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Phonological variations in typically-developing Italian-speaking children aged 3;0-4;11.

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Abstract:

Normative data on phonological acquisition of a language are a prerequisite for evaluating children's speech sound competences. To date, these data are not sufficiently available for Italian. This study, therefore, aimed to describe the phonological development of 183 typically-developing monolingual Italian-speaking children aged 3;0-4;11 (four 6-months age bands). Participants were assessed through a picture naming task, and performances analysed in terms of 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. Two cut-off criteria to distinguish InfrVar from phonological patterns were applied. Results showed a gradual reduction of all measures with increasing age. Twenty-two patterns generally in line with previous Italian and cross-linguistic studies were observed, with only five patterns and two phonetic distortions occurring across all age groups. Eight patterns only emerged when applying the lower cut-off criterion, while further seven patterns only occurred with very low frequency or in isolated age groups. These findings highlight the influence of the selected cut-off criterion on the identification of patterns and raise the question of whether some patterns should rather be considered InfVar. Data on younger children are still needed to clarify whether low frequency patterns are patterns of younger typically-developing children that have almost resolved in the age groups assessed. At least half of the phonological variation Tokens fell into the category of InfrVar, indicating a need to pay more attention to this so far ignored measure.

Keywords: Italian; phonological development; phonological patterns, phonological variations

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Introduction

Children with Speech Sound Disorders (SSD) represent a large proportion of Speech and Language Therapists' (SLT) caseloads (Brumbaugh & Smit, 2013; Joffe & Pring, 2008; McLeod & Baker, 2004). Prevalence estimates of SSD in children and adolescents range from 2 to 24% as a result of inconsistent terminologies and classifications as well as differences in the age groups studied (Black et al., 2015; Flipsen, 2015; Wren et al., 2016). Together with language impairments, they represent the most prevalent childhood disorder (e.g., Law et al., 2000; Shriberg et al., 1999). SSD in preschool children have been found to be closely linked with lower literacy outcomes (Dockrell et al., 2012; Overby et al., 2012; Peterson et al., 2009) and a greater risk of later literacy difficulties (e.g. Peterson et al., 2009). The prevalence rate as well as the relationship of early SSD with later literacy difficulties provide a strong argument for early diagnosis of and intervention for children with SSD.

One prerequisite for diagnosing SSD and providing targeted intervention is the availability of normative data on typical speech sound acquisition, specifically phonological development, for a specific language. Such data, in particular data on developmental phonological patterns, are vital for discriminating between children with typical speech development and those with SSD, and classifying them further into different subgroups (Dodd, 2014; McLeod & Baker, 2017; Waring & Knight, 2014). Phonological patterns, also sometimes referred to as phonological errors/processes or error patterns, have been defined as a rule-like occurrence of the same phonological variation within a child's speech (Kirk & Vigeland, 2015).

In order to use phonological patterns as part of the diagnostic process for SSD, two prerequisites are of importance: clearly defined phonological patterns as well as empirically-derived and reliable cut-off criteria for identifying them. The use of non-defined or too broadly defined patterns such as 'fronting' or 'cluster reduction' by many studies are questionable from

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a theoretical and clinical point of view (Bernhardt, et al., 2014). For example, many studies report the pattern 'fronting' as a developmental pattern without indicating to which sounds this might apply (e.g. fronting of velars /k, g/ or of post-alveolars /ʃ, ʒ/), while the term 'cluster reduction' is used without any reference to word positions (e.g. syllable initial or final). This differentiation is vital since, for example, the age at which both pattern types are overcome differs depending on the segment or word position affected. Furthermore, empirically-derived and reliable cut-off criteria for phonological patterns are required to avoid under- or over-identification of children deviating from typical phonological development. However, no agreement based on empirical data has yet been reached regarding the sufficient number of occurrences required for a phonological variation to be labelled as phonological pattern. Studies on normative data have applied various cut-off criteria, from counting every single variation within a speech sample as a pattern (e.g. Goldstein, 2005; Viterbori et al., 2018) up to five variations as a cut-off (e.g. Dodd et al., 2002; Fox-Boyer, 2014). This undoubtedly limits the comparability of normative data within and across studies and languages. While many studies follow the cut-off suggested by McReynolds and Elbert (1981) who regarded a phonological variation a pattern if it occurred at least four times (≥4), this criterion is arbitrary as acknowledged by the authors themselves, not based on empirical data, and likely to be too low for certain error types (Kirk & Vigeland, 2015). As a result, certain errors would be incorrectly labled as typical patterns, which in turn can lead to under-identfication of children with SSD.

