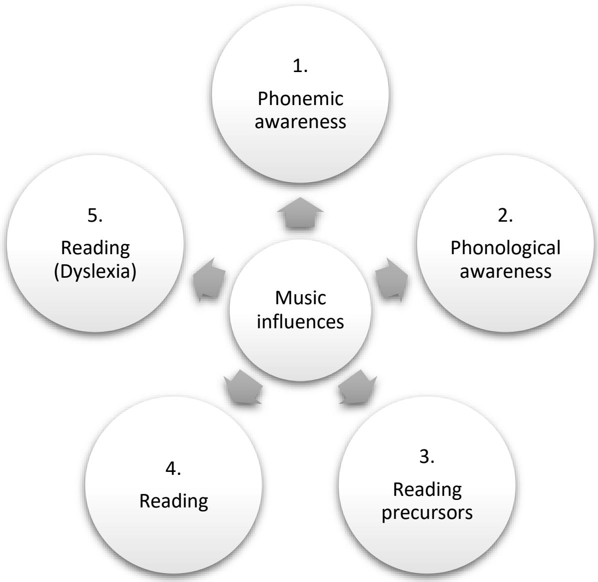
According to Patel (2008), music and language share the same mechanism for learning sound categories ("Shared Sound Category Learning Mechanism Hypothesis" – SSCLMH) which predicts comparable individual differences in language and musical abilities – the building blocks of language (e.g., phonemes / tones) should be related with the building blocks of music (e.g., pitches / notes), since speech and musical sounds are perceived in relation to one another. Besson, Chobert and Marie (2011) also mention the overlap of brain structure in music and language processes and report an enhanced sensitivity in musicians to auditory patterns like frequency and duration, fundamental in both music and speech processing, that can be an advantage in phonological processing. Degé and Schawrzer (2011) also claim that these shared mechanisms will lead to comparable gains in children exposed to phonological awareness and music programs.

A possible explanation for this acoustical sensitivity is given by the Precise Auditory Timing Hypothesis (PATH) (Tierney & Kraus, 2014), according to which music training leads to the precise perception of acoustic event timing since entrainment practice is crucial in both music and language (Patscheke et al., 2016). Over extended periods of musical training, this might result in the automated representation of acoustic events. This higher precision also benefits sound perception, and consequently phonological skills (Patscheke et al., 2016).

Patel's OPERA hypothesis (Patel, 2011), in turn, is a global model aiming to explain how music training might influence speech processing. According to the OPERA hypothesis, the benefits of training are due to adaptive plasticity in speech-processing networks. For producing these transfer effects Patel (2011) refers five necessary conditions: (1) Overlap (an anatomical overlap in brain networks in both music and speech); (2) Precision (in these shared networks, music places higher demands in terms of the precision of processing); (3) Emotion (the music activities elicit strong positive emotion); (4) Repetition (musical activities are frequently repeated); (5) Attention (music activities are associated with focused attention). According to the author, getting these conditions together leads to neural plasticity which drives the networks in question to function with higher precision than needed for daily speech communication. Thus, if speech shares these neural networks with music, speech processing benefits from music training (Patel, 2011).

Music influence in language development – state of art

Research on the association of music and language development has shown music effects on phonological awareness (word, syllabic and phonemic awareness), reading precursors, reading, and reading in dyslexia, as it depicted in Figure 2. In some work, the variability in linguistic skills is measured without music training, by measuring individual differences in music aptitude (Anvari et al., 2002; Degé et al., 2015; Degé & Schwarzer, 2012; Forgeard et al., 2008; Lamb & Gregory, 1993; Lathroum, 2011; Peynircioglu et al., 2002; Rubinson, 2009; Woodruff Carr et al., 2014; Zuk, Andrade, et al., 2013). Other studies rely on a test-training-retest methodology, being closer to prove a causal relation effect (Degé & Schwarzer, 2011; François et al., 2013; Herrera et al., 2011; Moreno et al., 2009; Moreno, Friesen, et al., 2011).



	Ages	References
1.	3-6	Gromko (2005)
	4:6-5:6	Lamb & Gregory (1993)
	4 - 7	Peynircioglu, Durgunoglu & Kusefoglu (2002)
2.	4-5	Anvari et al. (2002)
	5	Degé & Schwarzer (2011);
	8	François et al. (2013)
	5-6	Lathroum (2011)
		Moritz (2007)
	3-4	Woodroof Carr et al. (2014)
3.	4 – 5	Anvari et al. (2002)
	4	Degé, Kubicek, & Schawrzer (2015)
	6	Degé & Schawrzer (2012)
	4:6-5:6	Lamb &Gregory (1993)
	3-4	Woodruf Carr et al. (2014)
4.	6 - 9	Zuk et al (2013)
5.	7	Overy (2002);
	10	Forgeard, Schlaug, Norton, Rosam & Iyengar (2008)

Figure 2: Skills already investigated in the research on the influence of music in language development, with reference to the authors and the ages comprehended in each study.

When talking about music association with phonological awareness skills, Anvari et al (2002) concluded that in 5-year-olds pitch processing (but not rhythm) was significantly positively correlated with phonological (syllabic and phonemic) awareness. In 4-year-olds, musical skills (pitch and rhythm together) were significantly positively related to phonological and reading measures. The authors studied the relations among musical skills, phonological processing, and early reading ability in pre-school Canadian children with 4- and 5 years old (N = 50 in each group). Music assessment encompassed pitch, rhythm, harmony discrimination, and rhythmic production. Phonological awareness assessment included rhyme discrimination, oddity discrimination, phoneme blending, and sound segmentation.

Degé and Schwarzer (2012) showed positive associations between phonological (syllabic and phonemic) awareness and musical perception and reproduction skills, studying 55 German preschoolers (28 female, age mean 6:3 years old). The results showed significant positive associations between the total score of the phonological awareness test and music perception and production abilities (overall scores). Positive associations were found between phonological awareness and pitch perception, rhythm perception, and tone length perception, between phonological awareness and song reproduction, and phonological awareness and rhythm reproduction. A positive association was also found between working memory and rhythm abilities (perception and production). Language assessment included phonological awareness (rhymes, synthesis of phonemes, segmentation of words, and phoneme recognition in words), working memory (recall of nonsense words), selective attention (word comparison task), and rapid automatized naming (speed naming of fruits). The music abilities assessed (production and perception) included comparisons of melody, pitch, rhythm, meter, and tone length, and reproduction of a given rhythm, meter, and song.

Lathroum (2011) also found that music perception has a significant contribution to phonological awareness. The author defends the existence of a ‘perceptual overlap’ in language and music processing, since similar perceptual skills may be used in the detection of both speech and musical sounds, from linguistic and musical sequences to smaller units. In order to understand the role of music perception in predicting phonological awareness in 5- and 6-year-old children (N = 119), Lathroum (2011) assessed music perception (including perception of pitch, rhythm, and melody), phonological awareness skills (including blending, elision, and sound matching), and visual spatial skills – all the American children were proficient in English, as their first or second language. The results showed that, taken together, music perception, visual spatial skills and age predict phonological awareness development – together, these variables account for 30.3% of the variance in phonological awareness. When controlling for visual spatial skills and age, music perception had a significant contribution to phonological awareness (11.4% by itself). Omitting music perception as a predictor of phonological awareness development, age and visual spatial skills accounted for 18.9% of the variance.

Woodroof Carr et al. (2014) studied the relation between beat synchronization and pre-reading skills in 3-year-olds, investigating the hypothesis that beat synchronization predicts neural speech encoding and reading readiness in American monolingual preschoolers between age 3 and 4 (N = 35, 18 female). Beat synchronization task, IQ, vocabulary, phonological awareness, verbal memory, rapid automatized naming, and music perception were assessed. The authors found that preschoolers who can synchronize are better in pre-reading skills, arguing that this possibly indicates a common neural network in these tasks. Underlying both beat-keeping and language development, auditory motor synchrony has been claimed to influence both language and music abilities.

Moritz (2007) found that 1) phonological segmentation subskills (at the word, syllable and phoneme level) as well as rhyming ability, were significantly related to rhythm pattern production and discrimination abilities and 2) children with intensive music training showed disproportionate improvement in rhyming skills and better ability to perform phoneme segmentation tasks. Children were assessed at the beginning and at the end of the school year. Phonological awareness assessment included syllabification of words, rhyming discrimination, and isolation of medial phonemes. Music assessment included tempo production, rhythm pattern production, and rhythm pattern discrimination. In this study, musical rhythm subskills were assessed in kindergarten American children (N = 30), comparing students from two different schools with different amounts of music training (Kodály daily classes versus weekly classes that were not based on Kodály's methodology). Although these results seem very interesting, in order to fully interpret them, a control group with an alternative training would be needed to compare the results of children with music weekly classes with typical development; besides that, it is difficult to compare the two groups because of the methodological differences, namely in classes periodicity and in the teaching method.

Gordon et al. (2015) concluded that music training leads to gains in phonological awareness – the effects for rhyming skills tended to grow stronger with increased hours of training, and no significant transfer effect was found for reading fluency measures. In a meta-analysis, the authors analyzed 13 studies (N = 901) that tested the direct transfer hypothesis, including music training versus control groups, pre- versus post-comparison measures, and indication that reading was held constant across groups, meaning that intervention and control groups should have equivalent amounts of reading instruction. Participants in this meta-analysis were speakers of different languages: French, Brazilian and European Portuguese, German, English (US, UK and Canada), Spanish, and Tamazight. In these 13 studies, music intervention included different training components: phonology in music context (6/13); movement / kinesthetic (8/13); rhythm (9/13); instruments (7/13); rhyming (5/13); clapping / marching (5/13); visual representations (5/13); singing (12/13); and musical notation (3/13).

With a randomized control study, Bolduc (2009) found that children in a program specifically designed to increase preschoolers' interest in reading and writing by using musical activities, developed better phonological awareness skills when compared to the control group who had music lessons guided by the Menistére de l'Éducation du Quebec music program. In this study, 101 Canadian children, French speakers, (mean age 5:1 years old) had daily lessons, for 60 minutes, for 15 weeks. In other study, Degé and Schwarzer (2011) concluded that children submitted to a phonological skills and a music program showed significant increases from pre- to post-assessment, in large phonological units. In this randomized control study, the authors divided the sample (N= 41, 19 females, 5 to 6 years old) in 3 groups that were submitted to 1) a music program, 2) a phonological awareness program, and 3) a sports training program – 10 minutes, daily basis classes for 20 weeks.

Herrera et al (2011) showed that 1) a 1st experimental group with phonological awareness training and a 2nd one which associated music and phonological awareness outperformed the control group (with no training) in the rhyme task; 2) in syllabic tapping, both experimental groups outperformed the control group. The authors directed a stratified randomization procedure to understand the effects of phonological and musical training on Spanish- and Tamazight-speaking children reading readiness (45 children were Spanish native speakers and 52 children were Tamazight native speakers, mean age 4:6 years old). Training period was of 8 weeks (2 hours / week classes), plus a second period of training, six months after the first phase, where the procedure was repeated. Children were assessed in a pre-test and 3 post-test moments with a phonological awareness test including rhyme (different ending of the word – syllabic rhyme of the last syllable coincident with metrical rhyme of the word), syllabic tapping, and initial phoneme oddity task. Herrera et al. (2011) reported the rhyming results with a possible relation between rhymes in songs and rhymes as phonological awareness skill. Interestingly, the authors trained metrical rhyme with the 2nd experimental group, obtaining results when testing metrical rhyme coincident with syllabic rhyme - the authors did not use a comprehensive music program, only modifying a phonological entraining program by embedding the isolated words from this program in short songs. According to Patscheke et al. (2016) this fact makes it unclear whether music itself was responsible for producing the effects on phonological awareness. In addition to this fact, different types of rhymes were used in training and assessment, what may suggest that music class students benefit from the music stimuli per se – beyond the segmental part of songs.

Finding the same results that Herrera et al. (2011), Patscheke et al. (2016) did not design a music program specifically for promoting phonological awareness skills, implementing a music training 3 times per week, 20 minutes sessions for 14 weeks. Patscheke and colleagues found a significant increase in phonological awareness of large phonological units 1) in a music trained group and 2) a phonological skills trained group, when compared with a control group with sports training. The authors examined these effects in 4- to 6-year-old children of immigrant Kurdish, Russian, Asian and American families (N = 39, 20 female) that were in Germany at least at 5 years, and that reported to speak little German at home, indicating a poor German language level.

Studying the effect of music training in promoting pre-literacy skills in 4- to 6-year-old children (N = 60), Canadian English speakers, randomly assigned to music classes (experimental group) or visual arts classes (control group), Moreno, Friesen and Bialystock (2011) found no significant differences between the experimental group with music classes and the control group with visual arts classes, in rhyming assessment. Children had a training period of twice a day classes, for 45 minutes, in a total of 40 classes. These classes were based on a computerized training program created by the first author, projected on the classroom wall and included training on rhythm, melody, pitch, voice, and basic music concepts, like note to sound mapping. The program involved animated characters that engaged children after each response, and each lesson was conducted by a teacher, three teaching assistants and one research assistant. Pre- and post-assessment consisted on a phonological awareness test (rhyme comprehension and production), and a visual auditory learning test. On the visual auditory learning measure, music trained children improved significantly more than the art trained children. The authors suggest that this result is probably related to the training of note-to-sound mappings in music. No significant differences between groups were found in the rhyming assessment. But a difference emerges after pretest scores are equated in an ANCOVA. Because of this result the authors suggest that the effects of music training in pre-literacy skills should be considered preliminary and suggestive, justifying this non-significant difference with the fact of an existent qualitative difference between the groups at pre-assessment that enabled the music students to exhibit greater improvement. In our understanding, there is a generalization of rhymes ability that is being fundamental to the interpretation of these results, since this was the only task referred in pre-literacy assessment. It can happen that this particular ability is not affected by this specific program of music training that included “note to sound” mappings. This entrainment, on the other hand, made an improvement in the use of symbolic representations, which lead to gains in visual auditory learning.

François et al (2013) found improved segmentation skills (word awareness) for the music trained children French native speakers, opposed to the painting trained ones, at age 8 (N = 24, 10 female). With a test-training-retest procedure, children were pseudo-randomized and had lessons for 2 years. Pre- and post-assessment included a specific designed test to evaluate the ability to segmenting speech signal, recognizing a word within a sequence of pseudowords, and encompassed an artificial language, a learning phase, and the test itself.

Lamb and Gregory (1993) and Peynircioglu et al. (2002) found an association between music and phonemic awareness. Lamb and Gregory (1993) demonstrated that pitch discrimination was significantly correlated with phonemic awareness, suggesting that pitch perception appears to be related with the perception of small differences in phonemes. The authors developed a study to explore the relation between music and reading in beginning readers, from 4:6 to 5:6 years old (N = 18). The music skills assessed included an experimenter-designed pitch and timbre discrimination measure, rhythm production, rhythm discrimination, chord discrimination, chord analysis, and melody discrimination. Linguistic abilities assessed encompassed rhyme generation, blending (word synthesis from onset and rhyme), oddity (first, middle, or last sound discrimination), Wrat-3 reading subtest, and vocabulary.

In the same way, Peynircioglu et al. (2002) found that children with high musical aptitude (measured after the assessment with a musical aptitude test) had higher results in all linguistic and musical tasks (phoneme deletion tasks in words and pseudowords, and initial and final tone deletion tasks of snippets of melodies), showing that success in manipulating linguistic sounds is related to the awareness of distinct musical sounds in Turkish children aged 4:9 to 6:1 years (N = 32), and in American children aged 3:9 to 6:10 years (N = 40).

Table 2 systematizes the studies earlier presented, children spoken-languages, their ages and principal results.

Table 2: Studies that relate phonological awareness skills with music: children spoken languages, ages, and results.

Authors	Spoken Language	Ages	**Result**s
Anvari et al (2002)	English or French	4 and 5 years old	Pitch processing significantly positively correlated with syllabic and phonemic awareness
Degé and Schwarzer (2012)	Germane	6 years old	Music perception and reproduction skills associated with syllabic and phonemic awareness
Lathroum (2011)	American English as their first or second language	5 and 6 years old	Music perception, visual spatial skills and age predict phonological awareness development
Woodroof Carr et al. (2014)	American English	3 years old	Beat synchronization related with pre-reading skills
Moritz (2007)	American English	Pre-schoolers	1) Phonological segmentation subskills and rhyming ability, significantly related to rhythm pattern production and discrimination abilities 2) intensive music training related to improvement in rhyming skills
Gordon et al. (2015)	French, Brazilian and European Portuguese, German, English (US, UK and Canada), Spanish, and Tamazight	4 to 9 years old	1) Music training leads to gains in phonological awareness 2) Effects for rhyming skills tended to grow stronger with increased hours of training
Bolduc (2009)	French	5 years old	Music training designed to develop phonological awareness skills leads to a larger development when compared to a control group with regular music classes
Degé and Schwarzer (2011)		5 to 6 years old	Phonological skills and music programs showed significant increases in large phonological units
Herrera et al (2011)	Spanish- and Tamazight	4 years old	Phonological awareness training and associated training of music and phonological awareness leads to gains in rhyme task and syllabic tapping
Patscheke et al. (2016)	Poor German language level	4 to 6 years old	Music trained group and phonological skills trained group developed phonological awareness of large phonological units
Moreno, Friesen and Bialystock (2011)	Canadian English	4 to 6 years old	No significant differences in rhyming assessment between children with music classes and children with visual arts classes

Music influence in language disorder– state of art

DLD and Dyslexia may be seen as the same problem with different degrees of severity, in different stages of language development. In both developmental profiles, difficulties in auditory processing and motor sequencing are described. We address this topic in the next paragraphs because of its obvious role in music and language development and their interaction.

Knowing that linguistic and musical skills are correlated, lead to the hypothesis that individuals with DLD would also have deficits in musical processing (Gordon, Fehd, & McCandliss, 2015). In fact, in children with speech and language impairment, the sensitivity to auditory cues like rhythmic timing, amplitude envelope rise time and duration, is lower than in controls (Corriveau, Pasquini, & Goswami, 2007).

These linguistic rhythm problems appear to extend to rhythmic motor entrainment, since children are also impaired in paced rhythmic tapping (Corriveau & Goswami, 2009), while "tapping in synchrony with a beat has been described as the simplest rhythmic act that humans perform" (Corriveau & Goswami, 2009, p. 119). In line with this, Woodruff Carr, White-Schwoch, Tierney, Strait, and Kraus (2014) demonstrated that beat synchronization (which is a task that needs precise integration of auditory perception and motor production) is related to pre-reading skills – preschoolers that had problems in synchronize tapping with a paced phonemic condition had poorer results in phonological processing, auditory short-term memory and rapid naming tasks, as well as in music perception tasks.

Difficulties in speech segmentation have been described in children with language-based learning impairments (Evans, Saffran, & Robe-torres, 2009), as well as lower perception of speech rhythms (Goswami et al., 2011) and difficulties in tasks that evolve musical metrical structures (Huss, Verney, Fosker, Mead, & Goswami, 2011). According to Corriveau and Goswami (2009) this language deficit is very often reported with co-morbidity with motor coordination deficits. In dyslexia, deficits in responding to rapidly presented stimuli are described in visual processing, motor sequencing and auditory sequencing (Tallal, Sainburg, & Jernigan, 1991), suggesting that in fact this deficit may be related to linguistic and musical perception (Anvari et al., 2002).

According to Forgeard et al. (2008) in dyslexia there are difficulties in auditory discrimination, segmentation of sounds, grouping sounds into phrases and mapping of sounds into visual symbols. Overy (2003), in turn, reports that dyslexic children show timing difficulties in the domains of language, music, perception, cognition, and motor control.

According to Overy (2003), in music, dyslexic children often do not have difficulties in pitch discrimination, but they do show limited skills in timing, revealing problems in perceiving, copying, and tapping rhythms. However, pith discrimination deficits are referred by Forgeard and colleagues (2008) accompanying rhythm processing deficits in a group of 31 American children (mean age=10.05) that performed below average in both rhythmic and melodic subtests of Gordon's Intermediate Measures of Music Audition and in a Melodic/Rhythmic Discrimination task created by the authors. These results may mean that musical impairment in children with dyslexia is not just in the processing of rhythm. This seems consistent with Patel's hypothesis of shared resources and the existence of an overlap between language and music (Forgeard, Schlaug, et al., 2008).

Fine and gross motor skills seem to be impaired in children with DLD, but may not be globally impaired, being specific to certain tasks. Although there is no obvious neurological detection, it may happen that there are subtle impairments in both language and motor development in the neural mechanisms for the perception and the expression of rhythm and timing (Corriveau & Goswami, 2009). In the brain, electric responses were studied in 5-year-olds with and without language impairments. ERAN (early right anterior negativity) and ELAN (early left anterior negativity) were investigated. These types of brain responses are important because the first one happens by a violation of music regularities, and the second is linked to syntactic processing in language domain. Besides that, both are partly generated in the same brain regions, which can lead to a transfer effect between music and language. It was found that in the brain of 5-year-olds with SLI, no electric response existed for ERAN, indicating difficulties in musical syntax processing (Jentschke et al., 2005).

Some studies have also been developed about the relation between music and language in children with dyslexia. Trying to evaluate the potential of music lessons as a way of helping children with dyslexia, and to understand the nature of musical timing difficulties often reported for dyslexic children, Overy (2003) designed a test-training-retest methodology in an ongoing program of singing-based music lessons (20 minutes, 3 times per week) with a class of 28 children (mean age=6,7). Children were assessed with a Dyslexia screening test, looking for risk of literacy problems, as well as with musical tests created with this propose. The author found that the “strong risk” children performed significantly worse on the timing tests, but not on the pitch tasks.

In a second study Overy (2003) had a group of 9 dyslexic boys (mean age=8,8) with regular music classes (20 minutes, 3 times per week) for 15 weeks, whose development was compared with the development of the same group with no music classes during the 15 weeks after the first classes period. In this control period, to avoid the Hawthorne effect, the group was visited in their classroom 1 hour per week. The results showed that the music program positively influenced 4 areas of skills: rhythm copying, rapid auditory processing, phonological ability, and spelling ability.

In order to better understand the described timing difficulties and its relation with the development of language and literacy skills, Overy et al. (2003) assessed 15 dyslexic children (mean age=9) and 11 controls (mean age=8,9) with musical aptitude tests designed specifically for dyslexic children. Pitch skills had better results in the experimental group, which can be explained by a slightly greater musical experience of these children. However, this group scored lower than the control group on most of the tests of timing skills, especially when involving rapid temporal processing. A significant correlation was found between spelling ability and tapping the rhythm of a song.

While deficits in timing skills are consensual in the description of dyslexia, the compromise of pitch skills in these children is not so clear. Different results were found by Forgeard and colleagues (2008), who directed a study with 10-year-olds (n=31), American speaking dyslexics. Language assessment relied on a phonemic awareness test, while music assessment encompassed tonal/melodic and rhythmic tasks of Gordon’s Intermediate Measures of Music Audiation, and a discrimination task that was designed by the authors. The results demonstrated that both melodic and rhythmic discrimination abilities were compromised in dyslexic children and that phonemic awareness performace, which was correlated with reading abilities, was predicted by musical discrimination skills – reading abilities were not directly predicted by melodic and rhythmic discrimination skills.

Although these characteristics and its relationship with DLD and dyslexia still need further investigation, it is already clear that music can offer a beneficial, multisensory learning environment for working linguistic problems (Overy, 2003). For that reason, and considering the findings related to a language disorder in school aged children, we tried to seek for music influence prior to the ages already studied, in children aged 3 to 6 years old, with typical music lessons, in kindergarten context.

3.2. Methodology - Study 1 (TD Population) and Study 2 (AD Population)

Studies that relate music aptitude and language abilities may indicate a relationship between music and language, but they do not prove a causal relation effect. For this reason, data from longitudinal studies with test-training-retest methods are important to conclude about this possible effect.

The randomization process is also crucial, since it guarantees that children are distributed in the experimental and control groups, having no choice (more or less consciously) driven for its' previous aptitude or motivation.

In this study we randomized the sample within an experimental group with music classes (MC) and a control group with visual arts classes (VAC) and assessed the children before and after the training period (music versus alternative training), being considered a test-training-retest methodology. We aim to study music influence in phonological awareness in 3-year-olds with typical development (TD – Study 1) and 3- to 6-year-olds with phonologically based SSD and/or DLD (AD – Study 2), before the ages already studied.

We also want to know if this influence exists with regular music classes, in kindergartens regular days (once a week, for 45 minutes), in a preschool year, having no specific design to promote phonological awareness skills.

The general methodological procedures have already been detailed (see Chapter 2). Below we briefly summarize major aspects to bear in mind with respect to the method used in Study 1 and Study 2.

3.2.1. Participants

Study 1

In this study, 49 EP speaking children were assessed (26 female; mean age 3:6) prior and after the intervention period. The data were collected in two subsequent preschool years, in a kindergarten in Aveiro district.

Through the randomization process, two groups were established: the Music group (experimental group – MC – n=25, 15 female, mean age= 3:5 years old), and the Visual Arts group (control group – VAC – n=24, 12 female, mean age=3:6 years old) had weekly 45 minutes' classes.

Study 2

In this study, 16 EP monolingual children were included (5 female, mean age=4:9 years old). After being referenced by the kindergarten teachers as having a speech and/or language disorder that was not associated with any known biomedical condition, each child was assessed with the Teste de Linguagem - Avaliação da Linguagem Pré-Escolar (TL - ALPE), a standardized receptive and expressive language test (Mendes, Afonso, Lousada, & Andrade, 2014), and TFF-ALPE (Mendes et al., 2013). Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence— Revised (WPPSI-R) (Wechsler, 2003) was applied by a trained psychologist to assess Nonverbal IQ (NVIQ), in order to exclude children with intellectual disability (Bishop et al., 2017). All children were from two different kindergartens in Aveiro, came from the same demographical region, shared the same socioeconomic background and had different linguistic profiles: 11/16 children had a phonologically based SSD with no compromise found in linguistic receptive and expressive levels assessed with TL-ALPE; 5/11 children had a DLD. The MC group (experimental group) was composed by 8 children (1 female, mean age= 5:1 years old, NVIQ from 80 to 118), and the VAC group (control group) had 8 children (3 female, mean age=4:6 years old, NVIQ from 83 to 105).

3.2.2. Procedures

Study 1 and 2

Children were assessed with the phonological awareness test Conf-IRA (Alves et al., 2009) at the beginning and at the end of the training period (30 classes). All children were assessed in individual sessions at school, in a quiet room, with consent from the parents, the school board, and the teachers.

3.2.3. Dependent measures

Study 1 and 2

Pre- and post-assessment included phonological awareness skills, assessed with Conf-IRA (Alves et al., 2009), a test that comprises 18 tasks evaluating lexical, phonological and phonemic awareness in words and pseudowords with all syllabic structures existing in our language (already exposed in Chapter 2, Section 2.2.2.). Taking into account children's ages, 11 tasks were applied: 1. Lexical awareness (phrase segmentation into words); 2. Syllabification of words; 3. Syllabification of pseudowords; 4. Combining syllables into words; 5. Combining syllables into Pseudowords; 6. Final syllable omission; 7. Initial syllable omission; 8. Syllable inversion; 9. Rhyme identification (metrical rhyme); 10. First phoneme identification; 11. Last phoneme identification.

3.3. Design

Study 1 and 2

In this randomized control study, with a test-training-retest methodology, all the children were assessed at the beginning of the school year. After the recruitment period, all of them had 30 classes that occurred once a week for 45 minutes. MC and VAC groups were balanced in number of students. Two trained teachers implemented the program in each class – the same two teachers were training children in music and visual arts classes.

Children in each class (MC and VAC) came from eight different classes in two kindergartens, and both kindergartens had a music and a visual art group. The children did not receive other music or visual arts lessons during this period. Duration, themes (e.g., autumn, winter, animals, Disney) and materials (all materials were used for both classes:

autumn leaves, balloons, journal, rolls of toilet paper, among others) were common to the classes in both intervention groups.

To control for external variables some procedures were followed, which were described in Chapter 2 of this thesis.

3.4. Results - Study 1 (TD Population)

3.4.1. Reliability

Inter-judge reliability of transcriptions was analyzed through point-to-point agreement which was 97.99%.

3.4.2. Control Variables

Differences in gender and age within the music group and the visual art group were compared, as well as the number of children per classroom in each activity class (Table 3). Male/female ratio was the same in the visual arts group (50%) and also very similar in the music group (60% females and 40% males). The small difference in gender distribution in the music group was originated by the randomization process. There were no significant differences between the groups in terms of age ($p>0.05$).

Table 3: Means, standard deviations, and frequencies for the control variables of age and gender, in TD population.

Control variable	Music group	Visual art group
	M (SD)	M (SD)
Age	41.40 (3.428)	42.29 (3.873)
Gender	10 m / 15 f	12 m / 12 f

3.4.3. Results – Phonological awareness development

3.4.3.1. Phonological awareness total score

A mixed ANOVA with repeated measures was conducted to look for the effect of time and activity in these results, as well as for the interaction between them (Table 4).

Table 4: Results of Mixed ANOVA for time, activity, and the interaction between them, in TD population.

	F	Sig
Time	33.238	0.000
Time * Activity	9.404	0.004
Activity	1.297	0.261

From the analysis of these results, it is possible to see that the activity by itself has no impact on the development of phonological awareness skills (F=1.297, p>0.05). But if we consider the interaction between time and activity, there are significant differences between the two groups (F=9.404, Sig<0.01), showing that the type of activity influences the development of this linguistic skills. To understand this influence, T-Tests for independent and dependent samples were established.

To analyze the data, normality in both groups was analyzed with the Shapiro-Wilk test, in order to decide between parametric or non-parametric statistical analysis. After analyzing the Normality test results (and since it was found a Sig > 0.05 for both groups in both moments), it was considered that both groups had a normal distribution, so the analysis proceeded with a parametric analysis with an Independent-Samples T-Test.

Results of phonological awareness pre- and post-assessment of MC and VAC groups are displayed in Figure 2. As it can be seen, there were no significant differences between groups at pre-assessment moment (p>0.05).

In the post-assessment, by contrast, significant differences emerged (p<0.01), with the music group students showing significantly greater improvement in phonological awareness tasks, considering the total scores. These results reveal that the significant interaction demonstrated with the Mixed ANOVA analysis (interaction about time and activity) happens because music students showed significantly better results than visual art students ($p<0.05$) in the assessment made after the training period.

As shown in Figure 3, visual arts students began with a better performance, although the difference between the two groups at that time was not statistically significant. Furthermore, this group also showed an improvement in their phonological awareness skills in post-assessment. However, music students outperformed the visual arts trained children, showing a disproportionate development, since the mean score in post-training period more than duplicated mean score in pre-training moment.

