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An investigation of the speech sound and phonological development of monolingual Italian children aged 1;6-4;11.

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Abstract

Obtaining data on the typical speech sound and phonological acquisition of a language is fundamental for a detailed description of the language-specific development, and as a baseline for the identification of SSD in children of that population. To date, normative data on Italian are not sufficiently available. This study, therefore, aimed to describe the speech sound and phonological development of 213 typically developing monolingual Italian children aged 1;6–4;11, across two cohorts (i.e. primary data on 3;0-4;11, and secondary data on 1;6-3;0). Participants in the two cohorts were assessed through two different naming tasks. Accuracy was calculated in terms of PCC and PVC; consonants and vowels inventories were drawn; geminates and two types of consonant clusters were also investigated. Phone production was investigated by two means: inventories were derived from a picture naming and a phone imitation task for children in Cohort 1. The number of phonological variations (Tokens), Types and percentage of occurrence of patterns, and number of infrequent variants (InfrVar) as a measure of stability in speech production were calculated. Two cut-off criteria to distinguish InfrVar from phonological patterns were applied.

Overall results showed a gradual reduction of all measures with increasing age, demonstrating developmental progression. Replicating earlier data, the development of most Italian speech components was completed by the age of 4;11. Further studies on older children, particularly focussing on phonological patterns, are still needed. Unexpectedly, children did not show earlier production of consonants when these were imitated in isolation, thus raising questions on the appropriateness of the task for Italian. Even though clusters development was not investigated in enough detail, the analysis suggested the need for a more in-depth investigation, specifically with respect to the differences between development of tautosyllabic and heterosyllabic clusters, which have so far only been investigated as one group, as well as the observed phonological patterns affecting each type. Detailed data on typical phonological patterns and their age of overcoming are also presented. The application of two different cut-off criteria highlighted the significant influence of the selected criterion on which type of patterns might be considered developmental, and raises the issue of possible under-identification of SSD. InfrVar as a new measure was introduced for monolingual children; its diagnostic value needs to be further investigated. Finally, the influence of language-specific features and of regional variations children were exposed to was hypothesised in relation to a few findings across accuracy measures and phonological patterns found.

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Table of Content

List of Tables

List of Figures

List of Abbreviations

BVL_4-12: Batteria per la Valutazione del Linguaggio nei bambini dai 4 ai 12 anni

C: Consonant

C_{0-N}: none to N consonants in onset/coda

C1: first consonant in the cluster

C2: second consonant in the cluster

C3: third consonant in the cluster

CC, CCs: Consonant Cluster/s

CCC: three-element consonant cluster

CGV: Consonant-Glide-Vowel

CLV: Consonant-Liquid-Vowel

CV: Consonant-Vowel

GV: Glide-Vowel

ICS: Intelligibility in Context Scale

InfrVar: Infrequent Variants

IPA: International Phonetic Alphabet

L1: First Language/Native Language

L2: Second Language

M: Mean

PA: Phonological Awareness

PCC: Percentage of Consonants Correct

PCC-A: Percentage of Consonants Correct - Adjusted

PCI: Percentage of Consonants in the Inventory

PFLI: Prove per la valutazione Fonologica del Linguaggio Infantile

PPC: Percentage of Phonemes Correct

PPC-A: Percentage of Phonemes Correct - Adjusted

PVB: Primo Vocabolario del Bambino

PVC: Percentage of Vowels Correct

PVC-A: Percentage of Vowels Correct - Adjusted

PWM: Phonological Working Memory

SD: Standard Deviation

SES: Socioeconomical Status

SF: Syllable-Final

SI: Syllable-Initial

SICD: Syllable-Initial Consonant Deletion

SLT: Speech and Language Therapy/Therapist

SSD, SSDs: Speech Sound Disorder/s

TD: Typically Developing

TFPI: Test Fonetico della Prima Infanzia

TPL: Test di Primo Linguaggio

V: Vowel

$\mathbf{V_{1\text{-}2}}$: one to two vowels in nucleus

WF: Word-Final

WI: Word-Initial

WICD: Word-Initial Consonant Deletion

WM: Word-Middle

WMSI: Word-Middle Syllable-Initial

WSD: Weak Syllable Deletion

Other Conventions

<: lower

>: higher

≤: equal or lower

≥: equal or higher

n: partial number (e.g. subgroup)

N: total number

Introduction

A significant proportion of the caseloads of Speech and Language Therapists' (SLT) is composed of children with Speech Sound Disorders (Dockrell et al., 2012; McLeod & Baker, 2004), which represent one of the most common childhood difficulties alongside language disorders (Law et al., 2000). Although across literature different terminologies and classifications have been adopted to describe Speech Sound Disorders (SSD), studies estimating the occurrence of SSD in children and adolescents provide figures ranging from a prevalence of 2 to 24% (Flipsen, 2015; Wren et al., 2016). Research has provided ample evidence that these children are at high risk of developing, for instance, long-term language and literacy difficulties (Hayiou-Thomas et al., 2017; Peterson et al., 2009). Thus, an early diagnosis of speech difficulties is fundamental in order to appropriately plan and provide tailored intervention to reduce the impact of SSDs and prevent long-term difficulties (Law et al., 2000). Judgment on a child's speech needs to be based on language-specific, reliable information on the speech sound and phonological abilities of typically-developing (TD) children across different ages; a child's performance must be compared with data on the TD population the child belongs to (e.g. a 4-year-old monolingual Italian pupil should be compared to normative data on monolingual Italian children of a similar age, usually within a 6-month age range). Normative data are fundamental for discriminating between typical and atypical or delayed phonological development, and classifying children's speech into further subgroups (Dodd, 2014).

Currently, the vast majority of research on children's phonological development focuses on English speakers (Dodd et al., 2013; Dodd et al., 2003; Howard, 2007; McLeod, 2013). Nevertheless, children's speech sound and phonological acquisition is being increasingly investigated also across other languages (McLeod & Crowe, 2018). Research on individual languages is vital: although similarities have been observed cross-linguistically in children's development, language-specific developmental features have also been reported. For instance, in terms of phonological patterns, universal features can be found across languages, but specific patterns can also be identified for specific languages (Dodd et al., 2003; Fox, 2006). Similarly, differences have also been observed in the rate of phonological acquisition both across languages of different origins and within the same linguistic family (Bjerkan et al., 2018; Clausen & Fox-Boyer, 2017). It follows therefore that information on a language cannot be generalised to others of the same family.

To date, within the Romance languages, both Spanish and Portuguese have been well studied (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Lousada et al., 2012; Pavez et al., 2009). In contrast, relevant research available for Italian is limited and incomplete. Most of the studies available for speech sound and phonological development tested a small number of participants or focussed on children at a very young age (i.e. below 3;0 years old). Additionally, literature shows a lack of reliable and generalisable studies on the developmental occurrence and disappearance of phonological patterns in monolingual Italian children, with five studies solely commenting on the incidental emergence of phonological patterns in the population studied (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zmarich et al., 2012). None specifically focussed on the presence and disappearance of phonological patterns cross-sectionally.

The present project thus arises from the need of more accurate and reliable data on a wider age group, fundamental for understanding speech acquisition in Italian, and more specifically, for distinguishing between typical, delayed, or atypical phonological development (Preston et al., 2013) and thus, for reaching a differential diagnosis. In this perspective, the current research adopts a cross-sectional design, investigating monolingual Italian children's speech sound and phonological development in two cohorts of children. Data on the first cohort of children were collected first-hand in the autumn of 2019. Secondary data made up the second cohort. These data were shared by Dr Claudio Zmarich, and were collected for the study by Zmarich et al. (2012). The decision to add an additional cohort of secondary data to the main sample was made following the restrictions put in place by the UK Government in facing the spread of Covid-19. Indeed, the original project would have included the collection and analysis of data on the speech sound and phonological development of bilingual children speaking English and Italian. Due to the first lockdown taking place in the Spring of 2020, the collection of these data could not proceed. It was therefore decided to focus the project on the monolingual development: thus, obtaining the mentioned secondary data allowed to expand the age range under investigation, adding three age groups to the four already collected (i.e. 1;6-3;0 in addition to 3;0-4;11). The current data will in future be available as a baseline for the interpretation of new data on bilingual speakers of English and Italian.

The thesis is structured in eight chapters, organised as follows. The first chapter (i.e. Literature Review I) provides an overview of the available theories on monolingual phonological development and the models built as results of these theories. In addition,

it gives information on the practicalities of investigating children's speech and phonology, with particular focus on the measures and tasks involved in the assessment of speech production. The second Literature Review chapter (i.e. Literature Review II) summarises the features and development of the Italian phonetic and phonological system, providing an overview of the literature available to date, its strengths and limitations, and highlighting the need for further research.

Following the background chapters, the Methodology provides a detailed account of the research design, participant recruitment, data collection and analyses. The subsections covering information on the participants and procedures are separated for the first and second cohort, while the analyses are described jointly for the full sample.

Results from the analyses of the speech sound acquisition and quantitative measures such as the percentages correct of consonants and vowels are reported and discussed separately from the results regarding phonological variations. Thus, chapter 4. Results I

The first section of the research project aimed to investigate how Italian speech sound acquisition proceeds over time across the developmentally critical ages of 1;6-4;11. In order to address these research questions, several analyses were conducted through the use of the Phon software (Rose & MacWhinney, 2014) and subsequent manual calculations on the two cohorts (i.e. children aged 3;0-4;11; secondary data on children aged 1;6-3;0). Percentages of consonant and vowel correct, and their revised versions were calculated from the picture naming tasks. Phonetic inventories were drawn separately for the naming tasks and stimulability task. Additionally, percentages correct were calculated for tautosyllabic and heterosyllabic consonant clusters, as well as for geminates. The inventory for the tautosyllabic clusters were also evaluated. All analyses were performed on both cohorts. However, the stimulability task was solely implemented for the first cohort. The present chapter aims to report the findings obtained through these analyses.

4.1 Percentages of Consonant and Vowel Correct

Percentage of consonant (PCC) and vowel (PVC) correct were calculated on the basis of the naming tasks for both cohorts. Each measure was initially computed for all individual participants through Phon (Rose & MacWhinney, 2014). The mean, standard deviation, and range for each measure was then manually calculated across each age group. Additionally, following the same procedure, the revised measures (i.e. Percentage

of Consonant Correct – Revised, PCC-R: Percentage of Vowel Correct – Revised, PVC-R: Shriberg et al., 1997) were also calculated. These allowed for potential phonetic distortions in the realisation of the target phones to be considered as correct productions. In this perspective, the use of allophones and minor phonetic variations that did not compromise the conveyance of the word meaning were accounted for and did not weigh on the percentage of correctness.

4.1.1 PCC and PCC-R

Concerning consonant production, an overall steady improvement in children's performance across all ages of the two cohorts, both for the PCC and PCC-R measures, was observed (see

Table 17). As expected, the PCC-R scores were higher than the PCC ones, although only by a minor degree.

Table 17: Mean PCC, PCC-R, and relative SD and range for the Picture Naming tasks.

	PCC M(SD)	PCC Range	PCC-R M(SD)	PCC-R Range
1;6-1;11	45.22 (11.76)	21.54-65.82	45.93 (12.26)	21.54-65.82
2;0-2;5	56.60 (9.48)	39.10-67.27	57.32 (9.70)	39.10-67.27
2;6-3;0	68.22 (7.93)	54.25-82.67	68.64 (7.89)	54.72-83.11
3;0-3;5	75.24 (13.27)	40.69-96.40	76.83 (12.82)	42.27-96.40
3;6-3;11	76.88 (15.28)	16.39-97.13	78.95 (15.63)	16.39-97.13
4;0-4;5	84.86 (9.00)	51.49-97.60	86.65 (8.97)	52.61-97.60
4;6-4;11	87.27 (7.17)	68.72-97.60	88.48 (7.07)	68.72-98.35

Children performed with noticeably lower accuracy in the younger groups compared to older children, with less than half of the consonant produced correctly, even when phonetic distortions were accepted. Accuracy in consonant production steadily increased with age, with PCC and PCC-R being almost double for the older age group compared to the youngest children (PCC and PCC-R respectively 87.27% and 88.48% at the age of 4;6-4;11), indicating that children are approximating completion of the phonological system. It is worth noticing that both measures present large SD and ranges, manifesting a wide variability among children within the same age band. This is true in particular for the younger children and those between 3;5-3;11, with some children across all age groups in the first cohort performing at ceiling level. However, this measure is also reduced with age increase, indicating a gradual stabilisation of the development. Overall, all values for PCC-R appeared higher than PCC, although the differences were marginal, indicating a reduced impact of phonetic distortions on consonant acquisition.

4.1.2 PVC and PVC-R

Similarly to the trend observed for consonant production, vowel accuracy was found to largely increase from younger to older children (Table 18Table 18), with means PVC and PVC-R as high as 71.77% and 72.29% respectively already at the age of 1;6-1;11, and as 97.92% and 98.01% respectively at the age of 4;6-4;11, although with wide SD and range values. Despite the similar trend, however, accuracy in vowel production approximated a ceiling effect across all age groups from 3;0 years onward. Additionally, the difference between the younger and older children was less marked. PVC values across age group were markedly close to their correspondent PVC-R values, appearing identical across two age groups, suggesting that Italian children do not generally produce phonetic distortions in acquiring their vowel system.

Table 18: Mean PVC, PVC-R, and relative SD and range for the Picture Naming tasks.

	PVC M(SD)	PVC Range	PVC-R M(SD)	PVC-R Range
1;6-1;11	71.77 (11.06)	44.00-86.96	72.29 (11.18)	44.00-86.96
2;0-2;5	82.85 (6.34)	72.09-89.34	82.85 (6.34)	72.09-89.34
2;6-3;0	88.81 (4.65)	78.29-93.70	88.81 (4.65)	78.29-93.70
3;0-3;5	95.73 (5.38)	73.03-100.00	95.78 (5.25)	73.68-100.00
3;6-3;11	95.36 (6.09)	71.96-100.00	95.47 (5.97)	71.96-100.00
4;0-4;5	97.07 (3.70)	85.29-100.00	97.11 (3.72)	85.29-100.00
4;6-4;11	87.27 (7.17)	68.72-97.60	88.48 (7.07)	68.72-98.35

4.2 Phonetic Inventories

For the purpose of evaluating which phones are present at each developmental stage, phonetic inventories were drawn from both the picture naming tasks (both cohorts), and the phone imitation tasks (for cohort 1 only).

4.2.1 Phonetic Inventory derived from Picture Naming task

First, Phon (Rose & MacWhinney, 2014) was used to obtain the number of times each child produced each phone in the naming task. Subsequently, the number and percentage of children who produced each phone correctly (phonetic distortions counted as errors) at least twice was calculated, and a summary for each age group investigated was derived. All phones that were observed in one age group between 50-75% were labelled as emerging in that age group; all phones appearing in at least 75% of children were considered acquired; all phones present in more than 90% of children were considered mastered. Since the two cohorts were tested using different assessment tools, the findings from the two populations will be presented separately, starting with the second cohort following a developmental sequence.

4.2.1.1 Cohort 2 (1;6-3;0)

Secondary data obtained through the analyses of children from the second cohort are summarised in

Table 19, which reports the newly emerging, acquired, and mastered consonants in each age group. Table 47 in Appendix 6 reports the percentage of occurrence of each phone in each age group.

Table 19: Acquired and mastered phones at each age for the picture naming task in the second cohort.

	Emerging (≥50%)	Acquired (≥75%)	Mastered (≥90%)
1;6-1;11	d, k	m	p, t, n, l
2;0-2;5	g, ʃ	f, v	b, d, k, s, ʧ, m, j
2;6-3;0	z, ʤ, r	w	g, f, v

Already prior to the age of 2;0, a small number of consonants appears to be mastered, namely /p, t, n, l/. Between 2;0 and 3;0 years of age, the children's inventory largely increases, with mastery of all but one plosives, two of the three nasals, as well as /s, ʧ, j/. At the age of 3;0, /w, z, ʤ, r/ remain below the 90% threshold, while /ʦ, ʣ, ɲ, ʎ/ are still produced by low percentages of children.

Concerning vowels (Table 20), four out of seven vowels were mastered already in the youngest age group and the vowels /ɔ, u/ were mastered in the second age group. The last vowel to be mastered was /ɛ/ at the age of 2;6-2;11.

Table 20: Vowel Inventory for the picture naming task in the second cohort.

Vowels	1;6-1;11	2;0-2;5	2;6-3;0
i	90.00	100.00	100.00
u	80.00	100.00	100.00
e	90.00	100.00	100.00
o	100.00	100.00	100.00
ɛ	40.00	80.00	100.00
ɔ	60.00	90.00	100.00
a	100.00	100.00	100.00

4.2.1.2 Cohort 1 (3;0-4;11)

Table 21 reports a summary of the phones emerging, acquired, and mastered at each age in the first cohort. As for the second cohort, Appendix 6 contains the specific percentages for each phone in each age group (Table 48).

Table 21: Acquired and mastered phones at each age for the picture naming task in the first cohort.

	Emerging (≥50%)	Acquired (≥75%)	Mastered (≥90%)
3;0-3;5	z, ʣ, ʧ, ʤ	s, ʦ*	p, b, t, d, k, g, f, v, m, n, ɲ*, l, w*, j
3;6-3;11	ʃ, ʦ*, r	ʧ, ʤ	
4;0-4;5		z, ʃ*, ʦ, r	s
4;6-4;11		ʣ	

Note: * drop below the threshold in which they appear in the next age group, then rise back up in the following (/ɲ/ drops back again).

Consistently with the results obtained from the second cohort, at the age of 3;0-3;5, most of the phones of Italian are mastered by children in the population under study (/p, b, t, d, k, g, f, v, m, n, ɲ, l, w, j/). By age 4;0, both postalveolar affricates are acquired, and a small number of new phones emerges, although no consonant is mastered. Solely /s/ appeared to be added to the inventory of mastered phones prior to the age of 5;0, while four more consonants (/z, ʃ, ʦ, r/) pass the 75% threshold. A limited number of other consonants (i.e. /ʦ, ɲ, ŋ, w, ʃ/) oscillate in percentage of occurrence across age groups, alternatively meting a higher or lower criteria from the one met in the previous age group. Prior to the age of 5;0, /z, ʃ, ʦ, ʣ, r/ continue to be produced by less than 90% of children, while solely one consonant, /ʎ/, results not yet emerging, appearing in less than 30% of children in the oldest age group.

Given the presence of phonetic distortions across children's recorded speech, a second analysis was run in order to identify whether any difference in age of acquisition and mastery could be found when phonetic distortions were considered among the correct productions. In this light, the phone /s/ met the 90% criterion already at the age of 3;0-3;5. Similarly, its voiced counterpart /z/ passed the 75% criterion in two age groups (i.e. 3;0-3;5 and 4;0-4;5). Finally, /r/ also appeared to be mastered at a lower age (i.e. 3;6-3;11) compared to the age of mastery obtained when phonetic distortions were considered erroneous.

Concerning the acquisition of vowels, all phones were mastered by all children already in the youngest age group (see Table 22).

Table 22: Vowel Inventory for the picture naming task in the first cohort.

Vowels	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
i	100.00	100.00	100.00	100.00
u	100.00	98.18	100.00	100.00
e	100.00	100.00	100.00	100.00
o	100.00	100.00	100.00	100.00
ɛ	100.00	100.00	100.00	100.00
ɔ	100.00	100.00	100.00	100.00
a	100.00	100.00	100.00	100.00

Overall, the consonant and vowel systems show parallel development prior to the age of 3;0, with the latter reaching the adult target by that age. The first phones to be mastered already at the early age of 1;6-1;11 appear to be most voiceless plosives, alongside the nasal /n/, the approximant /l/, and the vowels /i, e, o, a/. The remaining plosives, nasals, semiconsonants, and vowels, together with the /f, v/ pass the 90% threshold by the age of 3;0-3:5. All other fricatives and affricates gradually emerge and are acquired before the age of 4;11, although solely /s/ is consolidated by that age. /r/ appears to follow a similar development to the fricatives and affricates, remaining below the 90% threshold in the older children. Finally, /ʎ/ is the latest sound to appear in children's production, emerging after the age of 5;0.

4.2.2 Phone Imitation task

The phone imitation task was only carried out with the children of the first cohort (i.e. 3;0-4;11) in order to evaluate the stimulability of consonants of Italian for each age group, and to compare these with the phones emerging at word level. As outlined in the methods section, each consonant was elicited only once in imitation, with children provided with three presentations, if required, for each phone. Therefore, children's performances were scored in terms of correct versus incorrect/omitted phone, and each production was assigned a score of 1 or 0, respectively: the total score was 24. For each individual, the number and list of consonants accurately produced was computed, and the number of correctly produced phones was transformed into percentage for each child. Subsequently, inventories were drawn for each age groups, and the mean, SD, and range for the percentage of consonants produced accurately was also derived for each age group. Table 49 in Appendix 6 reports the consonant inventory for the phone

imitation task, while Table 23 summarises the ages at which each phone was imitated correctly by at least 75% and 90% of children.

Table 23: Phones stimulable in at least 75% and at least 90% of children at each age from the phone imitation task.

	Stimulable ≥50%	Stimulable ≥75%	Stimulable ≥90%
3;0-3;5	ʃ, ʧ, ʤ	g*, f, v*	p, b, t, d, k, m, n, ɲ, l, w, j
3;6-3;11	v	ʧ	g*
4;0-4;5	s, ʦ, ʣ	ʃ, ʤ	f
4;6-4;11	z	s, ʦ	v, ʧ

Note: * drop below the threshold in which they appear in the next age group, then rise back up in the following.

Similarly to what was obtained from the naming task, most plosives and all nasals, as well as /l, w, j/ were already imitated correctly by over 90% of the youngest children. /g/ met the same criterion by 4;0 years of age. Following a similar hierarchy as that identified from the naming task, an increasingly higher percentage of children was able to imitate fricatives and affricates after the age of 4;0. However, solely /f, v, ʧ/ were stimulable in more than 90% of children by the age of 4;11, while the remaining phones were only stimulable in more than 50% or 75% of children. Finally, /r, ʎ/ did not meet the 50% criterion prior to the age of 5;0.

As for the naming task, an observation of the percentage of children presenting certain phones when accounting for phonetic distortions as acceptable productions was conducted. In this perspective both /s, z/ appeared correctly imitated already by more than 90% of the youngest children. Similarly, /r/ was found to be imitated correctly by at least 50% of children already at the age of 3;0-3;5, and passed the 75% threshold before the age of 4;0. Finally, /f, v/ also appeared to be affected by phonetic distortions, being occasionally produced in imitation as bilabial /ɸ, β/. When these realisations were considered correct, the target phones were imitated correctly respectively at the ages of 3;0-3;5 and 4;0-4;5.

4.2.3 Comparison between the two tasks

When comparing findings from the picture naming and phone imitation tasks, similar results were found. However, the phone imitation task showed children being able to produce marginally less consonants in isolation compared to those produced correctly

at word level when phonetic distortions were not considered correct productions (see Table 24).

Table 24: Newly acquired and mastered phones at each age for both the picture naming task and the phone imitation task.

	Picture Naming		Phone Imitation	
	Acquired (≥75%)	**Mastered (≥90%)**	**Stimulable ≥75%**	**Stimulable ≥90%**
3;0-3;5	s, ʦ*	p, b, t, d, k, g, f, v, m, n, ŋ*, l, w*, j	g*, f, v*	p, b, t, d, k, m, n, ŋ, l, w, j
3;6-3;11	ʧ, ʤ		ʧ	g*
4;0-4;5	z, ʃ*, ʦ, r	s	ʃ, ʤ	f
4;6-4;11	ʣ		s, ʦ	v, ʧ

Notes: phones were considered correct when produced or imitated phonetically correct (i.e. phonetic distortions were not accepted as correct production); *drop below the threshold in which they appear in the next age group, then rise back up in the following.

The differences presented were nonetheless small, and when a phone appeared in a higher criterion (i.e. ≥75%, ≥90%) for the naming rather than the imitation task, the percentage of occurrence in the latter generally approached the threshold for the higher criterion (see, for instance, /g, f/ and /v, ʧ/ approaching 90% respectively at 3;0-3;5 and 4;0-4;5 in Table 49 in Appendix 6). A more noticeable difference was found for /s, z/ and /ʦ, ʣ/, which were markedly more represented in the inventory from the picture naming task, although percentages for the affricates from the two tasks grew closer together in older children . Additionally, a large difference was found for /r/, produced by a higher percentage of children in the naming task. When phonetic distortions were accounted for and considered correct, a closer resemblance between the two tasks was observed. Indeed, both /s, f/ appeared in more than 90% of children already at the age of 3;0-3;5 across both tasks. /z/ was imitated by 90% of children already at the same age, while it solely passed the 75% threshold at 3;6-3;11 (and remained below 90% across all ages) for the picture naming task. Finally, both /r, v/ maintained a higher performance in the naming task, although they appeared to be produced by a higher percentage of children at younger ages (i.e. /r/ passed 75% at 3;6-3;11, while /v/ was produced by more than 90% at 4;0-4;5). Given the unexpected lower performance in the imitation task, a t-test was run between the percentages of children presenting each phone in naming and imitation in each age group both for the results considering phonetic distortions as incorrect production, and when accounting for them. In both cases, the resulting p values

were all above .05, indicating that the differences between the two tasks were statistically not significant (i.e. p = 0.267, p = 0.246, p = 0.120, p = 0.438 from the lowest to the highest age group for the former case; p = 0.929, p = 0.927, p = 0.459, p = 0.673 for the latter case).

4.3 Consonant co-occurrences: Consonant Clusters and Geminates

The acquisition of consonants in co-occurrence was also investigated. In this perspective, percentages of correct production were first calculated for consonant clusters (i.e. tautosyllabic and heterosyllabic) and geminates for each participant. Additionally, an inventory was drawn for the tautosyllabic clusters for each child. The mean numbers of consonant clusters and geminates correctly produced were then calculated at age-group level, and the age-related inventories for the initial clusters were computed. The following subsections present the results of the analyses for the two classes of clusters and for geminates separately.

4.3.1 Consonant Clusters

Due to the underrepresentation of clusters in the tests used, a cluster was considered present in the child's inventory if it was produced accurately at least once. Following the same criteria adopted for the consonant and vowel inventories in order to obtain an inventory of the initial CCs, a tautosyllabic cluster was considered emerging at a given age if present in at least 50% of the children in that age group, acquired when produced correctly by 75% or more of the children, and mastered when present in at least 90% of the participants in that age group.

4.3.1.1 Percentage correct: Tautosyllabic vs Heterosyllabic

Considering tautosyllabic CC (i.e. SI consonant clusters), a wide difference was found in the performance of children above and below the age of 3;0, with children in the oldest age group presenting an accuracy in the production of tautosyllabic clusters (i.e. 69.96%) that was over three times that of the younger children (i.e. 18.33%) and more than twice that of children aged 2;6-3;0 (i.e. 29.95%). Additionally, a significant increase in performance accuracy was found between children in the ages of 2;6-3;0 and 3;0-3;5: children below the age of 3;0 had a mean percentage accuracy of 29.95%, in contrast with that of children above the age of 3;0, i.e. 47.85% (see Table 25). When comparing the data obtained it is fundamental to remember that these were obtained through two separate tests eliciting different CC and CCC structures, as seen in Table 26 for the TCC.

Table 25: Mean percentage of correct production, and relative SD and range, for the tautosyllabic and heterosyllabic clusters.

	$M_T(SD)^a$	$Range_T^a$	$M_H(SD)^b$	$Range_H^b$
1;6-1;11	18.33 (33.75)	0.00-100.00	16.67 (25.82)	0.00-50.00
2;0-2;5	19.00 (25.39)	0.00-83.33	24.00 (17.66)	0.00-50.00
2;6-3;0	29.95 (16.41)	0.00-63.64	39.17 (14.24)	23.08-70.00
3;0-3;5	47.85 (22.89)	0.00-100	47.59 (27.84)	0.00-100.00
3;6-3;11	50.73 (23.63)	0.00-100	50.13 (26.93)	0.00-93.75
4;0-4;5	65.72 (18.87)	16.67-100.00	63.76 (25.46)	0.00-100.00
4;6-4;11	69.96 (18.04)	25.00-100.00	71.49 (22.87)	0.00-100.00

Note: [a]values for the tautosyllabic clusters; [b]values for the heterosyllabic clusters.

The markedly large ranges indicate that, within the same age group, there were children who had already acquired the consonant clusters tested while other did not yet present any of the target.

When comparing children's performance on heterosyllabic to that in tautosyllabic clusters, a similar trend of overall improvement can be spotted. However, children appeared to produce heterosyllabic clusters with higher accuracy at the age of 2;0-3;0 compared to the realisation of SI clusters at the same age. On the contrary, tautosyllabic clusters showed higher percentages of correct production for the population above the age of 3;0, with the exception of participants in the older age group. Notwithstanding, the differences in percentage of accuracy between the initial and heterosyllabic clusters were however marginal across all age groups. The improvement in performance was similar for both classes of clusters, with percentage of accuracy reaching 71.49% at the age of 4;6-4;11 for the clusters occurring across syllable boundaries. Again, ranges appeared to span from 0.00% to 100% across most age groups, suggesting that children below the age of 5;0 still present a large variability in terms of consonant clusters acquisition.

4.3.1.2 Tautosyllabic Clusters Inventory

Despite the limited elicitation of tautosyllabic clusters both in the BVL subtest (Marini et al., 2015) and in the TFPI (Zmarich et al., in progress) and the discrepancies between types of clusters elicited, a list of the acquired and mastered TCC was drawn from the data for each age group.

Table 26: Inventory of tautosyllabic consonant clusters.

	1;6-1;11	2;0-2;5	2;6-3;0	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
kj	10.00	40.00	60.00	*			
pj		40.00	80.00	92.86	87.27	100.00	97.50
gw			40.00				
fj				85.71	74.55	91.67	97.50
fw				82.14	70.91	95.00	85.00
mj	20.00						
nw				50.00	58.18	76.67	80.00
br		10.00					
tr			20.00	21.43	52.73	58.33	80.00
fr			10.00				
st				25.00	18.18	41.67	52.50
sk		10.00	10.00	25.00	20.00	45.00	60.00
zb				7.14	10.91	23.33	17.50
spj			20.00				
str			10.00				

Note: *when a percentage is not reported, the correspondent cluster was not elicited in the assessment material; orange highlight = Emerging clusters (i.e., 50%-74%), yellow highlight = Acquired clusters (i.e., 75%-89%), green highlight = Mastered clusters (i.e., ≥90%).

Table 26 shows the percentages of children producing each cluster in each age group. It is fundamental to highlight that the two assessments used to test the separate cohorts differed in number and types of consonant clusters elicited, thus results are not reliably comparable. As observable, there was limited overlap between the two cohorts. Overall, it appears from the data obtained that children below the age of 3;0 have no stable consonant cluster in their inventory. Mainly clusters formed with a semiconsonant appear to emerge and gradually stabilise with age increase. Solely clusters /fj, fw, pj/ are mastered by the population studied prior to the age of 5;0. Of the remaining clusters, solely /nw/ and /tr/ can be considered acquired at the respective ages of 4;0-4;5 and 4;6-4;11.

4.3.2 Geminates

Finally, the acquisition of geminates was also investigated. A noticeably higher accuracy was found for children's performance in the production of the same consonant appearing

at syllable boundaries in comparison to heterosyllabic CCs (see Table 27), even for the younger cohort.

Table 27: Mean percentage of correct production, and relative SD and range, for the Geminates.

	M(SD)	Range
1;6-1;11	44.98 (27.49)	8.33-80.00
2;0-2;5	64.26 (12.49)	40.00-85.71
2;6-3;0	64.42 (11.87)	47.83-81.82
3;0-3;5	88.12 (11.18)	43.75-100.00
3;6-3;11	84.42 (17.11)	10.00-100.00
4;0-4;5	91.65 (8.03)	64.71-100.00
4;6-4;11	93.73 (6.72)	70.59-100.00

Similarly to what was found for the tautosyllabic consonant clusters, children appeared to improve significantly in the production of geminates after turning 3;0 years old, moving from a score of 64.42% at 2;6-3;0, to 88.12% at 3;0-3;5, indicating that geminates are nearly mastered by children from that age on. As for the data on consonant clusters, these measures also showed large SD and ranges, although comparably narrower.

4.4 Summary

The current chapter aimed to present the findings from the analyses on consonant and vowel acquisition in terms of percentages of correct production and inventories, and report on the acquisition of consonant co-occurrences. Overall, the population under study showed an improvement with age increase in percentage of consonant, vowel, and phoneme correct production, with only a marginally higher accuracy for the revised measures. While PCC remained below the threshold of 90% accuracy, PVC approached 100% in the older children. These measures are reflected in the consonant and vowel inventories. Indeed, all vowels were mastered by the age of 2;6. Most consonants were instead mastered by children aged 3;0-3;5, with plosive, nasals, and semiconsonants being the first to appear at younger ages. The majority of fricatives and affricate, alongside the trill /r/ remained unstable at the age of 4;11, while the palatal approximant /ʎ/ was still absent among the oldest participants. Considering consonant co-occurrences, a similar trend in terms of accuracy was found for the two classes of consonant clusters (i.e. tautosyllabic and heterosyllabic), while a noticeably higher

accuracy was observed in the production of geminates. Indeed, both initial and heterosyllabic clusters were produced with less than 75% of accuracy at the age of 4;11. Correct production of geminates approached instead 100% at the same age.

Prior to presenting the findings on phonological variations, the results here introduced will be discussed in the following chapter in relation to the available Italian and international literature.

provides information on the phonetic inventories derived from both a naming task (for both cohorts) and a phone imitation task (for cohort 1), and on accuracy measures. These findings are discussed in chapter 5. Discussion I. Chapters 6. Results II

The second part of the research aimed to investigate which phonological variations occur in Italian speaking children developing typically between the age of 1;6-4;11 years, both in terms of the extent to which these variations change across time, and in terms of types of phonological patterns presented. The current chapter reports the findings of the analyses run for this purpose, focussing first on the quantitative measurements (i.e. Tokens, Types, and InfrVar), and subsequently on the developmental phonological patterns. Results will be presented with reference to the adoption of both cut-off criteria (i.e. ≥4, ≥6), and findings on phonological patterns from the first and second cohorts will be presented separately.

6.1 Quantitative measurements: Tokens, Types, and InfrVar

In order to explore the change across time in the occurrence of phonological variations, the number (Tokens) and Types of such phonological variations, as well as the number of InfrVar presented by individual children was calculated. The mean, standard deviation, and range were then computed for each age group. This analysis was carried out twice for the factors Types and InfrVar, once for each cut-off criterion. The measure Tokens is independent of the cut-off criterion adopted, since it considers each phonological variation found in a child.

As shown below in **Error! Reference source not found.**, children across Cohort 1 (i.e. 3;0-4;11) presented a noticeable reduction in the number of overall phonological variations (i.e. Tokens) with increasing age, with the mean number of Tokens for the oldest age group (i.e. *M*=26.93) being less than half of the mean for age group 3;0-3;5 (i.e. *M*=55.21). A similar trend can be observed for the number of phonological patterns (i.e. Types) that emerged. While the youngest children (i.e. 3;0-3;5) produced

approximately five Types of phonological patterns when the cut-off criterion of ≥4 was applied (*M*=5.39), the number was halved by the age of 4;6-4;11 (*M*=2.45). A similar presentation of pattern Types was observed when the cut-off was raised to ≥6. Overall, the number of InfrVar across age groups also decrease with increasing age for both criteria adopted. It is interesting to notice that, when the ≥6 criterion was applied, about half or more of the phonological variations were identified as InfrVar; this proportion was however noticeably reduced for the ≥4 criterion, for which over half of the phonological variations were classified as phonological patterns.

Table 28: Mean, SD, and Range for the number of Tokens, Types, and InfrVar across age groups in the two cohorts.

	n	Cut-off	Tokens M (SD)	Tokens Range	Types M (SD)	Types Range	InfrVar M (SD)	InfrVar Range
1;6-1;11	10	≥4	45.70 (13.93)	27-77	2.50 (1.35)	1-4	31.30 (7.70)	21-48
		≥6			1.60 (1.07)	1-5	35.10 (9.64)	21-52
2;0-2;5	10	≥4	75.90 (8.80)	64-91	4.80 (1.40)	3-8	42.30 (9.41)	24-56
		≥6			3.00 (0.94)	1-4	50.70 (8.77)	33-61
2;6-3;0	10	≥4	73.20 (25.07)	40-113	5.40 (2.41)	2-9	37.30 (9.44)	28-56
		≥6			2.80 (1.93)	0-7	48.70 (12.45)	37-76
3;0-3;5	28	≥4	55.21 (31.08)	6-134	5.39 (3.13)	0-13	19.90 (9.78)	3-47
		≥6			4.00 (2.37)	0-9	26.07 (13.87)	3-65
3;6-3;11	55	≥4	50.38 (43.66)	5-252	4.71 (4.13)	0-19	20.20 (10.70)	3-54
		≥6			3.33 (3.15)	0-15	26.20 (16.17)	3-71
4;0-4;5	60	≥4	32.15 (27.44)	1-156	3.23 (2.73)	0-16	13.00 (7.58)	1-30
		≥6			2.30 (2.09)	0-11	17.27 (10.91)	1-48
4;6-4;11	40	≥4	26.93 (19.80)	4-88	2.45 (1.95)	0-8	13.30 (5.93)	3-27
		≥6			1.83 (1.53)	0-7	15.65 (8.08)	3-38

A similar trend was followed for all measures across Cohort 2. However, unexpected results emerged for the youngest children (i.e. 1;6-1;11) in comparison with the other age groups within the cohort (i.e. 2;0-2;5 and 2;6-3;0). Their number of Tokens, Types, and InfrVar seemed particularly low across both criteria (e.g. Tokens *M*=45.70, SD=13.93). These values appear to be unlikely when compared to the rest of the data, and may be due to the limited word elicitation in the test subsection for this age group (see section 2.4.2). Data for this age group should thus be interpreted with caution. Across the remaining age groups in this cohort (i.e. 2;0-2;5 and 2;6-3;0) a noticeably higher number of Tokens as well as a higher proportion of InfrVar across both criteria was presented compared to children in Cohort 1 (i.e. above 3;0). Indeed, when both cut-offs were applied, the number of InfrVar across each age group in Cohort 2 represented about two thirds of the Tokens for that age. Across all age groups and independently from the cut-off criterion adopted, relatively large SDs and ranges reveal a considerable variability among children within the same age group.

6.2 Developmental Phonological Patterns

The occurrence of phonological patterns considered developmental for each age group (i.e. present in 10% or more of the children in a given age group) will now be presented; again with findings for children aged 3;0-4;11 being described first, followed by the secondary data on children aged 1;6-3;0.

6.2.1 Cohort 1: primary data, children aged 3;0-4;11

Concerning the occurrence of phonological variations that met the two different cut-off criteria to be considered patterns, 22 patterns (i.e. 20 phonological patterns and two phonetic patterns) were observed for children above 3;0 years of age. **Error! Reference source not found.** illustrates the percentages of occurrence of these patterns for each age group and cut-off criterion investigated.

Five phonological patterns (Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, Heterosyllabic Consonant Cluster to Geminate) and two phonetic distortions appeared across all age groups above 3;0 years of age, for both cut-off criteria, and decreased in occurrence with increasing age, although not resolving by the oldest age group.

Three additional phonological patterns (Deaffrication, Devoicing, and TCC Reduction) appeared across both criteria, for several age groups. These presented low or noticeably decreasing percentages of occurrence for the ≥4 criterion, and very low, if at all occurring,

for ≥6. Deaffrication appeared in less than 30% of the children in all age groups for the lower cut-off, but solely at the ages of 3;0-3;5 and 4;0-4;5 for the higher criteria. Devoicing was observed for the lower cut-off from 3;6 up to the age of 4;11, although with very low frequency. For the higher cut-off, Devoicing only appeared in 12% of children at the age of 4;0-4;5. Finally, TCC Reduction emerged with higher percentage of occurrence compared to the other two patterns across all age groups from the age of 3;0 when the lower cut-off was adopted, but had a reduced occurrence in the higher cut-off, disappearing at the age of 4;6.

Table 29: Percentage of occurrence of Phonological Patterns and Phonetic distortions observed across all age groups in the first cohort, for the ≥4 and ≥6 cut-off criteria.

	Cut-off	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
		n=28	n=55	n=60	n=40
Substitution Patterns					
Fronting of /ʃ/→ /[s]*	≥4	50	38	18	28
	≥6	50	38	18	28
Fronting of /ʧ, ʤ/ →[ʦ, ʣ]	≥4	32	13	17	13
	≥6	29	11	12	13
Gliding of /ʎ/→[j]	≥4	89	85	83	70
	≥6	89	85	83	70
Lateralisation of /r/ →[l]	≥4	64	31	20	18
	≥6	43	24	15	13
Deaffrication	≥4	25	11	23	13
	≥6	25		12	
Affrication	≥4	21			10
	≥6				
Devoicing	≥4		15	22	15
	≥6			12	
Vowel Substitution /eɨ↔ /ɛ/	≥4	11		10	
	≥6				
Vowel Substitution /oɨ↔ /ɔ/	≥4	11	11	17	
	≥6	11		10	
Stopping of Fricatives	≥4	11	13		
	≥6		11		
Stopping of Affricates	≥4		13		
	≥6				
Assimilation	≥4	18	11		
	≥6				
Heterosyllabic Cluster → Geminate	≥4	61	49	25	23
	≥6	57	27	15	13
Structural Patterns					
Tautosyllabic Cluster Reduction	≥4	50	40	20	10
	≥6	21	16	10	
Heterosyllabic Cluster Reduction	≥4	11	13		
	≥6				
Deletion of /r/	≥4	11			
	≥6	11			
Geminate Reduction	≥4		13		
	≥6				
Weak Syllable Deletion	≥4		15		
	≥6				
Word Initial Consonant Deletion	≥4	11			
	≥6	11			
Syllable Initial Consonant Deletion	≥4	11			
	≥6				
Phonetic distortions					
Distortions of /s, z/ (e.g. /s/→ [s̪])	≥4	50	49	33	18
	≥6	50	45	32	10
Distortions of /r/ (e.g. /r/ → [ɾ])	≥4	50	40	40	33
	≥6	43	35	37	33

*Definitions and examples of each pattern are reported in Appendix 6.

Further eight patterns (Affrication, Vowel Substitution /e/↤/ɛ/, Stopping of the Affricates, Assimilation, HCC Reduction, Geminate Reduction, Weak Syllable Deletion-WSD, and Syllable-Initial Consonant Deletion-SICD) emerged in low percentages only for the lower cut-off. Both Assimilation and HCC Reduction were present up to the age of 3;11. Furthermore, Affrication and the substitution of the open and closed vowels /e, ɛ/ were observed only at 3;0-3;5 and 4;6-4;11, and 3;0-3;5 and 4;0-4;5 respectively. The remaining four patterns (i.e. Stopping of Affricates, Geminate Reduction, WSD, and SICD) appeared only in one age group, all below 3;11 and with percentages of occurrence lower than 15%.

Finally, four more patterns (Vowel Substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, Word Initial Consonant Deletion-WICD) were found solely across the first two or three age groups, with noticeably low frequencies across both cut-offs. The mutual substitution of the open and closed vowels /o, ɔ/ emerged in the first three age groups for the ≥4 cut off, and solely at the ages of 3;0-3;5 and 4;0-4;5 for the ≥6 criterion. Stopping of the Fricatives appeared from the age of 3;0 to 3;11 for the lower cut-off, but only between 3;6-3;11 for the higher criterion. Deletion of /r/ and WICD appeared instead across both cut-offs, solely at the age of 3;0-3;5.

6.2.2 Cohort 2: secondary data, children aged 1;6-3;0

With regard to the secondary data (i.e. from Zmarich et al., 2012), the same patterns that were observed for the first cohort were found, with the exception of Gliding of /ʎ/. Furthermore, children in the second cohort presented six additional patterns. Thus, this second cohort showed 27 patterns (i.e. 25 phonological patterns and 2 phonetic patterns (**Error! Reference source not found.**). The trend in emergence of the patterns found will be described first, with the two cohorts being compared afterwards. Definitions and examples of each pattern are reported in Appendix 6.

Table 30: Percentage of occurrence of Phonological Patterns and Phonetic distortions observed across all age groups in the second cohorts, for the ≥4 and ≥6 cut-off criteria.

	Cut-off	1;6-1;11	2;0-2;5	2;6-3;0
		n=10	n=10	n=10
Substitution Patterns				
Fronting of Velars*	≥4	20	10	10
	≥6	20	10	10
Fronting of /ʃ/→ /[s]	≥4			10
	≥6			
Fronting of /ʧ, ʤ/ →[ʦ, ʣ]	≥4			10
	≥6			10
Lateralisation of /r/ →[l]	≥4			10
	≥6			10
Deaffrication	≥4	10	30	30
	≥6		20	20
Affrication	≥4		10	10
	≥6			
Devoicing	≥4	30	60	70
	≥6	10	60	30
Vowel Substitution /e/↔ /ɛ/	≥4	10	40	30
	≥6		30	20
Vowel Substitution /o/↔ /ɔ/	≥4			10
	≥6			
Stopping of Fricatives	≥4		10	10
	≥6			
Stopping of Affricates	≥4			10
	≥6			10
Assimilation	≥4	10	30	10
	≥6	10	10	
Heterosyllabic Cluster → Geminate	≥4		10	70
	≥6			60
Backing of /s, z/ → [ʃ, ʒ]	≥4		40	20
	≥6		40	20
Backing of /ʦ, ʣ/ → [ʧ, ʤ]	≥4			10
	≥6			
Nasalisation /b, d/ → [m, n]	≥4	10		10
	≥6			
Structural Patterns				
Tautosyllabic Cluster Reduction	≥4		90	90
	≥6		50	70
Heterosyllabic Cluster Reduction	≥4			40
	≥6			10
Epenthesis	≥4			20
	≥6			
Deletion of /r/	≥4		30	10
	≥6			
Geminate Reduction	≥4	60	60	40
	≥6	50	30	20
Gemination	≥4			10
	≥6			
Weak Syllable Deletion	≥4	60	40	
	≥6	60	30	
Word Initial Consonant Deletion	≥4	30	10	
	≥6		10	
Syllable Initial Consonant Deletion	≥4	10	10	
	≥6		10	
Phonetic distortions				
Distortions of /s, z/ (e.g. /s/→ [s̪])	≥4		20	10
	≥6		20	10
Distortions of /r/ (e.g. /r/ → [ɾ])	≥4		20	40
	≥6			20

Three patterns (Fronting of Velars, Devoicing, and Geminate Reduction) emerged across all age groups and for both cut-off criteria, although not always decreasing in percentage of occurrence. Both Fronting of Velars and Geminate Reduction decreased with increasing age, the former with much lower percentages of occurrence compared to the latter. Devoicing appeared instead in higher percentages in the older children (i.e. 2;6-3;0 and 2;0-2;5) compared to the youngest (i.e. 1;6-1;11).

Six phonological patterns (Deaffrication, Vowel Substitution /e/↦ /ɛ/, Assimilation, Backing of /s, z/, TCC Reduction, and WSD) and one phonetic pattern (Distortion of /s, z/) were found across most ages in both criteria, with varying percentages of occurrence. Deaffrication, Vowel Substitution /e/↦ /ɛ/, and Assimilation appeared across all age groups for the lower cut-off, but solely in two age groups for the higher criterion. All presented low or decreasing percentages and a very low occurrence at 1;6-1;11 compared to the older children in the same cohort, reflecting the limited elicitation of targets in the subtest used for the youngest children exposed in section 2.4.2. The remaining phonological patterns (Backing of /s, z/, TCC Reduction, and WSD) all emerged in two age groups across both criteria (2;0-3;0 for the first two patterns, 1;6-2;5 for WSD) with high percentages which decreased with increasing age. Similarly, the phonetic distortion of /s, z/ occurred solely between 2;0-3;0 and with decreasing frequency.

Three more phonological patterns (HCC to Geminate, HCC Reduction, and WICD), and the other phonetic pattern (Distortion of /r/) appeared only across some age groups in percentages higher than 20%, although disappearing for some age groups when the higher cut-off was applied. Both HCC to Geminate and the distortion of /r/ were present only from the age of 2;0 for the lower cut-off, and from the age of 2;6 for the higher cut-off, and both showing lower percentages of occurrence for the younger children (≥4). HCC Reduction and WICD appeared for the ≥6 cut-off solely in 10% of children and in one age group, while showing a marginally higher frequency for the ≥4 cut-off, which decreased with increasing age for WICD.

Four additional patterns (Fronting of /ʧ, ʤ/, Lateralisation of /r/, Stopping of Affricates, and SICD) occurred only in 10% of children for both criteria and in one age group. The first three were present in the older children of this cohort (i.e. 2;6-3;0), while SICD appeared across two age groups for the ≥4 cut-off, while occurring solely between 2;0-2;5 for the ≥6 cut-off.

Finally, the nine remaining patterns (Fronting of /ʃ/, Affrication, Vowel Substitution /o/↦ /ɔ/, Stopping of Fricatives, Backing of /ʦ, ʤ/, Nasalisation of /b, d/, Epenthesis, Deletion of /r/, and Gemination) appeared only for the lower criterion, in one or two age groups and with low occurrence. Fronting of /ʃ/, the substitution of vowels /o, ɔ/, Backing of /ʦ, ʤ/, Epenthesis, and Gemination were all found in the oldest children of Cohort 2 (i.e. 2;6-3;0) only. Affrication, Stopping of Fricatives, and Deletion of /r/ appeared instead across the age of 2;0-3;0. Finally, Nasalisation of /b, d/ occurred at 1;6-1;11 and then again at 2;6-3;0.

In comparison with the Cohort 1, six patterns emerged across Cohort 2 which were not observed in children above the age of 3;0 (Fronting of Velars, Backing of /s, z/, Backing of /ʦ, ʤ/, Nasalisation of /b, d/, Epenthesis, and Gemination). Of these, solely the first two appeared when both cut-offs were applied and across most or all age groups, suggesting that they may be typical of young children although early resolved. Contrarily, children in Cohort 1 showed one pattern which was not found in Cohort 2 (Gliding of /ʎ/): however, this is likely due to the absence of the target consonant across the TFPI assessment used to test children in Cohort 2.

Overall, patterns which were highly frequent across Cohort 1 appeared to emerge also in the adjacent age groups in Cohort 2 (e.g. HCC to Geminate, TCC Reduction, phonetic distortions). A few patterns which appeared in lower percentages in the oldest children (Cohort 1) were found with higher frequency in the youngest (Cohort 2), suggesting early occurrence and resolution (e.g. Geminate Reduction, WSD). Finally, some patterns appeared with only low percentages of occurrence and/or solely for the ≥4 cut-off across children in both cohorts (e.g. Stopping of Affricates, HCC Reduction), which may imply incidental occurrence.

6.3 Summary

In summary, the present chapter provided an overview of the findings concerning the phonological variations presented by children across the ages of 1;6-3;0 and 3;0-4;11. Overall, participants showed a decrease in all quantitative measures, although this was less marked for the InfrVar, which still accounted for about half of all the phonological variations by the age of 4;11. In terms of patterns, most were observed across both cohorts, if with different percentages of occurrences. An overall reduction in the presentation of phonological patterns, with some patterns disappearing across the ages investigated, was observed, suggesting developmental progression. Children in Cohort 1 presented one pattern that was not found for Cohort 2 (i.e. Gliding of /ʎ/) due to the phone not being elicited in the testing material. Six patterns emerged instead in Cohort 2 but not in Cohort 1. Finally, it is fundamental to remember that the two cohorts were obtained through different assessment tools and were composed differently in terms of sample (i.e. numbers, distribution), thus data should be interpreted with caution and a continuum between the two cohorts should not be assumed. The following chapter (i.e. Discussion II) will discuss the findings here outlined in light of the available literature. Considerations on the differences in methodologies across the two cohorts will also be discussed.

7. Discussion II

The second part of this research aimed at answering the following research questions:

2. Which phonological variations occur in the typical development of Italian speaking children of the population under study?

> a. To which extend does the occurrence of phonological variations (Tokens, Types, and Infrequent Variants) change with age indicating progress of phonological development?
>
> b. Which types of phonological pattern can be observed as developmentally typical at what age when two different cut-offs (i.e. ≥4, ≥6) are adopted?

In this chapter, the results will be discussed in relation to the available literature on Italian children's phonological development, as well as research on Romance languages and languages that share similarities with the phonological system of Italian. First, the quantitative measures of phonological development (i.e. Tokens, Types, and InfrVar) will be discussed across the two cohorts; secondly, the occurrence and types of phonological patterns will be examined separately for the first and second cohorts. As discussed at the beginning of the Discussion I, data from the two cohorts were collected through separate assessments and cannot therefore be considered a continuum due to differences in the assessment construction and sample composition (see section 2.4.2 in the Literature Review II and Discussion I).

7.1 To which extend does the occurrence of phonological variations (Tokens, Types, and Infrequent Variants) change with age indicating progress of phonological development?

Overall, with the exception of unexpectedly high results from the youngest age group (i.e. 1;6-1;11, likely due to the differentiated task for that age group in the testing material) and some results related to the number of Types for the second age group (i.e. 2;0-2;5), findings across the two cohorts appeared in agreement with the expected developmental improvement posited in hypothesis 2.a.i, which predicted that children would show an overall decrease across the measures investigated. Thus, results for Tokens, Types, and InfrVar will be here reported together for the two cohorts.

Children in the target population across both cohorts showed a steady reduction in the total number of phonological variations (Tokens) from the age of 2;0-2;5 to 4;6-4;11, reducing by about two thirds. As mentioned above, this was expected in hypothesis 2.a.i,

which posited change across time indicating developmental progress of phonological acquisition. Similarly, and in line with developmental progression, the number of phonological patterns (Types) decreased by around half at the age of 4;6-4;11 compared to the average at the age of 2;6-3;0, although the proportion was marginally different when the higher cut-off criterion was applied. Currently, no literature available for Italian has investigated these measures, preventing a direct comparison of the results. Nevertheless, a gradual reduction in the number of patterns found was also reported across research on Romance languages. Two studies which reported on the number of variations considered patterns on Chilean Spanish-speaking children (Pavez et al., 2009), and of pattern types on Brazilian Portuguese (da Silva et al., 2012). In particular, the study by da Silva et al. (2012), investigating children across the ages of 3;0-7;11 (in 12-months age groups), showed similarities to Cohort 1 of this study (i.e. 3;0-4;11), although Italian children appeared to present less Types compared to Brazilian-Portuguese children of the same age. da Silva et al. (2012) reported the mean number of types for the age groups 3;0-3;11 and 4;0-4;11 as being respectively *M*=5.80 and *M*=3.65 for children with high SES (means were higher for children with low SES). Children in Cohort 1 presented similar means of Types, when the cut-off of 4 occurrences was applied, for the lower half of those age groups (i.e. *M*=5.93 and *M*=3.23 for 3;0-3;5 and 4;0-4;5 respectively), but lower means in the higher half (i.e. *M*=4.71 and *M*=2.45 for 3;6-3;11 and 4;6-4;11 respectively). The disparity between Brazilian-Portuguese and Italian children was higher when the cut-off of 6 occurrences was applied to Cohort 1. However, no reference to the cut-off criterion used at individual level to mark a variation as pattern in the study by da Silva et al. (2012) is reported, suggesting that all phonological variations were counted as patterns, thus resulting in a higher number of types identified at each age compared to the current study.

As hypothesised in 2.a.iii, which predicted a remaining number of phonological variations being present at 4;11, the presence of phonological patterns in the oldest children in this research is in line with the study by Tresoldi et al. (2018), reporting that eleven of the phonemes in the Italian inventory were still not mastered (i.e. pronounced correctly by 90% of children) by the age of 5;0. The presence of pattern-like simplifications in Italian children at the age of 4;11 also agrees with findings across literature on Romance languages (i.e. Spanish, Portuguese, and French) and Maltese (see Table 35 in Appendix 1), which implicate a continuous development of the phonological system up until the age of seven in these languages (Ceron, Gubiani, de Oliveira, & Keske-Soares,

2017; da Silva et al., 2012; Galcerán, 1983; Grech & Dodd, 2008; Lousada et al., 2012; Pavez et al., 2009; Rvachew et al., 2013).

In contrast, findings from languages of different origin (e.g. Danish, German, English) showed that children's phonological development in these languages seems to be concluded earlier than for the romance languages. For instance, findings for Danish and German suggested that solely one and three patterns respectively persisted beyond the age of 4;0 (Clausen & Fox-Boyer, 2017; Fox, 2006). These studies however adopted potentially low cut-off criteria (i.e. ≥4, and ≥3 respectively), suggesting that, had a higher cut-off being used, an earlier conclusion of the phonological acquisition for these languages might have been implied. As seen in section 7.2, the criterion ≥4, also adopted in this research as the lower cut-off, may indeed prove too low and provide less accurate information in comparison to a higher (e.g. ≥6, as explored in this study) cut-off. Similarly to the findings for Danish and German, Dodd et al. (2003) for British English, and Roberts et al. (1990) for American English found respectively one and no pattern in more than 10% of children above the age of 4;11. In this perspective, it appears that children acquiring romance languages, among which Italian, develop more slowly compared to speakers of other languages. Hypotheses on the reason behind this (e.g. phonetic frequency) have already been discussed in section 5.1 (Giulivi et al., 2006; Zmarich et al., 2012).

Another measure supporting the hypothesis of a slower development of Italian children compared to speakers of other languages is the number of InfrVar. These were considered in this study as a measure of stability of the phonological development and developmental change in children's production. Contrarily to what hypothesised in 2.a.i, however, these variations appeared to present a less marked reduction with age increase than phonological patterns. Their presence across all ages in both cohorts and for both cut-offs, alongside their limited decrease in occurrence even in the oldest children, also supports the claim that InfrVar might play a relevant role in the development of phonology. Additionally, and most noticeably, when compared with the overall number of phonological variations found, InfrVar were observed to account for about half of all the phonological Tokens across all age groups. This proportion was however much higher for children in the second cohort (1;6-3;0), whose InfrVar accounted for about two thirds of the Tokens, compared to the first cohort (3;0-4;11). Furthermore, the SD for the InfrVar measures in children from Cohort 2 (i.e. 1;6-3;0) were comparatively lower than those of Cohort 1 (i.e. 3;0-4;11), with children producing no less than 21 errors that could not be ascribed to phonological patterns. In this

perspective, it might be the case that children below the age of 3;0 still have an unstable phonological system, and, as suggested by some theoretical models of phonological acquisition (Donegan & Stampe, 1979; Jakobson, 1968; Lindblom, 1992), have not yet acquired the simplification 'rules' regulating the acquisition of their language.

In line with the claim of a slower development of the Italian population compared to other languages, Danish children (Clausen, personal communication, September 2, 2021) were observed to reduce the number of InfrVar faster than Italian children (InfrVar decreasing from *M*=38.26 at 2;6-2;11 to *M*=5.46 at 4;6-4;11, compared to the decrease from *M*=37.30 to *M*=13.30 across the same ages in Italian children). However, Danish children showed a much wider variability within the same age group (e.g. SD=26.79 at 2;6-2;11 compared to the SD=9.44 of Italian children at the same age). Despite this difference and the seemingly more consistent performance among Italian children of the same age compared to children acquiring Danish, findings should be interpreted carefully: indeed, Italian and Danish do not belong to the same language family, and therefore share few similarities in terms of phonological system. Furthermore, Clausen (personal communication, September 2, 2021) calculated the number of InfrVar adopting a slightly lower cut-off for phonological patterns compared to the current study (i.e. cut-off of three occurrences), limiting the comparability of the data.

Despite InfrVar remaining present at 4;11, a progressively higher stability in children's production was observed with increasing age, with children performing gradually more rule-like simplifications compared to variations which could not be classified as patterns. This finding is in line with the prediction made in hypothesis 2.a.ii, which posited a higher proportion of InfrVar for younger children compared to older ones. Nevertheless, the number of InfrVar at all ages across the two cohorts remained high, even when the higher cut-off was applied. This suggests that InfrVar may be crucial in the description of children's phonological development, as they appear to occur frequently across ages, with the current findings suggesting that these types of variation be found also in children above the age of 5;0. Indeed, already previous studies have shown that children produce 'one-off' errors that cannot be accounted for as phonological patterns. McReynolds and Elbert (1981) first noticed that the phonological profile of American-English-speaking children reported to have 'articulatory disorder' changed when a quantitative criterion was applied to the identification of phonological patterns. Indeed, the number of variations that were identified as patterns reduced drastically when a cut-off of at least 4 occurrences was applied. In this case, children presented a much lower number of 'rule-like' variations while also presenting a large number of incidental/one-offs errors. More

recently, McIntosh and Dodd (2008) reported the occurrence of one-off errors also in typically-developing English children: very similarly to the data from Cohort 2 (i.e. 1;6-3;0) in this study, at least two thirds of the children in both their age groups (i.e. 2;1-2;5 and 2;6-2;11) presented phonological variations that could not be considered patterns, when a cut-off even as low as two occurrences was adopted. Similarly, two Italian studies also mentioned 'other substitutions' and 'phonologically plausible substitutions' (Viterbori et al., 2018; Zanobini et al., 2012) as occurring in their samples, although with low percentage of occurrence (see Table 34 in Appendix 1). Finally, Albrecht (2017) also found that bilingual Turkish-German children's phonological variations were constituted largely by InfrVar (on average for 80.55% in German, and 77.24% in Turkish). It was highlighted by Albrecht (2017) that, had the number of InfrVar been discarded as not relevant to the developmental picture, a few children potentially developing atypically would have been mislabelled as TD on account of their age-appropriate presentation of patterns in at least one language.