Furthermore, studies on phonological development tend to ignore those phonological variations from adult targets that occur parallel to a consistent usage of phonological patterns but not frequently enough to reach pattern status (i.e. Infrequent variants (InfrVar)), although already McReynolds and Elbert (1981) highlighted the importance of distinguishing between such InfrVar and actual phonological patterns. Recent research on bilingual children

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additionally indicates that the number of InfrVar might provide important insights into the stability of a child's phonological system (Albrecht, 2017; Fox-Boyer et al., 2020).

Normative data on the phonological development (mainly phoneme inventory, phonological patterns) in children is largely available for English (Dodd et al., 2003, 2013; Howard, 2007), and increasingly so for other languages, e.g. Finnish (Aalto et al., 2020), Danish (Clausen & Fox-Boyer, 2017), Arabic and Cantonese (see also McLeod, 2007). Cross-linguistic comparisons have shown similarities as well as language-specific developmental features such as universal versus language-specific phonological patterns (Dodd et al., 2003; Fox, 2006). Additionally, the rate of phonological development varies across languages even within the same language family; Danish-speaking children, for example, overcome all typical phonological patterns between 3;6 and 4;6 (Clausen & Fox-Boyer, 2017) while Norwegian-speaking children do so only beyond the age of 5;0 (Fox-Boyer et al., in preparation). Thus, even within a language family what we know about phonological development in one language cannot simply be generalised to another language.

Concerning the Romance languages, two major languages of this family, Spanish and Portuguese, have been well studied (Ceron et al., 2017; Da Silva et al., 2012; Galcerán, 1983; Goldstein, 2005; Lousada et al., 2012; Pavez et al., 2009; see Supplemental Online Material Table S1). Data are also available for Maltese (Grech, 1998; Grech & Dodd, 2008), a language which shares a number of features with the Romance language Italian. In contrast, data on Italian are limited, with the majority of Italian studies focussing on consonant acquisition in very young children (see below). Therefore, one key feature of phonological acquisition with fundamental relevance for differentiating between children with and without SSD of unknown origin (Preston et al., 2013), i.e. types and ages of occurrence and disappearance of phonological patterns, has not yet been fully investigated.

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Phonology of Italian

Italian belongs to the Romance languages and is spoken by 57 million people in Italy. It is also the official language of the Republic of San Marino, the Vatican City and the Canton of Ticino (Switzerland), (Bertinetto & Loporcaro, 2005; ISTAT, 2017). Standard Italian consists of 24 consonants (/p, b, t, d, k, g, m, n, ɲ, f, v s, z, ʃ, ʒ, ʦ, ʣ, ʧ, ʤ, l, j, w, ʎ, r/), seven monophthongs (/i, e, ɛ, a, ɔ, o, u/) that can be long or short depending on syllable stress and prosodic features of the discourse (Kramer, 2009), and nine diphthongs (/ei, eu, ɛi, ɛu, ai, au, ɔi, oi, ui/). Word-final vowels are always short (Bertinetto & Loporcaro, 2005; D'Imperio & Rosenthal, 1999). Most consonants have a phone and phoneme status, while some consonants are realised as allophones in certain word positions; the polivibrant /r/ is usually produced as a tap [ɾ] when in short word-medial position; the nasal /n/ acquires the place of articulation of the following consonant in word-medial consonant clusters (i.e. produced as labiodental [ɱ] in cluster with /f, v/, as velar [ŋ] when paired with /k, g/; Croatto, 1986; Kramer, 2009).

In Italian, the voiced/voiceless distinction and word-internal consonant length assume contrastive function. The contrastivity of length is realised in so-called 'geminates' (e.g. palla-['palːa]-'ball' vs. pala-['pala]-'shovel'). Most consonants can be realised as geminates except for /z, ʃ, ʒ, ɲ, ʎ, j, w/. All phonemes that can appear in geminate position can be long or short (except for affricates), with their length thus being contrastive. Affricates, /ʎ/, /ɲ/ and /ʃ/ are always long. Italian consonants are always short in word-initial position, although they are realized as long in some dialects in connected speech (Kramer, 2009).