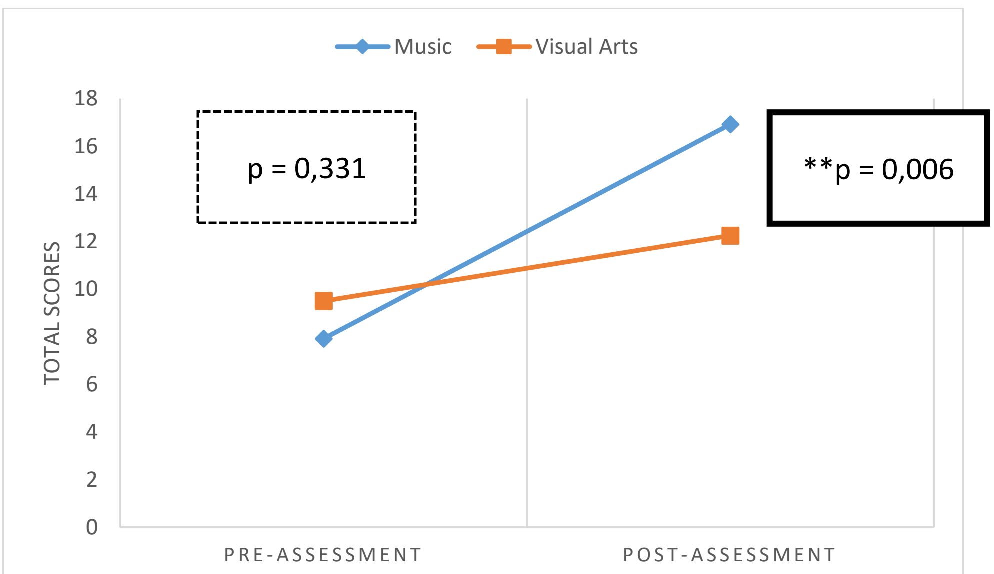


Figure 3: Phonological awareness at pre- and the post-assessment moments in music and visual arts groups, in TD population.

The results of the phonological awareness assessment for each group in pre- and post-assessment moments are presented in Figure 4, comparing the differences between the two moments in each group of students.

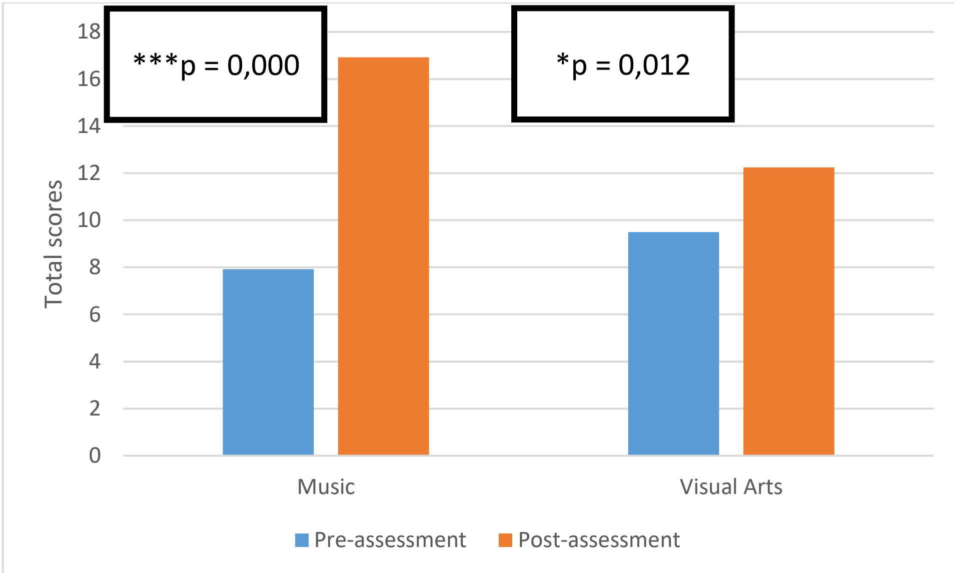


Figure 4: Total score of phonological awareness test in music pre- and post-assessment and in visual arts pre- and post-assessment, in TD population

Pre- and post-assessment results were compared in the experimental group, who had music classes. Normality Shapiro-Wilk tests revealed a normal distribution in pre- and post-assessment moments (sig>0.05), so a parametric analysis was done to seek for differences between the two moments. As it can be seen in Figure 3, Dependent-Samples T-Test revealed extremely significant differences (p=0.000) between the results before and after the training period. This data shows great improvement in phonological awareness skills in music trained children results between pre-assessment (M=7.92; SD=1.189) and post-assessment (M=16.92; SD=1.393).

In the analysis of the results from the children trained in visual arts, normality Shapiro-Wilk tests revealed a normal distribution in pre- and post-assessment moments (sig>0.05). A Dependent-Samples T-Test was used in order to understand the development between pre- and post-assessment moments in the control group.

A significant difference was found (p<0.05), showing improvement in phonological awareness also in the visual arts students from the beginning (M=9.5 SD=1.078) to the end of the school year (M=12.25 SD=1.094) (Figure 4).

3.4.3.2. Phonological awareness development per task

As reported in Chapter 2 (section 2.2.2.), eleven of the 18 tasks of Conf-IRA were applied. Shapiro-Wilk normality tests (sig<0.05) led us to analyze the data with non-parametric statistical analyses, with a Mann-Whitney Test for independent samples.

When comparing partial scores, significant differences were noted between groups, with the MC group showing significantly greater improvement in the following phonological awareness tasks (see Figure 5):

i) Syllabification of words ($p<0.05$) – task 2;
ii) Syllabification of Pseudowords ($p<0.01$) – task 3;
iii) Combining syllables into words ($p<0.05$) – task 4;
iv) Combining syllables into pseudowords (p=<0.05) – task 5.

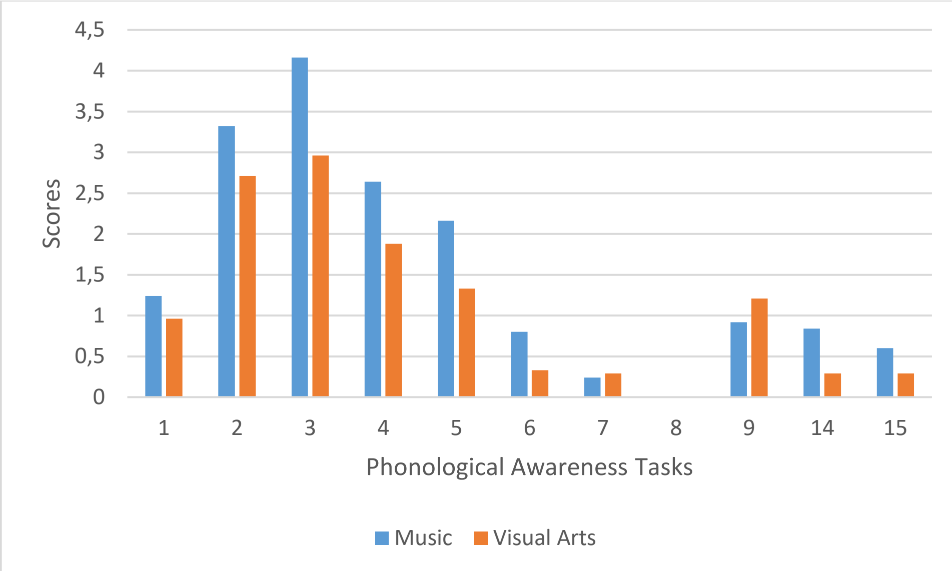
Phonemic awareness skills also showed a greater significant increase in music students:

i) Initial phoneme identification ($p<0.01$) – task 14;
ii) Last phoneme identification ($p<0.05$) – task 15.

No significant differences were found between groups in four tasks:

i) Phrase segmentation into words ($p>0.05$) – task 1;
ii) Final syllable omission ($p>0.05$) – task 6;
iii) Initial syllable omission ($p>0.05$) – task 7;
iv) Rhyme identification ($p>0.05$) – task 9.

The syllable inversion task (task 8) has proven to be too difficult for 3-year-olds, who failed to do the task irrespective of group considerations. Initial syllable omission and rhyme identification (tasks 7 and 9) revealed an inversion in the direction of the results expected, since visual arts students showed better results in these tasks, but the difference between the two groups is not significant ($p>0.05$ in both cases).



Phonological awareness tasks:
1. Lexical awareness;
2. Syllabification of words;
3. Syllabification of pseudo-words;
4. Combining syllables into words;
5. Combining syllables into pseudo-words;
6. Final syllable omission;
7. Initial syllable omission;
8. Syllable inversion;
9. Rhyme identification (metrical rhyme);
14. First phoneme identification;
15. Last phoneme identification.

Figure 5: Phonological awareness individual tasks results in post-assessment - music and visual arts groups' comparison, in TD population.

3.5. Results - Study 2 (AD Population)

In this section, Study 2 results will be presented, being related with music influence on phonological awareness development in children with phonologically based SSD and / or DLD.

3.5.1. Reliability

Inter-judge reliability of transcriptions was analyzed through the poin-to-point agreement which was 95,66%.

3.5.2. Control Variables

Differences in gender and age within the music group and the visual art group were compared, as well as the number of children per classroom in each activity class (Table 5). Male/female ratio was similar in the visual arts group (50%), but the same did not happened in the music group (12.5% females and 87.5% males). The randomization process created this difference in gender distribution. In term of ages distribution, there were no significant differences between the groups ($p>0.05$).

Table 5: Means, standard deviations, and frequencies for the control variables of age and gender, in AD population.

Control variable	Music group	Visual arts group
	M (SD)	M (SD)
Age	61.00 (12.54)	53.75 (13.60)
Gender	7m/1f	4m/4f

3.5.3. Results – Phonological awareness development

3.5.3.1. Phonological awareness total score

To look for the effect of time and activity (and their interaction) in phonological awareness total score, a Mixed ANOVA analysis with repeated measures was conducted (Table 6).

Table 6: Results of One Way ANOVA for time, activity, and the interaction between them, in AD population.

	F	Sig
Time	16.377	0.001
Time * Activity	0.149	0.706
Activity	1.322	0.270

It is possible to see that the activity has no impact on the development of phonological awareness skills ($F=1.322$, $p>0.05$), not even when it is interacting with time ($F=0.149$, $p>0.05$). The only aspect that had influence on phonological awareness skills in this group, was the time factor alone ($F=16.377$, $p>0.05$). To understand this difference, and since normality was ensured in MC and VAC groups through Shapiro Wilk's normality Test (MC $p=0.311$, VAC $p=0.678$), the analysis proceeded with an Independent Sample T-Test.

In the beginning of the year, as can be seen in Figure 6, MC students had a higher result in the total score of the phonological awareness test, although this difference was not statistically significant ($p>0.05$). This difference is maintained in the post-assessment moment. MC and VAC students performed better than in the pre-assessment moment, but this development occurs in both groups, with the music students scoring higher but not significantly different from visual arts children ($p>0.05$).

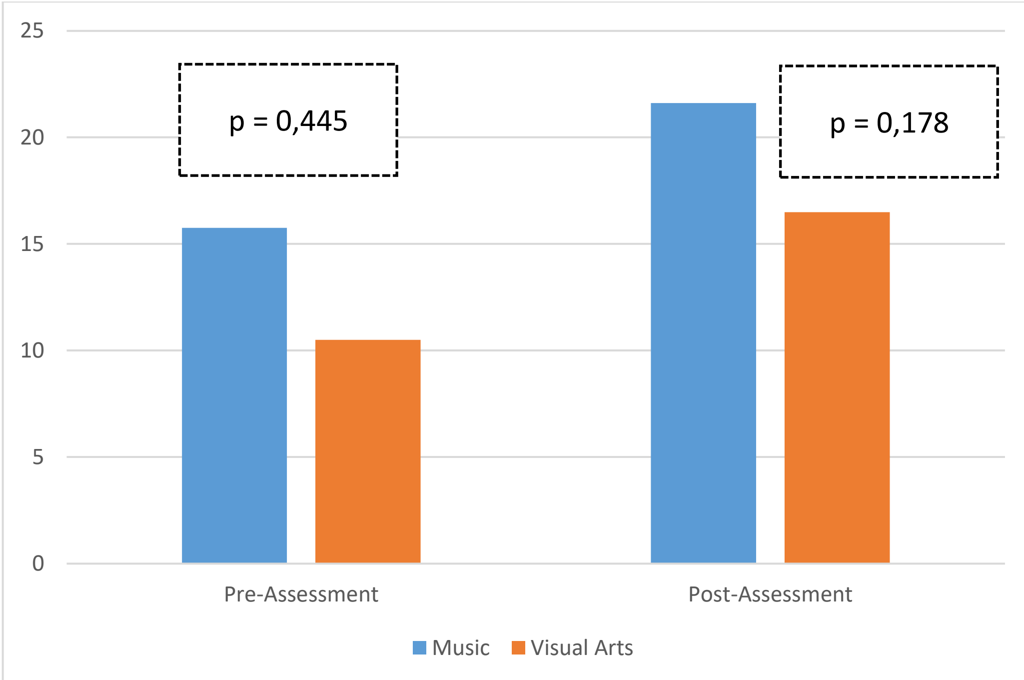


Figure 6: Phonological awareness results in pre- and post-training period in music and visual arts groups, in AD population.

In order to seek for differences in both groups between the beginning and the end of the training period, a dependent T-Test analysis was done, since the normality was guaranteed through the Shapiro-Wilk Test ($p>0.05$).

Figure 7 shows us the development of MC and VAC groups between the pre- and the post-assessment. As it was seen before, both groups developed during the period of the training, having significant differences between the results of phonological awareness total scores in the beginning and in the end of the school year ($p<0.05$).

3.5.3.2. Phonological awareness development per task

Since there were no significant differences between groups in the post-assessment moment, the differences between each sub-test were analyzed in MC and VAC groups between pre- and post-assessment. This analysis was done to look for the development of each ability after the music and the visual arts training. Even with no significant differences in the total score we tryed to understand if there are different patterns of development in different tasks. Figure 8 shows MC students results in each task in the pre- and post-assessment.

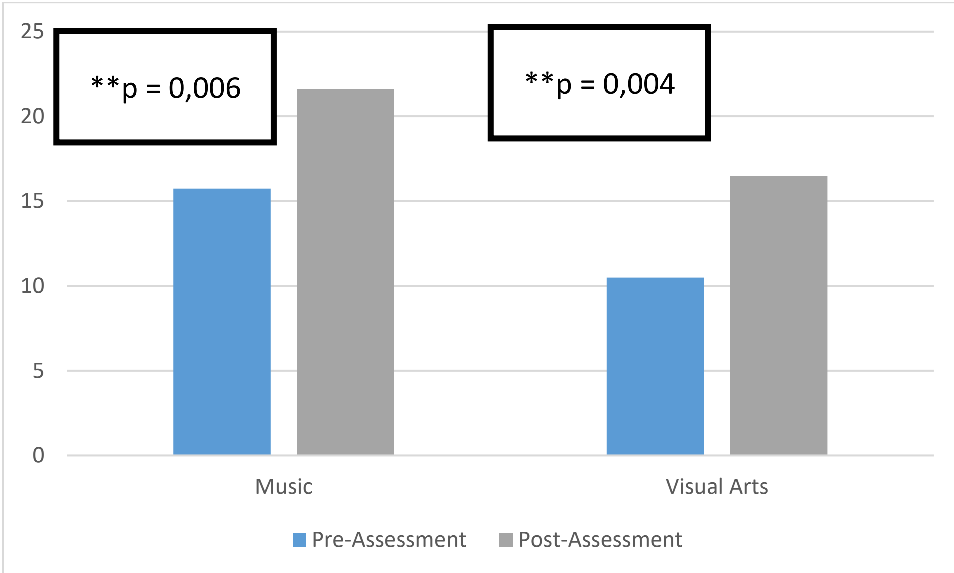


Figure 7: Phonological awareness results in MC group and VAC group in the moments pre- and post-training, in AD population.

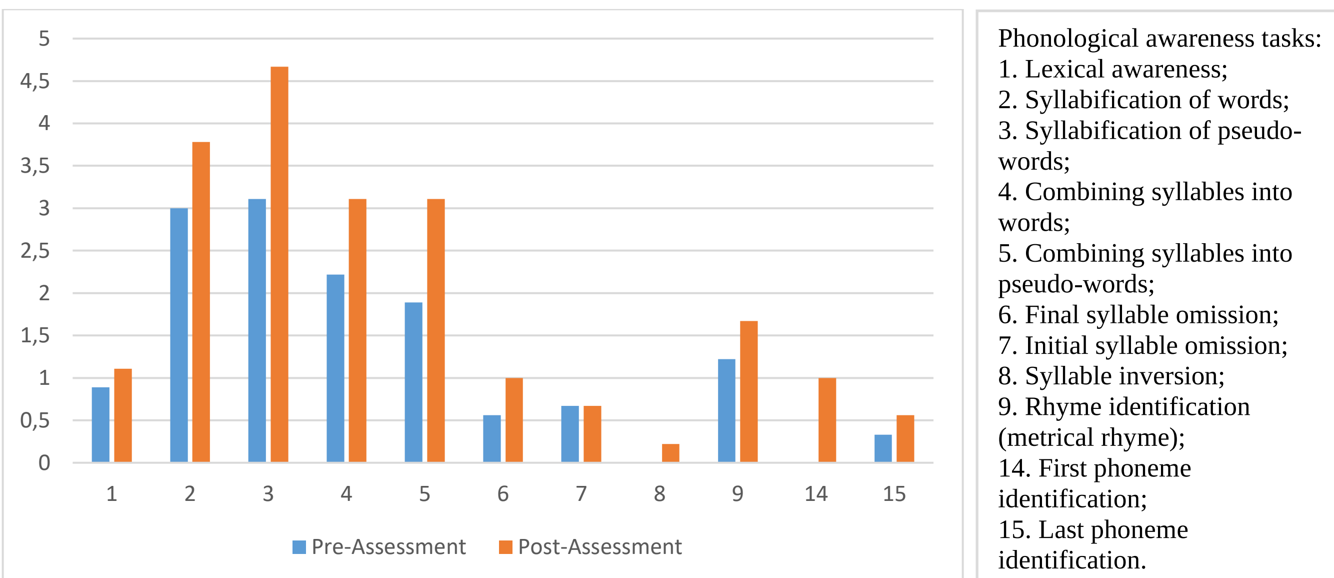


Figure 8: MC students results in the phonological awareness sub-tests - pre- and post-assessment comparison, in AD population.

Shapiro-Wilk normality tests (sig<0.05) lead us to analyze the data with non-parametric statistical analyses, with a Wilcoxon Test for dependent samples. In the 11 tasks of Conf-

IRA applied, when comparing partial scores between the two assessment moments in MC students (see Figure 7), significant differences were found in the tasks referred below:

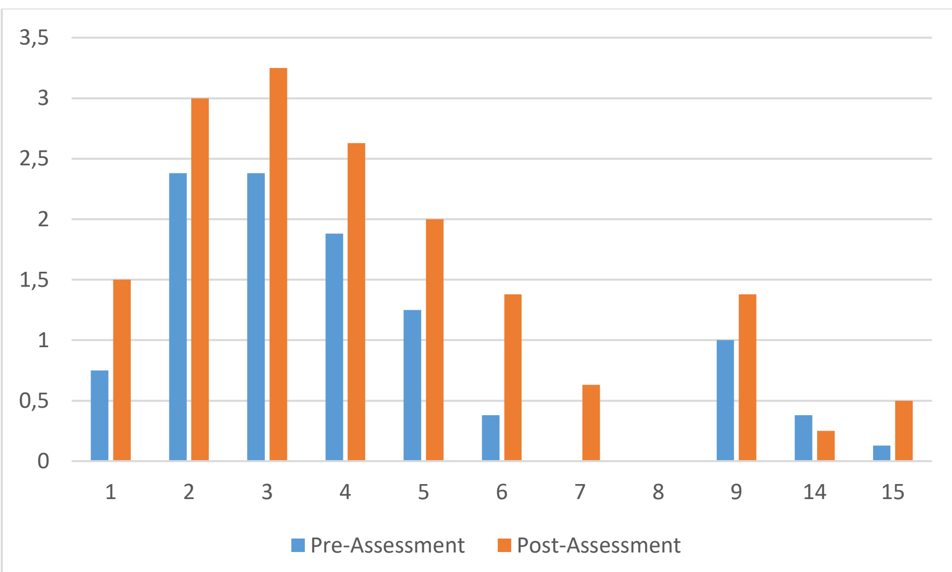
i) Syllabification of pseudowords ($p<0.05$) – task 3;

ii) Combining syllables into pseudowords ($p<0.05$) – task 5;

iii) First phoneme identification ($p<0.01$) – task 14.

In the subtest of combining syllables into words (task 4) and final syllable omission (task 6) the difference was almost significant ($p=0.051$).

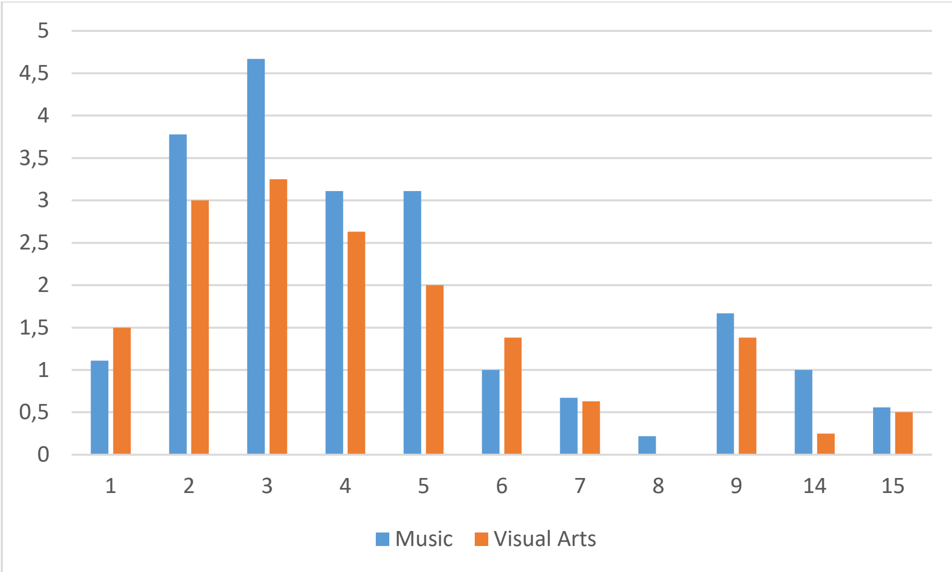
In the control group, however, it is shown that after being exposed to visual arts training, significant differences were found only on the syllabification of pseudowords ($p<0.05$) – task 3. Figure 9 presents the results obtained in VAC children in each subtest before and after the training period.



Phonological awareness tasks:
1. Lexical awareness;
2. Syllabification of words;
3. Syllabification of pseudo-words;
4. Combining syllables into words;
5. Combining syllables into pseudo-words;
6. Final syllable omission;
7. Initial syllable omission;
8. Syllable inversion;
9. Rhyme identification (metrical rhyme);
14. First phoneme identification;
15. Last phoneme identification.

Figure 9: VAC students results in the phonological awareness sub-tests - pre- and post-assessment comparison, in AD population.

The analysis of the phonological awareness sub-tests results of MC and VAC groups in the post-assessment moment was done, to look for differences between the experimental and control groups in each individual ability (Figure 10).



Phonological awareness tasks:
1. Lexical awareness;
2. Syllabification of words;
3. Syllabification of pseudo-words;
4. Combining syllables into words;
5. Combining syllables into pseudo-words;
6. Final syllable omission;
7. Initial syllable omission;
8. Syllable inversion;
9. Rhyme identification (metrical rhyme);
14. First phoneme identification;
15. Last phoneme identification.

Figure 10: Sub-tests MC and VAC groups' results in the post-assessment moment, in AD population.

After running a Shapiro-Wilks normality test and finding that there was no normality in most of the subtests ($p<0.05$), we proceeded with a Mann-Whitney Test for independent samples. We found significant differences in First phoneme identification task (task 14), where music students scored significantly above visual art students ($p<0.05$). In the remaining 10 subtests, there were no differences between music and visual arts students, after the training period.

3.6. Discussion - Study 1 (TD Population) and Study 2 (AD Population)

The aim of these studies was to investigate the effect of a school year of weekly music classes in phonological awareness skills of 3-year-old TD children and 3- to 6-year-olds with SSD and / or DLD, prior to the ages studied so far. Study 1 results indicate that the music classes, with the intensity delivered, lead to a greater development of phonological awareness skills, when compared with visual arts training. In Study 2, there were significant differences in phonological awareness total score between the pre- and post-assessment moment in both groups, revealing the effect of time, and not the effect of the activity, even when interacting with time. This means that both groups developed significantly in the intervention time, but they did not differ between one another. In spite of this it is possible to see that MC students developed significantly in more subtests that the VAC students, fact that is explored in this section.

3.6.1. Phonological awareness total score

Looking at results of TD children at pre- and post-assessment, we can see that both groups significantly developed phonological awareness skills (MC group $p=0.000$; VAC group $p<0.05$). This fact, specially in what refers to VAC group, is related with the expected development that occurs with age (Afonso, 2015; Lane & Pullen, 2004; Lathroum, 2011). However, music students outperformed visual arts students in the post-assessment moment, and there was a significant difference between both groups in the post-training assessment. These results are in line with Anvari et al. (2002), who concluded that 4- and 5-year-olds music perception ability is related to phonological awareness skills (including phonological and phonemic levels), as well as with Lathroum (2011), who showed that music perception predicts phonological awareness development in 5 and 6-year-old children. Woodruff Carr et al. (2014) also found that beat-synchronization is correlated with pre-reading skills in 3- and 4-year-olds (including, among others, phonological awareness skills), and Degé et al. (2015) found associations between music production and phonological awareness skills in 4-year-olds. Degé and Schwarzer (2012) also report significant positive associations between the total score of phonological awareness test and the overall scores of music perception and production.

With a test-training-retest methodology, using a control group with a non-related training, we can also put forth the hypothesis that music was the reason behind the greater development of phonological awareness skills found. This might thus suggest that there is a possible causal relation between music and phonological awareness development.

These results corroborate Patscheke et al. (2016), who found significant differences between children with music and phonological awareness training (1st and 2nd experimental groups), and the control group that was exposed to sports training, with music trained children showing a larger effect size in the phonological awareness results. Our experimental group behaved like the first experimental group of the authors, being exposed to music classes, but not phonological awareness training. Unlike Patscheke and colleagues, we did not design an intensive program (classes 3 times per week, 20 minutes sessions for 14 weeks), being closer to prove music training effect in regular classes.

Bolduc (2009) also found significant differences between the experimental group and the control group in phonological awareness skills, but here the experimental group followed a specific design program that joined music and phonological awareness stimuli, whereas the control group followed a music program only. In the present study, we found significant differences in phonological awareness total scores in typically developing 3-year-olds that seem to be due to musical training, since we did not design a specific program to develop phonological awareness skills, besides music training.

In their meta-analysis study Gordon et al. (2015) also concluded that music training has a positive effect on phonological awareness development above the age of 4. The present study goes further in the investigation, pointing to music and language relationship prior to these ages.

The findings of our first study thus suggest that music regular classes positively influence language development (specifically phonological awareness), earlier than previously though (at the age 3) and even when using a methodology that is not focused specifically in linguistic or phonological awareness development.

In our second study, with children with SSD or DLD, we found no significant differences between training groups in pre-assessment or in post-assessment (MC group $p>0.05$, VAC group $p>0.05$), meaning that the training activity of the control and experimental groups did not seem to influence phonological awareness development. In line with this result, Mixed ANOVA analysis showed that time, but not the activity or their interaction, had an effect on students' development. Significant differences were found in First phoneme identification task, showing that music trained children had a higher development on this phonemic task, than visual arts students. But this was the only task were significant differences were found.

Our results are not in line with the ones found by Overy (2003) in his second study, with dyslexic children, where she showed that the music program positively influenced phonological ability. However, this study was developed with older dyslexic children, with a music ongoing program with intensive periodicity in music classes. Overy (2003) found significant differences in dyslexic population at 9 years of age, with a music program that comprised 20 minutes classes 3 times per week, for 15 weeks. The differences in intensity and type of music training, as well as age differences may explain the disparity between Overy results and our owns.

Forgeard et al (2008) also found a relation between music entrainment (discrimination skills) and phonemic awareness development, which was correlated with reading abilities. In our AD population, in a previous stage of language pathology, we did not find a music training effect, since there was no relation between musical entrainment and the development of phonological awareness skills (not even in phonemic awareness subtests, as it will be shown later in this chapter), which are a fundamental part of pre-reading abilities. In any event, since in our study musical abilities were not measured, it is not possible to make a correlation between music and language specific developmental aspects.

At this point we need to explore deeper the goals behind the choice of the methodology used in our music and visual arts classes. The classes curriculum, and the issues worked in the lessons (rhythm, melody and harmony discrimination, imitation or improvisation, musical notation, sound discrimination, painting, creating, motor activities, etc.) may have a fundamental role on the impact of music and visual arts in phonological awareness results. Taking into consideration that DLD children should have benefits in this multisensory learning environment that comes with music entrainment for working linguistic problems (Overy, 2003), it is crucial to understand what type of activities would favour this interaction and under what frequency of entrainment. Figure 11 presents a list of musical difficulties already described, being checked only if they were worked in our music and visual arts classes.

As we can see in Figure 11, all the areas usually impaired in DLD children were worked in music classes, except for fine motor skills, visual processing, mapping sounds into visual symbols, and musical syntax discrimination. On the other way, VAC did not point specifically to these goals – within this long list, these classes just entrained children in motor entrainment and coordination (fine and gross motor skills), short term memory and visual processing.

Difficulty area	*Worked in MC?*	*Worked in VAC?*
Rhythmic timing	Yes	No
Rise time	Yes	No
Duration	Yes	No
Motor entrainment	Yes	Yes
Rhythmic tapping	Yes	No
Rhythmic copying	Yes	No
Rhythmic discrimination	Yes	No
Paced Beat synchronization	Yes	No
Unpaced beat synchronization	Yes	No
Short term memory	Yes	Yes
Metrical structures discrimination	Yes	No
Motor coordination	Yes	Yes
Gross motor skills	Yes	Yes
Fine motor skills	No	Yes
Visual processing	No	Yes
Motor sequencing	Yes	No
Auditory sequencing	Yes	No
Pitch discrimination	Yes	No
Segmentation of sounds	Yes	No
Grouping sound into phrases	Yes	No
Mapping sounds into visual symbols	No	No
Musical syntax processing	No	No

Figure 11: List of dyslexic and DLD described difficulties in music and language, worked in MC and/or VAC classes.

If almost all these characteristics were worked more in MC than in VAC, this points to the fact that simply exploring these abilities in a nonspecific musical curriculum may not be enough to promote linguistic development and phonological awareness since it did not produce a different developmental profile in both groups. This may mean that a specific curriculum has to look for the way these abilities should be worked, with goals specifically designed to this propose, and /or with higher intensity. Besides this, it is important to refer that the sample of the 2nd study here presented showed very heterogeneous profiles related to language development – in this small group it is possible to find children with DLD, with phonologically based SSD and also with a combination of both. It is unclear at this point how this heterogeneity might have influenced our results.

3.6.2. Phonological awareness partial scores

In Study 1 our partial results on the phonological awareness tasks indicate significant differences between MC and VAC groups at the level of phonological units larger than the segment – Syllabification of words ($p<0.05$), syllabification of pseudowords ($p<0.01$), combining syllables into words ($p<0.05$), and combining syllables into pseudowords ($p<0.05$), as well as at the phoneme level (small phonological units) – initial phoneme identification ($p<0.01$), and last phoneme identification ($p<0.05$). Intra-syllabic awareness was not assessed, taking into account the age groups included in our sample and the difficulty level of that tasks (Afonso, 2015).