It is evident that one-off errors which cannot be labelled as phonological patterns have now been recurringly found across languages, for both typically- and atypically-developing children, as well as for both monolingual and bilingual children. Thus, it seems necessary that InfrVar should be accounted for when investigating children's speech and phonological development. The difference in the identification of patterns according to a quantitative criterion not only influences knowledge of the developmental characteristics of phonological acquisition, as also seen in the different types of patterns discussed in section 7.2, but also has implications for clinical practice. InfrVar could indeed first of all provide additional information on the classification of a child's phonological development in relation to the norm for their age group and population. Additionally, in a diagnostic perspective, an analysis of the performance of children with SSD in terms of deviation from the norm for pattern types as well as InfrVar may indicate whether children with this diagnosis solely perform poorly concerning their number of InfrVar as found for bilingual children by Albrecht (2017). In terms of Italian development, additional research should be conducted on both typically and atypically developing children to investigate further the occurrence and role of InfrVar in children's phonological development.

Across all measures, large SD values could be observed, indicating a wide variability in the phonological development among Italian children of the same age, as already highlighted also for accuracy measures (see section 5.1). Indeed, some children aged 4;6-4;11 still presented up to eight or seven (according to the cut-off) phonological

patterns. On the contrary, already at the age of 3;0-3;5, and at the age of 2;6-3;0 for the higher cut-off, some children showed no more phonological patterns. Although developmental variability is usually reported for children in international studies, no Italian study calculated the measures here discussed, and the sole two studies on Romance languages (i.e. Chilean Spanish: Pavez et al., 2009; Brazilian Portuguese: da Silva et al., 2012) that reported on the number of patterns and of pattern types did not provide the SDs for these measures. Thus, it is not possible to compare the variability found in Italian children in light of previous research. Finally, in terms of variability across the ages, as mentioned in section 6.1, an apparently better performance of children at the ages of 1;6-1;11 across all measures, and at 2;0-2;5 for Types was observed in Cohort 2. This, however, could be an artifact of words having been selected specifically for each age groups and of the under-elicitation of target phones/structures (see section 2.4.2).

7.2 Which types of phonological pattern can be observed as developmentally typical at what age when two different cut-offs (i.e. ≥4, ≥6) are adopted?

Having discussed the quantitative measures relating to phonological variations, the types of phonological variations that met the criteria to be labelled as patterns will be now commented. In this perspective, various groups of patterns were identified which occurred in different trends. Findings will be here revised in terms of their distribution and occurrence in relation to the two cut-off criteria and age groups, as well as their similarities and differences with the available literature on Italian and romance languages.

As previously mentioned, 20 phonological and 2 phonetic patterns were observed across Cohort 1 (see **Error! Reference source not found.** in Results II). Of the 20 phonological patterns observed, four groups of patterns could be identified: 1) phonological patterns that appeared for both criteria and across all age groups; 2) patterns that occurred for both the cut-offs, across several age groups, although with low or noticeably decreasing percentages; 3) patterns that occurred solely for the ≥4 cut-off with low percentages; 4) patterns emerging across both cut-offs with very low percentages and solely in the first two/three age groups. Of the 20 patterns observed in the Cohort 1, all but one (i.e. Gliding of /ʎ/) were also found in the secondary data. It is worth noticing, however, that Gliding of /ʎ/ did not have the opportunity of occurring for the children between 1;6-1;11, and could only be presented in two occasions for children aged 2;0-3;0 in the assessment used by Zmarich et al (2012). Six patterns were instead identified exclusively in the three age groups (i.e. 1;6-3;0) of the Cohort 2. Findings from the analysis on children's

performance in Cohort 2 may shed some light on the hypotheses made for the patterns found in Cohort 1. Specifically, the age in which those highly frequent patterns found in Cohort 1 first appear may be identified. In addition, clarification might be gained with regard to the status of pattern vs. InfrVar of those low-frequency variations that were labelled as patterns for children above the age of 3;0. Nevertheless, it is necessary to remember that findings from these data are not entirely reliable and comparable due to the issues with the design of the assessment material, explored in detail in section 2.4.2. Patterns will be here evaluated following the order of presentation of the first cohort. Patterns solely found in this cohort will be then discussed. The two phonetic patterns will also be addressed separately.

7.2.1 Patterns occurring for both cut-off criteria across all age groups

Five patterns belonged to the first group in Cohort 1, i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, and HCC to Geminate. These appeared in high percentages and presented decreasing occurrence independently of the cut-off implemented, but did not resolve in the population studied. This fact suggests that the mentioned patterns could still be typical beyond the age of 4;11, in line with the hypothesis 2.b.iv of a continuous development beyond the age of 5;0. However, two patterns (i.e. Fronting of /ʧ, ʤ/ and Lateralisation of /r/) decreased to a very low percentage of occurrence by the age of 4;11, implying that they may remain below the threshold of 10% of children (e.g. Dodd et al., 2003) at the age of 5;0 and beyond. Overall, the occurrence of these five patterns agrees with findings from the most comprehensive study on Italian consonant acquisition. Indeed, Tresoldi et al. (2018) reported that the consonants /ʃ/, /ʧ, ʤ/, /ʎ/, and /r/, affected by the patterns discussed, were acquired above the age of 5;0. Italian studies that investigated phonological patterns however have considered solely children below the age of 3;0, with the exception of Bortolini (1995), and therefore are not appropriate for comparison.

Nevertheless, four out of the five patterns here discussed (i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, and Lateralisation of /r/) were also reported by some authors across previous Italian studies in their younger populations (i.e. 1;6-4;6 across studies), suggesting that they could be patterns typical also of children below the age of 3;0 (Bortolini, 1995; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). Findings on Cohort 2 will help shed some light on this matter. Of the patterns that were present across all ages for both cut-offs in the Cohort 1, Solely Fronting of /ʧ, ʤ/ and Lateralisation of /r/ were found across both cut-off in the second cohort, while Fronting

of /ʃ/ only occurred when the cut-off of 4 was applied. This disparity in the presentation of these phonological patterns may be ascribed to the limited elicitation of some of the consonants, particularly in the target list for the younger children in the TFPI test (Zmarich et al., in progress), as previously outlined in section 2.4.2.

As previously discussed for the findings of the first cohort, four out of five patterns (i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, and Lateralisation of /r/) here presented were also described in previous Italian research in two or more studies, either with exact correspondence in the pattern definition (e.g. Lateralisation of /r/), or within an overreaching pattern (e.g. Fronting). Since solely two studies assessed children below and above the age of 3;0 (Zanobini et al., 2012, up to 3;6; Bortolini, 1995, up to 4;6), but all studies reported these patterns across all ages in their populations (from the age of 1;6), the idea that these patterns are typical also of children below the age of 3;0 can be supported.

The pattern HCC to Geminate was never described before in Italian literature or literature on Romance languages and Maltese. Indeed, in the available Italian literature, studies addressing patterns on consonant clusters either classified cluster reduction as a pattern common to the two types, or solely considered SI clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), limiting the reliability and generalisability of the results. The lack of distinction between patterns affecting TCC and HCC may be due to the fact that the assimilation of a consonant to the other in an HCC (i.e. formation of a geminate) is considered by Italian practitioners to be a ‘stage’ of the evolution of the Consonant Cluster Reduction pattern (Santoro & Panero, 2013). In this perspective, the current research distinguished between patterns adopted to simplify TCC from those applied to HCC, providing novel information on how children treat the specific structures. The high frequency of the pattern HCC to Geminate across Cohort 1 (i.e. 3;0-4;11), together with the presence of TCC Reduction discussed below (section 7.2.2), provides baseline evidence that different types of patterns are applied to each type of cluster in children of the same age. Although the pattern had limited occurrence across Cohort 2, this may be an artefact of the reduced presentation of the clusters in the TFPI assessment (Zmarich et al., in progress). When present, however, this pattern occurred in a high percentage of children, suggesting that it may also be a pattern that is present already prior to the age of 3;0. This and a further observation of the way phonological patterns affect different types of clusters will be discussed below once the pattern affecting TCC has been introduced (see section 7.2.2).

Similarly to the classification of patterns affecting consonant clusters, across studies the descriptions of what patterns entail differ from one author to the other and are often too broad to allow for direct comparison (see section 1.2.1.2.3 in Literature Review I). An example is the definition of the pattern Fronting. While Bortolini's (1995) pattern Fronting is an overreaching pattern that includes fronting of velars and of postalveolars, findings from the current research suggest that these two subtypes occur differently within the same population. Although Fronting of Velars did not reach the 10% cut-off for children in Cohort 1, Fronting of /ʃ/ was still largely present at the age of 4;11. Similarly, the pattern Gliding was described by Bortolini (1995) as the substitution of any consonant with a semivowel/semiconsonant, and was reported in her sample up to the age of 2;9. However, the analysis of Cohort 1 of this study showed that Gliding of /ʎ/ was present across all ages and still not resolved by 4:11.

In terms of the literature available for languages that share features with Italian, studies on Romance languages and Maltese appear to show similarities in terms of occurrence and disappearance of the patterns here discussed (a detailed list of the patterns found in the comparison studies can be read in Table 35 in the Appendix 1). Their results support the findings on the occurrence of phonological variations here discussed that suggested a later conclusion of the phonological development in children acquiring romance languages compared to other languages (see section 7.1.1). Indeed, both Lateralisation of /r/ and Gliding (although Gliding was used as a broad pattern for substitution of a consonant with a semiconsonant) were accounted for across Castellan, Brazilian Portuguese, Portuguese, and Maltese. Both patterns were reported to disappear between the ages of 6;0-7;11 across the romance languages (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Lousada et al., 2012), although earlier (i.e. up to 4;11) for Maltese (Grech, 1998; Grech & Dodd, 2008). Although studies on the romance languages solely reported Fronting of Velars, the study by Grech and Dodd (2008) showed that the pattern Fronting, including both velars and affricates, was still present at the age of 6;0 in Maltese-speaking children. Overall, similarly to the Italian literature, all studies reported all occurrences of phonological variations at the individual level, and most also reported patterns occurring in less than 10% of children at age-group level, therefore including variations that might not have been considered typical patterns had a quantitative cut-off criterion been applied. Thus, the ages of occurrence and disappearance of the patterns here and below described should be given careful consideration.

7.2.2 Patterns occurring for both cut-off criteria across several age groups with low and/or fast-decreasing frequency

Three patterns occurred for both cut-offs and across several age groups although with low or rapidly decreasing frequency (Deaffrication, Devoicing, and TCC Reduction). Deaffrication and Devoicing were found with lower percentages of occurrence compared to TCC Reduction. Given the limited occurrence of these patterns when both criteria were applied, it could be hypothesised that these patterns may be typical or more frequent in children in lower age groups, and be about to fade out above the age of 3;0. Consistently, Deaffrication, and Devoicing also occurred with high frequencies (up to 90%) across both criteria in the population of Cohort 2. It is therefore possible to hypothesise that these patterns should be considered not chance findings but true patterns that are developmentally typical of the younger Italian children and resolving before the age of 5;0.

Across Italian literature, Viterbori et al. (2018) and Zanobini et al. (2012), despite not reporting the pattern Deaffrication, presented instead 'Frication' across their population of children above the age of 3;0. This pattern involved the substitution of either a plosive or an affricate with a fricative. In this perspective, then, the pattern Deaffrication was included in this broader pattern. Bortolini (1995) also reported Deaffrication and Devoicing up to the age of 4;6. These finding seem to support the suggestion that these patterns may be typical of the Italian population under the age of 3;0 and fading out above that age. Nevertheless, the constraints already presented on cut-off criteria and pattern description should be taken into consideration when interpreting the findings. Similarly across Romance Languages and Maltese, these patterns have also been reported below (Grech, 1998) and above the age of 3;0 (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; Galcerán, 1983; Grech & Dodd, 2008) for Maltese, Brazilian Portuguese, and Castellan-speaking children, with age of disappearance below 3;11, providing additional evidence to the claim, and suggesting a universal value of these patterns (i.e. patterns found across languages rather than being language-specific).

The pattern TCC Reduction showed a much faster reduction in occurrence compared to the patterns discussed in the previous category (section 7.2.1). However, the pattern was still markedly present across all ages in Cohort 1 when both cut-offs were applied, disappearing only in the older children (i.e. 4;6-4;11) for the cut-off of ≥6, and was highly frequent across Cohort 2 (see

Table 30). This presentation may imply that the pattern is typical of these and younger ages fading out after the age of 4;5. Additionally, the low occurrence of TCC Reduction across Cohort 1 could also be ascribed to the lack or low elicitation of some clusters involved in the assessment used for the collection of the primary data (i.e. BVL_4-12, Marini et al., 2015).

Interestingly, the separate analysis for the two types of consonant co-occurrence (i.e. TCC and HCC) allowed to determine that children treat tautosyllabic clusters differently from consonants co-occurring at syllable boundaries (i.e. heterosyllabic) on most occasions. Indeed, children appeared to reduce TCC to one element (e.g. 'treno' train /ˈtre.no/ - [ˈte.no]) across most ages with high prevalence. However, they kept both consonant of an heterosyllabic cluster but assimilated one to the other to create a geminate (e.g. 'albero' tree /ˈal.be.ro/ - [ˈab.be.ro]) in the majority of occasions (see above section). A specific mention needs to be made about consonant clusters with /s/. Findings from this study showed how clusters with the alveolar fricative appeared to be reduced to one element, usually by deleting /s/, when in WI (e.g. 'scopa' broom /ˈskopa/ - [ˈkopa]), but to be transformed into a geminate as for HCC in WM position (e.g. 'pasta' pasta /ˈpasta/ - [ˈpatta]). This appears to provide supporting evidence for the claim, outlined in section 2.2.1.1, that /s/-clusters may acquire variable status depending on their position, thus behaving as TCC when in WI and as HCC when in WM position (Bertinetto & Loporcaro, 2005).

Across the available Italian literature, all studies but Bortolini (1995) described the pattern Cluster Reduction with no distinction on the cluster position, marking its presence up until the age of 3;6 at least, as this was the oldest age group investigated across studies which reported cluster reduction (Zanobini et al., 2012). This supports the claim that patterns affecting consonant clusters are typical across the development of young children and may continue to occur over the age of 4;0. Findings from the study by Zmarich et al. (2012) should however be interpreted with caution with respect to the overreaching category 'cluster reduction', as they included the reduction of geminates within the pattern. Similarly to the Italian literature, no distinction in the position of consonant clusters was made when reporting cluster reduction patterns in most studies on romance languages and Maltese. However, research on Spanish and Portuguese account for this pattern up until the ages of 6;11 (da Silva et al., 2012; Galcerán, 1983; Lousada et al., 2012) and 7;11 (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017), suggesting that the hypothesis of the low occurrence of the pattern TCC Reduction in

the current data being due to the low elicitation in the assessment material might be true. In addition, TCC Reduction has been observed across other languages where possible (e.g. Hua & Dodd, 2006), and it has therefore been suggested that it be considered a universal pattern. Nonetheless, Grech and Dodd (2008) found that the pattern seem to instead disappear at the age of 4;11 in Maltese children, finding that would be in line with the result obtained in the present cohort. These divergencies highlight the necessity of collecting thorough data on Italian-speaking children up until the age of 7;0 at least, in order to provide a clearer picture of the developmental changes in the population.

7.2.3 Patterns occurring in low percentages either for the lower cut-off criterion and only below the age of 4;0, or mostly for the lower criterion and below the age of 4;6

Eight patterns (i.e. Affrication, Vowel Substitution /e/↔/ɛ/, Stopping of Affricates, Assimilation, HCC Reduction, Geminate Reduction, WSD, and SICD) were solely found for the cut-off of ≥4. The low occurrence of these patterns limited to the application of the lower cut-off criterion could suggest that these may not be true patterns, rather simplifications that were labelled as pattern due to the use of an inappropriate low cut-off (as suggested in the hypothesis 2.b.i, which predicted a lower number of pattern types emerging compared to available literature due to the application of a more strict cut-off). The remaining four patterns (i.e. Vowel Substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, and WICD) appeared below the age of 4;6, again with markedly low percentages of occurrence and mostly for the lower criterion. Similarly to the patterns showing fast decreasing occurrence (see section 7.2.2), these may be patterns typical of younger children. However, as they partially disappeared for the higher cut-off, they may instead also be InfrVar wrongly classified as patterns due to the use of a too low cut-off. From the analysis of the secondary data from children aged 1;6-3;0, it appears that both Geminate Reduction, and WSD could indeed be considered patterns typical of younger children, as they appeared with relatively high percentages (i.e. up to 60%) across both cut-off criteria in Cohort 2. The remaining patterns (i.e. Affrication, Vowel substitution /e/↔/ɛ/, Stopping of Affricates, Assimilation, HCC Reduction, SICD, Vowel substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, and WICD) all occurred for one or both criteria with markedly low frequency. This seems to support the proposal that these patterns were not true patterns, but rather incidental findings due to the use of an inappropriate cut-off. Indeed, as Kirk and Vigeland (2015) had previously suggested, the cut-off of four occurrences may be too low for some variations.

Despite the interpretation of these patterns being incidental findings in the current study, they were frequently reported in previous Italian literature below the age of 3;0 (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012), and across romance languages and Maltese (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Grech, 1998; Grech & Dodd, 2008; Lousada et al., 2012; Pavez et al., 2009). Notwithstanding, as for the patterns of Fronting and Gliding, all the patterns here discussed were described in previous research as part of overreaching patterns which included more than one category of sounds in their definition. For instance, all studies but Bortolini and Leonard (1991) reported Stopping, without differentiating between fricatives and affricates, which appeared with different frequencies in the current study. Most authors reported, across the entirety of the populations studied, the pattern 'Sound Deletion' without specifying the syllable and word position of the sounds deleted, nor whether the term 'sound' included both consonants and vowels or solely consonants (Bortolini, 1995; Viterbori et al., 2018; Zanobini et al., 2012). Patterns such as 'Syllable Deletion' and 'Vowel Substitution' were also reported across all Italian studies, appearing at different ages according to the populations studied, although no specifications were provided in terms of the type of syllable affected or the vowels involved. Had these variations being categorised more strictly, providing more specific patterns, their occurrences in the population studied might not have been as high, as already showed by the separation used in the current study (e.g. Fronting of Velars was not present among the typical patterns at any age in Cohort 1, while Fronting of /ʃ/ and /ʧ, ʤ/ were both found across all ages). Furthermore, despite these patterns were indeed reported across studies in all age groups assessed, it needs to be reminded that no or very low cut-offs were adopted in the identification of patterns both at child and age-group level, thus limiting the reliability of the results and their interpretation.

Concerning findings from other languages, studies on Spanish, Portuguese, and Maltese seem to present markedly different ages of occurrences for the patterns they also reported. Indeed, despite sharing the presentation of a pattern such as WSD, different ages of disappearance were observed across languages, spanning from as low as 3;0-3;11 for Castellan (Galcerán, 1983) and Maltese (Grech & Dodd, 2008), to as high as 5;5 for Brazilian Portuguese (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017) and 6;0-6;11 for Portuguese (Lousada et al., 2012). WICD and Stopping of Fricatives were reported across these languages as resolving usually around 3;0-3;11 (Galcerán, 1983; Grech & Dodd, 2008; Lousada et al., 2012). Contrarily, Deletion of /r/ was instead reported by Galcerán (1983) up until the age of 6;0-6;11. Despite the use of these data

for comparison, two considerations must be made. First, it is fundamental to remember that no cut-off was implemented at child level in the studies here mentioned. It could therefore be hypothesised that had a quantitative cut-off been adopted, some if not all of these patterns might have not reached the necessary frequency to be classified as such, therefore supporting the suggestion of these variations being incidental findings due to the use of an inappropriate cut-off. Secondly, the diverse ages at which these patterns are reported for each language suggest that, although patterns may be shared by different languages and similarities may be found, their ages of occurrence and disappearance are language-specific.

7.2.4 Patterns observed solely in the second cohort

Of the six patterns that were observed solely in Cohort 2 (i.e. Backing of /ʦ, ʣ/ → [ʧ, ʤ], Nasalisation /b, d/ → [m, n], Epenthesis, Gemination, Fronting of Velars, Backing of /s, z/ → [ʃ, ʒ]) none appeared with high frequency (i.e. all but one in solely 10-20%). Solely Backing of /s, z/ occurred in a slightly higher percentage of children at 2;0-2;5 (i.e. 40%), suggesting that this may be considered as a typical error pattern for children below the age of 3;0. Given their low percentage of occurrence, the remaining patterns might also be incidental findings, similarly to the patterns discussed above. It is indeed fundamental to remember that each age group in Cohort 2 was composed by solely 10 children, meaning that the occurrence of a pattern in 10% of children was given by the presentation of said pattern by solely one child in the age group. Thus, given the small size of the sample studied and the limitations of the assessment tool used previously outlined (sections 3.1.2 and 2.4.2 respectively), predictions on this cohort are unreliable and should be carefully considered. Nevertheless, all Italian studies but Zmarich et al. (2012) reported to have found Epenthesis. Two Romance languages studies also included it in their patterns, although for older children: Galcerán (1983) for Castellan children aged 3;0-3;11, and da Silva et al. (2012) for low SES Brazilian Portuguese children aged 4;0-4;11. Solely Grech (1998) reported Gemination for Maltese children at the age of 2;0-3;6. As for the previously described patterns, the lack of an appropriate cut-off may have led to the mislabelling of phonological variations as patterns. Nevertheless, the limitations discussed for this cohort warrant the need for further in-depth research on phonological patterns.

7.2.5 Phonetic Patterns

Finally, next to the phonological patterns found, two phonetic patterns were observed across all age-groups and both cut-off criteria in Cohort 1: i.e. the distortions of /s, z/ and /r/. Both were also observed for both cut-off criteria in Cohort 2 across the ages of 2;0-3;0 (Distortion of /r/ only above 2;6 for the higher cut-off). Despite their appearance for both the criteria used, the distortions occurred with very low frequency in Cohort 2 compared to Cohort 1. It is worth remembering, however, that the limited sample size (see Methodology, section 3.1.1) and items elicitation discussed for this cohort (see section 2.4.2) might have affected the presentation of these patterns.

Across literature, these sounds have been reported to be frequently distorted both from previous Italian research and in Romance languages and Maltese. Indeed, findings from the studies by Tresoldi et al. (2018), Tresoldi et al. (2015), and Viterbori et al. (2018) revealed the distortion of /s, z/ and /r/ across all age groups assessed. In addition to Italian, phonetic distortions affecting the alveolar fricatives and the trill have also been described across several other languages, including Romance languages such as Spanish for /r/ (Goldstein, 2005; Hernández & Hernández, 2016), as well as languages from different origins, such as Danish (Clausen & Fox-Boyer, 2017), German (Fox-Boyer, 2016), and Maltese for /s, z/ (Grech, 1998). Given that, for all languages reported, these phonetic error patterns do not affect meaning, they may be less considered and/or less investigated up to school age.

Overall, further research on Italian children older than five years of age is required to provide a complete description of the population's development and identify the age of disappearance of the patterns that were here discussed.

7.3 Summary of both discussions

Chapters 5 and 7 discussed findings on the population studied in relation to the available Italian and international literature. Across all measures explored, findings seem to suggest that Italian children present slower development compared to children acquiring languages of the same (i.e. Romance languages) and other families (e.g. Maltese, Danish). A few hypotheses have been proposed that might explain this finding, particularly in relation to specific features of the language (e.g. phonetic frequency), and to sample construction limitations (i.e. children exposed to different regional variations of Italian). Both these hypotheses would be in line with theoretical models postulating the importance of individual experience in the development of the phonological system. With respect to the first, as suggested by Bybee (2001), each individual's lexicon and their phonological development have a reciprocal influence across the development. In line with the second, emergentist models highlight the importance of the ambient language in determining children's development (Chomsky & Halle, 1968; Donegan & Stampe, 1979; McCarthy & Prince, 1998; Prince & Smolensky, 2004). In line with the influence of language-specific features on the results obtained, a hypothesis was proposed that the highly frequent CV structure typical of Italian, and the non-existence of syllabic consonants in the language, may have had an impact on children's apparently lower performance in the stimulability task (i.e. imitation of phones in isolation) compared to the naming task.

Overall, previous assumptions that the Italian vowel system is established before the age of 3;0 were supported by findings in this study. Furthermore, although the majority of elements of Italian appear to be acquired by 4;11, the presence of consonants not yet mastered and patterns not yet resolved by that age found from the naming task, suggest that Italian children's development proceeds beyond the age of 5;0, in line with previous Italian studies and research on Romance languages and Maltese (Anderson & Smith, 1987; Bortolini, 1995; D'Odorico et al., 2011; Grech, 1998; Grech & Dodd, 2008; MacLeod et al., 2011; Tresoldi et al., 2018; Viterbori et al., 2018; Zmarich et al., 2012). Furthermore, although consonant clusters have not been investigated in detail, the available findings (i.e. different rate of acquisition, different phonological patterns affecting each type of cluster) suggest the need to conduct further research on TCC and HCC separately, to explore their specific acquisition.

In spite of an apparent slower development compared to other languages, however, findings from the present study also appear to support the theoretical hypothesis T1,

being in line with theories suggesting the existence of a core array of sounds developed by children across languages in the early stages of their phonological development (MacNeilage, 1998; Zmarich et al., 2005). Patterns which could be considered universal (i.e. found across international literature, as posited in hypothesis 2.b.ii) were also observed. However, differentiation of the development following language-specific features has been observed in the three systematically-occurring variations which affected phones and/or phonological features typical of Italian (as hypothesised in 2.b.iii; i.e. Gliding of /ʎ/, reciprocal vowel substitution of /o/ and /ɔ/, and transformation of an HCC to a geminate). In particular the vowel substitutions were suggested to be potentially due to the different regional variations spoken at home by the children assessed. Indeed, over a third of parents that filled in the questionnaire for the first cohort reported speaking a different regional variation of Italian from that of the environment (see Table 36 in Appendix 4). Given that regional variations of the language are mostly differentiated by diverse preferences for the use of open and closed vowels (as explained in section 2.3.2), the one third of children exposed to non-Ligurian variations in Cohort 1, as well as the children recruited from different regions in Cohort 2, may have had an impact on the results, reflecting these differences. Despite the presence in the Italian inventory also of a nasal approximant (i.e. /ɲ/) and the existence of geminate consonants, these did not appear to be affected by phonological variations with sufficient frequency to emerge as patterns.

Additionally in terms of phonological variations, a lower number of phonological patterns was identified as typical for the development of Italian children compared to the available comparison literature, supporting the hypothesis that the use of a higher cut-off and of more restricted pattern categories influence the description of typical development. Indeed, several pattern types solely emerged when the lower (i.e. ≥4) cut-off was applied, raising the question whether these should indeed be considered as patterns or rather chance findings due to an inappropriate cut-off. In this perspective, adopting narrower, more precise pattern's definitions not only provides a different perception of what variations are typical and which are infrequent, but also allows a clearer understanding of the developmental trajectories in phonological acquisition.

Finally, InfrVar made up for about half of all these phonological variations. This factor highlights the importance of taking the occurrence of infrequent variations into account when assessing a child's phonological development; indeed, a these have been described already across literature as measures of phonological stability (e.g. McIntosh and Dodd, 2008). Furthermore, a child with SSD may perform outside the norm not only

for the production of atypical or not age-appropriate patterns but also for the number of InfrVar. Such a hypothesis was already made by Albrecht (2017) for bilingual Turkish-German children, and warrants the need for further study in the so far underdeveloped topic of infrequent phonological variations.

Further research exploring the phonological development of Italian-speaking children would benefit from exploring quantitative (e.g. PCC; Tokens) as well as qualitative measures (e.g. phone inventories, types of patterns) across a wider age group than the one here explored. In particular, research up to the age of seven is fundamental in order to evaluate the age at which the phonological system is completely acquired and corresponds to the adult target. A further general discussion will be provided in the next chapter, covering the strengths and limitations of the study, proposing future direction for research on the phonological development of monolingual Italian-speaking children, and discussing the theoretical and clinical implication of the results. Conclusions will be drawn at the end of the chapter.

and **Error! Reference source not found.** present and discuss the findings relating to the occurrence of phonological variations, distinguishing between Infrequent Variants and Phonological Patterns, through the application of two different cut-offs. Analyses include quantitative measures of the total number of errors (i.e. tokens), the types of patterns, and the number of Infrequent Variants, as well as the ages of occurrence and disappearance of the phonological patterns.

Finally, chapter 8. General Discussion and Conclusions draws a conclusion of the project, providing a summary of the main findings of the research, investigating its strengths and limitations, and proposing further directions for research exploring the monolingual speech sound and phonological development of Italian children.

1. Literature Review I

In order to give a context to the current research, this first chapter provides an overview of the theoretical and practical information at the base of the study of children's speech sound and phonological development. First, the theories and models that have been historically developed to explain the phonological development of monolingual children will be outlined, discussing the main commonalities and differences that characterise them. In a second section, the tasks and measures required to investigate children's speech and phonology are presented, with particular focus on the assessments of speech output. Finally, psychometric requirements for tests and sample constructions will be mentioned.

1.1 Theories in Phonological Acquisition

Normative data not only provide a baseline for clinical evaluation of children's speech competences but can also support or provide a basis of discussion for theoretical aspects of phonological acquisition. Different theories focus on a variety of factors (e.g. the role of internal and external factors in the development of the phonological system) attributing to them a variable degree of importance. Results from this thesis may contribute to this theoretical debate, as hypothesised in 2.6 Research Questions and Hypotheses. When approaching the theorisation of children's phonological development, several questions require focus. The ultimate scope of a theory or model of phonology is to provide an explanation of the nature and the aspects involved in the child's maturation towards an adult-like phonological system. A valid theory must therefore provide an answer to several issues, such as:

1. Which abilities do children already possess at the beginning of their language learning?
2. How does this knowledge support the acquisition of the phonological structures of a language?
3. What are the elements that need to be learnt and in which order?
4. Which are the general trends that can be expected during a child's development?
5. Are there (and which are the) external factors that influence the development of the phonological system?
6. How can the discrepancies between the child's production and the adult target be explained?
7. Is there a difference, and what is the relationship between phonetic and phonological development?

Additionally, a theoretical model of phonological acquisition needs to account for individual variations that occur not only among children who are speakers of the same language, but also across languages (Vihman, 2014a).

Over the course of the last few decades, several models and theories have been developed to address one or more of these aspects of phonological development. Although theories that focus on phonological perception do exist, these will not be explored here as the focus of the current research lies in speech and phonological production. Theories focussing on phonological production will instead be presented, according to their underlying principles, and the role that children are assigned in their own phonological development. In this perspective, two main streams of thought can be identified to categorise these models: a) Formalist approaches, and b) Functionalist (or Emergentist) models. While the former overall assume solely a linguistic perspective, and assign the child a more passive role in their development, the latter take into account a variety of fields (e.g. psycholinguistics, biology, cognitive sciences, etc.), and consider the child more as an active participant in their own acquisition of phonology (Stoel-Gammon, 1991).

Formalist approaches, which originated largely from Jakobson's (1968) Structuralist model, are linked by the assumption that children possess an innate linguistic knowledge that develops and expands with language experience. The phonological acquisition is then supported by a series of universal principles (i.e. rules/constraints). According to this concept, the influence from other skills (i.e. cognition) is minimal (Jakobson, 1968; Vihman, 2014a). Although sharing this fundamental core, functionalist approaches differ in their opinion about critical elements that influence the acquisition of phonology. For instance, Jakobson (1968) proposes that children's phonological acquisition follows the same path across languages, and at the basis of this progression, which unfolds from simple to complex, is the principle of maximal contrast. According to this principle, children acquire phonological oppositions, starting with sounds that are 'unmarked' and common across languages, to then move on to 'marked' (and in some degree language-specific) sounds. Similarly, Generative models which include the Generative phonology theory (Chomsky & Halle, 1968), Natural phonology (Donegan & Stampe, 1979), Nonlinear phonology (Goldsmith, 1990), and the Prosodic morphology (McCarthy & Prince, 1998), believe that a child has a set of universal rule/representations, but add that language experience supports these innate principles in the development of new, language-specific parameters. These rules, called phonological processes by Donegan

and Stampe (1979), are considered to be gradually suppressed through an increasing exposure to the ambient language.

Among formalist theories, and partly building on generative phonology, are approaches of the Optimality Theory (Barlow & Gierut, 1999; Prince & Smolensky, 2004; Stemberger & Bernhardt, 1999). Although sharing the assumption of the existence of universal rules, these approaches propose that speech acquisition unfolds through the re-ranking of conflicting constraints, namely 'markedness' (i.e. regulating limitations on segmental positions and sound features), and 'faithfulness' (i.e. regulation according to which the output should be as close as possible to the input structure). Surface presentations of speech output are generated by the resolution of the conflict between these two constraints.

Although taking into consideration the role of the ambient language, theories that are classified as formalist tend to overlook the influence of other external factors (e.g. the child's social interaction, the cultural context), as well as the physical limitations and abilities that impact the development of speech (Vihman, 2014a). In this perspective, a more comprehensive look at children's development of phonology has been undertaken by Functionalist/Emergentist theories (Vihman, 2014b). As previously mentioned, functionalist theories assign children a more active role in their development, who are stated to acquire speech through problem-solving and interaction with the environment (i.e. generating hypothesis about phonology of their language through input, then adapting their output) (Bybee, 2001; Vihman, 2014b). This perception-action mechanism is repeated throughout the acquisition of the lexicon, when the child gradually builds up their own phonological representations (Bybee, 2001).

Due to their interdisciplinarity, functionalist models differ in the degree of focus they put on a specific discipline. For instance, biologically-based approaches (Locke, 1983) among which are the Dynamic system (Thelen & Smith, 1994), the Self-organisational model (Kent, 1984), Lindblom's model (Lindblom, 1992), and the Frame/content model (MacNeilage, 1998), highlight the idea that children develop a core of sounds and subsequently present sound patterns that are adaptations to the biological constraint of their motoric and articulatory system. All of these models additionally stress the importance of variability and social interaction to create opportunities for adaptation (Kent, 1984; Thelen & Smith, 1994). Similarly, behaviourist models (Mowrer, 1952; Olmsted, 1966) recognise the relevance of the environment and how the child interacts with it: the child learns through imitation, and makes adaptations based on external reinforcement (Olmsted, 1966). Cognitive/usage-based theories (Menn et al., 2013;

Pierrehumbert, 2003; Vihman, 2014b; Vitevitch & Luce, 2016) more comprehensively point out that children's processing skills and other cognitive abilities share an influencing role with perception and motor skills, as well as with social interactions and the availability of an appropriate input of the ambient language (Menn et al., 2013). Finally, the Emergentist model (Davis & Bedore, 2013) has its roots in other functionalist theories, but expands on them by proposing that the child's biological (i.e. perception, processing, motor, articulatory) skills and social interaction abilities interact not only with external factors (i.e. input) but also with each other, reciprocally influencing one another (Davis & Bedore, 2013).

Overall, despite their shared purpose of providing an explanation to the trajectories taken by children's phonological development, the various approaches and models that have been theorised disagree in terms of elements and processes that underlie children's acquisition of speech. Specifically, a crucial difference resides in the degree of importance assigned to internal (i.e. cognitive, processing, motor) and external (i.e. input, environment) factors, with formalist approaches including in their models solely the role of the ambient language (Chomsky & Halle, 1968; Donegan & Stampe, 1979; McCarthy & Prince, 1998; Prince & Smolensky, 2004). Furthermore, individual differences that might be observed among children with the same linguistic background, as well as across languages are better accounted for in the functionalist/emergentist models, rather than formalist theories (Bybee, 2001).

Although the scope of this thesis is not to be a theoretical work, nor to prove/disprove any of the theories discussed, the theoretical background here provided will be referred to across the discussion of the thesis' results. In particular, findings on children's performances in terms of speech sound, accuracy, and variability in speech production may contribute to the debate on the existence of core sounds that develop across languages, as well as on the development of language-specific 'parameters' that rule the acquisition of the phonological system. Furthermore, potential discrepancies between the two cohorts analysed which are not ascribable to the effect of age may provide additional discussion points in relation to the role of external factors on children's developmental progression. Hypotheses on how the results of this thesis might tie in with the theories here discussed will be drawn in 2.6 Research Questions and Hypotheses.

1.2 Assessment of Phonological Development: tasks and measures

Following the theories on the acquisition of the phonological system, it is fundamental to highlight how to best evaluate children's speech and phonology, and the specific skills that need to be considered. As most theoretical approaches (particularly functionalist/emergentist) consider both internal and external factors contributing to a child's development of phonology, differences in one or more of these elements may lead to individual variability in children's development. It is therefore fundamental to obtain developmental data on specific populations (e.g. considering regional variations) as a basis for classifying each child's production against normative data of the relevant population the child belongs to (Dodd, 2014).

When considering the assessment of phonological development, it is therefore necessary to remember that there are several other components that define a child's phonological development other than speech production. Intelligibility (Camarata, 2010; Flipsen, 2006; Piazzalunga et al., 2020) provides information about the degree a child's speech is understood by a listener. Speech perception (Stackhouse & Wells, 1997), motor programming (McCauley & Strand, 2008), and articulation abilities (Williams & Stackhouse, 2000) also contribute to define a full picture of a child's development. Other measures available to investigate children's speech are Rapid Automatised Naming (RAN) to assess phonological access (Savage et al., 2007), nonword or unfamiliar word repetition to evaluate phonological working memory (McLeod & Baker, 2017), and tasks such as rhyming, segmentation, blending, isolation, and manipulation of phones or syllables, which give information on phonological awareness (Stackhouse & Wells, 1997). Given the focus of this thesis, detailed information will be provided solely for the tasks and measures involved in the assessment of speech production.

1.2.1 Speech Production

Speech production can be evaluated at different levels. First of all, children's ability to produce speech sounds may be investigated via different measures: imitation, naming or spontaneous speech. Secondly, inventories can be drawn in terms of phones and phonemes present, and phone accuracy in relation to the adult target can be measured. Thirdly, patterns of variations from adult speech occurring across the development can be explored. A description of these aspects will be provided in the following sections.

1.2.1.1 Phone Imitation: Stimulability

When assessing children's speech production, it is useful to address speech sound imitation. Children may not present certain phones in their spontaneous speech (either on a single word or connected speech level), but could be stimulable for them, i.e. they may be able to produce them in isolation through repetition, where there is no need to access lexical representations. The ability to correctly imitate phones has been suggested to be linked to typical development, implicating that the child possesses the required motricity and planning skills for correct articulation (Iuzzini & Forrest, 2010; Powell & Miccio, 1996). In this perspective, a phone imitation task can provide valuable information about those phones that are absent in the spontaneous inventory of a child at each age, but that have potential to develop through maturation (i.e. sounds which are stimulable at a specific age are likely already developing although still unstable in children's phonological system). Stimulability can however also be assessed at syllable and word/nonword level. Similarly to the repetition of isolated phones, repetition of syllables and nonwords provides information on whether the child is able to assemble the progressively more complex motor programme necessary for speech output when this is provided in input (Stackhouse & Wells, 1997). The assessment of imitation skills is therefore a valuable measurement that can provide additional information on the developmental milestones in children's speech sound development: normative data on the typical age in which phones are stimulable (and therefore likely to emerge next: (Miccio, 2002) can inform researchers and clinicians on what to expect in terms of speech sound development at specific ages, support the description of a child's speech and provide a basis for a potential diagnosis, through the comparison of a child's performance with that of typically-developing (TD) children in the same age group.

1.2.1.2 Single Words and Connected Speech: Picture Naming and Spontaneous Speech

In addition to the ability of a child to form a motor programme given a model to imitate, speech output needs to be assessed also in terms of access to stored, existing motor programmes in the child's lexical system (Stackhouse & Wells, 1997). In this perspective, children's output abilities can be evaluated on word or sentence level or on the level of spontaneous/connected speech. To obtain an appropriate speech sample that can allow for a thorough and reliable analysis, different methodologies can be adopted. Connected speech has been suggested by some authors as a suitable task and has been largely used across languages (D'Odorico et al., 2011; Iacono, 1998; McLeod & Baker, 2017). Connected speech allows the clinician to assess a more natural, 'everyday-like' form of

speech production. Utterances elicited in spontaneous speech also have the advantage that they can be evaluated not only in terms of phonology, but also in relation to prosodic features, intelligibility, and different levels of linguistic abilities (Bernhardt & Holdgrafer, 2001; McLeod & Baker, 2017; Morrison & Shriberg, 1992). Various approaches have been adopted across studies to elicit connected speech. Spontaneous conversation either during free play or through conversation supported by the use of a set of objects in play appears to be one of the most common methods, especially with very young children (D'Odorico et al., 2011; Morrison & Shriberg, 1992; Zmarich & Bonifacio, 2005). Alternatively, complex picture description has also been adopted (Bortolini, 1995; Bortolini & Leonard, 1991; Healy & Madison, 1987; Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012). Finally, retelling of stories can be found across literature (Bortolini, 1995; McLeod et al., 2014). Nevertheless, connected speech, independent of the elicitation method, provides little to no control over the targets produced and required for analysis (e.g. consonants). This not only might render the findings incomplete, but also limits the comparability of the analyses with findings on other children's speech.

Usually proposed in lieu of connected speech is confrontation picture naming. Despite being straightforward and easily administered, the use of naming is the subject of an ongoing debate on whether it accurately evokes a fully representative sample of typical speech performance (Klein & Liu-Shea, 2009; Morrison & Shriberg, 1992). Therefore, the task has been occasionally declared as inappropriate: as picture naming is limited to single word elicitation, it is stated that it does not reflect the natural occurrence of speech production, which overall occurs in utterances involving more than single words (Klein & Liu-Shea, 2009; Morrison & Shriberg, 1992; Stoel-Gammon & Dunn, 1985). However, it is also true that, compared to connected speech, naming allows for a higher inter-speaker consistency in sample acquisition, a stronger control on the target phones elicited, and is more easily referred to normative data (Bernhardt & Holdgrafer, 2001; Materson et al., 2005; Wolk & Meisler, 1998). It has therefore been argued that a well-designed picture naming task (see Literature Review I, section 1.3.1) should be as equally representative of a child's speech production abilities as spontaneous speech recording (Bernhardt & Holdgrafer, 2001).

Further factors which should be considered alongside the approach adopted to elicit speech output, are the types and depth of analyses conducted on the data collected. International literature (Joffe & Pring, 2008; McLeod & Baker, 2017) recommends that an analysis of children's speech should take into consideration elements including, but

not limited to, consonants, consonant clusters, and vowels (i.e. occurrence, accuracy, age of emergence, acquisition, and mastery), and phonological variations, both recurring and infrequent (i.e. age of occurrence and resolution, types). In this perspective, several analyses can be performed on the speech sample collected. These will be presented in the following subsections. First, measures of Percentage of Consonant, Vowel, and Phoneme Correct will be described; secondly, the relevance of phonetic and phonemic inventories will be discussed; finally, the topic of phonological variations will be covered.

1.2.1.2.1 Percentage of Consonants, Vowels, and Phonemes Correct

The most widely recognised and utilised measure of speech accuracy is the Percentage of Consonants Correct (PCC), first described by Shriberg and Kwiatkowski (1982) on children's spontaneous speech. This measure calculates the amount of accurately produced consonants in a speech sample in percentage terms. All types of errors involving consonants (i.e. omissions, substitutions, distortions, and additions) are marked as incorrect. Additional measures were developed by the same authors to include measures of vowel accuracy as well as overall phoneme accuracy (i.e. PVC, PPC), and involved the same calculations as PCC. Although Shriberg et al. (1997) argued for the measures' clinical relevance for diagnostic purposes (i.e. the types of errors presented by children allow to differentiate between typically-developing children from those who have a speech delay) their measures also have relevant value in a developmental perspective. Indeed, as discussed for stimulability, measures of percentage of correct production add to the variety of knowledge available for children's speech sound and phonological development. Information on the changes in accuracy of consonants, vowels and phonemes production across ages allows one to determine what milestones are expected at each developmental stage, and to describe a child's performance against the normative data of the population they belong to.

Variations of these measures can be adopted in order to account for common (Percentage of Consonant Correct – Adjusted: PCC-A) and/or uncommon (Percentage of Consonant, Vowel, and Phoneme Correct – Revised: PCC-R, PVC-R, PPC-R) clinical distortions, dialectal variations, and phonetic distortions of targets that are otherwise phonemically correct (Shriberg et al., 1997).

Shriberg et al. (1997) also provide recommendations in terms of use of the various measures and the contexts in which each is most appropriate. For instance, PCC provides the most information when applied to a homogenous sample in terms of age

and presence of speech delay. This is because the sample is less likely to present noticeable differences in e.g. language variation spoken, types of errors, etc., which would all reduce the percentage score in the case of PCC. PCC-A, instead, allows to discard common clinical distortions when the sample is more diverse, although still with speech difficulties involvement. Finally, PCC-R, as it focuses on deletions and substitutions only, has a greater sensitivity to the true erroneous productions, while being sensitive to speakers' differences in terms of age, speech status, dialectal and regional variation spoken, and so on.

1.2.1.2.2 Phonetic Inventory vs Phonemic Inventory

When investigating a child's phonological system, two types of inventories can be delineated, namely a) phonetic inventory, and b) phonemic inventory. Following the definition proposed by Ingram (1989), a phonetic inventory takes into consideration all singleton phones (i.e. consonants and vowels) that a child is able to produce in their speech. This refers to all speech phones a child uses, independently from their correct use in relation to the language's phonological system (Fox & Dodd, 2001). A child's phonetic inventory is defined by the consonants and vowels (i.e. phones) being observed in the child's speech. By drawing the phonetic inventory of a typically-developing population it is possible to determine at which age each phone is present in the said population, and thus at which age children possess the phonetic representation of each phone stored in their phonological system. This informs us on the child's ability to independently (i.e. spontaneously) access the phones' motor programmes. Across international literature, a common criterion proposed is that a phone be considered present in the child's inventory if produced accurately at least twice, regardless of whether it is phonologically correct (e.g. Clausen & Fox-Boyer, 2017; Fox & Dodd, 2001; Hua & Dodd, 2006).

Contrarily to the phonetic inventory, a phonemic inventory provides information on whether a child has knowledge of positional constraints for the phones present in their system. This type of inventory lists all the distinctive sounds (i.e. phonemes) the child produces that are part of their language. In this perspective, a consonant or vowel has to follow the phonological constraints (e.g. positional constraints; Bernhardt & Holdgrafer, 2001) of the language it belongs to. To be considered part of a child's phonemic inventory, a consonant or vowel therefore needs to appear in an environment in which it can be used according to the phonological system of the language. Nevertheless, a phoneme does not necessarily need to be produced phonetically correctly, as long as it is not phonemically challenging (i.e. does not change the meaning of the word). Across

several studies it may be difficult to gain from the description of the methodology whether the aim of the research was to collect data on phonetic or phonemic inventories. This happens as, at times, the path of analysis used in the study is not described in details (e.g. Zanobini et al., 2012 and Zmarich and Bonifacio, 2005, both reported analysing the presence of a sound in both WI and WM position, however did not specify any additional information to determine whether they investigated phonetic or phonemic inventories). Thus, it is fundamental to provide a clear methodology in order to make sure that data collected are appropriately comparable with available literature.

1.2.1.2.3 Phonological Variations: Phonological Patterns and Infrequent Variants

Among the analyses that can be run on a speech sample to investigate phonological development, data on the phonological variations are of fundamental relevance. These data are the basis for the description of children's phonological development in a specific population (i.e. specific age groups and language spoken). They allow for the identification of developmental milestones, determining which variations are developmentally typical at each age, as well as for the discrimination between typically-developing children and those with SSDs (Dodd, 2014; McLeod & Baker, 2017; Waring & Knight, 2013). Data on the occurrence and resolution of these variations, as well as the consistency with which they are presented, are necessary for each specific language. Although comparisons between languages identify cross-linguistic similarities in terms of phonological development, language-specific variations have been highlighted in addition to patterns considered universal (Dodd et al., 2003; Fox, 2006). Even among languages of the same family, the occurrence and resolution of phonological variations, as well as the rate of phonological development vary noticeably. For instance, typically-developing Norwegian children appeared to overcome all phonological patterns by the age of 5;0 (Bjerkan et al., 2018), while Danish children were reported to do so at younger ages, i.e. 3;6-4;6 (Clausen & Fox-Boyer, 2017). Thus, it is fundamental to obtain data specific for an individual language as it is not possible to generalise information on phonological development across languages.

When considering the phonological variations that children make in their speech production, the majority of literature refers to phonological patterns, also called 'phonological processes': these are those substitutions, omissions, and syllable structure variations which occur in a 'rule-like' manner, and are therefore recurring (Kirk & Vigeland, 2015). In order to use patterns as a descriptive tool for language-specific phonological development, two requirements need to be met: phonological patterns

need to a) be clearly defined in terms of the sounds and/or structures affected, and b) be identified by appropriate and empirically-derived cut-off criteria. Currently, a wide portion of studies investigating children's phonological acquisition across languages take in consideration patterns that are defined too broadly (Bernhardt et al., 2015; Bortolini, 1995; da Silva et al., 2012). Several studies define a pattern without reference to which sound or class of sounds are affected by it (e.g. 'Fronting' might refer to the fronting of velars, as well as of postalveolar fricatives and affricates), nor the position within the word (e.g. 'Cluster reduction' does not differentiate between syllable initial or syllable final). However, a clear definition of what a specific pattern entails, and the differentiation between patterns affecting different sounds assume normative and clinical relevance as patterns present different ages of occurrence and resolution in relation to the sound and word position involved. Clear definitions of each patterns and their typical age of emergence and resolution contribute to establishing appropriate and reliable normative data on the specific phonological development of a language. In this perspective, Dodd et al. (2002) propose that phonological patterns that are present in at least 10% of children in a given age group are age-appropriate for that age.

An appropriate criterion is also necessary at individual level to distinguish between variations occurring infrequently in a child's speech and those that can be considered rule-like (i.e. patterns). To date, a cut-off criteria commonly used across research is that of four occurrences (i.e. a pattern needs to be present four or more times in a child's speech to be considered a pattern), which was first proposed by McReynolds and Elbert (1981). This cut-off was however chosen arbitrarily and might not be suitable across languages and for certain types of patterns. On a normative level, the use of an inappropriate cut-off could lead to a mislabelling of certain simplifications, which would be mistakenly identify as typical patterns for a given population. A too low or too high criterion would also lead to a misinterpretation of speech data, generating an over- or under-identification of children with atypical speech development (Kirk & Vigeland, 2015). Currently, as there is no agreed cut-off criterion that can reliably discriminate between infrequent phonological variations and phonological patterns, there is variability among the methodologies adopted across languages. Normative studies have adopted cut-offs as low as one sole occurrence of a variation (Goldstein, 2005; Viterbori et al., 2018), or as high as five occurrences (Dodd et al., 2002; Fox-Boyer, 2014). These differences limit the comparability of studies. Furthermore, the use of a low cut-off criteria reduces the reliability of the results obtained: indeed, a 'pattern' identified through a low cut-off criteria cannot be defined as rule-like.

The use of an appropriate and reliable cut-off criteria also has a repercussion on the differentiation between those phonological variations that do not occur with enough frequency to be labelled as patterns, and may be due to developmental fluctuation or simply occur by chance, and true patterns. Despite these variations having been already described as present simultaneously to the phonological patterns by children in their development (McReynolds & Elbert, 1981), current and past research exploring children's phonological development has mostly ignored them, and focussed solely on patterns. More recently, research has investigated these variations in order to gain insight on whether these infrequent variations could be used as a reliable measure of phonological development. McIntosh and Dodd (2008) identified that around two thirds of children at both age groups assessed (i.e. 1;1-1;5, 1;6-1;11) produced 'one-off errors' alongside phonological simplifications which could be considered patterns (i.e. occurring two or more times in different lexical items). Children with a low PCC also showed a low number of typical patterns among the simplifications made. Furthermore, McIntosh and Dodd (2008) observed how quantitative measures did not appear as informative indicators of later development; on the contrary, the type of surface speech errors (i.e. the number of 'atypical errors') produced at initial assessment predicted phonological performance at age 3;0. These findings highlight the importance of distinguishing between those simplifications that are typical and rule-like, and those that are infrequent and cannot be considered patterns, in order to have a clear picture of the typical developmental stages of a population's phonological development. While phonological patterns show the typical simplifications of adult speech that children show while acquiring their language's system, the infrequent variations may provide information on the consistency and variability of the children's production (Albrecht, 2017; Fox, 2006) and may prove informative measure in the prediction of future phonological development.

Albrecht (2017) and Fox-Boyer et al. (2020) have addressed the issue of infrequent phonological variations (i.e. Infrequent Variants – InfrVar) in a longitudinal study on bilingual German-Turkish children. Their findings suggested that InfrVar may convey relevant information regarding the stability of children's phonological representations. At an individual level, they observed that while phonological patterns decreased from the first to the second testing point (i.e. with age increase) this was occasionally accompanied by an increase in the number of InfrVar. In this perspective, they suggested that the overcoming of a phonological pattern proceeded inconsistently, with the erroneous production still occurring in the child's speech although with a lower frequency than the cut-off to be considered a pattern, thus resulting in an increased number of

InfrVar. Consequently, in spite of the increased number of infrequent variations, the children in question did present in fact progress in their phonological development. This finding highlighted the importance of measures of phonological patterns being supported and completed by quantitative measures of InfrVar in order to provide a thorough picture of children's developmental trajectories. Some children, whether presenting few or many patterns, do indeed additionally show high numbers of InfrVar which, if ignored, might lead to misinterpretation of children's competences. Across monolingual populations, InfrVar should be investigated in order to highlight the gradual increase in stability after a stage of speech inconsistency.

1.3 Assessment of Phonological Development: test construction principles and psychometric properties

When evaluating children's speech, specific requirements need to be met in order to ensure its appropriate description, so that data can be gathered for specific populations and provide reliable information on children's speech sound and phonological development. Over the years, a range of internationally accepted prerequisites have been developed (AERA et al., 2014) and occasionally revised (Flipsen & Ogiela, 2015; McCauley & Swisher, 1984). These include several principles, e.g. content validity, reliability and requirements concerning normative samples. In the following sections, the role of Content Validity, Inter-rater Reliability, and characteristics of the normative sample will be discussed Since for the current research it was decided to rely on assessment tools already available, it was necessary to examine the available published assessments in order to select the most appropriate one for the purpose of the study. In this perspective, the material chosen needed to fulfil the international criteria in terms of task and items elicited (i.e. which, how many, which structure?). Furthermore, guidelines on the construction of a sample were taken into consideration in order to construct an appropriate sample for the current research. Other aspects of Validity and Reliability will not be presented as they are more closely related to the creation of assessment tools, which was not one of the goals of this research.

1.3.1 Content Validity

The first element to ascertain when evaluating an assessment is its validity, or the ability of the test to accurately measure what it is supposed to measure. The 'Standards for Educational and Psychological Testing' (AERA et al., 2014) emphasize that validity is the degree of evidence available that supports the scores interpretation in the relation to the scope of the test. In this perspective, a test should state clearly in its manual what its

purpose is. McCauley and Swisher (1984) identified several aspects of validity, which are hereby outlined. Specifically, Content Validity (or Content Relevance), refers to the degree to which a test assesses the target behaviour it aims to measure. In the case of phonological assessments, the issue would be weather a thorough and accurate analysis of speech sound production is obtainable through the tasks proposed. The nature of the task, quality of items and type of data analyses should all be explored.

In terms of task utilised for speech sound and phonological assessment, the positive aspects and drawbacks of using picture naming or spontaneous speech have been discussed above. While it is true that connected speech is more representative of the 'natural' occurrence of speech (Klein & Liu-Shea, 2009), it provides little control over the target items that need testing. On the contrary, the systematic collection of data implemented in a picture naming task allows for a significantly stricter control over the targets assessed as well as for the construction of normative scores (Materson et al., 2005). For the purpose of this thesis, solely the construction principles that regulate picture naming tests will be here discussed in detail.

Given the pros and cons of the naming task, a careful selection of test items should be made. First of all, the assessment material should enclose a large number of occurrences of phonological features: these occurrences should be enough for all phonemes (i.e. consonants and vowels) to be represented in all the possible phonotactic combinations and positions, including consonant clusters, with an occurrence of at least 1 to 5 times each (Bernhardt & Holdgrafer, 2001). Environments that stimulate the emergence of typical and atypical phonological patterns should also be sufficiently included (i.e. 4 to 5 potential occurrences recommended: (Kirk & Vigeland, 2015; Stoel-Gammon & Dunn, 1985). In this perspective, a minimum of 75 to 100 words are suggested as an appropriate target selection (Stoel-Gammon & Dunn, 1985). In addition, concerning word structure, multisyllabic words have been demonstrated to be particularly discriminative of SSD. Ideally, words with varying length and different stress patterns should additionally be examined, since the status of stressed or unstressed syllable appeared to influence children's production accuracy of consonants (Bernhardt & Holdgrafer, 2001; James et al., 2009; Stoel-Gammon & Dunn, 1985).

Finally, in order to account for the impact of linguistic knowledge, the ongoing vocabulary development in the targeted population and its relation to phonological knowledge (Stoel-Gammon & Williams, 2013) need to be taken into account. Age-appropriateness of the items should be investigated in terms of linguistic difficulty and familiarity (Flipsen &

Ogiela, 2015; McCauley & Swisher, 1984), so that words that are familiar to children in the age group under exam are selected.

1.3.2 Inter-Rater Reliability

A second category of features that determine the value of a test is Reliability. A functional test should consistently measure the behaviour of interest, allowing small room for error and bias. Inter-rater (or inter-examiner) reliability ensures that the test does not produce highly different scores for the same child across administrations by different examiners, but also across examiners analysing the performance. A high correlation coefficient indicates a minimum variation in the results if the test is conducted or interpreted by different examiners (McCauley & Swisher, 1984). This assumes fundamental relevance when collecting normative data: high inter-rater reliability ensures comparability and replicability of the test results across administrators.

1.3.3 Normative Sample

The normative sample used to collect data on a population and to standardise a test also needs to meet specific requirements. When constructing a sample in order to establish norms, the same principles need to be considered. An appropriately constructed normative sample is of fundamental relevance as it needs to be representative of the population which intends to describe. The normative sample therefore needs to be appropriate in terms of its composition and size, and must be accurately described when reporting the norms obtained. In addition, it is worth mentioning that, as language and demographics change over the years, it is consequently recommended to periodically update normative samples for specific populations.

1.3.3.1 Sample Composition

As the normative sample represents the population that will be described, it needs to account for the variability of its individuals. An appropriate sample includes children forming as much a continuum as possible within the population studied. Both genders should be equally represented, although no significant gender-related differences have been found in phonological development (Dodd et al., 2003; McIntosh & Dodd, 2008). Additionally, there should be a balanced demographic distribution, in terms of geographic and ethnic distribution, as well as socioeconomic status (SES). Finally, concerning speech and phonology development, a debate is ongoing on the appropriateness of including children with SSD in the normative sample. Various authors have been supporting the so-called ‘full-range sample’ (McFadden, 1996), as opposed to the

'truncated sample', only including typically developing children (Peña et al., 2006) On the one hand, authors such as McFadden (1996) sustained that the full-range sample would decrease the potential misdiagnosis of children in the lower end of the typical range as being atypical. On the other hand, the inclusion of children with SSDs in the normative sample would shift the parameters of 'typicality' towards a lower performance, potentially including atypical features as developmental. This would in turn facilitate the misidentification of children at the higher end of the atypical performance as being typically developing.

1.3.3.2 Sample Size

Concerning the numbers required for a sample to be extensive enough to generate generalizable results, Flipsen and Ogiela (2015) emphasise that the total number of participants is less relevant than the number of children in each specific subgroup (e.g. age bands) established for the clinical comparison. According to McCauley and Swisher (1984), a minimum of 100 subjects should be considered for each subgroup. In this perspective, the authors report that normative samples should be divided into 'multiple subgroups on the basis of somewhat narrow age ranges' (McCauley & Swisher, 1984), p. 170), in order for the analyses and comparisons across groups to reflect the rapidity of developmental changes. This would not only permit a more reliable statistical analysis, but also make the results more generalizable to the population, reflecting the wider variability of scores (Mean and Standard Deviations should be reported for each subgroup). In terms of how 'narrow' the age ranges of a single subgroup should be, there seems to be agreement across languages that a 6-month range is sufficient to capture the relevant developmental changes. However, authors such as Smit (1986) suggest that a smaller age range (e.g. 4-month) would be more sensitive to changes in the development.