The Italian syllable structure can be summarised as $C_{0-3}V_{1-2}C_{0-1}$. Consonant clusters can be classified as 'tautosyllabic' (e.g. 'scuola'-/'skwɔ.la/-school), following the most common definition of clusters occurring within one syllable (Kramer, 2009), but also as 'heterosyllabic'

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(e.g. 'barca'-/'bar.ka/-boat) across syllable boundaries. It should be acknowledged that heterosyllabic clusters are sometimes referred to as 'etherosyllabic clusters' in Italian sources (e.g. Santoro & Panero, 2013). 'Tautosyllabic' clusters with up to three elements exist in Italian only in onset position. A one-consonant coda might occur when the word presents a geminate or a 'heterosyllabic' cluster. Word-final consonants are however limited to function words (e.g. articles) and loanwords (e.g. /'bar/, /'stɔp/). Most Italian words are multisyllabic as monosyllabic words are prevalently articles and prepositions (Kramer, 2009).

Phonological Development in Italian

To date, 11 studies have explored the phonological development of Italian (Bortolini, 1995; Bortolini & Leonard, 1991; D'Odorico et al., 2011; Tresoldi et al., 2015, 2018; Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012; Zmarich et al., 2012, in progress; Zmarich & Bonifacio, 2005: see Supplemental Online Material Table S2). Looking at these Italian studies, several limitations of the existing data are evident: the majority of studies solely focussed on consonant acquisition and only included children at a very young age (1;6-3;6), an age range that does not represent the whole period of speech acquisition as indicated by findings of international phoneme acquisition studies investigating a broader age range. About half of the studies only tested a small number of children (n=9-41) usually spread across several age-groups, thus, limiting the interpretability, reliability and generalisability of the results. The only two studies with larger sample sizes of 557 and 694 children (Tresoldi et al., 2015, 2018), looked at consonant acquisition and phonemic inventories and did not investigate phonological patterns, which is the focus of this paper.

Phonological patterns were only investigated by five studies (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012, see Table 1), for which several limitations can be observed: First, for three studies, the sample size can

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be considered to be somewhat small (9-30 across 1-3 age groups) while this is not the case for Viterbori et al. (2018, *N*=88 across 1 age group, i.e. 2;1-2;8). Sample size information is not available for data by Bortolini (1995), which are only reported in the manual of the test 'Prove per la valutazione Fonologica del Linguaggio Infantile - PFLI' but used for reference by the majority of Italian clinicians. Second, four of these studies report every phonological variation found at least once or twice as a phonological pattern, which contradicts the typical definition of a pattern being a frequent, rule-like variation (Kirk & Vigeland, 2015). Information about definitions and cut-offs used for phonological patterns are again not available for Bortolini (1995). On the other hand, most of the patterns reported across studies (e.g., lateralisation of /r/ and initial cluster reduction) have indeed been reported as developmental patterns for many other languages.

[Table 1 near here]

Given that phonological development has been found to be influenced by language-specific features (Hua & Dodd, 2006), language-specific pattern could also be expected for Italian. Existing studies however define patterns very broadly (e.g. 'fronting' without reference to affected sounds) and do not specifically refer to patterns that could be language-specific (see Table 1). The occurrence of consonants in geminate position in Italian could, for example, lead to 'geminate reduction' and/or 'gemination' patterns. The inclusion of sounds generally considered late-acquired and articulatory complex such as the palatal approximants /ɲ/ and /ʎ/ as well as the poly-vibrant alveolar /r/ in the phonetic inventory of Italian could lead to substitutions or distortions of these phonemes, while the high prevalence of CV syllables could result in patterns such as syllable-final or word-final vowel deletion. Given the existence of tautosyllabic (e.g. ['treno]) and heterosyllabic (e.g. ['bar.ka]) CC in Italian, children might show different patterns for tautosyllabic CC in onset position than for heterosyllabic clusters

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(Santoro & Panero, 2013). Finally, the Ligurian variation of Italian spoken in the area of data collection for the present study mainly differs from Standard Italian in two features that may influence the types of phonological patterns: a preference for the closed vowels /e/ and /o/ over /ɛ/ and /ɔ/, and depalatalization/gliding of /ɲ/ (Bertinetto, 2010; Telmon, 2016).