Word and pseudo-word segmentation in syllables had a greater significant result in music trained children when compared to visual arts students. This is in line with the data in Moritz (2007), who compared syllable segmentation (among other phonological awareness skills) and rhythmic skills in kindergartners, and Herrera et al. (2011), who studied the influence of a phonological awareness program and a music program in syllabic tapping (mean age = 4;6), and who concluded that children with musical training in both experimental groups outperformed the control group, with no musical training – however it is impossible to exclude the effect of extra-attention in the experimental groups. In the present study by contrast, the only factor that seems to have played a role in the large significant difference in word and pseudoword segmentation tasks, was the music lessons to which the experimental group was exposed.

Significant differences in synthesis of words and pseudowords were also found between typically developed children of our study. This reveals that music students had a better ability to analyze and manipulate language at the syllable level. According to Lathroum (2011), blending seems to have a strong rhythmic component, and this may be one of the reasons behind this proved influence.

The assessment of small phonological units awareness showed significant differences between groups. Even with a very low mean (indicating that these phonemic tasks are too difficult at this stage) music students outperformed visual arts students, which goes in line with Lamb and Gregory's (1993) observation that pitch discrimination was significantly correlated with phonemic awareness in children with 4:6 to 5:6 years old. Even though we did not measure musical aptitude, the results of Study 1 show us that MC students are better in phonemic tasks, as it happened in the study developed by Peynircioglu et al. (2002), where a relation was found between music aptitude and a phoneme deletion task in 3:9 to 6:10 years old children.

Phrase segmentation in words appears to be a very difficult task for both groups (mean of the total sample in pre-assessment=0,71; mean of the total sample in post-assessment=1,10). In post-assessment moment, there were no significant differences between groups. These results do not support the conclusions by Anthony and Francis (2005) and Lathroum (2011) on the developmental sequence from larger to smaller units, and indicate instead that this is a complex task at this ages, as it has been defended by Afonso, (2015), Antunes (2013) and Cardoso (2011) for EP children.

Moritz (2007) found a significant correlation between phonological segmentation subskills at the word level and rhythm production and musical discrimination abilities. In our study, musical skills were not assessed, which makes it impossible to draw this type of conclusions. Although there were no significant differences between groups, there was a better result in the music trained children post-training that could be related to musical discrimination abilities. François et al. (2013) found improved speech segmentation skills in music trained children but not in visual arts students with 8 years old. This may indicate that this type of linguistic awareness is actually influenced by learning to separate the words with blank spaces (Basseti, 2005; Chaney, 1989).

Final syllable omission was also a difficult task to the children in both groups (mean of the total sample in pre-assessment=0,04; mean of the total sample in post-assessment=0,57), with no significant difference between experimental and control groups. Carvalho (2012) has shown that at 4 years old the mean score is 1.69 showing the difficulty of the task in an earlier stage, like the one our sample belonged to.

No significant results were observed in initial syllable omission task, where a low mean score was obtained (mean of the total sample in pre-assessment=0,1; mean of the total sample in post-assessment=0,27) revealing the difficulty of the task at this age. Between 4:8 and 6 years old children can achieve a mean of 1.29 in the same task (Carvalho, 2012). Afonso (2015) showed that at the 1st grade 66.8% of the children were able to realize this task, and only at the 3rd grade, 99.7% of the children can master this ability.

Similarly, no significant results were obtained in rhyme identification in the experimental group. This may seem surprising because it goes against what was found by Herrera et al. (2011), for 4:6-year-old children. On the other hand, in the meta-analysis study developed by Gordon, Fehd, et al., (2015) it was shown that rhyme skills results tended to grow stronger with increased hours of training, an observation also reported in Moritz (2007). This leads us to hypothesize that with an intensive training or longer period of intervention it could be possible to have differences between both groups. Other methodological differences may also explain the discrepancies between our results and those in the literature cited. An indication that this may indeed be the case is the fact that our results are similar to those reported in another study that followed a fundamentally similar method as we did, namely Moreno et al. (2011). In this study, no significant differences on rhyming assessment were found, and, although employing an intensive training methodology, using a computerized program and using musical staff like note to sound mapping, differently from what we did in our study, the music training program was similar to the one we used, including for instance training of rhythm, melody, pitch, and voice. The authors do not report, however, if they use the lyrics of the songs, which, most of the time, we didn't. This fact can also influence our results, and may indicate that together with the structural rhythmic, melodic and harmonic music constituents, the semantic part of the songs has an important effect on rhyming ability.

In Study 2, although there were no significant differences between the experimental and the control group in the post-training moment (Figure 9) important differences were found in the MC group between the pre- and the post-assessment moments. Significant differences were found at the syllabic level in the syllabification of words ($p<0.05$) (task 2) and in combining syllables into pseudowords ($p<0.05$) (task 5). At the segment level, first phoneme identification task (task 14) also had a significant higher result in the end of the school year, in MC students ($p<0.01$) and not in VAC students ($p>0.05$). Although not significant, subtests of word synthesis and final syllable omission were close to get a significant difference, showing a better development in music trained children that in controls. VAC students developed significantly between the two moments in the syllabification of pseudowords task ($p<0.05$). The referred improvement in the phonemic awareness task in MC group, goes in line with the results of Forgeard et al (2008) that relate phonemic awareness skills with musical discrimination abilities, although we did not measure musical skills. Despite this, having no significant differences between MC and VAC groups, we can only describe a slightly greater improvement in the students went through the music program, than the ones that had visual arts classes.

3.7. Conclusion

The results of the first study support the hypothesis that music influences phonological and phonemic awareness development in infancy, in 3 years old typically developing children. On the other hand, the results obtained with AD children in our second study, show that regular music classes with no specific program did not had an influence on phonological awareness development in music students, when compared to visual arts students, in this atypically developing population.

In Study 1 significant differences were found in the development of large phonological units' awareness in music students when compared to visual arts students – music trained children had a greater development in syllabification of words, syllabification of pseudowords, combining syllables into words, and combining syllables into pseudowords. Music students also significantly outperformed the visual arts trained children in tasks at the level of small phonological units, namely initial phoneme identification, and last phoneme identification.

In the first study, total score of Conf-IRA test showed that all students developed between the pre- and the post-assessment moments, but music 3-year-old students developed significantly more than the visual arts students, exhibiting at the end of the training period greater development when compared to the students of the control group.

In Study 2, both the experimental and the control groups developed between the beginning and the end of the school year – time proved its effect, in particular when this development was not related to the activity the child was exposed to. Knowing the characteristics of children with language disorders, almost all the difficult skills were trained in the music lessons prepared for this project. Even with such a methodological procedure, this was not enough to influence phonological awareness development, since significant differences between groups did not exist. However, looking at the development within each group, it was possible to see that MC group developed significantly in the following tasks: syllabification of pseudowords, combining syllables into pseudowords and first phoneme identification. Combining syllables into words and final syllable omission tasks were close to get a significant value in their development between this two moments. This may mean that music had an effect on language development, although it was not enough possibly due to this methodological procedure and / or classes frequency.

More investigation is needed to better understand DLD characteristics related to music. Only then it will be possible to design a proper music curriculum that will reinforce rhythm and possibly pitch abilities, which naturally can be worked with music, through music, to promote language skills development.

The present study has some methodological limitations that should be acknowledged, namely: 1. Children's motivation was not measured – this could be important to ensure that there was no difference between experimental and control groups in this respect (Degé & Schwarzer, 2011; Patscheke et al., 2016); however, only 1 dropout was due to demotivation (1 music class student in the total sample of studies 1 and 2: 1/65 – dropout because of demotivation rate = 1,54%). This fact suggests that children in both groups were equally motivated. 2. The author of this thesis was one of the teachers conducting the training in the second year, not being blind with respect to the aim of the study or to the training type received (Moreno, Friesen, et al., 2011). Under these conditions, teaching can be unconsciously biased, even when the ethical principles of objectivity, rigor and honesty were respected (Bolduc, 2009).

Some of the studies reviewed in this paper are music-based interventions specifically designed to promote specific reading skills, and some have an intensive periodicity that would be difficult to implement in our schools and daily lives. In the present study, the effect of music on phonological awareness development was proved to happen at the age of

3, in children with typical development, after regular music classes, with lessons that are likely to be applied by common music teachers in a kindergarten context. In Study 2, however, no beneficial effect of music was found in phonological awareness development. This means that for AD population a specific program may be needed, designed to achieve the same results, with the music teacher working together with a professional from the linguistics area and/or speech and language therapy. These observations have potential implications in the state policies regarding kindergarten education curricula, since more studies are needed in order to understand what type of music classes may enhance linguistic development in this population.

Study 1 showed that music promotes phonological awareness at a very early stage in several phonological awareness skills – word and pseudo-word segmentation in syllables, combining syllables into words and pseudowords, initial and last phoneme identification. Since it is known that these skills are relevant for the learning of writing and reading (Anthony & Francis, 2005; Gordon et al., 2015; Wright & Jacobs, 2003), our results suggest that generalized music lessons in kindergarten might positively contribute to the learning of writing and reading in the first school years.

Taken together the results from our first and second studies point to the fact that music influences phonological awareness skills, but although children with SSD and DLD will certainly benefit from music classes, where they may need particular attention, with specific curricula that focus rhythmic and (possibly) also melodic entrainment.

4 - Music effects on phonetic and phonological development

4.1. Literature Review

Defining Phonetics and Phonology

Speaking about speech sound development implies the definition of two distinct levels of analysis: phonetic versus phonemic acquisition. 'Phonetic acquisition' refers to the articulatory/motor skills needed to the speech sound production, and 'phonemic acquisition' considers the speech sound use – their functions, behavior, and organization in a sound system (Dodd, Holm, Hua, & Crosbie, 2003), corresponding to the phonological level.

In a very simple definition, phonology is the study of the sound structure in language, being an abstract cognitive system that deals with sound categories and rules in a mental grammar with a hierarchical structure (Odden, 2005). Rather than being concerned with the performance factors (Fikkert, 2007), sound production is examined in word initial, medial and final context, in terms of degree of production accuracy (Dodd et al., 2003), and may reflect phonological knowledge (Fikkert, 2007). Phonology is concerned with the combinations of sounds, since in each language there are rules that make some of them allowed, and some others systematically impossible.

However, it is difficult to find a clear boundary between phonology and phonetics, since studying phonology requires a phonetic output, and, on the other way, phonological component is obligatorily present in any phonetic study of language (Odden, 2005).

Phonetics is concerned with the physical sounds, from its' perception to its' production (Mateus, Falé, & Freitas, 2005), in concrete, instrumentally measurable physical properties – acoustic waveforms, formant values, duration, amplitude and frequency (Odden, 2005). Phonetics also concerns with the physical structures and principles in sound production – articulatory structures, muscles, and resonances used in producing speech sounds (Odden, 2005). In this way, verbal articulation can be defined as a motor process that implies the manipulation of the airflow, with coordinated articulatory movements of the structures involved in the vocal tract, making it possible to produce different speech sounds (Mateus et al., 2005; Odden, 2005).

Taking together all the sound systems in the languages of the world, there are around 600 consonants and 200 vowels, although each language counts with a set of about 40 distinct elements that contribute to form different words, with their respective distinct meanings – the phonemes (Kuhl, 2004). In standard EP there are 19 contrastive consonants in onset position (namely [p b t d k g f v s z ʃ ʒ m n ɲ l ʎ ɾ ʀ]) – in word-medial onsets all of them are contrastive, and in word-initial onsets all are contrastive except [ɲ ʎ ɾ] (Mateus & D'Andrade, 2000). These sounds can be divided in voiced and voiceless obstruents (stops and fricatives) and sonorants (nasal and liquids). Consonants can also be classified according to articulation places: labial (bilabial and labiodental), coronal (alveolar, post-alveolar – palate-alveolars), and dorsal (palatals, velars and uvular).

Phonetic and phonological development

Phonological development implies the development of production and reception channels – from a very early stage children may access detailed phonetic information, being sensible to the phonetic contrasts in their native language, simply by being exposed to it (Kent & Miolo, 1995). This input, through domain-general skills of auditory perception, will allow the child to use computational strategies that will detect the existence of the sounds and their respective frequency, and compute sound statistical and prosodic patterns of language (Kuhl, 2004; Maye, Werker, & Gerken, 2002).

In EP, however, no straightforward relation was found between the distribution of sounds in adult-like productions and the acquisition patterns in child development in a first stage (Costa, 2010). Sound acquisition, however, may be related with some other variables like the position of the sound in the word (initial ou medial position), the word stress, or the word boundarie. In EP the child may be sensitive to the sound in the left boundarie of the word, being able to extract information of this context and not only about the global frequency of sound occurrence, being sensitive to the phonotatic information of their language (Costa, Freitas, Frota, Martins, & Vigário, 2007).

While developing his/her phonological system the child may use a set of universal markedness constraints on outputs and computational principles and may have the same substance as an adult phonology. These markedness constraints can be innate and universal, grounded in perception and articulation but still universal, or originate from generalizations over a lexicon (Fikkert, 2007). The notion of markedness is common to all theoretical approaches, meaning that structures that are frequent in the languages of the world are the first ones to be acquired (e.g. unmarked segments) and that the acquisition of a marked segment presupposes the previous acquisition of the unmarked one (Costa, 2010). Furthermore, if two phonemes are distinguished by a single feature, having a binary opposition, one is unmarked for the given feature and the other is marked (Gaeta, 2017).

From a nativist point of view, there is a continuity between child and adult state that supposes that their phonological systems can only vary in limited ways (Fikkert, 2007). Children must discriminate the sounds of a language, also learning to perceptually group different sounds that are distinct but that belong to the same category, despite the variation in talker, rate or phonetic context (Kuhl, 2004).

In order to get the adult-like linguistic profile, children need to acquire the segmental inventory of her/his native language, its' distribution within words and syllables (Costa, 2010), the phonological processes, as well as the restrictions on phonotactics, prosodic words and larger prosodic units. Simultaneously the child builds a lexicon to store phonological representations (Fikkert, 2007).

During phonological development, typical phonological processes occur that are specific to the learning child, instead of occurring in adult language. These well-known phonological processes (described later in this chapter) occur due to articulatory limitations or processing difficulties in typical language development and may be described as belonging to one of the following types: rule reordering, rule simplification or rule loss. Such processes will be gradually disposed of during development, while the child becomes phonologically more competent, and till she/he reaches the adult-like productions (Fikkert, 2007; Stampe, 1973). This substitution processes provide insights into children's phonological systems (Bernhardt & Stemberger, 1998).

In autosegmental phonology, language segments are described as autonomous and interdependent constituents, hierarchically organized, working solely or in tandem (Clements & Hume, 1995). In this way, phonological development implies a growing structure of linking tiers, where through gradual addition of complexity, feature hierarchies are unfolded. In child development it is not considered that the she/he has a phonological system close to the adult one (Matzenauer-Hernandorena, 1996). The analysis of phonological development driven through the prosodic structure does not count with the storage of arbitrary segmental information, considering that segments are not acquired in isolation, but need a syllable and a word to surface on, and these units are part of a prosodic structure generated by grammatical rules (Fikkert, 2007). In this analysis not only the sound position in word is accounted for, but also the syllable structure development and the sound position in the syllable is analyzed (Fikkert, 2007).

Despite of the theoretical model used in phonological development analysis, knowing phonetic and phonological development with available normative data is crucial to educational contexts and clinical assessment. It is important to know for instance the age of acquisition of sounds, as well as the age when error patterns are suppressed (Dodd et al., 2003) while child language gradually develops to get the targeted language (Fikkert, 2007). Percentage of Correct Consonants (PCC) is a quantitative measure used in investigation and clinical contexts in order to classify SSD but also to demonstrate intervention efficiency. Through PCC measure it is possible to make between and within groups comparisons (Ramalho, 2017).

The PCC score is calculated by dividing the number of consonants produced correctly by the number of target phonemes and multiplied by 100. Jesus and colleagues (Jesus, Lousada, Domingues, Hall, & Tomé, 2015) analyzed production data from a sample of 232 children. Jesus and colleagues found a PCC of 84,7% (10,3) in 3- to 4-year-olds, of 90,7% (7,7) in 4- to 4:6-year-olds and of 95,1% (7,1) in 4:6- to 5-year-olds. In her study, Lousada (2012) analyzed the data from 14 typically developing children aged between 3:11 and 6:06 years old and found a PCC between 78.60% and 98.90%.

Studies on sound acquisition differ in the sample size, age of the subjects, elicitation techniques, criteria used and data presentation (Dodd et al., 2003), and very often there are databases that do not provide enough information making it more difficult to conclude about phonetic and phonemic development (Fikkert, 2007). According to Fikkert (2007) particular phenomena in child language data should be analyzed in relation to the developing phonological system, instead of being independently investigated. In the last years a great effort was made to better describe child language production data in various languages, including EP – as Costa (2010), Costa, Freitas, & Gonçalves (2016), Freitas & Ramalho (2007), Guerreiro & Frota (2010), Lousada, Mendes, Valente, & Hall (2012), Ramalho (2017), Ramalho & Freitas (2018), Ramalho, Lazzarotto-volcão, & Freitas (2017), among others, on EP phonological development.

Despite some variability between and within languages and ignoring variation in theoretical framework used, some typical patterns can be found across studies in phonological development (Costa, 2010). Considering phonological features, and more specifically manner features, most commonly stops and nasals are described to be acquired early, followed by the fricatives and the liquids. This sequence has been described for various languages (Bernhardt & Stemberger, 1998; Lamprecht et al., 2004; Matzenauer, 1990), including EP (Costa, 2010; Freitas, 1997; Lousada et al., 2012; Ramalho, 2017). As for place features, anterior features (Labial and Coronal [+ant]) tend to be acquired earlier, and non-anterior features (Coronal [-ant] and Dorsal) tend to be acquired later (Costa, 2010; Lamprecht et al., 2004). Rhotics seem to be an exception, since the dorsal trill appears before the flap (Miranda, 2007).

Some consonants of EP can occur in syllabic structures more complex than CV. Syllable patterns described include CV, V, CVC and CCV types (Andrade & Viana, 1994; Vigário & Falé, 1994; Vigário, Martins, & Frota, 2006). According to Freitas, Frota, Vigário, & Martins (2006) syllabic structures in EP are acquired following the order CV>V>CVG/CVN>CVC>CCV. Consonant clusters (C1C2V) are sequences of obstruent (stop or fricative) + liquid ([ɾ l] in C2 position) at the left edge of a syllable, being consider complex structures, and the last acquired by EP children (Amorim, 2014; Freitas, 1997; Lamprecht et al., 2004; Lousada et al., 2012; Mendes et al., 2013; Ramalho & Freitas, 2018), in line with what happens in other languages (Bernhardt & Stemberger, 1998; Fikkert, 2007). This may be related to a gradual mastery of articulatory gestures in child development, with the acoustic and articulatory properties of the sound and/or with the syllable complexity and it's prosodic variables (like word length or word stress) (Ramalho & Freitas, 2018), rather than with the sound production by itself. Instead of substitutions, the child may use deletion or epenthesis, violating structural constraints to face the difficulty in producing this sounds in more complex syllabic structures (Ramalho & Freitas, 2018).

Phonological processes may be a simplification strategy when the child is not able (yet) to produce a specific segment (or category) of her/his language. Segmental processes refer to how the sound features affect the features of another segment, while prosodic processes are related to the structures of syllables, word stress, rhythmic structure of the word, and to the position of the segment in a phonological domain (Odden, 2005). The segmental substitutions reflect, most of the times, substitutions between segments of the same class (Freitas, 1997), and may involve manner, place or voicing features.

Analyzing the data of children aged between 1:10 and 4:10 years old, Costa (2010) describes the substitution patterns in the development EP phonology. Fricatives and liquids are very often submitted to substitution patterns (Costa, 2010). The most predominant substitution affecting fricatives is for a consonantal stop, laterals are more often substituted for another sonorant (glide or nasal) and rhotics are very often substituted by another sonorant (lateral or glide), but substitutions for stops also occur, affecting the trill more than the flap (Costa, 2010). Substitutions affecting place features also happen, but according to Costa (2010) labials are not often submitted to this process. In turn, Coronal [-ant] consonants tend to be substituted for a labial or a dorsal. Dorsal consonants (the last place feature acquired) are predominantly substituted for Coronal consonants. Substitution patterns affecting voicing features, demonstrate that voiceless stops are acquired earlier than the voiced ones. Children can also substitute or omit vowels in weak word position – errors that reflect some difficulties in the acquisition of complex structures (Freitas, 1997; Mezzomo, 2004).

Processes at the segmental level

Phonological processes at the segmental level are defined and illustrated in Table 7 below (Guerreiro & Frota, 2010; Mendes et al., 2013).

Table 7: Segmental phonological processes, their definition, and examples of sounds substitutions and substitutions in word contexts.

Segmental Phonological Process	Definition	Example of the sound substitution	Example of the change in the word
Liquid semivocalization	Liquid substitution for a glide	/l/ → /w/ /ʎ/ → /j/	/'bɔlɐ/ → ['bɔwɐ] /pɐ'ʎasu/ → [pɐ'jasu]
Stopping	Fricative substitution for a stop	/f/ → /p/ /s/ → /t/	/'fakɐ/ → ['pakɐ] /'sinu/ → ['tinu]
Anteriorization	Velar substitution for a dental	/k/ → /t/ /g/ → /d/	/'kazɐ/ → ['tazɐ] /'gotɐ/ → ['dotɐ]
Posteriorization	Dental substitution for a velar	/t/ → /k/ /d/ → /g/	/'tigrɨ/ → ['kigrɨ] /'dadu/ → ['gagu]
Palatalization	Dental substitution for a palatal	/s/ → /ʃ/ /z/ → /ʒ/	/'sapu/ → ['ʃapu] /'zebrɐ/ → ['ʒebrɐ]
Depalatalization	Palatal substitution for a dental	/ʃ/ → /s/ /ʒ/ → /z/	/ʃɐ'pɛw/ → [sɛ'pɛw] /ʒɛ'nɛlɐ/ → [zɐ'nɛlɛ]
Devoicing	Voiced substitution for an unvoiced	/ʒ/ → /ʃ/ /b/ → /p/	/ ʒɛ'nɛlɐ / → [ʃɐ'nɛlɛ] /'bɔlɐ / → ['pɔlɐ]

Processes at the syllable level

At the prosodic level, phonological processes have an effect on the structure of the syllable, frequently by deleting or inserting a consonant or a vowel (Odden, 2005). In EP the child may simplify the complex nuclei of the syllable, by omitting the glide, reducing the syllabic element of that structure (Freitas, 1997). All phonological processes at the syllable level are described in Table 8. The possible processing of the consonants in the cluster as independent consonants may lead to a more frequent use of the epenthetic vowel [ɨ] in oldest children (Freitas, 1997, 2003). The author describes the use of the epenthetic vowel to fulfill empty prosodic constituents, referring a percentage of 16% in the whole sample, but 32% for the oldest children. Freitas (2003) describes the use of this strategy in children aged between 2:2 and 3:5 years old. Epenthesis is also described as a strategy to simplify the production of the consonant in Coda position, especially at the end of the word (Correia, 2004; Freitas, 1997; Mezzomo, 2004). Data in Mendes et al. (2013) contrasts with the one presented, since no epenthesis is described – this may be related with the methodology adopted, since speech-language therapists transcribed each child production, with no audio-recordings. On the other hand, Freitas (1997, 2003) data were transcribed from audio-recordings by trained linguistics in the task. Processes at the syllable level can occur from an early stage and even after 4 years old (weak syllable deletion) or after 5 years old (final consonant deletion and cluster reduction) (Castro, Gomes, Vicente, & Neves, 1997; Castro, Neves, Gomes, & Vicente, 1999a).

Table 8: Prosodic phonological processes, their definition, and examples in word contexts.

Prosodic Phonological Process	Definition	Example of the change in the word
Glide omission	Simplification of the complex nuclei of the syllable, reducing the syllabic element of that structure	/'kajʃɐ/ → [' kaʃɐ] /'pɐjʃɨ/ → ['pɐʃɨ]
Epenthesis	Insertion of an epenthetic vowel	/'pɾatu/ → [pɨ'ɾatu] /'mɛɫ/ → ['mɛlɨ]
Ressyllabification	Change in the syllabic structure of the word, usually by the insertion or omission of a vowel	/'pɾatu/ → [pɨ'ɾatu] /ku'meɾ/ → [ku'meɾɨ] /tɨlɨ'fɔnɨ/ → [tlɨ'fɔnɨ]
Final consonant deletion	Deletion of the consonant in Coda position	/'kazɐʃ/ → ['kazɐ] /ɔʃpi'taɫ/ → [ɔpi'taɫ]
Cluster reduction	Omission of the second consonant of the cluster	/'tigɾɨ/ → ['tigɨ] /'pɾatu / → ['patu]
Weak syllable deletion	Deletion of a pre-tonic syllable	/tɨlɨvi'zɐũ/ → [tɨvi'zɐũ] /ũ'bigu/ → ['bigu]
Intrassyllabic metathesis	Change in the order of the consonants within the syllable	/'pɾatu / → ['paɾtu] /duɾ'miɾ / → [dɾu'miɾ]
External metathesis	Change in the order of the consonants between syllables	/'tigɾɨ / → ['tiɾgɨ] / ɔʃpi'taɫ / → [ɔpiʃ'taɫ]

Guerreiro & Frota (2010) found that in order to avoid complex syllable structures, final consonant deletion and cluster reduction were the most frequent processes in 5 years old children. Lousada et al. (2012) in the standardization of the *Teste Fonético-Fonológico-ALPE* (TFF-ALPE) found that final consonant deletion, cluster reduction and weak syllable deletion can still occur between 6:06 and 6:11 years old.

Metathesis is also described as a strategy in acquiring complex Onset, making a change in the order of the consonants between or within syllables (Freitas, 1997; Ribas, 2004). All these data show that simplifying clusters is very common and one of the lasts processes to be suppressed, both in English and in EP (Dodd, 1995; Freitas, 1997; Lousada et al., 2012; Ribas, 2004).

The age of suppression of phonological processes

The age of suppression of phonological processes was studied by Castro, Gomes, Vicente, & Neves (1997) and Castro, Neves, Gomes, & Vicente (1999) who found that at the segment level some processes are suppressed after 4 years old (stopping, depalatalization, palatalization, devoicing, gliding of liquids). According to Lousada et al. (2012) , and considering that a phonological process is suppressed when 85% of the sample do not use it, stopping, backing and fronting are suppressed between 3:00-3:05 years old, palatalization and depalatalization are suppressed between 4:00-4:05 years old and devoicing is suppressed between 5:00-5:05. Liquids semivocalization is described as one of the last processes to disappear in language development in EP (Freitas, 1997; Jordão & Frota, 2008; Lousada et al., 2012; Mezzomo & Ribas, 2004). However developmental pattern seems to be different in what concerns to lateral liquids or vibrant liquids, since the first ones tend to be semivocalized, but the second ones tend to be substituted by another liquid or even omitted (Freitas, 1997; Mezzomo & Ribas, 2004). In what concerns the processes occurring at the syllable level, weak syllable deletion, final consonant deletion and cluster reduction are pointed as the processes that facilitate syllabic acquisition. Different authors point to different ages of suppression of those processes.

Table 9 systematizes the data about the age of phonological processes suppression in EP. Table 10 shows us the data found by Jesus et al. (2015) related to the percentage of the phonological processes in a sample aged between 3:00 and 5:00 years old. Although there are descriptions about epenthesis and metathesis and its' occurrence late in the development, it wasn't found data about the age of suppression of these prosodic processes.

Table 9: Age of phonological processes suppress.

	Phonological Processes	Castro et al. (1997, 1999)	Andrade et al. (2004)	Lousada et al. (2012)
Segmental level	Stopping	> 4:00	2:06	3:00 – 3:05
	Fronting	-	3:00	3:00 – 3:05
	Backing	-	-	3:00 – 3:05
	Palatalization	> 4:00	-	4:00 – 4:05
	Depalatalization	> 4:00	-	4:00 – 4:05
	Devoicing	> 4:00	-	5:00 – 5:05
	Gliding of Liquids	> 4:00	-	6:06 – 6:11
Prosodic Level	Epenthesis	-	-	-
	Weak syllable deletion	> 4:00	-	> 6:00 – 6:11
	Final consonant deletion	> 5:00	7:00	6:00 – 6:11
	Cluster reduction	> 5:00	7:00	6:00 – 6:11
	Metathesis	-	-	-

Table 10: Percentage of phonological processes that occur between 3:00 and 5:00 years old (Jesus et al., 2015).

	Phonological Process	**% of occurrence [3:00 – 3:06[**	**% of occurrence [3:06 – 4:00[**	**% of occurrence [4:00 – 5:00[**
Segmental level	Stopping	0.3%	0.3%	0.3%
	Fronting	0.2%	0.2%	0.2%
	Backing	-	-	-
	Palatalization	12.2%	12.2%	2.8%
	Depalatalization	5.5%	5.5.%	0.7%
	Devoicing of fricatives	11.5%	11.5%	11.5%
	Gliding of Liquids	16.4%	16.4%	8.7%
Prosodic Level	Weak syllable deletion	7.1%	7.1%	5.2%
	Final consonant deletion	21.6%	12.8%	5.1%
	Cluster reduction	48.6%	32.9%	11.8%

Phonetic and phonological development in DLD

Developmental Language Disorder (DLD) is an heterogeneous diagnose that includes a wide range of problems, where the clinician has to look for the principal areas for intervention, focusing her/his attention in one or more specific areas (Bishop et al., 2017).

When the child with phonological problems does not meet the criteria for a DLD (since they are not accompanied by problems in other language domains and simultaneously have a good prognosis), the child should be diagnosed with a Speech Sound Disorder (SSD) which can be related to a production disorder that have motor or physical origins or can be phonologically based disorder (Bishop et al., 2017).

Children with phonologically based SSD have difficulties in their phonology, presenting various atypical phonological processes in their speech. These processes typically may occur earlier in development, being a sign of a delay in phonological development, or may correspond to unusual patterns not typically seen in normal development (Beers, 1992; Bree, 2007; Mediavilla, Torrent, & Raventos, 2002; Orsolini, Sechi, Maronato, Bonvino, & Corcelli, 2001).

Many studies report the existence of consistent and severe phonological difficulties in children with phonologically based SSD and DLD (Beers, 1992; Bortolini & Leonard, 2000; Mediavilla et al., 2002). Their phonological production consist of many simplification processes at the word-, syllable-, phoneme- and feature-domain (Bree, 2007). Mediavilla et al. (2002) found that children with DLD have a delay in the acquisition of segments, syllabic structures and word structures, using more simplification process, when compared with their age group controls.

As the literature suggests an overlap between dyslexia and DLD, since they have similar symptoms, often characterized as a disorder with a core cognitive deficit in phonology (Snowling et al., 2000), it is valuable to look for phonological development in DLD, SSD and also in children with a familial risk of dyslexia, where the acquisition of phonology can be more difficult (Bree, 2007).

Scarborough (1989, 1990, 1991) studied language development of American English at-risk children. The author compared three different samples: at risk children later diagnosed with dyslexia; at-risk children that were not later diagnosed with dyslexia and a control group. In a retrospective study Scarborough showed that at 30 months children later diagnosed with dyslexia made more mispronunciations of consonants than the non-dyslexic at-risk children and the control group. Besides the difficulties in phonological processing, speech perception and speech production, at-risk children showed a lower grammatical sensitivity and expression, listening comprehension, verbal short-term memory, (rapid serial) naming, and vocabulary (Bree, 2007).