1.4 Overview

This chapter aimed to provide a theoretical background to the acquisition and evaluation of children's phonology. Theories and models that have been developed over the last decades have highlighted the importance of considering all internal and external factors that contribute to the child's development. Particular relevance is assumed by the external factors which influence children's phonological development, such as the type of input received and environmental factors (e.g. geographical area, SES). In order to have a reliable description of the stages of development of a specific population and

being able to pass judgment on an individual's development, normative data on typical development and its presentation at each age are fundamental. In this perspective, not only the tasks adopted for assessing children's speech and phonology need to be selected and constructed appropriately, but the population under study need to fulfil specific requirements (i.e. sample size and characteristics). Considering the focus of the current research, a description of the specific approaches and measures that can be undertaken in evaluating children's speech production was provided. Picture naming has been identified as a most appropriate task to ensure item control while also collecting a large enough speech sample to be representative of children's development. Requirements that a naming assessment should meet in order to be valid and reliable have been presented, with particular focus on item selection and inter-rater reliability, but also on the characteristics a normative sample should possess. This opens up for a discussion on the current knowledge of Italian speech and phonological development and the normative data available to date, which are presented in the following chapter.

2. Literature Review II

As mentioned at the end of Literature Review I, section 1.3, the current chapter discusses children's speech and phonological development and its assessment within the context of Italian, in order to provide a frame in which findings of the current study can be discussed. In this perspective, an initial overview of the demographics of Italian, as well as a description of the phonetic and phonological system of the language will be provided. In particular, this section will outline information on the consonants, consonant clusters, vowels, and diphthongs of the Italian language, as well as the phonotactic restrictions regulating their use, and world stress assignment norms. Following this, the current situation regarding the assessment of Italian children's speech will be described, in order to present a referring point for the subsequent section, which will discuss the available studies exploring the speech and phonological development of Italian children. Finally, the aims and objectives of the current research will be outlined with referral to the theoretical background discussed in Literature Review I and Literature Review II.

2.1 Demographics of Italian

Italian is the official language of Italy, where more than 51 million people (90.4% of the population) speak it as their native language (L1) and almost 5 million as second language (L2: 8.4% of the population) according to ISTAT (2017). Italian is also the official language of the Republic of San Marino, the Vatican City (both of which have however no census data reporting the use of languages) and the Canton of Ticino in Switzerland, where 88.6% of the population reported Italian as their main language in 2019 (BFS, 2021). Across Europe, Italian is spoken in several countries, among which the highest percentages of L1 and L2 speakers are found, according to the Eurobarometer (2014), in Malta (33.12%), Luxembourg (8.25%), Slovenia (7.38%), and Romania (4.76%). Concerning North America, the Canadian Census of 2016 (Canada, 2017) registered 375,635 people with L1 Italian, while in the USA 708,966 people reported to speak Italian at home in the American Community Survey (Bureau, 2015). Data for South America are available for Uruguay, where 9.6% of the population declared 'knowledge of Italian' in a telephone survey (INE, 2019), and Venezuela, where Italian has been reported being the second minority language, with approximately 600,000 speakers (Bondarenko, 2010). Finally, Italian is the fifth foreign language spoken in Australia, according to the 2016 Census, with 271,597 people reported to be using it as 'main language other than English at home' (ABS, 2016).

Italian is a romance language, as it descends directly from the Vulgar Latin. It has a written form and is considered a transparent language, although there are some exceptions to the one-to-one phoneme-grapheme correspondence. Although many dialects have evolved in different regions, the Standard Italian is historically based on the Tuscan, and especially Florentine, variety (Bertinetto, 2010; Lepschy, 2002). When describing the Italian language, it is necessary to distinguish between dialects and variations. Indeed, local dialects are not varieties of Italian, but rather full languages that have their own grammar and vocabulary, so that they can as a result be unintelligible to people of other regions, and which developed from spoken Latin. The modern classification of dialects coincides with the regions of Italy; to date, however, a low percentage of the population speaks local dialects (Lepschy, 2002). Regional variations of Italian are spoken instead; these are comparable to the English phenomenon where the language spoken in different areas is a variety of the standard, national language, that differ from one another in terms of accent and pronunciation (Lepschy & Lepschy, 2013).

It is fundamental to account for dialectal and regional variation differences when describing and assessing children's speech and language. In terms of language use, some children may not know the standard name for specific objects, having always used the dialect label. Although regional variations do not present the same issues in terms of speech and language assessment as the dialects, they differ among themselves in terms of pronunciation and accent (Lepschy & Lepschy, 2013); in addition, some phoneme substitutions, both consonants and vowels, are typical of certain varieties (e.g. some regional varieties in the north-east of Italy devoice /z/, as in 'casa' /kaza/ realised as [kasa]; deaffrication of /ts/ is also a feature, as in 'ragazzi' /ragat:si/ produced as [ragas:i]). Thus, speech assessments should be based on the regional variation spoken by the child being assessed, and differences from the standard Italian should not be regarded as errors. This is particularly important in the current study since, as outlined in the Methodology chapter (section 3.1), children forming the two cohorts studied were recruited in different regions of the north and central Italy. A more detailed description of the differences in the regional variations of Italian that pertain the current research will be provided in section 2.3.2 of this chapter.

2.2 Italian Phonological System

Having outlined the demographic characteristics of the Italian language, the present section will describe the Italian phonological system in terms of consonants, consonant clusters, vowels, and diphthongs that are part of the language's inventory, the

phonotactical norms governing their occurrence in speech, and the word stress assignment rules.

2.2.1 Consonants

Italian consists of 24 consonants. Phonetically, seven manners and seven places of articulation can be distinguished (see Table 1). Concerning manner of articulation, the Italian phonological system allows both oral and nasal resonance. The oral sounds can be realised as plosives (/p, b, t, d, k, g/), fricatives (/f, v, s, z, ʃ, ʒ), affricates (/ʦ, ʣ, ʧ, ʤ/), approximants (/l, j, w, ʎ/) and the polivibrant/trill (/r/). /r/ is usually realized as a tap [ɾ] when short in word-middle (WM) position and as a trill /r/ when long across word positions. Nasal sounds can be alveolar (/n/), bilabial (/m/) and palatal (/ɲ/). When /m, n/ are in word-internal pre-consonantal position, they take up the place of articulation of the following element, leading to surface/allophonic realisations (the labiodental [ɱ] when preceding /f, v/, and the velar [ŋ], when paired with /k, g/) (Mioni, 1993). Given their restricted occurrence and their non-contrastive function, allophones are usually not included by authors when describing the Italian inventory. However, they are part of the Italian phonological system and will be reported in this thesis following Kramer (2009) and Croatto (1986).

A subject of controversy in Italian research is the identification of the status of the palatal and bilabial glides /j/ and /w/ as semiconsonants or semivowels. Vincent (1988) excluded them from his inventory of contrastive consonants, following the idea that high glides are phonetically identical to high vowels. This opinion originates from the fact that, in Italian, high vowels are realized as glides in rising diphthong (e.g. 'pianta' /ˈpjan.ta/ plant). This distinction has also been discussed across research on French and Spanish, other romance languages which share features with Italian. A case study on two French-speaking children conducted by Rose (2000) seemed to suggest that the sequences consonant-glide-vowel (CGV) are indeed syllabified as a consonant followed by a rising diphthongs. However, a more extensive research by Kehoe et al. (2008), examining 14 French children (aged 1;10-2;10) and five Spanish-speaking children (aged 1;3-3;0) found no definitive evidence for differentiating between rising diphthongs in CGV and branching onsets like consonant-liquid-vowel (CLV) structure. Indeed, no error patterns were observed that distinguished the two structures, while some patterns were consistent with similarities between CGV and CLV sequences, suggesting that children aligned the glide with the onset rather than with the following vowel. A similar statement

has been made for Italian by Marotta (1987), who suggested that the sequence GV (i.e. glide-vowel) is commonly assimilated to the consonant-vowel (CV) structure across Indo-European languages. In this perspective, and given the existence of similarities between Italian and French and Spanish, languages that have addressed the issue of rising diphthongs vs branching onsets, glides will be here considered with their common label of consonants, and therefore included in the phonetic inventory (Croatto, 1986; Kramer, 2009; Marotta, 1987). GV structures will thus be considered a consonant plus a vowel while triphthongs usually reported in Italian will be considered as formed by two glides followed by a vowel, as in the words 'seguiamo' [segwjamo], 'we follow' and 'quieto' [kwjeto], 'quiet' (Bertinetto & Loporcaro, 2005). Consistently, CG and CCG structures will be considered as two- and three-element consonant clusters.

Table 1: Consonants of Italian, following Kramer (2009) and Croatto (1986), with voiceless and voiced realisations respectively on the left and on the right.

	Bilabial	**Labio-Dental**	**Dental**	**Alveolar**	**Post-Alveolar**	**Palatal**	**Velar**
Plosive	p b			t d			k g
Nasal	m	(ɱ)		n		ɲ	(ŋ)
Trill				r (ɾ)			
Fricative		f v		s z	ʃ ʒ		
Affricate				ʦ ʣ	ʧ ʤ		
Lateral Appr.				l		ʎ	
Semi-cons.	w					j	

Note: in brackets = allophones.

In Italian, the voiced/voiceless distinction has a contrastive function. Some regional dialects allow for devoicing of fricatives and affricates, but this occurs in words with no devoiced minimal pairs. All plosives, affricates and fricatives are present both in a voiceless and a voiced form.

Word-internally, length is also contrastive, as demonstrated by the so-called ‘geminate’ (e.g. ‘palla’ [pal:a] ‘ball’ vs. ‘pala’ [pala] ‘shovel’). All consonants can occur in geminate position, except for /z, ʃ, ʒ, ɲ, ʎ, j, w/. /. It is relevant to notice that the existence of such feature in the Italian phonology is likely to influence the speech and phonological development in terms of patterns adopted by children in their simplifications (e.g. gemination or reduction of the geminate, as outlined in section 2.4.2 of the current chapter for the regional variations from the Liguria, Marche, and Veneto regions). Affricates, along with /ʎ, ɲ, ʃ/ are always long word-internally, and therefore not contrastive for length. The voiced alveolar fricative /z/ never occurs in long form. In WI position, all consonants are realised as short; however, different dialects and regional variations produce WI consonants as long in connected speech (Kramer, 2009). In the perspective of this thesis, this fact is not likely to influence data collection, as children were recruited from regions whose variation do not present this feature, as outlined in section 2.4.2 of this chapter and in section 3.1 of the Methodology.

2.2.1.1 Consonant Clusters

Following the definition that consonant clusters (CCs) can only occur within one syllable (Grunwell, 1987; Kramer, 2009; Vennemann, 2012), in Italian consonant clusters up to three elements are allowed only in onset position (i.e. word and syllable initially). These clusters are the so called ‘tautosyllabic’ (i.e. initial) clusters.

Table 2 and

Table 3 list possible tautosyllabic clusters in the Italian onsets, and are based on the discussions on phonotactic restrictions in Italian by Kramer (2009), Bertinetto (2010), and on the clinical material from Santoro and Panero (2013).

Table 2: Allowed CC structures in onset position in Italian.

C1 \ C2	/k/	/t/	/p/	/f/	/s/	/g/	/d/	/b/	/v/	/m/	/n/	/r/	/l/	/j/	/w/	/dʒ/
/s/	✓	✓	✓	(✓)										✓	✓	
/z/						(✓)	(✓)	✓	✓	(✓)	(✓)	(✓)	(✓)	✓	✓	(✓)
/p/		(✓)			✓						(✓)	✓	(✓)	✓	(✓)	
/b/												✓	(✓)	(✓)	✓	
/k/												✓	(✓)	✓	✓	
/g/												✓	(✓)	(✓)	(✓)	
/t/										(✓)		✓		(✓)	(✓)	
/d/												✓		✓	(✓)	
/f/												✓	(✓)	✓	✓	
/v/												✓	(✓)	✓	✓	
/l/														(✓)	(✓)	
/r/														(✓)	✓	
/m/											(✓)			(✓)	(✓)	
/n/														(✓)	(✓)	
/ʦ/														(✓)	(✓)	

Note: ✓= consonant combination allowed, (✓) = combination allowed, although presenting a low frequency and usually appearing in words acquired later in vocabulary development.

Table 3: Allowed CCC structures in onset in Italian.

C1 \ C2	/t/	/k/	/p/	/f/	/d/	/g/	/b/	/r/	/w/	C2 / C3
/s/	(✓)	(✓)	(✓)	(✓)						/r/
		(✓)	(✓)							/l/
	(✓)	(✓)	(✓)	(✓)						/j/
	(✓)	(✓)								/w/
/z/					(✓)	(✓)	(✓)			/r/
							(✓)			/l/
							(✓)			/j/
						(✓)				/w/
/f/								(✓)	(✓)	/j/
								(✓)		/w/
/v/								(✓)	(✓)	/j/
								(✓)		/w/
plosive								(✓)	(✓)	/j/
								(✓)		/w/
nasal								(✓)		/w/

Note: ✓= consonant combination allowed, (✓) = combination allowed, although presenting a low frequency and usually appearing in words acquired later in vocabulary development.

In addition to initial clusters, Italian literature mentions WM clusters that can emerge across syllable boundaries (e.g. [bar.ka]), called ‘heterosyllabic’ (Santoro & Panero, 2013). Since these clusters represent the majority of CCs in Italian, a list of all the potential occurrences will not be reported as for the tautosyllabic clusters (see

Table 2 and

Table 3), as the list would be too vast. Although clusters with /s/ as first element have been reported among the tautosyllabic cluster (TCC), as they are common in word-initial (WI) position, some literature on Italian proposes them as heterosyllabic (HCC), both in WM but also in WI position when in connected speech (Kramer, 2009; Morelli, 1999). Nevertheless, Diez-Itza and Martinez (2004) posit that heterosyllabic clusters can only appear when in WM position, thus supporting the status of tautosyllabic for /s/-clusters, as they also appear in WI in Italian. In this perspective, Bertinetto and Loporcaro (2005) propose that /s/ clusters have a variable status of tautosyllabic or heterosyllabic depending on the context in which they appear.

All other HCC should not be considered as clusters if the traditional definition of clusters as occurring within the same syllable was followed. Nevertheless, HCC have been reported across studies on Spanish addressing the occurrence of phonological patterns. In particular, Diez-Itza and Martinez (2004) and Barlow (2003) refer to heterosyllabic clusters and actively target them in their analysis of children's speech development, as these are reported to be a feature of the Spanish language. Diez-Itza and Martinez (2004) did not differentiate between HCC and TCC in terms of types of reductions applied and elements deleted; however, they calculated the frequency of occurrence of reduction of syllable-initial clusters versus clusters occurring across syllable boundaries. Their results from 240 Spanish-speaking participants aged 3;0-6;0 showed that children produced a larger number of reduction pattern tokens for the heterosyllabic clusters compared to the tautosyllabic clusters, implying a better performance on the latter across all ages.

Barlow (2003) conducted a case study on three girls: one was a typically-developing bilingual Spanish-English speaker aged 2;8, while the other were two Spanish monolinguals aged 3;4 and 3;9. Findings from these children showed a separation in how tautosyllabic and heterosyllabic patterns are treated in development; one of the children presented patterns of reduction on tautosyllabic clusters only, one on heterosyllabic clusters only, while the last showed reduction patterns for both types of clusters. Barlow (2003) thus concluded that the reduction of the tautosyllabic clusters is independent from that of the heterosyllabic ones. It is worth mentioning that clusters with /s/+C were excluded from the analysis. This decision was made due to the lack of cross-linguistic evidence on the status of these clusters. It is interesting to notice in the study by Barlow (2003) that two children presented patterns on the heterosyllabic clusters that differed from those affecting tautosyllabic clusters, while one child treated the two types of clusters similarly, reducing the clusters in a similar manner.

It is necessary to highlight that both studies present limitations. First, comparability of the results is limited, as the two studies presented noticeably different methodologies. For instance, Diez-Itza and Martinez (2004) assessed spontaneous speech, while Barlow (2003) implemented a naming task; second the former conducted a large cross-sectional study, while the latter tested solely three children. Additionally, data on the children in the study by Barlow (2003) were taken from two separate datasets (i.e. one of TD bilingual speakers of Spanish and English, one of phonologically disordered monolingual Spanish speakers), and children were tested with different assessments.

Despite these limitations, results from these studies open up for discussion about the specific behaviour of tautosyllabic and heterosyllabic clusters in phonological development across languages that present these two types of clusters, and they provide evidence for the necessity of analysing them separately in further research. As no previous study on Italian has distinguished between tautosyllabic and heterosyllabic clusters in terms of types of patterns, data collected in this thesis might give information on whether these consonant clusters are treated differently by Italian children in their development or if the same reduction patterns are applied on both types. Additionally, the study might shed some light on how the /s/-clusters are specifically treated in WI and WM position during the development of Italian.

2.2.2 Vowels

Italian consists of a seven-vowel system (Flege & MacKay, 2004; Flege et al., 1999), as presented in Figure 1. Considering tongue and lip position, three vowels can be described as front and unrounded (i.e. /i, e, ɛ/), and three as back and rounded (i.e. /ɔ, o, u/). The last vowel (/a/) is low and mostly regarded as phonetically central. Other features can be used for identifying vowels, such as the degree of height, and tongue root position, which distinguish tense from lax vowels. The two high vowels (/i, u/) are always tense and the low vowel (/a/) is lax, while the mid vowels (/e, ɛ, ɔ, o/) distinguish between tense or mid-closed (/e, o/) and lax or mid-open (/ɛ, ɔ/). All vowels occur both as long and short, according to their role in the prosodic structure. Vowels in word-final position, regardless of their stress status, are never long. However, vowel length is never contrastive (Kramer, 2009). Vowel lengthening and reduction occur according to the syllable stress status (Bertinetto & Loporcaro, 2005; D'Imperio & Rosenthal, 1999), as described in section 2.2.4 of this chapter. Notwithstanding, vowels are significantly reduced solely in connected speech (Cutugno & Savy, 1999). Given that Italian is a

syllable-timed language, vowel reduction does not carry lexical meaning and is therefore not relevant in language comprehension (Bertinetto & Loporcaro, 2005).

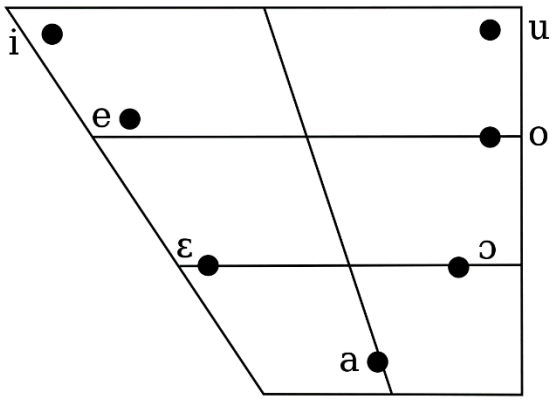

Figure 1: Italian Vowel chart, adapted from the International Phonetic Alphabet (IPA, 2015) following Croatto (1986).

2.2.2.1 Diphthongs and Triphthongs

Italian presents a relatively high number of vowel co-occurrence (Kramer, 2009). True diphthongs combine /e, ɛ, ɔ, o, u/ with either /i/ or /u/. /e, ɛ, a/ can occur with both /i/ and /u/, while /ɔ, o, u/ can only combine with /i/ (Mioni, 1993).

2.2.3 Phonotactic Restrictions

Concerning word structure, the most common type of syllable in Italian is CV, although, as specified above, consonant clusters can appear in onset, and a coda might occur as well: $C_{0-3}V_{1-2}C_{0-1}$ (Santoro & Panero, 2013, see However, a limited amount of content words ending in consonants exist in the language, most of which can be identified as loanwords (e.g. [stɔp], [bar]).

Table 4). Most Italian words are disyllabic or multisyllabic, while monosyllabic words are generally articles and prepositions. The Italian onset can span from a total of 3 consonants to no onsets: C_{0-3} (see

Table 2 and

Table 3). All consonants can be present at syllable onset, although with differences among dialects (e.g. /ʦ/ is found in WI only in some northern regional varieties of Italian) and in frequency of occurrence. In particular, the lateral (/ʎ/) and nasal (/ɲ/) palatals are extremely rare. Glides are another low-frequency category, although slightly more represented than palatals (Kramer, 2009; Santoro & Panero, 2013).

Italian rhyme is regulated by more restrictive parameters compared to the onset. According to Kramer (2009), the syllable nucleus can only be occupied by either a short vowel or a long vowel or diphthong. Vogel (1982) identified that in Italian long vowels/diphthongs and coda consonants within the same rhyme are mutually exclusive: the presence of one in the rhyme prevents the other to occur. Only one-consonant codas are allowed (C_{0-1}). However, as previously debated in section 2.2.1, the status and consequent syllabification of co-occurring consonants that appear across syllable boundaries (HCC) needs to be further analysed to determine if, phonetically, they occur as codas plus onsets or as across syllable CC. It is additionally important to mention that Italian generally does not allow word-final (WF) consonants in content words, while prepositions and articles do occur with WF consonants. However, a limited amount of content words ending in consonants exist in the language, most of which can be identified as loanwords (e.g. [stɔp], [bar]).

Table 4: Consonant occurrence in onset and coda (table constructed on the basis of the information provided by Croatto, 1986; Kramer, 2009; Santoro & Panero, 2013; Vogel, 1982).

	Word Onset	**Syllable Onset**	**Syllable Coda**	**Word Coda**
Plosives	p, b, t, d, k, g	p, b, t, d, k, g	p, b, t, d, k, g	(p), (b)
Nasals	m, n, ɲ	m, n, ɲ	m̲, n̲, ŋ̲	n
Fricatives	f, v, s, z, ʃ	f, v, s, z, ʃ, (ʒ)	f, v, s	(s), (ʒ)
Affricates	ʦ, ʣ, ʧ, ʤ	ʦ, ʣ, ʧ, ʤ	ʦ, ʣ, ʧ, ʤ	
Trill	r	r	r̲	r

Approximants	l, ʎ, j, w	l, ʎ, j	l

Note: All the consonant presented appear in syllable coda when occurring as geminates (with the exception of /ŋ/), the underlined phonemes also appear in this position when followed by another consonant; consonants in brackets are rare in Italian.

2.2.4 Stress Assignment

In Italian, primary stress is lexically distinctive (Bertinetto & Loporcaro, 2005). Different position of the stress within a word can create minimal pairs, as in the case of 'ancora' ([ˈa:ŋkora] 'anchor' vs. [aŋˈko:ra] 'again'). It is therefore necessary to know how to assign word-stress. Italian is a syllable-timed, mainly trochaic language (Bertinetto, 1980, 1985). Binary and ternary rhythms are common in the language. As Kramer (2009) and Bertinetto and Loporcaro (2005) noticed, any of the last four syllables can be stressed in this language, however, tress is usually held by the penultimate syllable (e.g. [ˈkaza], [maˈtita], [lavaˈtriʧe]; D'Imperio, 2002; D'Imperio & Rosenthal, 1999; Giometti, 1982). Although this is the general pattern for both disyllabic and longer words, multisyllabic words can also present stress on the antepenultimate syllable (e.g. [ˈta:volo] 'table'). Stress on the preantepenultimate ([veˈri:fikano] 'they verify') and fourth-to-the-last syllables are rare but also present in Italian, mostly in verb inflections and words with affixes. Final stress can be found, in addition to monosyllabic words, in some disyllabic words and multisyllabic verb inflections (e.g. [peˈrɔ] 'but', [kaˈf:ɛ] 'coffee', [paˈpa] 'dad', [anˈdɔ] 'he went', [mastiˈkɔ] 'he chewed': Jacobs, 1994). Nevertheless, vowels that appear in stressed WF position are not lengthened (Bertinetto, 1980; Bertinetto & Loporcaro, 2005).

Having presented the characteristics of Italian phonological system, children's typical development will be discussed according to the available literature. However, in order to appropriately interpret the literature findings, and understand the limitations and strengths of the studies conducted, an overview of the assessment material for children's speech sound and phonological development currently existing in Italy will be provided first.

2.3 Phonological Development of Italian

As introduced, this section will discuss the available data on Italian children's phonological development. In this perspective, the studies conducted to date will be

presented and critically evaluated and a summary of the results will be provided. Subsequently, information on Italian will be compared to findings available for other Romance languages (i.e. Spanish, Portuguese, and French) and for Maltese, as they share features with the Italian phonological system. The first subsections will be dedicated to the acquisition of consonants, vowels, and consonant clusters, and the comparison of these with information on the Romance languages and Maltese. The subsequent part will discuss the occurrence of phonological patterns across developmental stages, also referring to the findings on the other languages considered.

To date, several studies explored the acquisition of speech sounds and the occurrence of phonological patterns across the development of Italian monolingual children. However, these studies present limitations in terms of methodologies adopted and analyses conducted, as will be discussed across the following sections. As shown in Similar tasks were implemented across studies, as outlined in **Error! Not a valid bookmark self-reference.**. Three studies aimed at collecting developmental data (Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zmarich & Bonifacio, 2005), while several studies aimed instead at gathering normative data on specific measures for tests already available (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress; Zmarich et al., 2012). Of these, one study implemented a repetition task, thus assessing solely the stimulability of Italian phones (Tresoldi et al., 2015). The remaining studies used Bortolini's (1995) 'Prove per la valutazione Fonologica del Linguaggio Infantile' (PFLI) test (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012); although this does have normative data (Bortolini, 1995), neither demographic information on the sample nor the number of participant assessed was reported.

In terms of measures investigated, all but Bortolini and Leonard (1991) reported the phonetic inventory of the population under scrutiny, some additionally providing information on consonant clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), as well as number or percentage of consonants correct (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012). It is necessary to mention that the task administered by Zmarich et al. (2012) did not elicit all Italian phones, but rather tested solely the ones considered typical in the vocabulary of each age group. Consequently, children who might have been able to correctly produce some of the phones absent from the test were potentially penalised in terms of PCC scores. Only five studies explored phonological patterns (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). A critical evaluation of the characteristics of the studies investigating phonological patterns will be

provided later in the chapter (see section 2.3.2), while an analysis of the methodologies used for the study of consonant acquisition will be discussed here.

Table 5, studies differed noticeably in terms of sample sizes and ages, tasks and tests implemented, as well as criteria adopted for the analyses.

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Table 5: Studies on phonological acquisition in Italian children.

Study	Sample	Task	Analysis	Criteria
Tresoldi et al. (2018)	694 (347m, 347f) 3;0-7;0 years old	Picture naming and word repetition: Test di Articolazione (Rossi et al., 1999)	Consonants, and clusters inventories	Phone: present in all positions tested; Mastered: ≥90% Acquired: 75-89% Customary Prod.: 50-74%
Viterbori et al. (2018)	88 (42m, 46f) 2;1-2;8 years old	Spontaneous speech (complex picture description): PFLI (Bortolini, 1995)	Consonant inventory, number of consonant correct, phonological patterns	Phone: at least 3 different words, different positions; all Perc. reported at group level. Pattern: at least once
Tresoldi et al. (2015)	557 (282m, 257f) 3;0-5;11 years old	Word repetition: Esame Fonemico di Prima Consultazione (Schindler, 1986)	Consonant and cluster inventories	Phone: present in all positions tested Mastered: ≥90% Acquired: 75-89% Customary Prod.: 50-74%
Zanobini et al. (2012)	30 (13m, 17f) 3;0-3;6 years old	Spontaneous speech (complex picture description): PFLI (Bortolini, 1995)	Consonant inventory, number of consonant correct, phonological patterns	Phone: at least 3 different words, different positions; <50%, 50-80%, >80%; Pattern: at least once
Zmarich et al. (2012)	30 (15m, 15f) 1;6-3;0 years old	Picture naming: TFPI (Zmarich et al., in progress)	Consonant inventory, consonant clusters inventory, PCC, phonological patterns	Phone: at least half of possible occurrences; ≤50%, 51-79%, ≥80%; Pattern: at least once
D'Odorico et al. (2011)	24 pre-term (13m, 11f); 15 full-term (9m, 6f) 1;6-2;3 years old	Spontaneous speech with standard set of toys	Consonant inventory	Phone: WI or WM in at least 2 separate productions (word/babbling); 'Almost 50%, >80%
Zanobini and Viterbori (2009)	41 (18m, 23f) 2:0-2;7 years old	Spontaneous speech (complex picture description): PFLI (Bortolini, 1995)	Consonant inventory, number of consonant correct	Phone: at least 3 times in any position; all % reported at group level.
Zmarich and Bonifacio (2005)	13 (6m, 7. f) 1;6-2;3 years old	Spontaneous speech in free play	Consonant inventory	Phone: WI or WM in at least 2 separate words; 50-90%, >90%
Bortolini (1995)	n unknown 2;0-4;6 years old	Spontaneous speech (complex picture description): PFLI (Bortolini, 1995)	Consonant inventory, phonological patterns	<50% 50-80% >80%
Bortolini and Leonard (1991)	9 (5m, 4f) 2;2-2;11 years old	Picture naming/description	Phonological patterns	Pattern present if occurring at least twice per child
Zmarich et al. (in progress)	71 1;6-3;8 years old	Picture naming: TFPI (Zmarich et al., in progress)	Consonant inventory	50-75% >75%

Note: Prod. = Production, Perc. = Percentages.

In terms of samples examined, most studies investigated only children in restricted age frames, at very young ages (1;6-4;6). Such narrow age groups cannot be representative of the whole period of children's phonological acquisition, which has been reported to continue beyond the age of 5;0 and usually up to around the age of 7;0 (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; Galcerán, 1983; Tresoldi et al., 2018). Exceptions were Tresoldi et al. (2018) and Tresoldi et al. (2015) who assessed respectively children up to the ages of 7;0 and 5;11. The number of participants tested in almost half of the studies was also small (n=9-41), compared to what is suggested in international psychometric guidelines. Indeed, McCauley and Swisher (1984) proposed 100 as an appropriate number of participants to recruit in each age group targeted (see section 1.3.3.2). In this perspective, solely the two studies by Tresoldi et al. (2018) and Tresoldi et al. (2015) approximated this proportion of participants. However, they were among those studies which did not take into consideration phonological patterns. All of the five studies that did explore phonological patterns investigated a rather small number of participants, as shown in Similar tasks were implemented across studies, as outlined in **Error! Not a valid bookmark self-reference.**. Three studies aimed at collecting developmental data (Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zmarich & Bonifacio, 2005), while several studies aimed instead at gathering normative data on specific measures for tests already available (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress; Zmarich et al., 2012). Of these, one study implemented a repetition task, thus assessing solely the stimulability of Italian phones (Tresoldi et al., 2015). The remaining studies used Bortolini's (1995) 'Prove per la valutazione Fonologica del Linguaggio Infantile' (PFLI) test (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012); although this does have normative data (Bortolini, 1995), neither demographic information on the sample nor the number of participant assessed was reported.

In terms of measures investigated, all but Bortolini and Leonard (1991) reported the phonetic inventory of the population under scrutiny, some additionally providing information on consonant clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), as well as number or percentage of consonants correct (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012). It is necessary to mention that the task administered by Zmarich et al. (2012) did not elicit all Italian phones, but rather tested solely the ones considered typical in the vocabulary of each age group. Consequently, children who might have been able to correctly produce some of the phones absent from the test were potentially penalised in terms of PCC scores.

Only five studies explored phonological patterns (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). A critical evaluation of the characteristics of the studies investigating phonological patterns will be provided later in the chapter (see section 2.3.2), while an analysis of the methodologies used for the study of consonant acquisition will be discussed here.

Table 5 (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012).

Finally, even among studies that conducted the same analyses, different cut-off criteria were used to determine whether a phone or a pattern was considered present at individual's and/or at group level. In particular for the phonetic inventory, the arbitrary cut-offs differed noticeably across research: two studies considered a phone present in a child's inventory if produced correctly at least once in each possible position (Tresoldi et al., 2015; Tresoldi et al., 2018), two if the phone was produced in at least three separate words in different positions (Viterbori et al., 2018; Zanobini et al., 2012), three across at least two (D'Odorico et al., 2011; Zmarich & Bonifacio, 2005) or three separate words in any position (Zanobini & Viterbori, 2009), and one at least half of the possible occurrences (Zmarich et al., 2012). Two studies did not specify the criteria adopted at child's level (Bortolini, 1995; Zmarich et al., in progress). A similar disparity was found across studies at age-group level. While Tresoldi et al. (2018) and Tresoldi et al. (2015) labelled phones that were part of the inventory of at least 50%, 75%, and 90% of children to be respectively 'customary production', 'acquired', and 'mastered', the other studies did not adopt similar categories. Three studies distinguished between phones that were produced by less than 50%, 50-80%, and more than 80% if children (Bortolini, 1995; Zanobini et al., 2012; Zmarich et al., 2012). Of the remaining studies, two reported all percentages of occurrence (Viterbori et al., 2018; Zanobini & Viterbori, 2009), while the other three used the >50% as lower cut-off but adopted either >75% (Zmarich et al., in progress), >80% (D'Odorico et al., 2011), or >90% (Zmarich & Bonifacio, 2005) as higher criterion.

In relation to the research available for Italian, other languages in the romance family have been comparably well studied. In particular, Spanish, Portuguese, and French share similarities with the Italian phonetic and phonological system, thus providing comparison ground for the Italian literature. Additionally, Maltese, despite having Arabic origins, presents shared features with Italian. Literature available for these languages is more substantial for Spanish and Portuguese, covering different variations of the languages (Jimenez, 1987): European Spanish; Anderson & Smith, 1987: Puerto Rican Spanish; Galcerán, 1983: Castellan; Vivar & León, 2009: Chilean Spanish; Ceron, Gubiani, de Oliveira, & Keske-Soaresa, 2017; da Silva et al., 2012: Brazilian Portuguese; Guimarães et al., 2019: European Portuguese), while is rather limited for Maltese and French (Grech, 1998; Grech & Dodd, 2008: Maltese; MacLeod et al., 2011: Quebecois French). Overall, the studies here reported can be considered having higher

interpretability and reliability of the data when compared to the Italian literature. Sample sizes were significantly higher, with a minimum of 72 and a maximum of 733 children, with only two studies examining a small number of participants (six in Anderson & Smith, 1987; 21 in Grech, 1998). The age groups explored were also larger than those considered in the Italian research, with children being as young as 1;8 and as old as 11;0 years of age (Guimarães et al., 2019; MacLeod et al., 2011).

In the following sections, the specific information available on the acquisition of Italian speech sounds, consonant clusters, and the occurrence of phonological patterns will be presented and discussed. Comparisons with the romance and Maltese literature introduced here will also be addressed.

2.3.1 Speech Sounds Acquisition

Ten out of the eleven studies currently available for Italian investigated children's phonetic acquisition. In the following section, results concerning consonant acquisition will be presented, as this was the focus of the research considered. Vowel acquisition was not investigated across the existing studies.

2.3.1.1 Phonetic Inventory: Consonants

Table 6 summarises the results, outlining the studies according to the age groups investigated. Due to the differences in cut-off criteria used, as highlighted in chapter 2.4, phones reported as 'mastered' (i.e. percentages being either >80% or >90%), and those reported as 'emerging' or 'customary production' (i.e. >50%) are presented in the table. Overall, Italian children seem to acquire and master most phones of the language before the fourth year of age, with only a few exceptions. Across studies, agreement was found for most consonants. Early mastered phones (i.e. produced in at least 80% of children before the age of 3;0) were reported to be /p, b, t, d, k, m, n, w/ before 1;11, and /g, f, v, l, j/ before 2;11. The only consonant consistently reported as mastered between 3;0-3;11 was /ɲ/. The latest consonant to be mastered was /ʎ/, reported beyond the age of 6;0. The remaining consonants (i.e. /s, z, ʃ, ʦ, ʣ, ʧ, ʤ, r/ were described with wide variability across studies. Of these, mastery was reported for /s, z, ʃ, ʧ, ʤ/ as early as below the age of 3;0, and as late as 4;0-5;11. Both /r, ʦ / were reported mastered between 3;0-3;6, but also as late as 5;0-5;5 and 6;0-6;5 respectively. Finally, /ʣ/ was reported at both 4;6-4;11 and 5;6-5;11.

It is worth remembering, however, that different authors adopted different cut-offs when considering a phone as emerging, acquired, or mastered, with some not making the distinctions but rather reporting all percentages, as shown in Similar tasks were implemented across studies, as outlined in **Error! Not a valid bookmark self-reference.**. Three studies aimed at collecting developmental data (Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zmarich & Bonifacio, 2005), while several studies aimed instead at gathering normative data on specific measures for tests already available (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress; Zmarich et al., 2012). Of these, one study implemented a repetition task, thus assessing solely the stimulability of Italian phones (Tresoldi et al., 2015). The remaining studies used Bortolini's (1995) 'Prove per la valutazione Fonologica del Linguaggio Infantile' (PFLI) test (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012); although this does have normative data (Bortolini, 1995), neither demographic information on the sample nor the number of participant assessed was reported.

In terms of measures investigated, all but Bortolini and Leonard (1991) reported the phonetic inventory of the population under scrutiny, some additionally providing information on consonant clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), as well as number or percentage of consonants correct (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012). It is necessary to mention that the task administered by Zmarich et al. (2012) did not elicit all Italian phones, but rather tested solely the ones considered typical in the vocabulary of each age group. Consequently, children who might have been able to correctly produce some of the phones absent from the test were potentially penalised in terms of PCC scores. Only five studies explored phonological patterns (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). A critical evaluation of the characteristics of the studies investigating phonological patterns will be provided later in the chapter (see section 2.3.2), while an analysis of the methodologies used for the study of consonant acquisition will be discussed here.

Table 5. Given the limitations of the current available research discussed at the beginning of section 2.3, further research investigating the phonetic development of Italian children is necessary in order to provide more ground for data interpretation. In this perspective, a comparison will be made with findings available from research on romance languages and Maltese, languages that share features with the phonological system of Italian.

Table 6: Consonants' age of acquisition in Italian (age phones reported for the highest criterion, i.e. >80% or >90%; in brackets, age phones reported in ≥50% of children).

Study	**D'Odorico et al. (2011)**		**Zmarich and Bonifacio (2005)**		**Zmarich et al. (2012)**		**Zmarich et al. (in progress)**	**Zanobini and Viterbori (2009)***			**Viterbori et al. (2018)***	**Bortolini (1995)**	**Zanobini et al. (2012)**		**Tresoldi et al. (2015)**	**Tresoldi et al. (2018)**
Age	1;0, 1;6		1;6, 1;9, 2;0, 2;3		1;6-3;0		1;6-3;8	2;0-2;7			2;1-2;8	2;0-4;6	3;0-3;6		3;0-5;11	3;0-7;0
Cut-offs	'almost 50%', >80%		>50%, >90%		≤50%, 50-80%, ≥80%		50-75%, >75%	All reported			All reported	≤50%, 50-80%, ≥80%	<50%, 50-80%, >80%		50-74%, 75-90%, ≥90%	50-74%, 75-90%, ≥90%
	Pre-term	Full-term	WI	WM	WI	WM		Voc. <25° perc.	Voc. 25°-75° perc.	Voc. >75° perc.			WI	WM		
p	1;6 *(1;0)*	1;0	1;6	1;9 (1;6)	1;6-1;11	1;6-1;11	1;6-1;8	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	3;0-3;6	3;0-3;5	3;0-3;5
b	1;6 *(1;0)*	1;6 *(1;0)*	2;0 (1;6)	(1;9)	1;6-1;11	2;6-3;0 (2;0-2;5)	3;0-3;2 (1;6-1;8)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6		3;0-3;5	3;0-3;5
k	*(1;0)*	1;6 *(1;0)*	2;3 (1;6)	1;9 (1;6)	2;0-2;5 (1;6-1;11)	2;0-2;5	2;0-2;2 (1;6-1;8)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	3;0-3;6	3;0-3;5	3;6-3;11
g			(2;3)	(2;3)	(2;0-2;5)	(2;0-2;5)	3;6-3;8 (1;9-1;11)	(2;0-2;7)	2;0-2;7	2;0-2;7	(2;1-2;8)	2;0-2;6			3;6-3;11 (3;0-3;5)	4;0-4;5 (3;0-3;5)
t	*(1;0)*	1;6 *(1;0)*	1;9 (1;6)	1;9 (1;6)	1;6-1;11	1;6-1;11	1;9-1;11 (1;6-1;8)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	3;0-3;6	3;0-3;5	3;0-3;5
d	*(1;0)*	1;6 *(1;0)*	2;3 (2;0)	2;0 (1;9)	2;6-3;0 (2;0-2;5)	2;0-2;5	2;6-2;8 (1;9-1;11)	(2;0-2;7)	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	(3;0-3;6)	3;0-3;5	3;0-3;5
m	*(1;0)*	1;0	2;0 (1;6)	2;0 (1;6)	2;0-2;5 (1;6-1;11)	2;0-2;5	1;9-1;11 (1;6-1;8)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	(3;0-3;6)	3;0-3;5	3;0-3;5
n		1;6 *(1;0)*	2;3 (1;9)	1;9	2;0-2;5	1;6-1;11	1;9-1;11 (1;6-1;8)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	3;0-3;6	3;0-3;5	3;0-3;5

Study	D'Odorico et al. (2011)	Zmarich and Bonifacio (2005)		Zmarich et al. (2012)		Zmarich et al. (in progress)	Zanobini and Viterbori (2009)*			Viterbori et al. (2018)*	Bortolini (1995)	Zanobini et al. (2012)		Tresoldi et al. (2015)	Tresoldi et al. (2018)
Age	1;0, 1;6	1;6, 1;9, 2;0, 2;3		1;6-3;0		1;6-3;8	2;0-2;7			2;1-2;8	2;0-4;6	3;0-3;6		3;0-5;11	3;0-7;0
Cut-offs	'almost 50%', >80%	>50%, >90%		≤50%, 50-80%, ≥80%		50-75%, >75%	All reported			All reported	≤50%, 50-80%, ≥80%	<50%, 50-80%, >80%		50-74%, 75-90%, ≥90%	50-74%, 75-90%, ≥90%
ɲ						3;6-3;8	(2;0-2;7)	(2;0-2;7)	2;0-2;7	(2;1-2;8)	3;1-3;6 (2;7-3;0)			4;0-4;5 (3;0-3;5)	4;0-4;5 (3;6-3;11)
f		(2;0)	(2;0)	2;6-3;0 (2;0-2;5)	2;6-3;0 (2;0-2;5)	2;6-2;8 (2;0-2;2)	(2;0-2;7)	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6		3;0-3;5	3;0-3;5
v		(2;3)	(2;0)	2;0-2;5	2;0-2;5 (1;6-1;11)	2;6-2;8 (1;9-1;11)	(2;0-2;7)	2;0-2;7	2;0-2;7	(2;1-2;8)	2;7-3;0 (2;0-2;6)	3;0-3;6	(3;0-3;6)	3;0-3;5	4;0-4;5 (3;6-3;11)
s		(2;3)	(2;0)	2;6-3;0 (2;0-2;5)	2;6-3;0 (2;0-2;5)	2;9-2;11 (2;0-2;2)	(2;0-2;7)	2;0-2;7	2;0-2;7	2;1-2;8	2;7-3;0 (2;0-2;6)	3;0-3;6	(3;0-3;6)	4;0-4;5 (3;0-3;5)	5;6-5;11 (3;0-3;5)
z					2;0-2;5	3;0-3;2 (2;0-2;2)		(2;0-2;7)	2;0-2;7		3;1-3;6 (2;0-2;6)			5;0-5;5 (3;0-3;5)	3;6-3;11 (3;0-3;5)
ʃ				(2;6-3;0)	2;6-3;0 (2;0-2;5)	(2;0-2;2)		(2;0-2;7)	(2;0-2;7)					5;0-5;5 (3;0-3;5)	4;6-4;11 (3;0-3;5)
ts					(2;0-2;5)	3;3-3;5 (2;0-2;2)					3;1-3;6 (2;7-3;0)			4;6-4;11 (3;0-3;5)	6;0-6;5
dz				(2;6-3;0)		(2;6-2;8)					(2;7-3;0)			4;6-4;11 (3;0-3;5)	5;6-5;11 (3;6-3;11)
tʃ			(1;9)		2;0-2;5 (1;6-1;11)	2;9-2;11 (2;0-2;2)	2;0-2;7	2;0-2;7	2;0-2;7	(2;1-2;8)	2;7-3;0 (2;0-2;6)	(3;0-3;6)	(3;0-3;6)	4;0-4;5 (3;0-3;5)	4;0-4;5 (3;0-3;5)
dʒ						(2;6-2;8)	(2;0-2;7)	2;0-2;7	2;0-2;7	(2;1-2;8)	2;7-3;0 (2;0-2;6)			4;0-4;5 (3;0-3;5)	4;0-4;5 (3;0-3;5)
l		2;3 (2;0)	1;9			2;6-2;8 (1;9-1;11)	2;0-2;7	2;0-2;7	2;0-2;7	2;1-2;8	2;0-2;6	3;0-3;6	3;0-3;6	3;0-3;5	3;0-3;5

Study	D'Odorico et al. (2011)	Zmarich and Bonifacio (2005)	Zmarich et al. (2012)	Zmarich et al. (in progress)	Zanobini and Viterbori (2009)*	Viterbori et al. (2018)*	Bortolini (1995)	Zanobini et al. (2012)	Tresoldi et al. (2015)	Tresoldi et al. (2018)
Age	1;0, 1;6	1;6, 1;9, 2;0, 2;3	1;6-3;0	1;6-3;8	2;0-2;7	2;1-2;8	2;0-4;6	3;0-3;6	3;0-5;11	3;0-7;0
Cut-offs	'almost 50%', >80%	>50%, >90%	≤50%, 50-80%, ≥80%	50-75%, >75%	All reported	All reported	≤50%, 50-80%, ≥80%	<50%, 50-80%, >80%	50-74%, 75-90%, ≥90%	50-74%, 75-90%, ≥90%
ʌ									(3;0-3;5)	6;0-6;5 (5;0-5;5)
r				3;3-3;5 /R/	(2;0-2;7)	2;0-2;7 (2;1-2;8)	3;7-4;0 (2;7-3;0)	3;0-3;6	5;0-5;5 (3;0-3;5)	4;6-4;11 (4;0-4;5)
j			2;0-2;5	2;0-2;2 (1;6-1;8)	2;0-2;7	2;0-2;7 2;0-2;7 (2;1-2;8)	2;0-2;6	3;0-3;6		
w	1;6 *(1;0)* *(1;6)*	(2;3 /kw/)		2;9-2;11 (2;0-2;2)	2;0-2;7	2;0-2;7 2;0-2;7 2;1-2;8	3;1-3;6 (2;7-3;0)	3;0-3;6		

Note: *(1;0)*: Phones reported for the lower cut-off by D'Odorico et al. (2011) were present in 'almost 50%' of children for the age group; * As Zanobini and Viterbori (2009) and Viterbori et al. (2018) reported all percentages, phones presented by ≥50% (in brackets) and ≥80% were reported in this table to be in line with other studies.

Research on romance languages and Maltese appears to agree with data on Italian speech sound development in terms of age of acquisition of sounds, deviating only marginally across languages. A detailed account of the findings across languages for speech sound acquisition can be found in Table 31 in Appendix 1. Before addressing any similarity and difference among the languages, it is necessary to mention that not all studies on romance languages investigated phonetic acquisition. Jimenez (1987) reported that they conducted the analyses item per item, implying an investigation the presence and correctness of speech sounds within their target position, setting the focus of the analysis on the phonemic acquisition, as opposed to phonetic. Additionally, Guimarães et al. (2019) analysed the target sounds as being present in WI or WM, although did not specify whether this was within the target environment or generally across the data corpus. In this perspective, it cannot be assumed with certainty whether they reported the phonetic of phonemic inventory. Furthermore, only two of the romance languages (Anderson & Smith, 1987; MacLeod et al., 2011) and the two Maltese studies tested children below the age of three, reducing the comparability with Italian findings.

Concerning the age of mastery of specific consonants, most studies seem to agree that the majority are acquired by the end of the fourth year of age, with only a few being mastered in the following years. All plosives but /g/, the nasals, and semiconsonants were found to be the earliest developing sounds across both Italian and all comparison languages, with most studies reporting that over 90% of children presented these sounds before the end of their third year of age. A slightly wider variability was found across studies for the age of mastery of the fricatives, /ɡ/, /ɲ/, and /l/. Despite being mostly reported between 3;0-3;11 years, some studies on both Italian and the other languages showed children mastering the sounds at much higher ages, e.g. 6;0-8;0 for Portuguese (Guimarães et al., 2019). A similar variability found across Italian studies for late developing sounds, i.e. /ʦ, ʣ, ʧ, ʤ, r/, has also been observed in the comparison research. For instance, /r/ appeared to develop further in Castellan and Portuguese, up to the ages of 7;0 and 8;0 respectively (Galcerán, 1983; Guimarães et al., 2019), compared to Italian and Maltese. An opposite trend can be identified for the alveolar affricates. Although solely /ʦ/ have been reported in a study on Maltese (Grech & Dodd, 2008), with more than 90% of children presenting the sound at the age of 4;0, this is in contrast with findings on Italian: indeed, /ʦ, ʣ/ have been reported by Tresoldi et al. (2018) to develop for a longer time, specifically up to the ages of 6;0 and 5;6 respectively. Finally, despite /ʎ/ being underrepresented in Italian studies, results are in line with

studies on Portuguese, which reported mastery of the palatal approximant between the ages of 4;0 (da Silva et al., 2012) and 8;0 (Guimarães et al., 2019).

The similarities and differences highlighted across languages show a shared developmental trajectory in terms of the order in which speech sounds are acquired, in particular in the initial stages of the development. Nevertheless, despite belonging to the same family and/or presenting common features in their phonological systems, each language differs from the others in the rate of acquisition of individual phones. In this perspective, it is possible to hypothesise that phones that are acquired early in one language may be more frequent in children's early vocabulary compared to that of speakers of a language that develops it later. Further comparison of children's phonetic development across languages can be obtained through the investigation of quantitative measures, such as for example PCC, which will be discussed in the following section.

2.3.1.2 Percentage of Consonant Correct

As mentioned above and discussed in Literature Review I (section 1.2.1.2.1), a useful measure of accuracy, that provides information on the approximation to the adult target and can therefore inform on the overall trend in children's speech sound acquisition, is the Percentage of Consonant Correct - PCC (Shriberg & Kwiatkowski, 1982). Among the available studies for Italian (reported in Similar tasks were implemented across studies, as outlined in **Error! Not a valid bookmark self-reference.**. Three studies aimed at collecting developmental data (Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zmarich & Bonifacio, 2005), while several studies aimed instead at gathering normative data on specific measures for tests already available (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress; Zmarich et al., 2012). Of these, one study implemented a repetition task, thus assessing solely the stimulability of Italian phones (Tresoldi et al., 2015). The remaining studies used Bortolini's (1995) 'Prove per la valutazione Fonologica del Linguaggio Infantile' (PFLI) test (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012); although this does have normative data (Bortolini, 1995), neither demographic information on the sample nor the number of participant assessed was reported.

In terms of measures investigated, all but Bortolini and Leonard (1991) reported the phonetic inventory of the population under scrutiny, some additionally providing information on consonant clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), as well as number or percentage of consonants correct (Viterbori et al., 2018;

Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012). It is necessary to mention that the task administered by Zmarich et al. (2012) did not elicit all Italian phones, but rather tested solely the ones considered typical in the vocabulary of each age group. Consequently, children who might have been able to correctly produce some of the phones absent from the test were potentially penalised in terms of PCC scores. Only five studies explored phonological patterns (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). A critical evaluation of the characteristics of the studies investigating phonological patterns will be provided later in the chapter (see section 2.3.2), while an analysis of the methodologies used for the study of consonant acquisition will be discussed here.

Table 5), solely Zmarich et al. (2012) provided this information on the sample studied (i.e. 1;6-3;0). According to the results from these authors, children's accuracy increases significantly after the second year of age, and variability among children diminishes with age increase. Zmarich et al. (2012) found that, despite a PCC of 37.0 at the age of 1;6-1;11, with a standard deviation (SD) of 10.4, the measure increases to 60.2 (SD=13.5) at 2;0-2;5, and 69.6 (SD=8.0) before the age of 3;0.

Table 7: Percentage of Consonant Correct (PCC) and Percentage of Consonants in the Inventory (PCI) in the available Italian literature.

	N	Age	Subgroups	PCC (SD)**	PCI***
Zmarich et al. (2012)	30	1;6-3;0	1;6-1;11	37.0 (10.4)	
			2;0-2;5	60.2 (13.5)	
			2;6-3;0	69.6 (8.0)	
Zanobini & Viterbori (2009)	41	2;0-2;6	overall		75.0
Viterbori et al. (2018)	88	2;1-2;8	overall		66.2
			Low-V*		45.8
			Aver-V		73.3
			High-V		75.0
Zanobini et al. (2012)	30	3;0-3;6	overall		67.7
			Low-V		52.1
			Aver-V		69.6
			High-V		69.6

Note: *Children were classified within the age group according to their vocabulary skills (i.e. Low, Average, and High). **All PCC and PCI values are percentages. ***PCI: Percentage of Consonants in the Inventory, derived from the average number of consonants considered acquired (i.e. meeting the cut-off of at least 3 correct occurrences across different words and positions).

Three further studies (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012) reported instead the number of consonant in the phonetic inventory (i.e. considering a phone present if occurring phonetically correct in at least 3 instances across different items/positions), from which each PCI was derived in Table 7 to allow for comparison with Zmarich et al. (2012). This measure is less informative than PCC, as it does not account for the instability of the phonological system during its development, and therefore leaves out phones that might be realised correctly only in some of the possible occasions.

Differences in the measures notwithstanding, Zmarich et al. (2012) and Viterbori et al. (2018) found similar results for children in the same age group. Contrarily, despite testing a matching age group, Zanobini and Viterbori (2009) reported instead a higher result. It is necessary to remember that, as discussed at the beginning of section 2.4.2, authors adopted different methodologies, thus limiting the comparability of the results across studies. The data here presented should therefore be interpreted with caution. Furthermore, results for the youngest (Zmarich et al., 2012) and oldest (Zanobini et al., 2012) children cannot be compared with any other investigated age group. Given the

limited information on PCC currently available, additional research addressing this measure for Italian-speaking children across the developmental period is needed.

Because of the limited number of studies investigating accuracy measures for Italian, a useful comparison can be derived from findings on romance languages and Maltese, which will also be taken in consideration more in details when discussing the results from the present study (see Discussion I, section 5.1). A relevant number of authors across these languages calculated PCC scores in their populations. However, research on these languages mostly considered children at later stages in the development. Overall, all studies seem to agree that the percentage of consonant produced correctly approaches and pass 90% already at the age of 3;0-3;11. Since Italian literature lacks data on PCC for children from this age onward, these studies have limited comparability. When compared to the available knowledge on Italian, the results found for Brazilian Portuguese, Quebecois and European French, and Maltese children (see Table 8) suggest a superior performance of these populations. Although it might be the case that a more restricted number of consonants are frequent across the vocabulary of young children speaking Italian compared to that of children speaking one of the comparison languages, it is possible that the lower PCCs found for Italian are the result of limitations in the study design. Additional information for the studies discussed, both in terms of speech sounds acquisition and PCC may be visualised in Table 31and Table 32 in Appendix 1.

Table 8: Percentage of Consonant Correct (PCC) in the available comparison literature.

	L*	Age	Subgroups	PCC (SD)
MacLeod et al. (2011)	QF	1;6-3;5	1;6-1;11	54.7
			2;0-2;5	68.8
			2;6-2;11	81.5
			3;0-3;5	87.8
Kehoe et al. (2018)	F	2;0-2;11	Overall	79.94
Kehoe et al. (2020)	F	2:0-3;11	2;0-2;11	79.94
			3;0-3;11	86.66
Grech and Dodd (2008)	M	2;0-3;5	2;0-2;11	84.9
			3;0-3;5	89.6
Ceron, Gubiani, de Oliveira and Keske-Soares (2017)	BP	3;0-3;5	overall	90.11
da Silva et al. (2012)	BP	3;0-3;11	low SES	86.99
			high SES	58.65

Note: *L: language; QF: Quebecois French; F: French; M: Maltese; BP: Brazilian Portuguese.

2.3.1.3 Consonant Clusters

Concerning the acquisition of consonant clusters, only three studies reported these kind of data (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012). Authors did not distinguish between tautosyllabic and heterosyllabic clusters. However, the authors adopted different approaches of reporting their results. While Tresoldi et al. (2015) listed the clusters tested, as these were a limited number, Zmarich et al. (2012) gave a detailed account of the specific types of clusters investigated (e.g. plosive+semiconsonant in WI). Similarly, Tresoldi et al. (2018) reported classes of clusters (e.g. nasal+stop). However, they summarised their results by solely providing an overview of the main findings in terms of age of mastery (cluster present in ≥90% of children). Before discussing the findings, characteristics of the studies in question need to be presented in order to appropriately interpret the data. Both Zmarich et al. (2012) and Tresoldi et al. (2018) implemented picture naming tasks, while Tresoldi et al. (2015) assessed children through a word repetition test. In all cases, given the limited elicitation of different types of clusters across the assessment materials, a consonant cluster was considered present in a child's inventory if produced correctly at least once. At group level, however, different cut-offs were adopted (see **Error! Not a valid bookmark self-reference.** and Table 10). Due to the differences in criteria adopted, clusters reported as being at the age of acquisition (i.e. ≥75%) and of customary production (i.e. ≥50%) in the two most recent studies are grouped together in Table 9 and Table 10 to facilitate the comparison with the finding from Zmarich et al. (2012). Additionally, it is worth noticing that the repetition task implemented by Tresoldi et al. (2015) elicited items that cannot be considered part of children's vocabulary (e.g. 'Sardanapalo', 'Afghanistan'), and also contain infrequent clusters; thus, it could be argued that results from these items do not provide relevant information in terms of natural speech sound development in Italian children.

Table 9 and **Error! Reference source not found.** report the results from the studies described. In these tables, specific groups of clusters have been reported, following the classification used Zmarich et al. (2012) and Tresoldi et al. (2018). In this perspective, solely the specific clusters elicited in the tests used were reported after scanning of the materials adopted (e.g. when 'plosive+liquid' clusters mentioned, the test was scanned for which clusters elicited were composed by a plosive and a liquid). Classification of the clusters from Zmarich et al. (2012) was reported in relation to the cluster's position (i.e. WI vs. WM), according to their results.

Before discussing the findings, characteristics of the studies in question need to be presented in order to appropriately interpret the data. Both Zmarich et al. (2012) and Tresoldi et al. (2018) implemented picture naming tasks, while Tresoldi et al. (2015) assessed children through a word repetition test. In all cases, given the limited elicitation of different types of clusters across the assessment materials, a consonant cluster was considered present in a child's inventory if produced correctly at least once. At group level, however, different cut-offs were adopted (see **Error! Not a valid bookmark self-reference.** and **Error! Reference source not found.**). Due to the differences in criteria adopted, clusters reported as being at the age of acquisition (i.e. ≥75%) and of customary production (i.e. ≥50%) in the two most recent studies are grouped together in **Error! Not a valid bookmark self-reference.** and **Error! Reference source not found.** to facilitate the comparison with the finding from Zmarich et al. (2012). Additionally, it is worth noticing that the repetition task implemented by Tresoldi et al. (2015) elicited items that cannot be considered part of children's vocabulary (e.g. 'Sardanapalo', 'Afghanistan'), and also contain infrequent clusters; thus, it could be argued that results from these items do not provide relevant information in terms of natural speech sound development in Italian children.

Table 9: Age of mastery (meeting the highest cut-off, i.e. ≥80% or ≥90% according to the study) of initial consonant clusters in Italian, and age at which the clusters are found in at least 50% of children (in brackets).

	Zmarich et al. (2012)		**Tresoldi et al. (2018)**	**Tresoldi et al. (2015)**
N	30		694	557
Age	1;6-3;0		3;0-7;0	3;0-5;11
Cut-off	≥80%, 50-80%, ≤50%		≥90%, 75-90%, 50-75%	≥90%, 75-90%, 50-75%
	WI	WMSI		
Biconsonantal				
pj, kj, gw	(2;0-2;5)	2;6-3;0		
pr, br, tr, dr, kr, gr	-	-		
pl, bl, kl	-	-	stop+liquid mastered by 4;0-year-olds	
sp, st, sk, zb, zg	-	-	Fricatives as first element mastered by 6;0-year-olds	/sk/ (3;0-4;6) >4;6
sf, zv				
fr, vr	-	-		
zm				(4;6-6;0)
fl	-	-		
ks				(5;0-6;0)
Triconsonantal				
spj, skw	-	(2;0-2;5)	7;0-year-olds: more accurately tri-consonant clusters	
str, spr, skr, zbr, zgr	-	-		/spr/ (3;0-5;0) >5;0
spl, skl	-	-		
sfr				

Note: - cc not reported or present in low percentage; blank space: cc not tested.