Concerning the assessments used to collect the speech data, six of the Italian studies administered published tests, which do not meet the international standards for tests of speech sound production (AERA et al., 2014; Flipsen & Ogiela, 2015). One study (Tresoldi et al., 2015) assessed children administering a short word repetition test (Schindler, 1986), which therefore only elicits imitative speech. Four studies (Bortolini, 1995; Viterbori et al., 2018; Zanobini & Viterbori, 2009; Zanobini et al., 2012) used the PFLI test (Bortolini, 1995) that asks children to describe pictures with the aim to collect spontaneous speech samples resulting in the examiner having limited control over the elicited items. Similar limitations apply to the two studies recording language samples of children in free play situations using a standard set of toys (D'Odorico et al., 2011; Zmarich & Bonifacio, 2005).

In summary, even though a number of studies on the phonological development in Italian exist, reliable normative data, specifically on phonological patterns, are missing. No study with a reliable sample size focussed on the occurrence and disappearance of phonological patterns cross-sectionally for the developmentally important age range 3;0-4;11. Such data are however fundamental for understanding typical phonological development in Italian and for distinguishing children who follow such a typical phonological acquisition from those who deviate from it (Preston et al., 2013).

Research aim

The research presented in this paper therefore aimed to investigate the occurrence and disappearance of phonological patterns in Italian speech acquisition, applying two different

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cut-off criteria. We report data and analyses examining phonological variations and patterns in a group of children aged 3;0-4;11, who are part of a larger study investigating the phonological development in monolingual Italian-speaking children aged 2;0-4;11 (data 2;0-2;11 by Zmarich et al., 2012; 3;0-4;11 by second author: Lavaggi, in preparation).

The specific research questions were:

RQ1. To which extend does the occurrence of phonological variations (Tokens and Types) change across time indicating progress of phonological development?

RQ2. Which types of phonological pattern can be observed as typical developmental pattern at which age, applying two different cut-off criteria?

Materials and Methods

A cross-sectional design was used to investigate the phonological development of monolingual Italian-speaking children at a single point in time.

Participants

One hundred eighty-three monolingual Italian-speaking children were recruited from 16 nurseries across the area of Genoa, in the north of Italy. They form four 6-months age bands (3;0-3;5, 3;6-3;11, 4;0-4;5 and 4;6-4;11 years; see Table 2). Participating nurseries were provided with parent/carer information sheets, consent forms and parent questionnaires, and asked to distribute these among parents/carers whose children met the following criteria: aged 3;0-4;11, growing up monolingual Italian, and typically-developing (i.e. no known syndromes or cognitive difficulties, hearing or cranio-facial disorders). Informed consent was received for 222 children from 16 nurseries, of which 21 were not recruited to the study as the parent questionnaire revealed that they did not fulfil the selection criteria. We excluded any children for whom parent/carer concerns about speech and language development, diagnosed speech

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and language difficulties, and/or received SLT was reported in the parent questionnaires. Eighteen additional children were either absent from nursery at the time of testing or did not want to take part, resulting in the final study sample of *N*=183. For this final sample the majority of parents/carers reported to have a secondary school diploma (46.45%), a postgraduate degree (26.50%), or an undergraduate degree (11.48%). A minority completed either a lower (i.e. Primary School 6.01% or Middle School Diploma 0.82%) or higher level of education (i.e. PhD 2.18%), with 6.56% of data missing regarding parents/carers education level.

[Table 2 near here]

Materials

Speech Assessment

The 'Naming and Articulation' subtest of the BVL_4-12 (Marini et al., 2015) was used to assess children's speech in Italian since it generally fulfils international, linguistic guidelines for speech test construction (Flipsen & Ogiela, 2015; McLeod, 2012; McLeod & Verdon, 2014). Exceptions are the less frequent sounds in Italian (i.e. ʦ, ʣ, ʎ, ɲ, j, w), which are elicited only ≤4 times. All target words are two- to four-syllabic. The subtest does however not provide any reference or norm data on phonological patterns. Children are asked to name 77 black and white (with the exception of three colour names) pictures representing nouns and verbs (including 3 practice items).

Parental Background Questionnaire

To ensure that children fulfilled the selection criteria, parents were asked to complete a questionnaire about their child's socio-linguistic background as well as their speech and general development.

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Procedure

All children were assessed individually in one session in a quiet room at their nursery during normal nursery hours. The assessment was conducted by the second author or one of four test assistants (three SLTs and one SLT student). In order to ensure consistency across assessors, all assistants were trained in administering the subtest by the second author and observed the second author completing a test session followed by being observed administering the assessment.