In a study developed by Bree & Van der Pas (2003) it was found that Dutch speaking DLD children in two age groups (1;11-2;6 and 2;7-4;0) apply more weak syllable truncation and cluster avoidance than their controls. Similarly Bree (2007) refers these two processes at the syllable level as being frequent in these children, referring that they may also use less common processes, such as cluster or onset omission (e.g. bloem 'flower' realized as /um/ and kaas 'cheese' realized as [as]). At the segmental level, the author found the occurrence of phonological processes of stopping and fronting (already described in Table 7 in this text). According to Beers (1992) the most frequent substitution processes are those that alter the production of /d/ /ɾ/ and /l/ segments. Mediavilla et al. (2002) found that DLD children were less accurate in the use of stops, nasals and laterals. In a study developed by Carroll & Snowling (2004) the speech production of 17 children at risk of dyslexia aged between 3;11 and 6;6 were assessed. Results showed PCC differences between the control (92%) and at-risk groups (81%), and higher speech production difficulties in the at-risk group.

In their study, Gallagher, Frith, & Snowling (2000) and Bree (2007) made a qualitative analysis and found that, in general, there is a delay on speech production of the at-risk children, rather than a deviant profile – the types of simplification processes found were the same in at-risk children and their controls. When studying the difference on the phonological performance of at-risk children, DLD children and controls, at 5 years of age, Bree (2007) found significant differences between the DLD group and the others on PCC: DLD Group 66%; At-risk Group 79%; Control Group 90%. In this measure, the at-risk group did not differ from the control group neither the DLD Group. As for the qualitative analyses of phonological processes, the author found that the at-risk group was in-between the control and DLD group, which consistently reach the highest scores at the syllable-level processes (weak syllable omission and cluster reduction processes) and at the phoneme-level (fronting and stopping) – although the differences in truncation, fronting and stopping (/s/ produced as [t]) were not statistically significant. Mediavilla et al. (2002), however, found significant differences in the occurrence of weak syllable omission process, between a group of children with DLD (N=5) and their controls (N=5) at age three. Nettelbladt (1992) and Rescorla & Ratner (1996) refer the occurrence of weak syllable omissions, cluster reductions and final consonant omissions in DLD children, who are described as having a low rate of verbalization, a small inventory of consonants and vowels being more unintelligible.

In EP a little is known about the phonological and phonetic development in DLD and / or phonologically based SSD children. With the data obtained in a study realized by Jesus et al. (2015) it was found a PCC that varied between 29.1% (SD=11.9) (in a first group with children with PCC below 50% - a severe SSD, N=11) and 61.3% (SD=8.1) (in the second sub-group with PCC above 50%, N=9).

At the syllable-level, and in consonance with other languages, the authors found the predominance of three simplification processes in 20 children diagnosed with SSD: cluster reduction (66.0% first sub-group; 76.0% in the second sub-group), last consonant omission (67.2% in the first sub-group; 48.4% in the second sub-group) and weak syllable truncation (30.9% in the first sub-group; 22.7% in the second sub-goup).

At the segment level devoicing of fricatives was the phonological process that the children used more frequently (24.2% in the first sub-group; 75.9% in the second sub-group). Although the control group (with typically developing children) also presented these processes, the DLD group used them significantly more. The same, in a lower percentage, happened with liquid gliding (9.0% in the first sub-group; 16.1% in the second sub-group), stopping (18.5% in the first sub-group; 2.0% in the second sub-group) and fronting (15.2% in the first sub-group; 2.3% in the second sub-group) (Jesus et al., 2015).

EP recent studies showed some differences in the percentage of occurrence of phonological processes in children with phonologically based SSD with a PCC below or above 50% (Jesus et al., 2015) (Table 11).

Table 11: Phonological Processes occurrence in children with phonologically based SSD with a PCC < 50% and a PCC > 50% (Jesus et al., 2015).

Phonological Process	**Sub-group PCC < 50%**	**Sub-group PCC > 50%**
Cluster reduction	66.0%	76.0%
Last consonant omission	67.2%	48.4%
Weak syllable truncation	30.9%	22.7%
Devoicing of fricatives	24.2%	75.9%
Liquid gliding	9.0%	16.1%
Stopping	18.5%	2.0%
Fronting	15.2%	2.3%
Depalatalization	4.3%	7.2%
Backing	-	-
Palatalization	5.5.%	8.9%

Ramalho et al. (2017) studied 3 children aged 5- to 7:06 years of age with DLD or SSD, comparing them with typically development children, in the production of /ɾ/ and /l/. The authors found significant differences in production of these problematic root nodes between disordered children and their controls, founding the effect of syllable constituency, word position and word length in the first ones. In a case study of one child with phonologically based SSD, with 4:09 years old, Freitas & Ramalho (2007) found that the acquisition of the contrast "alveolar *versus* palatal" happened in the obstruents class – devoiced before voiced (/s ʃ/ before /z ʒ/), and only after in the class of sonorants (/n ɲ/ and /l ʎ/).

Studying music and phonetic-phonological development

Music and language are related in various ways – from their auditory domain, their structure, function, expressive and receptive neuronal bases, brain activation patterns or learning processes. The neuroanatomical structures studied so far in relation to both areas are common to the perception of musical and speech sounds and specifically related do the development of metaphonological skills (Tervaniemi, 2006; Warrier et al., 2009). Domain transfer effects may imply a direct interaction or a domain-general influence, which have been pointed to justify this influence. Music seems to be related with auditory and cognitive mechanisms beyond those that are needed to phonological awareness development (Anvari et al., 2002; Skoe & Kraus, 2012). This relation has been largely explored in Chapter 3 (section 3.1.) of this document.

In this work, besides trying to better understand the already known music influence in phonological awareness development (although in a younger population at age 3 and also in DLD children aged 3 to 6 years of age), it was hypothesized that music classes may enhance phonetic and phonological development in 3-year-olds with typical development and 3- to 6-year-olds with DLD and phonologically based SSD. We found no work so far investigating music influence in the development of these linguistic areas. Our hypothesis is based on the relation between phonetic-phonological development and phonological awareness in language pathology since SSD are frequently associated with difficulties in phonological awareness development (Botting et al., 2006; Gillon, 2000; Stackhouse et al., 2002). For this reason, it was expected that by influencing metaphonological skills, music would also influence phonetic and phonological development in both populations.

The activation of common neural systems in music and language also made us explore this influence – specifically the use of the posterior portion of the left and right superior temporal gyrus (STG) and superior temporal sulcus (STS), and the left inferior frontal gyrus (IFG – Broca's area) (Lathroum, 2011). The auditory brainstem, fundamental in the processing of all sounds that enter the cochlea, is a structure used in processing music and speech sounds, justifying music effect in the subcortical encoding of linguistic patterns (Strait et al., 2011; Wong et al., 2007). According to Strait et al. (2011) the enhanced responses of the auditory brainstem and the subcortical development of regularly-occurring speech are related to a better performance in reading or speaking under optimal conditions. Besides that, the dorsal stream (responsible for mapping acoustic speech signals to the articulatory networks in the frontal lobe and that may also have an auditory-motor integration role) (Hickok & Poeppel, 2007; Sophie K. Scott & Johnsrude, 2003; Wise et al., 2001) also plays a crucial role in the relationship about music and language - receiving acoustic and non-acoustic information, it links the vocal tract gestures to speech, tones, music, environmental sounds and visual speech (Hickok & Poeppel, 2007). These facts would also justify the influence of music training in developing speech.

For the reasons explained above, we tried to see if music influences phonetic and phonological development (never studied before, as far as we know) in children aged 3 to 4 years old with TD (Study 3) and 3 to 6 years old children with DLD and / or phonologically based SSD, with typical music lessons, in kindergarten context.

4.2. Methodology - Study 3 (TD Population) and Study 4 (AD Population)

Through a longitudinal randomized controlled study, with a test-training-retest methodology (widely described in Chapter 2, about general methodology) we expected to find some relation about music training and phonetic-phonological development in 3-year-olds with TD (Study 3) and 3- to 6-year-olds with AD (Study 4). Following the methodology already described, after an initial assessment of phonetic and phonological development, children were randomized in two groups: the experimental group had 45 minutes per week music classes, and the control group had 45 minutes per week visual arts classes. Children were assessed with the same test in the end of the school year, so that results between and within groups could be compared.

4.2.1. Participants

Study 3

In this study, 31 children (20 female; mean age 3:5 years old) composed the sample. From the initial sample of 39 children, 11,43% dropped out - one child was transferred to a different kindergarten, 2 children were not EP native speakers, and the other child did not attend 70% of the classes. Sixteen children composed the experimental group – MC (10 female, mean age=3:4 years old) and 15 children composed the control group – VAC (10 female, mean age = 3:6 years old).

Study 4

In this study, children were referenced by the kindergarten teachers as having a speech and/or language disorder, with unknown origin, being not associated to a biomedical condition (e.g. autism or deafness). After the referral process, children were assessed with the Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence—

Revised (WPPSI-R) (Wechsler, 2003) by a trained psychologist. Children whose minimum NVIQ was a score of 80 (Bishop, 2014) were included. In order to confirm the diagnose of DLD and / or SSD, every child were assessed with the Teste de Linguagem - Avaliação da Linguagem Pré-Escolar (TL - ALPE), a standardized receptive and expressive language test (Mendes, Afonso, Lousada, & Andrade, 2014), and TFF-ALPE (Mendes et al., 2013).

From the initial sample of 22 children (from two different kindergartens in Aveiro), 6 children dropped out (1 was transferred to a different school, 1 quitted being demotivated, 2 children did not reach the rate 80 in the NVIQ assessment, and 2 others had no speech and/or language disorder). The final sample was composed by 16 children (5 female, mean age of 4:9 years old), with different linguistic profiles: 11/16 children have a phonologically based SSD with no compromise found in linguistic receptive and expressive levels assessed with TL-ALPE; 5/11 children have a DLD (for more information, see Table 1 in Chapter 2, pp 34). The MC group was composed by 8 children (1 female, mean age= 5:1 years old, NVIQ from 80 to 118), and VAC group had 8 children (3 female, mean age=4:6 years old, NVIQ from 83 to 105).

4.2.2. Procedures

Study 3 and 4

Every ethical procedures were followed. At the beginning and at the end of the training period (30 classes), all children were assessed in individual sessions at school, in a quiet room, with consent from the parents, the school board, and the teachers.

4.2.3. Dependent measures

Study 3 and 4

Teste Fonético-Fonológico – Avaliação da Linguagem na Criança Pré-Escolar (TFF - ALPE, Mendes, Afonso, Lousada, & Andrade, 2013) was used to assess phonetic and phonological development. This picture naming test comprises 69 words, with all the sounds in different word position and syllable structures possible in EP (Lousada et al., 2012), in individual images, that the child names one by one. Data related with the segment and the syllable were then transcribed and analyzed with Paediatric Automatic

Phonological Analysis Tools (APAT, Saraiva, Lousada, & Jesus, 2017) – Ferramentas para Análise Fonológica Automática (FAFA Version 1.3.00). Transcription was made in 4 levels: the targeted word using Speech Assessment Methods Phonetic Alphabet – SAMPA alphabet (Wells, 1997); the child's actual production using SAMPA alphabet; the targeted syllabic structures of each word, using the code C for consonants and V for vowels; and the child's syllabic structure production, using the same code.

It was possible to automatically obtain the Percentage of Correct Consonants (PCC) score, Percentage of Correct Vowels (PCV) score and Percentage of Correct Phonemes (PCP) score.

In the segmental analysis some phonological processes were analyzed: stopping, fronting, backing, depalatalization, palatalization, devoicing, devoicing of fricatives, substitution of liquids, gliding of liquids, substitution of vowels and denazalisation.

In the syllabic analysis final consonant deletion, weak syllable deletion, cluster reduction, intra-syllabic metathesis and reduction of diphthongs were automatically analyzed. The phonological processes of epenthesis and ressyllabification were two additional processes manually analyzed.

4.3. Design

In the present thesis all the children were assessed in the beginning of the school year. After this, the sample was randomized to compose the experimental (MC) and the control (VAC) groups, with balanced number of students. Both groups had 30 classes that occurred 45 minutes per week, with two trained teachers. Each class (MC and VAC) had children from eight different classrooms in two kindergartens, and both participating kindergartens had a music and a visual art group. In order to guarantee the effect of the methodology used in this project classes, children did not receive other music or visual arts lessons during this period. Both intervention groups had common themes (e.g., autumn, winter, animals, Disney) and materials (all materials were used for both classes: autumn leaves, balloons, journal, rolls of toilet paper, among others).

External variables were controlled through some procedures that have already been described in Chapter 2 of this thesis.

4.4. Results - Study 3 (TD Population)

4.4.1. Reliability

Phonetic transcriptions were made by the author of this thesis. Additionally, three children (10% of the sample) were randomly selected and their productions in the pre- and post-assessment were transcribed by a trained Speech and Language Therapist, blind with respect to the aim of the study. Point to point reliability was 91,8% in the pre-assessment moment, and 92,2% in the post assessment moment. This values were considered adequate for the objective of this study, being comparable with ones referred by Lousada et al. (2013), Shriberg & Lof (1991) and Shriberg, Tomblin, & McSweeny (1999).

4.4.2. Control variables

All children were monolingual EP speakers and have 3 to 4 years old. No one had the history of referral to speech and language therapy neither was referenced by her/his childhood educator has having a speech or language problem. MC group had 60% female and 40% male, and VAC group had 50% each. Neither the groups had significant differences in terms of age ($p>0.05$). All children were in two different kindergartens in the same city, where this study was developed in a single school year (more detailed information is present in Table 3, pp.67, in Chapter 2, about general methodology).

4.4.3. Results – Phonetic development

PCC, PCV and PCP comparison between groups in pre- and post-assessment moments

Results on the realization of segments are presented by the calculation of the PCC, the PCV and the PCP. These values were automatically obtained with FAFA (Saraiva et al., 2017), after the transcription of the picture naming test applied. The results presented in Table 12, show PCC, PCV and PCP in pre- and post-assessment moment, in the MC and VAC groups.

Table 12: PCC, PCV and PCP values in pre- and post-assessment, for both intervention (MC) and control (VAC) groups, in TD population.

	PCC		PCV		PCP	
Group	**Pre** (SD)	**Post** (SD)	**Pre** (SD)	**Post** (SD)	**Pre** (SD)	**Post** (SD)
MC	71.06% (2.02)	80.48% (8.19)	94.75% (2.98)	96.60% (1.18)	81.96% (5.15)	87.91% (4.70)
VAC	74.03% (10.33)	86.18% (8.30)	94.60% (2.30)	96.73% (0.98)	83.49% (6.12)	91.06% (4.66)

To analyze the differences between the experimental and the control group before and after the intervention period, and since there was no normal distribution in every moment in each group (Shapiro-Wilk test $p<0.05$), the statistical analysis pursued with a non-parametric test – Mann-Whitney U Test to independent samples. These results can be seen in Figure 12.

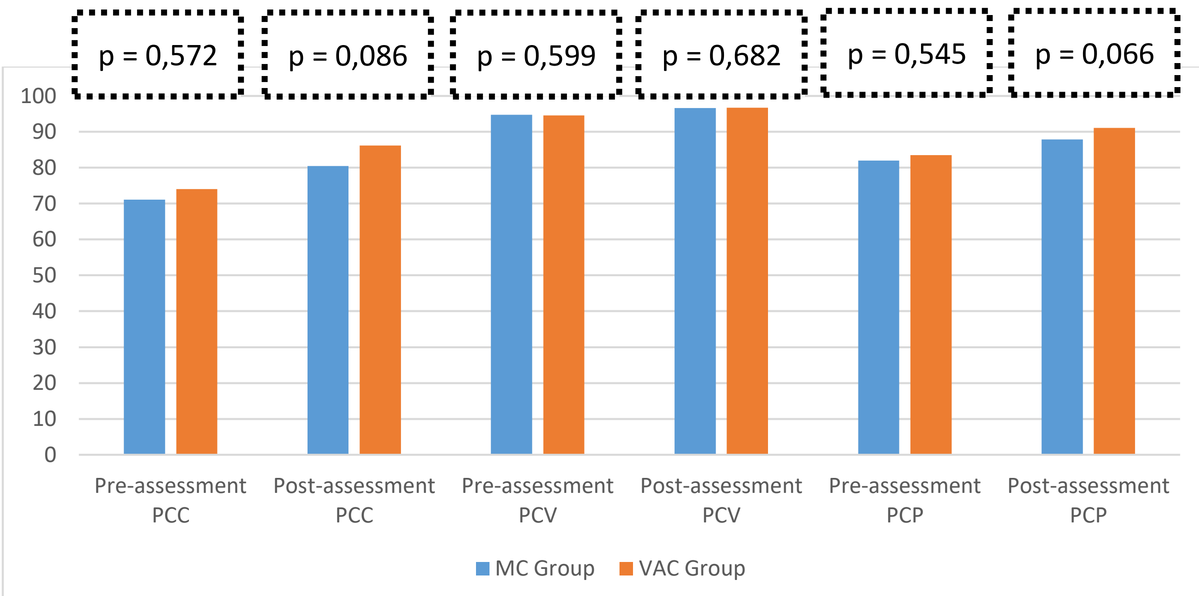


Figure 12: Comparison of PCC, PCV and PCP in MC group and VAC group in the pre- and post-assessment moments, in TD population.

As it can be seen in Figure 12 there are no significant differences between MC and VAC groups neither in pre-assessment moment neither in post-assessment moment. Although VAC results are always higher than MC results, the difference is not statistically significant

(Pre-assessment PCC $p>0.05$; Post-assessment PCC $p>0.05$; Pre-assessment PCV $p>0.05$; Post-assessment PCV $p>0.05$; Pre-assessment PCP $p>0.05$; Post-assessment PCP $p>0.05$).

PCC, PCV and PCP comparison within groups in pre- and post-assessment

The measures obtained after the picture naming test, its transcription and analyses with FAFA (Saraiva et al., 2017), showed that experimental and control group developed between the beginning and the end of the school year, as expected. In the MC and VAC group, all the measures have significant differences between pre- and post-assessment ($p<0.05$) – within groups results are shown in Figure 13 (MC group) and Figure 14 (VAC Group).

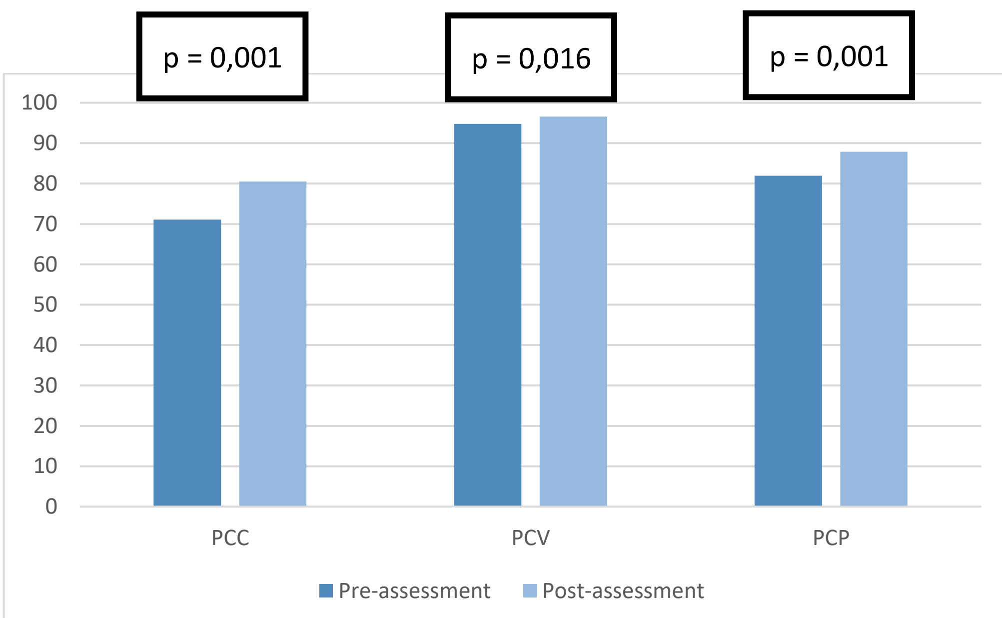


Figure 13: MC Group PCC, PCV and PCP results in pre- and post-assessment moments, in TD population.

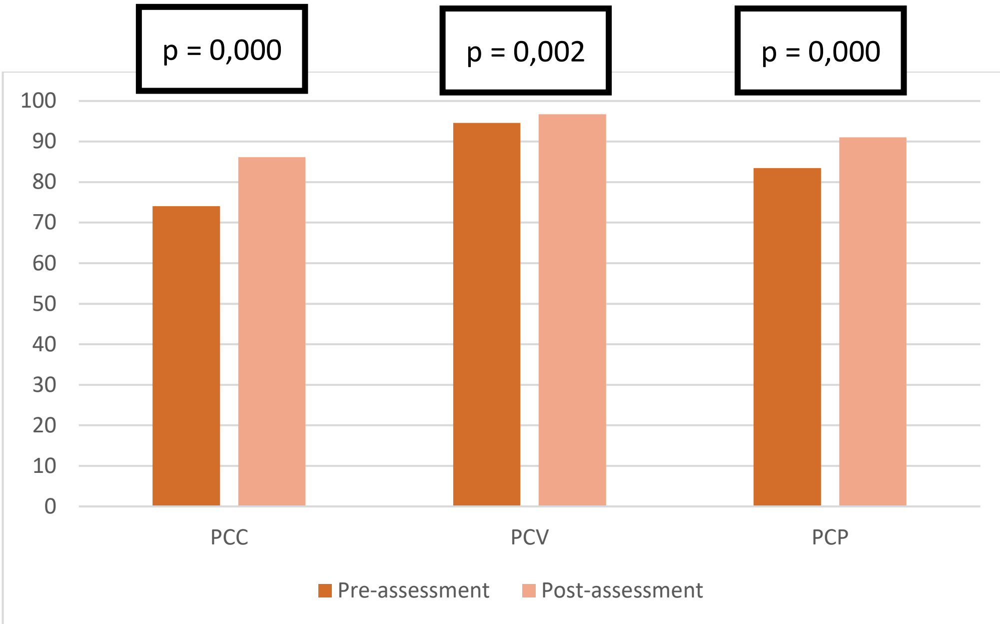


Figure 14: VAC Group PCC, PCV and PCP results in pre- and post-assessment moments, in TD population.

4.4.4. Results – Phonological development

Table 13 shows the results of TFF-ALPE (Lousada et al., 2012) concerning the percentage of occurrence of the segmental and prosodic phonological processes, that occurred in the all sample (N=31) before the randomization process and the intervention (MC or VAC) period.

In what concerns the syllable-level analysis, epenthesis and ressyllabification processes were divided in three different rows, comprehending the total result, and the process when it occurs in two different syllable structures: CCV and (C)VC as it can be seen in Table 8 prior in this Chapter.

As it can be seen in the Table 13, in this group of 31 children aged 3 to 4 years old, there are 5 processes at the segment-level that occur more frequently: Palatalization (36.83%) > Fricative Devoicing (21.08%) > Gliding of liquids (13.26%) > Depalatalization (11.19%) > Devoicing (8.39%).

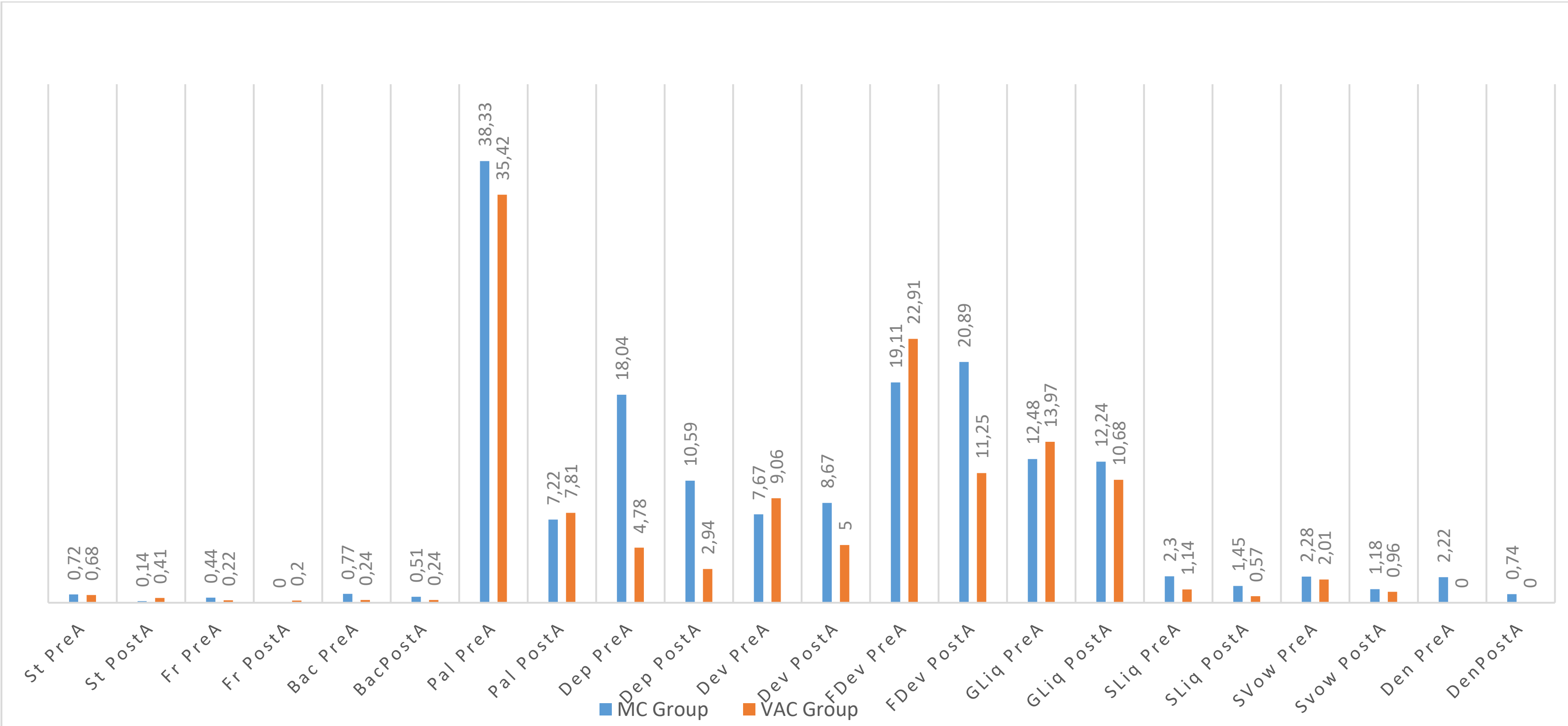
In what concerns the processes used to simplify the syllable structure, 3-year-olds frequently made Cluster reduction (84.04%) > Final consonant deletion (43.66%) > Epenthesis and Ressyllabification in CCV and (C)VC contexts (Total – 11.04%; CCV context – 11.22%; VC context – 10.90%) > Weak syllable deletion (4.48%).

Table 13: Percentage of occurrence of the segmental and prosodic phonological processes, in the total sample in pre-assessment moment (N=31), in TD population (percentages of the most used segmental and phonological processes signaled in boldface).

	Phonological Process	% of occurrence
Segmental level	Stopping	0.70%
	Fronting	0.43%
	Backing	0.50%
	Palatalization	**36.83%**
	Depalatalization	**11.19%**
	Devoicing	**8.39%**
	Fricative Devoicing	**21.08%**
	Gliding of Liquids	**13.26%**
	Substitution of Liquids	1.70%
	Substitution of Vowels	2.14%
	Denasalization	1.07%
Prosodic Level	**Weak syllable deletion**	**4.48%**
	Final consonant deletion	**43.66%**
	Cluster reduction	**84.04%**
	Intrassyllabic metathesis	0.59%
	Diphthong reduction	2.51%
	Epenthesis and ressyllabification CCV Context	11.22%
	Epenthesis and ressyllabification (C)VC Context	10.90%
	Epenthesis and ressyllabification (all contexts)	**11.04%**

4.4.4.1. Segment-level phonological processes comparison between groups in pre- and post-assessment moments

Phonological processes at the segment-level results in pre-assessment (where no intervention was made) were already described for the total sample. In this section, phonological processes are compared between the randomized samples, prior and after the intervention period. In Figure 15 it is possible to see the results of each phonological process at the segment-level, in MC and VAC group, in the pre- and the post-assessment moment.



Legend: St PreA– Stopping Pre-assessment; St PostA– Stopping Post-assessment; Fr PreA – Fronting Pre-assessment; Fr PostA – Fronting Post-assessment; Bac PreA– Backing Pre-assessment; Bac PostA– Backing Post-assessment; Dep PreA – Depalatalization Pre-assessment; Dep PostA – Depalatalization Post-assessment; Pal PreA– Palatalization Pre-assessment; Pal PostA– Palatalization Post-assessment; Dev PreA– Devoicing Pre-assessment; Dev PostA– Devoicing Post-assessment; FDev PreA– Fricative Devoicing Pre-assessment; ; FDev PostA– Fricative Devoicing Post-assessment; SLiq PreA– Substitution of Liquids Pre-assessment; SLiq PostA– Substitution of Liquids Post-assessment; GLiq PreA– Gliding of Liquids Pre-assessment; GLiq PostA– Gliding of Liquids Post-assessment; SVow PreA– Substitution of Vowels Pre-assessment; SVow PostA– Substitution of Vowels Post-assessment; Den PreA– Denasalization Pre-assessment; Den PostA– Denasalization Post-assessment.

Figure 15: Comparison of phonological processes at the segment-level MC group and VAC group in the pre- and post-assessment moments, in TD population.

As it was already mentioned, there are 5 phonological processes that occur more frequently, even though there is a small difference in their order at the end of the school year. MC and VAC groups behaved differently in the use of these simplification processes, although no significant differences were found between groups, neither in the pre- nor in the post-assessment moments ($p>0.05$).

The data are now presented in the moment pre- and post-intervention (Table 14 for the first moment, and Table 15 for the second moment), with the significant values of each comparison, obtained through Mann-Whitney non parametric U test for independent samples, since Shapiro Wilk normality test showed us no normal distribution in 6 of the 11 processes in study.

Through the analysis of the Tables 14 and 15, and even there are no significant differences between the groups, we can find different orders in what concerns the use of this simplification processes.

In the pre assessment moment, MC students used:

Palatalization > Fricative devoicing > Depalatalization > Gliding of liquids > Devoicing.

After the intervention period, the following order was found:

Fricative devoicing > Gliding of liquids > Depalatalization > Devoicing > Palatalization.

In the beginning of the school year VAC students used these processes in this order:

Palatalization > Fricative devoicing > Gliding of Liquids > Devoicing > Depalatalization.

In the post-assessment moment VA trained children used mostly the following processes:

Fricative Devoicing > Gliding of Liquids > Palatalization > Devoicing > Depalatalization.

Table 14: Percentage of occurrence of each phonological process and their significant values, for MC and VAC groups, in pre-assessment moment, in TD population (most used processes signaled in boldface).