Table 10: Age of mastery (meeting the highest cut-off, i.e. ≥80% or ≥90% according to the study) of heterosyllabic consonant clusters in Italian, and age at which the clusters are found in at least 50% of children (in brackets).

	Zmarich et al. (2012)	**Tresoldi et al. (2018)**	**Tresoldi et al (2015)**
N	30	694	557
Age	1;6-3;0	3;0-7;0	3;0-5;11
Biconsonantal			
mp, mb, nt, nd, ŋk, ŋg	/mb, nt, ŋg/ 2;6-3;0	nasal+stop mastered by 4;0-year-olds	
mf, mv			
ns			
nts, ndz, ntʃ, ndʒ	/ndz, ntʃ, ndʒ/ 2;6-3;0		
mj	-		
rp, rb, r, rd, rk, rg	-	Liquids as first element mastered by 6;0-year-olds	/rd/ (4;6-6;0)
rs, rf, rv	-		
rts, rtʃ	-		
rm, rn	-		
rl			
lj			
lp, lb, lt, ld, lk, lg			
ls, lf, lv			
lts, ltʃ, ldʒ			
lm			
fg			(>6;0)
tst			(4;6-5;6) > 5;6
Triconsonantal			
ŋgj, ŋgw	(2;6-3;0)	7;0-year-olds: more accurately tri-consonant clusters (preference for nasal as C1)	
mpl, mpr, mbr, ntr, ndr, ŋkr, ŋgr			/mpl/ (3;0-4;6) > 4;6
mfr			
mfl			

Note: - when cc not found/not reported or present in low percentage; blank space: cc not tested.

Considering tautosyllabic clusters, Italian children appear to begin producing some clusters correctly already before the age of 3;0. In particular, Zmarich et al. (2012) found clusters with the semiconsonant /j/ (i.e. /pj, kj, mj, lj/) in at least 50% of children already at two years of age. However, mastery of the first clusters seems to take place from 3;6 years of age. Plosive+liquid clusters were reported as mastered (i.e. ≥ 90% of children) by Tresoldi et al. (2018) at the age of 3;6-3;11. Fricatives appear in first position of cluster

structures in more than 50% of children around the age of 4;6-4;11 (e.g. /zm/ in Tresoldi et al., 2015), and are mastered before the end of the fifth year of age. Finally, CCC structures seem to emerge in at least 50% of children as early as 3;0 years of age (e.g. /spr/ in Tresoldi et al., 2015) but require a longer development and are more consistently produced across the population (i.e. ≥90%) around the age of 6;6-6;11 (Tresoldi et al., 2018).

With respect to the heterosyllabic clusters, these seemed to appear later in children's development. The majority of CC structures elicited were reported to be mastered by the ages of 4;0 (i.e. nasal+plosive), and 6;0 (i.e. liquid+plosive/fricative/affricate/nasal) by Tresoldi et al. (2018), although results from Zmarich et al. (2012) seemed to suggest a younger age of mastery for the nasal clusters (i.e. 2;6-3;0). All CCC structures elicited were found in less than 80% (Zmarich et al., 2012) and 90% (Tresoldi et al., 2015) of children, with the exception of /mpl/, which was repeated correctly by more than 90% of children in the study by Tresoldi et al. (2015). Tresoldi et al. (2018) reported that children improved in their performance on tri-consonant clusters around the age of 7;0, although did not specify which clusters were found nor their frequency.

There is not only little information on CC acquisition in Italian but also in other romance languages. Few studies in Spanish (Fernández, 1997; Galcerán, 1983) and Portuguese (Ceron et al., 2020; da Silva et al., 2012; Guimarães et al., 2019), and the main French study, which investigated the Quebecois variation (MacLeod et al., 2011), have targeted consonant co-occurrence with variable detail. Nonetheless, data collection methodologies and cut-off criteria used in accounting for the presence of consonant clusters differed across studies, as well as the strategies for reporting findings. Similarly to Tresoldi et al. (2018), Galcerán (1983) and Ceron et al. (2020) preferred a classification of the clusters according to the manner of articulation of their elements (e.g. 'nasal + plosive'). On the contrary, the other authors specified the individual clusters that were elicited in their assessments. A summary of the results from these studies can be found in Table 33 in Appendix 1.

There appears to be agreement across romance languages and Italian that the first clusters to be mastered by children are two-element tautosyllabic clusters. Particularly, the romance languages studies appear to report as first (i.e. ≤3;11) clusters those with plosive+liquid (Fernández, 1997; MacLeod et al., 2011). Compared to Italian, clusters with the semiconsonants /j, w/ seems to be stabilised at similar ages in children's speech across all languages except in MacLeod et al. (2011), which reports a slightly later

mastering of /pw, bw/ (i.e. 4;0). Also similarly to Italian, fricatives appeared to be mastered in CC structures at later stages of the development, with Italian literature placing their mastery around the age of 6;0, and studies such as those by Ceron et al. (2020) and Guimarães et al. (2019) reporting them solely in less than 90% of children across their populations.

Furthermore, similarities can be found for three-element clusters as well. These seem to make their appearance across languages in children's speech before the end of the fourth year of age, but to be mastered at later stages in the development. Indeed, similarly to findings on Italian, Galcerán (1983) presents the emergence of CCC structures with /s/ in more than 50% of children already at the age of 3;0-3;5; however, mastery (i.e. ≥90%) of these structures is reported at the age of 6;0-6;5 in the same study.

In terms of heterosyllabic clusters, similarities can be found for nasal clusters between Italian (Tresoldi et al., 2018) and Castellan (Galcerán, 1983). Divergence in the results across languages is found instead for clusters including a liquid as first element (e.g. /rk/, as in Italian 'barca' /bar.ka/ 'boat'). Although studies on Castellan and Portuguese placed their emergence at the early age of 3;0-3;5 (Ceron et al., 2020; Galcerán, 1983), Tresoldi et al. (2015) reported customary production (≥50%) of cluster /rd/ only at the age of 4;6-4;11. The opposite trend, however, was shown in the same studies for the mastery of these clusters: Italian children seemed to stabilise clusters with liquids earlier than Castellan and Portuguese children.

It is worth noticing that Galcerán (1983) did not explicitly distinguish between tautosyllabic and heterosyllabic clusters, including the latter in the definition of clusters. Although the other romance languages studies here mentioned solely considered initial clusters, several Italian studies and previously-mentioned studies investigating other aspects of phonological development in Spanish-speaking children (Barlow, 2003; Diez-Itza & Martinez, 2004) have instead included heterosyllabic clusters. In light of the available findings from studies investigating both types of clusters it could be hypothesised that consonant co-occurrences across syllable boundaries could indeed have a status of CC, although being affected marginally differently in terms of phonological patterns (see discussion of consonant clusters in section 2.2.1.1). As mentioned above in the chapter, the current analyses on consonant clusters and phonological patterns may shed some light on the matter.

2.3.1.4 Vowels

Concerning vowels, there is no systematic study investigating their acquisition in Italian speakers. Giulivi et al. (2006) claim that all seven vowels are generally assumed to be acquired by the age of 3;0, based on international literature on languages sharing similar vowel systems (e.g. Portuguese), although they did not undertake an investigation to confirm the claim for Italian. This hypothesis could be considered appropriate in light of the restricted number of vowels (i.e. seven), and thus their high percentage of occurrence across the vocabulary, as well as their simplicity in terms of lexical distinction. Similarly, across other romance languages, there seems to be a paucity of studies, with only three published studies targeting European (Fikkert & Freitas, 2006; Freitas, 2003) and Brazilian (Bohn, 2017) Portuguese vowels. Solely the Portuguese study investigated the acquisition of the entire vowel system, which is comparable to the Italian system as it is composed by the same seven vowels /i, e, ɛ, a, ɔ, o, u/. Bohn (2017) used a longitudinal case study on three children from the age of 1;0 to 3;5. Findings from this research appear to agree with the statement made for Italian that children complete their acquisition of the seven-vowel system by the age of three: indeed, two out of the three children acquired (i.e. presented in 9 or more occasions) all vowels by 2;7, while the third child completed the acquisition of the two remaining vowels (i.e. /e, ɛ/) between 3;0-3;2. Despite these preliminary results, additional evidence is needed on the development of the vowel systems across not only Italian but other romance languages.

Having discussed the available evidence on the acquisition of consonants and vowel of Italian, the simplifications that children present during this developmental period will be discussed, in order to gain a better understanding of the pattern of acquisition of the phonetic and phonological system of the language.

2.3.2 Phonological Patterns

Five studies have analysed phonological patterns in a developmental perspective for the Italian population. Table 11 presents the available studies, summarising information regarding the sample (i.e. numbers, gender distribution, age groups assessed and the age bands in which participants were divided), the task implemented, and the cut-off criteria adopted for the identification of phonological patterns. As all studies but Bortolini and Leonard (1991) specified the use of published assessment materials, and the task adopted by Bortolini and Leonard (1991) was complex picture description, equivalent to the PFLI test (Bortolini, 1995), aspects of data collection will not be discussed here. Methodological aspects related to the sample size and composition, as well as to the

cut-off criteria and definitions adopted for the identification of phonological patterns will be critically evaluated in the present section.

Table 11: Studies on Italian Phonological Patterns Development.

	Age	Age bands	N	Data collection	Test name	Criteria
Viterbori et al. (2018)	2;1-2;8		88 (42m; 46f)	Spontaneous speech (complex pictures description)	PFLI	At least once
Zanobini et al. (2012)	3;0-3;6		30	Spontaneous speech (complex picture description)	PFLI	At least once
Zmarich et al. (2012)	1;6-3;0		30 (15m; 15f)	Picture naming	TFPI	At least once
Bortolini (1995)	2;0-4;6		unknown	Spontaneous speech (complex pictures description)	PFLI	<50% 50-80% >80%
Bortolini and Leonard (1991)	2;2-2;11		9 (4m; 5f)	Spontaneous speech (complex pictures description)	None specified	At least in 2 words

To date, current clinical practice in Italy mainly refers to the manual of the PFLI test (Bortolini, 1995) for data on developmental pattern and the ages at when children overcome each pattern (see section 2.3.1). However, data on how the normative sample was built and its size and composition has not been reported. Few other authors have investigated phonological patterns within studies on the phonological development of Italian children. In terms of sample size, no study met the internationally suggested number of 100 participants per age group (McCauley & Swisher, 1984). Both Zmarich et al. (2012) and Zanobini et al. (2012) tested only 30 participants. Of the two other studies available, Viterbori et al. (2018) assessed 88 children, while Bortolini and Leonard (1991) analysed 9 children. Such small numbers cannot be considered to be appropriately representative of the populations investigated; thus data collected through these studies are limited I terms of generalisability.

With respect to the sample composition, and in terms of age assessed, all studies tested children below the age of 3:6, and focussed on a small age range, with the largest spanning an eight-month gap. Exceptions were the research by Bortolini herself

(Bortolini, 1995) and the study by Zmarich et al. (2012). As mentioned above, no information is available for the sample investigated by Bortolini (1995), although it is possible to assume that children assessed were between 24 and 54 months (2;0-4;6 years old). Children were grouped into uneven age bands, with some including children across a five-month and some a six-month range. Furthermore, patterns were reported, through a coloured bar graph, to emerge and/or disappear within certain age bands, with no reference to the specific age (i.e. coloured bar started/ended in a non-described point within a specific age band; for a view of the results see Bortolini (1995), p. 21). The sample examined in Zmarich et al (2012), although including children below the age of 3;0, covered instead a range of 18 months, with equally distributed age bands (i.e. 6-month age range), providing a more developmental perspective.

Concerning the cut-off criteria adopted for the identification of phonological patterns, four out of five of the studies did not specify a cut-off at individual level, implying they counted each phonological error presented by a child as a pattern. Solely Bortolini and Leonard (1991) adopted a cut-off for distinguishing patterns from an incidental error occurrence. The authors marked as pattern only those phonological variations that occurred in at least two separate words. At age group level, all patterns were reported across studies, independently from their percentage of occurrence. Solely Bortolini (1995) marked those which occurred in less than 50%, between 50-80%, and more than 80% of children, however solely providing a line graph, without giving precise indication if the exact percentages of occurrence and ages at which these were calculated (for a view of the graph, see the PFLI manual by Bortolini, 1995, p. 21).

It is necessary to notice that not all studies reported the percentage of children presenting the patterns in each age group. While Bortolini and Leonard (1991) indicated the number of children in which each pattern occurred at least twice, Zmarich et al. (2012) calculated the percentage of occurrence of each pattern in each age group in relation to the number of potential occurrences across that age group (e.g. to determine the percentage of occurrence of the pattern ‘devoicing’, the total number of occurrences of the pattern across all children in one age group was related to the total number of voiced consonants across the data corpus for that age group). In light of the available literature, it can be stated that the lack or low cut-off adopted in the Italian studies limits the reliability of the data and is likely to have led to an overidentification of patterns considered typical for the populations under scrutiny. Indeed, to date, most authors choose to adopt the cut-off of four occurrences to distinguish between phonological patterns and infrequent phonological variations, as discussed in detail in section 1.2.1.2.3 in Literature Review I.

Further research adopting a more appropriate criterion is therefore needed. In this perspective, the current project might shed some light on the suitability of different, albeit arbitrary, cut-off criteria (see Methodology, section 3.4.4).

Across the available research, no study specifically targeted all the potential patterns, focussing instead on reporting only the incidental emergence of patterns undertaken by children during the phonological evaluation. This was due mainly to the use of spontaneous speech as a common method for data collection across all but one study (Zmarich et al., 2012). Indeed, eliciting spontaneous speech, although potentially more reflective of the real-life performance of a child (see Literature Review I, section 1.2.1.2), does not allow for appropriate control of the speech sample, in terms of numbers of phoneme occurrences in each possible position, and the potential emergence of phonological variations (McLeod & Baker, 2017). In the case of Complex Picture Description tasks, as is the case for the PFLI test (Bortolini, 1995) used in most of the Italian studies, a slightly higher control over the sample collected is possible, since children will be prompted to mention specific elements in the pictures. However, as it will be discussed more in detail in section 2.4.1, the PFLI construction results in an overstimulation of certain words, and consequently of specific phonemes and syllable structures, and an underrepresentation of others, reducing the interpretability of the results.

The methodological features here described need to be taken into account when considering the results obtained in the available research. Table 12 reports all the phonological patterns identified in each of the available studies. A detailed account of the specific ages of emergence and disappearance of each pattern according to these studies can be found in Table 34 in Appendix 1.

Table 12: Phonological patterns identified in Italian children across the available research (>80%).

	Zmarich et al. (2012)	**Viterbori et al. (2018)**	**Bortolini and Leonard (1991)**	**Zanobini et al. (2012)**	**Bortolini (1995)**
Sample	n=30 1;6-3;0	n=88 2;1-2;8	n=9 2;2-2;11	n=30 3;0-3;6	n=unknown 2;0-4;6
Cut-off criterium	at least 1 per child	at least 1 per child	at least 2 per child	at least 1 per child	unknown
Structure Patterns					
Syllable Deletion	x	x	x	x	x
Diphthong Reduction		x		x	x
Sound Deletion		x		x	x
Metathesis		x	x	x	x
Epenthesis		x	x	x	x
Migration			x		
Vowel Harmony		x			x
Consonant Assimilation			x	x	x
Consonant Cluster Reduction	x	x	x	x	
Substitution Patterns					
Stopping	x	x		x	x
Frication	x	x		x	
Affrication		x		x	x
Gliding	x	x		x	x
Fronting	x				x
Backing	x				x
Devoicing	x	x	x	x	x
Voicing	x	x		x	
Other errors					
/r-l/ substitutions		x		x	
Phonologically plausible substitutions		x		x	
other substitutions		x		x	
vowel substitutions		x		x	
liquid deviation			x		
spirantisation*			x		
vowel dissimilation					x

Note: * defined as the affrication of plosives.

Although studies generally agreed in the type of patterns found, some percentages of occurrence of the commonly observed patterns in the same age group resulted to be vastly different across studies (see Table 34 in Appendix 1). For instance, Viterbori et al. (2018) found scarce presence (14.24%) of syllable deletion in children aged 25-32 months, while both the studies by Bortolini and Leonard (1991) and by Bortolini (1995) recorded a percentage of around 80% in peers. The research conducted by Zmarich et al (2012), although examining this age group as part of his sample, only found the patterns in younger children (18-23 months), with an occurrence of 30-35%. These differences, however, are likely due to the limitations in sample sizes and age bands examined. The pattern of Stopping, for instance, is reported by Zmarich et al. (2012) in 20-25% of children between the age of 1;6-2;11, but did not appear in older children. A small percentage of older children still presenting the Stopping pattern may have been found if a larger number of participants had been tested. Indeed, in Viterbori et al. (2018), around 7% of children aged 3;1-3;8 did present the pattern, suggesting that Stopping could be gradually resolving around the age of 3;0. Finally, despite the fact that most of the patterns reported by these studies have been found as developmentally typical patterns in many other languages (e.g. Initial Cluster Reduction, lateralisation of /r/), the Italian authors considered a pattern every phonological variations that occurred as low as one or two times: considering the typical definition of phonological patterns as rule-like, frequent variations (Kirk & Vigeland, 2015), the interpretability of these data cannot be considered entirely reliable.

When considering the occurrence of phonological patterns, in addition to the previously discussed issues with sample sizes and composition, elicitation methods, and cut-off criteria adopted in the identification of patterns (see beginning of this section), it is fundamental to remember that different regions present specific features that differ from Standard Italian. The existence of these differences may result in the emergence of diverse phonological patterns. In this perspective, incongruencies in the identification of phonological patterns from the studies currently available for Italian may therefore also be partially due to differences in the areas of participants' recruitment.

An example of these differences can be provided considering the variations from the Liguria, Marche, and Veneto regions, which are relevant to this study as they are the regions of participants' recruitment (see Methodology, section 3.1). These regional variations all share a tendency towards weakening of geminates and long consonants (e.g. /ʎ/), although this is not a systematic reduction. The Veneto variation may present

gliding/depalatalization of the lateral approximant /ʎ/, while the Ligurian variation shows a similar pattern on the nasal approximant /ɲ/. These two regions also share a prevalent use of voiced alveolars /z, ʣ/, rather than the corresponding voiceless, in WI and intervocalic position, within the limitations imposed by phonotactic restrictions (e.g. /z/ is never found in WI). The variation from Marche variates more from the Standard Italian. A deaffrication of /ʧ, ʤ/ is often found both in WI and intervocalic position (e.g. /baʧo/ - [baʃo]; /ʤente/ - [ʒente]). Geminate /r/ can be reduced; on the contrary, the voiced plosive /b/ can undergo gemination in intervocalic position (e.g. /abete/ - [abbete]). Additionally, there is a tendency in this regional variation to reduce consonant clusters, both tautosyllabic and across-syllable boundaries, through epenthesis of a vowel and strengthening of a consonant (e.g. /atmosfera/ - [attomosfera]; /psikoloʤia/ - [pissikoloʤia]). Finally, concerning vowels, the Marche variation presents all vowels across positions, with variable distributions; the Liguria and Veneto variations, however, present almost diametrically opposite features, with the former having a tendency towards closed vowels /e, o/, while the latter tends to present mostly open mid-low vowels /ɛ, ɔ/ (closed mid vowels /e, o/ appear in open syllables).

Although the Italian language does present a variety of different features across its regional variations, it also possesses similarities with other languages (i.e. romance languages, Maltese). In the following section, studies exploring the occurrence of phonological patterns across these languages will be taken into consideration to provide a comparison with the available Italian research.

2.3.2.1 Comparison with Romance languages and Maltese

Similarities in terms of phonological variations observed in typically developing children can be found between results of Italian studies and those from research on Spanish, Portuguese, and Maltese. As mentioned above, these languages share similarities with the phonetic and phonological system of Italian, thus offering a useful comparison for the limited Italian research. Table 35 in Appendix 1 provides detailed information on the patterns found in the studies on Romance languages and Maltese. These studies adopted the same broad cut-off as the Italian authors, accepting as ‘pattern’ every phonological variation that a child produced at least once. The Maltese study by Grech (1998) only considered patterns variations emerging in two or more instances. In terms of tasks undertaken for testing the children, differently from the majority of Italian studies, most authors utilised single word picture naming tasks (Ceron, Gubiani, de Oliveira, &

Keske-Soares, 2017; da Silva et al., 2012; Goldstein, 2005; Grech & Dodd, 2008; Lousada et al., 2012). Galcerán (1983), who tested Castellan-speaking children, and Grech (1998), who assessed Maltese children, both adopted spontaneous speech prompted through a complex picture description task. Additionally, Grech (1998) also recorded spontaneous speech sample in a natural communication setting and in a play setting with toys and books and requested the children to complete a picture naming task.

Most phonological patterns that were reported in the Italian studies were also common among the other languages. The majority of these (e.g. Weak Syllable Deletion, Consonant Cluster Reduction, Assimilation, Devoicing, etc) have been described in international literature, appearing to be common across languages. For instance, Syllable deletion and Devoicing were found by all Italian authors and all but three of the Romance languages and Maltese studies (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Grech, 1998; Lousada et al., 2012). Similarly, Lateralization of /r/ appears to be typical and resolve late in the development across languages: Galcerán (1983) and da Silva et al. (2012) report the presence of the pattern in at least 10% of the children up to the ages of 6;11 and 7;11 respectively. The two studies on Maltese also observed Lateralization of /r/, although the pattern appeared to be resolved by a younger age (Grech & Dodd, 2008, reported its presence up to the age of 4;11, in a sample of children spanning from 2;0-7;11 years of age).

Several patterns that could be considered typical for Italian and the romance languages, however, pose an issue for their comparison: many studies lack a precise definition of the phonological patterns mentioned, limiting both the interpretability of the results and their comparison with different studies. For example, given the existence of the polivibrant /r/ in the languages here considered, Gliding of /r/ could be expected in examining typically developing speakers of these languages. However, Gliding can also apply to other phonemes that are substituted by a semiconsonant (e.g. in Italian Gliding of /ʎ/). A precise and clear definition of the patterns explored is fundamental for the interpretability and comparison of the data (see Literature Review I, section 1.2.1.2.3). Indeed, several studies across Italian, Spanish, Portuguese, and Maltese report the occurrence of Gliding in various age groups; notwithstanding, solely some provide information of the phonemes that are substituted by a glide (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; Grech, 1998; Grech & Dodd, 2008; Lousada et al., 2012). Others, however, only refer to the term Gliding (Bortolini, 1995; Bortolini & Leonard, 1991; da

Silva et al., 2012; Galcerán, 1983; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). This distinction needs to be provided for several different patterns that could apply to different classes of sounds (e.g. Fronting of velars vs fronting of postalveolars or alveolars; Stopping of fricatives vs Stopping of affricates), in order to provide a clear and detailed description of children's phonological development.

2.3.3 Overview of the available data for Italian

Overall, as seen across this section, data on the typical Italian phonological development are limited in terms of ages investigated and types of measures explored. First of all, most studies explored the acquisition of consonants, three of which reported consonant clusters in general terms. One of these studies aimed at collective normative data for a short repetition test (Schindler, 1986), thus assessing stimulability. No study targeted the acquisition of the vowel system, while solely one addressed PCC in children up to the age of 3;0. Finally, in terms of phonological variations, no investigation has been conducted in terms of the number of tokens presented at each age, nor a distinction been made between phonological patterns and variations which are infrequent. The five studies which explored phonological patterns assessed children solely up to the age of 4;6, and presented limitations in terms of the cut-off criteria adopted to define a pattern.

Norms are thus currently available in Italian for consonant acquisition, albeit with limitations due to differences in methodologies adopted across studies. Normative data are missing with respect to percentages correct, consonant clusters acquisition, and developmental phonological variations, in terms of overall tokens, types of patterns, and variations which do not meet the threshold to be considered as such.

2.4 Assessment of Italian Phonological Development

As introduced in the previous section, data currently available on the typical development of Italian-speaking children are limited in terms of ages and measures investigates. Moreover, some of the assessment used across Italian literature present limitations which have impacted on the data obtained. In this perspective, and following from the discussion in Literature Review I (section 1.3) on the general principles of phonology assessment, the tests available for Italian will be discussed in terms of strengths and limitations with the perspective of identifying the most appropriate tool which may be considered in order to collect the missing data. The BVL_4-12 and TFPI assessments will be discussed and compared in more detail due to their relevance for this thesis (i.e. being used to collect data from respectively cohort 1 and cohort 2).

2.4.1 The current situation: assessments available, strengths and limitations

Currently, the available tests for the assessment of Italian children's speech (see

In terms of task administered, it was argued in Literature Review I (section 1.2.1.2) that a picture naming task is the most appropriate to collect developmental data on children's speech. In addition to being a time-effective task both in terms of recording and analysis, a naming task allows for a high item control and thus inter-individual comparability (Bernhardt & Holdgrafer, 2001; Materson et al., 2005). This excludes from the available potential tests to obtain missing normative data Schindler (1986)'s repetition task, which can only provide information on the stimulability of the phones and phonemes, as the motor programme is already provided by the examiner presenting the target item (Stackhouse & Wells, 1997). Assessments from Bortolini (1995) and Degasperi (2018) have also been discarded as eliciting spontaneous speech through complex picture description. Despite having the potential to elicit a more 'natural' speech sample (i.e. spontaneous utterances prompted by pictures vs. single-word picture naming) while still maintaining some control over the phonemes' representation, these present limitations that may reduce their reliability. Pictures in the PFLI (Bortolini, 1995) have different potential for discussion, some relying too much on the child's willingness to talk as well as their language skills, thus penalising children with lower language skills and/or who are less willing to speak. Across both tests, some items/words are overstimulated while others appear rarely, leading to over- or under-representation of certain phonemes over others, thus limiting the reliability of the results (see Literature Review I, section 1.3.1).

Table 13) are not solid in terms of psychometric properties, and all present limitations in item selection, phonological representation, and task construction (Zmarich et al., 2012). All tests were originally constructed with the scope of providing a tool for the description of children's speech in the perspective of identifying SSDs.

In terms of task administered, it was argued in Literature Review I (section 1.2.1.2) that a picture naming task is the most appropriate to collect developmental data on children's speech. In addition to being a time-effective task both in terms of recording and analysis, a naming task allows for a high item control and thus inter-individual comparability (Bernhardt & Holdgrafer, 2001; Materson et al., 2005). This excludes from the available potential tests to obtain missing normative data Schindler (1986)'s repetition task, which can only provide information on the stimulability of the phones and phonemes, as the motor programme is already provided by the examiner presenting the target item (Stackhouse & Wells, 1997). Assessments from Bortolini (1995) and Degasperi (2018) have also been discarded as eliciting spontaneous speech through complex picture description. Despite having the potential to elicit a more 'natural' speech sample (i.e. spontaneous utterances prompted by pictures vs. single-word picture naming) while still maintaining some control over the phonemes' representation, these present limitations that may reduce their reliability. Pictures in the PFLI (Bortolini, 1995) have different potential for discussion, some relying too much on the child's willingness to talk as well as their language skills, thus penalising children with lower language skills and/or who are less willing to speak. Across both tests, some items/words are overstimulated while others appear rarely, leading to over- or under-representation of certain phonemes over others, thus limiting the reliability of the results (see Literature Review I, section 1.3.1).

Table 13: Currently available assessments of Italian children's phonetic and phonological development.

Author/s	Test	Target Age	Task/s	Analysis	Normative Data
Fanzago (1983)	Test di Valutazione dell' Articolazione	Not specified	Picture Naming	Each phoneme recorded if correct, omitted, substituted, distorted (for each phoneme in each position)	None reported
Bortolini (1995)	PFLI - Prove per la valutazione fonologica del linguaggio infantile	2;0-5;0	Complex Picture Description + 3 Story Telling	Independent and relational: only descriptive, no scoring assigned	Unknown sample and procedure
Rossi et al. (1999)	Test di Articolazione	Not specified, initially standardised on 5;0-6;0	Picture Naming + 6 Repetitions	Each phoneme recorded if correct, omitted, substitutes, distorted, correct in repetition or correction attempted but failed	100 children + Tresoldi et al. (2018): 694 children (347 females, 347 males)
Marini et al. (2015)	BVL_4-12 - Batteria per la Valutazione del Linguaggio nei bambini dai 4 ai 12 anni (Subtest Articolazione e Denominazione)	4;0-11;11	Picture Naming	Articulation Score (2 if correct word articulation, 1 if correct in repetition, 0 if incorrect) + descriptive table for substitutions/ omissions	1086 children (563 females, 523 males)
Degasperi (2018)	FON-FUN Fonologia in Gioco	From 3;0	Complex Picture Description through an interactive task	Independent and relational: only descriptive, no scoring assigned	Longitudinal on 562 children aged 2;0-4;0 (TD and SSD)
Zmarich et al. (in progress)	TFPI - Test Fonetico per la Prima Infanzia	1;6-3;0	Object (18-23m)/ Picture (24-36m) Naming	Independent and relational: only descriptive, no scoring assigned	Version of 2010: tested on 30 children (15 females, 15 males)
Schindler (1986)	Esame Fonemico di Prima Consultazione	Not specified	Word Repetition	None reported	Tresoldi et al. (2015) :557 children (257 females, 282 males)

Among the assessments implementing a naming task, the TFPI (Zmarich et al., 2012) is currently under continuous revision and not yet published, although preliminary norms

on a group of 30 children. Two assessments remain which could be chosen to collect new data: the articulation test by Rossi et al. (1999), and the BVL_4-12 (Marini et al., 2015). The former was originally standardised on 100 children between the age of 5;0-6;0, although no resulting data is provided in the test manual for normative comparison. In recent years, Tresoldi et al. (2018) standardised it on a much wider population and age group (see Similar tasks were implemented across studies, as outlined in **Error! Not a valid bookmark self-reference.**. Three studies aimed at collecting developmental data (Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zmarich & Bonifacio, 2005), while several studies aimed instead at gathering normative data on specific measures for tests already available (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress; Zmarich et al., 2012). Of these, one study implemented a repetition task, thus assessing solely the stimulability of Italian phones (Tresoldi et al., 2015). The remaining studies used Bortolini's (1995) 'Prove per la valutazione Fonologica del Linguaggio Infantile' (PFLI) test (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012); although this does have normative data (Bortolini, 1995), neither demographic information on the sample nor the number of participant assessed was reported.

In terms of measures investigated, all but Bortolini and Leonard (1991) reported the phonetic inventory of the population under scrutiny, some additionally providing information on consonant clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), as well as number or percentage of consonants correct (Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012). It is necessary to mention that the task administered by Zmarich et al. (2012) did not elicit all Italian phones, but rather tested solely the ones considered typical in the vocabulary of each age group. Consequently, children who might have been able to correctly produce some of the phones absent from the test were potentially penalised in terms of PCC scores. Only five studies explored phonological patterns (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). A critical evaluation of the characteristics of the studies investigating phonological patterns will be provided later in the chapter (see section 2.3.2), while an analysis of the methodologies used for the study of consonant acquisition will be discussed here.

Table 5). Solely an articulation score (see

In terms of task administered, it was argued in Literature Review I (section 1.2.1.2) that a picture naming task is the most appropriate to collect developmental data on children's speech. In addition to being a time-effective task both in terms of recording and analysis, a naming task allows for a high item control and thus inter-individual comparability (Bernhardt & Holdgrafer, 2001; Materson et al., 2005). This excludes from the available potential tests to obtain missing normative data Schindler (1986)'s repetition task, which can only provide information on the stimulability of the phones and phonemes, as the motor programme is already provided by the examiner presenting the target item (Stackhouse & Wells, 1997). Assessments from Bortolini (1995) and Degasperi (2018) have also been discarded as eliciting spontaneous speech through complex picture description. Despite having the potential to elicit a more 'natural' speech sample (i.e. spontaneous utterances prompted by pictures vs. single-word picture naming) while still maintaining some control over the phonemes' representation, these present limitations that may reduce their reliability. Pictures in the PFLI (Bortolini, 1995) have different potential for discussion, some relying too much on the child's willingness to talk as well as their language skills, thus penalising children with lower language skills and/or who are less willing to speak. Across both tests, some items/words are overstimulated while others appear rarely, leading to over- or under-representation of certain phonemes over others, thus limiting the reliability of the results (see Literature Review I, section 1.3.1).

Table 13) is provided instead for the subtest by Marini et al. (2015).

Of the two remaining tests, in terms of test construction, Rossi et al. (1999) elicit targets which cannot all be considered developmentally appropriate for young children and which include infrequent CC/CCC structures (e.g. disgrazia /dizgratsja/ 'disgrace'; rinfresca /rimfreska/ 'refresh'). Additionally, some clusters are elicited through word repetition (e.g. artrite /artrite/ 'arthritis'), thus providing stimulability information which are not comparable with the spontaneous production elicited through naming. Although the BVL_4-12 subtest is aimed at children from 4;0 years onward, items elicited appear to be suitable for children already from the age of 3;0 when cross-checked with the PVB-Primo Vocabolario del Bambino (Caselli et al., 2015), which contains the adapted version of the MacArthur questionnaire (Fenson et al., 2007). Additional detail on the BVL_4-12 and the TFPI test will be provided in the following section in order to obtain a better understanding of the tools adopted for the data collection in this thesis.

2.4.2 The BVL_4-12 subtest vs the TFPI

The subtest 'Articolazione e Denominazione' (i.e. 'Naming and Articulation') of the BVL_4-12 (Marini et al., 2015) was implemented for the collection of primary data (i.e. Cohort 1) as it was judged to be the most appropriate Italian assessment based on the previous discussion (2.4.1). The 2011 version of the TFPI was instead used by Zmarich et al. (2012) to collect preliminary normative data for the test under development. These data were shared for the purpose of this thesis as secondary data (i.e. Cohort 2). A comparison of strengths and limitations of the two assessments will be provided in this section. Table 14 gives an overview of the psychometric characteristics of the assessments and outline their main construction features, while Table 42, Table 43, and Table 44 in Appendix 5 specify the numbers of consonants, consonant clusters, and vowels across all word positions for the two tests.

Although both tests aim to elicit single word production through naming, the TFPI differentiates the task for the lower age group, using toys in place of the images adopted with the two higher age bands and by the BVL_4-12. Concerning the target population, there is no overlap in the age groups targeted by each test, with the TFPI being aimed at younger and the BVL_4-12 at older children (see Table 14). Target words in both tests were selected to reflect the phonotactic rules of Italian, presenting all the main syllable structures and word stress of Italian (see Table 45 in Appendix 5 for detailed information of word stress types present in both tests). Both are also in line with international recommendations in accounting for the effect of age-appropriateness of the target items

on children's performances, as discussed in Literature Review I, section 1.3.1 (Flipsen & Ogiela, 2015; McCauley & Swisher, 1984).

Of the two assessments, the BVL_4-12 presents a higher phoneme elicitation, in line with the guidelines available in international literature (James et al., 2009; Stoel-Gammon & Dunn, 1985), compared to the TFPI. Although presenting the risk of certain items being more frequent in the vocabulary of older children compared to younger children, the BVL_4-12 utilises a single item list for the entire population tested, independent from children's age. This permits not only a comparison of data across children but also the possibility to replicate the test longitudinally at different testing points to evaluate developmental progress. On the contrary, the TFPI is divided into three subtests, one for each 6-month age group, which differ between each other in terms of words selected (with increase of complexity in terms of number and type of syllables) and phonemes represented: phonemes not elicited in the younger age groups are introduced in words with simple CVCV structures in the following age group, while phonemes already part of the lists for the younger children are inserted in words with higher complexity. The use of different items for the individual age groups and the adoption of the object naming task for the youngest children limit the comparability of the findings from the TFPI. Furthermore, this prevents the possibility of children with a higher development to emerge, as the lower age bands are not presented with all phonemes, and the ones elicited are not addressed in all possible occasions (see Table 42, Table 43, and Table 44 in Appendix 5).

Finally, across both tests, solely the most frequent consonant clusters are elicited in only one or two occasions, in WI and/or WM syllable-initial position. As explained by Zmarich et al. (2012) for the TFPI, and observed for Marini et al. (2015)'s BVL_4-12, both tests do not consistently elicit the same CC/CCC structures more than once, but rather present different sequences of the same phonological classes (e.g. do not repeat cluster /sk/, but elicits other sibilant+plosive types of clusters, e.g. /zb/). All the phonological patterns so far suggested across Italian literature have the chance to emerge across various items.

Table 14: Features of the BVL_4-12 subtest and the TFPI test.

	BVL_4-12 (Naming and Articulation)	**TFPI**
Target Age Group	4;0-12;0	1;6-3;0

Task	Black and white picture Naming (+ 2 coloured pictures)	Object (1;6-1;11) and Picture (2;0-2;5, 2;6-3;0) Naming
Phonemes Assessed	All.	Progressively more with age increase; missing /ɲ/.
Positions	At least once in all possible positions, except for 7 phonemes (positions not elicited are very rare in Italian)	At least once for the most frequent positions; fewer and less complex structures elicited at 1;6-1;11, progressively more with age increase.
Occurrences	All phonemes ≥ 4, except /ʃ/ (3), /ʤ/ (3), /ŋ/ (1), /ɲ/ (2), /ʎ/ (3)	All phonemes ≥ 4, except /z/ (2), /ʤ/ (3), /ŋ/ (2), /ʎ/ (2)
Phonological Processes	All potentially occurring 6 times or more, except for patterns affecting /ʃ, ʎ/.	More or fewer potential occurrences according to age tested.
Syllable Structure	2-4 syllables	2-4 syllables

2.5 Overview

Overall, the Literature Reviews I and II have provided key information regarding the theories behind the acquisition of the phonological system and the necessity of evaluating children's speech sound and phonological development, as well as the current situation for Italian. Literature Review I identified elements of the theoretical models currently available on phonological development which could find supporting evidence in the current research, highlighted the main pros and cons of adopting a naming task to evaluate speech production, and provided information on its related analyses and their outcome (e.g. phonetic vs. phonemic inventories, percentages correct, phonological patterns vs. infrequent variants). An appropriate and reliable collection on data on the phonological development of children is fundamental for understanding the language-specific typical development of a population, and for distinguishing children who follow the typical acquisition from those who deviate from it (Preston et al., 2013).

Literature Review II have identified the normative data currently available across Italian literature investigating children's phonological development (Bortolini, 1995; Bortolini & Leonard, 1991; D'Odorico et al., 2011; Tresoldi et al., 2015; Tresoldi et al., 2018; Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., in progress; Zmarich & Bonifacio, 2005; Zmarich et al., 2012). Despite the existence of 11 studies,

there is still a paucity of reliable information available for consonant clusters and vowels acquisition, as well as for numbers of phonological variation tokens, the emergence and disappearance of phonological pattern types, and for InfrVar. It is therefore necessary that further data in these areas be collected. In this light, the available Italian assessments of children's speech have been explored in order to identify the most appropriate for this purpose.

Having concluded the presentation of the available evidence for the development of the Italian phonological system, and identified the BVL_4-12 assessment as the most appropriate to collect data on the missing measures (i.e. percentages correct, phonological variations tokens, phonological pattern types, and InfrVar), the aims and objective of the current research need to be outlined.

2.6 Research Questions and Hypotheses

Following from the discussion and key information raised in these first two chapters, the current research aims to describe the typical speech sound acquisition and phonological development of monolingual Italian-speaking children aged 1;6-4;11. Based on the available literature, hypotheses were drawn in relation to each of the research questions.

The research questions and relative hypotheses are as follows:

1. How does Italian speech sound acquisition proceed over time across the critical age of 1;6-4;11?

    a. To which degree do Italian children approximate the adult target, in terms of percentage of consonant and vowel correct at each age?

        i Italian children will present developmental progression in consonant production accuracy, with higher PCC with age increase (e.g. Zmarich et al., 2012), and approaching, although not reaching, 100% at 4;11 (e.g. Lousada et al., 2012; Rvachew et al., 2013). Vowel production will approach the adult target already at the age of 3;0-3;5 (e.g. Bohn, 2017; Giulivi et al., 2006).

    b. Which consonants, vowels, and consonant clusters are present at each age as shown in the inventory from the picture naming task?

i The acquisition of consonants across ages will overall follow the sequence identified across previous Italian studies and research on romance languages, albeit with some differences likely due to different cut-off criteria adopted to describe phones present in children's inventories.

ii Italian children will show mastery of most phones before the age of 4;0, although consonants such as /r, ʎ/ will remain below the cut-off for mastery in the older age group, showing continuous development beyond the age of 5;0 (e.g. Guimarães et al., 2019; Tresoldi et al., 2018).

iii The complete vowel system will be present at age 3;0-3;5 (Bohn, 2017; Giulivi et al., 2006).

iv Italian children will demonstrate similar ages of acquisition for tautosyllabic and heterosyllabic clusters, with earlier acquisition of CC structures with semiconsonants, and later mastery of clusters with fricatives and CCC structures (Tresoldi et al., 2018; Zmarich et al., 2012).

c. What is the percentage of correctly imitated phones at each age, and which sounds can be considered part of the inventory in terms of stimulability (i.e. child's ability to repeat them)?

i In terms of stimulability, Italian children will show earlier age of mastery for most consonants produced in repetition (e.g. alveolar and postalveolar affricates as reported by Tresoldi et al., 2015). However, features of the Italian syllabic system (i.e. the absence of syllabic consonants, and the high frequency of CV structures) may have an impact on the task, reducing the accuracy in children's performance on phone repetition in isolation.

2. Which phonological variations occur in the typical development of Italian speaking children of the population under study?

a. To which extend does the occurrence of phonological variations (Tokens, Types, and Infrequent Variants) change with age indicating progress of phonological development?

    i It can be hypothesised that children will present a decreasing number of overall Tokens, of types of phonological patterns, and of infrequent variants presented with age increase, demonstrating developmental progression.
    ii The proportion between patterns and InfrVar may change with age increase; the majority of the phonological variations presented by older children will be classified as patterns as the phonological system becomes more stable, while at younger ages a higher percentage of InfrVar will be observed alongside a larger number of pattern types.
    iii A number of tokens, types of patterns, and InfrVar will still be present at the age of 4;11, in line with the continuation of the development beyond the age of 5;0 (e.g. Tresoldi et al., 2018).

b. Which types of phonological pattern can be observed as developmentally typical at what age when two different cut-offs (i.e. ≥4, ≥6) are adopted?

    i A lower number of patterns compared to the currently available literature will be considered to be typical across the development due to more restrict cut-offs applied to determine a phonological pattern, and to a more specific definition of each pattern (focussing on one sound or class of sounds rather than the same pattern applied to diverse classes of phones: e.g. ‘fronting of velars’ and ‘fronting of postalveolar’ vs. the broader pattern ‘fronting’).
    ii Patterns typically found across the development of speakers of other languages (e.g. initial cluster reduction; Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012) and which could generally be considered ‘universal patterns’ are expected.
    iii Italian children will present language-specific patterns in line with features of the Italian phonological system which are not presented across other languages (e.g. geminates, heterosyllabic consonant clusters).
    iv Most patterns will appear to be resolved by the age of 4;11, although a few patterns involving late-mastered sounds will remain present in

the higher age group, suggesting continuation of the development beyond the age of 5;0.

Despite the current thesis not aiming to prove any theoretical framework, a few considerations may be done on the contribution of the results of the present study to the debate on theories of phonological acquisition discussed in 1.1 Theories in Phonological Acquisition. Indeed, three main hypotheses have been derived from the available models, with particular focus on Emergentist models.

T1. Italian children are hypothesised to demonstrate early acquisition of those sounds which are commonly acknowledged as being the first to be developed across languages (e.g. plosives, semiconsonants). This would provide supporting evidence for the existence of a core set of sounds shared across languages postulated by emergentist models such as, for instance, the Frame/content model by MacNeilage (1998).
T2. The predicted presentation of language-specific phonological patterns (see point 2b above) will tie with the discussed role of the ambient language in the development of children's phonological system considered by both formalist (e.g. Donegan & Stampe, 1979) and emergentist (e.g. Menn et al., 2013) models.
T3. Discrepancies, not attributed to age differences, between the two cohorts investigated will support the idea, brought forward by Davis and Bedore (2013), that the interaction between external (e.g. input, geographical area) and internal factors (e.g. personal/biological skills, social interaction abilities) plays a role in differentiating the development of children who share a linguistic background.

3. Methodology

To address the research questions, a cross-sectional study was undertaken, and two sets of data were analysed. The first set of data (i.e. Cohort 1) was collected on children aged 3;0-4;11 years old; the second (i.e. Cohort 2) involved secondary data of children aged 1;6-3;0 (from Zmarich et al., 2012). Figure 2 summarises the design of the research. The current chapter presents information on participants recruitment and sample information separately for the two cohorts, and outlines the analyses undertaken on the data.

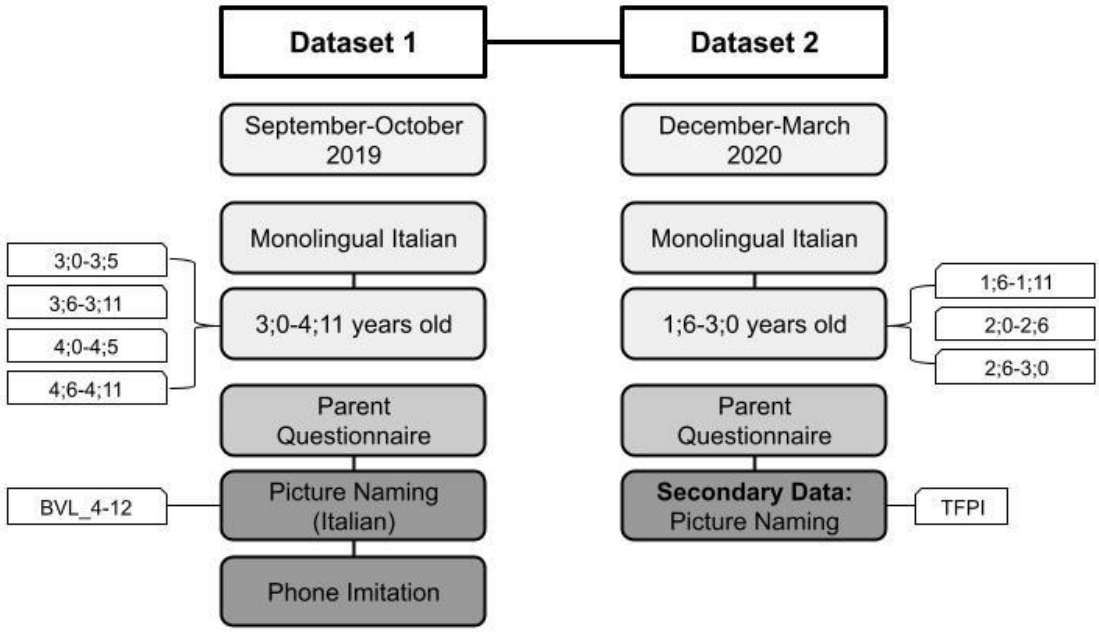

Figure 2: Study Design (data collection period, sample composition, and tasks information for the two cohorts of the project).

3.1 Participants

Two cohorts of children (Cohort 1 and Cohort 2) were involved in the current project, which are described separately.

3.1.1 Cohort 1

183 monolingual Italian-speaking children participated in the study, forming four 6-months age groups, i.e. 3;0-3;5, 3;6-3;11, 4;0-4;5 and 4;6-4;11 years (see

Table 15). Male participants outnumbered female participants in all but one age groups. This uneven distribution was not considered an issue as, so far, no consistent gender related differences have been found in speech acquisition research (Dodd et al., 2003).

Table 15: Distribution of Cohort 1 across gender and age bands.

Age group	n	M	F	$M_{age(months)}$	$SD_{(months)}$	% of sample
3;0-3;5	28	15	13	38.39	1.75	15.30%
3;6-3;11	55	26	29	44.58	1.77	30.05%
4;0-4;5	60	37	23	50.08	1.83	32.79%
4;6-4;11	40	27	13	56.10	1.57	21.86%
Total	183	105	78			

Children were recruited from 16 nurseries across the area of Genoa in the north of Italy. Nurseries' head educators of seven Comprehensive Institutes (i.e. local groups of nurseries and schools for students aged three to 18 years) were emailed an invitation to participate in the research, an information leaflet explaining the project and the selection criteria for the participants, and consent forms for the nursery (see Appendix 3: all the documents are provided in English. Italian translations of these were used for the settings and parents). Head educators were asked to present the project for approval to the director of their Institute in the first Institute Council meeting of the academic year, at the beginning of September 2019. Head educators were then required to sign the consent form for their setting. In four cases in which emails remained unanswered, directors and head educators were contacted directly over the phone by the researcher through the admin offices. Following first contact, a meeting was scheduled between the researcher and the educators of each Institute to discuss the project details and answer any queries. Six Comprehensive Institutes, comprising a total of 17 nurseries, agreed to participate in the project. One of the nurseries within a Comprehensive Institute did not agree to take part in the study. The remaining 16 participating settings were provided with paper copies of information leaflets, consent forms and questionnaires regarding parents' and child's background information, as well as language use and development (e.g. regional variation of Italian and the potential local dialects spoken by both parents, parents' level of education; see Appendix 3) to hand to parents of children they identified as meeting the following selection criteria:

- aged between 3;0 and 4;11 years old
- growing up monolingually with Italian (i.e. not being consistently exposed to any other language in the home environment),
- typically developing (i.e. no known syndromes or cognitive difficulties),
- no diagnosed hearing disorders or speech and language difficulties,
- not having received speech and language therapy.

A total of 330 children were invited to take part in the project. Signed consent to participate and questionnaires were obtained for 222 children across settings. In order to control for eligibility of children to participate in the study, answers to the questionnaires were examined prior to the beginning of the testing period in each nursery. In the case of 21 children who did not fulfil all selection criteria, parents were informed that their children did not meet the required criteria and therefore could not take part in the study. Out of the 201 children who met the inclusion criteria and were recruited, 18 were either absent from their school on the days of testing or were unwilling to participate, resulting in the final study sample for Cohort 1 of 183 children (

Table 15).

Information obtained through the questionnaires is summarised in Table 36, Table 37, and Table 38 in Appendix 4. Regional variations and dialects spoken were considered in order to account for potential phonetic and phonological variations that could emerge due to children being exposed to different variations of Italian. Overall, the majority of parents reported to speak the Ligurian regional variation of Italian. Other regional variations and few local dialects were reported to be spoken by one or both parents, although only for a minority of participants (Table 36 and Table 37, Appendix 4).Taking parent's education as an indicator of Socio-Economical Status (SES), the sample appears to be representative of the Italian society (Table 38, Appendix 4).

3.1.2 Cohort 2

Speech data of 30 children aged 1;6-3;0 were shared by the first author of Zmarich et al. (2012) in the form of Phon files, including the original voice recording and IPA transcription. Data on the sample compositions will be reported below as provided by Zmarich et al. (2012). It is relevant to specify that data on this age group were not collected first-hand due to the limited time-frame of the original research plan, which was changed following the national restrictions due to the Covid-19 pandemic (see Introduction). Additionally, the subtest adopted to assess children in the first cohort (i.e. Naming and Articulation, from BVL_4-12) is designed for children above the age of 4;0, although all items included are acquired by the age of 3;0: this renders the assessment suitable for Cohort 1, but not appropriate for a younger population.

Cohort 2 included equal numbers of male and female participants (15 boys and 15 girls). 19 children were recruited in the Veneto region, while 11 were from the Marche region. Participants were divided into three 6-month age groups, i.e. 1;6-1;11, 2;0-2;5, 2;6-3;0. Data on the number of male and female participants in each age group and mean age are summarised in Table 16.

Table 16: Sample composition of Cohort 2 from Zmarich et al. (2012).

Age group	n	M	F	$M_{age(months)}$	$SD_{(months)}$	% of sample
1;6-1;11	10	4	6	20.40	2.50	33.33
2;0-2;5	10	5	5	27.00	2.00	33.33
2;6-3;0	10	6	4	32.50	3.00	33.33
Total	30	15	15			

In addition to age, selection criteria required the child not to present any speech, language, and communication difficulties, not to have a diagnosis of or suspected hearing disorder, and to be a monolingual Italian speaker. These criteria, with the exception of age, were in line with the selection criteria of the first cohort. Solely previous speech and language therapy was not mentioned among the criteria for Cohort 2. As for Cohort 1, children's eligibility to participate was evaluated through a parental questionnaire that was checked by the paper authors during the recruiting process. Data on the participants' receptive and productive language and communication skills were also collected. The second checklist ('Parole e Frasi', 'Words and Sentences') of the Italian version of the MacArthur-Bates Communicative Development Inventories, the test PVB – Primo Vocabolario del Bambino (Caselli & Casadio, 1995) was provided to parents and carers to fill in alongside the above-mentioned questionnaire; both the questionnaire and the PVB were collected and scanned prior to testing in order to select only children who matched the inclusion criteria. In addition to the phonological testing, the Test del Primo Linguaggio – TPL (Axia, 1995), was also administered, in a separate session with each child, in order to collect in-depth information on their communicative and linguistic skills. Information on children's performance on this test can be read in detail in the original paper by Zmarich et al. (2012), and are not reported here as they were not involved in the secondary analyses undertaken here.

3.2 Assessment tasks and materials

Both a picture naming test and a phone imitation task were administered with Cohort 1. A different naming test was used to assess children in the second cohort. This section presents the individual tasks separately for each cohort.

3.2.1 Cohort 1

3.2.1.1 Picture Naming: BVL_4-12

The picture naming task of the 'Naming and Articulation' subtest of the 'Batteria per la Valutazione del Linguaggio in Bambini dai 4 ai 12 anni' (Marini et al., 2015) was adopted. Although the battery is aimed at children above the age of 4;0, words elicited in the subtest were all checked for age of acquisition through scanning of the test PVB (Caselli & Casadio, 1995; Caselli et al., 2007). It was ensured that all words elicited via the 77

items are typically acquired before the age of 3;0 years and were therefore appropriate to use with the target population of this research. Three practice items are included in the test to ensure understanding of the instructions. A list of all items and their IPA transcription, as well as tables reporting the occurrence of consonants, vowels, consonant clusters, ad stress structures elicited can be found in Appendix 5 (Table 39, Table 42, Table 43, Table 44, and Table 45).

Despite an under-representation of certain phonemes in the assessment (as presented in the Literature Review II, section 2.4.2), it is essential to notice that the choice of test was made according to the original project's time constraints. As it was originally planned to collect a second set of data on bilingual children speaking English and Italian, data on monolingual Italian-speaking children had to be collected in a limited time frame. For this reason, it was decided not to create a specific assessment tool, but to select a test that met as many criteria for test construction as possible, but which was already available and published. Limitations due to the arising of the Covid-19 pandemic prevented the second part of the data collection (i.e. bilingual English-Italian children) from taking place (see Introduction), and the monolingual set of data consequently became the sole focus of the project.

During administration, for all items presented in the naming task, spontaneous production of the target word was elicited through the use of questions such as 'what is this?', 'what can you see in the picture?' for names, and 'what is s/he (are they) doing?' for actions. If a child was not able to retrieve the target word, three progressive cues were given (see Table 40 in Appendix 5). First, a semantic cue was provided, describing the definition or function of the object/action. If the child was still unable to name the item, a choice between two words was given. The target word was preferably provided first, in order to avoid direct repetition. Repetition of the target word was solely elicited in the case when a child did not choose the correct name when given the choice.

3.2.1.2 Phone Imitation

All phones present in the Italian consonant inventory were presented in isolation by the examiner for children to repeat (see Appendix 5, Table 46). A total of three repetitions were allowed. In case a child could not imitate the target or produced it incorrectly, a repetition was provided by the examiner and the child encouraged to attempt it again. If the child proved again unable to imitate the target or unwilling to try and produce it, one

last model was provided, while the child was prompted to pay attention to the examiner's mouth and attempt repetition again.

3.2.2 Cohort 2

This section gives an overview of the task that was implemented in the original study from Zmarich et al. (2012).

3.2.2.1 Picture Naming: TFPI

The TFPI assessment (Zmarich et al., 2012) was administered with children of the second cohort. As outlined in the Literature Review, the test differentiates item lists for its three target age groups, implementing an object naming task with the youngest children (i.e. 1;6-1;11), as opposed to a picture naming task for the other two age groups (i.e. 2;0-2;5 and 2;6-3;0). 33 words are elicited in the list for children aged 1;6-1;11, 48 words are elicited in the 2;0-2;5 list, and 58 words are present in the 2;6-3;0 list. As for the BVL_4-12 subtest, a list of items and information on the occurrence of targets elicited can be viewed in Appendix 5 (Table 41, Table 42, Table 43, Table 44, and Table 45).

3.3 Procedure

Having presented information on the populations investigated and the materials adopted, the following sections outline the steps undertaken to collect the data in the two cohorts.

3.3.1 Cohort 1

Prior to the beginning of the data collection, testing assistants were recruited in order to ensure completion of the data collection within the anticipated time frame and cover a wider geographical area. Speech and Language Therapists and/or SLT students were contacted and recruited through personal contacts of the researcher; those interested in participating in the data collection were provided with the setting's project Information Leaflet and a Consent Form for testing assistants (see Appendix 3) to give permission to be recorded. Four testing assistants responded to the request and were recruited. At the beginning of the testing period, the testing assistants were trained on how to deliver the assessment (e.g. following cues hierarchy) and observed the main researcher conducting a testing session. Following this step, the main researcher observed each of their first sessions and gave feedback on the administration of the tasks. This procedure was implemented in order to ensure consistency of test administration across testers.

The assessment phase was conducted throughout the month of October 2019. Data collection took place during typical nursery hours. Upon arrival at a nursery, on the first arranged testing day, parents' questionnaires were examined to determine whether children met the inclusion criteria and were therefore eligible to participate in the study: examiners checked these before testing, and informed the parents of those who were not suitable for participating through nursery staff. At the beginning of the first testing day in each nursery, the researcher and testing assistants spent some time with the groups of children within the classroom environment in order for the children to get accustomed to their presence and get to know them before their first testing session. A puppet used in the assessment sessions was introduced to the classrooms and the children were allowed to play with it before the beginning of the testing sessions. Each participant was then taken out of the classroom individually for one assessment session conducted in an available quiet space withing the nursery (Mean duration=21 minutes and 45 seconds).

The assessment sessions started with clear and simple verbal information about the study and the activities involved being given to each child, with the support of a brief power-point presentation (see Appendix 3). It was made clear that participation was not compulsory, that they could ask for breaks if they felt they needed one, and that they could ask to return to class at any time. Verbal assent was sought at the end of the explanation through the use of a 2-picture choice with a happy and a sad face. The naming tasks and the phone imitation tasks were administered by the researcher or one of the trained assistants. Paper-based record sheets specifically designed for this data collection were used during testing for online transcription of responses using IPA (see Appendix 5). Answers provided through all eliciting methods were recorded. As sessions were audio-recorded, solely erroneous productions of the targets were fully transcribed online using the International Phonetic Alphabet (IPA); when a response was correct, this was marked with a tick on the scoring sheet. For the naming task, notes were also taken on whether a child named each target spontaneously (✓ on the record sheet), after being provided with the semantic cue (S), selected the correct choice (C), or repeated the target (R). For the imitation task, the number of models provided (i.e. up to three) was marked.

3.3.2 Cohort 2

Detailed information about the participants recruitment and testing procedure may be found in the original paper by Zmarich et al. (2012). Overall, following the recruitment steps (i.e. obtaining consent, questionnaire, and PVB compilation from parents, and

scanning of questionnaire and PVB answers to check for inclusion criteria), children that were selected to participate had been individually tested in a quiet room in their preschool setting, over two separate sessions, i.e. the first investigating speech and phonological development (through the TFPI test), the second addressing language and communication skills (through the TPL test). All sessions with the TFPI were audio-recorded in order to allow for a delayed transcription in IPA and upload of the recordings on the Phon software (Rose & MacWhinney, 2014). Children's production of each target was marked to be produced as either spontaneously (i.e. aim of the assessment), or in imitation (i.e. target provided for repetition in case of null or misidentification).

3.4 Scoring and Data Analysis of all Data

Transcriptions of children's productions for the first cohort were inserted directly into a pre-prepared template in the Phon software for speech analysis (Rose & MacWhinney, 2014), in order to allow a direct comparison between the children's responses and the target words. A screenshot of the Phon interface is provided in Appendix 5 (

Figure 5). As for the first cohort, Zmarich and colleagues had also created a template for each test list (i.e. one for each age group) of their assessment, and segmented and transcribed individual productions against the targets. Children's recordings were shared by the first author in Phon format, but transcribed anew for the purpose of this research, in order to ensure consistency.