The BVL subtest 'Naming and Articulation' was presented on a tablet in form of a PowerPoint presentation following established guidelines for picture naming tasks (e.g. following an elicitation hierarchy of spontaneous production, and semantic, forced choice and imitation cues).

All utterances were transcribed online using broad IPA transcription (International Phonetic Alphabet: IPA, 2015). Furthermore, all testing sessions and thus utterances were audio recorded using an MP-3 device. These recordings were subsequently used by the second author to verify the online transcriptions. All transcripts as well as the respective audio files were entered into the Phon software (Rose & MacWhinney, 2014). Phon was however not used for the analyses presented here. We extracted the transcript for each child from Phon containing the target words and the child's realisations, which was followed by a non-automised pattern analysis. The target forms were derived from the BVL handbook. If a child used a different word than expected or a variation such as diminutive form, this word or form was used as a target for the specific child. Each phonological variation deviating from the target was noted and labelled as detailed as possible, i.e. sounds or word positions affected were noted (e.g. /skala/ ➔ [tala] = word initial cluster reduction /sk/ ➔ [k] + word initial fronting of /k/ ➔ [t]. If a certain phonological variation was not restricted to specific word positions (e.g. fronting

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of /k/ across word positions within a child), these variations were labelled as position independent patterns. Potential patterns emerged from the children's data and were not limited to a list of pattens found in previous studies.

Data Analysis

The data analyses presented here were used to describe the occurrence (Types and Tokens) of phonological patterns typical for Italian-speaking children as well as those phonological variations that occur in children's speech but not frequently enough to be counted as a phonological pattern (InfrVar).

Rooted in the lack of an empirically supported and internationally agreed cut-off criteria to distinguish between the two types of variations, and Kirk and Vigeland's (2015) suggestion that the widely applied cut-off of four occurrences is not suitable for all error types, we used two cut-off criteria to classify phonological variations as patterns or InfrVar for all those variations that could occur ≥6 times in the elicited data: first, phonological variations of the same type occurring at least four times (≥4) within a transcript were classified as a phonological pattern/phonetic error pattern, while phonological variations occurring less than four times were summed up as InfrVar. For a second analysis the cut-off criterion between the two types of variations was raised to ≥6. In cases where certain types of phonological variations could only occur less than six times due to the structure of test items (e.g. fronting of /ʃ/ only occurs up to four times), the cut-off criterion was always half of the possible occurrence frequency (e.g. for a variation that could occur three or four times, the cut-off between phonological pattern and InfrVar was two). Following this differentiation, the total number of phonological variations (i.e. Tokens), the number of patterns (Types) and the number of InfrVar were evaluated for each child. The means and standard deviations for Tokens, Types as well as InfrVar were then computed for each age group. These analyses were run twice, i.e. for both

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cut-off criteria. In order to better compare our results with previous studies, which often report Percentage Consonants Correct (PCC) and not Tokens, PCC values (mean and SD) per age group were additionally derived using Phon.

In line with previous studies investigating the phonological development of children (Clausen & Fox-Boyer, 2017; Dodd et al., 2003; Fox & Dodd, 2001), phonological patterns were defined as typically occurring in an age group and thus, developmental if they occurred in >10% of children in an age group.

Inter-rater reliability was investigated for transcriptions and phonological patterns (Types/Tokens) for 10% of the children (~4 per age group). Reliability for broad phonetic transcription was investigated via phoneme-to-phoneme comparison carried out by the second author and another experienced native Italian transcriber (both SLPs) and was found to be very high (mean phoneme agreement= 99.28; SD= 0.79).

Inter-rater reliability for phonological patterns was examined by comparing pattern Types and Tokens identified by two experienced SLPs (first and second author). The agreement with regard to Types for the cut-off criterion ≥4 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).

Results

Tokens, Types, Infrequent Variants and PCC

In order to address the first research question, the number (Tokens) and Types of phonological variations produced by each child was computed and the mean and standard deviation (SD) calculated for each age group. The average number of InfrVar produced by children across age groups was also calculated as a measure of developmental change and stability in speech

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production (see Table 3). The mean PCC per age group is also reported for comparability with other studies.