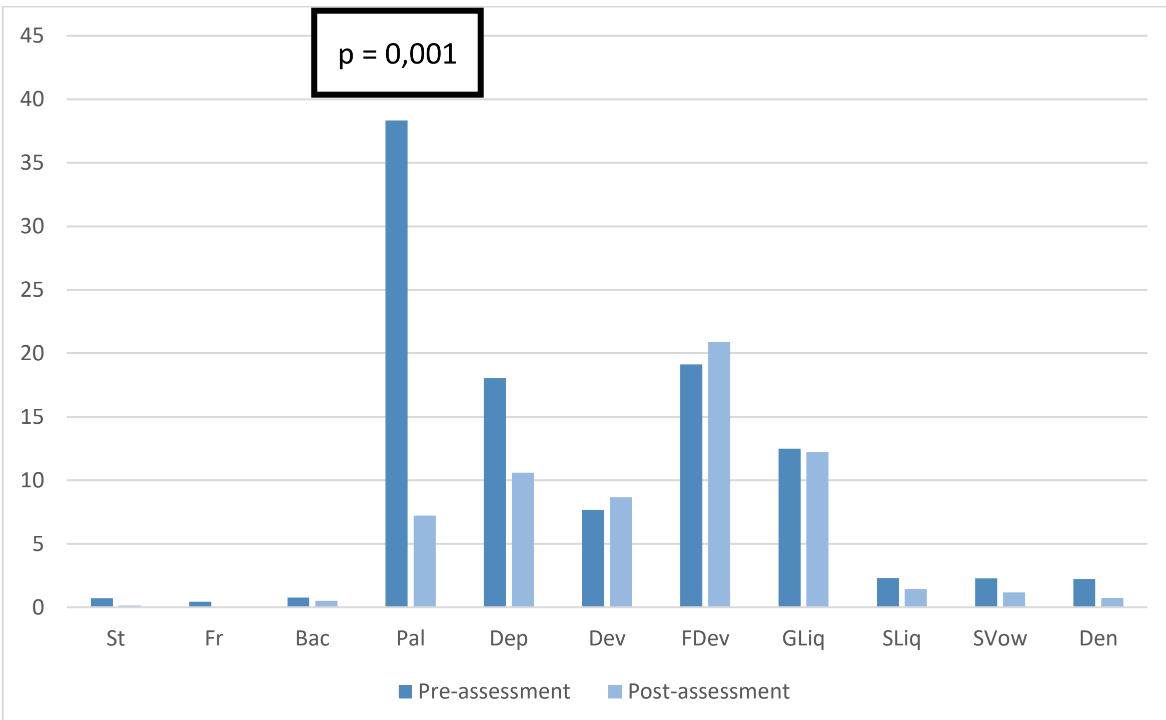
Phonological Process	**MC**	**VAC**	**Sig**
1. Palatalization	38.33%	35.42%	p = 0.626
2. Fricative devoicing	19.11%	22.91%	p = 0.495
3. Gliding of liquids	12.48%	13.97%	p = 0.470
4. Depalatalization	18.04%	4.78%	p = 0.281
5. Devoicing	7.67%	9.06%	p = 0.572
6. Substitution of vowels	2.28%	2.01%	p = 0.800
7. Substitution of liquids	2.13%	1.13%	p = 0.264
8. Denasalization	2.22%	0.00%	p = 0.358
9. Stopping	0.72%	0.68%	p = 0.953
10. Backing	0.77%	0.24%	p = 0.740
11. Fronting	0.44%	0.22%	p = 0.770

Table 15: Percentage of occurrence of each phonological process and their significant values, for MC and VAC groups, in post-assessment moment, in TD population (most used processes signaled in boldface).

Phonological Process	**MC**	**VAC**	**Sig**
1. Fricative devoicing	20.89%	11.25%	p = 0.093
2. Gliding of liquids	12.24%	10.68%	p = 0.470
3. Palatalization	7.22%	7.81%	p = 0.495
4. Devoicing	8.67%	5.00%	p = 0.129
5. Depalatalization	10.59%	2.94%	p = 0.358
6. Substitution of liquids	1.45%	0.57%	p = 0.654
7. Substitution of vowels	1.18%	0.96%	p = 0.52
8 Backing	0.51%	0.24%	p = 0.984
9. Denasalization	0.74%	0.00%	p = 0.770
10. Stopping.	0.14%	0.41%	p = 1.000
11. Fronting	0.00%	0.2%	p = 0.770

4.4.4.2. Segment-level phonological processes comparison within MC group in pre- and post-assessment moments

Even no effect of the activity was found in segment-level phonological awareness processes, it is important to seek for differences within the activity group, between the beginning and the end of the intervention period. In this way, Figure 16 shows the result in each process, in the pre- and post-assessment moments, in the experimental group, with music classes.



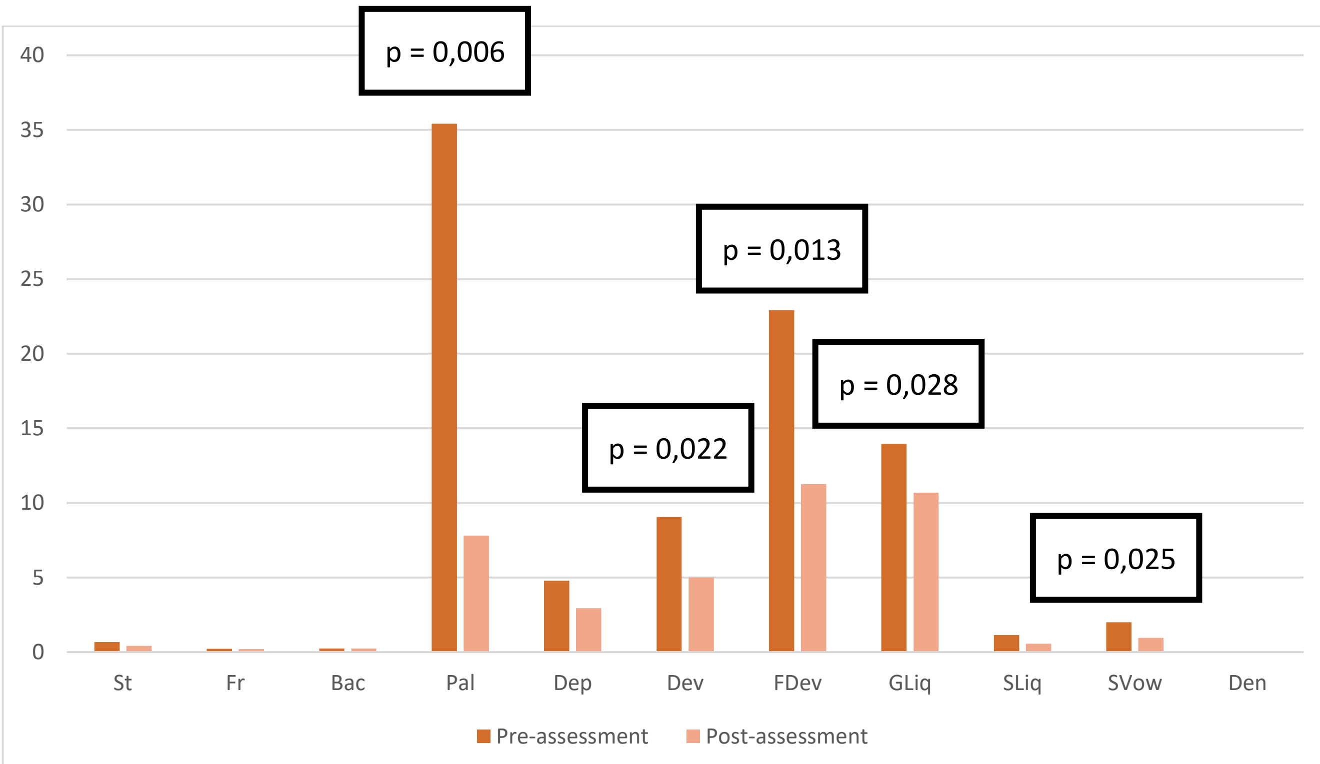
Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization

Figure 16: Comparison of the segment-level phonological processes in the MC group in the pre- and post-assessment moments, in TD population.

As it can be seen, all the processes (with exception of devoicing and fricative devoicing) had a lower result in the end of the intervention period. Applying a Wilcoxon Test to related samples, it was possible to conclude that only Palatalization had a lower statistically significant result ($p<0.05$).

4.4.4.3. Segment-level phonological processes comparison within VAC group in pre- and post-assessment moments

In the VAC group the percentage of occurrence of all the processes decreased between the pre- and the post-assessment moment (Figure 17). Significant differences were found with a non parametric test to related samples (Wilcoxon Test) in the following processes: Palatalization, Devoicing, Devoicing of fricatives, Gliding of liquids and Substitution of vowels.

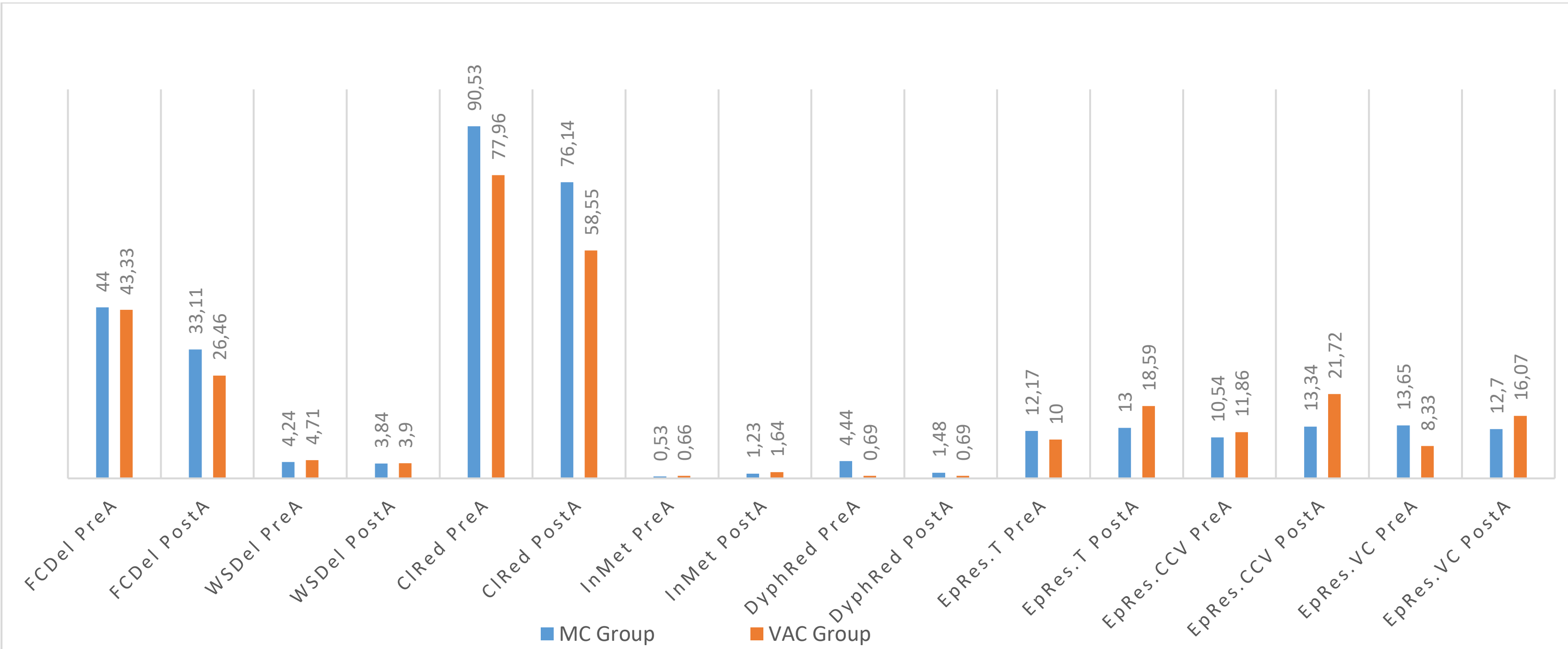


Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization.

Figure 17: Comparison of the segment-level phonological processes in the MC group in the pre- and post-assessment moments, in TD population.

4.4.4.4. Syllable-level phonological processes comparison between groups in pre- and post-assessment moments

Simplification processes at the syllable level have already been explained in this Chapter, describing the total sample behavior (N=31, 3 to 4 years old), before the randomization process. Is this section, these phonological processes are described in each group (experimental versus control group) in the moments pre- and post-intervention (music or visual arts) – Figure 18.



Legend: FCDel PreA– Final Consonant Deletion Pre-assessment; FCDel PostA– Final Consonant Deletion Post-assessment; WSDel PreA– Weak Syllable Deletion Pre-assessment; WSDel PostA– Weak Syllable Deletion Post-assessment; ClRed PreA– Cluster Reduction Pre-assessment; ClRed PostA– Cluster Reduction Post-assessment; InMet PreA– Intrassyllabic Metathesis Pre-assessment; InMet PostA– Intrassyllabic Metathesis Post-assessment; DyphRed PreA– Dyphthong Reduction Pre-assessment; DyphRed PostA– Dyphthong Reduction Post-assessment; EpRes.T PreA– Epenthesis and Ressyllabification in CCV and VC contexts Pre-assessment; EpRes.T PostA– Epenthesis and Ressyllabification in CCV and VC contexts Post-assessment; EpRes.CCV PreA – Epenthesis and Ressyllabification in CCV context Pre-assessment; EpRes.CCV PostA – Epenthesis and Ressyllabification in CCV context Post-assessment; EpRes.VC PreA– Epenthesis and Ressyllabification in (C)VC context Pre-assessment; EpRes.VC PostA– Epenthesis and Ressyllabification in (C)VC context Post-assessment

Figure 18: Comparison of phonological processes at the syllable-level in MC group and VAC group in the pre- and post-assessment moments, in TD population.

Four phonological processes at the syllable level were already mentioned as the most frequents in the total sample of this study in the beginning of the school year. In both assessment moments MC and VAC groups behaved very closely in the production of these simplification processes, and no significant differences were found between the groups neither in the pre- nor in the post-assessment moments ($p>0.05$). Table 16 and Table 17 present the data of each phonological process in the moments pre- and post-intervention (respectively), as well as the significant values of each comparison. Mann-Whitney non parametric U tests for independent samples were done, since Shapiro Wilk normality test showed us no normal distribution in 6 of the 8 processes in study.

Table 16: Percentage of occurrence of each phonological process and their significant values, for MC and VAC groups, in pre-assessment moment (most used processes signaled in boldface).

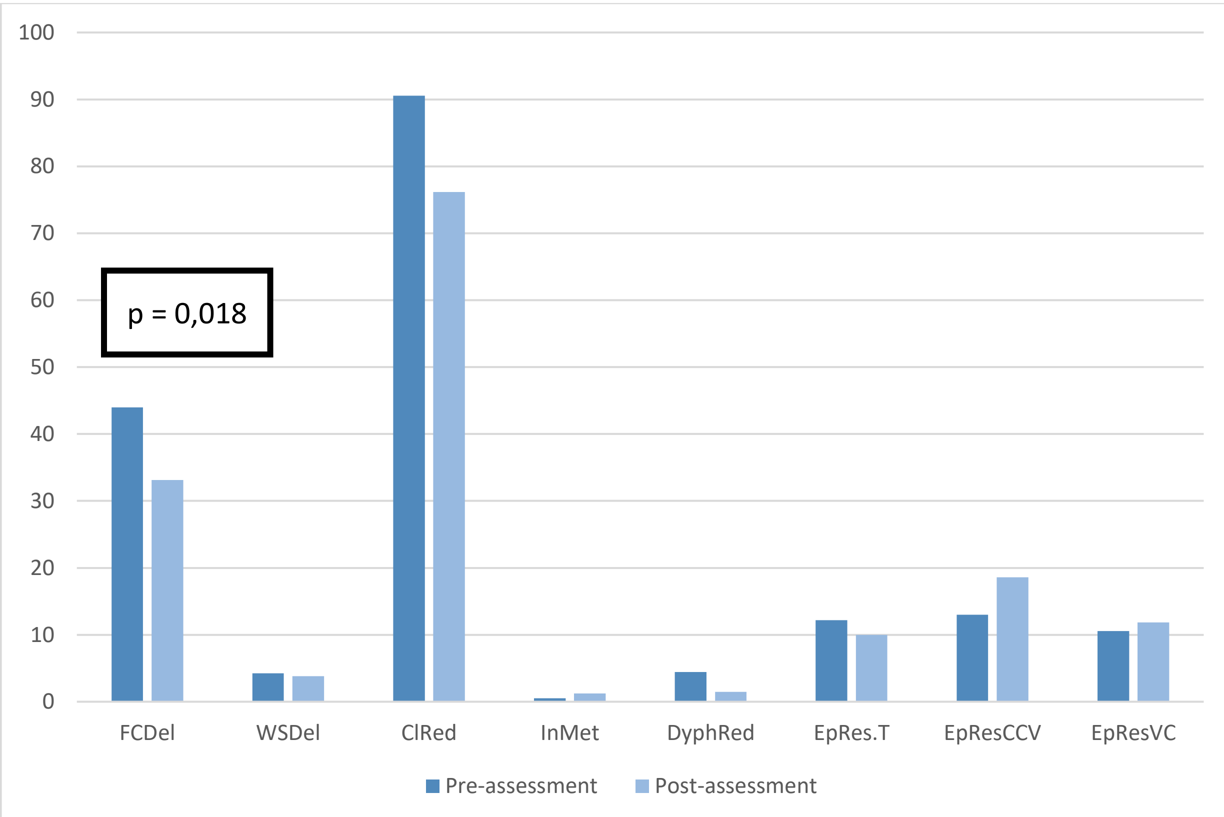
Phonological Process	**MC**	**VAC**	**Sig**
1. Cluster reduction	90.53%	77.96%	p = 0.078
2. Final consonant deletion	44%	43.33%	p = 1.000
3. Epenthesis and Ressyllabification (total contexts)	12.17%	10%	p = 0.446
4. Epenthesis and Ressyllabification CCV context	10.54%	11.86%	p = 0.770
5. Epenthesis and Ressyllabification (C)VC context	13.65%	8.33%	p = 0.299
6. Weak syllable deletion	4.24%	4.71%	p = 0.338
7. Dyphthong reduction	4.44%	0.69%	p = 0.495
8. Intrassyllabic metathesis	0.53%	0.66%	p = 0.830

Table 17: Percentage of occurrence of each phonological process and their significant values, for MC and VAC groups, in post-assessment moment (most used processes signaled in boldface).

Phonological Process	**MC**	**VAC**	**Sig**
1. Cluster reduction	76.14%	58.55%	p = 0.101
2. Final consonant deletion	33.11%	26.46%	p = 0.202
3. Epenthesis and Ressyllabification (total contexts)	13%	18.59%	p = 0.338
4. Epenthesis and Ressyllabification CCV context	13.34%	21.72%	p = 0.281
5. Epenthesis and Ressyllabification (C)VC context	12.7%	16.07%	p = 0.379
6. Weak syllable deletion	3.84%	3.9%	p = 0.861
7. Intrassyllabic metathesis	1.23%	1.64%	p = 0.495
8. Dyphthong reduction	1.48%	0.69%	p = 0.984

4.4.4.5. Syllable-level phonological processes comparison within MC group in pre- and post-assessment moments

Analyzing the results of music trained children before and after the intervention period, it is possible to see the decrease in the use of the phonological processes at the syllable level. Through the Wilcoxon Test for related samples it was found a significant difference in the frequency of Final consonant omission ($p<0.05$). An inverted tendency is observed in the processes of Epenthesis and Ressyllabification, that shows an increase in the percentage of occurrence, but this tendency is not significant (Figure 19).

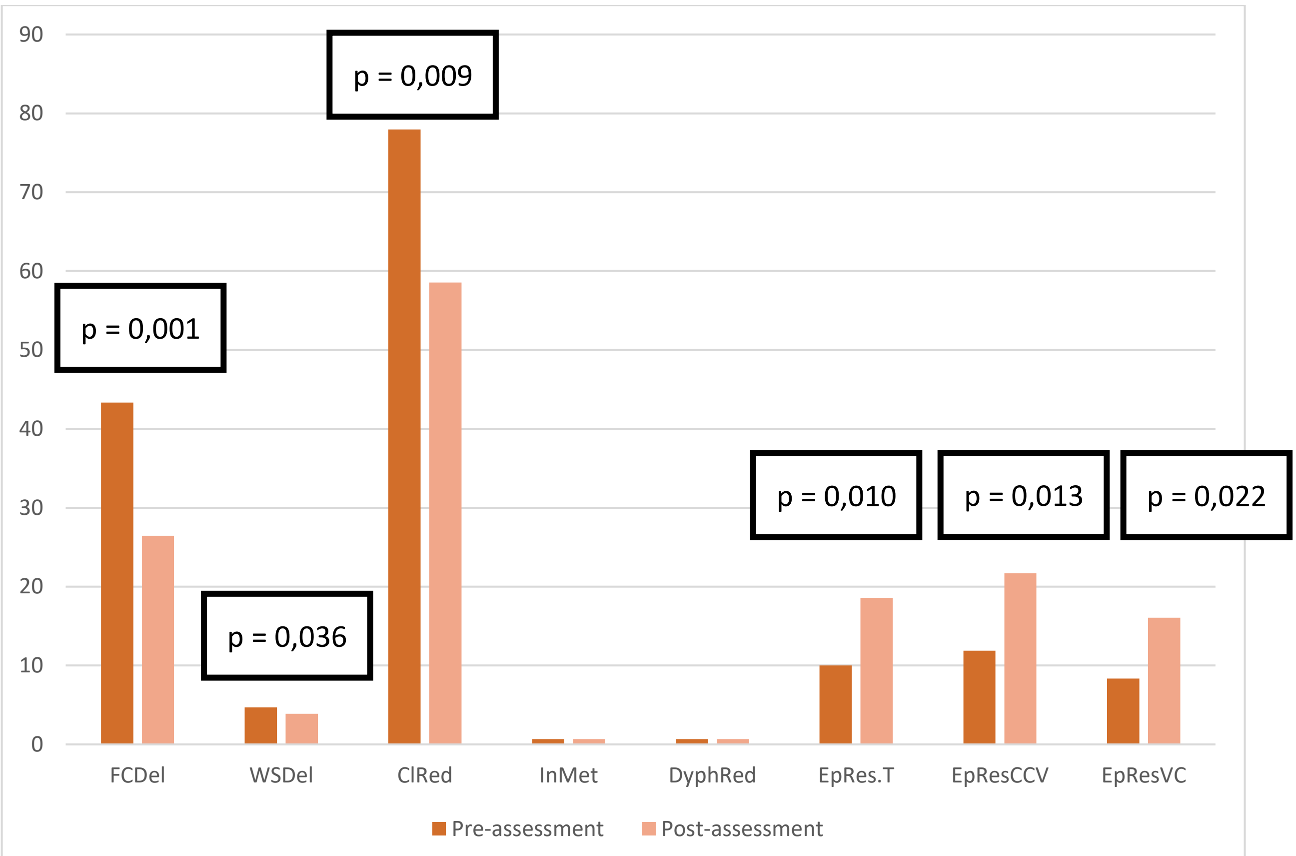


Legend: FCDel – Final Consonant Deletion; WSDel – Weak Syllable Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.T – Epenthesis and Ressyllabification in CCV and VC contexts; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context.

Figure 19: Comparison of the syllable-level phonological processes in the MC group in the pre- and post-assessment moments, in TD population.

4.4.4.6. Syllable-level phonological processes comparison within VAC group in pre- and post-assessment moments

In the VAC group a statistical significant lower percentage was found on the production of the processes of Final Consonant Omission, Weak Syllable Deletion and Cluster Reduction ($p<0.05$). Once again, the processes of Epenthesis and Ressyllabification exhibit a higher percentage of occurrence in the end of the school year, but, in this group, they have significant differences ($p<0.05$), found through the Wilcoxon Test to Related Samples (Figure 20).



Legend: FCDel – Final Consonant Deletion; WSDel – Weak Syllable Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.T – Epenthesis and Ressyllabification in CCV and VC contexts; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context.

Figure 20: Comparison of the syllable-level phonological processes in the VAC group in the pre- and post-assessment moments, in TD population.

4.5. Results - Study 4 (AD Population)

4.5.1. Reliability

As in Study 3, phonetic transcriptions were made by the author of this project. Two children (12.5% of the sample) were randomly selected and their productions in the pre- and post-assessment were then transcribed by a trained Speech and Language Therapist, blind with respect to the aim of the study. Point to point reliability was 90,04% in the pre-assessment moment, and 91,7% in the post assessment moment. Being comparable with the values referred in studies in disordered child phonology (Lousada et al., 2013; Shriberg & Lof, 1991; Shriberg et al., 1999) this values were considered adequate for the objective of this study.

4.5.2. Control variables

In this study children were EP monolingual speakers aged between 3:00 and 5:11 years old. They were referenced has having a speech and/or language disorder not associated with a biomedical condition by their childhood educators. The diagnose was confirmed with the Teste de Linguagem – Avaliação da Linguagem Pré-Escolar (Mendes et al., 2014) and the picture naming test – Teste Fonético-Fonológico – Avaliação da Linguagem Pré-Escolar (Lousada et al., 2012). To ensure that NVIQ of each participant had a minimum score of 80, each child was assessed with the Performance Scale of the Wechsler Preschool and Primary Scale of Intelligence— Revised (WPPSI-R) (Wechsler, 2003) by a trained psychologist. This study was developed in a single school year, and all the children belonged to two different kindergartens in the same city.

4.5.3. Results – Phonetic development

4.5.3.1. PCC, PCV and PCP comparison between groups in pre- and post-assessment moments

After the assessment with the picture naming test TFF-ALPE (Mendes et al., 2013), the data were transcripted by a trained speech and language therapist, author of this thesis, to the Paediatric Automatic Phonological Analysis Tools (Saraiva et al., 2017). FAFA automatically presented PCC, PCV and PCP results for MC and VAC groups in the pre- and post-assessment moments, in Table 18 below.

Table 18: PCC, PCV and PCP values in pre- and post-assessment, for both intervention (MC) and control (VAC) DLD groups.

	PCC		**PCV**		**PCP**	
Group	Pre (SD)	Post (SD)	Pre (SD)	Post (SD)	Pre (SD)	Post (SD)
MC	67.66% (20.23)	76.61% (17.12)	94.68% (4.03)	96.69% (1.06)	79.82% (12.63)	85.82% (9.70)
VAC	68.88% (17.24)	79.06% (14.72)	93.63% (7.22)	96.93% (1.82)	80.13% (12.28)	87.18% (8.58)

Normality was tested with Shapiro-Wilks Test. Since no normal distribution was found, non parametric Man-Whitney U Test for independent samples was used to search for differences between both intervention groups in the end of the school year – results in Figure 21.

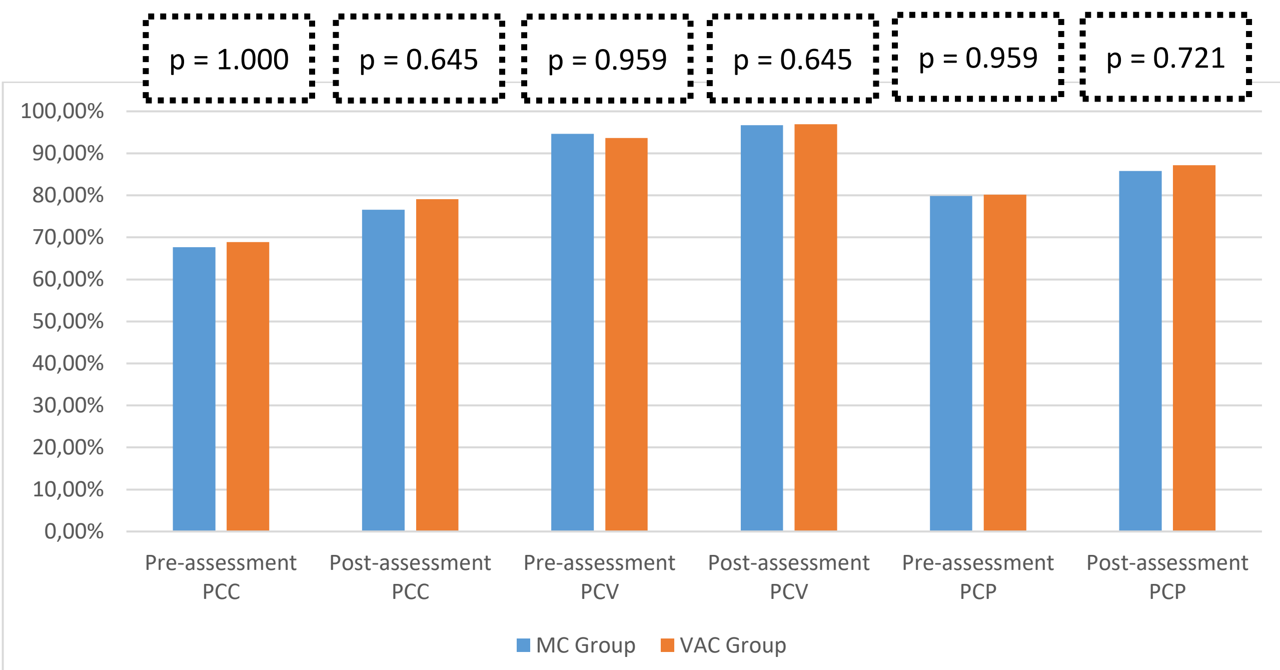


Figure 21: Comparison of PCC, PCV and PCP in DLD population – MC group and VAC group in the pre- and the post-assessment moments, in AD population.

PCC, PCV and PCP obtained, show a slightly higher result in VAC trained children (with exception of PCV in pre-assessment). This difference, however, is never statistically significant ($p>0.05$) (Pre-assessment PCC $p>0.05$; Post-assessment PCC $p>0.05$; Pre-assessment PCV $p>0.05$; Post-assessment PCV $p>0.05$; Pre-assessment PCP $p>0.05$; Post-assessment PCP $p>0.05$).

4.5.3.2. PCC, PCV and PCP comparison within groups in pre- and post-assessment moments

The participants in the experimental and control group with DLD had an increase on PCC and PCP between the beginning and the end of the school year. PCV measures revealed an increase in MC group, but a decrease on VAC group, although the difference is not significant ($p>0.05$). PCC and PCP in the MC and VAC groups and also PCP in VAC group have significant differences between pre- and post-assessment moments ($p<0.05$). Figure 22 (MC group) and Figure 23 (VAC Group) show within groups results.