The following subsections provide an overview of the measures and analyses implemented on the speech data from each cohort. First, measures of percentages of consonants, vowels, and phonemes correct will be introduced the picture naming tasks. Information on the calculation of phonetic inventories will be presented for both the naming task (on both cohorts) and the phone imitation task (cohort 1). Subsequently, analyses of the consonant co-occurrences will be described. Phonological variations measures will be presented last.

3.4.1 Percentages of Consonants, Vowels and Phonemes Correct

In order to determine a child's approximation to the adult's target, measures of percentage of consonant (PCC) and vowels correct (PVC) were implemented (Shriberg & Kwiatkowski, 1982). In particular, the revised measures (Shriberg et al., 1997) were used, as considered more appropriate for the purpose of the study. Percentage of Consonants Correct-Revised (PPC-R) is calculated as Percentage of Consonants Correct PCC), with omissions and substitutions marked as errors, but does not consider

phonetic distortions and dialectal/regional variations features as erroneous production. This permits to account for dialectal variations and other phonetic distortions on targets that are otherwise phonemically correct. Distortions of a phonetic nature were also enlisted as correct productions. In a similar way, the Percentages of Vowels Correct-Revised (PVC-R) represents the closeness to the adult target of the children's production of vowels, considering all distortions as correct. These versions of the percentage correct measures were adopted since, as explained in the Literature Review I (section 1.2.1.2.1), they are highly sensitive to individual differences (Shriberg et al., 1997). PCC and PVC, as well as their revised versions, were evaluated initially for each child individually, then summarised as mean, standard deviations, and ranges per age group.

3.4.2 Phonetic Inventories

As stated above, the phonetic inventory of each child in cohort 1 was evaluated by two means: based on 1) the picture naming task, and 2) the phone imitation task. For children in cohort 2 the phonetic inventory was only calculated through the naming task, although following the same procedure as cohort 1.

For the analysis of the inventory via the picture naming task, a phone (i.e. consonants and vowels) was considered to be part of a child's inventory if it appeared correctly in at least two occasions (Fox & Dodd, 2001; Ray, 2002; Yang & Hua, 2010). Previous studies analysing phonological development proposed different arbitrary cut-off measures (D'Odorico et al., 2011; Dodd et al., 2003; Viterbori et al., 2018; Zmarich & Bonifacio, 2005); however, the decision to adopt this cut-off was made in order to avoid a misclassification of sounds that are under-represented in the assessment (i.e. less frequent consonants in Italian). For phones that are prone to phonetic distortions, it was marked whether they were present a) phonetically correct, or b) in distorted form (e.g. distortion of /s, z/, realised as interdental). The list and number of consonants and vowels present in each child's inventory were computed. In a further step, age-related inventories were drawn for both consonants and vowels. A phone was considered to be acquired by a specific age group if this was present in at least 75% of the children within the group; it was considered mastered when present in over 90% of the participants in the group.

The inventory from the phone imitation task was derived as it provides information on the stimulability of sounds that might be absent or unstable/emerging in the child's spontaneous connected speech. As each consonant sound of the Italian inventory was

elicited only once in isolation, a phone was considered to be part of the stimulability inventory if produced correctly once. As with the naming task, each phone was marked as produced phonetically correct or phonetically distorted. In both analyses the list and number of accurately realised phones were calculated for each participant and per age band, following the same criteria at age level (i.e. 75% and 90% occurrence) implemented for the picture naming task. A comparison between the phonetic inventories from the two tasks (i.e. inventories that consider phonetic distortions as incorrect, and inventories allowing for phonetic distortions) allows to determine if a child is able to produce a sound, either with or without distortions, when provided with the motor programme (i.e. target sound provided for imitation), when this is not present in spontaneous speech.

3.4.3 Consonant co-occurrences: Consonant Clusters and Geminates

In addition to single sounds inventories, a separate inventory was created for initial/tautosyllabic consonant clusters. Due to a reduced representation of clusters compared to single consonants in the assessment, a tautosyllabic cluster was considered present in a child's speech if produced phonetically correct at least once. The criteria used to determine the acquisition of a CC by a specific age group reflected the one implemented for consonant and vowel acquisition: a CC was considered acquired when present in at least 75% of the children within the group; it was marked as mastered when present in over 90% of the participants in a group. The percentage of tautosyllabic clusters correct was also calculated for each child and summarised for each age group, in terms of mean, standard deviation, and range.

Concerning the other consonant co-occurrences, i.e. heterosyllabic clusters and geminates, solely the measures of percentages correct were computed (i.e. percentage of heterosyllabic clusters correct, and percentage of geminates correct) both at child and age group level. Inventories for the heterosyllabic clusters and geminates were not considered as the lists of clusters occurring across syllable boundaries and geminates are vast and were not exhaustively elicited in the assessment used.

3.4.4 Phonological Variations

Simplification strategies in form of phonological variations found in children across development were analysed in terms of occurrence and distinguished in Phonological Patterns and Infrequent Variants. First of all, the total number of phonological variation Tokens, the total number of phonological pattern Types, and the total number of InfrVar presented by each child were calculated. The mean number of Tokens, Types, and

InfrVar, as well as their standard deviations and ranges, were then calculated across each age group. These measures, which were not investigated in previous Italian literature (see Literature Review II, section 2.3.2), are informative as they provide information on the extent to which the occurrence of phonological variations change across time, and thus indicate progression in children's development. In addition, the proportion of Types and InfrVar in relation to the total Tokens is indication of the stability of the phonological system. Indeed, when the number of Types is closer to the total Tokens compared to the number of InfrVar, the child will make more systematic simplifications, rather than occasional errors. On the contrary, a child presenting a higher number of InfrVar compared to phonological patterns (Types) will simplify the phonological system with wider variability and less consistency. A gradual change in the proportion between Types and InfrVar, with a shift towards a majority of Types with age increase, would indicate a progressive stabilisation in the phonological system across children's development.

In order to make the distinction between Types and InfrVar measures, a phonological pattern was considered to be a recurring variation that occurred in a rule-like fashion (Kirk & Vigeland, 2015); an InfrVar was instead defined as a variation emerging in children's speech with a frequency not high enough to be considered systematic simplifications (McReynolds & Elbert, 1981). Given the lack of evidence and international agreement on cut-off criteria discussed in the Literature Review I, two separate cut-offs were adopted within this project. For all those variations that could occur at least 6 times across the test, a lower cut-off of ≥4 and a higher cut-off of ≥6 manifestations were adopted to distinguish between InfrVar and Phonological Patterns. Wherever a phonological variation could only be presented in less than six times due to the construction of the test, this was considered patterns when emerging in at least half of the possible occurrences (e.g. for a simplification that could only be presented three or four time, the cut-off was two).

Thus, for each child a phonological pattern analysis was carried out twice, once according to each cut-off criterion. In addition, the age of emergence and resolution of phonological patterns was calculated across age groups. In accordance with the available research across languages (Clausen & Fox-Boyer, 2017; Dodd et al., 2003; Fox & Dodd, 2001), a pattern was classified as typical for an age group, and therefore developmental, if it was found in at least 10% of children within the same age band.

3.4.5 Inter-rater Reliability

Measures of reliability were calculated across raters for IPA transcription of the speech data, as well as for the judgment of phonological variations (i.e. Token and Types). The measures were conducted on 10% of the sample (i.e. approximately four children per age group), randomly selected and balanced across gender. Inter-rater reliability in the broad phonetic transcription was carried out at phoneme-to-phoneme comparison level. An experienced native Italian speech and language therapist acted as second rater. The mean phoneme agreement appeared to be very high (i.e. *M*=99.28, SD=0.79).

Concerning reliability of the phonological pattern analysis, the measure was calculated both on the Types of phonological patterns identified and on the total number of Tokens, based on the lower cut-off criterion adopted (i.e. ≥4). The analysis for comparison was conducted by an experienced SLT (i.e. second supervisor). The reliability score obtained for the Types was 89%. The inter-rater agreement for Tokens was also very high (Total Token Rater 1= 803 and Rater 2= 845), with a mean difference between raters per child of 2.39 (SD= 2.23).

3.5 Overview of the following chapters

In the following chapters, the findings from the analyses of percentages correct, the inventories for the naming and phone imitation tasks, and the measures calculated on consonant co-occurrences will be presented and discussed first (i.e. Results I, and Discussion I). The results on the phonological variations measures (i.e. Token, Types, InfrVar, and the occurrence of phonological patterns) will be instead reported and discussed in the subsequent chapters (i.e. Results II, and Discussion II). An overall discussion of all findings, limitations of the study and future directions will be proposed in the final chapter (i.e. General Discussion).

4. Results I

The first section of the research project aimed to investigate how Italian speech sound acquisition proceeds over time across the developmentally critical ages of 1;6-4;11. In order to address these research questions, several analyses were conducted through the use of the Phon software (Rose & MacWhinney, 2014) and subsequent manual calculations on the two cohorts (i.e. children aged 3;0-4;11; secondary data on children aged 1;6-3;0). Percentages of consonant and vowel correct, and their revised versions were calculated from the picture naming tasks. Phonetic inventories were drawn separately for the naming tasks and stimulability task. Additionally, percentages correct were calculated for tautosyllabic and heterosyllabic consonant clusters, as well as for geminates. The inventory for the tautosyllabic clusters were also evaluated. All analyses were performed on both cohorts. However, the stimulability task was solely implemented for the first cohort. The present chapter aims to report the findings obtained through these analyses.

4.1 Percentages of Consonant and Vowel Correct

Percentage of consonant (PCC) and vowel (PVC) correct were calculated on the basis of the naming tasks for both cohorts. Each measure was initially computed for all individual participants through Phon (Rose & MacWhinney, 2014). The mean, standard deviation, and range for each measure was then manually calculated across each age group. Additionally, following the same procedure, the revised measures (i.e. Percentage of Consonant Correct – Revised, PCC-R: Percentage of Vowel Correct – Revised, PVC-R: Shriberg et al., 1997) were also calculated. These allowed for potential phonetic distortions in the realisation of the target phones to be considered as correct productions. In this perspective, the use of allophones and minor phonetic variations that did not compromise the conveyance of the word meaning were accounted for and did not weigh on the percentage of correctness.

4.1.1 PCC and PCC-R

Concerning consonant production, an overall steady improvement in children's performance across all ages of the two cohorts, both for the PCC and PCC-R measures, was observed (see

Table 17). As expected, the PCC-R scores were higher than the PCC ones, although only by a minor degree.

Table 17: Mean PCC, PCC-R, and relative SD and range for the Picture Naming tasks.

	PCC M(SD)	PCC Range	PCC-R M(SD)	PCC-R Range
1;6-1;11	45.22 (11.76)	21.54-65.82	45.93 (12.26)	21.54-65.82
2;0-2;5	56.60 (9.48)	39.10-67.27	57.32 (9.70)	39.10-67.27
2;6-3;0	68.22 (7.93)	54.25-82.67	68.64 (7.89)	54.72-83.11
3;0-3;5	75.24 (13.27)	40.69-96.40	76.83 (12.82)	42.27-96.40
3;6-3;11	76.88 (15.28)	16.39-97.13	78.95 (15.63)	16.39-97.13
4;0-4;5	84.86 (9.00)	51.49-97.60	86.65 (8.97)	52.61-97.60
4;6-4;11	87.27 (7.17)	68.72-97.60	88.48 (7.07)	68.72-98.35

Children performed with noticeably lower accuracy in the younger groups compared to older children, with less than half of the consonant produced correctly, even when phonetic distortions were accepted. Accuracy in consonant production steadily increased with age, with PCC and PCC-R being almost double for the older age group compared to the youngest children (PCC and PCC-R respectively 87.27% and 88.48% at the age of 4;6-4;11), indicating that children are approximating completion of the phonological system. It is worth noticing that both measures present large SD and ranges, manifesting a wide variability among children within the same age band. This is true in particular for the younger children and those between 3;5-3;11, with some children across all age groups in the first cohort performing at ceiling level. However, this measure is also reduced with age increase, indicating a gradual stabilisation of the development. Overall, all values for PCC-R appeared higher than PCC, although the differences were marginal, indicating a reduced impact of phonetic distortions on consonant acquisition.

4.1.2 PVC and PVC-R

Similarly to the trend observed for consonant production, vowel accuracy was found to largely increase from younger to older children (Table 18Table 18), with means PVC and PVC-R as high as 71.77% and 72.29% respectively already at the age of 1;6-1;11, and as 97.92% and 98.01% respectively at the age of 4;6-4;11, although with wide SD and range values. Despite the similar trend, however, accuracy in vowel production approximated a ceiling effect across all age groups from 3;0 years onward. Additionally, the difference between the younger and older children was less marked. PVC values across age group were markedly close to their correspondent PVC-R values, appearing identical across two age groups, suggesting that Italian children do not generally produce phonetic distortions in acquiring their vowel system.

Table 18: Mean PVC, PVC-R, and relative SD and range for the Picture Naming tasks.

	PVC M(SD)	PVC Range	PVC-R M(SD)	PVC-R Range
1;6-1;11	71.77 (11.06)	44.00-86.96	72.29 (11.18)	44.00-86.96
2;0-2;5	82.85 (6.34)	72.09-89.34	82.85 (6.34)	72.09-89.34
2;6-3;0	88.81 (4.65)	78.29-93.70	88.81 (4.65)	78.29-93.70
3;0-3;5	95.73 (5.38)	73.03-100.00	95.78 (5.25)	73.68-100.00
3;6-3;11	95.36 (6.09)	71.96-100.00	95.47 (5.97)	71.96-100.00
4;0-4;5	97.07 (3.70)	85.29-100.00	97.11 (3.72)	85.29-100.00
4;6-4;11	87.27 (7.17)	68.72-97.60	88.48 (7.07)	68.72-98.35

4.2 Phonetic Inventories

For the purpose of evaluating which phones are present at each developmental stage, phonetic inventories were drawn from both the picture naming tasks (both cohorts), and the phone imitation tasks (for cohort 1 only).

4.2.1 Phonetic Inventory derived from Picture Naming task

First, Phon (Rose & MacWhinney, 2014) was used to obtain the number of times each child produced each phone in the naming task. Subsequently, the number and percentage of children who produced each phone correctly (phonetic distortions counted as errors) at least twice was calculated, and a summary for each age group investigated was derived. All phones that were observed in one age group between 50-75% were labelled as emerging in that age group; all phones appearing in at least 75% of children were considered acquired; all phones present in more than 90% of children were considered mastered. Since the two cohorts were tested using different assessment tools, the findings from the two populations will be presented separately, starting with the second cohort following a developmental sequence.

4.2.1.1 Cohort 2 (1;6-3;0)

Secondary data obtained through the analyses of children from the second cohort are summarised in

Table 19, which reports the newly emerging, acquired, and mastered consonants in each age group. Table 47 in Appendix 6 reports the percentage of occurrence of each phone in each age group.

Table 19: Acquired and mastered phones at each age for the picture naming task in the second cohort.

	Emerging (≥50%)	Acquired (≥75%)	Mastered (≥90%)
1;6-1;11	d, k	m	p, t, n, l
2;0-2;5	g, ʃ	f, v	b, d, k, s, ʧ, m, j
2;6-3;0	z, ʤ, r	w	g, f, v

Already prior to the age of 2;0, a small number of consonants appears to be mastered, namely /p, t, n, l/. Between 2;0 and 3;0 years of age, the children's inventory largely increases, with mastery of all but one plosives, two of the three nasals, as well as /s, ʧ, j/. At the age of 3;0, /w, z, ʤ, r/ remain below the 90% threshold, while /ʦ, ʣ, ɲ, ʎ/ are still produced by low percentages of children.

Concerning vowels (Table 20), four out of seven vowels were mastered already in the youngest age group and the vowels /ɔ, u/ were mastered in the second age group. The last vowel to be mastered was /ɛ/ at the age of 2;6-2;11.

Table 20: Vowel Inventory for the picture naming task in the second cohort.

Vowels	1;6-1;11	2;0-2;5	2;6-3;0
i	90.00	100.00	100.00
u	80.00	100.00	100.00
e	90.00	100.00	100.00
o	100.00	100.00	100.00
ɛ	40.00	80.00	100.00
ɔ	60.00	90.00	100.00
a	100.00	100.00	100.00

4.2.1.2 Cohort 1 (3;0-4;11)

Table 21 reports a summary of the phones emerging, acquired, and mastered at each age in the first cohort. As for the second cohort, Appendix 6 contains the specific percentages for each phone in each age group (Table 48).

Table 21: Acquired and mastered phones at each age for the picture naming task in the first cohort.

	Emerging (≥50%)	Acquired (≥75%)	Mastered (≥90%)
3;0-3;5	z, ʣ, ʧ, ʤ	s, ʦ*	p, b, t, d, k, g, f, v, m, n, ɲ*, l, w*, j
3;6-3;11	ʃ, ʦ*, r	ʧ, ʤ	
4;0-4;5		z, ʃ*, ʦ, r	s
4;6-4;11		ʣ	

Note: * drop below the threshold in which they appear in the next age group, then rise back up in the following (/ɲ/ drops back again).

Consistently with the results obtained from the second cohort, at the age of 3;0-3;5, most of the phones of Italian are mastered by children in the population under study (/p, b, t, d, k, g, f, v, m, n, ɲ, l, w, j/). By age 4;0, both postalveolar affricates are acquired, and a small number of new phones emerges, although no consonant is mastered. Solely /s/ appeared to be added to the inventory of mastered phones prior to the age of 5;0, while four more consonants (/z, ʃ, ʦ, r/) pass the 75% threshold. A limited number of other consonants (i.e. /ʦ, ɲ, ŋ, w, ʃ/) oscillate in percentage of occurrence across age groups, alternatively meting a higher or lower criteria from the one met in the previous age group. Prior to the age of 5;0, /z, ʃ, ʦ, ʣ, r/ continue to be produced by less than 90% of children, while solely one consonant, /ʎ/, results not yet emerging, appearing in less than 30% of children in the oldest age group.

Given the presence of phonetic distortions across children's recorded speech, a second analysis was run in order to identify whether any difference in age of acquisition and mastery could be found when phonetic distortions were considered among the correct productions. In this light, the phone /s/ met the 90% criterion already at the age of 3;0-3;5. Similarly, its voiced counterpart /z/ passed the 75% criterion in two age groups (i.e. 3;0-3;5 and 4;0-4;5). Finally, /r/ also appeared to be mastered at a lower age (i.e. 3;6-3;11) compared to the age of mastery obtained when phonetic distortions were considered erroneous.

Concerning the acquisition of vowels, all phones were mastered by all children already in the youngest age group (see Table 22).

Table 22: Vowel Inventory for the picture naming task in the first cohort.

Vowels	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
i	100.00	100.00	100.00	100.00
u	100.00	98.18	100.00	100.00
e	100.00	100.00	100.00	100.00
o	100.00	100.00	100.00	100.00
ɛ	100.00	100.00	100.00	100.00
ɔ	100.00	100.00	100.00	100.00
a	100.00	100.00	100.00	100.00

Overall, the consonant and vowel systems show parallel development prior to the age of 3;0, with the latter reaching the adult target by that age. The first phones to be mastered already at the early age of 1;6-1;11 appear to be most voiceless plosives, alongside the nasal /n/, the approximant /l/, and the vowels /i, e, o, a/. The remaining plosives, nasals, semiconsonants, and vowels, together with the /f, v/ pass the 90% threshold by the age of 3;0-3:5. All other fricatives and affricates gradually emerge and are acquired before the age of 4;11, although solely /s/ is consolidated by that age. /r/ appears to follow a similar development to the fricatives and affricates, remaining below the 90% threshold in the older children. Finally, /ʎ/ is the latest sound to appear in children's production, emerging after the age of 5;0.

4.2.2 Phone Imitation task

The phone imitation task was only carried out with the children of the first cohort (i.e. 3;0-4;11) in order to evaluate the stimulability of consonants of Italian for each age group, and to compare these with the phones emerging at word level. As outlined in the methods section, each consonant was elicited only once in imitation, with children provided with three presentations, if required, for each phone. Therefore, children's performances were scored in terms of correct versus incorrect/omitted phone, and each production was assigned a score of 1 or 0, respectively: the total score was 24. For each individual, the number and list of consonants accurately produced was computed, and the number of correctly produced phones was transformed into percentage for each child. Subsequently, inventories were drawn for each age groups, and the mean, SD, and range for the percentage of consonants produced accurately was also derived for each age group. Table 49 in Appendix 6 reports the consonant inventory for the phone imitation task, while Table 23 summarises the ages at which each phone was imitated correctly by at least 75% and 90% of children.

Table 23: Phones stimulable in at least 75% and at least 90% of children at each age from the phone imitation task.

	Stimulable ≥50%	Stimulable ≥75%	Stimulable ≥90%
3;0-3;5	ʃ, ʧ, ʤ	g*, f, v*	p, b, t, d, k, m, n, ɲ, l, w, j
3;6-3;11	v	ʧ	g*
4;0-4;5	s, ʦ, ʣ	ʃ, ʤ	f
4;6-4;11	z	s, ʦ	v, ʧ

Note: * drop below the threshold in which they appear in the next age group, then rise back up in the following.

Similarly to what was obtained from the naming task, most plosives and all nasals, as well as /l, w, j/ were already imitated correctly by over 90% of the youngest children. /g/ met the same criterion by 4;0 years of age. Following a similar hierarchy as that identified from the naming task, an increasingly higher percentage of children was able to imitate fricatives and affricates after the age of 4;0. However, solely /f, v, ʧ/ were stimulable in more than 90% of children by the age of 4;11, while the remaining phones were only stimulable in more than 50% or 75% of children. Finally, /r, ʎ/ did not meet the 50% criterion prior to the age of 5;0.

As for the naming task, an observation of the percentage of children presenting certain phones when accounting for phonetic distortions as acceptable productions was conducted. In this perspective both /s, z/ appeared correctly imitated already by more than 90% of the youngest children. Similarly, /r/ was found to be imitated correctly by at least 50% of children already at the age of 3;0-3;5, and passed the 75% threshold before the age of 4;0. Finally, /f, v/ also appeared to be affected by phonetic distortions, being occasionally produced in imitation as bilabial /ɸ, β/. When these realisations were considered correct, the target phones were imitated correctly respectively at the ages of 3;0-3;5 and 4;0-4;5.

4.2.3 Comparison between the two tasks

When comparing findings from the picture naming and phone imitation tasks, similar results were found. However, the phone imitation task showed children being able to produce marginally less consonants in isolation compared to those produced correctly at word level when phonetic distortions were not considered correct productions (see Table 24).

Table 24: Newly acquired and mastered phones at each age for both the picture naming task and the phone imitation task.

	Picture Naming		Phone Imitation	
	Acquired (≥75%)	**Mastered (≥90%)**	**Stimulable ≥75%**	**Stimulable ≥90%**
3;0-3;5	s, ʦ*	p, b, t, d, k, g, f, v, m, n, ɲ*, l, w*, j	g*, f, v*	p, b, t, d, k, m, n, ɲ, l, w, j
3;6-3;11	ʧ, ʤ		ʧ	g*
4;0-4;5	z, ʃ*, ʦ, r	s	ʃ, ʤ	f
4;6-4;11	ʣ		s, ʦ	v, ʧ

Notes: phones were considered correct when produced or imitated phonetically correct (i.e. phonetic distortions were not accepted as correct production); *drop below the threshold in which they appear in the next age group, then rise back up in the following.

The differences presented were nonetheless small, and when a phone appeared in a higher criterion (i.e. ≥75%, ≥90%) for the naming rather than the imitation task, the percentage of occurrence in the latter generally approached the threshold for the higher criterion (see, for instance, /g, f/ and /v, ʧ/ approaching 90% respectively at 3;0-3;5 and 4;0-4;5 in Table 49 in Appendix 6). A more noticeable difference was found for /s, z/ and /ʦ, ʣ/, which were markedly more represented in the inventory from the picture naming task, although percentages for the affricates from the two tasks grew closer together in older children . Additionally, a large difference was found for /r/, produced by a higher percentage of children in the naming task. When phonetic distortions were accounted for and considered correct, a closer resemblance between the two tasks was observed. Indeed, both /s, f/ appeared in more than 90% of children already at the age of 3;0-3;5 across both tasks. /z/ was imitated by 90% of children already at the same age, while it solely passed the 75% threshold at 3;6-3;11 (and remained below 90% across all ages) for the picture naming task. Finally, both /r, v/ maintained a higher performance in the naming task, although they appeared to be produced by a higher percentage of children at younger ages (i.e. /r/ passed 75% at 3;6-3;11, while /v/ was produced by more than 90% at 4;0-4;5). Given the unexpected lower performance in the imitation task, a t-test was run between the percentages of children presenting each phone in naming and imitation in each age group both for the results considering phonetic distortions as incorrect production, and when accounting for them. In both cases, the resulting p values were all above .05, indicating that the differences between the two tasks were statistically not significant (i.e. $p = 0.267$, $p = 0.246$, $p = 0.120$, $p = 0.438$ from the lowest to the

highest age group for the former case; $p = 0.929$, $p = 0.927$, $p = 0.459$, $p = 0.673$ for the latter case).

4.3 Consonant co-occurrences: Consonant Clusters and Geminates

The acquisition of consonants in co-occurrence was also investigated. In this perspective, percentages of correct production were first calculated for consonant clusters (i.e. tautosyllabic and heterosyllabic) and geminates for each participant. Additionally, an inventory was drawn for the tautosyllabic clusters for each child. The mean numbers of consonant clusters and geminates correctly produced were then calculated at age-group level, and the age-related inventories for the initial clusters were computed. The following subsections present the results of the analyses for the two classes of clusters and for geminates separately.

4.3.1 Consonant Clusters

Due to the underrepresentation of clusters in the tests used, a cluster was considered present in the child's inventory if it was produced accurately at least once. Following the same criteria adopted for the consonant and vowel inventories in order to obtain an inventory of the initial CCs, a tautosyllabic cluster was considered emerging at a given age if present in at least 50% of the children in that age group, acquired when produced correctly by 75% or more of the children, and mastered when present in at least 90% of the participants in that age group.

4.3.1.1 Percentage correct: Tautosyllabic vs Heterosyllabic

Considering tautosyllabic CC (i.e. SI consonant clusters), a wide difference was found in the performance of children above and below the age of 3;0, with children in the oldest age group presenting an accuracy in the production of tautosyllabic clusters (i.e. 69.96%) that was over three times that of the younger children (i.e. 18.33%) and more than twice that of children aged 2;6-3;0 (i.e. 29.95%). Additionally, a significant increase in performance accuracy was found between children in the ages of 2;6-3;0 and 3;0-3;5: children below the age of 3;0 had a mean percentage accuracy of 29.95%, in contrast with that of children above the age of 3;0, i.e. 47.85% (see Table 25). When comparing the data obtained it is fundamental to remember that these were obtained through two separate tests eliciting different CC and CCC structures, as seen in Table 26 for the TCC.

Table 25: Mean percentage of correct production, and relative SD and range, for the tautosyllabic and heterosyllabic clusters.

	M_T(SD)[a]	$Range_T$[a]	M_H(SD)[b]	$Range_H$[b]
1;6-1;11	18.33 (33.75)	0.00-100.00	16.67 (25.82)	0.00-50.00
2;0-2;5	19.00 (25.39)	0.00-83.33	24.00 (17.66)	0.00-50.00
2;6-3;0	29.95 (16.41)	0.00-63.64	39.17 (14.24)	23.08-70.00
3;0-3;5	47.85 (22.89)	0.00-100	47.59 (27.84)	0.00-100.00
3;6-3;11	50.73 (23.63)	0.00-100	50.13 (26.93)	0.00-93.75
4;0-4;5	65.72 (18.87)	16.67-100.00	63.76 (25.46)	0.00-100.00
4;6-4;11	69.96 (18.04)	25.00-100.00	71.49 (22.87)	0.00-100.00

Note: [a]values for the tautosyllabic clusters; [b]values for the heterosyllabic clusters.

The markedly large ranges indicate that, within the same age group, there were children who had already acquired the consonant clusters tested while other did not yet present any of the target.

When comparing children's performance on heterosyllabic to that in tautosyllabic clusters, a similar trend of overall improvement can be spotted. However, children appeared to produce heterosyllabic clusters with higher accuracy at the age of 2;0-3;0 compared to the realisation of SI clusters at the same age. On the contrary, tautosyllabic clusters showed higher percentages of correct production for the population above the age of 3;0, with the exception of participants in the older age group. Notwithstanding, the differences in percentage of accuracy between the initial and heterosyllabic clusters were however marginal across all age groups. The improvement in performance was similar for both classes of clusters, with percentage of accuracy reaching 71.49% at the age of 4;6-4;11 for the clusters occurring across syllable boundaries. Again, ranges appeared to span from 0.00% to 100% across most age groups, suggesting that children below the age of 5;0 still present a large variability in terms of consonant clusters acquisition.

4.3.1.2 Tautosyllabic Clusters Inventory

Despite the limited elicitation of tautosyllabic clusters both in the BVL subtest (Marini et al., 2015) and in the TFPI (Zmarich et al., in progress) and the discrepancies between types of clusters elicited, a list of the acquired and mastered TCC was drawn from the data for each age group.

Table 26: Inventory of tautosyllabic consonant clusters.

	1;6-1;11	2;0-2;5	2;6-3;0	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
kj	10.00	40.00	60.00	*			
pj		40.00	80.00	92.86	87.27	100.00	97.50
gw			40.00				
fj				85.71	74.55	91.67	97.50
fw				82.14	70.91	95.00	85.00
mj	20.00						
nw				50.00	58.18	76.67	80.00
br		10.00					
tr			20.00	21.43	52.73	58.33	80.00
fr			10.00				
st				25.00	18.18	41.67	52.50
sk		10.00	10.00	25.00	20.00	45.00	60.00
zb				7.14	10.91	23.33	17.50
spj			20.00				
str			10.00				

Note: *when a percentage is not reported, the correspondent cluster was not elicited in the assessment material; orange highlight = Emerging clusters (i.e., 50%-74%), yellow highlight = Acquired clusters (i.e., 75%-89%), green highlight = Mastered clusters (i.e., ≥90%).

Table 26 shows the percentages of children producing each cluster in each age group. It is fundamental to highlight that the two assessments used to test the separate cohorts differed in number and types of consonant clusters elicited, thus results are not reliably comparable. As observable, there was limited overlap between the two cohorts. Overall, it appears from the data obtained that children below the age of 3;0 have no stable consonant cluster in their inventory. Mainly clusters formed with a semiconsonant appear to emerge and gradually stabilise with age increase. Solely clusters /fj, fw, pj/ are mastered by the population studied prior to the age of 5;0. Of the remaining clusters, solely /nw/ and /tr/ can be considered acquired at the respective ages of 4;0-4;5 and 4;6-4;11.

4.3.2 Geminates

Finally, the acquisition of geminates was also investigated. A noticeably higher accuracy was found for children's performance in the production of the same consonant appearing

at syllable boundaries in comparison to heterosyllabic CCs (see Table 27), even for the younger cohort.

Table 27: Mean percentage of correct production, and relative SD and range, for the Geminates.

	M(SD)	Range
1;6-1;11	44.98 (27.49)	8.33-80.00
2;0-2;5	64.26 (12.49)	40.00-85.71
2;6-3;0	64.42 (11.87)	47.83-81.82
3;0-3;5	88.12 (11.18)	43.75-100.00
3;6-3;11	84.42 (17.11)	10.00-100.00
4;0-4;5	91.65 (8.03)	64.71-100.00
4;6-4;11	93.73 (6.72)	70.59-100.00

Similarly to what was found for the tautosyllabic consonant clusters, children appeared to improve significantly in the production of geminates after turning 3;0 years old, moving from a score of 64.42% at 2;6-3;0, to 88.12% at 3;0-3;5, indicating that geminates are nearly mastered by children from that age on. As for the data on consonant clusters, these measures also showed large SD and ranges, although comparably narrower.

4.4 Summary

The current chapter aimed to present the findings from the analyses on consonant and vowel acquisition in terms of percentages of correct production and inventories, and report on the acquisition of consonant co-occurrences. Overall, the population under study showed an improvement with age increase in percentage of consonant, vowel, and phoneme correct production, with only a marginally higher accuracy for the revised measures. While PCC remained below the threshold of 90% accuracy, PVC approached 100% in the older children. These measures are reflected in the consonant and vowel inventories. Indeed, all vowels were mastered by the age of 2;6. Most consonants were instead mastered by children aged 3;0-3;5, with plosive, nasals, and semiconsonants being the first to appear at younger ages. The majority of fricatives and affricate, alongside the trill /r/ remained unstable at the age of 4;11, while the palatal approximant /ʎ/ was still absent among the oldest participants. Considering consonant co-occurrences, a similar trend in terms of accuracy was found for the two classes of consonant clusters (i.e. tautosyllabic and heterosyllabic), while a noticeably higher accuracy was observed in the production of geminates. Indeed, both initial and

heterosyllabic clusters were produced with less than 75% of accuracy at the age of 4;11. Correct production of geminates approached instead 100% at the same age.

Prior to presenting the findings on phonological variations, the results here introduced will be discussed in the following chapter in relation to the available Italian and international literature.

5. Discussion I

As presented in the previous chapter, the first part of this research aimed at answering the following research questions:

1. How does Italian speech sound acquisition proceed over time across the critical age of 1;6-4;11?

    a. To which degree do Italian children approximate the adult target, in terms of percentage of consonant and vowel correct at each age?

    b. Which consonants, vowels, and consonant clusters are present at each age as shown in the inventory from the picture naming task?

    c. What is the percentage of correctly imitated phones at each age, and which sounds can be considered part of the inventory in terms of stimulability (i.e. child's ability to repeat them)?

Findings from the analyses implemented to this end will be discussed here in relation to the available literature.

5.1 To which degree do Italian children approximate the adult target, in terms of percentage of consonant and vowel correct at each age?

In order to investigate progress over time, measures of PCC and PVC were calculated, alongside the revised measures PCC-R and PVC-R. As predicted in the hypotheses outlined in hypothesis 1.a.i which posited developmental progression, all measures showed a steady increase across age groups, with PCC and PCC-R almost doubling in the oldest children compared to the youngest (i.e. 1.6-1;11). Measures of PCC and PCC-R from Cohort 2 closely approximate those from the only available study of Italian that conducted this analysis, by Zmarich et al. (2012). It should be noted that the study in question is the one from which the data of the second cohort were shared. The small difference in PCC could be ascribed to the different transcribers (i.e. data of the second cohort were transcribed again for the purpose of this project to ensure transcription consistency across the data).

Overall, although in line with the available Italian research, PCC data from the present study appeared to be lower than the measures found for other Romance languages and Maltese. Indeed, while the youngest Italian children only reached around 45% at the age of 1;6-1;11, the PCC of French children calculated at the same age was 57.4% (MacLeod

et al., 2011). Both French and Maltese showed a PCC higher than 80% already below the age of 3;0, while Italian children approximated the same percentage at 3;6-3;11 and 4;0-4;5, with minimal difference when phonetic variations were allowed. Concerning older children, studies on Portuguese, French, and Maltese all reported PCC above 80% before and around the age of 3;0, and above 90% from the ages of 3;6 for Maltese, and 4;0 for Portuguese and French (da Silva et al., 2012; Grech & Dodd, 2008; Kehoe et al., 2020; Lousada et al., 2012; MacLeod et al., 2011). This suggests that Italian children, who did not reach 90% in the oldest age group (i.e. 4;6-4;11), may develop their phonological system more slowly than speakers of other languages. In this perspective, phonetic frequency could be a factor explaining the longer development of Italian speech sound acquisition. Indeed, the frequency of occurrence of each phone within the early-acquired vocabulary has an effect on the degree of exposition children have to certain phones (Zmarich et al., 2011), thus potentially resulting in an earlier acquisition (and mastery) of those phones that are more common in the children's vocabulary. In this perspective, Zmarich et al. (2011) examined the frequency of phonetic features across the vocabulary reported in the Italian adapted version of the MacArthur questionnaire (Caselli et al., 2015). In line with the available data on consonant acquisition, the authors found that a vast majority of the inventory before the age of 3 is represented by fricatives, plosives, and nasals in terms of manner of articulation, and bilabials, alveolar, and velar in terms of place. Contrarily, laterals, trills, and approximants make up to less then 15% of the manners of articulation combined, while palatals represent less than 2% of the places of articulation. This low representation of the features described in the vocabulary of young children may be at the root of the later acquisition of phones such as, for instance, /ʎ/ (palatal approximant), which are not yet mastered at 4;11 (see sections 4.2.1.2 and 5.3). Thus, the presence of phones such as /ʎ/, which, although a specific feature of Italian, is infrequent in children's vocabulary and are acquired after the age of 5;0, may have lowered the accuracy scores for the population under investigation.

Measures of PVC and PVC-R confirmed previous statements about the Italian vowel system being simple and early-established (Giulivi et al., 2006), Although in no age group PVC (and PVC-R) reached 100%, PVC appeared already above 70% at the age of 1;6-1;11, and reached ceiling (i.e. 90%) at the age of 3;0-3;5. When also considering the vowel inventory, results are consistent with hypothesis 1.b.iii predicting full acquisition of the vowel system by the age of 3;0, based on findings from the Italian literature. All vowels but three (i.e. /u, ɛ, ɔ/) were mastered at the age of 1;6-1;11, with only one (i.e. /ɛ/) remaining below the 90% threshold at the age of 2;0. While the low accuracy for /u/

at 1;6-1;11 may have been due to chance, findings for the open vowels /ɛ, ɔ/ support the emergentist theories' postulate that external factors (e.g. geographical areas, type of input) have an impact in differentiating the typical development of children sharing the same linguistic background, as predicted in the T3. These findings could indeed be explained with the different regions where children were recruited in the study by Zmarich et al. (2012), from which data of the second cohort were shared. Indeed, children in the sample were from two different regions of the north and central Italy (i.e. Veneto and Marche), which are characterised by a different use of open and closed vowels across their vocabulary (see section 2.3.2). While the regional variation from Marche has a generally equal presentation of the open and closed vowels /e, ɛ, o, ɔ/, the Veneto variation has a tendency towards the use of the open vowels /ɛ, ɔ/. This difference is likely to have affected the results of this cohort as the target IPA transcriptions were set by the authors of the original research, from the region of Veneto, therefore sharing the prevalent use of open vowels. Across Cohort 1, despite all children having been recruited in the same region, and the different regional variations to which they had been exposed (i.e. spoken by parents) were on average similarly distributed across age groups, the second and fourth age groups (i.e. 3;6-3;11 and 4;6-4;11) had higher proportions of children exposed to different variations compared to the other two groups. This may explain the comparably lower PVC in these two age groups. These findings are also consistent with two patterns, emerged across both cohorts in the analysis of phonological variations, which report mutual substitution between the closed and open vowels /e/↔ /ɛ/ and /o/↔ /ɔ/ (reported and discussed in sections 6.2 and 7.2). Overall, the mastery of all seven vowels prior to the age of 3;0 is consistent with previous statements from Italian literature postulating that the Italian vowels system is simple and usually assumed to be fully developed around three years of age (Giulivi et al., 2006).

Overall, large SDs and ranges were found for all percentage measures across all age groups in the two cohorts, implying a wide variability among children of the same age, and the relevance of individual/personal experience (Bybee, 2001). However, data on Italian children above the age of 3;0 are not available in terms of percentages of consonants and vowels correct by earlier studies, providing no comparison for the findings of the current study. Finally, it is worth highlighting that the revised measures did not differ noticeably from the PCC and PVC measures. The sole phones that were affected by phonetic distortions were the alveolar fricatives /s, z/ and the trill /r/. These distortions have been reported in previous literature across both Italian and other languages where appropriate (see Discussion II, section 7.2.5), and might be considered common phonetic distortions in children's development. In addition, although some

regional variations of Italian present distortions of certain consonants, these are not usually found in the variations spoken by the children assessed in the two cohorts (see section 2.3.2).

5.2 Which consonants, vowels, and consonant clusters are present at each age as shown in the inventory from the picture naming task?

In the Results I chapter, phonetic inventories were presented separately for the two tasks from which they were derived (i.e. Picture naming and Phone imitation) as well as for the two cohorts (for the Picture naming task). Results from the two tasks will be discussed separately in this section, although results from the picture naming task will be presented across both cohorts at the same time, undertaking a developmental perspective. Stimulability data were solely collected on Cohort 1 and will thus be discussed separately.

5.2.1 Consonant and vowel acquisition across the two cohorts.

In the perspective of phones acquisition, it was hypothesised that a similar sequence of consonant and vowel acquisition to that reported in previous Italian and romance language research would be followed. In terms of timing, it was predicted that Italian children would complete the entire vowel system by the age of 3;0, while mastering most consonants by the age of 4;0, although with few exceptions (i.e. suggesting continuing development beyond the age of 5;0). The majority of consonants were mastered before the age of 4;0, although a few sounds remained below the threshold by the age of 4;11 (as hypothesised in 1.b.ii, which suggested continuous development beyond the age of 5;0). Overall, findings from the current project across both cohorts appeared to agree with previous Italian research and most research on other Romance languages and proved in line with the hypotheses made. Phone acquisition appeared to follow a similar sequence to that found across previous literature, although differences have been found in the specific ages of mastery, which were likely due to different cut-offs being adopted (as predicted in hypothesis 1.b.i) in the current and previous research as well as the sample sizes of the populations investigated.

Findings for children below the age of 3;0 were mostly consistent with previous Italian research on phone acquisition as well as results on children from Cohort 1 (see section 5.2.1). Overall, the finding that all plosives, the labiodental and voiceless alveolar fricatives /f, v/ and /s/, alongside the nasals /m, n/ and lateral /l/ were mastered before the age of 3;0 is in agreement with most studies that investigated Italian children below

that age (Bortolini, 1995; D'Odorico et al., 2011; Viterbori et al., 2018; Zmarich et al., in progress; Zmarich & Bonifacio, 2005). Some variability can be identified for the plosives /b, k/, which were attested by some as early as 1;6 years of age (D'Odorico et al., 2011; Zmarich et al., 2012) and by others above the age of 3;0 (Zanobini et al., 2012). Contrarily to what is available for Italian, few studies on Romance languages and Maltese have investigated children below the age of 3;0 (Anderson & Smith, 1987; Grech, 1998; Grech & Dodd, 2008; MacLeod et al., 2011), thus comparison is limited in this perspective. However, studies on Puerto Rican Spanish, Maltese, and French reported that most of the consonants here mentioned were mastered prior to the age of 3;0 across their populations (Anderson & Smith, 1987; Grech, 1998; Grech & Dodd, 2008; MacLeod et al., 2011). Consistently, findings on Cohort 1 of this study (i.e. 3;0-4;11) showed that these phones were indeed all mastered already by the youngest children. These findings seem to support the idea of a core array of sounds that are commonly developed by children at the beginning of their speech acquisition across languages (MacNeilage, 1998; Zmarich et al., 2005), as hypothesised in T1.

A finding in disagreement with most other studies, as well as with findings from the first cohort, is the presence of the postalveolar affricate /ʧ/ in more than 90% of children at the age of 2;0. Previous literature on Italian, French, and Maltese place instead the acquisition and mastering of the consonant at a later stage of the development (i.e. most studies reported it to be acquired above the age of 3;0, e.g. Grech & Dodd, 2008; MacLeod et al., 2011; Zanobini et al., 2012). This results could be due to the relatively low number of elicitations of /ʧ/ in the assessment used with the second cohort compared to other consonants, which would have provided fewer opportunities for mistakes (see Table 47 in Appendix 5).

Disparities were also found between the current study, previous Italian research, and research on other romance languages and Maltese, on the late acquired phones. For instance, phones such as /s, z, ʃ, ʤ/ were reported as mastered before the age of 3;0 across several studies (Anderson & Smith, 1987; Bortolini, 1995; Grech, 1998; Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zmarich et al., in progress; Zmarich & Bonifacio, 2005; Zmarich et al., 2012). Studies that investigated children above 3;0 placed instead mastery at later stages (e.g. Tresoldi et al., 2018, reported as age of mastery for /s, z, ʃ/ respectively 5;6, 3;6, and 4;6). This is more in line with findings from Cohort 1 of the current study, in which these consonants except for /s/ (which was mastered at 4;0-4;5) remained below the 90% threshold across all age groups. Nevertheless, cut-offs of ≥75% (Zmarich et al., in progress) and of ≥80% (Bortolini, 1995; D'Odorico et al., 2011;

Zanobini et al., 2012; Zmarich et al., 2012) were adopted by several Italian studies to indicate mastery, which thus considered a wider number of phones as mastered at a certain age compared to children of the same age in research that adopted the cut-off of 90%. Additionally, differences in the material used (spontaneous speech vs. picture naming, see section 2.4.2) are also likely to have affected target elicitation and therefore provided a higher or lower chance of error.

Similarly, across studies, /r/ appears to be acquired by children below the age of 3;0, (e.g. Grech, 1998; Tresoldi et al., 2015; Viterbori et al., 2018; Zanobini et al., 2012), while this was not the case in the present study. However, it should be noticed that, when accounting for phonetic distortions, /r/ was indeed acquired by children below the age of 3;0 in the second cohort, suggesting that a phonetic variation of /r/ does appear in the development at earlier stages, although not phonetically accurate. In this perspective, previous studies reporting early acquisition of /r/ did not specify whether they allowed as correct realisations all phonetic variations of the phone /r/. A comparison of their results with the current study should thus be interpreted with caution. Additionally, it is necessary to remember that, as mentioned above, despite adopting similar cut-offs at child level (i.e. one to three correct realisations), several studies on Italian (Bortolini, 1995; D'Odorico et al., 2011; Zanobini et al., 2012; Zmarich et al., 2012) considered the criterion “mastered” at age-group level for all phones that were present in at least 75% (Zmarich et al., in progress) or 80% of children (Bortolini, 1995; D'Odorico et al., 2011; Zanobini et al., 2012; Zmarich et al., 2012) rather than 90% as in the present and other research (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich & Bonifacio, 2005). In this perspective, studies that adopted this lower cut-off would have included a higher number of phones as being mastered at a specific age which might have been instead considered only acquired, as in the case of /w/, had a higher criterion been applied. Thus, a comparison with data from the current study (adopting the criterion of 90% for mastery) is limited is limited.

Overall, findings from this study are in line with hypothesis 1.b.ii that children’s speech sound development proceeds beyond the age of 5;0, up until at least the age of 6;0-7;0 (Tresoldi et al., 2018). In this perspective, Italian children appear to have a similar developmental pace compared to speakers of romance languages and Maltese, but to be slower than their peers acquiring languages of a different family. For instance, Fox and Dodd (1999) reported that most consonants were produced by at least 90% of German-speaking children by the age of 3;5, with only two phones being mastered

before 4;5. Similarly, all consonants were produced by at least 90% of Turkish-speaking children assessed by Topbaş (2006) by the age of 4;6. These differences support the idea that, although languages might share an overall trajectory in the order of acquisition of categories of speech sounds, as proposed by Jakobson (1968) in his structuralist model of speech acquisition (see Literature Review I, section 1.1), the specific age at which phones are acquired and mastered is language-specific, and can differ noticeably even among languages of the same family .

This is in line with theoretical models of phonological development (both formalist and emergentist, see Literature Review I, section 1.1), which postulate the influence of the ambient language in the acquisition of phonology. In particular, differences in speech sound acquisition between Italian and other romance languages appear to support the perception-action mechanism proposed by Bybee (2001) according to which children's acquisition of the language lexicon influences the construction of their own phonological system. Indeed, even languages that share common phonetic and phonological features differ from each other for example in the prevalence of occurrence of individual phones in their vocabulary. Thus, children acquiring a language with a lower prevalence of occurrence of a specific phone across the early-acquired vocabulary would be likely to master that sound at a later stage of their development.

5.2.2 Consonant Co-occurrences

In addition to the analyses on singleton phones, consonant co-occurrences were investigated (i.e. TCC, HCC, and geminates). It is fundamental to remember that findings on consonant clusters and geminates have limited ground for comparison across previous Italian literature (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012). Furthermore, this is the first study to clearly distinguish between the acquisition of tautosyllabic and heterosyllabic clusters, as previous Italian and romance languages research either reported both indistinctively or solely considered tautosyllabic clusters. Only two of the Italian studies provided a detailed account of the clusters (Tresoldi et al., 2015; Zmarich et al., 2012), while the third study presented solely the classes of clusters found (Tresoldi et al., 2018). No study of Italian explored geminate consonants.

Similar trends were found for the acquisition of TCC and HCC in the current study with respect to percentages correct. This appears in line with hypothesis 1.b.iv, predicting that TCC and HCC would show similar ages of acquisition. Indeed, differences in terms of PCCC were limited: accuracy in production of TCC appeared better than HCC in four out of seven age groups (i.e. 1;6-1;11, 3;0-3;5, 3;6-3;11, and 4;0-4;5), while the opposite

was found for the remaining three age groups. A wide disparity was found between Cohort 1 and 2 in terms of percentage of clusters produced correctly, with children at the age of 3;0-3;5 in Cohort 1 producing correctly almost double the consonant clusters produced by children at the age of 2;6-3;0 in Cohort 2. This difference may however be accounted for by the different assessment material used Cohort 1 and 2, which limits the comparability of the two populations. Indeed, the two tests (Marini et al., 2015; Zmarich et al., in progress) present little overlap in the CC and CCC structures elicited; furthermore, the number and types of clusters targeted across the two assessments were limited (see Table 26, and Table 43 in Appendix 5). Thus, interpretation of the data collected in this perspective needs to be conducted with caution, and only hypotheses can be made on what the data might imply for the development of clusters in Italian.

In accordance with findings from Zmarich et al. (2012) for Italian, Fernández (1997) for Spanish, and MacLeod et al. (2011) for French, the current study found that the cluster /pj/ was already mastered at the age of 3;0. Clusters with fricatives /fj, fw/ were mastered at 4;0, as also predicted in 1.b.iv. This is in line with previous findings suggesting that, above the age of 3;0, CC with plosives and semiconsonants continue to be the most prevalent across languages (Ceron et al., 2020; da Silva et al., 2012; Galcerán, 1983; MacLeod et al., 2011; Tresoldi et al., 2018), with fricatives and nasals appearing in cluster with the semiconsonants (e.g. /fj, nw/), and liquids emerging with plosives (e.g. /tr/). Additionally, the low PCCC shown even in the oldest children in this study (i.e. <70% and <72% at the age of 4;6-4;11 for TCC and HCC respectively) are in agreement with the reports of late mastery (i.e. above the age of 5;0) of several types of CC across romance languages (Ceron et al., 2020; da Silva et al., 2012; Galcerán, 1983; Tresoldi et al., 2015; Tresoldi et al., 2018).

Finally, data from this study showed how clusters /sk, st/ were present in more than 50% of children at the age of 4;6, but were never mastered by the population examined, while /zb/ remained below 50% across all children. This could suggest late mastery of clusters with /s, z/, and is in line with Tresoldi et al. (2018) and Tresoldi et al. (2015), who found that biconsonantal clusters with /s, z/ were mastered above the age of 4;6 and before 6;0, while triconsonantal clusters with the alveolar fricatives were mastered between the ages of 5;0 and 7;0. Consistently, Galcerán (1983) reported that clusters with /s/ were already acquired by Castellan-speaking children aged 3;0-3;11, but were mastered above the age of 6;0. Overall, late mastery of these clusters may be due to the late

mastery of the singleton phones /s, z/, as found in this and previous research on both Italian and romance languages (Guimarães et al., 2019; Tresoldi et al., 2018; Vivar & León, 2009), as well as from languages from a different family, such as, for instance, Norwegian (Kristoffersen & Simonsen, 2006).

Consistently with the trends in acquisition and mastery of consonants, and with the occurrence of phonological patterns involving consonant clusters (see Results II and Discussion II), children of both cohorts showed a marked variability among them. While some children presented no TCC up to the age of 3;11 and no HCC across all ages, already from the age of 3;0 some produced 100% clusters correct (both TCC and HCC). This suggests that there is a noticeable internal variability among children of the same age in terms of acquisition of consonant clusters, as well as for singleton consonants, as discussed above.

Finally, children's performance on geminates appeared to be more advanced than that on consonant clusters, with children in Cohort 2 already presenting more than 40% of geminates correct at the age of 1;6, and more than 60% at the age of 2;0. Children in Cohort 1 produced almost 90% of geminates correctly already at the age of 3;0, and reaching ceiling in the oldest age group (i.e. 93% at 4;6-4;11). This finding suggest that the geminate consonant co-occurrence might be less complex to develop when compared to both tautosyllabic and heterosyllabic consonant clusters, and is in line with the limited occurrence of phonological patterns affecting geminates compared to those involving consonant clusters (see Results II and Discussion II). In this perspective, it may be the case that children perceive the consonants in geminate position as a syllable-final and a syllable-initial consonant, thus treating them differently compared to heterosyllabic consonant clusters. In terms of the overall simplicity of the length contrast, already Kunnari et al. (2001) identified how Finnish children were able to distinguish between singleton and geminate plosives in their spontaneous speech at the end of the one-word period (i.e. about 15 months). Although additional research across languages is needed on the ages at which speakers of different languages master the WM consonant length distinction, this seems to suggest that the singleton/geminate distinction is indeed acquired early in the development.

Overall, the comparability and interpretability of the findings on consonant co-occurrences from this research remain limited not only because of the paucity of literature available at present, but also due to the differences in targets and presentation of the results in the existing studies, as well as to the low elicitation of consonant co-occurrences, and consonant clusters in particular, in the assessments used. Indeed,

Italian presents a large number of consonant clusters, HCC, which need to be investigated in detail. Further research exploring the acquisition of TCC and HCC, targeting at least all different types (e.g. plosive+liquid) of clusters in a sufficient number (i.e. 1-5 times across all possible positions: James et al., 2009), is therefore necessary in order to provide a more complete view of the speech sound and phonological development of Italian children.

5.3 What is the percentage of correctly imitated phones at each age, and which sounds can be considered part of the inventory in terms of stimulability (i.e. child's ability to repeat them)?

A second inventory was drawn from the stimulability task that was undertaken with Cohort 1 only (i.e. 3;0-4;11). As described in section 1.2.1.1, a stimulability/imitation task provides information on whether certain phones that might not be present in spontaneous speech can be produced when the motor programme is provided in input (Miccio, 2002). Thus, typically developing children at a specific age would be expected to be able to produce more phones in imitation, when no access to lexical representations is needed, than spontaneously in connected speech. In this study, however, although most phones were produced by children across the sample in both tasks, they presented differences in the age at which they met the cut-offs of 75% and 90%, with children producing several phones in naming at younger ages than in imitation. Nevertheless, as outlined in section 4.2.3, the difference between the two tasks was not statistically significant at any age. Indeed, phones such as, for instance, /f, v/ which passed the 90% threshold in the youngest children (i.e. 3;0-3;5) in the naming task, but met the same cut-off above the age of 4;0 in the imitation task, showed similar percentages across the two tasks, only remaining marginally below or above the thresholds.

Solely a handful of phones presented widely different percentages of occurrence across the two tasks in certain age groups, although most showed similar percentages by the older age groups. /s, z, ts, dz, r/ all showed much higher percentages of occurrence in the naming tasks compared to the imitation task; however, for all phones but /r/, percentages were almost identical at age 4;6-4;11. /r/ remained well below the 50% threshold in the older children (i.e. 4;6-4;11) in the imitation task. /ʃ/ demonstrated the opposite trend, with children producing it more accurately in imitation rather than in picture naming, finding which was more in line with the hypothesis that children would perform better in imitation than naming (hypothesis 1.c.i).

In the perspective of the presentations of /s, z, ts, dz, r/, it is necessary to remember that phonetic distortions played a relevant role in the differences in age of acquisition and mastery of some of the phones. Indeed, when considering phonetic distortions as appropriate productions, these phones all presented similar percentages across both tasks at most ages, as it can be observed in Table 49, in Appendix 6.

In addition to the influence of phonetic distortions, it is worth highlighting that, although two additional repetitions of the target phones were provided to children (one of which focussing the child's attention to the examiner's mouth when producing the phone) during the assessment, the task was always conducted at the end of the testing session, after the conclusion of the naming task. Thus, children's performance is likely to have been affected by motivation as well as fatigue caused by the length of the first task (sessions on average lasted approximately 20 minutes, with most of the time taken up by the naming task). This might therefore partly explain the lower performance of children in the imitation rather than the naming task. This interpretation of the findings is supported by the result of the t-test that was run between the picture naming and the imitation task in terms of percentage of occurrence of each phone. As described in Results I, section 4.2.3, the p value revealed that the difference in the performance on the two tasks was not statistically significant (both when phonetic distortions were considered correct or erroneous), and therefore likely due to chance and/or environmental constraints, in this case tiredness and reduced compliance in the second task. A further hypothesis that might explain these results, and which was proposed in 1.c.i, is that in Italian there are no syllabic consonants; thus, Italian children may have found more difficult to produce consonant sounds in isolation compared to consonants in CV or intervocalic structures. Further research should be conducted on speech sound stimulability across the development for Italian children.

The next two chapters will present (Results II) and discuss (Discussion II) the findings related to the occurrence and resolution of phonological variations, in terms of number of total Tokens, number of InfrVar, number and Types of phonological patterns across the two cohorts studied.

6. Results II

The second part of the research aimed to investigate which phonological variations occur in Italian speaking children developing typically between the age of 1;6-4;11 years, both in terms of the extent to which these variations change across time, and in terms of types of phonological patterns presented. The current chapter reports the findings of the analyses run for this purpose, focussing first on the quantitative measurements (i.e. Tokens, Types, and InfrVar), and subsequently on the developmental phonological patterns. Results will be presented with reference to the adoption of both cut-off criteria (i.e. ≥4, ≥6), and findings on phonological patterns from the first and second cohorts will be presented separately.

6.1 Quantitative measurements: Tokens, Types, and InfrVar

In order to explore the change across time in the occurrence of phonological variations, the number (Tokens) and Types of such phonological variations, as well as the number of InfrVar presented by individual children was calculated. The mean, standard deviation, and range were then computed for each age group. This analysis was carried out twice for the factors Types and InfrVar, once for each cut-off criterion. The measure Tokens is independent of the cut-off criterion adopted, since it considers each phonological variation found in a child.

As shown below in **Error! Reference source not found.**, children across Cohort 1 (i.e. 3;0-4;11) presented a noticeable reduction in the number of overall phonological variations (i.e. Tokens) with increasing age, with the mean number of Tokens for the oldest age group (i.e. *M*=26.93) being less than half of the mean for age group 3;0-3;5 (i.e. *M*=55.21). A similar trend can be observed for the number of phonological patterns (i.e. Types) that emerged. While the youngest children (i.e. 3;0-3;5) produced approximately five Types of phonological patterns when the cut-off criterion of ≥4 was applied (*M*=5.39), the number was halved by the age of 4;6-4;11 (*M*=2.45). A similar presentation of pattern Types was observed when the cut-off was raised to ≥6. Overall, the number of InfrVar across age groups also decrease with increasing age for both criteria adopted. It is interesting to notice that, when the ≥6 criterion was applied, about half or more of the phonological variations were identified as InfrVar; this proportion was however noticeably reduced for the ≥4 criterion, for which over half of the phonological variations were classified as phonological patterns.

Table 28: Mean, SD, and Range for the number of Tokens, Types, and InfrVar across age groups in the two cohorts.

	n	Cut-off	Tokens M (SD)	Tokens Range	Types M (SD)	Types Range	InfrVar M (SD)	InfrVar Range
1;6-1;11	10	≥4	45.70 (13.93)	27-77	2.50 (1.35)	1-4	31.30 (7.70)	21-48
		≥6			1.60 (1.07)	1-5	35.10 (9.64)	21-52
2;0-2;5	10	≥4	75.90 (8.80)	64-91	4.80 (1.40)	3-8	42.30 (9.41)	24-56
		≥6			3.00 (0.94)	1-4	50.70 (8.77)	33-61
2;6-3;0	10	≥4	73.20 (25.07)	40-113	5.40 (2.41)	2-9	37.30 (9.44)	28-56
		≥6			2.80 (1.93)	0-7	48.70 (12.45)	37-76
3;0-3;5	28	≥4	55.21 (31.08)	6-134	5.39 (3.13)	0-13	19.90 (9.78)	3-47
		≥6			4.00 (2.37)	0-9	26.07 (13.87)	3-65
3;6-3;11	55	≥4	50.38 (43.66)	5-252	4.71 (4.13)	0-19	20.20 (10.70)	3-54
		≥6			3.33 (3.15)	0-15	26.20 (16.17)	3-71
4;0-4;5	60	≥4	32.15 (27.44)	1-156	3.23 (2.73)	0-16	13.00 (7.58)	1-30
		≥6			2.30 (2.09)	0-11	17.27 (10.91)	1-48
4;6-4;11	40	≥4	26.93 (19.80)	4-88	2.45 (1.95)	0-8	13.30 (5.93)	3-27
		≥6			1.83 (1.53)	0-7	15.65 (8.08)	3-38

A similar trend was followed for all measures across Cohort 2. However, unexpected results emerged for the youngest children (i.e. 1;6-1;11) in comparison with the other age groups within the cohort (i.e. 2;0-2;5 and 2;6-3;0). Their number of Tokens, Types, and InfrVar seemed particularly low across both criteria (e.g. Tokens *M*=45.70, SD=13.93). These values appear to be unlikely when compared to the rest of the data, and may be due to the limited word elicitation in the test subsection for this age group (see section 2.4.2). Data for this age group should thus be interpreted with caution. Across the remaining age groups in this cohort (i.e. 2;0-2;5 and 2;6-3;0) a noticeably higher number of Tokens as well as a higher proportion of InfrVar across both criteria was presented compared to children in Cohort 1 (i.e. above 3;0). Indeed, when both cut-offs were applied, the number of InfrVar across each age group in Cohort 2 represented

about two thirds of the Tokens for that age. Across all age groups and independently from the cut-off criterion adopted, relatively large SDs and ranges reveal a considerable variability among children within the same age group.