[Table 3 near here]

Children presented a decreasing number of phonological variations with increasing age, with the mean number of Tokens almost halved from 3;0-3;5 (*M*=55.21) to 4;6-4;11 (*M*=26.93). The same trend was found for the derived PCC rate as well as the mean of phonological patterns (Types) independent of the applied cut-off criterion. While children in the youngest age group produced on average 5.39 (cut-off ≥4) or 4.00 (cut-off ≥6) Types, this was reduced to 2.45 and 1.83 respectively in the oldest age-group. The relatively large ranges and SDs however highlight a noticeable variability among children within the same age group; a finding that is again independent of the cut-off criterion applied.

Looking at the findings for InfrVar, they also decreased with age. In addition, Table 3 reveals that, when comparing the mean of Tokens with the one of InfrVar for the cut-off criterion ≥6, at least half of the children's phonological variations at any given age group cannot be attributed to phonological patterns. This proportion is, as expected, slightly lower for the cut-of criterion ≥4.

Developmental Phonological Patterns

To answer the second research question, phonological variations occurring at least four (≥4) or six (≥6) times depending on the cut-off criterion were classified as phonological patterns and their percentage of occurrence in each age group was calculated (see Table 4). Clearly defined pattern descriptions were used (e.g. instead of grouping all 'fronting' occurrences in one category, different fronting patterns were identified so that the different pattern labels reflect and clarify what sounds or what word positions are affected).

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[Table 4 near here]

Twenty-two patterns were observed within the population of children assessed aged 3;0-4;11.

Of these, five phonological patterns (Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, Heterosyllabic Cluster ▯ Gemination) as well as two phonetic error patterns (Distortions of /s, z/ and /r/) occurred across all age-groups and both cut-off criteria, and with decreasing occurrence as children grew older.

Three patterns (Deaffrication, Devoicing and Initial Cluster Reduction) were found to occur across several age groups, even though with already low or significantly decreasing numbers for the lower cut-off criterion and with very low occurrence percentages, if at all, for the higher criterion.

Eight phonological patterns (Affrication, Vowel Substitution /e/↔/ɛ/ Stopping of Affricates, Assimilation, Heterosyllabic Cluster Reduction, Geminate Reduction, Weak Syllable Deletion, Syllable Initial Consonant Deletion) only occurred for the lower cut-off criterion, in the first or second youngest age groups and relatively low percentages of children (11-21% of children).

Further four patterns (Vowel Substitution /o/ ↔ /ɔ/ Stopping of Fricatives, Deletion of /r/ and Word Initial Consonant Deletion) only occurred in the first two or three youngest age groups ~~and~~ with a comparably low percentage (11-17% of children) for the lower cut-off criterion and only once with a percentage of 11% for the higher cut-off criterion.

Discussion

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The aim of this paper was to investigate the phonological development in 183 Italian-speaking children aged 3;0-4;11 with focus on phonological variations. Phonological variations per age group were investigated by means of total variations per child (Tokens), number and kind of phonological patterns (Types) as reoccurring variations of the same kind within the same child for either at least four (lower cut-off criterion) or six times (higher cut-off criterion), and the number of InfVar.

Quantitative measures of phonological development

In line with other studies measuring PCC within the Romance language family (e.g. Portuguese: Ceron et al., 2017; Da Silva et al., 2012) or Maltese (e.g. Grech & Dodd, 2008), our findings demonstrate a steady decrease from the youngest to the oldest age group in all three measures (i.e. Tokens, Types and InfVar), signalling a stabilisation of the phonological system over time. In addition, our means for PCC even though in line with results from prior Italian studies lower than those reported for Portuguese and Maltese and showed higher standard deviations in each age group. These indicate a larger variability in phonological development among Italian-speaking children. While some children had overcome all phonological patterns by the age of 3;0-3;5, this was still not the case for all children of the oldest age-group (4;6-4;11). The latter agrees with findings by Tresoldi et al. (2018) who found that in Italian eleven phonemes were not mastered (i.e. pronounced 90% correct) by the age of 5;0. It further agrees with Spanish and Portuguese studies, which reported that phonological development continues until the age of seven (Ceron et al., 2017; Galcerán, 1983). Further research investigating phonological development in Italian-speaking children up to the age of seven seems therefore required to determine at what age the acquisition of the adult phonological system is completed. Moreover, future analyses should investigate whether children who perform at least one SD above the mean for Tokens or Types and thus, outside

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what is often referred to as a numerical indicator for delayed or atypical development (Dodd, 2014), show indeed a delayed or deviant phonological development.