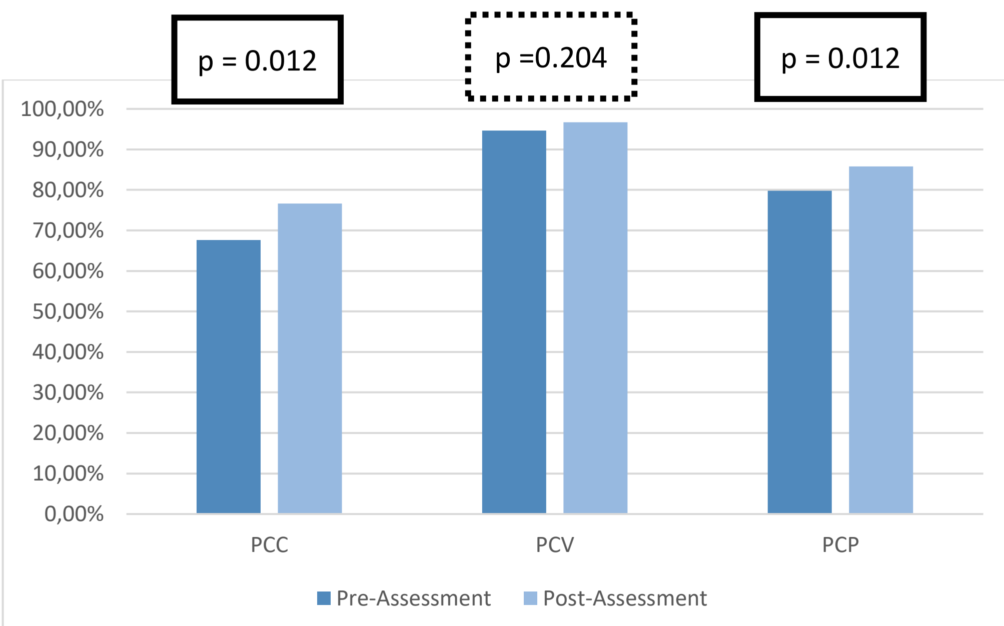


Figure 22: MC Group PCC, PCV and PCP results in pre- and post-assessment moments, in AD population.

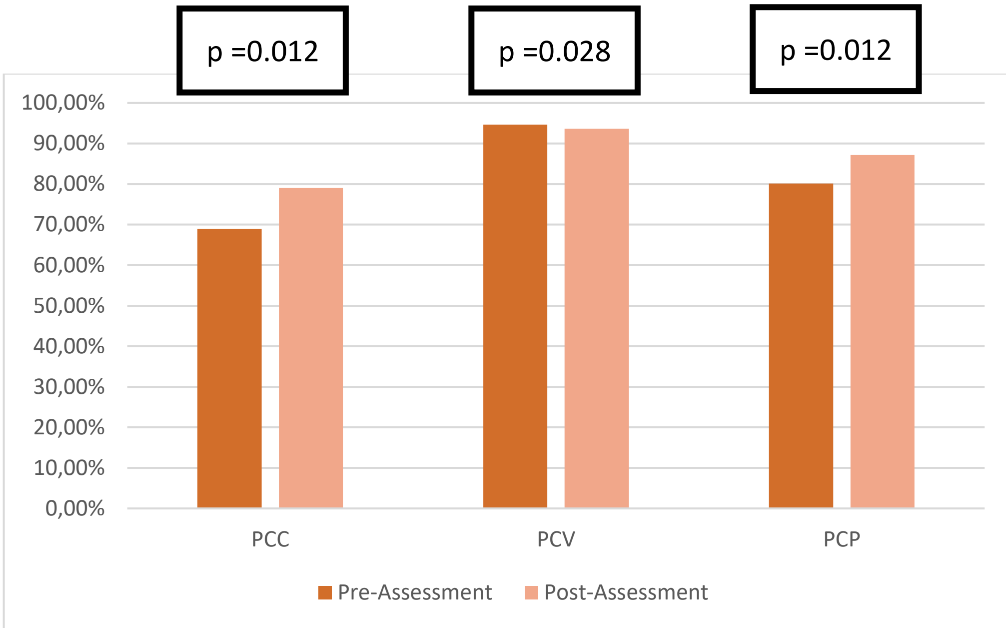


Figure 23: VAC Group PCC, PCV and PCP results in pre- and post-assessment moments, in AD population.

4.5.4. Results – Phonological development

Phonological results include the analysis of segmental and syllabic phonological processes, already described for the TD samples in Study 3, earlier in this Chapter.

Since DLD children is a heterogeneous group, it is important to analyze the percentage of occurrence of each process by child, thus the analysis will be carried in-depth. Percentages of each process will be presented, but number of processes in each child will be compared between the beginning and the end of the school year, trying to find not only a decrease on the percentage of each process, but also a decrease in the number of processes that co-occur. At the same time, it will be possible to see the processes that more frequently happen in order to simplify the phonological structure of DLD children.

Table 19 shows the percentage of occurrence of the total sample (N=16, 3- to 5-year-olds) prior to the randomization process. As it can be seen, the frequency of phonological processes at the segment-level occur in these DLD children aged 3 to 6 years old, in the following order: Palatalization> Fricative Devoicing > Gliding of Liquids > Devoicing > Fronting. In order to simplify the syllable structure, children used Cluster Reduction > Final Consonant Deletion > Epenthesis and Ressyllabification.

Table 19: Percentage of occurrence of the segmental and prosodic phonological processes, in the total sample of the DLD group (N=16) (percentages of the most used processes signaled in boldface).

	Phonological Process	**% of occurrence**
Segmental level	Stopping	3.12%
	Fronting	**10.21%**
	Backing	5.53%
	Palatalization	**32.29%**
	Depalatalization	**9.19%**
	Devoicing	**10.78%**
	Fricative Devoicing	**22.5%**
	Gliding of Liquids	**12.28%**
	Substitution of Liquids	2.04%
	Substitution of Vowels	2.52%
	Denasalization	6.25%
Prosodic Level	Weak syllable deletion	5.14%
	Final consonant deletion	**49.44%**
	Cluster reduction	**78.62%**
	Intrassyllabic metathesis	0.82%
	Diphthong reduction	**11.11%**
	Epenthesis and ressyllabification CCV Context	13.82%
	Epenthesis and ressyllabification (C)VC Context	9.82%
	Epenthesis and ressyllabification (all contexts)	**11.72%**

4.5.4.1. Segment-level phonological processes comparison in pre- and post-assessment moments

In order to understand DLD children development during the intervention period, information about the percentage and number of occurrences of phonological processes for each child, in each intervention group, was organized in Table 20 and 21 for MC group in pre-and post-assessment, and Table 22 and 23 for VAC group also in both assessment moments. In what concerns the process of Vowel substitution, it is signalled when it is considered atypical, or not. In the second case (for example /tɨlɨ'fɔnɨ/ produced as [tu'fɔnɨ]) the percentage of occurrence is noted in the table, but the process is not counted in the total number of processes for each child.

In Figure 24, in order to see the evolution of each child, there's the comparison of the total number of phonological processes at the segment-level used, in Pre- and Post-assessment moments in MC Group. Figure 25 presents the results obtained by VAC students in the beginning and in the end of the school year. Figure 26 shows the phonological processes mean result for each group prior and after the intervention period.

As it can be seen in Table 20 the more frequent processes used by this group of children with language disorder in pre-assessment are: 1) Gliding of Liquids (N=8) > 2) Devoicing (N=7) = 2) Fricative Devoicing (N=7) > 3) Palatalization (N=5) = 3) Substitution of Liquids (N=5). Each child used more than one process, varying between 3 and 8 in the total.

In Table 21 we can see the results in the post assessment moment, were the order of the most frequent processes used is the same: 1) Gliding of Liquids (N=8) > 2) Devoicing (N=7) = 2) Fricative Devoicing (N=7) > 3) Palatalization (N=5) = 3) Substitution of Liquids (N=5). Children continue to use one or more phonological processes. A decrease in the number of processes used is found in 4 children (C3, C6, C13 and C14). C7 and C8 maintained the exactly same processes in both moments, while C1 and C16 produced more segment-level processes in the end of the school year than in the beginning (Figure 24).

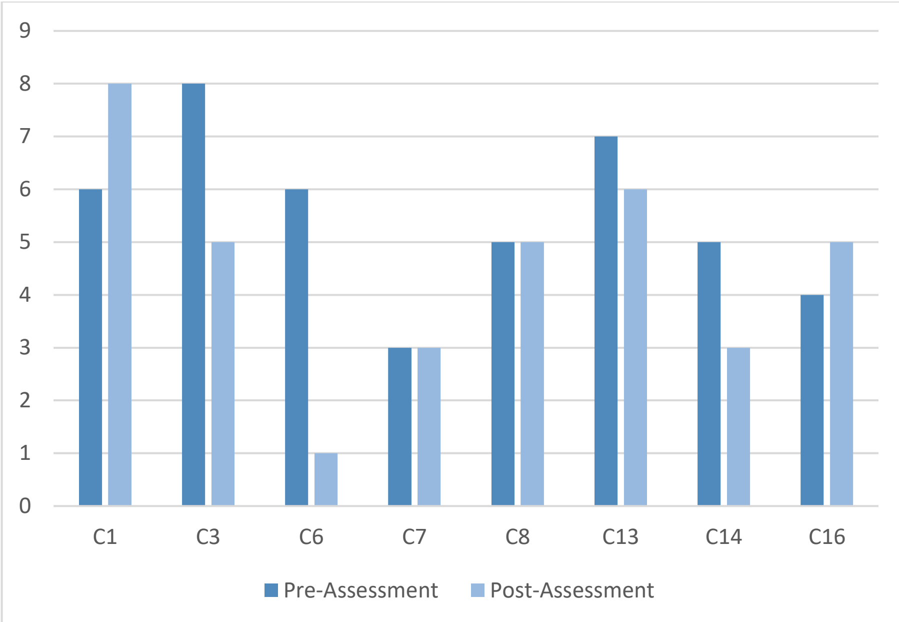


Figure 24: Comparison of the total number of phonological processes at the segment-level used by child, in Pre- and Post-assessment moments in MC group, in AD population.

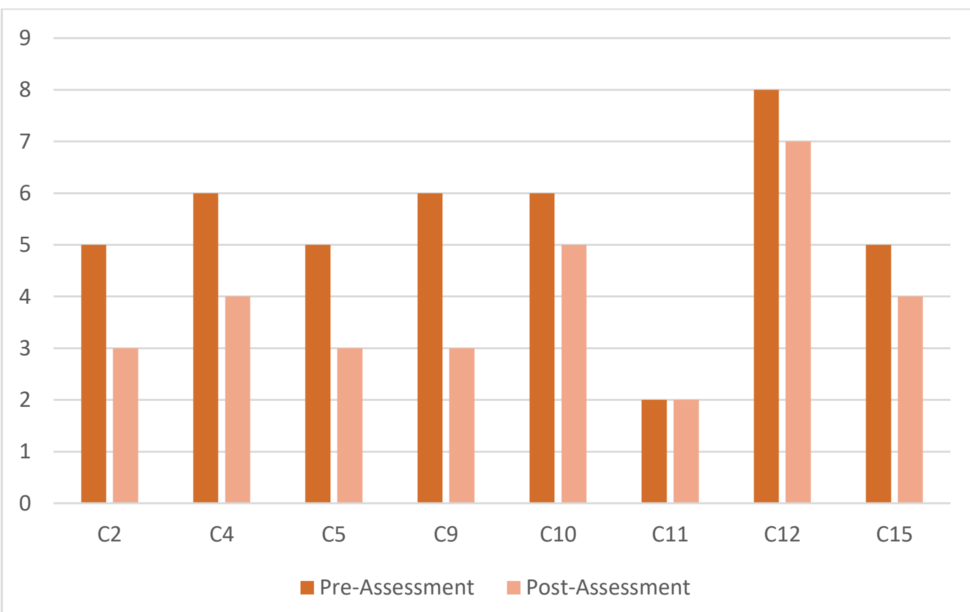


Figure 25: Comparison of the total number of phonological processes at the segment-level used by child, in Pre- and Post-assessment moments in VAC group, in AD population.

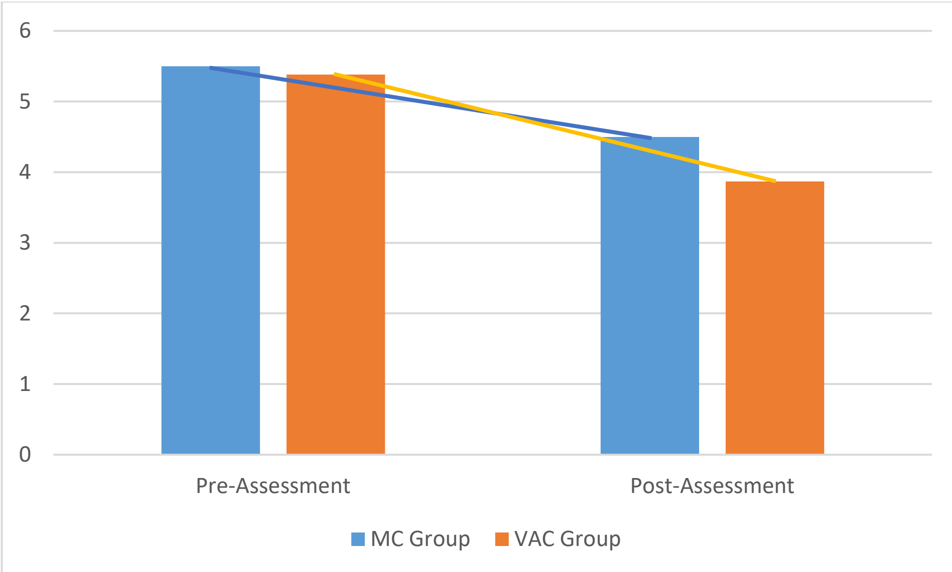


Figure 26: comparison of the mean number of phonological processes at the segment-level used by MC and VAC Groups in Pre- and Post-assessment, in AD population.

In Figure 26 it is possible to see that the mean number of phonological processes used by MC and VAC groups in each moment was very close. Each group developed in the sense of showing less phonological processes (MC Group Pre-assessment M= 5.50, Post-assessment M=4.50; VAC Group Pre-assessment M= 5.38, Post-assessment M=3.87).

Tables 20, 21, 22 and 23 are presented below.

Table 20: AD children description in MC group in Pre-assessment moment: Age, diagnose, PCC, frequency, percentage of occurrence and number of phonological processes at the segment-level.

	Age	Gender	Diagnose	PCC	Segment-level Phonological Processes %											Total Number
					St	Fr	Bac	Dep	Pal	Dev	FDev	SLiq	GLiq	SVow	Den	
C1	41	M	DLD	47,94%	0.00	83.33	0.00	0.00	83.33	15.00	40.00	3.64	9.09	2.05*	0.00	6
C3	42	M	SSD	55,67%	2.17	0.00	0.00	0.00	75.00	30.00	53.33	12.73	10.91	4.11	44.44	8
C6	71	M	SSD	88.14%	0.00	0.00	0.00	5.88	25.00	10.00	20.00	1.82	12.73	1.37*	0.00	6
C7	68	F	SSD	92,78%	0.00	0.00	0.00	0.00	0.00	5.00	13.33	0.00	9.09	0.00	0.00	3
C8	71	M	SSD	73,20%	0.00	0.00	0.00	5.88	75.00	7.5	20.00	0.00	16.36	2.05*	0.00	5
C13	60	M	SSD	34,02%	28.26	76.67	0.00	0.00	25.00	0.00	0.00	5.45	16.36	4.79	22.22	7
C14	69	M	SSD	71,65%	0.00	0.00	0.00	0.00	0.00	7.50	13.33	1.82	12.73	2.05*	11.11	5
C16	66	M	SSD	77,84%	0.00	0.00	3.85	0.00	0.00	5.00	6.67	0.00	7.27	0.00	0.00	4
				Total Number	2	2	1	2	5	7	7	5	8	2	3	Mean = 5.50

Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization.

* Phonological process that is not considered atypical and therefore not being counted in the total number.

Table 21: AD children description in MC group in Post-assessment moment: Age, diagnose, PCC, percentage of occurrence and number of phonological processes at the segment-level.

	Age	Gender	Diagnose	PCC	Segment-level Phonological Processes %											Total Number
					St	Fr	Bac	Dep	Pal	Dev	FDev	SLiq	GLiq	SVow	Den	
C1	41	M	DLD	65.46%	2.17	0.00	7.69	5.88	75.00	20.00	46.67	3.64	9.09	2.74*	0.00	8
C3	42	M	SSD	75.26%	0.00	0.00	3.85	35.29	25.00	2.50	0.00	0.00	10.91	0.68*	0.00	5
C6	71	M	SSD	95.88%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.09	0.68*	0.00	1
C7	68	F	SSD	95.36%	0.00	0.00	0.00	0.00	0.00	5.00	13.33	0.00	7.27	0.68*	0.00	3
C8	71	M	SSD	76.80%	0.00	0.00	0.00	11.76	66.67	2.50	6.67	0.00	9.09	1.37*	0.00	5
C13	60	M	SSD	43.30%	6.52	70.00	7.69	35.29	16.67	0.00	0.00	0.00	14.55	1.37*	0.00	6
C14	69	M	SSD	74.74%	0.00	0.00	0.00	0.00	0.00	5.00	13.33	0.00	18.18	1.37*	0.00	3
C16	66	M	SSD	86.08%	0.00	0.00	3.85	0.00	0.00	10.00	26.67	1.82	7.27	0.00	0.00	5
				Total Number	2	2	1	2	5	7	7	5	8	0	3	Mean = 4.5

Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization.

* Phonological process that is not consider pathologic, not being counted in the total number

Table 22: AD children description in VAC group in Pre-assessment moment: Age, diagnose, PCC, percentage of occurrence and number of phonological processes at the segment-level.

					Segment-level Phonological Processes %											**Total**
	Age	**Gender**	**Diagnose**	**PCC**	St	Fr	Bac	Dep	Pal	Dev	FDev	SLiq	GLiq	SVow	Den	**Number**
C2	36	F	DLD	64,43%	0.00	0.00	0.00	0.00	41.67	17.50	40.00	0.00	20.00	1.37*	11.11	5
C4	44	M	DLD	66,49%	10.87	3.33	0.00	52.94	0.00	15.00	6.67	0.00	1.82	0.68*	0.00	6
C5	52	M	SSD	80,93%	4.35	0.00	3.85	0.00	0.00	12.50	33.33	0.00	18.18	0.68*	0.00	5
C9	59	F	SSD	68,04%	0.00	0.00	0.00	58.82	8.33	10.00	26.67	1.82	25.45	2.74*	0.00	6
C10	65	F	SSD	60,82%	0.00	0.00	0.00	11.76	100.0	7.50	20.00	1.82	14.55	2.74*	0.00	6
C11	66	F	DLD	94,33%	0.00	0.00	0.00	11.76	0.00	0.00	0.00	1.82	0.00	2.05*	0.00	2
C12	37	M	SSD	36,08%	2.17	0.00	80.77	0.00	83.33	17.50	46.67	0.00	10.91	13.01	11.11	8
C15	71	M	DLD	79,90%	2.17	0.00	0.00	0.00	0.00	12.50	20.00	1.82	10.91	0.68*	0.00	5
				Total Number	4	1	2	4	4	7	7	4	7	1	2	Mean = 5.38

Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization.

* Phonological process that is not consider pathologic, not being counted in the total number

Table 23: AD children description in VAC group in Post-Assessment moment: Age, diagnose, PCC, frequency, percentage of occurrence and number of phonological processes at the segment-level.

					Segment-level Phonological Processes %											Total
	Age	**Gender**	**Diagnose**	**PCC**	St	Fr	Bac	Dep	Pal	Dev	FDev	SLiq	GLiq	SVow	Den	**Number**
C2	36	F	DLD	77.32%	0.00	0.00	0.00	0.00	0.00	7.50	20.00	0.00	10.91	2.05*	0.00	3
C4	44	M	DLD	84.02%	0.00	3.33	0.00	0.00	0.00	12.50	26.67	0.00	12.73	0.68*	0.00	4
C5	52	M	SSD	84.02%	0.00	0.00	0.00	0.00	0.00	7.50	20.00	0.00	14.55	0.68*	0.00	3
C9	59	F	SSD	81.96%	0.00	0.00	0.00	76.47	0.00	0.00	0.00	1.82	14.55	0.68*	0.00	3
C10	65	F	SSD	70.10%	0.00	0.00	0.00	5.88	50.00	5.00	13.33	0.00	7.27	0.68*	0.00	5
C11	66	F	DLD	97.42%	0.00	0.00	0.00	0.00	0.00	2.50	6.67	0.00	0.00	0.68*	0.00	2
C12	37	M	SSD	48.45%	2.17	0.00	84.62	0.00	91.67	17.50	40.00	0.00	9.09	2.74	0.00	7
C15	71	M	DLD	89.18%	0.00	0.00	0.00	0.00	0.00	2.50	6.67	1.82	9.09	0.00	0.00	4
				Total Number	4	1	2	4	4	7	7	4	7	1	2	Mean = 3.87

Legend: St – Stopping; Fr – Fronting; Bac – Backing; Dep – Depalatalization; Pal – Palatalization; Dev – Devoicing; FDev – Fricative Devoicing; SLiq – Substitution of Liquids; GLiq – Gliding of Liquids; SVow – Substitution of Vowels; Den – Denasalization.

* Phonological process that is not consider pathologic, not being counted in the total number

In VAC group, as it is shown in Tables 22 and 23, the same processes already numbered for MC Group are used, but Stopping is also frequent, being used by 4 children. Between the pre- and post-assessment moments, C11 maintained the 2 processes that she was using, and all other children were using less phonological processes at the segment-level in the end of the school year (Figure 25).

4.5.4.2. Syllable-level phonological processes comparison in pre- and post-assessment moments

The simplifying processes in syllable productions AD children are present in Table 24 and 25 for MC group in pre- and post-assessment moments (respectively). For VAC group description, Table 26 and 27 were organized. By the analysis of these Tables it is possible so see which are the processes, how many and how frequently each child used them. In these tables, since the processes of Epenthesis and Ressyllabification are presented 3 different contexts (CCV, VC and both), the total value that counts with CCV and (C)VC contexts together, will not be counted in the number of processes per child (in the last column).

Figure 27 shows the evolution of each music trained child between the periods pre- and post-intervention in terms of total number of syllable-level processes, and Figure 28 is related to Visual Arts students results. Figure 29 and 30 show the total number of processes used by MC and VAC groups (respectively) prior and after the intervention period.

Through the analysis of Table 24 it is possible to see that each children with DLD and or/ phonological based SSD in MC group used between 4 and 6 simplification processes on the syllable production. In this group, in the beginning of the school year, Weak syllable omission, Final consonant omission, and Cluster reduction were the most frequently used (N=8), followed by Epenthesis and Ressyllabification in CCV context (N=7), Epenthesis and Ressyllabification in (C)VC context (N=6), Dyphthong reduction (N=5) and Internal metathesis (N=1).

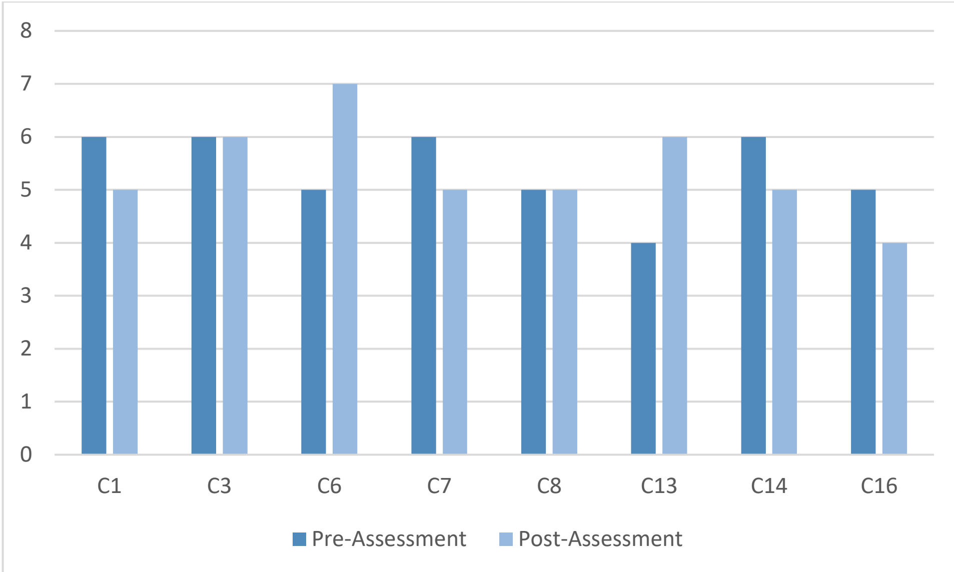
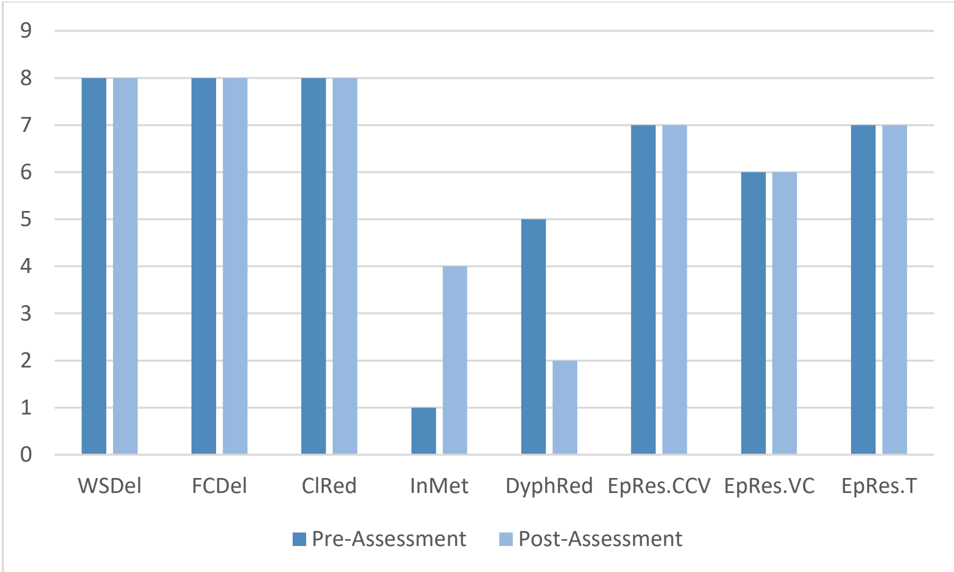


Figure 27: Comparison of the total number of phonological processes at the syllable-level used by each child, in Pre- and Post-assessment moments in MC Group, in AD population.

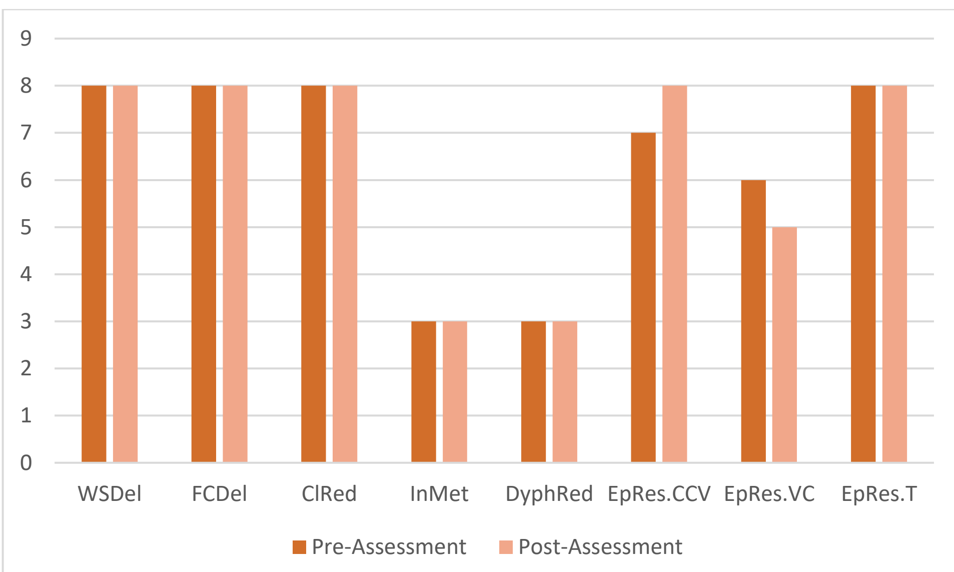
Figure 28: Comparison of the total number of phonological processes at the syllable-level used by each child, in Pre- and Post-assessment moments in VAC Group, in AD population.

Figure 29 and 30 show how the groups behaved in terms of number of phonological processes that occurred in pre- and post-assessment.



Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts

Figure 29: Total number of syllable-level phonological processes used by MC group in pre- and post-assessment moments, in AD population.



Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts

Figure 30: Total number of syllable-level phonological processes used by VAC group in pre- and post-assessment moments, in AD population.

Table 24: AD children description in MC Group in Pre-assessment moment: Age, diagnose, percentage of occurrence and number of phonological processes at the syllable-level.

	Age	Gender	Diagnose	Syllable-level Phonological Processes %								Total Number
				WS Del	FC Del	Cl Red	In Met	Dyph Red	EpRes. CCV	EpRes. VC	EpRes. T	
C1	41	M	DLD	3.53	63.33	100.00	0.00	44.44	10.53	9.52	10.00	6
C3	42	M	SSD	8.24	60.00	89.47	0.00	22.22	15.79	28.57	22.50	6
C6	71	M	SSD	4.71	16.67	21.05	0.00	11.11	21.05	0.00	10.00	5
C7	68	F	SSD	2.35	30.00	26.32	2.63	0.00	21.05	4.76	12.50	6
C8	71	M	SSD	3.53	53.33	100.00	0.00	0.00	15.79	9.52	12.50	5
C13	60	M	SSD	9.41	83.33	100.00	0.00	22.22	0.00	0.00	0.00	4
C14	69	M	SSD	3.53	63.33	94.74	0.00	11.11	5.30	9.52	7.50	6
C16	66	M	SSD	3.53	26.67	84.21	0.00	0.00	21.05	14.28	17.50	5
			Total Number	8	8	8	1	5	7	6	7	Mean = 5.38

Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts.

Table 25: AD children description in MC Group in Post-assessment moment: Age, diagnose, percentage of occurrence and number of phonological processes at the syllable-level.

	Age	Gender	Diagnose	Syllable-level Phonological Processes %								Total Number
				WS Del	FC Del	Cl Red	In Met	Dyph Red	EpRes. CCV	EpRes. VC	EpRes. T	
C1	41	M	DLD	3.53	63.33	94.74	0.00	0.00	5.30	9.52	7.50	5
C3	42	M	SSD	5.88	56.67	100.00	2.63	0.00	42.10	14.28	27.50	6
C6	71	M	SSD	2.35	33.33	31.58	2.63	11.11	26.32	19.05	22.50	7
C7	68	F	SSD	2.35	10.00	26.32	2.63	0.00	21.05	0.00	10.00	5
C8	71	M	SSD	3.53	46.67	100.00	0.00	0.00	15.79	19.05	17.50	5
C13	60	M	SSD	5.88	76.67	100.00	0.00	11.11	10.53	14.28	12.50	6
C14	69	M	SSD	2.35	66.67	100.00	0.00	0.00	10.53	4.76	7.50	5
C16	66	M	SSD	3.53	3.33	57.89	2.63	0.00	0.00	0.00	0.00	4
			Total Number	8	8	8	4	2	7	6	7	Mean = 5.38

Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts.

In the end of the school year all the children used between 4 and 7 phonological processes. As it can be seen in Figure 26, in the post-assessment moment, 4 children used less processes (C1, C7, C14 and C16), 2 children used the same number of processes (C3 and C8) and 2 others used more processes than in the beginning of the year (C6 and C13). The order of the most to the less frequent process used is very similar to what was described earlier for TD children: Weak syllable omission (N=8) = Final consonant omission (N=8) = Cluster reduction (N=8) > Epenthesis and Ressyllabification in CCV context (N=7) > Epenthesis and Ressyllabification in (C)VC context (N=6) > Internal metathesis (N=4) > Dyphthong reduction (N=2).