6.2 Developmental Phonological Patterns

The occurrence of phonological patterns considered developmental for each age group (i.e. present in 10% or more of the children in a given age group) will now be presented; again with findings for children aged 3;0-4;11 being described first, followed by the secondary data on children aged 1;6-3;0.

6.2.1 Cohort 1: primary data, children aged 3;0-4;11

Concerning the occurrence of phonological variations that met the two different cut-off criteria to be considered patterns, 22 patterns (i.e. 20 phonological patterns and two phonetic patterns) were observed for children above 3;0 years of age. **Error! Reference source not found.** illustrates the percentages of occurrence of these patterns for each age group and cut-off criterion investigated.

Five phonological patterns (Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, Heterosyllabic Consonant Cluster to Geminate) and two phonetic distortions appeared across all age groups above 3;0 years of age, for both cut-off criteria, and decreased in occurrence with increasing age, although not resolving by the oldest age group.

Three additional phonological patterns (Deaffrication, Devoicing, and TCC Reduction) appeared across both criteria, for several age groups. These presented low or noticeably decreasing percentages of occurrence for the ≥4 criterion, and very low, if at all occurring, for ≥6. Deaffrication appeared in less than 30% of the children in all age groups for the lower cut-off, but solely at the ages of 3;0-3;5 and 4;0-4;5 for the higher criteria. Devoicing was observed for the lower cut-off from 3;6 up to the age of 4;11, although with very low frequency. For the higher cut-off, Devoicing only appeared in 12% of children at the age of 4;0-4;5. Finally, TCC Reduction emerged with higher percentage of occurrence compared to the other two patterns across all age groups from the age of 3;0 when the lower cut-off was adopted, but had a reduced occurrence in the higher cut-off, disappearing at the age of 4;6.

Table 29: Percentage of occurrence of Phonological Patterns and Phonetic distortions observed across all age groups in the first cohort, for the ≥4 and ≥6 cut-off criteria.

	Cut-off	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
		n=28	n=55	n=60	n=40
Substitution Patterns					
Fronting of /ʃ/→ /[s]*	≥4	50	38	18	28
	≥6	50	38	18	28
Fronting of /ʧ, ʤ/ →[ʦ, ʣ]	≥4	32	13	17	13
	≥6	29	11	12	13
Gliding of /ʎ/→[j]	≥4	89	85	83	70
	≥6	89	85	83	70
Lateralisation of /r/ →[l]	≥4	64	31	20	18
	≥6	43	24	15	13
Deaffrication	≥4	25	11	23	13
	≥6	25		12	
Affrication	≥4	21			10
	≥6				
Devoicing	≥4		15	22	15
	≥6			12	
Vowel Substitution /eɨ↔ /ɛ/	≥4	11		10	
	≥6				
Vowel Substitution /oɨ↔ /ɔ/	≥4	11	11	17	
	≥6	11		10	
Stopping of Fricatives	≥4	11	13		
	≥6		11		
Stopping of Affricates	≥4		13		
	≥6				
Assimilation	≥4	18	11		
	≥6				
Heterosyllabic Cluster → Geminate	≥4	61	49	25	23
	≥6	57	27	15	13
Structural Patterns					
Tautosyllabic Cluster Reduction	≥4	50	40	20	10
	≥6	21	16	10	
Heterosyllabic Cluster Reduction	≥4	11	13		
	≥6				
Deletion of /r/	≥4	11			
	≥6	11			
Geminate Reduction	≥4		13		
	≥6				
Weak Syllable Deletion	≥4		15		
	≥6				
Word Initial Consonant Deletion	≥4	11			
	≥6	11			
Syllable Initial Consonant Deletion	≥4	11			
	≥6				
Phonetic distortions					
Distortions of /s, z/ (e.g. /s/→ [s̪])	≥4	50	49	33	18
	≥6	50	45	32	10
Distortions of /r/ (e.g. /r/ → [ɾ])	≥4	50	40	40	33
	≥6	43	35	37	33

*Definitions and examples of each pattern are reported in Appendix 6.

Further eight patterns (Affrication, Vowel Substitution /e/↔/ɛ/, Stopping of the Affricates, Assimilation, HCC Reduction, Geminate Reduction, Weak Syllable Deletion-WSD, and Syllable-Initial Consonant Deletion-SICD) emerged in low percentages only for the lower cut-off. Both Assimilation and HCC Reduction were present up to the age of 3;11. Furthermore, Affrication and the substitution of the open and closed vowels /e, ɛ/ were observed only at 3;0-3;5 and 4;6-4;11, and 3;0-3;5 and 4;0-4;5 respectively. The remaining four patterns (i.e. Stopping of Affricates, Geminate Reduction, WSD, and SICD) appeared only in one age group, all below 3;11 and with percentages of occurrence lower than 15%.

Finally, four more patterns (Vowel Substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, Word Initial Consonant Deletion-WICD) were found solely across the first two or three age groups, with noticeably low frequencies across both cut-offs. The mutual substitution of the open and closed vowels /o, ɔ/ emerged in the first three age groups for the ≥4 cut off, and solely at the ages of 3;0-3;5 and 4;0-4;5 for the ≥6 criterion. Stopping of the Fricatives appeared from the age of 3;0 to 3;11 for the lower cut-off, but only between 3;6-3;11 for the higher criterion. Deletion of /r/ and WICD appeared instead across both cut-offs, solely at the age of 3;0-3;5.

6.2.2 Cohort 2: secondary data, children aged 1;6-3;0

With regard to the secondary data (i.e. from Zmarich et al., 2012), the same patterns that were observed for the first cohort were found, with the exception of Gliding of /ʎ/. Furthermore, children in the second cohort presented six additional patterns. Thus, this second cohort showed 27 patterns (i.e. 25 phonological patterns and 2 phonetic patterns (**Error! Reference source not found.**). The trend in emergence of the patterns found will be described first, with the two cohorts being compared afterwards. Definitions and examples of each pattern are reported in Appendix 6.

Table 30: Percentage of occurrence of Phonological Patterns and Phonetic distortions observed across all age groups in the second cohorts, for the ≥4 and ≥6 cut-off criteria.

	Cut-off	1;6-1;11	2;0-2;5	2;6-3;0
		n=10	n=10	n=10
Substitution Patterns				
Fronting of Velars*	≥4	20	10	10
	≥6	20	10	10
Fronting of /ʃ/→ /[s]	≥4			10
	≥6			
Fronting of /ʧ, ʤ/ →[ʦ, ʣ]	≥4			10
	≥6			10
Lateralisation of /r/ →[l]	≥4			10
	≥6			10
Deaffrication	≥4	10	30	30
	≥6		20	20
Affrication	≥4		10	10
	≥6			
Devoicing	≥4	30	60	70
	≥6	10	60	30
Vowel Substitution /e/↔ /ɛ/	≥4	10	40	30
	≥6		30	20
Vowel Substitution /o/↔ /ɔ/	≥4			10
	≥6			
Stopping of Fricatives	≥4		10	10
	≥6			
Stopping of Affricates	≥4			10
	≥6			10
Assimilation	≥4	10	30	10
	≥6	10	10	
Heterosyllabic Cluster → Geminate	≥4		10	70
	≥6			60
Backing of /s, z/ → [ʃ, ʒ]	≥4		40	20
	≥6		40	20
Backing of /ʦ, ʣ/ → [ʧ, ʤ]	≥4			10
	≥6			
Nasalisation /b, d/ → [m, n]	≥4	10		10
	≥6			
Structural Patterns				
Tautosyllabic Cluster Reduction	≥4		90	90
	≥6		50	70
Heterosyllabic Cluster Reduction	≥4			40
	≥6			10
Epenthesis	≥4			20
	≥6			
Deletion of /r/	≥4		30	10
	≥6			
Geminate Reduction	≥4	60	60	40
	≥6	50	30	20
Gemination	≥4			10
	≥6			
Weak Syllable Deletion	≥4	60	40	
	≥6	60	30	
Word Initial Consonant Deletion	≥4	30	10	
	≥6		10	
Syllable Initial Consonant Deletion	≥4	10	10	
	≥6		10	
Phonetic distortions				
Distortions of /s, z/ (e.g. /s/→ [s̪])	≥4		20	10
	≥6		20	10
Distortions of /r/ (e.g. /r/ → [ɾ])	≥4		20	40
	≥6			20

Three patterns (Fronting of Velars, Devoicing, and Geminate Reduction) emerged across all age groups and for both cut-off criteria, although not always decreasing in percentage of occurrence. Both Fronting of Velars and Geminate Reduction decreased with increasing age, the former with much lower percentages of occurrence compared to the latter. Devoicing appeared instead in higher percentages in the older children (i.e. 2;6-3;0 and 2;0-2;5) compared to the youngest (i.e. 1;6-1;11).

Six phonological patterns (Deaffrication, Vowel Substitution /e/↦ /ɛ/, Assimilation, Backing of /s, z/, TCC Reduction, and WSD) and one phonetic pattern (Distortion of /s, z/) were found across most ages in both criteria, with varying percentages of occurrence. Deaffrication, Vowel Substitution /e/↦ /ɛ/, and Assimilation appeared across all age groups for the lower cut-off, but solely in two age groups for the higher criterion. All presented low or decreasing percentages and a very low occurrence at 1;6-1;11 compared to the older children in the same cohort, reflecting the limited elicitation of targets in the subtest used for the youngest children exposed in section 2.4.2. The remaining phonological patterns (Backing of /s, z/, TCC Reduction, and WSD) all emerged in two age groups across both criteria (2;0-3;0 for the first two patterns, 1;6-2;5 for WSD) with high percentages which decreased with increasing age. Similarly, the phonetic distortion of /s, z/ occurred solely between 2;0-3;0 and with decreasing frequency.

Three more phonological patterns (HCC to Geminate, HCC Reduction, and WICD), and the other phonetic pattern (Distortion of /r/) appeared only across some age groups in percentages higher than 20%, although disappearing for some age groups when the higher cut-off was applied. Both HCC to Geminate and the distortion of /r/ were present only from the age of 2;0 for the lower cut-off, and from the age of 2;6 for the higher cut-off, and both showing lower percentages of occurrence for the younger children (≥4). HCC Reduction and WICD appeared for the ≥6 cut-off solely in 10% of children and in one age group, while showing a marginally higher frequency for the ≥4 cut-off, which decreased with increasing age for WICD.

Four additional patterns (Fronting of /ʧ, ʤ/, Lateralisation of /r/, Stopping of Affricates, and SICD) occurred only in 10% of children for both criteria and in one age group. The first three were present in the older children of this cohort (i.e. 2;6-3;0), while SICD appeared across two age groups for the ≥4 cut-off, while occurring solely between 2;0-2;5 for the ≥6 cut-off.

Finally, the nine remaining patterns (Fronting of /ʃ/, Affrication, Vowel Substitution /o/↦ /ɔ/, Stopping of Fricatives, Backing of /ʦ, ʤ/, Nasalisation of /b, d/, Epenthesis, Deletion of /r/, and Gemination) appeared only for the lower criterion, in one or two age groups and with low occurrence. Fronting of /ʃ/, the substitution of vowels /o, ɔ/, Backing of /ʦ, ʤ/, Epenthesis, and Gemination were all found in the oldest children of Cohort 2 (i.e. 2;6-3;0) only. Affrication, Stopping of Fricatives, and Deletion of /r/ appeared instead across the age of 2;0-3;0. Finally, Nasalisation of /b, d/ occurred at 1;6-1;11 and then again at 2;6-3;0.

In comparison with the Cohort 1, six patterns emerged across Cohort 2 which were not observed in children above the age of 3;0 (Fronting of Velars, Backing of /s, z/, Backing of /ʦ, ʤ/, Nasalisation of /b, d/, Epenthesis, and Gemination). Of these, solely the first two appeared when both cut-offs were applied and across most or all age groups, suggesting that they may be typical of young children although early resolved. Contrarily, children in Cohort 1 showed one pattern which was not found in Cohort 2 (Gliding of /ʎ/): however, this is likely due to the absence of the target consonant across the TFPI assessment used to test children in Cohort 2.

Overall, patterns which were highly frequent across Cohort 1 appeared to emerge also in the adjacent age groups in Cohort 2 (e.g. HCC to Geminate, TCC Reduction, phonetic distortions). A few patterns which appeared in lower percentages in the oldest children (Cohort 1) were found with higher frequency in the youngest (Cohort 2), suggesting early occurrence and resolution (e.g. Geminate Reduction, WSD). Finally, some patterns appeared with only low percentages of occurrence and/or solely for the ≥4 cut-off across children in both cohorts (e.g. Stopping of Affricates, HCC Reduction), which may imply incidental occurrence.

6.3 Summary

In summary, the present chapter provided an overview of the findings concerning the phonological variations presented by children across the ages of 1;6-3;0 and 3;0-4;11. Overall, participants showed a decrease in all quantitative measures, although this was less marked for the InfrVar, which still accounted for about half of all the phonological variations by the age of 4;11. In terms of patterns, most were observed across both cohorts, if with different percentages of occurrences. An overall reduction in the presentation of phonological patterns, with some patterns disappearing across the ages investigated, was observed, suggesting developmental progression. Children in Cohort 1 presented one pattern that was not found for Cohort 2 (i.e. Gliding of /ʎ/) due to the phone not being elicited in the testing material. Six patterns emerged instead in Cohort 2 but not in Cohort 1. Finally, it is fundamental to remember that the two cohorts were obtained through different assessment tools and were composed differently in terms of sample (i.e. numbers, distribution), thus data should be interpreted with caution and a continuum between the two cohorts should not be assumed. The following chapter (i.e. Discussion II) will discuss the findings here outlined in light of the available literature. Considerations on the differences in methodologies across the two cohorts will also be discussed.

7. Discussion II

The second part of this research aimed at answering the following research questions:

2. Which phonological variations occur in the typical development of Italian speaking children of the population under study?

> a. To which extend does the occurrence of phonological variations (Tokens, Types, and Infrequent Variants) change with age indicating progress of phonological development?
>
> b. Which types of phonological pattern can be observed as developmentally typical at what age when two different cut-offs (i.e. ≥4, ≥6) are adopted?

In this chapter, the results will be discussed in relation to the available literature on Italian children's phonological development, as well as research on Romance languages and languages that share similarities with the phonological system of Italian. First, the quantitative measures of phonological development (i.e. Tokens, Types, and InfrVar) will be discussed across the two cohorts; secondly, the occurrence and types of phonological patterns will be examined separately for the first and second cohorts. As discussed at the beginning of the Discussion I, data from the two cohorts were collected through separate assessments and cannot therefore be considered a continuum due to differences in the assessment construction and sample composition (see section 2.4.2 in the Literature Review II and Discussion I).

7.1 To which extend does the occurrence of phonological variations (Tokens, Types, and Infrequent Variants) change with age indicating progress of phonological development?

Overall, with the exception of unexpectedly high results from the youngest age group (i.e. 1;6-1;11, likely due to the differentiated task for that age group in the testing material) and some results related to the number of Types for the second age group (i.e. 2;0-2;5), findings across the two cohorts appeared in agreement with the expected developmental improvement posited in hypothesis 2.a.i, which predicted that children would show an overall decrease across the measures investigated. Thus, results for Tokens, Types, and InfrVar will be here reported together for the two cohorts.

Children in the target population across both cohorts showed a steady reduction in the total number of phonological variations (Tokens) from the age of 2;0-2;5 to 4;6-4;11, reducing by about two thirds. As mentioned above, this was expected in hypothesis 2.a.i,

which posited change across time indicating developmental progress of phonological acquisition. Similarly, and in line with developmental progression, the number of phonological patterns (Types) decreased by around half at the age of 4;6-4;11 compared to the average at the age of 2;6-3;0, although the proportion was marginally different when the higher cut-off criterion was applied. Currently, no literature available for Italian has investigated these measures, preventing a direct comparison of the results. Nevertheless, a gradual reduction in the number of patterns found was also reported across research on Romance languages. Two studies which reported on the number of variations considered patterns on Chilean Spanish-speaking children (Pavez et al., 2009), and of pattern types on Brazilian Portuguese (da Silva et al., 2012). In particular, the study by da Silva et al. (2012), investigating children across the ages of 3;0-7;11 (in 12-months age groups), showed similarities to Cohort 1 of this study (i.e. 3;0-4;11), although Italian children appeared to present less Types compared to Brazilian-Portuguese children of the same age. da Silva et al. (2012) reported the mean number of types for the age groups 3;0-3;11 and 4;0-4;11 as being respectively *M*=5.80 and *M*=3.65 for children with high SES (means were higher for children with low SES). Children in Cohort 1 presented similar means of Types, when the cut-off of 4 occurrences was applied, for the lower half of those age groups (i.e. *M*=5.93 and *M*=3.23 for 3;0-3;5 and 4;0-4;5 respectively), but lower means in the higher half (i.e. *M*=4.71 and *M*=2.45 for 3;6-3;11 and 4;6-4;11 respectively). The disparity between Brazilian-Portuguese and Italian children was higher when the cut-off of 6 occurrences was applied to Cohort 1. However, no reference to the cut-off criterion used at individual level to mark a variation as pattern in the study by da Silva et al. (2012) is reported, suggesting that all phonological variations were counted as patterns, thus resulting in a higher number of types identified at each age compared to the current study.

As hypothesised in 2.a.iii, which predicted a remaining number of phonological variations being present at 4;11, the presence of phonological patterns in the oldest children in this research is in line with the study by Tresoldi et al. (2018), reporting that eleven of the phonemes in the Italian inventory were still not mastered (i.e. pronounced correctly by 90% of children) by the age of 5;0. The presence of pattern-like simplifications in Italian children at the age of 4;11 also agrees with findings across literature on Romance languages (i.e. Spanish, Portuguese, and French) and Maltese (see Table 35 in Appendix 1), which implicate a continuous development of the phonological system up until the age of seven in these languages (Ceron, Gubiani, de Oliveira, & Keske-Soares,

2017; da Silva et al., 2012; Galcerán, 1983; Grech & Dodd, 2008; Lousada et al., 2012; Pavez et al., 2009; Rvachew et al., 2013).

In contrast, findings from languages of different origin (e.g. Danish, German, English) showed that children's phonological development in these languages seems to be concluded earlier than for the romance languages. For instance, findings for Danish and German suggested that solely one and three patterns respectively persisted beyond the age of 4;0 (Clausen & Fox-Boyer, 2017; Fox, 2006). These studies however adopted potentially low cut-off criteria (i.e. ≥4, and ≥3 respectively), suggesting that, had a higher cut-off being used, an earlier conclusion of the phonological acquisition for these languages might have been implied. As seen in section 7.2, the criterion ≥4, also adopted in this research as the lower cut-off, may indeed prove too low and provide less accurate information in comparison to a higher (e.g. ≥6, as explored in this study) cut-off. Similarly to the findings for Danish and German, Dodd et al. (2003) for British English, and Roberts et al. (1990) for American English found respectively one and no pattern in more than 10% of children above the age of 4;11. In this perspective, it appears that children acquiring romance languages, among which Italian, develop more slowly compared to speakers of other languages. Hypotheses on the reason behind this (e.g. phonetic frequency) have already been discussed in section 5.1 (Giulivi et al., 2006; Zmarich et al., 2012).

Another measure supporting the hypothesis of a slower development of Italian children compared to speakers of other languages is the number of InfrVar. These were considered in this study as a measure of stability of the phonological development and developmental change in children's production. Contrarily to what hypothesised in 2.a.i, however, these variations appeared to present a less marked reduction with age increase than phonological patterns. Their presence across all ages in both cohorts and for both cut-offs, alongside their limited decrease in occurrence even in the oldest children, also supports the claim that InfrVar might play a relevant role in the development of phonology. Additionally, and most noticeably, when compared with the overall number of phonological variations found, InfrVar were observed to account for about half of all the phonological Tokens across all age groups. This proportion was however much higher for children in the second cohort (1;6-3;0), whose InfrVar accounted for about two thirds of the Tokens, compared to the first cohort (3;0-4;11). Furthermore, the SD for the InfrVar measures in children from Cohort 2 (i.e. 1;6-3;0) were comparatively lower than those of Cohort 1 (i.e. 3;0-4;11), with children producing no less than 21 errors that could not be ascribed to phonological patterns. In this

perspective, it might be the case that children below the age of 3;0 still have an unstable phonological system, and, as suggested by some theoretical models of phonological acquisition (Donegan & Stampe, 1979; Jakobson, 1968; Lindblom, 1992), have not yet acquired the simplification 'rules' regulating the acquisition of their language.

In line with the claim of a slower development of the Italian population compared to other languages, Danish children (Clausen, personal communication, September 2, 2021) were observed to reduce the number of InfrVar faster than Italian children (InfrVar decreasing from *M*=38.26 at 2;6-2;11 to *M*=5.46 at 4;6-4;11, compared to the decrease from *M*=37.30 to *M*=13.30 across the same ages in Italian children). However, Danish children showed a much wider variability within the same age group (e.g. SD=26.79 at 2;6-2;11 compared to the SD=9.44 of Italian children at the same age). Despite this difference and the seemingly more consistent performance among Italian children of the same age compared to children acquiring Danish, findings should be interpreted carefully: indeed, Italian and Danish do not belong to the same language family, and therefore share few similarities in terms of phonological system. Furthermore, Clausen (personal communication, September 2, 2021) calculated the number of InfrVar adopting a slightly lower cut-off for phonological patterns compared to the current study (i.e. cut-off of three occurrences), limiting the comparability of the data.

Despite InfrVar remaining present at 4;11, a progressively higher stability in children's production was observed with increasing age, with children performing gradually more rule-like simplifications compared to variations which could not be classified as patterns. This finding is in line with the prediction made in hypothesis 2.a.ii, which posited a higher proportion of InfrVar for younger children compared to older ones. Nevertheless, the number of InfrVar at all ages across the two cohorts remained high, even when the higher cut-off was applied. This suggests that InfrVar may be crucial in the description of children's phonological development, as they appear to occur frequently across ages, with the current findings suggesting that these types of variation be found also in children above the age of 5;0. Indeed, already previous studies have shown that children produce 'one-off' errors that cannot be accounted for as phonological patterns. McReynolds and Elbert (1981) first noticed that the phonological profile of American-English-speaking children reported to have 'articulatory disorder' changed when a quantitative criterion was applied to the identification of phonological patterns. Indeed, the number of variations that were identified as patterns reduced drastically when a cut-off of at least 4 occurrences was applied. In this case, children presented a much lower number of 'rule-like' variations while also presenting a large number of incidental/one-offs errors. More

recently, McIntosh and Dodd (2008) reported the occurrence of one-off errors also in typically-developing English children: very similarly to the data from Cohort 2 (i.e. 1;6-3;0) in this study, at least two thirds of the children in both their age groups (i.e. 2;1-2;5 and 2;6-2;11) presented phonological variations that could not be considered patterns, when a cut-off even as low as two occurrences was adopted. Similarly, two Italian studies also mentioned 'other substitutions' and 'phonologically plausible substitutions' (Viterbori et al., 2018; Zanobini et al., 2012) as occurring in their samples, although with low percentage of occurrence (see Table 34 in Appendix 1). Finally, Albrecht (2017) also found that bilingual Turkish-German children's phonological variations were constituted largely by InfrVar (on average for 80.55% in German, and 77.24% in Turkish). It was highlighted by Albrecht (2017) that, had the number of InfrVar been discarded as not relevant to the developmental picture, a few children potentially developing atypically would have been mislabelled as TD on account of their age-appropriate presentation of patterns in at least one language.

It is evident that one-off errors which cannot be labelled as phonological patterns have now been recurringly found across languages, for both typically- and atypically-developing children, as well as for both monolingual and bilingual children. Thus, it seems necessary that InfrVar should be accounted for when investigating children's speech and phonological development. The difference in the identification of patterns according to a quantitative criterion not only influences knowledge of the developmental characteristics of phonological acquisition, as also seen in the different types of patterns discussed in section 7.2, but also has implications for clinical practice. InfrVar could indeed first of all provide additional information on the classification of a child's phonological development in relation to the norm for their age group and population. Additionally, in a diagnostic perspective, an analysis of the performance of children with SSD in terms of deviation from the norm for pattern types as well as InfrVar may indicate whether children with this diagnosis solely perform poorly concerning their number of InfrVar as found for bilingual children by Albrecht (2017). In terms of Italian development, additional research should be conducted on both typically and atypically developing children to investigate further the occurrence and role of InfrVar in children's phonological development.

Across all measures, large SD values could be observed, indicating a wide variability in the phonological development among Italian children of the same age, as already highlighted also for accuracy measures (see section 5.1). Indeed, some children aged 4;6-4;11 still presented up to eight or seven (according to the cut-off) phonological

patterns. On the contrary, already at the age of 3;0-3;5, and at the age of 2;6-3;0 for the higher cut-off, some children showed no more phonological patterns. Although developmental variability is usually reported for children in international studies, no Italian study calculated the measures here discussed, and the sole two studies on Romance languages (i.e. Chilean Spanish: Pavez et al., 2009; Brazilian Portuguese: da Silva et al., 2012) that reported on the number of patterns and of pattern types did not provide the SDs for these measures. Thus, it is not possible to compare the variability found in Italian children in light of previous research. Finally, in terms of variability across the ages, as mentioned in section 6.1, an apparently better performance of children at the ages of 1;6-1;11 across all measures, and at 2;0-2;5 for Types was observed in Cohort 2. This, however, could be an artifact of words having been selected specifically for each age groups and of the under-elicitation of target phones/structures (see section 2.4.2).

7.2 Which types of phonological pattern can be observed as developmentally typical at what age when two different cut-offs (i.e. ≥4, ≥6) are adopted?

Having discussed the quantitative measures relating to phonological variations, the types of phonological variations that met the criteria to be labelled as patterns will be now commented. In this perspective, various groups of patterns were identified which occurred in different trends. Findings will be here revised in terms of their distribution and occurrence in relation to the two cut-off criteria and age groups, as well as their similarities and differences with the available literature on Italian and romance languages.

As previously mentioned, 20 phonological and 2 phonetic patterns were observed across Cohort 1 (see **Error! Reference source not found.** in Results II). Of the 20 phonological patterns observed, four groups of patterns could be identified: 1) phonological patterns that appeared for both criteria and across all age groups; 2) patterns that occurred for both the cut-offs, across several age groups, although with low or noticeably decreasing percentages; 3) patterns that occurred solely for the ≥4 cut-off with low percentages; 4) patterns emerging across both cut-offs with very low percentages and solely in the first two/three age groups. Of the 20 patterns observed in the Cohort 1, all but one (i.e. Gliding of /ʎ/) were also found in the secondary data. It is worth noticing, however, that Gliding of /ʎ/ did not have the opportunity of occurring for the children between 1;6-1;11, and could only be presented in two occasions for children aged 2;0-3;0 in the assessment used by Zmarich et al (2012). Six patterns were instead identified exclusively in the three age groups (i.e. 1;6-3;0) of the Cohort 2. Findings from the analysis on children's

performance in Cohort 2 may shed some light on the hypotheses made for the patterns found in Cohort 1. Specifically, the age in which those highly frequent patterns found in Cohort 1 first appear may be identified. In addition, clarification might be gained with regard to the status of pattern vs. InfrVar of those low-frequency variations that were labelled as patterns for children above the age of 3;0. Nevertheless, it is necessary to remember that findings from these data are not entirely reliable and comparable due to the issues with the design of the assessment material, explored in detail in section 2.4.2. Patterns will be here evaluated following the order of presentation of the first cohort. Patterns solely found in this cohort will be then discussed. The two phonetic patterns will also be addressed separately.

7.2.1 Patterns occurring for both cut-off criteria across all age groups

Five patterns belonged to the first group in Cohort 1, i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, and HCC to Geminate. These appeared in high percentages and presented decreasing occurrence independently of the cut-off implemented, but did not resolve in the population studied. This fact suggests that the mentioned patterns could still be typical beyond the age of 4;11, in line with the hypothesis 2.b.iv of a continuous development beyond the age of 5;0. However, two patterns (i.e. Fronting of /ʧ, ʤ/ and Lateralisation of /r/) decreased to a very low percentage of occurrence by the age of 4;11, implying that they may remain below the threshold of 10% of children (e.g. Dodd et al., 2003) at the age of 5;0 and beyond. Overall, the occurrence of these five patterns agrees with findings from the most comprehensive study on Italian consonant acquisition. Indeed, Tresoldi et al. (2018) reported that the consonants /ʃ/, /ʧ, ʤ/, /ʎ/, and /r/, affected by the patterns discussed, were acquired above the age of 5;0. Italian studies that investigated phonological patterns however have considered solely children below the age of 3;0, with the exception of Bortolini (1995), and therefore are not appropriate for comparison.

Nevertheless, four out of the five patterns here discussed (i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, and Lateralisation of /r/) were also reported by some authors across previous Italian studies in their younger populations (i.e. 1;6-4;6 across studies), suggesting that they could be patterns typical also of children below the age of 3;0 (Bortolini, 1995; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012). Findings on Cohort 2 will help shed some light on this matter. Of the patterns that were present across all ages for both cut-offs in the Cohort 1, Solely Fronting of /ʧ, ʤ/ and Lateralisation of /r/ were found across both cut-off in the second cohort, while Fronting

of /ʃ/ only occurred when the cut-off of 4 was applied. This disparity in the presentation of these phonological patterns may be ascribed to the limited elicitation of some of the consonants, particularly in the target list for the younger children in the TFPI test (Zmarich et al., in progress), as previously outlined in section 2.4.2.

As previously discussed for the findings of the first cohort, four out of five patterns (i.e. Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, and Lateralisation of /r/) here presented were also described in previous Italian research in two or more studies, either with exact correspondence in the pattern definition (e.g. Lateralisation of /r/), or within an overreaching pattern (e.g. Fronting). Since solely two studies assessed children below and above the age of 3;0 (Zanobini et al., 2012, up to 3;6; Bortolini, 1995, up to 4;6), but all studies reported these patterns across all ages in their populations (from the age of 1;6), the idea that these patterns are typical also of children below the age of 3;0 can be supported.

The pattern HCC to Geminate was never described before in Italian literature or literature on Romance languages and Maltese. Indeed, in the available Italian literature, studies addressing patterns on consonant clusters either classified cluster reduction as a pattern common to the two types, or solely considered SI clusters (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), limiting the reliability and generalisability of the results. The lack of distinction between patterns affecting TCC and HCC may be due to the fact that the assimilation of a consonant to the other in an HCC (i.e. formation of a geminate) is considered by Italian practitioners to be a ‘stage’ of the evolution of the Consonant Cluster Reduction pattern (Santoro & Panero, 2013). In this perspective, the current research distinguished between patterns adopted to simplify TCC from those applied to HCC, providing novel information on how children treat the specific structures. The high frequency of the pattern HCC to Geminate across Cohort 1 (i.e. 3;0-4;11), together with the presence of TCC Reduction discussed below (section 7.2.2), provides baseline evidence that different types of patterns are applied to each type of cluster in children of the same age. Although the pattern had limited occurrence across Cohort 2, this may be an artefact of the reduced presentation of the clusters in the TFPI assessment (Zmarich et al., in progress). When present, however, this pattern occurred in a high percentage of children, suggesting that it may also be a pattern that is present already prior to the age of 3;0. This and a further observation of the way phonological patterns affect different types of clusters will be discussed below once the pattern affecting TCC has been introduced (see section 7.2.2).

Similarly to the classification of patterns affecting consonant clusters, across studies the descriptions of what patterns entail differ from one author to the other and are often too broad to allow for direct comparison (see section 1.2.1.2.3 in Literature Review I). An example is the definition of the pattern Fronting. While Bortolini's (1995) pattern Fronting is an overreaching pattern that includes fronting of velars and of postalveolars, findings from the current research suggest that these two subtypes occur differently within the same population. Although Fronting of Velars did not reach the 10% cut-off for children in Cohort 1, Fronting of /ʃ/ was still largely present at the age of 4;11. Similarly, the pattern Gliding was described by Bortolini (1995) as the substitution of any consonant with a semivowel/semiconsonant, and was reported in her sample up to the age of 2;9. However, the analysis of Cohort 1 of this study showed that Gliding of /ʎ/ was present across all ages and still not resolved by 4:11.

In terms of the literature available for languages that share features with Italian, studies on Romance languages and Maltese appear to show similarities in terms of occurrence and disappearance of the patterns here discussed (a detailed list of the patterns found in the comparison studies can be read in Table 35 in the Appendix 1). Their results support the findings on the occurrence of phonological variations here discussed that suggested a later conclusion of the phonological development in children acquiring romance languages compared to other languages (see section 7.1.1). Indeed, both Lateralisation of /r/ and Gliding (although Gliding was used as a broad pattern for substitution of a consonant with a semiconsonant) were accounted for across Castellan, Brazilian Portuguese, Portuguese, and Maltese. Both patterns were reported to disappear between the ages of 6;0-7;11 across the romance languages (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Lousada et al., 2012), although earlier (i.e. up to 4;11) for Maltese (Grech, 1998; Grech & Dodd, 2008). Although studies on the romance languages solely reported Fronting of Velars, the study by Grech and Dodd (2008) showed that the pattern Fronting, including both velars and affricates, was still present at the age of 6;0 in Maltese-speaking children. Overall, similarly to the Italian literature, all studies reported all occurrences of phonological variations at the individual level, and most also reported patterns occurring in less than 10% of children at age-group level, therefore including variations that might not have been considered typical patterns had a quantitative cut-off criterion been applied. Thus, the ages of occurrence and disappearance of the patterns here and below described should be given careful consideration.

7.2.2 Patterns occurring for both cut-off criteria across several age groups with low and/or fast-decreasing frequency

Three patterns occurred for both cut-offs and across several age groups although with low or rapidly decreasing frequency (Deaffrication, Devoicing, and TCC Reduction). Deaffrication and Devoicing were found with lower percentages of occurrence compared to TCC Reduction. Given the limited occurrence of these patterns when both criteria were applied, it could be hypothesised that these patterns may be typical or more frequent in children in lower age groups, and be about to fade out above the age of 3;0. Consistently, Deaffrication, and Devoicing also occurred with high frequencies (up to 90%) across both criteria in the population of Cohort 2. It is therefore possible to hypothesise that these patterns should be considered not chance findings but true patterns that are developmentally typical of the younger Italian children and resolving before the age of 5;0.

Across Italian literature, Viterbori et al. (2018) and Zanobini et al. (2012), despite not reporting the pattern Deaffrication, presented instead 'Frication' across their population of children above the age of 3;0. This pattern involved the substitution of either a plosive or an affricate with a fricative. In this perspective, then, the pattern Deaffrication was included in this broader pattern. Bortolini (1995) also reported Deaffrication and Devoicing up to the age of 4;6. These finding seem to support the suggestion that these patterns may be typical of the Italian population under the age of 3;0 and fading out above that age. Nevertheless, the constraints already presented on cut-off criteria and pattern description should be taken into consideration when interpreting the findings. Similarly across Romance Languages and Maltese, these patterns have also been reported below (Grech, 1998) and above the age of 3;0 (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; Galcerán, 1983; Grech & Dodd, 2008) for Maltese, Brazilian Portuguese, and Castellan-speaking children, with age of disappearance below 3;11, providing additional evidence to the claim, and suggesting a universal value of these patterns (i.e. patterns found across languages rather than being language-specific).

The pattern TCC Reduction showed a much faster reduction in occurrence compared to the patterns discussed in the previous category (section 7.2.1). However, the pattern was still markedly present across all ages in Cohort 1 when both cut-offs were applied, disappearing only in the older children (i.e. 4;6-4;11) for the cut-off of ≥6, and was highly frequent across Cohort 2 (see

Table 30). This presentation may imply that the pattern is typical of these and younger ages fading out after the age of 4;5. Additionally, the low occurrence of TCC Reduction across Cohort 1 could also be ascribed to the lack or low elicitation of some clusters involved in the assessment used for the collection of the primary data (i.e. BVL_4-12, Marini et al., 2015).

Interestingly, the separate analysis for the two types of consonant co-occurrence (i.e. TCC and HCC) allowed to determine that children treat tautosyllabic clusters differently from consonants co-occurring at syllable boundaries (i.e. heterosyllabic) on most occasions. Indeed, children appeared to reduce TCC to one element (e.g. 'treno' train /ˈtre.no/ - [ˈte.no]) across most ages with high prevalence. However, they kept both consonant of an heterosyllabic cluster but assimilated one to the other to create a geminate (e.g. 'albero' tree /ˈal.be.ro/ - [ˈab.be.ro]) in the majority of occasions (see above section). A specific mention needs to be made about consonant clusters with /s/. Findings from this study showed how clusters with the alveolar fricative appeared to be reduced to one element, usually by deleting /s/, when in WI (e.g. 'scopa' broom /ˈskopa/ - [ˈkopa]), but to be transformed into a geminate as for HCC in WM position (e.g. 'pasta' pasta /ˈpasta/ - [ˈpatta]). This appears to provide supporting evidence for the claim, outlined in section 2.2.1.1, that /s/-clusters may acquire variable status depending on their position, thus behaving as TCC when in WI and as HCC when in WM position (Bertinetto & Loporcaro, 2005).

Across the available Italian literature, all studies but Bortolini (1995) described the pattern Cluster Reduction with no distinction on the cluster position, marking its presence up until the age of 3;6 at least, as this was the oldest age group investigated across studies which reported cluster reduction (Zanobini et al., 2012). This supports the claim that patterns affecting consonant clusters are typical across the development of young children and may continue to occur over the age of 4;0. Findings from the study by Zmarich et al. (2012) should however be interpreted with caution with respect to the overreaching category 'cluster reduction', as they included the reduction of geminates within the pattern. Similarly to the Italian literature, no distinction in the position of consonant clusters was made when reporting cluster reduction patterns in most studies on romance languages and Maltese. However, research on Spanish and Portuguese account for this pattern up until the ages of 6;11 (da Silva et al., 2012; Galcerán, 1983; Lousada et al., 2012) and 7;11 (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017), suggesting that the hypothesis of the low occurrence of the pattern TCC Reduction in

the current data being due to the low elicitation in the assessment material might be true. In addition, TCC Reduction has been observed across other languages where possible (e.g. Hua & Dodd, 2006), and it has therefore been suggested that it be considered a universal pattern. Nonetheless, Grech and Dodd (2008) found that the pattern seem to instead disappear at the age of 4;11 in Maltese children, finding that would be in line with the result obtained in the present cohort. These divergencies highlight the necessity of collecting thorough data on Italian-speaking children up until the age of 7;0 at least, in order to provide a clearer picture of the developmental changes in the population.

7.2.3 Patterns occurring in low percentages either for the lower cut-off criterion and only below the age of 4;0, or mostly for the lower criterion and below the age of 4;6

Eight patterns (i.e. Affrication, Vowel Substitution /e/↔/ɛ/, Stopping of Affricates, Assimilation, HCC Reduction, Geminate Reduction, WSD, and SICD) were solely found for the cut-off of ≥4. The low occurrence of these patterns limited to the application of the lower cut-off criterion could suggest that these may not be true patterns, rather simplifications that were labelled as pattern due to the use of an inappropriate low cut-off (as suggested in the hypothesis 2.b.i, which predicted a lower number of pattern types emerging compared to available literature due to the application of a more strict cut-off). The remaining four patterns (i.e. Vowel Substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, and WICD) appeared below the age of 4;6, again with markedly low percentages of occurrence and mostly for the lower criterion. Similarly to the patterns showing fast decreasing occurrence (see section 7.2.2), these may be patterns typical of younger children. However, as they partially disappeared for the higher cut-off, they may instead also be InfrVar wrongly classified as patterns due to the use of a too low cut-off. From the analysis of the secondary data from children aged 1;6-3;0, it appears that both Geminate Reduction, and WSD could indeed be considered patterns typical of younger children, as they appeared with relatively high percentages (i.e. up to 60%) across both cut-off criteria in Cohort 2. The remaining patterns (i.e. Affrication, Vowel substitution /e/↔/ɛ/, Stopping of Affricates, Assimilation, HCC Reduction, SICD, Vowel substitution /o/↔/ɔ/, Stopping of Fricatives, Deletion of /r/, and WICD) all occurred for one or both criteria with markedly low frequency. This seems to support the proposal that these patterns were not true patterns, but rather incidental findings due to the use of an inappropriate cut-off. Indeed, as Kirk and Vigeland (2015) had previously suggested, the cut-off of four occurrences may be too low for some variations.

Despite the interpretation of these patterns being incidental findings in the current study, they were frequently reported in previous Italian literature below the age of 3;0 (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012), and across romance languages and Maltese (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017; da Silva et al., 2012; Galcerán, 1983; Grech, 1998; Grech & Dodd, 2008; Lousada et al., 2012; Pavez et al., 2009). Notwithstanding, as for the patterns of Fronting and Gliding, all the patterns here discussed were described in previous research as part of overreaching patterns which included more than one category of sounds in their definition. For instance, all studies but Bortolini and Leonard (1991) reported Stopping, without differentiating between fricatives and affricates, which appeared with different frequencies in the current study. Most authors reported, across the entirety of the populations studied, the pattern 'Sound Deletion' without specifying the syllable and word position of the sounds deleted, nor whether the term 'sound' included both consonants and vowels or solely consonants (Bortolini, 1995; Viterbori et al., 2018; Zanobini et al., 2012). Patterns such as 'Syllable Deletion' and 'Vowel Substitution' were also reported across all Italian studies, appearing at different ages according to the populations studied, although no specifications were provided in terms of the type of syllable affected or the vowels involved. Had these variations being categorised more strictly, providing more specific patterns, their occurrences in the population studied might not have been as high, as already showed by the separation used in the current study (e.g. Fronting of Velars was not present among the typical patterns at any age in Cohort 1, while Fronting of /ʃ/ and /ʧ, ʤ/ were both found across all ages). Furthermore, despite these patterns were indeed reported across studies in all age groups assessed, it needs to be reminded that no or very low cut-offs were adopted in the identification of patterns both at child and age-group level, thus limiting the reliability of the results and their interpretation.

Concerning findings from other languages, studies on Spanish, Portuguese, and Maltese seem to present markedly different ages of occurrences for the patterns they also reported. Indeed, despite sharing the presentation of a pattern such as WSD, different ages of disappearance were observed across languages, spanning from as low as 3;0-3;11 for Castellan (Galcerán, 1983) and Maltese (Grech & Dodd, 2008), to as high as 5;5 for Brazilian Portuguese (Ceron, Gubiani, de Oliveira, & Keske-Soares, 2017) and 6;0-6;11 for Portuguese (Lousada et al., 2012). WICD and Stopping of Fricatives were reported across these languages as resolving usually around 3;0-3;11 (Galcerán, 1983; Grech & Dodd, 2008; Lousada et al., 2012). Contrarily, Deletion of /r/ was instead reported by Galcerán (1983) up until the age of 6;0-6;11. Despite the use of these data

for comparison, two considerations must be made. First, it is fundamental to remember that no cut-off was implemented at child level in the studies here mentioned. It could therefore be hypothesised that had a quantitative cut-off been adopted, some if not all of these patterns might have not reached the necessary frequency to be classified as such, therefore supporting the suggestion of these variations being incidental findings due to the use of an inappropriate cut-off. Secondly, the diverse ages at which these patterns are reported for each language suggest that, although patterns may be shared by different languages and similarities may be found, their ages of occurrence and disappearance are language-specific.

7.2.4 Patterns observed solely in the second cohort

Of the six patterns that were observed solely in Cohort 2 (i.e. Backing of /ʦ, ʣ/ → [ʧ, ʤ], Nasalisation /b, d/ → [m, n], Epenthesis, Gemination, Fronting of Velars, Backing of /s, z/ → [ʃ, ʒ]) none appeared with high frequency (i.e. all but one in solely 10-20%). Solely Backing of /s, z/ occurred in a slightly higher percentage of children at 2;0-2;5 (i.e. 40%), suggesting that this may be considered as a typical error pattern for children below the age of 3;0. Given their low percentage of occurrence, the remaining patterns might also be incidental findings, similarly to the patterns discussed above. It is indeed fundamental to remember that each age group in Cohort 2 was composed by solely 10 children, meaning that the occurrence of a pattern in 10% of children was given by the presentation of said pattern by solely one child in the age group. Thus, given the small size of the sample studied and the limitations of the assessment tool used previously outlined (sections 3.1.2 and 2.4.2 respectively), predictions on this cohort are unreliable and should be carefully considered. Nevertheless, all Italian studies but Zmarich et al. (2012) reported to have found Epenthesis. Two Romance languages studies also included it in their patterns, although for older children: Galcerán (1983) for Castellan children aged 3;0-3;11, and da Silva et al. (2012) for low SES Brazilian Portuguese children aged 4;0-4;11. Solely Grech (1998) reported Gemination for Maltese children at the age of 2;0-3;6. As for the previously described patterns, the lack of an appropriate cut-off may have led to the mislabelling of phonological variations as patterns. Nevertheless, the limitations discussed for this cohort warrant the need for further in-depth research on phonological patterns.

7.2.5 Phonetic Patterns

Finally, next to the phonological patterns found, two phonetic patterns were observed across all age-groups and both cut-off criteria in Cohort 1: i.e. the distortions of /s, z/ and /r/. Both were also observed for both cut-off criteria in Cohort 2 across the ages of 2;0-3;0 (Distortion of /r/ only above 2;6 for the higher cut-off). Despite their appearance for both the criteria used, the distortions occurred with very low frequency in Cohort 2 compared to Cohort 1. It is worth remembering, however, that the limited sample size (see Methodology, section 3.1.1) and items elicitation discussed for this cohort (see section 2.4.2) might have affected the presentation of these patterns.

Across literature, these sounds have been reported to be frequently distorted both from previous Italian research and in Romance languages and Maltese. Indeed, findings from the studies by Tresoldi et al. (2018), Tresoldi et al. (2015), and Viterbori et al. (2018) revealed the distortion of /s, z/ and /r/ across all age groups assessed. In addition to Italian, phonetic distortions affecting the alveolar fricatives and the trill have also been described across several other languages, including Romance languages such as Spanish for /r/ (Goldstein, 2005; Hernández & Hernández, 2016), as well as languages from different origins, such as Danish (Clausen & Fox-Boyer, 2017), German (Fox-Boyer, 2016), and Maltese for /s, z/ (Grech, 1998). Given that, for all languages reported, these phonetic error patterns do not affect meaning, they may be less considered and/or less investigated up to school age.

Overall, further research on Italian children older than five years of age is required to provide a complete description of the population's development and identify the age of disappearance of the patterns that were here discussed.

7.3 Summary of both discussions

Chapters 5 and 7 discussed findings on the population studied in relation to the available Italian and international literature. Across all measures explored, findings seem to suggest that Italian children present slower development compared to children acquiring languages of the same (i.e. Romance languages) and other families (e.g. Maltese, Danish). A few hypotheses have been proposed that might explain this finding, particularly in relation to specific features of the language (e.g. phonetic frequency), and to sample construction limitations (i.e. children exposed to different regional variations of Italian). Both these hypotheses would be in line with theoretical models postulating the importance of individual experience in the development of the phonological system. With respect to the first, as suggested by Bybee (2001), each individual's lexicon and their phonological development have a reciprocal influence across the development. In line with the second, emergentist models highlight the importance of the ambient language in determining children's development (Chomsky & Halle, 1968; Donegan & Stampe, 1979; McCarthy & Prince, 1998; Prince & Smolensky, 2004). In line with the influence of language-specific features on the results obtained, a hypothesis was proposed that the highly frequent CV structure typical of Italian, and the non-existence of syllabic consonants in the language, may have had an impact on children's apparently lower performance in the stimulability task (i.e. imitation of phones in isolation) compared to the naming task.

Overall, previous assumptions that the Italian vowel system is established before the age of 3;0 were supported by findings in this study. Furthermore, although the majority of elements of Italian appear to be acquired by 4;11, the presence of consonants not yet mastered and patterns not yet resolved by that age found from the naming task, suggest that Italian children's development proceeds beyond the age of 5;0, in line with previous Italian studies and research on Romance languages and Maltese (Anderson & Smith, 1987; Bortolini, 1995; D'Odorico et al., 2011; Grech, 1998; Grech & Dodd, 2008; MacLeod et al., 2011; Tresoldi et al., 2018; Viterbori et al., 2018; Zmarich et al., 2012). Furthermore, although consonant clusters have not been investigated in detail, the available findings (i.e. different rate of acquisition, different phonological patterns affecting each type of cluster) suggest the need to conduct further research on TCC and HCC separately, to explore their specific acquisition.

In spite of an apparent slower development compared to other languages, however, findings from the present study also appear to support the theoretical hypothesis T1,

being in line with theories suggesting the existence of a core array of sounds developed by children across languages in the early stages of their phonological development (MacNeilage, 1998; Zmarich et al., 2005). Patterns which could be considered universal (i.e. found across international literature, as posited in hypothesis 2.b.ii) were also observed. However, differentiation of the development following language-specific features has been observed in the three systematically-occurring variations which affected phones and/or phonological features typical of Italian (as hypothesised in 2.b.iii; i.e. Gliding of /ʎ/, reciprocal vowel substitution of /o/ and /ɔ/, and transformation of an HCC to a geminate). In particular the vowel substitutions were suggested to be potentially due to the different regional variations spoken at home by the children assessed. Indeed, over a third of parents that filled in the questionnaire for the first cohort reported speaking a different regional variation of Italian from that of the environment (see Table 36 in Appendix 4). Given that regional variations of the language are mostly differentiated by diverse preferences for the use of open and closed vowels (as explained in section 2.3.2), the one third of children exposed to non-Ligurian variations in Cohort 1, as well as the children recruited from different regions in Cohort 2, may have had an impact on the results, reflecting these differences. Despite the presence in the Italian inventory also of a nasal approximant (i.e. /ɲ/) and the existence of geminate consonants, these did not appear to be affected by phonological variations with sufficient frequency to emerge as patterns.

Additionally in terms of phonological variations, a lower number of phonological patterns was identified as typical for the development of Italian children compared to the available comparison literature, supporting the hypothesis that the use of a higher cut-off and of more restricted pattern categories influence the description of typical development. Indeed, several pattern types solely emerged when the lower (i.e. ≥4) cut-off was applied, raising the question whether these should indeed be considered as patterns or rather chance findings due to an inappropriate cut-off. In this perspective, adopting narrower, more precise pattern's definitions not only provides a different perception of what variations are typical and which are infrequent, but also allows a clearer understanding of the developmental trajectories in phonological acquisition.

Finally, InfrVar made up for about half of all these phonological variations. This factor highlights the importance of taking the occurrence of infrequent variations into account when assessing a child's phonological development; indeed, a these have been described already across literature as measures of phonological stability (e.g. McIntosh and Dodd, 2008). Furthermore, a child with SSD may perform outside the norm not only

for the production of atypical or not age-appropriate patterns but also for the number of InfrVar. Such a hypothesis was already made by Albrecht (2017) for bilingual Turkish-German children, and warrants the need for further study in the so far underdeveloped topic of infrequent phonological variations.

Further research exploring the phonological development of Italian-speaking children would benefit from exploring quantitative (e.g. PCC; Tokens) as well as qualitative measures (e.g. phone inventories, types of patterns) across a wider age group than the one here explored. In particular, research up to the age of seven is fundamental in order to evaluate the age at which the phonological system is completely acquired and corresponds to the adult target. A further general discussion will be provided in the next chapter, covering the strengths and limitations of the study, proposing future direction for research on the phonological development of monolingual Italian-speaking children, and discussing the theoretical and clinical implication of the results. Conclusions will be drawn at the end of the chapter.

8. General Discussion and Conclusions

Overall, the current research project aimed to investigate the speech sound and phonological development of monolingual Italian children across the critical ages of 1;6-4;11. Having provided a summary of the main conclusion drawn from the results of this research (see previous section 7.3), a critical evaluation of the work will be discussed in this chapter. First, strengths and limitations of the projects will be outlined. The future directions for research on the typical development of monolingual Italian children's phonology will be identified on this basis. Lastly, theoretical and clinical implications arising from this research will also be highlighted, before drawing the final conclusions.

8.1 Strengths and Limitations of the research project, and Future Directions

The current project differs from previous research on Italian for several methodological aspects, which permitted a more detailed description of the speech sound and phonological development of the population under investigation, also considering previously unexplored measures. Nevertheless, the study presents some limitations, which will be here taken in consideration alongside the strengths of the research. Across the following sections, directions for further research arising from the discussion of strengths and limitations will be outlined.

8.1.1 Population

First of all, the population considered across the two cohorts spanned from the age of 1;6 to 4;11, allowing to gather information on a developmentally-crucial period which was largely understudied in previous Italian research. Across previous Italian research, solely a handful of studies investigated the development of children above the age of 3;0, some only reaching up to 3;6-3;8 (Zanobini et al., 2012; Zmarich et al., in progress), while others focussing only on consonant acquisition (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., in progress). In this perspective, the current study expanded on the knowledge available and provided in-depth information on a wider developmental period. Indeed, as observed across romance languages and supported by findings from the present research, speech sound and phonological acquisition proceeds beyond the age of 5;0 (da Silva et al., 2012; Galcerán, 1983; Tresoldi et al., 2015; Tresoldi et al., 2018; Vivar & León, 2009), rendering data on children across a wider age spectrum fundamental for understanding typical development. Furthermore, although data in the first cohort were initially collected as a comparison group for bilingual data (not collected due to Covid-19 restrictions, as explained in the Introduction), the total sample from the two cohorts resulted in a large enough database to provide some statistical reliability and

generalisability of the results, compared to smaller size populations from previous research (Bortolini, 1995; Bortolini & Leonard, 1991; D'Odorico et al., 2011; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich & Bonifacio, 2005; Zmarich et al., 2012).

Notwithstanding, the dataset presented a few limitations that need mentioning. Although the sample size was higher than most of the previous studies on Italian, it was still much lower than what literature suggests for an appropriate normative sample, i.e. about 100 participants in each age group, as suggested by McCauley and Swisher (1984). This was particularly true for Cohort 2, which investigated 30 children in each age group, thus, just three children constituted 10% of the age group. In this perspective, a minor change in one participant could have a large effect on the measures investigated. Moreover, an imbalance in the male/female ratio resulted from the recruitment of participants in Cohort 1. McLeod (2013) found gender-related differences in the typical acquisition of children's phonology. Although this has not been directly targeted in Italian literature, an equal representation of participants from both genders should be included in the sample, in order to investigate potential differences in the development, and obtained balanced data. In addition, the current study aimed to recruit children that were overall typically developing, following the concept of 'truncated sample' from Peña et al. (2006). However, considering the methodology with which the inclusion criteria for recruitment were controlled (i.e. parents' questionnaire), it might have been the case that some children for whom no concern in terms of speech and language was reported (i.e. thus included in the sample) were instead developing atypically but had not been previously identified as such. This would have had an impact on the variability on children's measures within an age group, thus skewing the data towards a lower performance. Finally, the examination of two separate cohorts (i.e. 1;6-3;0 secondary data, and 3;0-4;11 data collected) meant that children from the two samples had slightly different characteristics. In fact, children from the cohort shared by Zmarich et al. (2012) were recruited in two separate regions (i.e. Veneto and Marche) different from that of the first cohort (i.e. Liguria). Data obtained from the analyses of these participants cannot therefore be considered a continuum, and should be interpreted with caution.

Bearing in mind the limitations here considered, and the implications from the results for a continuing development above the age of 5;0, new research should collect data on the full developmentally-crucial period, across the ages of at least 2;6-7;0. Indeed, research has shown that children become more consistent in their speech sound production above the age of 2;5 (Dodd et al., 2003; Schäfer & Fox, 2006), and continue to develop beyond the age of 5;0 (da Silva et al., 2012; Galcerán, 1983; Tresoldi et al., 2015; Tresoldi et al.,

2018; Vivar & León, 2009). Furthermore, careful consideration should be given to the sample construction when accounting for the regional variations of the language children have been exposed to, as this has been shown to have potential effect on the accuracy measures (see section 5.2.1) and phonological patterns presented (see section 7.2). Additionally, more appropriate measuring of abilities determining inclusion or exclusion from the sample should be adopted in addition to parents' reports. Indeed, most previous Italian studies did assess children's speech and language prior to beginning of testing, either to distinguish children between typically and atypically developing children in the presentation of the results, or for recruitment purposes (Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012).

8.1.2 Tasks and Materials

Children in the two cohorts were assessed using separate testing materials, as presented in section 3.1 in the Methodology, and outlined in Appendix 5. The differences in assessment material used (i.e. BVL_4-12 and TFPI), in terms of construction and items elicited, limit the comparability of the data, and has had an impact on children's performances across several tasks. In particular, the TFPI test (Zmarich et al., in progress), used with Cohort 2, involves the administration of three different lists of targets according to the 6-month age group the child belongs to, containing a lower number of items compared to the BVL_4-12 subtest (Marini et al., 2015) adopted with Cohort 1. This choice limited not only the number of times consonants, vowels, and consonant clusters could be elicited, but also which consonants and word structures were presented (see Table 42 to Table 45 in Appendix 5): children were in fact tested solely on the words that are usually part of the vocabulary acquired at the age in question (see section 2.4.2). Confining the items elicited to word and syllable structures that are already acquired at a certain age, however, limits the potential identification of children who might be able to produce more complex structures, therefore preventing to obtain a comprehensive description of that age group. Furthermore, stimulability data were not obtained for the second cohort. Data on the stimulability of individual phones below the age of 3;0 would however have been useful, as children in this age group usually present with higher instability in their phonological system (Dodd et al., 2003; Schäfer & Fox, 2006), thus rendering information on phones stimulability all the more valuable.

Given the current limited availability of psychometrically-appropriate assessments (as seen across section 2.4), future research could also aim at the creation of a tool more in line with internationally-agreed psychometric requirements (AERA et al., 2014; Flipsen & Ogiela, 2015; McCauley & Swisher, 1984). This is particularly important for Italian in

terms of elicitation of an appropriate number and types of consonant clusters (both TCC and HCC), in order to conduct further research on these under-investigated targets (see sections 4.3.1 and 5.2.2).

8.1.3 Analyses

The current study included a series of analyses and measures that were only in part explored in previous studies on Italian. Indeed, accuracy measures such as percentages of consonant, vowel, and phoneme correct, vowel and CC inventories, and quantitative measures on phonological variations (i.e. tokens, types, and InfrVar) were previously under-investigated, if at all considered. The present research comprehensively looked not only at the acquisition of consonants, but also at consonant clusters, geminates, and vowels. It additionally investigated the number and types of recurring (i.e. patterns) and occasional (i.e. InfrVar) phonological variations.

Although the analysis on consonant clusters cannot be considered entirely reliable and representative of the typical development, due to limitations in the assessments' construction, it provides baseline data on the differences in acquisition of tautosyllabic and heterosyllabic clusters. Indeed, the two types of clusters were investigated separately in the current project in order to evaluate their status and their individual treatment across the development. This provides novel information on Italian children's development, as previous research had either solely investigated TCC (Tresoldi et al., 2015; Tresoldi et al., 2018; Zmarich et al., 2012), or considered the two types as a unified category. Findings from the current study show instead that TCC and HCC are not only acquired at different times across the ages, but are subject to separate phonological patterns. Indeed, TCC appeared to be either deleted or reduced to one element, while HCC were usually transformed into a geminate. The study also highlighted the singular behaviour of /s/-clusters, which appeared to be treated as tautosyllabic in WI position, but as heterosyllabic in WM (see section 7.2.1).

In relation to the analyses on phonological variations, the current research differed from all previous Italian studies in that it distinguished between those variations that occurred regularly, and could thus be considered patterns, and those that solely appeared occasionally (i.e. InfrVar). This distinction is fundamental in order to avoid an overidentification of phonological variation as 'typical' in children's development. Indeed, when labelling 'pattern' all occurring variations, a wide variety of error types become

classified as typical, thus incurring in the risk of under-identifying children with atypical development when comparing their performance to the normative sample.

A further element of strength of the current study is the comparison of results made available when applying two different cut-off criteria in the distinction between patterns and InfrVar. This distinction allowed to highlight the impact that choosing an appropriate cut-off have on the interpretation of findings. Adopting two different, although close (i.e. 4 and 6) cut-offs made indeed a noticeable difference in which variations were considered developmentally typical at the different ages (see sections 7.2 and 8.1.3). Additionally, using narrower rather than broad pattern category (e.g. 'fronting of velar' and 'fronting of postalveolar' vs. a more generic 'fronting') allowed to provide a more detailed description of the phonological development of the population studied. Indeed, results highlighted that the same pattern type occurring on different sounds (e.g. Stopping of Fricatives vs. Stopping of Affricate) appear and resolve at different stages of the development. Finally, quantitative measures were also investigated for the occurrence of phonological variations. Measures such as Tokens, Types, and InfrVar provided additional information that were previously never explored in Italian research, particularly in relation to the proportion between number of phonological patterns and InfrVar. The implications of these findings will be discussed in the following section (8.2).

Overall, some limitations could also be observed in the analyses of the data collected. First of all, although children's performances were recorded as being spontaneous, following cue (i.e. semantic or choice), or in repetition, a specific analyses considering the different productions was not conducted on this occasion. Furthermore, as previously mentioned, the stimulability data were only available for children in the Cohort 1. In this perspective, results obtained from the imitation task (see section 4.2.2) appeared unusual compared to the naming task. Potential reasons behind these findings have been discussed in section 5.3, and warrant further investigation.

As mentioned, the current data have the potential to be further analysed to investigate other aspects of the phonological development of monolingual Italian children. In first instance, a phonemic inventory could be drawn, in order to gain information on children's acquisition of consonants and vowels within specific syllabic contexts. Additionally, correlational analyses between the accuracy measures and the presentation of phonological variations in terms of total Tokens, number and types of patterns, and InfrVar could be run. Moreover, since data on the regional variations spoken by the participants and their families are available, individual children's performances could be investigated in relation to the variation of Italian they are exposed to. Indeed, consistent

and significant differences may be found in the type of patterns presented and/or on the phones acquired earlier or later (e.g. vowel performance, as discussed in sections 5.1 and 5.2) across children speaking different variations of the language.

As the inclusion of individual children in the sample relied entirely on answers to the parent questionnaire, an analysis could be conducted to classify individual children as typical or atypical on the basis of the data obtained for their age group. Children's performance could be compared to the age-group mean in terms of accuracy measures, Tokens, Types, and InfrVar, and the SD from the mean calculated. In this perspective, patterns presented by individual children that performed one or two standard deviations below the mean for their age could be investigated in order to provide a qualitative description of a performance considered 'atypical' on the basis of quantitative measures.

Additional research investigating Italian should further explore the acquisition of consonant clusters, differentiating between tautosyllabic and heterosyllabic clusters, and paying particular attention to the /s/ clusters. Stimulability data are also a valuable addition to age-related knowledge, as they provide information to the clinicians on which sounds may be indeed stimulable and have the potential to emerge soon in a child's development, and should thus be further investigated through imitation tasks. Further consideration, in this perspective, should be given to the target for imitation (i.e. single phones vs. VCV structure, etc.) given the features of the language discussed (section 5.3).

Finally, and overall across languages, there should be more focus on investigating cut-off criteria to distinguish between recurring and occasional phonological variations (i.e. patterns vs. InfrVar), and on their specificity for each language and each pattern within an individual language. More space in research should additionally be given to InfrVar, which could be found to be a valuable clinical marker for the identification of SSD, both in monolingual and bilingual children across languages (e.g. Albrecht, 2017). An investigation of their presentation and progression across ages should be conducted in relation to future speech and language skills in longitudinal studies, in order to evaluate whether InfrVar might have predictive value on children's development.

8.2 Theoretical and clinical implications

Information on the various aspects of typical development of speech sounds and phonology of Italian children across the ages of 1;6-4;11 has implications not only on

theoretical knowledge of the topic, but also on SLTs' clinical practice. In this section, findings will be discussed in this light.

Three hypotheses were drawn on the relevance of the current research for the theoretical debate on children's speech sound and phonological acquisition. All three hypotheses have found support in the results obtained. First of all, as predicted in T1, children across both cohorts demonstrated early acquisition of a series of consonants which have previously been described across research on other languages as early-mastered. This is in line with the frame/content model (MacNeilage, 1998) and other emergentist theories (e.g. Lindblom, 1992), postulating the existence of a core array of sounds which are common across languages in the early stages of the development.

Secondly, as hypothesised in 2.b.iii and T2, children across both cohorts have presented three language-specific patterns which tie to the presence in their phonological system of features not shared across languages (e.g. geminate consonants). This is in line with the statement from both formalist (e.g. Donegan & Stampe, 1979) and emergentist (e.g. Menn et al., 2013) theories that language-specific parameters regulate the acquisition of the phonological system of speakers of that language.

Finally, in line with T3, the impact which external factors such as the geographical area of provenance, and the specific language input to which children are exposed on the specific phonological development of individuals sharing the same linguistic background has found backing evidence in the results. Particular support to this hypothesis has been provided by differences spotted in the acquisition of open and closed vowels between the two cohorts, which included children recruited across different areas of northern Italy and had thus been exposed to different regional variations of the language.

Results from the current study also have some implications on clinical practice. Firstly, the accuracy measures and inventories drawn showed that children at the age of 4;11 have not yet reached adult-like speech production, and some phones are not yet acquired and/or mastered at that age. This implies that the development and acquisition of speech sounds proceeds beyond the age of 5;0. Pattern analysis confirmed this finding, as several patterns observed as typical were still present in the older children, suggesting a later disappearance. Data should therefore be collected to cover the entire developmental period, up to the age of 7;0, as it has been previously demonstrated that phonological development can be protracted up to this age (da Silva et al., 2012; Galcerán, 1983; Tresoldi et al., 2015; Tresoldi et al., 2018; Vivar & León, 2009). Currently, as presented in section 2.4.1, SLT practitioners in Italy rely on normative data

from the PFLI manual (Bortolini, 1995), which solely provides data up to the age of 4;6. Children with potentially remaining speech sound difficulties beyond that age cannot therefore be compared with age-appropriate data. An accurate description of the trajectories of the development across the age group 1;6-7;0 will allow for appropriate comparison of children's speech at all ages in the developmentally-critical period.

Moreover, having separately looked at TCC and HCC, it emerged that there is indeed a difference in their acquisition. Normative data should therefore reflect this separation and provide information accordingly. This is particularly relevant in terms of patterns applied on each type of CC; as they are treated differently, it is fundamental to assess them and consider them separately when making judgment on a child's development. Having limited or overly generalised normative data on consonant clusters could lead to a misinterpretation of an individual's performance, and thus limit planning of an appropriate potential intervention.

In terms of phonological variations, differentiating between patterns (recurring variations) and InfrVar (occasional errors) showed that, even with a reduction in number of Tokens with age increase, a wide proportion of the variations presented by children across all ages were InfrVar, representing about 50% of children's erroneous productions. In this perspective, InfrVar should be further investigated across languages as similar results were found in previous research conducted, for example, on Turkish-German bilingual children (Albrecht, 2017). Practitioners should also take InfrVar in consideration when assessing children's speech, as disregarding them would mean losing a valuable indicator of the child's performance. Nevertheless, the current research has highlighted what was previously introduced by McReynolds and Elbert (1981): when investigating phonological patterns and InfrVar, it is fundamental to adopt an appropriate cut-off criterion to distinguish between the two types of variations. Indeed, it may be the case that different cut-off should be adopted for different languages. However, it might also be possible that different patterns within the same language may require a specifically-tailored cut-off, as each may have different opportunities of occurring. For instance, Italian presents several fricatives and affricates, thus the pattern 'stopping' may have higher chances of occurring compared to a pattern such as 'gliding', and therefore warrant a different cut-off. This is relevant for clinical practice as adopting a too low or too high cut-off presents the risk of over- or under-identifying typical or atypical patterns, and consequently inappropriately plan for intervention. Finally, a further factor that needs to be taken into consideration when assessing children's speech is that specific patterns applied to different sounds appear and disappear at different ages, even when they all

fall under the same ‘umbrella’ category (e.g. fronting). It is therefore necessary to adopt narrower categories when labelling patterns in order to make a more accurate clinical judgement on children’s speech and avoid the risk of over or under identification of speech sound disorders.

Having discussed the general findings obtained from the current research, the strengths and limitation of the project, the theoretical and clinical implication, and potential future lines of research, conclusions will now be outlined.

8.3 Conclusions

The current research has investigated key aspects of the speech sound and phonological development of monolingual Italian children aged 1;6-4;11. Findings from the analyses run provided valuable information on the phonetic inventory at each stage of the development examined, both in terms of spontaneous production and in imitation, as well as on the accuracy in consonant, vowel, and phoneme production in relation to the adult model. They have further provided insight in the acquisition of consonant clusters, differentiating between tautosyllabic and heterosyllabic clusters, as well as geminate consonants. Novel information was obtained through the analyses of phonological variations, in particular for the quantitative measures of Token, Types, and InfrVar. A more in-depth view of the presentation and disappearance of phonological patterns across ages, compared to previous Italian research, was also obtained thanks to the comparison between two cut-off criteria and the differentiation between patterns and InfrVar, as well as the adoption of more specific, narrower pattern categories.

Further analyses on the current data and new research should be conducted in order to gain a more in-depth and complete picture of the phonological acquisition process across the development. In particular, given the limited research on children above the age of 3;0 and the evidence available for the continuation of the development beyond the age of 5;0, age groups spanning up to the age of 7;0 should be investigated. More inclusive samples should be created also in terms of regional variations of Italian spoken, and the influence of the variation spoken on the individuals’ performance explored. This would allow for a better understanding of the influence that individual experiences and different backgrounds have on children’s phonological development. New lines of research should additionally address the topic of Infrequent Variants, and their role in children’s phonological development across languages, as well as the necessary cut-offs that can be considered appropriate in their identification against phonological patterns.

Overall, the current research provided some more in-depth and some novel information on the speech sound and phonological development of the population studied. The present findings can be considered a valuable foundation for further exploration of the typical phonological acquisition if Italian children across all stages of the development, and the basis for the collection of more accurate and reliable normative data for the Italian language.

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Appendices

Appendix 1: Italian and Romance languages comparison studies

Table 31: Studies investigating speech sound acquisition in Spanish, Portuguese, French, and Maltese (in parenthesis: customary production 50-90%, outside: mastery ≥90%).

	Jimenez (1987)	Anderson & Smith (1987)	Galcerán (1983)	Vivar & Leon (2009)	Ceron et al. (2020)	Guimaraes et al. (2019)	Da Silva et al. (2011)		MacLeod et al. (2011)	Grech (1998)	Grech & Dodd (2008)
Language	**Spanish (EAL?)**	**Puerto Rican Spanish**	**Castellan**	**Chilean Spanish**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**		**Quebecois French**	**Maltese**	**Maltese**
N	120 (67m, 53f)	6	293	72 (6m and 6f per age group)	733 (401f, 332m)	240	240 low SES	156 (76m, 80f)	240 high SES	21	138
Age groups	3;0-3;3, 3;4-3;7, 3;8-3;11, 4;0-4;3, 4;4-4;7, 4;8-4;11, 5;0-5;3, 5;4-5;7	2;4-2;10	3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11	3;0-3;5, 3;6-3;11, 4;0-4;5, 4;6-4;11, 5;0-5;5, 5;6-5;11	3;0-8;11 in 4-month bands (e.g. 3;0-3;3, 3;4-3;7, 3;8-3;11)	3;0-11;0	3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11		1;8-1;11, 2;0-2;5, 2;6-2;11, 3;0-3;5, 3;6-3;11, 4;0-4;5	Longitudinal 2;0-3;6	2;0-2;11, 3;0-3;5, 3;6-3;11, 4;0-4;5, 4;6-4;11, 5;0-5;5, 5;6-6;0
Task	Spontaneous speech?	Spontaneous speech with prompts	Complex picture description	Picture naming	Picture naming	Picture naming	Picture naming		Picture naming	Picture naming and spontaneous speech with set of toys	Picture naming

	Jimenez (1987)	Anderson & Smith (1987)	Galcerán (1983)	Vivar & Leon (2009)	Ceron et al. (2020)	Guimaraes et al. (2019)	Da Silva et al. (2011)		MacLeod et al. (2011)	Grech (1998)	Grech & Dodd (2008)
Language	**Spanish (EAL?)**	**Puerto Rican Spanish**	**Castellan**	**Chilean Spanish**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**		**Quebecois French**	**Maltese**	**Maltese**
Cut-off criteria		Phoneme in>75% occasions in a specific position		At least once	Phoneme in >80% occasions; mastery in age group:90%	Mastered 90%, acquired 75-89%, present 50-74%	Phoneme in 75% occasions		Customary >50%, acquired >75%, mastered >90%	Phoneme customary prod. At least 50% of all occasions	
p	(3;0-3;3) >3;3	2;4-2;10	3;0	3;0-3;5	3;0-3;3	6;0-6;11	3;0-3;11	(1;8-1;11) 2;0-2;5	3;0-3;11	(2;0)	<3;0
b	(3;0-3;3) >3;3	2;4-2;10	3;0	3;0-3;5	3;0-3;3	6;0-6;11	3;0-3;11	(1;8-1;11) 2;0-2;5	3;0-3;11	(2;0)	<3;0
k	(3;0-3;7) >3;7	2;4-2;10	3;0	(3;0-3;5) 4;0-4;5	3;0-3;3	6;0-6;11	3;0-3;11	(1;8-1;11) 3;0-3;5 (3;6-3;11) 4;0-4;5	3;0-3;11	(2;0)	<3;0
g	(3;3-4;7) >4;7		(3;0) 4;0	(3;0-3;5) 4;0-4;5	3;0-3;3	6;0-6;11 WI, (6;0-6;11) 7;0-7;11 WM	3;0-3;11	(1;8-1;11) 3;0-3;5 (3;6-3;11) 4;0-4;5	3;0-3;11	(3;0)	<3;0

	Jimenez (1987)	Anderson & Smith (1987)	Galcerán (1983)	Vivar & Leon (2009)	Ceron et al. (2020)	Guimaraes et al. (2019)	Da Silva et al. (2011)		MacLeod et al. (2011)	Grech (1998)	Grech & Dodd (2008)
Language	**Spanish (EAL?)**	**Puerto Rican Spanish**	**Castellan**	**Chilean Spanish**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**		**Quebecois French**	**Maltese**	**Maltese**
t	(3;0-3;3) >3;3	2;4-2;10	3;0	3;0-3;5	3;0-3;3	6;0-6;11 WI, (6;0-6;11) 8;0-8;11 WM	3;0-3;11	(1;8-1;11) 2;6-2;11	3;0-3;11	(2;0)	<3;0
d	(3;3-4;7) >4;7	2;4-2;10	(3;0) 4;0	(3;0-3;5) 4;0-4;5	3;0-3;3	6;0-6;11	3;0-3;11	(1;8-1;11) 2;0-2;5 (2;6-2;11) 3;0-3;5	3;0-3;11	(2;0)	<3;0
m	(3;0-3;7) >3;7	2;4-2;10	3;0	3;0-3;5	3;0-3;3	6;0-6;11	3;0-3;11	1;8-1;11	3;0-3;11	(2;0)	<3;0
n	(3;0-3;7) >3;7	2;4-2;10	3;0	(3;0-3;5) 3;6-3;11	3;0-3;3 onset, (3;0-3;3) 3;4-3;7 coda	6;0-6;11	3;0-3;11	1;8-1;11 (2;0-2;5) 2;6-2;11 (3;0-3;5) 3;6-3;11	3;0-3;11	(2;0)	<3;0
ɲ	(3;7-4;11) >4;11		3;0	3;0-3;5	3;0-3;3	6;0-6;11	3;0-3;11	(2;0-2;5) 4;0-4;5	(3;0-3;11) 5;0-5;11	-	-
f	(3;0-4;3) >4;3		(3;0) 4;0	(3;0-3;5) 4;6-4;11	3;0-3;3	6;0-6;11	3;0-3;11	(1;8-1;11) 3;0-3;5	3;0-3;11	(2;5)	<3;0
v					(3;0-3;3) 3;4-3;7	6;0-6;11	3;0-3;11	(1;8-1;11) 4;0-4;5	3;0-3;11	(3;0)	<3;0

	Jimenez (1987)	Anderson & Smith (1987)	Galcerán (1983)	Vivar & Leon (2009)	Ceron et al. (2020)	Guimaraes et al. (2019)	Da Silva et al. (2011)		MacLeod et al. (2011)	Grech (1998)	Grech & Dodd (2008)
Language	**Spanish (EAL?)**	**Puerto Rican Spanish**	**Castellan**	**Chilean Spanish**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**		**Quebecois French**	**Maltese**	**Maltese**
s	(3;3-5;7)	2;4-2;10	(3;0) 6;0	(3;0-3;5) 5;6-5;11	3;0-3;3 onset, (3;0-3;3) 3;4-3;7 coda	(6;0-6;11) 7;0-7;11 WI, (6;0-6;11) 8;0-8;11 WM	(3;0-3;11) 4;0-4;11	(1;8-1;11) 3;6-3;11 (4;0-4;5)	3;0-3;11	(2;5)	<3;0
z					3;0-3;3	(6;0-6;11) 8;0-8;11	3;0-3;11	(1;8-1;11) 2;6-2;11	3;0-3;11	(3;6)	<3;0
ʃ		2;4-2;10			(3;0-3;7) 3;8-4;3	6;0-6;11 WI, (6;0-6;11) 8;0-8;11 WM WF	(3;0-3;11) 4;0-4;11	(1;8-1;11)	(3;0-3;11) 4;0-4;11	(2;5)	4;0
ʒ		2;4-2;10			(3;0-3;7) 3;8-4;3	6;0-6;11 WM, (6;0-6;11) 8;0-8;11 WI	3;0-3;11	(1;8-1;11)	(3;0-3;11) 4;0-4;11	-	-
ts		2;4-2;10									4;0
dz										-?	-?
tʃ	(3;0-4;7) >4;7		(3;0) 4;0	(3;0-3;5) 4;0-4;5			3;0-3;11		3;0-3;11	(3;0)	4;0
dʒ							3;0-3;11		3;0-3;11	(3;6)	3;6-3;11
l	(3;3-3;11) >3;11	2;4-2;10	3;0	(3;0-3;5) 3;6-3;11	(3;0-3;3) 3;4-3;7 onset, 3;0-3;3 coda	(6;0-6;11) 8;0-8;11	3;0-3;11	(1;8-1;11) 3;6-3;11	3;0-3;11	(2;0)	<3;0

	Jimenez (1987)	Anderson & Smith (1987)	Galcerán (1983)	Vivar & Leon (2009)	Ceron et al. (2020)	Guimaraes et al. (2019)	Da Silva et al. (2011)		MacLeod et al. (2011)	Grech (1998)	Grech & Dodd (2008)
Language	**Spanish (EAL?)**	**Puerto Rican Spanish**	**Castellan**	**Chilean Spanish**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**		**Quebecois French**	**Maltese**	**Maltese**
ʌ			(3;0)		(3;3-4;3) 4;4-5;7	(6;0-6;11) 8;0-8;11	(3;0-3;11) 5;0-5;11		(3;0-3;11) 4;0-4;11	-	-
r			(3;0) 7;0 WI and WF, (3;0) 4;0 IV	(3;6-3;11)		6;0-6;11 WM, (6;0-6;11) 8;0-8;11 WF		-		(2;5)	4;0
j	(3;0-3;11) >3;11	2;4-2;10						(1;8-1;11)		(2;0)	<3;0
w	(3;0-3;7) >3;7	2;4-2;10						(1;8-1;11) 3;6-3;11		(2;0)	<3;0

Table 32: Percentage of Consonant Correct in speech sound acquisition in Spanish, Portuguese, French, and Maltese (SD in parenthesis).

	Vivar and León (2009)	Lousada et al. (2019)	da Silva et al. (2012)		Ceron, Gubiani, de Oliveira and Keske-Soares (2017)	MacLeod et al. (2011)	Kehoe et al. (2018)	Kehoe et al. (2020)	Rvachew et al. (2013)		Grech and Dodd (2008)
Language	**Chilean Spanish**	**Portuguese**	**Brazilian Portuguese**		**Brazilian Portuguese**	**Quebecois French**	**French**	**French**	**Québec French**		**Maltese**
N	72 (6m and 6f per age group)	76	240 low SES	156 (76m, 80f)	733	156 (76m, 80f)	36	119	24 final year nursery	12 first grade	138
Age group	3;0-3;5, 3;6-3;11, 4;0-4;5, 4;6-4;11, 5;0-5;5, 5;6-5;11	3;11-4;5, 4;6-5;4, 5;5-6;2	3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11		3;0-8;11 (in 6-month age bands)	1;8-1;11, 2;0-2;5, 2;6-2;11, 3;0-3;5, 3;6-3;11, 4;0-4;5	2;5	2;5, 3;0, 4;0	M=6;1	M=7;2	2;0-2;11, 3;0-3;5, 3;6-3;11, 4;0-4;5, 4;6-4;11, 5;0-5;5, 5;6-6;0
1;0-1;5											
1;6-1;11						57.4 (16.3)					
2;0-2;5						68.8 (16.6)	79.94 (Range: 42.81-95.45%)	79.94 (10.10)			84.9 (19.8)
2;6-2;11						81.5 (12.7)					
3;0-3;5	/m, n, ɲ, p, t, k, ʧ/ 95-100%; /b, d, g, ʝ/ 95%; /l, r, ɾ, s, f, x/ 80-85%		86.99	85.65	90.11 (6.56)	87.8 (7.7)		86.66 (8.23)			89.6 (9.2)
3;6-3;11					93.73 (5.61)	89.9 (10.4)					93.0 (6.5)
4;0-4;5		80.2 (17.2)	91.02	92.85	96.48 (4.38)	95.3 (4.9)		95.43 (3.00)			95.3 (6.2)
4;6-4;11		91.7 (9.2)			98.83 (1.65)						97.2 (2.7)
5;0-5;5			93.12	96.69	99.02 (0.98)						99.3 (2.5)

	Vivar and León (2009)	Lousada et al. (2019)	da Silva et al. (2012)		Ceron, Gubiani, de Oliveira and Keske-Soares (2017)	MacLeod et al. (2011)	Kehoe et al. (2018)	Kehoe et al. (2020)	Rvachew et al. (2013)		Grech and Dodd (2008)
Language	**Chilean Spanish**	**Portuguese**	**Brazilian Portuguese**		**Brazilian Portuguese**	**Quebecois French**	**French**	**French**	**Québec French**		**Maltese**
5;6-5;11		91.6 (10.4)			99.37 (0.63)						95.5 (5.9)
6;0-6;5			96.26	99.12	99.53 (0.56)				90.37 (6.34)		
6;6-6;11					99.68 (0.43)						
7;0-7;5			95.28	99.78	99.62 (0.52)					94.15 (3.44)	
7;6-7;11					99.76 (0.35)						
8;0-8;5					99.69 (0.49)						
8;6-8;11					99.80 (0.33)						

Table 33: Studies investigating Consonant Cluster acquisition in Spanish, Portuguese and French (in parenthesis: customary production 50-90%, outside: mastery ≥90%).

	Galceran (1983)	Fernandez (1997)	Ceron et al. (2020)	Da Silva et al. (2011)		Guimaraes et al. (2019)	MacLeod et al. (2011)
Language	**Castellan**	**Spanish**	**Brazilian Portuguese**	**Brazilian Portuguese**		**Portuguese**	**Quebecois French**
N	293	104	733 (401f, 332m)	240 low SES	240	156 (76m, 80f)	
Age groups	3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11	1;0-6;0 in 6-month age bands	3;0-8;11 in 4-month bands (e.g. 3;0-3;3, 3;4-3;7, 3;8-3;11)	3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11		3;0-11;0	1;8-1;11, 2;0-2;5, 2;6-2;11, 3;0-3;5, 3;6-3;11, 4;0-4;5
Task	Complex picture description	Spontaneous speech	Picture naming	Picture naming		Picture naming	Picture naming
Criteria		At least once					
1;0-1;5							
1;6-1;11		/tr/					
2;0-2;5		/pl, bl, kr/? beginning of cc with voiceless plosives /p, t, k/					(/bl, fl WI, bw WM/)
2;6-2;11		/fl/					(/kʁ, pw, tʁ, vj WI, skɥ WM/)
3;0-3;5	nasal+C, (/s/+C, /s/+CC, C+/l/, C+/r/, liquid+C)	/pl, pr, tr, br, dr/	(plosive+/r/, plosive+/l/, fricatiive+/r/, fricative+/l/)	Clusters with /p, b, t, d, k, g, f, v/	Clusters with /p, b, t, d, k, g, f, v/		(/fʁ WI/) /bl, fl WI/
3;6-3;11		/pl, kl, bl, dr/					(/bʁ WF/) /pw WI/
4;0-4;5		Appears to be age in which all SI cc are consolidated					/kʁ WI, bw WM/
4;6-4;11							
5;0-5;5		Few imperfections in /gr, tr/	(plosive+/l/, fricative+/r/ at 5;4)				
5;6-5;11							

	Galceran (1983)	Fernandez (1997)	Ceron et al. (2020)	Da Silva et al. (2011)		Guimaraes et al. (2019)	MacLeod et al. (2011)
Language	**Castellan**	**Spanish**	**Brazilian Portuguese**	**Brazilian Portuguese**		**Portuguese**	**Quebecois French**
6;0-6;5	/s/+C, /s/+CC, C+/l/, C+/r/		Plosive+/r/, fricative+/l/ at 6;4	Clusters with /r/	Clusters with /r, l/	/vr/, (/pr, br, tr, dr, kr, gr, fr/)	
6;6-6;11							
7;0-7;5	liquid+C			(Clusters with /l/)		/pr, br, kr, gr WM/	
7;6-7;11							
8;0-8;5						/tr, dr, gr WM, fr/	
8;6-8;11							

Table 34: Phonological patterns found across Italian studies and ages of occurrence.

	Zmarich, Fava, Del Monego, and Bonifacio (2012)			Viterbori et al. (2018)	Bortolini and Leonard (1991)	Zanobini et al. (2012)	Bortolini (1995)				
Age groups	1;6-1;11	2;0-2;5	2;6-3;0	2;1-2;8	2;2-2;11	3;0-3;6	2;0-2;6	2;7-3;0	3;1-3;6	3;7-4;0	4;1-4;6
N/n	10	10	10	88	9	30	unknown	unknown	unknown	unknown	unknown
Data reported as:	% occurrence in relation to potential occurrences			Mean (SD) n_o of token for each pattern	N_o of children presenting pattern	Mean n_o of token for each pattern	% of children presenting pattern				
Cut-off criterion at child level	once	once	once	once	twice	once	unknown	unknown	unknown	unknown	unknown
Cut-off criterion at age group level	All reported	All reported	All reported	All reported	All reported	All reported	≥80%, 50-80%, ≤50%	≥80%, 50-80%, ≤50%	≥80%, 50-80%, ≤50%	≥80%, 50-80%, ≤50%	≥80%, 50-80%, ≤50%
Structure Patterns											
(Weak) Syllable Deletion	30-40%*	20-30%*	10-20%*	14.24 (15.69)	7	2	≥80%	≥80%	≥80% then 50-80%***	50-80% then ≤50%	≤50%
Diphthong Reduction				7.97 (12.48)		1	≥80%	≥80%	50-80% then ≤50%	≤50%	≤50%
Sound Deletion	30-40%*	20-30%*	10-20%*	34.63 (33.26)		6	≥80%	≥80%	50-80% then ≤50%	≤50%	≤50%
Metathesis				1.10 (1.84)	5	0-1	≥80%	≥80%	≥80% then 50-80%	50-80% then ≤50%	≤50%
Epenthesis				2.89 (4.75)	5	0-1	≥80%	≥80%	≥80% then 50-80%	50-80% then ≤50%	≤50%
Migration					3						
Vowel Harmony				7.22 (7.93)			≥80%	≥80%	≥80% then 50-80%	50-80% then ≤50%	≤50%
Consonant Assimilation					manner: 7 place: 5	0-1	≥80%	≥80%	≥80%	≥80% then 50-80%	50-80% then ≤50%

	Zmarich, Fava, Del Monego, and Bonifacio (2012)			Viterbori et al. (2018)	Bortolini and Leonard (1991)	Zanobini et al. (2012)	Bortolini (1995)				
Age groups	1;6-1;11	2;0-2;5	2;6-3;0	2;1-2;8	2;2-2;11	3;0-3;6	2;0-2;6	2;7-3;0	3;1-3;6	3;7-4;0	4;1-4;6
N/n	10	10	10	88	9	30	unknown	unknown	unknown	unknown	unknown
Data reported as:	% occurrence in relation to potential occurrences			Mean (SD) n_o of token for each pattern	N_o of children presenting pattern	Mean n_o of token for each pattern	% of children presenting pattern				
Consonant Cluster Reduction	60-70%*	40-50%*	40-50%*	58.20 (47.66)	liquid: 9 nasal: 2 sibilant: 5	8-9					
Substitution Patterns											
Stopping	20-30%	10%	0-10%	7.56 (11.73)	0		≥80%	≥80% then 50-80%	50-80% then ≤50%	≤50%	≤50%
Frication	0-10%	0-10%	0-10%	9.24 (16.79)**	1	1-2***					
Affrication				9.24 (16.79)**		1-2***	≤50%	≥80% then 50-80%	50-80% then ≤50%	≤50%	≤50%
Gliding	0-10%	0-10%	0-10%	6.20 (8.00)		0-1	≥80%	≥80% then ≤50%	≤50%	≤50%	≤50%
Fronting	30-40%	10-20%	20-30%		0		≥80%	≥80%	≥80% then 50-80%	≤50%	≤50%
Backing	0-10%	0-10%	0-10%				≤50%	≥80%	≥80% then 50-80%	≤50%	≤50%
Devoicing	10-20%	20-30%	10-20%	1.79 (3.82)**	obstruent: 1	0-1***	≥80%	≥80%	≥80%	≥80% then 50-80%	≤50%
Voicing	0-10%	0-10%	0%	1.79 (3.82)**		0-1***	≤50%	≤50%	≤50%	≤50%	≤50%
Other Patterns											
/r-l/ substitutions				13.05 (15.10)		3-4					

	Zmarich, Fava, Del Monego, and Bonifacio (2012)			Viterbori et al. (2018)	Bortolini and Leonard (1991)	Zanobini et al. (2012)	Bortolini (1995)				
Age groups	1;6-1;11	2;0-2;5	2;6-3;0	2;1-2;8	2;2-2;11	3;0-3;6	2;0-2;6	2;7-3;0	3;1-3;6	3;7-4;0	4;1-4;6
N/n	10	10	10	88	9	30	unknown	unknown	unknown	unknown	unknown
Data reported as:	% occurrence in relation to potential occurrences			Mean (SD) n_o of token for each pattern	N_o of children presenting pattern	Mean n_o of token for each pattern	% of children presenting pattern				
Phonol. plausible subst				10.77 (11.96)		1					
Other substitutions				5.87 (11.38)		0-1					
Vowel substitutions				5.31 (9.16)		0-1					
Liquid deviation					8						
Vowel dissimilation							80%	80%	≤50%	≤50%	≤50%

Note: *: Zmarich et al. (2012) included Geminate reduction in Consonant Cluster reduction; **: Viterbori et al. (2018) merged the patterns Frication/Affrication and Voicing/Devoicing; *** Bortolini (1995) reported patterns in a coloured bar chart, representing the change in percentage of occurrence within a specific age group with no reference to the specific age point.

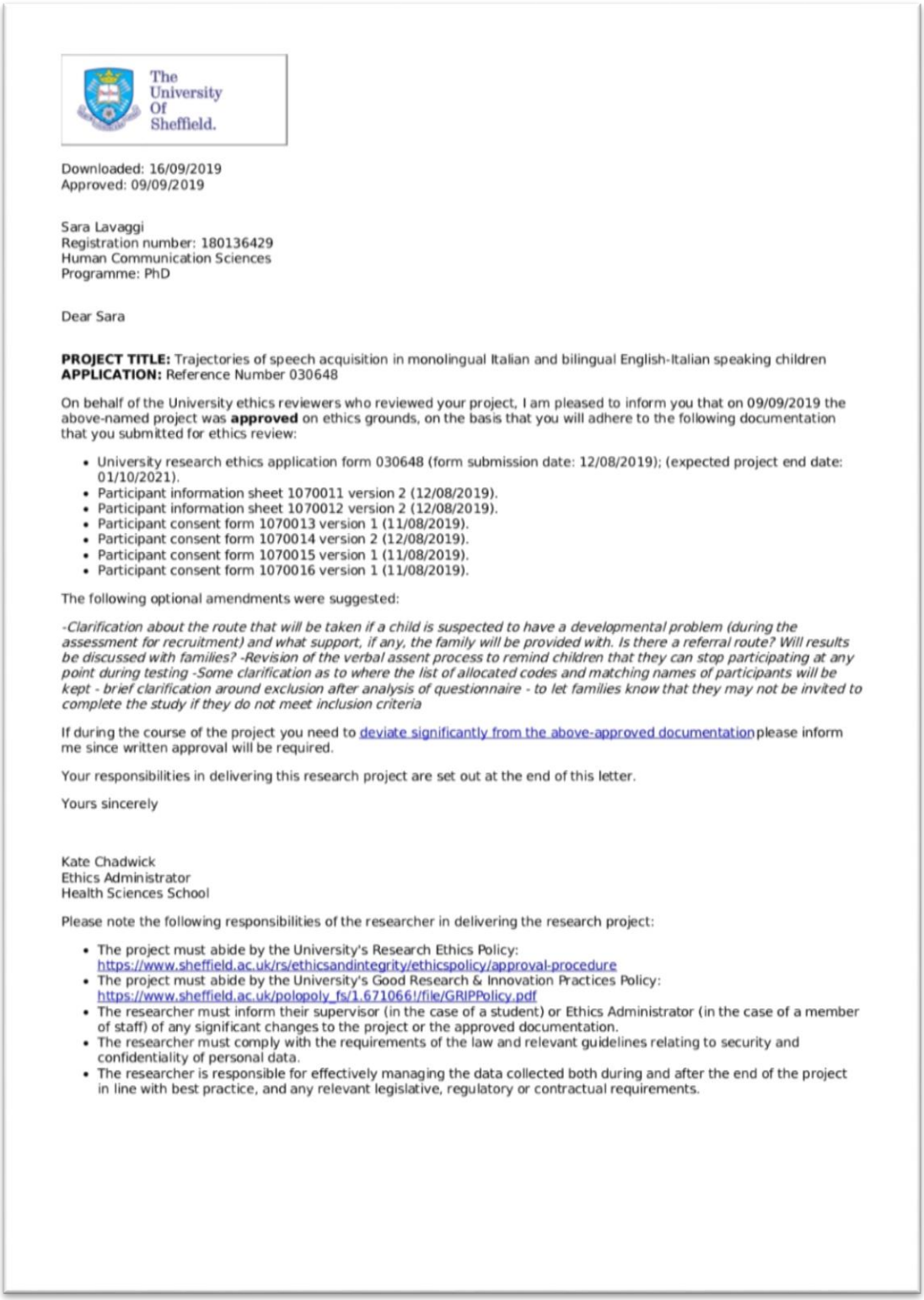
Table 35: Comparison of data available for phonological patterns on Spanish, Portuguese, and Maltese.

	Pavez et al (2009)	Goldstein (2005)	Galcerán (1983)	Ceron et al (2017)	Lousada et al (2012)	Da Silva et al (2011)	Grech & Dodd (2008)	Grech (1998)
Language	**Chilean Spanish**	**Spanish**	**Castellan**	**Brazilian Portuguese**	**Portuguese**	**Brazilian Portuguese**	**Maltese**	**Maltese**
Sample	N=360 3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11	N=39 3;2-4;11	N=293 3;0-3;11, 4;0-4;11, 5;0-5;11, 6;0-6;11, 7;0-7;11	N=733 3;0-8;11 (in 6-month age bands)	N=768 3;0-6;11 (in 6-month age bands)	N=480 3;0-7;11 (in 12-month age bands) high and low SES	N=137 3;0-3;5, 3;6-3;11, 4;0-4;5, 4;6-4;11, 5;0-5;5, 5;6-6;0	N=21 2;0, 2;5, 3;0, 3;6
Cut-off Criterium	All reported	All reported	All reported (>10%)	10% in age group	All reported, ≥15% in age group	All reported (≥10%) high & low SES resp.	All reported (≥10%)	Pattern emerging in more than one word
Structural Patterns								
Weak Syllable Deletion			3;0-3;11 only x	Up to 5;5 x	Up to 6;6-6;11 x		Up to 3;5 x	x
Syllable Reduction						Up to 5;0-5;11 x		
Syllable reduplication								x
Diphthong Reduction			Up to 7;0-7;11 x			Up to 4;0-4;11, 7;0-7;11 x		
Initial C Deletion			3;0-3;11 only x				Up to 3;11 x	
Syllable Initial Consonant Deletion								x
Final C Deletion			Up to 6;0-6;11 x		Up to 6;6-6;11 x	Up to 5;0-5;11, 7;0-7;11 x	Up to 4;11 x	
Syllable Final Consonant Deletion								x
Metathesis			Up to 4;0-4;11 x			Up to 7;0-7;11 x	Up to 3;5 x	

	Pavez et al (2009)	Goldstein (2005)	Galcerán (1983)	Ceron et al (2017)	Lousada et al (2012)	Da Silva et al (2011)	Grech & Dodd (2008)	Grech (1998)
Epenthesis			3;0-3;11 only x			In low SES 4;0-4;11 only x		
Consonant Assimilation	x		Up to 5;0-5;11 x			Up tp 5;0-5;11. 7;0-7;11 x		x
Coalescence			3;0-3;11 only x					
Gemination of C in sequence								x
CC reduction			Up to 6;0-6;11 x	Up to 7;11 x	Up to 6;6-6;11 x	Up to 6;0-6;11, 7;0-7;11 x	Up to 4;11x	(syllable-initial and syllable-final) x
Non-def. syllable simplification	x							
Non-def. structure patterns								x
Substitution Patterns								
Stopping of fricatives		Bilabial and dental x	3;0-3;11 only x		At 3;0 only x	Up to 4;0-4;11 in low SES only x	Up to 3;11 x	(and affricates) x
Affrication						Up to 3;0-3;11 in low SES only x	Up to 3;5 x	
Deaffrication		x	3;0-3;11 only x				Up to 4;11 x	
Delinking of affricates								x
Gliding			Up to 7;0-7;11 x	(of liquid) up to to 7;11 x	(of liquid) up to 6;6-6;11 x	Up to 3;0-3;11, 4;0-4;11 x	Up to 4;11 (of /r/) x	(of /r/) x
Lateral. of /r/			Up to 6;0-6;11 x			Up to 5;0-5;11, 7;0-7;11 x	Up to 4;11 x	x
Fronting of velars			3;0-3;11 only x	Up to 3;11 x	At 3;0 only x	Up to 4;0-4;11, 7;0-7;11 x	Up to 6;0 (and fricatives) x	(and affricates) x
Backing of alveolars		x		Up to 3;11 x	At 3;0 only x	Up to 5;0-5;11, 7;0-7;11 x	Up to 3;5 x	
Voicing							Up to 3;5 x	

	Pavez et al (2009)	Goldstein (2005)	Galcerán (1983)	Ceron et al (2017)	Lousada et al (2012)	Da Silva et al (2011)	Grech & Dodd (2008)	Grech (1998)
Devoicing			3;0-3;11 only x	Up to 3;11 x	Up to 5;0-5;5 x		Up to 3;5 x	x
Palatalisation					Up to 4;0-4;5 x			
Depalatalisation					Up to 4;0-4;5 x			
Others								
/r/ distortions		/r/ -[ɾ, ɹ] x						
/r/ deletion			Up to 6;0-6;11 x					
/ɾ/ deletion			Up to 5;0-5;11 x					
Nasal deletion				Up to 4;5 x				
Fricative del.				(In SF) up to 7;5 x				
Liquid del.				Up to 4;5 x				
Liquid subst.				Up to 4;11 x		Up to 7;0-7;11 in low SES only x		
Liquid semplific.						Up to 4;0-4;11, 7;0-7;11 x		
Non-def. substit.	x							x
/l/ - [n]		x						
Lateralisation of /n/							Up to 4;11 x	
/l/ - [ɾ]		x						
/ð/ - [ɾ]		x						
/ɣ/ - [g]		x						
/θ/ - [f, s]			Up to 5;0-5;11 x					
Vowel lengthening								x

Appendix 2: Ethical Approval



The University Of Sheffield.

Downloaded: 16/09/2019
Approved: 09/09/2019

Sara Lavaggi
Registration number: 180136429
Human Communication Sciences
Programme: PhD

Dear Sara

PROJECT TITLE: Trajectories of speech acquisition in monolingual Italian and bilingual English-Italian speaking children
APPLICATION: Reference Number 030648

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 09/09/2019 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 030648 (form submission date: 12/08/2019); (expected project end date: 01/10/2021).
- Participant information sheet 1070011 version 2 (12/08/2019).
- Participant information sheet 1070012 version 2 (12/08/2019).
- Participant consent form 1070013 version 1 (11/08/2019).
- Participant consent form 1070014 version 2 (12/08/2019).
- Participant consent form 1070015 version 1 (11/08/2019).
- Participant consent form 1070016 version 1 (11/08/2019).

The following optional amendments were suggested:

-Clarification about the route that will be taken if a child is suspected to have a developmental problem (during the assessment for recruitment) and what support, if any, the family will be provided with. Is there a referral route? Will results be discussed with families? -Revision of the verbal assent process to remind children that they can stop participating at any point during testing -Some clarification as to where the list of allocated codes and matching names of participants will be kept - brief clarification around exclusion after analysis of questionnaire - to let families know that they may not be invited to complete the study if they do not meet inclusion criteria

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

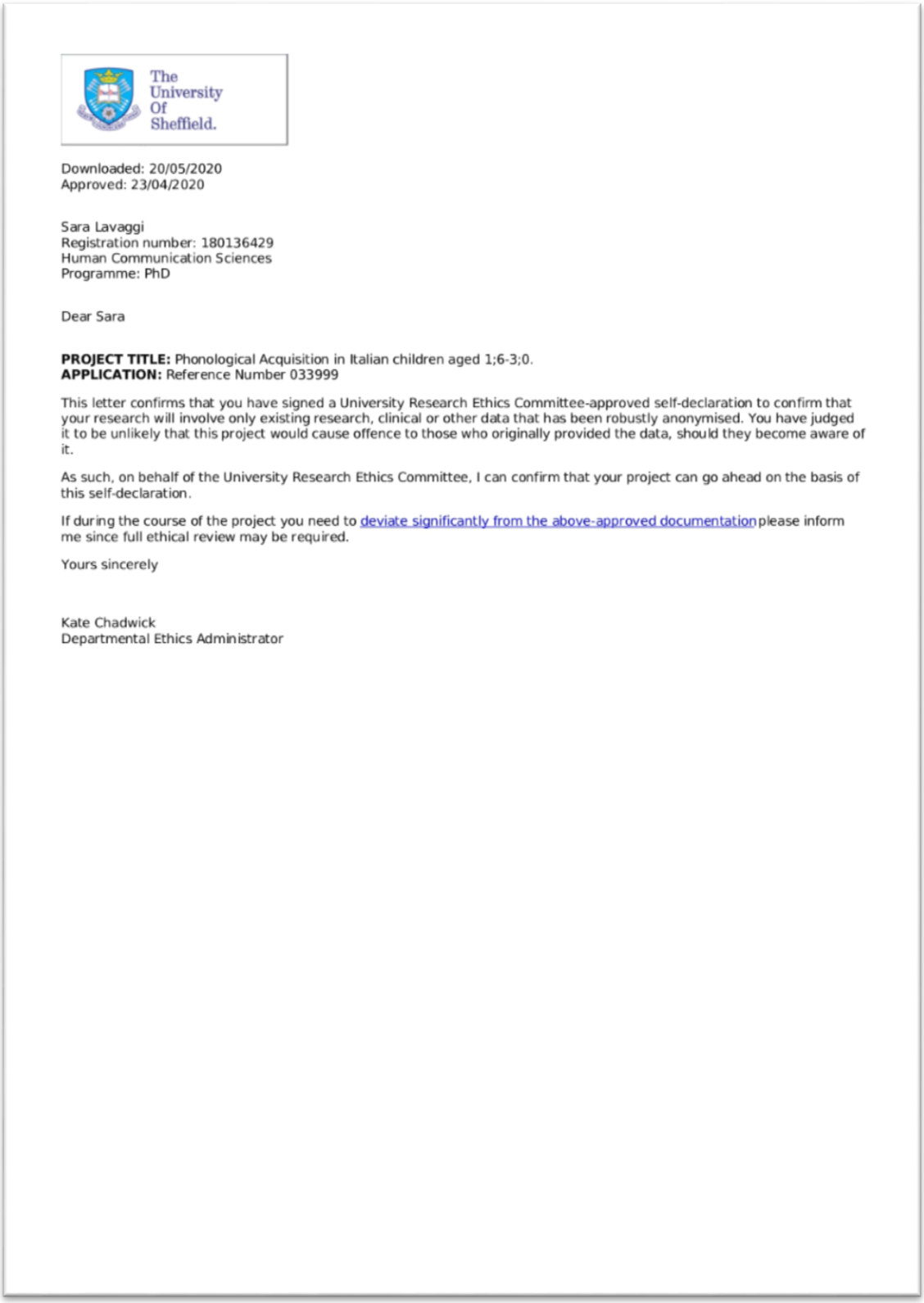
Yours sincerely

Kate Chadwick
Ethics Administrator
Health Sciences School

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Figure 3: Ethical approval letter for data collection and analysis on the first cohort (i.e. monolingual Italian-speaking children aged 3;0-4;11).



The University Of Sheffield.

Downloaded: 20/05/2020
Approved: 23/04/2020

Sara Lavaggi
Registration number: 180136429
Human Communication Sciences
Programme: PhD

Dear Sara

PROJECT TITLE: Phonological Acquisition in Italian children aged 1;6-3;0.
APPLICATION: Reference Number 033999

This letter confirms that you have signed a University Research Ethics Committee-approved self-declaration to confirm that your research will involve only existing research, clinical or other data that has been robustly anonymised. You have judged it to be unlikely that this project would cause offence to those who originally provided the data, should they become aware of it.

As such, on behalf of the University Research Ethics Committee, I can confirm that your project can go ahead on the basis of this self-declaration.

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since full ethical review may be required.

Yours sincerely

Kate Chadwick
Departmental Ethics Administrator

Figure 4: Ethical approval letter for the analysis of secondary data of the second cohort (i.e. monolingual Italian-speaking children aged 1;6-3;0).

Appendix 3: Documentation

Invite Letter for Nurseries

The University Of Sheffield.

Department of Human Communication Sciences
University of Sheffield
362 Mushroom Lane
Sheffield
S10 2TS

Dear Nursery Manager,

RE: Research Project: Trajectories of speech acquisition in monolingual Italian speaking children.

Your nursery is being invited to participate in a research project looking at how speech develops in monolingual Italian children. Specifically, this project aims to gather normative data on the typical acquisition of vowels and consonant clusters, and the typical phonological patterns present in children acquiring Italian as sole language. This project is part of a larger research investigating phonological development of children simultaneously acquiring English and Italian, vital information needed as empirical and theoretical basis to reliably identify bilingual children with Speech Sound Disorders (SSD) and consequently provide tailored intervention to reduce long-term difficulties.

This project thus aims to recruit monolingual Italian children, in the Liguria region, aged between 3;0 and 4;11 years old.

Please take some time to read the information leaflet that is attached to this email and to consider whether you would be happy for children at your nursery to participate in the project. If you agree for children at your nursery to participate, please reply to this email and I will provide you with a consent form for you to complete in order to formally confirm the participation of your institute. I will also enclose an information sheet, consent form and questionnaire to send home to the parents of children who meet the inclusion criteria stated in the information leaflet. Further information on the testing procedure and the project running are listed in the information sheet attached.

If you have any question, feel free to contact me using the contacts enclosed in the information sheet.

Looking forward to hearing from you at your earliest convenience, I thank you in advance for your consideration of the project.

Yours faithfully,

Sara Lavaggi

Lead Researcher

Information Leaflet for Nurseries

Trajectories of speech acquisition in monolingual Italian-speaking children

Your nursery is being invited to take part in a project aimed at exploring the **development of speech in monolingual Italian children**. This project is part of a larger research investigating the phonological development of children growing up bilingually with English and Italian in the UK. I am an Italian Speech and Language Therapist, with a Master's degree in Speech Difficulties and experience in working with children. This project is part of my PhD research. Please take time to read the following information carefully and discuss it with others if you wish. Feel free to ask for more information and clarification through the contact details provided at the end of this leaflet.

What is the project purpose?

This project aims to understand at what age typically-developing Italian-speaking children typically pronounce the different sounds (i.e. vowels, constant, and consonant clusters) correctly. Also, we are interested in what kind of pronunciation errors are typical (error patterns) in what age. Information on the trajectories of speech sound acquisition is vital as it provides empirical and theoretical basis to reliably identify children with Speech Sound Disorders (SSD) and consequently provide tailored intervention to reduce long-term difficulties. These data are also fundamental as a comparison between languages and between monolingual and bilingual development. This will in turn help to inform practitioners on potential errors that children make during their development in the various conditions, reducing the risk of overlooking children with difficulties or misdiagnosing those that have none.

Why has my nursery been chosen?

Your nursery has been contacted as it is incorporated in one of the Comprehensive Institutes in the Liguria region, which have been listed as potential settings for the research.

Do I have to take part?

Taking part in this project is entirely voluntary. If you do agree for your nursery's participation, you will be asked to complete a consent form. You can withdraw your nursery at any time if the necessity arises by contacting me through the contact details provided in this leaflet.

What would this project involve for my nursery?

If you agree to participate, you will be provided with information sheets, consent forms and questionnaires to forward to the parents of the children in your nursery who you believe are fulfilling the following selection criteria:

- Being aged between 3;0-4;11 years old;
- Growing up monolingually with Italian;
- Developing typically (i.e. no known syndrome or cognitive difficulties, no diagnosed hearing disorders or speech and language difficulties);
- Not having received speech and language therapy.

Parents happy for their child to participate in the project will be asked to return the consent forms and questionnaires via your nursery, in a sealed envelope enclosed with the documents. The testing phase is anticipated to begin in **September 2019**. I will arrange a time for me or a testing assistant to see the children that is convenient for you. All signed consent forms will be collected from your nursery prior to testing any children.

What is the procedure?

The participating children will be taken out of the nursery classroom individually, by the main researcher or a testing assistant, for one testing session (approximately **30 minutes**) within the daily routine of your nursery.

Children will be asked to complete 2 tasks, as follows:

- Picture naming (BVL_4-12 test: children will be asked to look at one picture at a time and name what they see. If they need help identify the image, they will be provided with progressively revealing cues);

- Sound imitation (language-specific sounds will be said out loud by the tester and children will be asked to repeat them once).

All activities will be presented in a fun and child-appropriate manner. Children will be able to have breaks during the activities, as needed. Testers will write down each child's responses on a record sheet during testing as well as audio-record the session. This will later support the data analysis as it will allow the researcher to check written answers.

Will children be recorded, and how will the recorded media be used?

Yes. In addition to the transcription of children's responses, the sessions will be audio-recorded with a digital voice recorder in order to allow for a delayed analysis of the speech samples. The data collected will be kept strictly confidential and handled as explained below.

What are the possible disadvantages/risks of taking part?

There are **no foreseeable disadvantages** of taking part. Testing will take place during normal nursery time in a quiet room near the classroom, and it will be ensured that the testing session lasts for a maximum of 30 minutes. All activities will be presented in a fun and child-appropriate manner. Children will be able to have breaks during the activities, as needed. Should they be unhappy about being withdrawn from their class for assessments a simple explanation of what the assessments entail and why they have been asked to take part will be given. If they still do not want to take part they will not be taken out of their classroom.

What are the possible benefits of taking part?

Whilst there is no immediate benefits for participating in the project, it is hoped that this research project will give us understanding of speech development in monolingual Italian children, vital information needed as basis to reliably identify children with SSD and provide tailored intervention.

Will the children's and the nursery's participation in this project be kept confidential?

Yes. At the beginning of the testing phase, each child will be allocated a **number/letter code**. Children's names will therefore not be used in the project. The code only will be written on record sheets used during the testing, on electronic data, and for audio

recordings. During the recording, the tester will name the child's code only, and will not say the children's names. Should a child's name nevertheless be recorded, this will be removed. The digital audio files labelled with children's codes only will be stored on an encrypted external hard drive, only accessible by the main researcher and her supervisors. Children will not be able to be identified in any reports or publications. Parents will be asked to complete a consent form, regarding the handling of personal data, as explained below. If any information disclosed by a child alerts the researcher to be concerned about his/her safety, this will be passed on to the appropriate parties.

What will happen to the data collected, and the results of the research project?

Recordings will be transferred to an encrypted USB stick by each tester ant the end of each testing day, and immediately deleted from the digital audio-recording device. The lead researcher and testing assistant/s will meet at the end of each week to transfer the audio-recordings to the researcher's encrypted hard-drive. Only the researcher and her supervisors will have access to the encrypted anonymised data. All paper data will be stored in a lockable cabinet in the researcher's house in Italy during data collection, then mailed, through tracked delivery, to the University of Sheffield at the end of the testing phase, where they will be stored in a locked cabinet in the Department of Human Communication Sciences. All electronic data apart from the audio-recordings will be stored on a secure electronic database on the University of Sheffield's secure Google Drive. All data will be analysed by me (the main researcher, Sara Lavaggi), supervised by Dr Silke Fricke and Prof Annette Fox-Boyer. The audio recordings will be anonymously retained or destroyed at the end of the project according to parents' choice expressed on the consent form. In case of permission to maintain the anonymous recordings, parents will also be required to indicate if they agree for the recordings to be archived as part of the CHILDES/PhonBank web-accessible scientific database for future research on speech acquisition (https://phonbank.talkbank.org/). Paper-record sheets will be destroyed through the University's confidential waste once the data has been entered to the anonymous electronic database. The list matching anonymous codes to names will be destroyed at end of data collection period (anticipated for Nov 2019).

The results from this research project will be presented in the lead researcher's PhD thesis, by September 2021 and might be published in (inter-)national journals, but no individuals will be identifiable from this data. All nurseries that participate in the project will be provided with a summary of the results.. You can request a copy of the thesis using the contact details below, if you wish. The results will also inform Speech and

Language practitioners and Educators and Teachers about the monolingual speech acquisition of Italian.

What is the legal basis for processing the participants' personal data?

According to the data protection legislation, we are required to inform you that the legal basis we are applying in order to process your personal data is that 'processing is necessary for the performance of a task carried out in the public interest' (Article 6(1)(e)). Further information can be found in the University's Privacy Practice Notice

https://www.sheffield.ac.uk/govern/data-protection/privacy/general

Who is the data controller?

The University of Sheffield will act as the Data Controller for this study. This means that the University is responsible for looking after the participants information and using it properly.

Who has ethically reviewed the project?

This project has been ethically approved via the University of Sheffield's Ethics Review Procedure as administered by the Department of Human Communication Sciences.

What if something goes wrong and I wish to complain about the research?

If you have any complaints about your experience of taking part in this study, please contact the main researcher, Sara Lavaggi. If you feel your complaint has not been handled appropriately please contact the Chair of Ethics at the Department of Human Communication Sciences, Dr Traci Walker at traci.walker@sheffield.ac.uk

If your complaint relates to how personal data has been handled, information about how to raise a complaint can be found in the University's Privacy Practice Notice

https://www.sheffield.ac.uk/govern/data-protection/privacy/general

Contact and further information:

If you have any questions or would like further information, please contact the main researcher in the first instance: **Sara Lavaggi,** slavaggi1@sheffield.ac.uk, +39 3401794802 , Department of Human Communication Sciences, University of Sheffield, 362 Mushroom Lane, Sheffield S10 2TS.

Alternatively, you can contact the supervisor **Dr Silke Fricke,** s.fricke@sheffield.ac.uk, Department of Human Communication Sciences, University of Sheffield, 362 Mushroom Lane, Sheffield S10 2TS

Thank you for reading this information and considering whether or not you would like to take part in this study.

Consent Form for Nurseries

The University Of Sheffield.

Nursery Consent Form

Research Project: Trajectories of Speech acquisition in monolingual Italian speaking children

Please complete and sign this consent form and return it to Sara Lavaggi (slavaggi1@sheffield.ac.uk)

Name of Nursery: _____

Contact person for the Project: _____

Position of contact person: _____

Tel (contact person): _____

Email (contact person): _____

Preferred way of contact:

☐ Telephone ☐ Email ☐ Post

Please tick as appropriate.

I confirm that I have read and I understand the information sheet explaining the research project, and that I have had the opportunity to ask questions. ☐

I understand that:

- Only children whose parents gave consent and who fulfil the selection criteria will participate in the project. ☐

- All the information gained will be kept strictly confidential and children's names will be removed from any material used in the research. ☐

- Participation is voluntary, and I can withdraw from the project at any time, if felt necessary. ☐

- I can contact the researcher, Sara Lavaggi, and her supervisor, Dr Silke Fricke, at the address/number provided on the information leaflet, at any time in the course of the study. ☐

I give permission for _____ to take part in this research project.

(Name of Nursery)

_____	_____	_____
Name of Head Nursery Educator	Date	Signature
_____	_____	_____
Name of Comprehensive Institute Director	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature

Consent Form for Testing Assistants

Trajectories of speech acquisition in monolingual Italian speaking children

Testing Assistants' Consent Form

Please tick where appropriate.

I confirm that I have read and I understand the information sheet explaining the research project, and that I have had the opportunity to ask questions.	☐
I agree to attend a testing session conducted by the main researcher to observe the administration procedure prior to begin testing.	☐
I agree for the main researcher to observe me during my first testing session to give me feedback on the administration procedure.	☐
I agree to audio-record my testing sessions to allow for delayed transcription of the speech data.	☐
I understand that, according to parents' consent, **the audio-recordings** may be stored **anonymously** by the main researcher for future, ethically-approved research'	☐
I understand that, according to parents' consent, anonymised recordings collected as part of this research may be archived as part of the **CHILDES/PhonBank** web-accessible scientific database for future research on speech acquisition (https://phonbank.talkbank.org/).	☐
I agree to participate in the project.	☐

_____	_____	_____
Name	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature

Please return this Consent Form to Sara Lavaggi.

Information Leaflet for Parents/Carers

Trajectories of speech acquisition in monolingual Italian-speaking children

Dear parents/carer,

You and your child are being invited to take part in a project aimed at exploring the **development of speech in monolingual Italian children**. This project is part of a larger research investigating the phonological development of children growing up bilingually with English and Italian in the UK. I am an Italian Speech and Language Therapist, with a Master's degree in Speech Difficulties and experience in working with children. This project is part of my PhD research. Before you decide, please take time to read the following information carefully and discuss it with others if you wish. Feel free to ask for more information and clarification through the contact details provided at the end of this document.

What is the project purpose?

This project aims to understand at what age typically-developing Italian-speaking children typically pronounce the different sounds (i.e. vowels (such as 'a', 'e', 'i', etc.), consonants (such as 'b, d, t, k, m, etc.), and consonant clusters (such as 'st', 'sc', 'pr', etc.)) correctly. We are also interested in what kind of pronunciation errors are typical (error patterns) in what age. Information on the trajectories of speech sound acquisition is vital as it provides an important basis to reliably identify children with Speech Sound Disorders (SSD) and consequently provide tailored intervention to reduce long-term difficulties. These data are also fundamental as a comparison between languages and between monolingual and bilingual development. This will in turn help to inform practitioners on potential errors that children make during their development in the various conditions, reducing the risk of overlooking children with difficulties or misdiagnosing those that have none.

Why has my child been chosen?

Your child has been selected as meeting the following inclusion criteria:

- Being aged between 3;0-4;11 years old;

- Growing up monolingually with Italian;
- Developing typically (i.e. no known syndrome or cognitive difficulties, no diagnosed hearing disorders or speech and language difficulties);
- Not having received speech and language therapy.

Taking part in this project is entirely voluntary. If you do agree for their participation, you will be asked to complete a consent form.

Do my child and I need to take part?

No. Participation is entirely voluntary. You can withdraw your child at any time, should necessity arise, by contacting me through the contact details provided in this leaflet. If you do so before the list of matching anonymous codes to names will be destroyed at the end of the data collection period (anticipated by Nov 2019), your child's anonymised data can be removed from the study.

What will happen to my child if s/he takes part?