Table 26: AD children description in VAC group in Pre-assessment moment: Age, diagnose, frequency, percentage of occurrence and number of phonological processes at the syllable-level.

	Age	Gender	Diagnose	Syllable-level Phonological Processes %								Total Number
				WS Del	FC Del	Cl Red	In Met	Dyph Red	EpRes. CCV	EpRes. VC	EpRes. T	
C2	36	F	DLD	7.06	46.67	94.74	5.26	0.00	10.53	19.05	15.00	6
C4	44	M	DLD	4.71	63.33	100.00	0.00	0.00	5.30	14.28	10.00	5
C5	52	M	SSD	3.53	23.33	57.89	2.63	11.11	36.84	0.00	17.50	6
C9	59	F	SSD	3.53	60.00	100.00	0.00	0.00	0.00	9.52	5.00	4
C10	65	F	SSD	3.53	66.67	89.47	0.00	22.22	5.30	0.00	2.50	5
C11	66	F	DLD	2.35	13.33	36.84	2.63	0.00	21.05	9.52	15.00	6
C12	37	M	SSD	17.65	63.33	89.47	0.00	33.33	5.30	9.52	7.50	6
C15	71	M	DLD	1.18	56.67	73.68	0.00	0.00	26.32	19.05	22.50	5
			Total Number	8	8	8	3	3	7	6	8	Mean = 5.38

Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts.

Children in VAC group in the pre-assessment moment also resort to different strategies in simplifying syllable productions, presenting among 4 and 6 phonological processes each one. The most frequent processes respect the same order already described above: Weak syllable omission (N=8) = Final consonant omission (N=8) = Cluster reduction (N=8) > Epenthesis and Ressyllabification in CCV context (N=7) > Epenthesis and Ressyllabification in (C)VC context (N=6) > Internal metathesis (N=3) = Dyphthong reduction (N=3).

Table 27: AD children description in VAC Group in Post-assessment moment: Age, diagnose, percentage of occurrence and number of phonological processes at the syllable-level.

	Age	Gender	Diagnose	Syllable-level Phonological Processes %								Total Number
				WS Del	FC Del	Cl Red	In Met	Dyph Red	EpRes. CCV	EpRes. VC	EpRes. T	
C2	36	F	DLD	4.71	36.67	100.00	0.00	33.33	15.79	14.28	15.00	6
C4	44	M	DLD	4.71	26.67	89.47	0.00	0.00	10.53	4.76	7.50	5
C5	52	M	SSD	4.71	20.00	36.84	2.63	0.00	10.53	0.00	5.00	5
C9	59	F	SSD	1.18	36.67	57.89	2.63	0.00	10.53	9.52	10.00	6
C10	65	F	SSD	3.53	63.33	89.47	0.00	0.00	5.30	0.00	2.50	4
C11	66	F	DLD	3.53	13.33	36.84	2.63	0.00	31.58	23.81	27.50	6
C12	37	M	SSD	5.88	63.33	100.00	0.00	11.11	5.30	0.00	2.50	5
C15	71	M	DLD	1.18	40.00	68.42	0.00	11.11	57.89	19.05	37.50	6
			Total Number	8	8	8	3	3	8	5	8	Mean = 5.38

Legend: WSDel – Weak Syllable Deletion; FCDel – Final Consonant Deletion; ClRed – Cluster Reduction; InMet – Intrassyllabic Metathesis; DyphRed– Dyphthong Reduction; EpRes.CCV – Epenthesis and Ressyllabification in CCV context; EpRes.VC – Epenthesis and Ressyllabification in (C)VC context; EpRes.T – Epenthesis and Ressyllabification in both contexts.

In the post-assessment moment VAC trained children used 4 to 6 syllable-level phonological processes each one. According to the data, and as it can be seen in Figure 28, 3 children used less processes at the end of the school year (C5, C10 and C12), 3 children used the same number of processes (C2, C4 and C11) and 2 children used more processes than in the moment prior to training period (C9 and C15). From the most to the less frequent, this was the order in the use of these strategies: Weak syllable omission (N=8) = Final consonant omission (N=8) = Cluster reduction (N=8) = Epenthesis and Ressyllabification in CCV context (N=8) > Epenthesis and Ressyllabification in (C)VC context (N=5) > Internal metathesis (N=3) = Dyphthong reduction (N=3).

From the analysis of the last two graphs it is possible to understand that both groups used all of the syllable-level phonological processes in study, with a frequency that was, most of the time, similar between the pre- and post-assessment moment. In the MC group, an increase was found in the use of Intrassyllabic Metathesis, and a decrease was registered in Dyphthong Reduction. Visual Arts students showed a difference in the use of Epenthesis and Ressyllabification processes – in the post-assessment moment there was an increase in the use of those processes in CCV context, and a decrease in (C)VC context.

The increase in the use of the epenthetical vowel may be related with in the production of the CCV syllabic structure, corresponding to an intermediate stage of production of that structure in EP, like it was described earlier in this document.

Because this information is not as clarifying as it is necessary, since each child in this atypical group is unique in terms of phonological profile, an individual analysis will be done, reporting segmental and syllabic information child by child, helping us to understand this apparent non-evolution between assessment moments.

4.6. Discussion - Study 3 (TD Population) and Study 4 (AD Population)

The aim of these studies was to explore music relation with phonetic and phonological development of 3-year-old TD children and 3- to 6-year-olds with phonologically based SSD and/or DLD. Both studies revealed no significant differences in phonetic and phonological development, showing no interaction of the music and visual arts training in speech sound development. Both groups developed in the intervention time, but they did not differ from one another.

4.6.1. Results – Phonetic development

In Study 3, it is possible to see that TD children in MC Group developed from a PCC of 71.06% in the beginning of the school year to 80.48% in the end of the year ($p<0.05$). VAC TD children also developed from a PCC of 74.03% to 86.18% ($p<0.05$). Both groups developed significantly between pre- and the post-assessment – this development, however, is not related to the type of activity trained in the intervention period, since no significant differences were found between groups in any of these moments. The data in the beginning of the school year (prior to any intervention) are very close to the values found by Jesus et al. (2015), where a PCC of 84,7% (SD=10,3) was found in 232 typically developing children.

In Study 4 similar results were obtained, in that no differences were found between groups in both assessment moments. MC Group PCC changed from 67.66% to 76.61% from the beginning till the end of the school year ($p<0.05$) and in VAC Group PCC developed from 68.88% to 79.06% ($p<0.05$). The difference between groups, however, is not significant, showing no effect of the activity on the development of speech sounds production. Our results in both groups are lower than the ones present by Carroll & Snowling (2004) who found a PCC of 92% in the typical developing group (N=17, aged 3:11 to 6:06 years old) and 81% in the at-risk of dyslexia group (N=17, aged 3:11 to 6:06 years old). The lower percentage found in our group may be related with the range on the age of the children (since we assess 3- to 6-year-olds) but also with the inclusion criteria used, since in our study phonological and /or language disorder was proved in a speech and language assessment, rather than looking for at-risk children with familial history of language or dyslexia pathology. In this line, in PCC analysis, Bree (2007) found significant differences between the DLD group (66%), the At-risk group (79%) and the Control group (90%).

Data already available for EP in SSD children, from Jesus et al. (2015), showed a PCC that varied between 29.1% (SD=11.9) (in children with severe SSD - PCC below 50%) and 61.3% (SD=8.1) (in children with a PCC above 50%). Thus, our results of PCC in MC (67.66%) and VAC (68.88%) groups prior to the intervention period are in line with the authors' findings for the group with no severe SSD.

When comparing Study 3 and 4 results, it is possible to see a lower PCC in DLD and / or SSD children, when compared to TD children, in agreement with Scarborough (1989, 1990, 1991) that showed that at 30 months children later diagnosed with dyslexia, made more mispronunciations of consonants. A follow up study of the children in Study 4 would be very useful, in order to understand if those children diagnosed with a language pathology in the pre-school years would maintain a DLD with repercussions on reading and writing learning.

In both studies, with TD and AD populations, evolution in PCC may be explained by the factor time or, on the other hand, may be related to both activities. In this way we may hypothesize that music and visual arts training may affect speech sound development, even if for different reasons – if in MC Group music training may have an effect on speech sound development, in VAC Group children were exposed to a larger amount of verbal stimuli, since these classes were always based in verbal explanations of the activities within the class and vocabulary (artists, countries, stories of lives, materials, colors, shapes, among other). To explore this hypothesis, a control group with no activity or with an activity almost with little verbal interaction and without music (for example: karate) would be necessary, in order to look for the influence of these activities in face of normal development with no extra musical or verbal stimulation.

4.6.2. Results – Phonological development

In what concerns to phonological analysis, and taking into account the lack of data in EP normative data in typical development and disordered children, segment-level and prosodic-level phonological processes and their percentage of occurrence were analyzed in the total sample, in the beginning of the school year. These data, prior to any experimental intervention may contribute to better understand phonological development in TD children (Study 3, 31 children) and AD children (Study 4, 16 children).

Between groups comparison was also made, concluding about no significant differences between groups in the pre- and the post-assessment moments, in any of the populations. Within groups analyses showed significant differences in some segment- and prosodic-level in both groups, which is explained later on this text. Phonological results in Study 4 are presented in a different way, since it was considered that DLD and SSD children profile made it unuseful to calculate medium values. It was found that calculating the total number of processes presented by each child in pre-assessment moment and its evolution till the post-assessment moment provided more useful information in order to look for the interaction of the type of intervention on phonological development.

4.6.2.1. Segment- and prosodic-level analysis in the total TD Sample in pre-assessment moment – Study 3

At the segment-level, 5 phonological processes occurred more frequently in 3- to 4-year-olds, following this order of frequency: Palatalization > Fricative Devoicing > Gliding of liquids > Depalatalization > Devoicing.

The occurrence of a high percentage of palatalization and depalatalization corroborates the fact that substitutions affecting place features most frequently involve Coronal [-ant] consonants, that tend to be substituted for a Dorsal, and Dorsal consonants, predominantly substituted by Coronal consonants (Costa, 2010). According to Lousada et al. (2012) palatalization and depalatalization are suppressed between 4:00-4:05 years old. Since children in this sample are aged between 3 and 4 years old, these data seem to be in the line of the previous studies done for EP.

In accordance to what was stated by Costa (2010) liquids were very often submitted to substitution patterns and laterals are more often substituted for another sonorant (glide). Devoicing, found by Lousada et al (2012) to be suppressed between 5:00-5:05, also occurs in 3- to 4-year-olds of this study. Gliding of liquids, described as one of the last processes to disappear in language development in EP and BP (Freitas, 1997; Jordão & Frota, 2008; Lousada et al., 2012; Mezzomo & Ribas, 2004), also occurred in a high percentage in this sample, showing that lateral liquids tend to be semivocalized, as stated by Freitas (1997) and Mezzomo & Ribas (2004). The low percentage of occurrence of the phonological processes of stopping, backing and fronting makes sense since it is pointed by Lousada et al. (2012) that these processes are suppressed between 3:00-3:05 years old.

Table 28 presents the data found by Jesus et al. (2015) and the data obtained in our study. In the present study a higher percentage of occurrence of palatalization is shown when related to Jesus et al. (2015) data. On the other hand, the authors found a higher percentage of occurrence of gliding of liquids process. In spite of that, it is possible to see the same pattern in the frequency of occurrence of the processes, and a very close percentage in all the other processes.

Table 28: Percentage of phonological processes at segmental level found between 3:00 and 3:11 years old (Jesus et al., 2015) and 3:00 and 3:11 (present study).

	Phonological Process	% of occurrence Jesus et al. (2015)	% of occurrence Present Study
Segmental level	Stopping	0.3%	0.70%
	Fronting	0.2%	0.43%
	Backing	-	0.50%
	Palatalization	12.2%	36.86%
	Depalatalization	5.5%	11.19%
	Devoicing	11.5%	8.39%
	Gliding of Liquids	16.4%	1.70%

At the prosodic-level these were the most common processes used in order to simplify the syllable structure production: Cluster Reduction > Final Consonant Deletion > Epenthesis and Ressyllabification > Weak Syllable Deletion. By deleting a consonant in cluster reduction and final consonant deletion or inserting a vowel in epenthesis, it is possible to see that phonological processes have an effect on the structure of the syllable (Odden, 2005). Epenthesis is described as a strategy to simplify the production of the consonant in Cluster and Coda position, in the second case especially in the end of the word (Correia, 2004; Freitas, 1997; Mezzomo, 2004). In this study, epenthesis was found in both contexts – 11,22% to avoid cluster production, 10.90% to simplify Coda production. This data contrasts with the one presented in Mendes et al. (2013) where epenthesis is not described – as it was already explained, this difference may be related with the methodology adopted, since in Freitas (1997, 2003) as well as in the present study data were transcribed from audio-recordings by trained linguistics in the task, rather than being immediately transcribed by a speech and language pathologist after the child's production.

In accordance to what was found by Castro, Gomes, Vivente, & Neves (1997), Castro et al. (1999) and Lousada et al (2013) phonological processes of weak syllable deletion and final consonant deletion can still occur at 3 years of age, as well as cluster reduction (Lousada et al, 2013). Corroborating data found by Guerreiro & Frota (2010) for 5-year-olds, final consonant deletion and cluster reduction were the most frequent processes used to avoid complex syllable structures.

Table 29 presents the data found in our study and compared with the results found by Jesus et al. (2015). The processes of epenthesis and ressyllabification are not presented by the authors probably being related with methodological issues already explained when comparing our data with Mendes et al. (2013) results. Children in our sample showed a higher percentage of occurrence of Final consonant deletion and Cluster reduction, and a similar percentage of occurrence of weak syllable deletion. This difference may be related with the diagnose of the children that composed the sample, since Jesus and colleagues only included children with phonologically based SSD. In the present study, a more heterogeneous sample was composed by children with phonological deficits, diagnosed with SSD and DLD.

Table 29: Percentage of phonological processes at prosodic level found between 3:11 and 6:06 years old (N=20, Jesus et al., 2015) and 3:00 and 3:11 (N=31, present study).

	Phonological Process	**% of occurrence Jesus et al. (2015) [3:00-3:05[**	**% of occurrence Jesus et al. (2015) [3:06-3:11]**	**% of occurrence Present Study [3:00-3:11[**
Prosodic Level	Weak syllable deletion	7.1%	7.1%	4.48%
	Final consonant deletion	21.6%	12.8%	43.66%
	Cluster reduction	48.6%	32.9%	84.04%
	Epenthesis and Ressyllabification	-	-	11.04%

As stated by Freitas (1997) for EP, children also simplified the complex nuclei of the syllable, reducing the syllabic element by omitting the glide, although with a lower percentage of occurrence (2.51%). Intrassyllabic metathesis described by Freitas (1997) and Ribas (2004) was also found in our sample as a strategy in acquiring complex Onset, with a percentage of occurrence of 0.59%.

4.6.2.2. Segment-level analysis between and within groups – Study 3

MC and VAC groups were compared in what concerns the occurrence of phonological processes at segment-level, although no difference was found between groups in the beggining neither in the end of the school year. The order of these phonological processes from the most frequent to the less frequent was very similar in both groups. In MC group the following order was found in pre-assessment moment: Palatalization > Fricative

Devoicing > Gliding of Liquids > Depalatalization > Devoicing. In VAC Group only Devoicing was more frequent than Depalatalization process. In the post-assessment moment VAC Group made Fricative Devoicing > Gliding of Liquids > Palatalization > Devoicing > Depalatalization, and MC Group used more frequently Fricative Devoicing > Gliding of liquids followed by Depalatalization > Devoicing > Palatalization. Since no significant differences were found between groups, we may only suppose that the differences in the percentage of occurrence of those phonological processes were due to normal evolution. As described for the total results of the sample in the beginning of the school year previously in this section, all these results are in line with the results described by other authors for EP - Costa (2010), Freitas (1997), Jesus et al. (2015), Jordão & Frota (2008) and Lousada et al. (2012).

The comparison between pre- and post-assessment moments in what concerns the segment-level phonological process reveals significant differences in Palatalization in MC Group ($p<0.05$), meaning that music trainned children produced less simplification processes afecting the Dental Fricatives in the end than in the beginning of the school year. In VAC Group, significant differences ($p<0.05$) were found in Palatalization, Devoicing, Fricative Devoicing, Gliding of Liquids and Substitution of Vowels, between both assessment moments. Although between groups did not reveal significant differences, it is possible to note that MC students developed significantly in one segment-level phonological process, and VAC students developed significantly in five segment-level phonological processes. This fact may be related to a larger exposure to verbal stimuli in visual arts classes. In order to clarify this question, another control group would be necessary, including children with a visual art activity with less verbal interaction. Only this methodological change would make it possible to see if this evolution of speech sounds production was due to the visual art training or to the verbal stimulation during the visual arts classes.

4.6.2.3. Prosodic-level analysis between and within groups – Study 3

Syllable-level simplification processes occurred in MC and VAC groups in the beginning and in the end of the school year, in accordance to the data described for EP (Castro, Neves, Gomes, & Vicente, 1999b, 1997; Correia, S., 2004; Freitas, 1997, 2003; Guerreiro & Frota, 2010; Jesus et al., 2015; Lousada, 2012; Lousada et al., 2013; Mendes et al., 2013), as it was already stated in this section for the total sample of the study. With no significant differences between groups ($p>0.05$) the order of syllable of occurrence of these processes in both moments was Cluster Reduction > Final consonant deletion > Epenthesis and ressyllabification > Weak syllable deletion.

Music trained children significantly developed in the way of producing a lower percentage of Final consonant deletion ($p<0.05$). Visual arts students significantly developed in Final consonant deletion, Weak syllable deletion and Cluster reduction, since a lower percentage of those processes was found in post-assessment moment. In what concerns the Epenthesis and Ressyllabification processes, it is possible to see a significant increase in those processes in VAC students (in simplifying cluster and coda contexts).

Although not significant MC students also present the same evolution pattern, showing a higher percentage of occurrence of these processes in post-assessment moment. These findings are in line with the description on Freitas (1997, 2003) where the author describes the use of the epenthetic vowel on percentage of 16% of a younger sample, but 32% for the oldest children. This fact may mean that children are developing in producing both consonantal elements of the cluster or coda segments, but treating them as separate elements of CV structures.

Since no significant results were found on phonetic and phonological development of TD children aged 3:00 to 3:11 years old, depending on the activity they were trained for in a school year, it is possible to conclude that our music training program, with its specific methodology and periodicity, did not influence speech sound development in this group of children. This result may be related to the periodicity of music classes, since we were trying to seek for music influence in regular music classes, once a weak, for 45 minutes, on the kindergarten for one school year. A study with longer and /or more intensive training would be needed to understand if this could be the reason behind our results.

4.6.2.4. Segment- and prosodic-level analysis in the total AD sample in pre-assessment moment – Study 4

In order to simplify phonological structure, children with DLD and / or phonologically based SSD use various phonological strategies. Study 4 corroborates other studies reporting consistent and severe phonological difficulties in children with DLD (Beers, 1992; Bortolini & Leonard, 2000; Mediavilla et al., 2002).

In our sample (N=16, aged 3 to 6 years old) it was possible to see the use of Palatalization > Fricative Devoicing > Gliding of Liquids > Devoicing > Fronting > Depalatalization. According to Mediavilla et al. (2002) children with DLD use more simplification processes, when compared with their age group controls. Comparing our results with the data in Jesus et al. (2015) it is possible to agree with Mediavilla et al. (2002) since SSD children present a higher percentage of occurrence of phonological processes at segmental level than the ones presented by TD 3-year-olds, but also TD children aged between 3:00 and 4:11 years old (Jesus et al., 2015). Comparing Jesus et al. (2015) data in terms of number of processes used by TD children aged 3:00- to 4:11 years old and the data obtained in the present study, it is possible to see that SSD children use seven phonological processes, and TD children only three. Stopping, Fronting, Backing and Palatalization are used in children with language and /or SSD and not by TD children. When compared to TD younger children of Study 3, we can see a higher percentage of occurrence of Stopping, Fronting and Backing, and a very similar percentage of occurrence of the processes of Palatalization, Depalatalization and Devoicing.

In table 30 it is possible to see the results of disordered children in our sample, compared to TD children of Study 3 (already described on this document) and also with SSD children on Jesus et al. (2015). Our data related to the percentage of occurrence of phonological processes of Stopping and Depalatalization in Jesus and colleagues SSD second sub-group (PCC>50%). Fronting and Gliding of Liquids are very similar to the one presented in the first more severe SSD Group (aged 3:00 to 3:11 years old). Children in our study present a higher percentage of Palatalization, and a lower percentage of Devoicing. As it was already stated these differences may be related with the heterogeneity of the diagnose in the sample of the present study.

Table 30: Percentage of phonological processes at segmental level found between 3:00 and 3:11 (Study 3), 3:00 and 3:11 years old (Jesus et al. 2015), 3:00 and 6:00 DLD children (present study) and 3:00 and 4:11 years old (SSD children, Jesus et al., 2015).

	Phonological Process	**Study 3**	**Jesus et al. (2015)**	**Present Study DLD and SSD Children**	**Jesus et al. (2015) SSD Children PCC<50%**	**Jesus et al. (2015) SSD Children PCC>50%**
Segmental level	Stopping	0.70%	0.3%	3.12%	18.5%	2.0%
	Fronting	0.43%	0.2%	10.21%	15.2%	2.3%
	Backing	0.50%	-	5.53%	-	-
	Palatalization	36.86%	12.2%	32.29%	5.5%	8.9%
	Depalatalization	11.19%	5.5%	9.19%	4.3%	7.2%
	Devoicing	8.39%	11.5%	10.78%	24.2%	75.9%
	Gliding of Liquids	1.70%	16.4%	12.28%	9.0%	16.1%

As it was stated by Beers (1992), Bree (2007), Mediavilla, Torrent, & Raventos (2002) and Orsolini, Sechi, Maronato, Bonvino, & Corcelli (2001) the phonological processes registered in language disordered children may be the same that typically occur earlier in development (Palatalization, Depalatalization, Devoicing, Gliding of liquids), or may correspond to unusual patterns not typically seen in normal development (higher percentage of Stopping, Fronting and Backing). The use of a bigger percentage of Stopping and Fronting by children with language disorder is also described by Bree (2007).

When analyzing the simplification processes at the syllable level, it is possible to find the same pattern of using either the same processes that are used by younger children (Final consonant omission, Epenthesis and ressyllabification), or other common processes in a bigger percentage (Cluster reduction, Diphthong reduction). Table 31 resumes the existing data for EP for TD children aged 3:00 to 3:11 (Study 3 of the present document) and 3:00- to 4:11 (Jesus et al., 2015), and for DLD and /or SSD children in the present study (3:00- to 5:11-year-olds) and SSD children in Jesus et al. (2015, 3:00 to 3:11-year-olds).

Table 31: Percentage of phonological processes at prosodic level found between 3:00 and 3:11 (Study 3), 3:00 and 3:11 years old (Jesus et al., 2015), 3:00 and 6:00 DLD and SSD children (present study) and 3:00 and 4:11 years old (SSD children, Jesus et al., 2015).

	Phonological Process	**Study 3 TD Children [3:00-4:00[**	**Jesus et al. (2015) TD Children [3:00-3:06[**	**Jesus et al. (2015) TD Children [3:06-4:00[**	**Present Study DLD and SSD Children**	**Jesus et al. (2015) SSD children PCC<50%**	**Jesus et al. (2015) SSD children PCC>50%**
Prosodic level	Cluster reduction	4.48%	48.6%	32.9%	78.62%	66.0%	76.0%
	Final consonant omission	43.66%	21.6%	12.8%	49.44%	67.2%	48.4%
	Weak syllable truncation	84.04%	7.1%	7.1%	5.14%	30.9%	22.7%
	Diphthong reduction	2.51%	-	-	11.11%	-	-
	Epenthesis and Ressyllabification	11.04%	-	-	11.72%	-	-

Our data is also in line with Bree & Van der Pas (2003), Bree (2007), Nettelbladt (1992) and Rescorla & Ratner (1996) that found that DLD children applied Weak syllable truncation and Cluster reduction processes. Mediavilla et al. (2002), Nettelbladt (1992) and Rescorla & Ratner (1996) also found the occurrence of weak syllable omission process in this population.

4.6.2.5. Segment-level analysis between and within groups – Study 4

In order to seek for the evolution of DLD and / or SSD children in the use of Segment-level phonological processes, the number of phonological processes that occurred in the beginning and in the end of the school year was compared between groups and within groups.

In MC Group the more frequent processes in the pre- and post-assessment moments were the same: Gliding of Liquids > Devoicing > Fricative Devoicing > Palatalization > Substitution of Liquids. In the beginning of the school year each child with language pathology used between 3 and 8 phonological processes (mean=5.50) and after the intervention period, we can notice a development, since there's a decrease in the number of processes used (mean=4.50). In VAC Group, Stopping was also frequent (plus the other processes already described for the intervention group). In the pre-assessment moment children in the control group used between 2 and 8 phonological processes (mean=5.38) and in the post-assessment all children but one used less processes (mean=3.87).

An increase on the number of phonological processes was found in two children of the MC Group: C1 and C16. However, this increase may also be a sign of development. C1 passed from 83.33% to 0.00% of occurrence of Fronting. On the other hand, Backing emerges, which may happen in the systematization of the [ant] distinct trace. The same appears to happen with [Coronal] distinct trace, since C1 went from the use of systematic Palatalization (83.33%) to the use of Palatalization (75%) and Depalatalization (5.88%). Stopping didn't occur in the beginning but in the end of the school year. It is considered, by the reasons explained that this child, although there's an increase in the number of processes used, developed between the two assessment moments. C16 shows an increase in the use of Substitution of liquids. However, when looking for the phonetic inventory of the child in both moments, we can see an increase of the correct use of the laterals (/l/ from 3 to 17 times; /ɾ/ 21 times in both moments; /ʀ/ from 3 to 4 times). We hypothesize that although there's the occurrence of one more phonological process of substitution of liquids, there's clear evolution in the production of those segments.

We may then say that in MC Group 6 children developed from the beginning till the end of the year. In VAC Group 7 children developed from the beginning till the end of the intervention period. In this way both groups developed. This evolution may be result of the interaction of the factor time, and not of the activity, since both groups developed, with no significant differences between them.

4.6.2.6. Prosodic-level analysis between and within groups – Study 4

As it was mentioned before, our experimental and control group with phonological and / or language disorder used phonological processes to simplify syllable structures. In MC Group the most frequent processes were Weak syllable omission = Final Consonant Omission = Cluster Reduction > Epenthesis and Ressyllabification (in cluster context) > Epenthesis and Ressyllabification (in coda context) > Diphthong reduction > Internal Metathesis. Each child used between 4 and 6 phonological processes (mean = 5.38). In the end of the year each child used between 2 and 8 phonological processes (mean = 5.38) and the order of frequency was almost the same – only internal metathesis occurred more than diphthong reduction.

In VAC Group we could find the same mean in what concerns the number of phonological processes used in both assessment moments. The order of frequency was the same found for MC Group in the end of the school year.

In MC Group, 4 children developed showing a decrease in the number of phonological processes from the beginning till the end of the year. C6 and C13 increased the number of processes at the syllable level. C6 use Internal Metathesis and Epenthesis in the end of the school year. Since those processes may reflect an evolution in the use of the sound in coda or cluster positions, it is considered that this increase may also reflect an evolution. C13 presents the same pattern of development, since in the end of the year it is possible to see the use of two new processes: Epenthesis and ressyllabification in coda and in cluster contexts. For the same reason, and taking into account the data found in Freitas (1997, 1999), it is considered that C13 also developed between the pre- and the post-assessment moment.

In VAC Group, 3 children used a lower number of processes at the syllable level in the end of the year. As it happened in the experimental group, two children presented a higher number of processes. C9 (just like C6) used Internal Metathesis and Epenthesis in cluster context in the post-assessment moment. For the reasons already explained, we considered this an evolution. C15, however, uses diphthong reduction in the end but not in the beginning of the school year, and thus this is not considered an evolution.

We can conclude that in MC Group, 6 children developed between pre- and post-assessment moments. In VAC Group, 4 children developed between the two moments. Once again, we may see the evolution through the time, not being influenced by the activity, since both groups developed significantly between the beginning and the end of the year, but they do not differ from one another.

No significant differences were found between MC and VAC Groups in Language disorder population in phonetic and phonological assessment. This fact lead us to conclude that our music classes, with this specific methodology and periodicity were not enough to impact phonetic and phonological development in our atypically developing group of children. Considering language characteristics of DLD children, largely described in Chapter 3 (section 3.1.), it is possible to argue that a different musical methodology would be needed to influence language development – with more intensive training on rhythmic patterns (for example). On the other hand, since no significant results were found also in Study 3, with TD children, it is probable that even with a different methodology, a study with intensive training would be necessary to understand if only a greater intensity and periodicity of music classes would change the results on phonetics and phonology in the post-assessment moment.

4.7. Conclusion - Study 3 (TD Population) and Study 4 (AD Population)

Studying music influence on phonetic and phonological development was a challenge that was originated from the knowledge about music influence on other linguistic domains and on neuronal development. However, even with the existence of a clear relation between phonological awareness (which relation to music has largely been explore on this thesis) and phonological development, and with the common bases of music and language that we explained earlier in this chapter, no differences were found related to the type of activity that the children were exposed to. Music and Visual Arts trained children developed between the pre- and post-assessment moment, but the groups did no differ. This led us to think that the evolution that was found is only due to the interaction with factor time.

To further explore this issue, and still believing that music may influence phonetic and phonological development, investigation is needed with changes on music classes methodology and music classes intensity – would twice a week classes have impact on these linguistic domains? Besides that, investigation with three different control groups could also be informative, including: 1) a control group with no extra activity; 2) a control group with visual art classes with no verbal and musical exposure; 3) a control group with a different type of activity with little exposure to verbal stimuli (like Karate, for example).

With the first control group it would be possible to see if the development found in MC and VAC groups was only due to the factor time, or if they both developed more than a third group with no extra-activity – meaning that music and visual arts classes were influencing phonetic and phonological development.

With the second control group suggested, it would be possible to see if visual arts influence was due to the activity itself, or because of the extra amount of verbal stimuli that always accompanied these classes.

The third control group would try to give an extra activity that had no verbal stimuli, but could guarantee that those children would also have extra-attention with the same periodicity as the experimental group.

In spite of this, and taking into account that 31 TD children (on Study 3) and 16 AD children (on Study 4) were assessed in a moment prior to any experimental intervention, some data were found and collected in this Chapter, that may contribute to a better knowledge of linguistic development of those groups – with and without language pathology. In this way, PCC values were described for 3-year-olds with typical development, in the line of the studies presented for EP (Jesus et al., 2015; Lousada, 2012; Lousada et al., 2012; Mendes et al., 2013). In Study 4, PCC was described for language and speech sound disordered children aged 3:00 to 5:11 – data that was compared to Lousada (2012) and Jesus et al. (2015) findings. Considering the lack of data existent for EP, this may be one of the biggest contributes of this work. On the same way, phonological analysis on segmental and prosodic levels may contribute to better understand linguistic development and characteristics of TD population (at the age of 3) and DLD population (between 3:00 and 5:11 years old).