Your child will be asked to take part in one testing session, when s/he will be asked to complete a **picture naming** and a **sound imitation** tasks. Children will be asked to look at individual pictures and say the name of what they see and repeat single sounds produced by the tester, respectively. All activities will be presented in a fun and child-appropriate manner. Additionally, you will be asked to complete a **questionnaire** on personal information (e.g. age of the child, etc.) and environmental factors (e.g. language proficiency, etc.). Either I or a trained test assistant will perform the assessment. The testing phase is anticipated to begin in September 2019. Testers will write down each child's responses on a record sheet during testing as well as audio-record the session. This will later support the data analysis as it will allow the researcher to check written answers.

Will my child be recorded, and how will the recorded media be used?

Yes. In addition to the transcription of your child's responses, the sessions will be audio-recorded with a digital voice recorder in order to allow for a delayed analysis of the speech samples. The data collected will be kept strictly confidential and handled as explained below.

What are the possible disadvantages/risks of taking part?

There are **no foreseeable disadvantages** if your child takes part. Testing will take place during normal nursery time in a quiet room near the classroom, and it will be ensured that the testing session lasts for a maximum of 30 minutes. All activities will be presented in a fun and child-appropriate manner. Your child will be able to have breaks during the activities, as needed. Should your child be unhappy about being withdrawn from their class for assessments a simple explanation of what the assessments entail and why they have been asked to take part will be given. If they still do not want to take part they will not be taken out of their classroom.

What are the possible benefits of taking part?

Whilst there is no immediate benefits for your child for participating in the project, it is hoped that this research project will give us a better understanding of speech development in monolingual Italian children, vital information needed as basis to reliably identify children with SSD and provide tailored intervention.

Will my child's participation in this project be kept confidential?

At the beginning of the testing phase, you child will be allocated a **number/letter code**. Your child's name will therefore not be used in the project, as the code only will be written on record sheets used during the testing, in electronic databases, and recorded on audio recordings. During the recordings, the tester will say the code only, and not your child's name. Should your child's name nevertheless be recorded, this will be removed. The digital audio files labelled with your child's code only will be stored on an encrypted external hard drive, only accessible by the main researcher and her supervisors. Your child will not be able to be identified in any reports or publications.

What will happen to the data collected, and the results of the research project?

Recordings will be transferred to an encrypted USB stick by each tester ant the end of each testing day, and immediately deleted from the digital audio-recording device. The lead researcher and testing assistant/s will meet at the end of each week to transfer the audio-recordings to the researcher's encrypted hard-drive. Only the researcher and her supervisors will have access to the encrypted anonymised data. All paper data will be stored in a lockable cabinet in the researcher's house in Italy during data collection, then mailed, through tracked delivery, to the University of Sheffield, at the end of the testing phase, where they will be stored in a locked cabinet in the Department of Human

Communication Sciences. All electronic data apart from the audio-recordings will be stored in a secure electronic database on the University of Sheffield's secure Google Drive. All data will be analysed by me (the main researcher, Sara Lavaggi), supervised by Dr Silke Fricke and Prof Annette Fox-Boyer. The audio recordings will be anonymously retained or destroyed at the end of the project according to your choice expressed on the consent form. In case you agree for us to maintain the anonymous recordings, you will also be required to indicate if you agree for the recordings to be archived as part of the CHILDES/PhonBank web-accessible scientific database for future research on speech acquisition (https://phonbank.talkbank.org/). Paper-record sheets will be destroyed through the University's confidential waste once the data has been entered to the anonymous electronic database. The list matching anonymous codes to names will be destroyed at end of data collection period (anticipated for Nov 2019).

The results from this research project will be presented in my PhD thesis, and might be published in (inter-)national journals, but no individuals will be identifiable from these data. All nurseries that participate in the project will be provided with a summary of the results. You can request a copy of the thesis using the contact details below, if you wish. The results will also inform Speech and Language Therapists, Educators and Teachers about the monolingual speech acquisition of Italian.

What is the legal basis for processing the participants' personal data?

According to the data protection legislation, we are required to inform you that the legal basis we are applying in order to process your personal data is that 'processing is necessary for the performance of a task carried out in the public interest' (Article 6(1)(e)). Further information can be found in the University's Privacy Practice Notice

https://www.sheffield.ac.uk/govern/data-protection/privacy/general

Who is the data controller?

The University of Sheffield will act as the Data Controller for this study. This means that the University is responsible for looking after the participants information and using it properly.

Who has ethically reviewed the project?

This project has been ethically approved via the University of Sheffield's Ethics Review Procedure as administered by the Department of Human Communication Sciences.

What if something goes wrong and I wish to complain about the research?

If you have any complaints about your experience of taking part in this study, please contact the main researcher, Sara Lavaggi. If you feel your complaint has not been handled appropriately please contact the Chair of Ethics at the Department of Human Communication Sciences, Dr Traci Walker at traci.walker@sheffield.ac.uk

If your complaint relates to how personal data has been handled, information about how to raise a complaint can be found in the University's Privacy Practice Notice

https://www.sheffield.ac.uk/govern/data-protection/privacy/general

What do I have to do if I and my child take part?

If you agree for your child to take part in the research, please keep this information sheet and **complete the consent form**. Please also fill the attached **questionnaire**, and return both this and the consent form to your child's nursery staff using the enclosed envelope.

Contact and further information:

If you have any questions or would like further information, please contact the main researcher in the first instance: **Sara Lavaggi,** slavaggi1@sheffield.ac.uk, +39 3401794802 , Department of Human Communication Sciences, University of Sheffield, 362 Mushroom Lane, Sheffield S10 2TS.

Alternatively, you can contact the supervisor **Dr Silke Fricke,** s.fricke@sheffield.ac.uk, Department of Human Communication Sciences, University of Sheffield, 362 Mushroom Lane, Sheffield S10 2TS

Thank you for reading this information and considering whether or not you would like to take part in this study.

Consent Form for Parents/Carers

The University Of Sheffield.

Trajectories of speech acquisition in monolingual Italian speaking children

Parents' Consent Form

Please tick where appropriate.

I confirm that I have read and I understand the information sheet explaining the research project, and that I have had the opportunity to ask questions.	☐
I understand that my child's participation is voluntary, and I can withdraw my child at any time, without giving reasons and without there being any negative consequences.	☐
I agree for the anonymised data in the questionnaire to be used to check my child eligibility for participation in the study, and to provide socio-linguistic information for complementing the research.	☐
I understand that my child will be audio-recorded, and that the recordings will be anonymised through the assignment of a unique code and will be stored as digital media to be kept securely in a password protected, encrypted device.	☐
Please tick one of the statement below: 'I agree for **both the audio-recordings and the transcriptions** to be stored **anonymously** by the main researcher for future, ethically-approved research' 'I agree for the **transcriptions** to be stored **anonymously** by the main researcher for future, ethically-approved research. I want the recordings to be destroyed at the end of the research project'. 'I **do not agree** for the **transcriptions** to be stored anonymously by the main researcher for future, ethically-approved research. I want the recordings to be destroyed at the end of the research project'	☐ ☐ ☐

Please tick one of the statements below: I agree for the anonymised recordings collected as part of this research to be archived as part of the **CHILDES/PhonBank** web-accessible scientific database for future research on speech acquisition (https://phonbank.talkbank.org/). I do not agree for the anonymised recordings collected as part of this research to be archived as part of the **CHILDES/PhonBank** web-accessible scientific database for future research on speech acquisition.	☐ ☐
I agree for my child to participate in the project.	☐

Name of Parent/Guardian	Date	Signature
Name of Person collecting Consent (if different from researcher)	Date	Signature
Name of Researcher	Date	Signature

Please return this Consent Form to Sara Lavaggi via your nursery educators using the envelope provided.

The University Of Sheffield.

Trajectories of Speech Acquisition in Monolingual Italian Speaking Children

Parents' Questionnaire

Thank you for agreeing for your child to participate in this research project. You are now kindly asked to fill in this questionnaire to provide information on your family's linguistic environment and your child's exposure and use of Italian. This will be used to confirm your child's eligibility to take part in the study, and to analyse potentially influencing factors affecting children's speech sound development and performance in assessment. Please note that any information you provide will be treated as strictly confidential as stated in the information sheet and consent form.

This page showing your child's name will be destroyed in the first phase of the project, and your child will be assigned a code, that will be reported on the second page of this questionnaire by the researcher, so that it will be possible to match this information to your child's assessment results.

Your Child's Name:

_____

Child's Code:

(to be filled by the researcher)

_____

Section A - Child's Information

- Child's date of birth (dd/mm/yyyy): _____
- Child's place of birth: _____

A1 - Language (the information provided here will also be used to confirm that your child fulfils the study selection criteria as outlined in the information sheet)

- Does your child grow up monolingually Italian (i.e. does your child only learn Italian at home)?

  ☐ Yes ☐ No

- Have you ever been worried about your child's speech and/or language development?

  ☐ Yes ☐ No

- If yes, what areas have been of concern to you?

  ☐ Speech (e.g. pronouncing sounds incorrectly, substituting sounds with others, etc.)
  ☐ Vocabulary (e.g. understanding and/or use of limited amount of words, difficulties finding words while speaking, etc.)
  ☐ Grammar (e.g. using short, simple sentences that appear typical of younger children, not using or using the wrong articles/prepositions/pronouns, etc.)
  ☐ Other: _____

- Do people outside your family struggle to understand your child?

  ☐ Yes ☐ No

- Compared to other Italian speaking children of the same age, do you think your child's speech is intelligible?

☐ Yes ☐ No

- Have you ever been concerned about your child's hearing?

  ☐ Yes ☐ No

- If yes has your child been diagnosed with a hearing impairment?

  ☐ Yes ☐ No

- Has your child ever received Speech and Language Therapy?

  ☐ Yes ☐ No

- If yes, for what reason?

  _____

- Has your child so far been typically developing (i.e. no known developmental disorder or syndromes)?

  ☐ Yes

  ☐ No: _____

A1 - Nursery attendance

- When did your child start to attend nursery?
  (please state month and year)

  _____

- How frequently does your child attend nursery?

  ☐ Monday to Friday

  ☐ 4/3/2/1 days per week (circle as appropriate)

How many hours does your child spend in nursery/school on an attendance day? _____

Section B - Family Information

- What is your relation to the child? (e.g. mother, father, female/male carer, grandma, etc.) _____

- What regional variation/dialectal form of Italian is spoken by the mother/female carer?

☐ Ligure	☐ Toscano
☐ Piemontese	☐ Lombardo
☐ Veneto	☐ Valdostano
☐ Friulano	☐ Emiliano/Romagnolo
☐ Aquilano	☐ Marchigiano
☐ Abruzzese	☐ Laziale
☐ Campano	☐ Siculo
☐ Sardo	☐ Calabrese
☐ Pugliese	☐ Lucano
☐ Molisano	☐ Tirolese
☐ Trentino	☐ Umbro

☐ Other: _____

- What regional variation of Italian is spoken by the father/male carer?

☐ Ligure	☐ Toscano
☐ Piemontese	☐ Lombardo
☐ Veneto	☐ Valdostano
☐ Friulano	☐ Emiliano/Romagnolo
☐ Aquilano	☐ Marchigiano
☐ Abruzzese	☐ Laziale
☐ Campano	☐ Siculo
☐ Sardo	☐ Calabrese
☐ Pugliese	☐ Lucano
☐ Molisano	☐ Tirolese
☐ Trentino	☐ Umbro

☐ Other: _____

- First/home language(s) of mother/female carer: _____

If this is/these are different from Italian,

- Do you speak your first language to your child?

  ☐ Yes ☐ No

- Do you speak Italian to your child?

  ☐ Yes ☐ No

- If you speak Italian with your child, how would you rate your proficiency in Italian?

  ☐ Very good ☐ Good ☐ Average ☐ Poor

- First/home language(s) of father/male carer: _____

  If this is/these are different from Italian,

  - Do you speak your first language to your child?

    ☐ Yes ☐ No

  - Do you speak Italian to your child?

    ☐ Yes ☐ No

  - If you speak Italian with your child, how would you rate your proficiency in Italian?

    ☐ Very good ☐ Good ☐ Average ☐ Poor

- What level of formal education has been achieved by the mother/female carer?

  ☐ Primary (up to 11 years old)
  ☐ Secondary 1st degree (up to 14 years old)
  ☐ Secondary 2nd degree (up to 19 years old)
  ☐ Undergraduate
  ☐ Postgraduate

- What level of formal education has been achieved by the father/male carer?

- ☐ Primary (up to 11 years old)
- ☐ Secondary 1st degree (up to 14 years old)
- ☐ Secondary 2nd degree (up to 19 years old)
- ☐ Undergraduate
- ☐ Postgraduate

- What is the mother's/female carer's profession?

  _____

- What is the father's/male carer's profession?

  _____

Thank You for completing the questionnaire!

(Please return this with the consent form to your nursery staff)

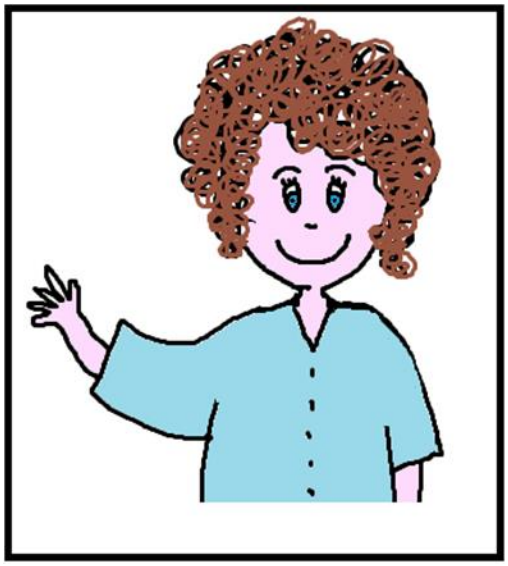
Instructions and Assent Images for Children

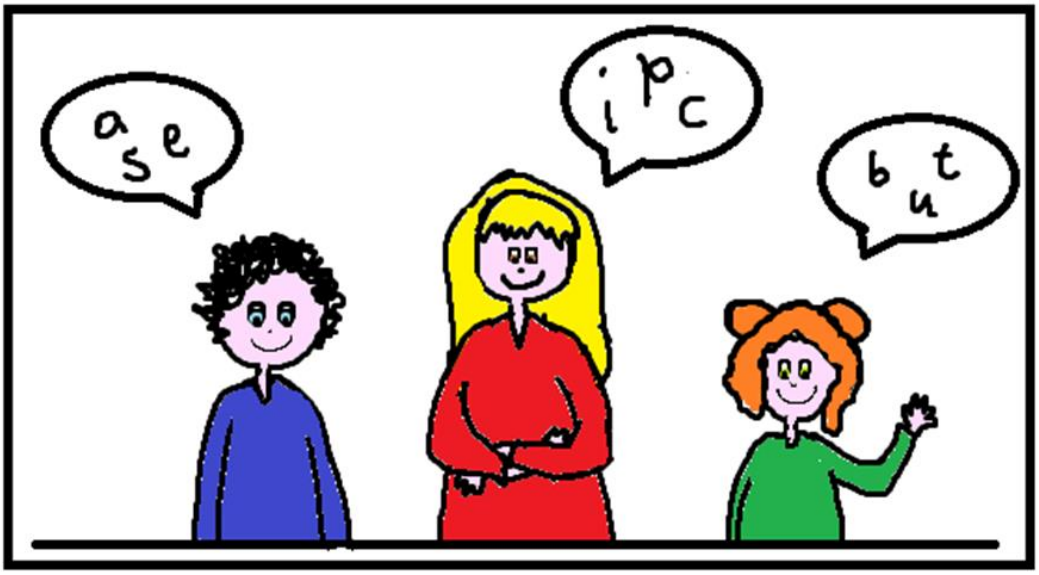
Children Information sheet and Assent Form

Trajectories of speech acquisition in monolingual Italian speaking children.

To be administered verbally with visual support.

- Hello, my name is Sara/name of testing assistant.
- I am trying to find out how children like you learn to speak and say all the sounds of the words. Would you like to help with my investigation?
- I am going to ask you to do two things.
- First, we are going to look at some pictures together and I am going to ask you to say the name of what you see. If you don't know what something is, don't worry, I can give you a hint.
- In a second task I am going to ask you to repeat a sound I say.
- You don't have to do the tasks if you don't want to.
- If you participate, you can take breaks when you need to.
- You can stop at any time. You will not get in any trouble if you change your mind.
- I will use a voice recorder to record our session, but I will delete the recordings after I've checked them.
- Would you like to participate?

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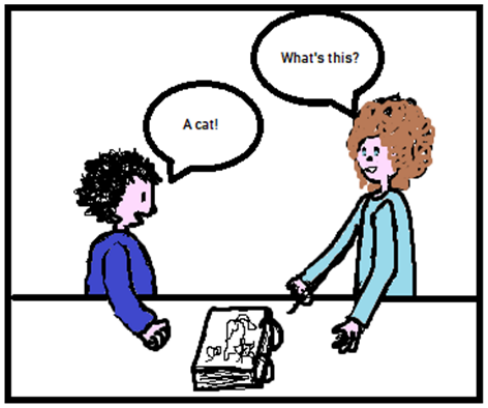
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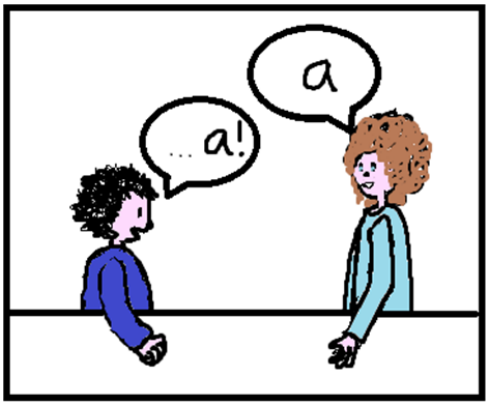
A cat!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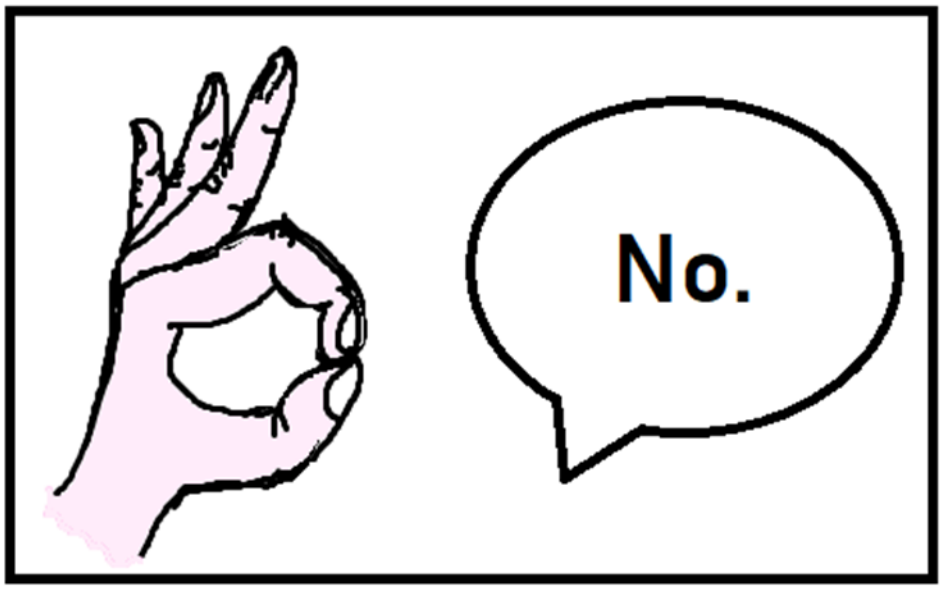
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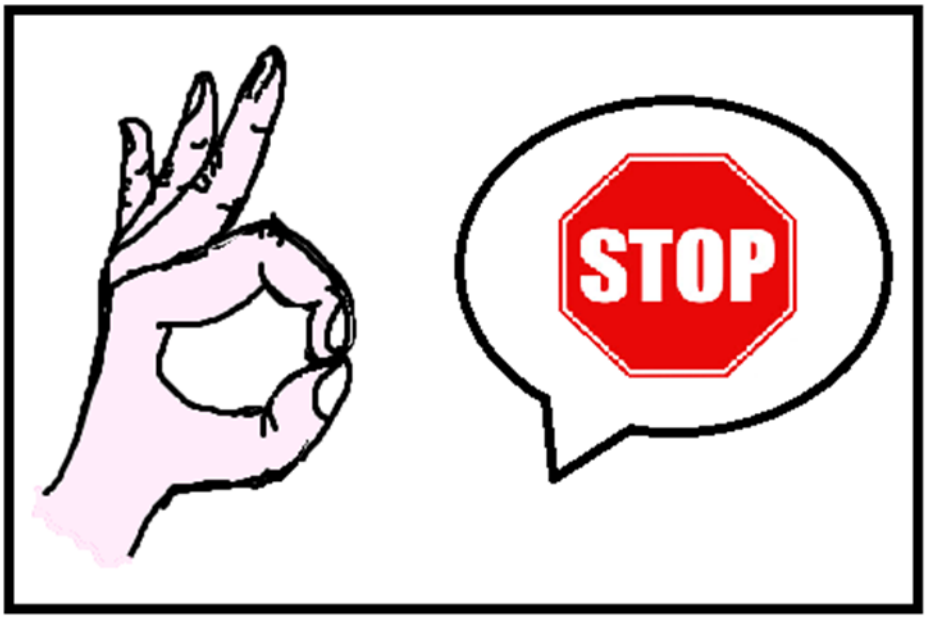
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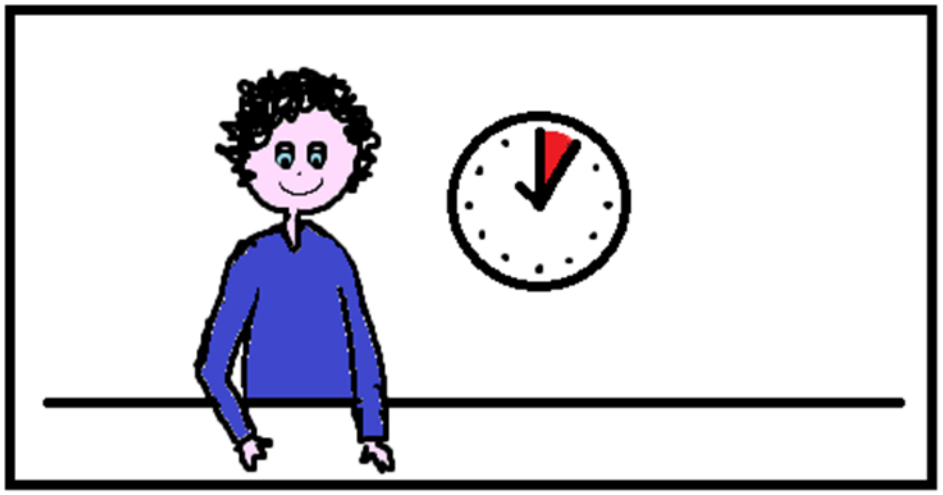
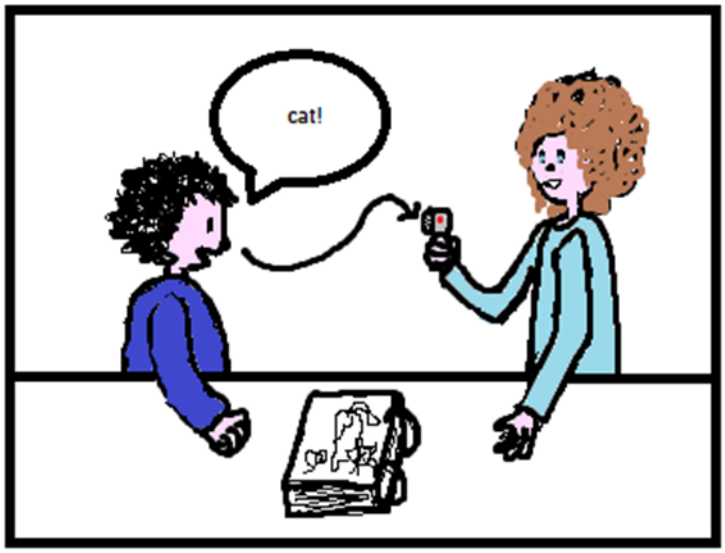
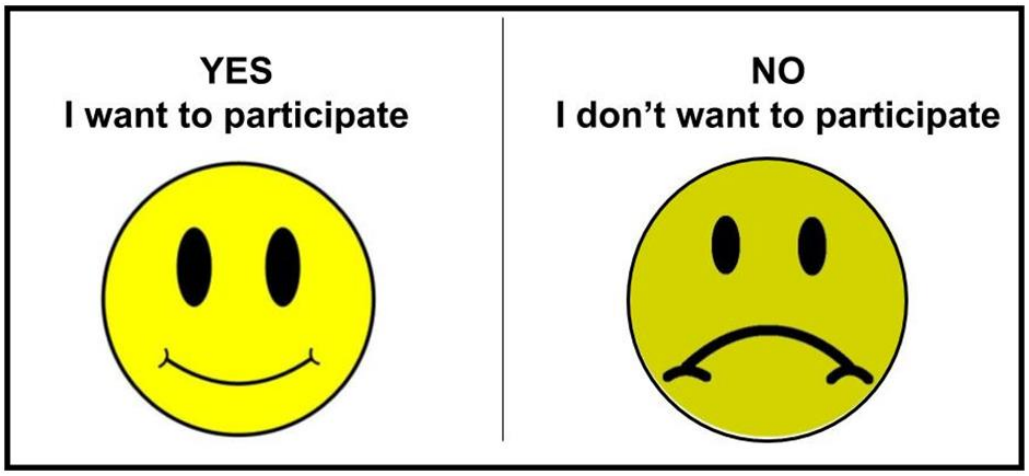




Do you want to participate?



Appendix 4: Additional Information on Cohort 1

Table 36: Regional Variations of Italian spoken by children's parents, in terms of number of mothers (M) and fathers (F) in each age group, and relative and overall percentages.

	3;0-3;5 (n=28)		3;6-3;11 (n=55)		4;0-4;5 (n=60)		4;6-4;11 (n=40)		overall (N=183)		% overall (N=183)		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**overall (N=366)**
Ligure	20	21	29	27	40	40	25	26	114	114	62.3	62.3	62.3
Calabrese	2		1	1		1		1	3	3	1.6	1.64	1.6
Sardo		1			2				2	1	1.1	0.55	0.8
Siculo			3		4	3			7	3	3.8	1.64	2.7
Piemontese			2	1	3		3	2	8	3	4.4	1.64	3.0
Lombardo				1		2	1	1	1	4	0.6	2.19	1.4
Campano				3	2	2	2	2	4	7	2.2	3.82	3.0
Trentino							1		1		0.6	0.00	0.3
unknown/ not present	6	6	20	22	9	12	8	8	43	48	23.5	26.2	24.9

Table 37: Dialects spoken by children's parents, in terms of number of mothers (M) and fathers (F) in each age group, and relative and overall percentages.

	3;0-3;5 (n=28)		3;6-3;11 (n=55)		4;0-4;5 (n=60)		4;6-4;11 (n=40)		overall (N=183)		% overall (N=183)		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**overall (N=366)**
Genovese	6	6	6	6	3	4	1	3	16	19	8.7	10.4	9.6
Calabrese	1		1						2		1.1	0.0	0.6
Siculo			2		2	3			4	3	2.2	1.6	1.9
Sardo			1			2			1	2	0.6	1.1	0.8
Napoletano				2			1	1	1	3	0.6	1.6	1.1
no dialect/ not present	21	22	45	47	55	51	38	36	159	156	86.9	85.2	86.1

Table 38: Mothers (M) and fathers' (F) level of education for each age group of participating children and overall.

		3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11	Tot	% (x/183)	M+F	%m+f (x/366)
Primary School Diploma (11 y.o.)	M	1	1	3	2	7	3.8	22	6.0
	F	4	5	2	4	15	8.2		
Middle School Diploma (14 y.o.)	M			1		1	0.6	3	0.8
	F		1	1		2	1.1		
Secondary School Diploma (19 y.o)	M	10	22	28	14	74	40.4	170	46.4
	F	13	28	36	19	96	52.5		
Undergraduate Degree	M	3	7	10	8	28	15.3	42	11.5
	F		4	5	5	14	7.7		
Postgraduate Degree	M	13	18	16	12	59	32.2	97	26.5
	F	7	10	13	8	38	20.8		
PhD	M		2		1	3	1.6	8	2.2
	F	2	2		1	5	2.7		
Unknown	M	1	5	2	3	11	6.0	24	6.6
	F	2	5	3	3	13	7.1		

Appendix 5: Additional information on materials and tools

Table 39: Scoring sheet for BVL_4-12 'Naming and Articulation' subtest, with orthographical and IPA target forms.

Item	IPA	✓	Child's realisation
palla	/ˈpalla/	S/C/R	
ape	/ˈape/		
cappello	/kapˈpɛllo/		
topo	/ˈtɔpo/		
banana	/baˈnana/		
libro	/ˈlibro/		
gabbia	/ˈgabbja/		
albero	/ˈalbero/		
toro	/ˈtɔro/		
treno	/ˈtreno/		
tavolo	/ˈtavolo/		
letto	/ˈlɛtto/		
piede	/ˈpjede/		
dito	/ˈdito/		
nido	/ˈnido/		
dente	/ˈdente/		
cavallo	/kaˈvallo/		
mucca	/ˈmukka/		
cane	/ˈkane/		
gatto	/ˈgatto/		
lago	/ˈlago/		
lingua	/ˈliŋgwa/		
rosso	/ˈrosso/		
scopa	/ˈskopa/		
pasta	/ˈpasta/		
sole	/ˈsole/		
rosa	/ˈrɔza/		
casa	/ˈkaza/		
naso	/ˈnazo/		
sbadiglio	/zbaˈdiʌo/		
fiore	/ˈfjore/		
farfalla	/farˈfalle/		
fuoco	/ˈfwɔko/		
caffè	/kafˈfɛ/		
nave	/ˈnave/		
uva	/ˈuva/		
pesce	/ˈpeʃe/		
scivolo	/ˈʃivolo/		

Item	IPA	✓	Child's realisation
tazza	/ˈtatstsa/		
calza	/ˈkaltsa/		
zanzara	/ʣanˈʣara/		
zebra	/ˈʣebra/		
uccello	/uʧˈʧɛllo/		
arancione	/aranˈʧone/		
bicicletta	/biʧiˈkletta/		
giornale	/ʤorˈnale/		
gelato	/ʤeˈlato/		
orologio	/oroˈlɔʤo/		
mano	/ˈmano/		
mela	/ˈmela/		
scimmia	/ˈʃimmja/		
gomma	/ˈgomma/		
canna da pesca	/ˈkanna ˈda ˈpeska/		
ragno	/ˈraɲo/		
lavagna	/laˈvaɲa/		
gallo	/ˈgallo/		
leone	/leˈone/		
bottiglia	/botˈtiʎa/		
maglione	/maˈʎone/		
carota	/kaˈrɔta/		
porta	/ˈpɔrta/		
rana	/ˈrana/		
torta	ˈ/torta/		
cucchiao	/kukˈkjajo/		
dorme	/ˈdɔrme/		
cintura	/ʧinˈtura/		
versa	/ˈvɛrsa/		
gioca	/ˈʤɔka/		
cucina	/kuˈʧina/		
elefante	/eleˈfante/		
mangia	/ˈmanʤa/		
ventilatore	/ventilaˈtore/		
ascia	/ˈaʃa/		
trottola	/ˈtrɔttola/		
nuota	/ˈnwɔta/		
cammello	/kamˈmɛllo/		
soffia	/ˈsoffja/		

Note: ✓: Spontaneous correct naming; **S**: correct naming after semantic cue; **C**: correct naming after choice; **R**: correct naming in repetition.

Table 40: Semantic cues and alternatives for choice for the BVL naming task.

Item	Semantic cues	Alternative for choice
palla	That object you use for playing football, volley, basketball, etc.	casa
ape	That insect that flies on flowers and has a sting	ago
cappello	You put it on your head to protect yourself from the sun	sciarpa
topo	That animal that is chased by cats	penna
banana	That yellow fruit with a slippery peel	piede
libro	The object that has pages, and you can read	macchina
gabbia	It is where you can keep pet birds	gatto
albero	That plant where fruits grow, that has branches and leaves	fiume
toro	The male of the cow, that snorts and has horns	serpente
treno	The transport that stops at stations	cane
tavolo	You sit around it at lunch or dinner	panna
letto	Where you go to sleep under the covers/blankets	gioco
piede	The part of our body on which we walk, that is at the end of our leg	camicia
dito	One of the five attached to the hand, we use it for pointing	palla
nido	The house of birds, where they leave their eggs	giornale
dente	We have several at the top and bottom of our mouth, when you lose one, the fairy comes at night to leave a coin	topo
cavallo	The animal that nighs and gallops	banana
mucca	The animal that sounds like ‘muuu’ and from which we get milk	foglio
cane	The pet animal that is man’s best friend, it barks when there are intruders	strada
gatto	The pet animal that meows, that chase the mouse	scuola
lago	A big natural pool of water, a bit like the sea but smaller and closed, we have the one of Garda, of Como, etc.	martello
lingua	We use it to lick an ice cream	toro
rosso	The colour of roses, and blood	verme
scopa	We use it to swipe the floor when it is dusty	volante
pasta	We eat it with pesto, tomato sauce, etc	libro
sole	The star that we see in the sky during the day and light the day up	capanna
rosa	The flower with thorns	tavolo
casa	The place where we live, that has a kitchen, a bathroom, etc.	mucca

Item	Semantic cues	Alternative for choice
naso	The part of the body that is in the middle of our face, that we use for smelling and we blow when we have a cold	ape
sbadiglio	It is what we do opening our mouth when we are sleepy	figura
fiore	Grows on the grass and has a nice perfume	testa
farfalla	The insect that first is a caterpillar, then grows colourful wings	caviglia
fuoco	It is hot, has flames, and we make it with wood	sole
caffè	The hot dark drink the grownups drink	treno
nave	A very big boat, on which we can take a cruise	telefono
uva	The fruit that grows on vines	mare
pesce	The animal that lives in the sea and we can eat	farfalla
scivolo	We go on it in the playground and we slide down	medusa
tazza	You can drink milk or tea from it	penna
calza	You wear them under your shoes	disco
zanzara	The fastidious insect that stings in summer	luce
zebra	That animal that looks a bit like a horse but has stripes	pesce
uccello	The animal that flies	tasto
arancione	The colour of tangerines	occhiali
bicicletta	You ride it pedalling	calza
giornale	Grownups read it to know the news	uva
gelato	It's the cold food that you can eat in different flavours and comes in scoops in a cone or a cup	fiore
orologio	You look at it to know the time	caffè
mano	The part of our body at the end of the arm, that you wave to say hello	arancia
mela	The fruit that grows on a tree, and the witch gave Snowhite to make her sleep	pasta
scimmia	The animal that is similar to man and swings from trees	pista
gomma	We use it to erase pencil marks	montagna
canna da pesca	Fishermen use it to catch fish	musica
ragno	The animal with 8 legs, that stung spiderman	matita
lavagna	Teachers write on it with chalk	libro
gallo	The make of the hen, that sings in the morning	casco
leone	The king of the savannah, that roars and has a mane	figurina
bottiglia	The container for water, coca cola, wine, etc.	puzzle
maglione	We wear it over our t-shirts when it's cold	occhiali
carota	The orange vegetable that rabbits like	gelato

Item	Semantic cues	Alternative for choice
porta	You open it to enter or exit a room and lock it when you leave the house	mela
rana	Sounds like ‘ribbit ribbit’ and jumps around in ponds	nuvola
torta	You put candles on it when it’s your birthday	cielo
cucchiao	The cutlery that you use to eat soup	pioggia
dorme	It is what you do in your bed during the night	mangiare
cintura	It’s the piece of clothing that you wear to hold trousers up	cadere
versa	The action you do to put water or juice in a glass	correre
gioca	It is what you do with your friends with toys	studiare
cucina	To prepare lunch or dinner	leggere
elefante	The animal with very large ears, like Dumbo	pigiama
mangia	When you put food in your mouth	scrivere
ventilatore	The object we turn on when it’s hot outside, it has blades	piscina
ascia	The woodsman use it to cut trees	mare
trottola	The toy that spins	forchetta
nuota	The sport that you do in the water, in a swimming pool or in the sea	salutare
cammello	The animal with humps that live in the desert	delfino
soffia	The action we do with our mouth to turn off candles or make bubbles	pensare

Table 41: Orthographical and IPA target forms for the TFPI items, for each age group.

Items	IPA	Age group
cane	/kane/	1[a]
gatto	/gatto/	1, 2, 3
gallo	/gallo/	1
baubau	/babau/	1
cubo	/kubo/	1, 2
lego	/lego/	1
palla	/palla/	1
bici	/biʧi/	1, 2
latte	/latte/	1
pappa	/pappa/	1
pomodoro	/pomodɔro/	1, 2, 3
succo	/sukko/	1, 2, 3
torta	/tɔrta/	1
ciabatta	/ʧabatta/	1, 2, 3
bocca	/bokka/	1, 2
capelli	/kapelli/	1
denti	/dɛnti/	1, 2, 3
dito	/dito/	1, 2, 3
gambe	/gambe/	1
mano	/mano/	1
piede	/pjɛde/	1, 2, 3
biberon	/biberɔn/	1, 2, 3
chiave	/kjave/	1, 2, 3
ciuccio	/ʧuʧʧo/	1, 2, 3
tappo	/tappo/	1
mago	/mago/	1
mamma	/mamma/	1, 2
luna	/luna/	1
sasso	/sasso/	1, 3
ciao	/ʧao/	1
nanna	/nanna/	1, 2
no	/nɔ/	1
si	/si/	1
coniglio	/koniʌo/	2, 3
gallina	/gallina/	2, 3
giraffa	/ʤiraffa/	2, 3
lupo	/lupo/	2, 3
maiale	/majale/	2
pesce	/peʃe/	2, 3
rana	/rana/	2, 3
scimmia	/ʃimmja/	2, 3
tartaruga	/tartaruga/	2, 3
biscotti	/biskɔtti/	2, 3

Items	IPA	Age group
ciliegie	/ʧiliɛʤe/	2, 3
formaggio	/formaʤʤo/	2, 3
fragola	/fragola/	2, 3
gelato	/ʤelato/	2, 3
pasta	/pasta/	2, 3
pizza	/pitstsa/	2, 3
scarpe	/skarpe/	2
braccio	/braʧʧo/	2
lingua	/liŋgwa/	2, 3
naso	/nazo/	2, 3
unghie	/uŋgje/	2
cuscino	/kuʃino/	2, 3
scopa	/skopa/	2
tazza	/tatstsa/	2
telefono	/telɛfono/	2
vasino	/vazino/	2, 3
foglia	/foʌa/	2, 3
scivolo	/ʃivolo/	2
sole	/sole/	2
cassetto	/kassetto/	2
rosso	/rosso/	2, 3
verde	/verde/	2, 3
elefante	/elefante/	3
pinguino	/piŋgwino/	3
scoiattolo	/skojattolo/	3
zanzara	/ʣanʣara/	3
zebra	/ʣebra/	3
martello	/martɛllo/	3
tromba	/tromba/	3
barca	/barka/	3
moto	/mɔto/	3
caramella	/karamɛlla/	3
cioccolata	/ʧokkolata/	3
guanti	/gwanti/	3
sciarpa	/ʃarpa/	3
giornale	/ʤornale/	3
sapone	/sapone/	3
spazzolino	/spatstsolino/	3
straccio	/straʧʧo/	3
spiaggia	/spjaʤʤa/	3
strada	/strada/	3
finestra	/finɛstra/	3
tavolo	/tavola/	3
giostra	/ʤɔstra/	3

Items	IPA	Age group
scuola	/skwɔla/	3

Note: [a]1, 2, 3 respectively refer to the age groups 1;6-1;11, 2;0-2;5, and 2;6-3;0.

Table 42: Consonants' occurrence and position across the BVL_4-12 and the subtests of the TFPI.

			WI		WM				WF
			SI		SI		AB		SF
			C	CC	C	CC	CC	G	C
p	BVL		5	1 /pj/	3			1	
	TFPI	18-23m	3	1 /pj/	1			4	
		24-29m	4	1 /pj/	2		1 /rp/		
		30-36m	5	3 /pj, sp, spj/	2		1 /rp/		
b	BVL		2	1 /zb/		2 /br/	1 /lb/	1	
	TFPI	18-23m	4		4		1 /mb/		
		24-29m	4	1 /br/	3				
		30-36m	4		2	1 /br/	1 /mb/		
t	BVL		5	2 /tr/	5	1 /st/	4 /nt/, 2 /rt/	6	
	TFPI	18-23m	2		1		2 /rt, nt/	6	
		24-29m	3		2	1 /st/	2 /rt, nt/	8	
		30-36m	3	1 /tr/, 2 /str/	3	1 /st/, 2 /str/	3 /rt/, 3 /nt/	8	
d	BVL		4		3				
	TFPI	18-23m	2		2				
		24-29m	2		2		1 /rd/		
		30-36m	2		3		1 /rd/		
k	BVL		11	1 /sk/	2	1 /kl/, 1 /sk/		2	
	TFPI	18-23m	3	1 /kj/				4	
		24-29m	6	2 /sk,/ 1 /kj/		3 /sk, kkj/		4	
		30-36m	3	3 /sk, skw, kj/		3 /sk, kkj/	1 /rk/	4	
g	BVL		4		1		1 /ŋg/		
	TFPI	18-23m	3		2				
		24-29m	2		2		2 /ŋgw, ŋgj/		
		30-36m	2	1/gw/	2		2/ŋgw/		
m	BVL		5				1 /rm/	3	
	TFPI	18-23m	3		1		1 /mb/	2	
		24-29m	2		2		3 /rm,mmj/	2	
		30-36m	2		1	2 /mmj/	2 /mb, rm/		

			WI		WM				WF
			SI		SI	AB			SF
			C	CC	C	CC	CC	G	C
n	BVL		3	1 /nw/	9		4 /nt/, 1 /ntʃ/, 1 /rn/, 1 /ndʒ/, 1 /ndz/	1	
	TFPI	18-23m	2		3		1 /nt/	2	1
		24-29m	2		6		1 /nt/	2	1
		30-36m	1		9		3 /nt/, 1 /rn/, 1 /ndz/		1
ɲ	BVL				2				
	TFPI	18-23m							
		24-29m							
		30-36m							
ŋ	BVL						1 /ŋg/		
	TFPI	18-23m							
		24-29m					2 /ŋgw, ŋgj/		
		30-36m					2 /ŋgw/		
f	BVL		1	1 /fj/, 1 /fw/	1			2	
	TFPI	18-23m							
		24-29m	2	1 /fr/	1			2	
		30-36m	3	1 /fr/	1			2	
v	BVL		2		6				
	TFPI	18-23m			1				
		24-29m	2		2				
		30-36m	2		2				
s	BVL		2	1 /sk/		1 /st/, 1 /sk/	1 /rs/	1	
	TFPI	18-23m	3					2	
		24-29m	2	2 /sk/		2 /sk, st/		4	
		30-36m	3	4 /sk, skw, sp, spj/, 2 /str/		2 /sk, st/, 2 /str/		4	
z	BVL			1 /zb/	3				
	TFPI	18-23m							
		24-29m			2				
		30-36m			2				

			WI		WM				WF
			SI		SI		AB		SF
			C	CC	C	CC	CC	G	C
ʃ	BVL		2		1				
	TFPI	18-23m							
		24-29m	2		2				
		30-36m	2		2				
ʦ	BVL						1 /lts/	1	
	TFPI	18-23m							
		24-29m						4	
		30-36m						4	
ʤ	BVL		2				1 /ndz/		
	TFPI	18-23m							
		24-29m							
		30-36m	2				1 /ndz/		
ʧ	BVL		1		2		1 /ntʃ/	2	
	TFPI	18-23m	3		1			2	
		24-29m	3		1			2	
		30-36m	4		1			4	
ʤ	BVL		3		1		1 /ndʒ/		
	TFPI	18-23m							
		24-29m	2		1			2	
		30-36m	3		1			4	
l	BVL		6		10	1 /kl/	1 /lb/, 1 /lts/	7	
	TFPI	18-23m	3					6	
		24-29m	2		5	1 /lj/		4	
		30-36m	2		7	1 /lj/		4	
ʌ	BVL				3				
	TFPI	18-23m							
		24-29m			2				
		30-36m			2				

			WI		WM				WF
			SI		SI		AB		SF
			C	CC	C	CC	CC	G	C
r	BVL		4	2 /tr/	9	2 /br/	1 /rf/, 1 /rn/, 2 /rt/, 1 /rm/, 1 /rs/		
	TFPI	18-23m			2		1 /rt/		
		24-29m	2	2 /fr, br/	5		4 /rt, rm, rp, rd/		
		30-36m	2	2 /tr, fr/, 2 /str/	5	1 /br/, 2 /str/	3 /rt/, 5 /rk, rn, rm, rp, rd/		
j	BVL			1 /pj/, 1 /fj/					
	TFPI	18-23m		2 /kj, pj/					
		24-29m		2 /kj, pj/	2	3 /mmj, kkj,lj/	1 /ŋgj/		
		30-36m		3 /pj, spj, kj/	1	4 /mmj, lj, kkj, spj/			
w	BVL			1 /fw/					
	TFPI	18-23m							1
		24-29m					1 /ŋgw/		
		30-36m		2 /gw, skw/			2 /ŋgw/		

Note: WI: word-initial; WM: word-medial; WF: word-final; SI: syllable-initial; AB: across syllable boundary; SF: syllable final; C: single consonant; CC: consonant cluster; G: geminate.

Table 43: Consonant co-occurrences representation and position across the BVL_4-12 and the subtests of the TFPI.

			WI	WM		
			SI	SI	AB	
			TCC	TCC	HCC	G
types	BVL		7	6	13	11
	TFPI	18-23m	2	0	3	8
		24-29m	5	5	8	10
		30-36m	10	8	10	8
total	BVL		8	7	16	27
	TFPI	18-23m	4	0	6	14
		24-29m	12	10	18	17
		30-36m	26	21	32	15

Note: WI: word-initial; WM: word-medial; SI: syllable-initial; AB: across syllable boundaries; TCC: tautosyllabic consonant cluster; HCC: heterosyllabic consonant cluster; G: geminate.

Table 44: Vowels' occurrence and position across the BVL_4-12 and the subtests of the TFPI.

			WI		WM		WF
			$C_0V_1C_{0-1}$	$C_0V_1C_{0-1}$	$C_{1-3}V_1C_1$	$C_{1-3}V_1C_0$	$C_{0-3}V_1C_0$
			s	s	s	s	s
i	BVL				3	10	
	TFPI	18-23m				3	4
		24-29m			3	10	3
		30-36m			4	11	4
e	BVL		1		3	10	15
	TFPI	18-23m				3	6
		24-29m			2	5	10
		30-36m	1		1	4	9
ɛ	BVL				5		1
	TFPI	18-23m			1	1	
		24-29m			2	2	
		30-36m			2	3	
a	BVL		4		17	23	37
	TFPI	18-23m			12	8	7
		24-29m			11	15	16
		30-36m			17	15	22
ɔ	BVL				3	8	
	TFPI	18-23m			2	1	1
		24-29m			2	2	
		30-36m			3	4	
o	BVL		1	1	6	10	26
	TFPI	18-23m		1	1	2	12
		24-29m			3	8	19
		30-36m			5	11	21
u	BVL		2		2	2	
	TFPI	18-23m			2	2	
		24-29m	1		3	4	
		30-36m			3	3	

Note: WI: word initial; WM: word-medial; WF: word-final; $C_0V_1C_{0-1}$: zero onset, but potential coda; $C_{1-3}V_1C_1$: both onset and coda present; $C_{1-3}V_1C_0$; absent coda; $C_{0-3}V_1C_0$: potentially present onset, but absent coda.

Table 45: Word stress occurrence across the BVL_4-12 and the subtests of the TFPI.

		Stress on the Last syllable				
		Monosillabe	**Disillabe**	**Trisillabe**	**Tetrasillabe**	**Pentasillabe**
	example	ˈ**da**	kafˈ**fɛ**	bibeˈ**rɔn**		
	BVL	1	1	0	0	0
TFPI	18-23m	2	0	1	0	0
	24-29m	0	0	1	0	0
	30-36m	0	0	1	0	0

		Stress on the Second to the last syllable				
		Monosillabe	**Disillabe**	**Trisillabe**	**Tetrasillabe**	**Pentasillabe**
	example		ˈ**tɔ**po	kapˈ**pɛl**lo	aranˈ**ʧo**ne	ventilaˈ**to**re
	BVL	-	50	19	3	1
TFPI	18-23m	-	26	3	1	0
	24-29m	-	29	13	2	0
	30-36m	-	30	16	6	0

		Stress on the Third to the last syllable				
		Monosillabe	**Disillabe**	**Trisillabe**	**Tetrasillabe**	**Pentasillabe**
	example			ˈ**trɔt**tola	kuˈ**ʧi**nano	
	BVL	-	-	4	0	0
TFPI	18-23m	-	-	0	0	0
	24-29m	-	-	2	1	0
	30-36m	-	-	3	1	0

Table 46: Scoring sheet for the Phone Imitation task.

Target	**1/2/3**: first/second/third presentation, **x**: absent/distorted (transcribe in next column)	**Child's realisation**
p		
b		
t		
d		
k		
g		
m		
n		
ŋ		
ɲ		
f		
v		
s		
z		
ʃ		
ʒ		
ʦ		
ʣ		
ʧ		
ʤ		
l		
ʎ		
r		
j		
w		

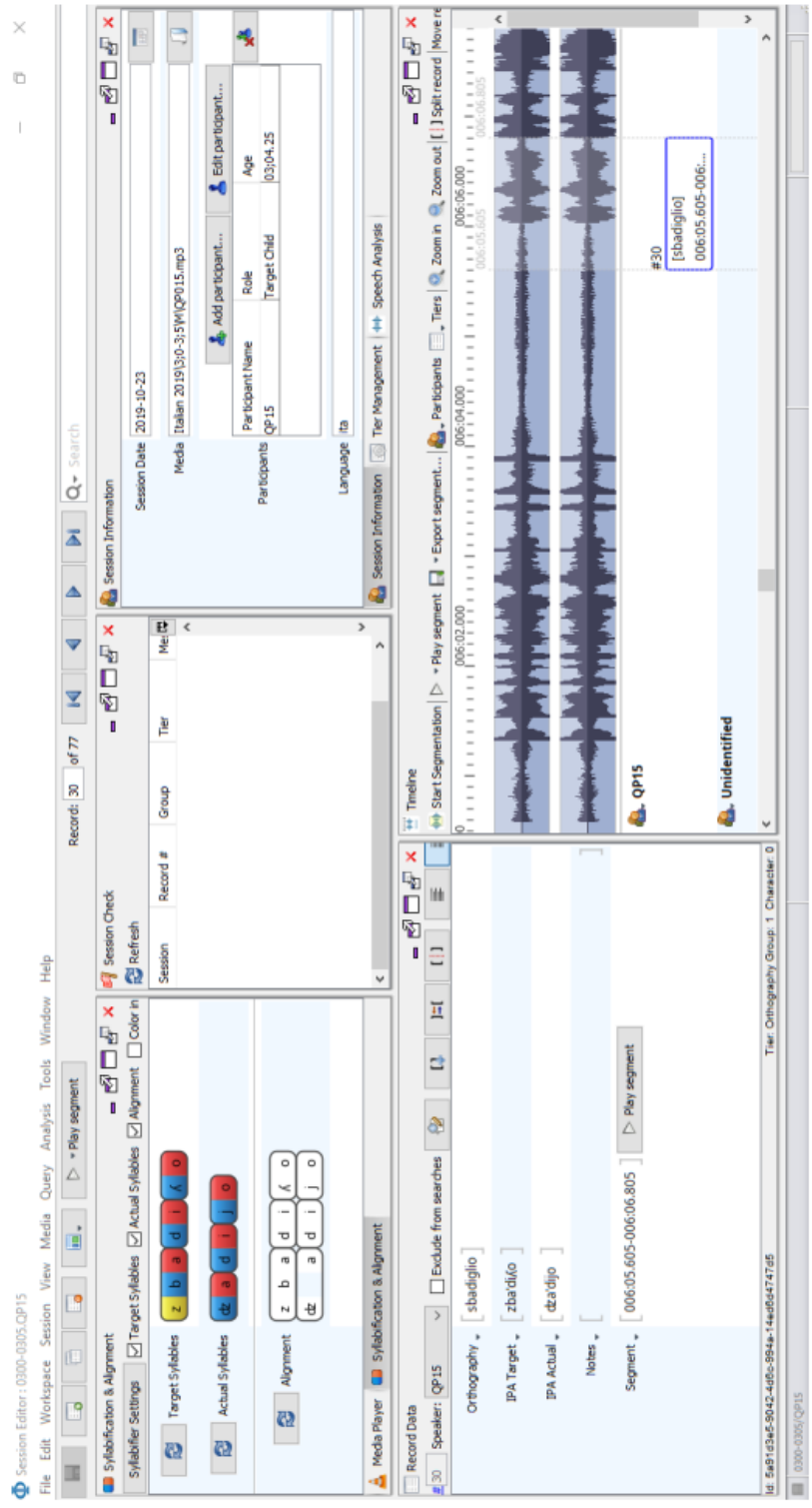


Figure 5: Phon interface for transcription of speech data.

Appendix 6: Phonetic Inventories

Table 47: Consonant Inventory for the picture naming task in the second cohort (missing data: consonants not elicited in the age group).

Consonants	1;6-1;11	2;0-2;5	2;6-3;0
p	100.00	100.00	100.00
b	40.00	100.00	90.00
t	100.00	100.00	100.00
d	50.00	100.00	100.00
k	60.00	100.00	100.00
g	20.00	60.00	100.00
f	0.00	80.00	100.00
v	30.00	80.00	100.00
s	20.00	90.00	100.00
z	-	10.00	50.00
ʃ	-	50.00	70.00
ʦ	0.00	30.00	10.00
ʣ	-	-	20.00
ʧ	40.00	90.00	90.00
ʤ	-	40.00	70.00
m	80.00	100.00	100.00
n	90.00	100.00	100.00
ɲ	-	-	-
l	90.00	100.00	100.00
ʎ	-	0.00	0.00
r	0.00	10.00	60.00
w	0.00	20.00	80.00
j	40.00	90.00	100.00

Table 48: Consonant Inventory for the picture naming task in the first cohort.

Consonant	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
p	100.00	100.00	100.00	100.00
b	100.00	100.00	100.00	100.00
t	100.00	100.00	100.00	100.00
d	100.00	100.00	96.67	100.00
k	96.43	100.00	100.00	100.00
g	96.43	98.18	96.67	95.00
f	96.43	90.91	100.00	100.00
v	92.86	90.91	100.00	97.50
s	89.29	81.82	90.00	97.50
z	64.29	32.73	60.00	72.50
ʃ	32.14	58.18	78.33	65.00
ʦ	85.71	67.27	76.67	80.00
ʣ	71.43	64.81	71.67	77.50
ʧ	67.86	83.64	88.33	87.50
ʤ	71.43	78.18	83.33	80.00
m	100.00	98.18	98.33	100.00
n	100.00	100.00	100.00	100.00
ɲ	92.86	81.82	96.67	87.50
l	100.00	100.00	100.00	100.00
ʌ	7.14	3.70	8.33	27.50
r	32.14	69.09	76.67	85.00
w	96.43	87.27	100.00	97.50
j	100.00	100.00	100.00	100.00

Table 49: Consonant Inventory for each age group for the phone imitation task.

Consonant	3;0-3;5	3;6-3;11	4;0-4;5	4;6-4;11
p	100.00	100.00	96.36	97.50
b	100.00	97.87	94.55	97.50
t	100.00	97.87	92.55	100.00
d	95.65	91.49	92.73	97.50
k	95.65	97.87	94.55	97.50
g	86.96	95.74	89.09	95.00
f	86.96	87.23	92.73	90.00
v	78.26	72.34	87.27	92.50
s	39.13	40.43	50.91	85.00
z	39.13	42.55	40.00	72.50
ʃ	73.91	68.09	81.82	82.50
ʦ	30.43	48.94	60.00	80.00
ʣ	43.48	42.55	52.73	72.50
ʧ	69.57	76.60	85.45	90.00
ʤ	52.17	74.47	78.18	72.50
m	100.00	100.00	98.18	100.00
n	100.00	100.00	96.36	97.50
ɲ	95.65	93.62	89.09	92.50
l	100.00	100.00	98.18	97.50
ʌ	17.39	14.89	29.09	35.00
r	21.74	42.55	45.45	42.50
w	100.00	97.87	94.55	90.00
j	100.00	100.00	96.36	92.50

Appendix 7: Phonological Patterns' definitions and examples

System Patterns

- Fronting of Velars /k, g/: substitution of the velar plosives /k, g/ with the correspondent alveolar /t, d/; e.g. /kaˈvallo/→[taˈvallo] ('horse').
- Fronting of /ʃ/: substitution of the postalveolar fricative as the correspondent alveolar [s]; e.g. /ˈʃivolo/→[ˈsivolo] ('slide').
- Fronting of /ʧ, ʤ/: substitution of the postalveolar affricates with the correspondent alveolar [ʦ, ʣ]; e.g. /biʧiˈkletta/→[biʦiˈkletta] ('bike').
- Stopping of Fricatives: fricative produced as the correspondent plosive (e.g. /s/-[t], /f/-[p], /ʦ/-[t]); e.g. /kaˈvallo/→[kaˈballo] ('horse').
- Stopping of Affricates: alveolar and postalveolar affricates produced as alveolar plosives [t, d]; e.g. /ʤeˈlato/→[deˈlato] ('ice cream').
- Gliding of /ʎ/: realisation of the target sound as the semiconsonant/glide [j]; e.g. /zbaˈdiʎo/→[zbaˈdijo] ('yawn').
- Lateralisation of /r/: /r/ realised as lateral [l]; e.g. /ˈraŋo/→[ˈlaŋo] ('spider').
- Affrication: fricative produced as the correspondent affricate; e.g. /ˈsoffja/→[ˈʦoffja] ('blows').
- Deaffrication: affricate produced as the correspondent fricative; e.g. /ˈtaʦʦa/→[ˈtassa] ('cup').
- Devoicing: realisation of a voiced phoneme as the correspondent voiceless; e.g. /ˈgomma/→[ˈkomma] ('rubber').
- Vowel /o/-/ɔ/ (or vice versa): substitution of the closed vowel /o/ with the open /ɔ/, or vice versa; e.g. /ˈpɔrta/→[ˈporta] ('door').
- /e/-/ɛ/ (or vice versa): substitution of the closed vowel /e/ with the open /ɛ/, or vice versa; e.g. /ˈmela/→[ˈmɛla] ('apple').
- Assimilation: consonant in a word assumes one or more phonetic features of other consonant sounds in the same word; e.g. /banana/ - [manana] ('banana').
- Heterosyllabic Consonant Clusters to Geminate: deletion of one of the elements of the cluster occurring across the syllable boundary and gemination of the remaining sound; e.g. /ˈalbero/→[ˈabbelo] ('tree').

- Backing of the alveolar fricatives /s, z/: substitution of the alveolar /s, z/ with the postalveolar or palatal fricative [ʃ, ʒ, ɕ, ʑ]; e.g. /ˈsole/→[ˈʃole] (‘sun’).
- Backing of the alveolar affricates /ʦ, ʣ/: substitution of the alveolar /ʦ, ʣ/ with the postalveolar of palatal affricates [ʧ, ʤ, ʨ, ʥ]; e.g. /ˈpiʦʦa/→[ˈpiʧʧa] (‘pizza’).
- Nasalisation of the voiced plosives /b, d/: substitution of /b, d/ with the correspondent nasals /m, n/; e.g. /bibeˈrɔn/→[ˈmimeˈrɔn] (‘baby bottle’).

Structure Patterns

- Initial Consonant Cluster reduction: reduction of the tautosyllabic CC structure to one member; e.g. /ˈtreno/→[ˈteno] (‘train’).
- Heterosyllabic Consonant Cluster reduction: reduction to one sound of a cluster appearing across syllable boundaries; e.g. /ˈalbero/→[ˈabelo] (‘tree’).
- /r/ deletion: omission of the consonant /r/; e.g. /kaˈrɔta/→[kaˈɔta] (‘carrot’).
- Word Initial Consonant Deletion: cancellation of the consonant in WI position; e.g. /ˈnave/→[ˈave] (‘ship’).
- Syllable Initial Consonant Deletion: cancellation of the consonant in WMSI position; e.g. /ˈtrɔttola/→[ˈtrɔttoa] (‘spinning top’).
- Weak Syllable Deletion: omission of one of the non-accented syllables; e.g. /ʣanˈʣara/→[ˈʣara] (‘mosquito’).
- Epenthesis: insertion of an additional sound; e.g. /ˈpasta/→[ˈspasta] (‘pasta’).
- Gemination: reduplication of an intervocalic consonant; e.g. /ˈlupo/→[ˈluppo] (‘wolf’).