In Study 3 it was possible to confirm what phonological processes are used at age 3, which ones are more frequent and the percentage of occurrence of each one, in a sample that comprised 31 children. These results were compared to those in Jesus et al. (2015), who describes phonetic and phonological development of TD and AD children diagnosed with SSD. In Study 4, phonological processes (their frequency and percentage of occurrence) were also described, as well as the number of phonological processes used simultaneously by each child. The data were in the line of the one reported in Jesus et al. (2015) for EP, and also compared with the descriptions made for language development in language disordered children for other languages - Beers (1992), Bree (2007), Mediavilla, Torrent, & Raventos (2002), Orsolini, Sechi, Maronato, Bonvino, & Corcelli (2001).

So far as we know, music relashionship with phonetic and phonological development was never investigated untill now. Even showing no impact of the activity on child development in those areas, further investigation is needed in order to better understand a possible relation that we still believe can exist. Changes in music methodology or classes periodicity is crucial to a deeper understanding of music training effect on phonetic and phonological development in TD and AD populations.

The limited information available on phonetic and phonological development, specially when talking about language and / or speech sound disorder, made us consider that the data found on this chapter may be essencial on contributing to better understand language development under special conditions.

5 – General Conclusions

The investigation on music and language relashionship has increased greatly in the last two decades. Proving the effect of music on language abilities is important. This is different, however, from proving the influence of music on language development. Until now, this relation had been investigated in children above 4 years old, proving the effect of music training on phonemic and phonological awareness, reading precursors, reading and reading in dyslexics.

In this thesis, using a test-training-retest methodology, with an experimental and a control group with distinct training activities, we investigated the influence of music training on language development. Our goal was to answer the following questions:

1. Does music training influence phonological awareness development in 3-year-olds with typical development, prior to the ages already studied?
2. Does this sort of influence occur with a methodological procedure that does not count with intensive training, making it possible to be replicated in our daylives?
3. Does this kind of influence extend to other linguistic skills, having an impact for instance on phonetic and phonological development?
4. Is it possible that music training, with the same methodological procedure, influences phonological awareness, phonetic and phonological development in children diagnosed with phonologically based SSD and/or DLD (and this before the ages where a similar influence was already proven for dyslexic children)?

In order to answer these questions, we conducted 4 different studies, with a total of 65 children, recruited from two different kindergartens in Aveiro.

With Study 1 it was possible to see that music classes had significantly greater effect then the visual arts classes on the development of phonological awareness skills in 3-year-olds with typical developmet. After a school year, both groups of children developed, but children trained with music lessons significantly outperformed the control group, in the following phonological awareness tasks: syllabification of words, syllabification of pseudowords, combining syllables into words, combining syllables into pseudowords, initial phoneme identification, and last phoneme identification.

In Study 2, conducted with AD children with phonologically based SDD and/or DLD, aged 3 to 6 years old, results showed that phonological awareness development was not promoted by one of the activities in particular. In fact, (similar) development was observed in both groups, and thus development may be attributed to the elapsed time alone. It is nevertheless possible that significant results might emerge if different methodological options were made - for example, by increasing the intensity of music training (e.g. increasing the number of weekly lessons or their length) or, in the case of atypical children, by designing a specif curriculum that enables the child to work rhythmic abilities (and possibly melodic abilities also) in order to bridge the difficulties related with rhythm and picth processing described in the literature. In this study, the only task where significant differences were found was First phoneme identification task. This is not enough to point to an effective influence of the music classes in our study.

In Study 3, considering that phonetic, phonological and phonological awareness development are related, we investigated if the influence previously tested in Study 1, in TD population, would also occur in speech sound development. Following the same methodology, we found no significant differences between the experimental and the control group, neither at the beginning nor at the end of the school year. Phonetic development occurred in both groups, showing a significant higher PCC in the end of the lessons period when compared to the beginning of the school year. This development, however, was not related with the type of training, but most likely with the elapsed time.

The last study of this thesis (Study 4) investigated the association between music training and phonetic and phonological development of atypically developing 3- to 6-year-olds, with phonologically based SSD and / or DLD. In these groups, significant differences were found between PCC in the pre- and post-assessment, but not between the groups. Considering the heterogeneity of speech and language disorders in our small sample, a descriptive statistic analysis was done in order to assess the effect of phonological development in AD sample. We concluded that children in Music group as in Visual Arts group developed between the two assessment moments, showing a lower number of phonological processes in the end of the school year – 6/8 music students and 4/8 visual arts students developed between pre- and post-assessment.

We consider that one of the major contributions of our study is the description of phonetic and phonological characteristics of children with speech and language disorders, since little is known in this domain in EP. Our results complement the data presented by Lousada (2012) and Jesus et al. (2015) for typically and atippically developing children, corroborating findings described for different languages. It is considered that in AD, children use phonological processes that typically are used by younger children (Palatalization, Depalatalization, Devoicing, Gliding of liquids), but also that some less typical processes also occur (higher percentage of Stopping, Fronting and Backing). When talking about the syllable level, we have observed that AD children use either the same processes that occur earlier in development (Final consonant omission, Epenthesis and ressyllabification), or use other common processes more frequently than TD children (Cluster reduction and Diphthong reduction).

Some limitations were pointed to the study through chapters 2, 3 and 4. In what concerns methodological procedures, children's motivation was not measured. Assessing children's motivation in attending music and visual arts classes would have been important in order to understand if MC and VAC were equally appealing to the participants. We may point out, nevertheless, that only one child abandoned the classes due to demotivation. The fact that the other children remained in each group may be an indication that both activities were attractive to the children.

Another methodological issue refers to the researcher's involvement in lessons teaching. Although we have tried to create the conditions for the author of this thesis not to participate in the study as a teacher, this could only happen in the first school year of testing. For reasons that could not be escaped, the author of the studies reported here was one of the teachers of MC and VAC in the second school year of implementation of this project. Even though ethical principles of objectivity, rigor and honesty were respected, it is impossible to unequivocally guarantee imparciality in designing classes' goals and assessing children, as the objectives of the study and the distribution of children per class were known to the researcher. We should stress, however, that the other three teachers involved were blind to the aims of the study, and the results of the second year replicated the findings obtained in the first year, where we were not involved in lessons' teaching. These facts make us believe that these methodological aspects did not negatively influence our results.

The rather small number of AD children was also a limitation of our study. A larger and homogenous sample in AD population would have been very important and contribute to sounder and more reliable results in Studies 2 and 4.

Future research is needed in order to understand if a program with more intensive music classes may promote phonetic and phonological development in TD children, and phonological awareness, phonetic and phonological development in AD children. Studies 2 and 4 (with speech and language disordered children) could also be replicated with a music classes curriculum that comprised specific exercises to work rhythm and picth processing, trying to bridge the difficulties already known in these children linguistic profiles. Another suggestion for future studies is the design of a test-training-retest methodology with an experimental group and different control groups – namely a control group of visual arts classes with less verbal stimuli, a control group with classes that include a physical activity with no music and almost no verbal stimuli (like karate) and also possibly a control group with no activity.

Two main aspects deserve to be particularly highlighted as positive results of this thesis. First of all, our results indicate that music training has a positive effect on phonological awareness development as soon as 3 years of age. Since it is well known that phonological awareness abilities are crucial precursors of reading and writing, informed programs to be implemented with the goal of stimulating these abilities are most relevant. The results of our study clearly suggest that incorporating music lessons in such programs may contribute to their effectiveness. We may further note that music and activities related to music are present in everyday lives in kindergartens, being used by kindergarten teachers in various moments of the day routine, as well introducing and working different themes in the school year curriculum (like seasons, colours, festive days, etc.). Our results show that music related activities can be used in a more efficient way, potentiating children's development in their everyday contexts.

The second aspect we would like to highlight is of a more practical nature and has to do with the methodology adopted in our investigation, with implications for the use of music in the promotion of phonological awareness in kindergardens. Since we aimed to study the effects of music training with no specific methodology – for instance, music curriculum was not adapted for promoting the development of specific phonological awareness skills–, in order to obtain similar positive results the teacher does not need special training in language development. Besides that, no intensive methodology was used either. This means that it is most feasible to replicate the procedures we followed in every day kindergarten lives, with regular music classes, once a week, 45 minutes per class.

We now find ourselves closer to prove a causal relation between music training and phonological awareness development as soon as age 3. Making music lessons available to every child in kindergarten contexts would be very important, and a very easy step to help children in their future devolopment and integration, since reading and writing are fundamental skills throughout life.

We believe that our work is far from discarding the possibility that the beneficial influence of music in the development of phonological awareness proved in TD population can also be observed in children with speech and language disorders. What we have found is that *regular* music classes are not enough to significantly improve development in the areas investigated here. Future research with AD children is needed in order to understand if music training with more intensity or specifically designed to target the development of particular skills, with impact in the development in phonetic, phonologic and phonological awareness, can be used with children with speech and language disorders as part of an intervention process.

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Supplementary material

Planning of Music Classes

AULA 1

1. Canção de Bom Dia / Boa tarde (Companhia de Música Teatral – CMT) – apresentação dos professores e dos alunos
2. Os sons do Outono – exploração dos sons de folhas secas – explorações rítmicas e associação a pequenos excertos melódicos
3. Exploração melódica e rítmica de canções:
    a. O Caracol (modo Dórico; compasso de subdivisão binária)
    b. A Borboleta (modo Mixolídio; compasso de subdivisão binária)
4. Associação de movimento do corpo ao movimento e ritmo dos animais
5. O adufe e o jogo de sinos
6. Canção dos abraços (Sérgio Godinho)

AULA 2

1. Canção de Bom Dia / Boa tarde (CMT)
2. Associação do movimento do corpo à percussão
3. Jogo de audição e movimento (estátua) – parar quando há silêncio
4. Utilização de métricas variadas – compassos de subdivisão binária e ternária
5. O adufe e a melódica
6. Canção dos abraços (Sérgio Godinho)

AULA 3

1. Canção de Bom Dia / Boa tarde (CMT)
2. Introdução do tema: Cinema
3. Visualização do filme: "13 Monkey Melodies", da Walt Disney (1930)
4. Exploração melódica e rítmica associada à projeção: sons realizados com o nosso corpo (percussão corporal), sons com o andar ou correr, sons com a nossa voz (a entoação da nossa voz - como se falássemos com papapas), sons com objetos, flores ou alimentos (como tirar a banana do cacho e comer a banana), sons como se fossemos animais (como os crocodilos).
5. O adufe e a melódica
6. Canção dos abraços (Sérgio Godinho)

AULA 4

1. Canção de Bom Dia / Boa tarde (CMT)
2. Exploração melódica e rítmica de canções ou cantos com a utilização materiais do dia-a-dia: as palhinhas
3. Associação à música do Caracol (modo Dórico, compasso de subdivisão binária)
4. A exploração do som das palhinhas
5. Movimentos do dia-a-dia associados ao ato de comer e beber:
    a. Exploração de diferenças de ritmo, intensidade e timbre: pápápás com fome, saciados, a comer depressa, a comer devagar, a comer a sopa, a comer cereais, a beber, a arrefecer, a aquecer, etc.
    b. Músicas associadas: "Dois ratinhos" (Cantar Juntos), "Come a papa, Joana" (José Barata Moura); "A Borboleta" (Companhia de Música Teatral); "O elefante" (Camille Saint-Saens).
6. Canção dos abraços (Sérgio Godinho)

AULA 5

1. Canção de Bom Dia / Boa tarde (CMT)
2. Apresentação dos instrumentos de percussão: caixa chinesa, reco-reco, bloco de dois sons, récula, *afouché*, clavas, rela, tamborim, pandeireta com pele, pandeireta sem pele, maracas, castanholas,triângulo
3. Associação de pequenas melodias a cada um dos instrumentos
4. Canção dos abraços (Sérgio Godinho)

AULA 6

1. Entrada / Chamada – O inverno, "As Quatro Estações" de Vivaldi
2. Canção de Bom dia / Boa tarde (CMT)
3. Apresentação do Instrumento: Flauta transversal
4. Exploração melódica e rítmica das seguintes canções:
    a. O Inverno (Cantar Juntos), compasso de subdivisão ternária, Modo Maior
    b. Plic Ploc (Companhia de Música Teatral), compasso de subdivisão quaternária, Modo Lócrio – Exploração de sons do próprio corpo (a chuva), exploração de diferenças tímbricas e expressivas (o frio)
    c. Canção da chuva (Edwin Gordon), compasso de subdivisão ternária, Modo menor
    d. Canção do Pinguim (Companhia de Música Teatral), Compasso misto 11/8 + 12/8, Modo Lócrio
5. Audição e exploração do movimento do corpo com um excerto de António Vivaldi: O Inverno (As Quatro Estações) - CD
6. Canção dos abraços (Sérgio Godinho)

AULA 7

1. Canção de Bom dia / Boa tarde (CMT) - utilização de objectos da sala de aula
2. Exploração dos objetos da sala e utilização dos mesmos como instrumentos musicais
3. O som / os sons de cada um dos objetos - escolha e exploração individual
4. Realização de padrões rítmicos em diferentes subdivisões de tempo: compassos com subdivisão binária e ternária, compassos simples, compostos e mistos.
5. Imitação de padrões rítmicos simples
6. A canção: "A tua sala é música"
7. Canção dos abraços (Sérgio Godinho)

AULA 8

1. Bom dia / Boa tarde (CMT) – voz e balão/maraca
2. O balão maraca e o balão do silêncio
3. Construção de maracas a partir de balões com feijões
4. Os vários sons que fazemos com o balão:
    a. O som da chuva fraca
    b. O som da chuva forte
    c. A tempestade
    d. O coração
    e. O comboio
    f. As pipocas
    g. Os foguetes
    h. A maraca
    i. O silêncio
5. Acompanhamento de canções com o balão/maraca:
    a. Plic Ploc (CMT)
    b. O comboio (Cantar Juntos)
    c. A Canção dos Abraços (Sérgio Godinho)

AULA 9

1. Bom dia / Boa tarde (CMT) – utilização de material da sala para percutir
2. A obra: "Quadros de uma Exposição" (Modest Mussorgsky)
3. Audição da obra e de uma história que a acompanha
4. Associação das músicas aos momentos da história
5. Associação do movimento à história e a alguns dos andamentos da sinfonia
6. A canção dos abraços (Sérgio Godinho)

AULA 10

1. Bom dia / Boa tarde (CMT)
2. A música “A saquinha das surpresas” (Cantar Juntos) - exploração da escala pentatónica. Apresentação e utilização do instrumento “jogo de sinos”
3. Exploração melódica e rítmica das canções:
    a. Borboleta (CMT) - Modo Mixolídeo
    b. A Rã (Cantar juntos) - Modo Maior
4. Associação do movimento de um tecido ao andamento da canção da Borboleta, exploração rítmica da canção (compasso quaternário)
5. Exploração de diferentes timbres associados à história da Rã e a diferentes estados de espírito
6. Exploração de diferentes intensidades associadas à exploração rítmica da canção da Rã (compasso quaternário)
7. A canção dos abraços (Sérgio Godinho)

AULA 11

1. Bom dia / Boa tarde (CMT)
2. Música de Natal – exploração de objetos de Natal e do som que produzem: fitas de Natal, bolas de Natal, presentes, guisos, sinos, laços, papel de embrulho
3. Realização de ritmos a acompanhar músicas de Natal (compassos de subdivisão binária e ternária)
4. A canção dos abraços (Sérgio Godinho)

AULA 12

1. Bom dia / Boa tarde (CMT)
2. Conjunto de sinos – escala de Dó M
3. Música de Natal acompanhada pelos sinos – harmonização da canção “Pinheirinho” (Jingle Bells)
4. A canção dos abraços (Sérgio Godinho)

AULA 13

1. Bom dia / Boa tarde (CMT)
2. Instrumentos de Percussão: caixa chinesa, reco-reco, bloco de dois sons, récula, afouché, clavas, rela, tamborim, pandeireta com pele, pandeireta sem pele, maracas, castanholas,triângulo
3. Distribuição dos instrumentos e realização de diferentes rítmos em compassos de subdivisão binária e quaternária, simples e compostos
4. A canção dos abraços (Sérgio Godinho)

AULA 14

1. Bom dia / Boa tarde (CMT)
2. Discriminação auditiva de instrumentos de percussão:
    a. Audição (de olhos vendados) de um instrumento de percussão, entre os diversos instrumentos existentes;
    b. Seleção do instrumento de percussão utilizado, acedendo apenas à informação auditiva;
    c. Aumento do grau de dificuldade do exercício mediante a resposta da criança, pela junção de instrumentos com timbres muito semelhantes (e.g. pandeireta e pandeireta com pele; *afouché* e maracas; caixa chinesa e clavas)
3. A canção dos abraços (Sérgio Godinho)

AULA 15

1. Bom dia / Boa tarde (CMT)
2. Exploração melódica e rítmica das seguintes canções:
    a. O caracol (Companhia de Música Teatral)
    b. O elefante (Canção infantil tradicional)
    c. O leãozinho (Caetano Veloso)
4. Associação do movimento do corpo aos sons produzidos pelos animais, e às respectivas canções. Sensação de peso, intensidade e velocidade
5. A canção dos abraços (Sérgio Godinho)

AULA 16

1. Bom dia / Boa tarde (CMT)
2. A canção da saquinha das surpresas. Exploração melódica e rítmica das canções:
    a. A D.Aranha (tradicional)
    b. A Borboleta (CMT)
    c. Olha o sol (Cantar Juntos)
    d. A Galinha Pedrês (CMT)
    e. A rã (Cantar Juntos)
3. Associação do movimento de tecidos ou pequenos bonecos na exploração rítmica e melódica das canções
4. A canção dos abraços (Sérgio Godinho)

AULA 17

1. Bom dia / Boa tarde (CMT) – utilização de material da sala para percutir
2. O Carnaval dos Animais (Camille Saint-Saens)
3. Audição da obra e de uma história que a acompanha

4. Associação das músicas aos respetivos animais
5. Associação do movimento dos animais às músicas, implicando breve análise de tempo e intensidade
6. A canção dos abraços (Sérgio Godinho)

AULA 18

1. Bom dia / Boa tarde (CMT)
2. Exploração do som do papel de jornal:
    a. Os sons que podemos fazer com a folha de jornal (amachucar, esticar, rasgar, abanar, etc.)
    b. Associação do movimento do nosso corpo
    c. Associação de movimentos de animais e interpretação desses movimentos com o papel de jornal (e.g. as asas do pássaro, as asas da borboleta, a carapaça da tartaruga, etc.)
3. A canção dos abraços (Sérgio Godinho)

AULA 19

1. Bom dia / Boa tarde (CMT)
2. A canção "O teu corpo é música":
    a. Exploração melódica (modo Maior)
    b. Exploração rítmica (compasso de subdivisão binária)
    c. Exploração do som que podemos fazer com as diferentes partes do nosso corpo
    d. Introdução desses sons na canção
3. A canção dos abraços (Sérgio Godinho)

AULA 20

1. Bom dia / Boa tarde (CMT)
2. Discriminação auditiva de instrumentos de percussão:
    a. Audição (de olhos vendados) de uma sequência de 2 ou 3 instrumentos de percussão, entre os diversos instrumentos existentes;
    b. Seleção dos instrumentos de percussão utilizados na ordem correta, acedendo apenas à informação auditiva
    c. Aumento do grau de dificuldade da sequência, pela introdução de maior número de instrumentos ou de instrumentos com timbres semelhantes, mediante a reposta da criança
3. A canção dos abraços (Sérgio Godinho)

AULA 21

1. Bom dia / Boa tarde (CMT)
    a. Exploração melódica e rítmica da Canção do Pai (Modo Maior, Compasso de subdivisão binária)
    b. Exploração de diferenças rítmicas e tímbricas, associadas à voz do pai e a diferentes estados de espírito – como cantaria o pai os papapás quando está alegre, triste, zangado, cansado, com fome, com falor, com frio...
2. A canção dos abraços (Sérgio Godinho)

AULA 22

1. Bom dia / Boa tarde (CMT)
2. A canção do Balão Amarelo
    a. Os vários sons produzidos pelo balão
    b. Imitação e exploração dos seus diversos sons (encher, esvaziar devagar, esvaziar depressa, esvaziar e voar, vibração das membranas, puxar o balão pelo nó, etc.)
    c. Exploração dos vários movimentos do balão
    d. Associação do movimento do corpo aos diversos movimentos do balão
    e. Associação destes movimentos à canção
3. A canção dos abraços (Sérgio Godinho)

AULA 23

1. Bom dia / Boa tarde (CMT)
2. A música tradicional portuguesa – exploração melódica e rítmica de músicas típicas de diversas regiões do nosso país
    a. A Laurinda (música tradicional do Alentejo)
    b. O Pingacho (música tradicional de Trás-os-Montes)
    c. Vira de Coimbra
    d. Senhora do Almortão (música tradicional da Beira Baixa)
    e. A laranjinha (música tradicional da Beira Baixa)
3. A canção dos abraços (Sérgio Godinho)

AULA 24

1. Bom dia / Boa tarde (CMT)
2. Discriminação auditiva de instrumentos de percussão:
    a. Audição (de olhos vendados) de 2 ou 3 instrumentos de percussão tocados em simultâneo, entre os diversos instrumentos existentes;

    b. Seleção dos instrumentos de percussão utilizados, acedendo apenas à informação auditiva;
    c. Aumento do grau de dificuldade do exercício, pelo aumento do número de instrumentos ou pela introdução de instrumentos com timbre semelhante, mediante a resposta da criança
3. A canção dos abraços (Sérgio Godinho)

AULA 25

1. Bom dia / Boa tarde (CMT)
    a. Exploração melódica e rítmica da Canção da Mãe (Susana Ralha)
    b. Exploração de diferenças rítmicas e tímbricas, associadas à voz da mãe e a diferentes estados de espírito – como cantaria a mãe os papapás quando está alegre, triste, zangada, cansada, com fome, com falor, com frio...
2. A canção dos abraços (Sérgio Godinho)

AULA 26

1. Bom dia / Boa tarde (CMT)
2. Orquestra de papel:
    a. Exploração de instrumentos realizados com rolos de papel higiénico ou papel absorvente, decorados com papel autocolante – o boom-walker (audição das diferenças na altura tonal do instrumento, de acordo com o seu comprimento), o reco-reco e a maraca
    b. Realização (improvisação e imitação) de ritmos em compassos de subdivisão binária, ternária e mistos
3. A canção dos abraços (Sérgio Godinho)

AULA 27

1. Bom dia / Boa tarde (CMT)
    a. Exploração melódica e rítmica de cantos de Edwin Gordon em diferentes modos gregos (o Dórico, o Mixolídeo, o Lócrio), com compassos de subdivisão binária, ternária e mistos
2. A canção dos abraços (Sérgio Godinho)

AULA 28

1. Bom dia / Boa tarde (CMT)
2. Interpretação da Canção "Olha o Sol" – coreografar a canção com gestos escolhidos pelas crianças, mediante a interpretação da letra da canção
3. A canção dos abraços (Sérgio Godinho)

AULA 29

1. Bom dia / Boa tarde (CMT)
2. Exploração de sons da Natureza (o som do vento na rua): dinâmicas, sons de animais, do vento, da chuva
3. Utilização do corpo e da voz para reprodução dos sons da natureza
4. A canção dos abraços (Sérgio Godinho)

AULA 30

1. Bom dia / Boa tarde (CMT)
2. A Saquinha das Surpresas, exploração melódica e rítmica e associação do movimento do corpo às seguintes canções:
    a. A Borboleta (CMT)
    b. O Caracol (CMT)
    c. O Pinguim (CMT)
    d. Olha o Sol (Cantar Juntos)
    e. A D.Aranha (tradicional)
    f. Plic Ploc (CMT)
    g. A rã (Cantar Juntos)
3. A canção dos abraços (Sérgio Godinho)

Planning of Visual Arts Classes

AULA 1

1. Associação de "Bom dia" ou "Boa tarde" a um movimento do nosso corpo: uma estátua – apresentação dos professores e dos alunos
2. Introdução do tema: O Outono
3. As cores do Outono
4. As folhas do Outono e os desenhos que podemos fazer com elas no chão – registo fotográfico. As crianças devem escolher quais os desenhos que querem fazer
5. Final

AULA 2

1. Bom dia / Boa tarde
2. Explorar estátuas com o corpo
3. Registo fotográfico de diferentes ideias de estátuas
4. Estátuas em grupo e estátuas individuais
5. Estátuas diferentes e estátuas iguais
6. Final

AULA 3

1. Bom dia / Boa tarde
2. Introdução do tema: o Cinema – o Walt Disney e o primeiro filme do Rato Mickey
3. Projeção do filme: "O avião maluco", o primeiro filme do Rato Mickey (projetado a 15 de Maio de 1928)
4. Visualização de uma apresentação sobre o autor do Rato Mickey e a evolução do seu desenho
5. Pintura de desenhos do Rato Mickey nas suas várias fases – contacto com materiais de pintura
6. Final

AULA 4

1. Bom dia / Boa tarde
2. Introdução do tema: Pintura – o pintor Kandinsky
3. A vida e obra do pintor
4. Visualização de reproduções de quadros do pintor
5. Identificação e nomeação das formas e cores presentes no quadro
6. Reprodução dos quadros através da montagem com materiais diversos em folhas de cartolina – registo fotográfico
7. Final

AULA 5

1. Bom dia / Boa tarde
2. Pintura livre com recurso ao guache e ao pincel
3. Final

AULA 6

1. Bom dia / Boa tarde
2. Introdução ao tema: Vida e obra de Gustav Klimt
3. Visualização de ppt sobre o autor e a sua vida
4. Visualização de quadros, murais e esboços do pintor
5. Observação do quadro “A Árvore da Vida” e análise dos seguintes aspectos:
    a. os desenhos realizados
    b. as formas geométricas utilizadas
    c. as cores do quadro
6. Pintura individual recriando Klimt e o quadro “A Árvore da Vida”
7. Pintura de grupo, utilizando pastel de óleo e tela
8. Final

AULA 7

1. Bom dia / Boa tarde
2. Introdução ao tema: as formas geométricas
3. Que formas conhecem?
4. Que formas têm os objectos da nossa sala?
5. Desenho de formas geométricas com diferentes cores, utilizando marcadores e papel
6. O desenho com a mão esquerda e com a mão direita (trabalho da motricidade fina), em separado e em simultâneo
7. Observação final dos desenhos e conversa sobre os mesmos
8. Final

AULA 8

1. Bom dia / Boa tarde
2. Continuação do trabalho sobre as formas geométricas
3. Montagem e colagem de diferentes formas geométricas para formar objetos, animais ou outras figuras
4. Final

AULA 9

1. Bom dia / Boa tarde
2. Introdução ao tema: o pontilhismo
3. Observação de um livro com quadros de Georges Seurat
4. Desenhar com técnica de pontilhismo
   (Materiais utilizados: Folhas A4 brancas, lápis de cera e marcadores de várias espessuras)
5. Final

AULA 10

1. Bom dia / Boa tarde
2. Pintura em folha branca com cola branca e purpurinas
3. Final

AULA 11

1. Bom dia / Boa tarde
2. Realização de desenhos realizados com a sobreposição de materiais usualmente utilizados nas decorações de Natal – as fitas e as bolas
3. Final

AULA 12

1. Bom dia / Boa tarde
2. Introdução ao tema: a moda
3. Apresentação de imagens de diferentes estilistas e figurinistas
4. Criação, em pares, de um figurino – cada criança elabora um figurino para o seu par, invertendo depois os papéis
   (Materiais: imagens de estilistas e figurinistas; tecidos diversos)
5. Final

AULA 13

1. Bom dia
2. Introdução ao tema: Escultura de sal – O boneco de neve
3. Apresentação dos materiais:
   a. Sal
   b. Água
   c. Olhos
   d. Lã

e. Palitos
f. Paus coloridos
g. Molas
h. Cartolinas

4. Registo fotográfico dos bonecos com os nomes das crianças
5. Final

AULA 14

1. Bom dia / Boa tarde
2. Construção de máscaras de carnaval com balões, jornal e cola branca
3. Visualização de um balão já finalizado.
4. Início da construção das máscaras – cobrir o balão. Trabalho realizado em pares.
5. Final

AULA 15

1. Bom dia / Boa tarde
2. Continuação do trabalho de construção de máscaras de carnaval com balões, jornal e cola branca
3. Final

AULA 16

1. Bom dia / Boa tarde
2. Continuação do trabalho de construção de máscaras de carnaval: pintura das máscaras e colagem de materiais reutilizáveis (tecidos, tampas, lãs, etc.)
3. Final

AULA 17

1. Bom dia / Boa tarde
2. Introdução ao tema: Escultura – Vida e obra de Miró
3. Visualização de ppt sobre o autor e a sua vida
4. Visualização de imagens das esculturas do autor
5. Reprodução das esculturas do autor, com recurso à plasticina
6. Final

AULA 18

1. Bom dia / Boa tarde
2. Continuação do trabalho relacionado com a obra de Gustav Klimt
3. Reprodução dos Murais de Klimt realizados com mosaicos:
    a. trabalho individual realizado com colagens de papel autocolante aos quadrados coloridos, em folha de papel
    b. demonstração dos diversos padrões possíveis
    c. a colagem abstrata e os desenhos com pequenos "mosaicos"
4. Final

AULA 19

1. Bom dia / Boa tarde
2. Continuação da aula anterior
3. Final

AULA 20

1. Bom dia / Boa tarde
2. A modelagem de argila
3. Elaboração de uma figura para oferecer ao Pai
4. Final

AULA 21

1. Bom dia / Boa tarde
2. Continuação da aula anterior
3. Pintura da figura anteriormente elaborada para oferecer ao Pai
4. Final

AULA 22

1. Bom dia / Boa tarde
2. Desenho de olhos vendados, a partir da descrição de um gato, numa história infantil
3. Análise dos desenhos de cada um
4. Final

AULA 23

1. Bom dia / Boa tarde
2. A modelagem de argila

3. Elaboração de pequenas contas para elaborar um colar para oferecer à Mãe
4. Final

AULA 24

1. Bom dia / Boa tarde
2. Continuação da aula anterior
3. Pintura das contas para colocar no colar para oferecer à Mãe
4. Final

AULA 25

1. Bom dia / Boa tarde
2. Continuação da aula anterior
3. Montagem do colar para oferecer à Mãe
4. Final

AULA 26

1. Bom dia / Boa tarde
2. Introdução do tema: Pinturas rupestres
3. Observação de imagens de pinturas rupestres
4. Reprodução de figuras rupestres, utilizando guaches e pintando com as mãos num papel de cenário colocado na parede
5. Final

AULA 27

1. Bom dia / Boa tarde
2. Experiência sensorial de desenho – o desenho nas costas do colega reproduzido em papel
3. Análise do resultado e conversa entre os pares de crianças
4. Final

AULA 28

1. Bom dia / Boa tarde
2. Utilização de rolos de papel higiénico ou papel absorvente para realizar pequenas esculturas, utilizando materiais reutilizáveis
3. Final

AULA 29

1. Bom dia / Boa tarde
2. Tema: Pintura – a vida e obra do pintor Amedeo Modigliani
3. Observação dos retratos pintados pelo pintor
4. Realização de retratos dos colegas (em trabalho de par), reproduzindo as pinturas de Modigliani
5. Final

AULA 30

1. Bom dia / Boa tarde
2. Tema: Arquitetura
3. Realização de uma construção em grupo, com recurso a bolas de plasticina e esparguete
4. Final