InfrVar were found to make up at least half of the Tokens across all age groups and showed a less marked reduction with age. This finding suggests that InfrVar do indeed play an important role in children's phonological development as already highlighted by McReynolds and Elbert (1981) and should not be ignored as presently done. For example, future studies may want to examine whether some children with SSD only perform outside the norm concerning their number of InfrVar as suggested for bilingual children by Albrecht (2017).

Qualitative measures of phonological development

One aim of this study was to investigate the Types of phonological pattern in Italian-speaking children aged 3;0-4;11 as well as their age of occurrence. Three groups of patterns were observed: phonological patterns across all age-groups and both cut-off criteria, phonological patterns with low percentages of occurrence, and phonetic patterns across all age-groups and both cut-off criteria.

Five phonological patterns were found independent of the cut-off criterion, across all age-groups and with decreasing percentages of occurrence with age (Fronting of /ʃ/, Fronting of /ʧ, ʤ/, Gliding of /ʎ/, Lateralisation of /r/, Heterosyllabic Cluster Gemination). These findings are overall in agreement with consonant acquisition data by Tresoldi et al. (2018) indicating that the sounds affected by four of the five patterns (i.e. /ʃ/, /ʧ, ʤ/, /ʎ/, /r/) are acquired beyond the age of 5;0. For only two of the observed patterns (Fronting of /ʧ, ʤ/ and Lateralisation of /r/) the occurrence percentage fell to a very low level (13% for both cut-off criteria) in the oldest age-group. This could suggest that these two patterns would not emerge as typical developmental patterns in children older than 4;11 anymore as they would stay below

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the threshold of >10% of children (e.g. Dodd et al., 2003). Data on older children are needed to confirm the age of disappearance for all five patterns.

Fifteen patterns were observed with low percentages of occurrence (11-21%), of which eight (i.e. Affrication, Vowel Substitution /e/↔/ɛ/, Stopping of Affricates, Assimilation, Heterosyllabic Cluster Reduction, Geminate Reduction, Weak Syllable Deletion, Syllable Initial Consonant Deletion) were only observed for the lower cut-off criterion (≥4) and only for the first or second youngest age groups. The low percentages of occurrence of all 15 patterns might indicate that these patterns are more frequent in younger children and are about to disappear at the ages assessed. Our ongoing analysis of additional data from children aged 2;0-2;11 (Lavaggi, in preparation) should help to resolve this question. For those eight patterns that did not emerge when applying the higher cut-off criterion (≥6) and also not across consecutive age groups, it might be the case that they are not actually true patterns. In line with Kirk and Vigeland's (2015) suggestion that the cut-off of at least four occurrences might be too low for certain variations, these patterns might occur more or less by chance due to the application of a cut-off criterion unsuitable for the variations in question. To date it is, however, not possible to conclude whether these patterns should be considered typical for a younger age or atypical in general. Again, our ongoing analysis of a younger age group (2;0-2;11) will hopefully also be able to shed more light on this issue and provide another step towards the identification of the most suitable cut-off criterion. In general, our findings highlight the importance of data being collected and analysed from the age when children have been found to be consistent in their speech production and thus, show identifiable patterns (i.e. 2;0-2;6, e.g. Dodd et al., 2003; Schäfer & Fox, 2006). Normative data for speech assessments starting at the age of 3;0 only might lead to a misinterpretation of patterns and consequently to over- or under-identification of SSD and referrals.

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Finally, two phonetic error patterns were found across all age-groups and both cut-off criteria, the distortions of /s, z/ and /r/; a finding in agreement with Italian studies by Tresoldi et al. (2015, 2018) and Viterbori et al. (2018) who also reported these sounds to be frequently distorted for all age groups assessed. Beyond Italian, these phonetic error patterns have also been found for other languages such as Spanish with regards to /r/ (Goldstein, 2005; Hernández & Hernández, 2016), and for example, for German (Fox-Boyer, 2016), Danish (Clausen & Fox-Boyer, 2017) and Maltese (Grech, 1998) with regard to /s, z/. For all languages reported these distortions do not affect meaning and might, therefore, receive little attention up to school age.

Types of Phonological Patterns

Concerning the Types of patterns, seven *structural patterns* were found: Initial Cluster Reduction, Heterosyllabic Cluster Reduction, Word and Syllable Initial Consonant Deletion, Geminate Reduction, Weak Syllable Deletion, and Deletion of /r/. Initial Cluster Reduction is the only structural pattern that occurred across all age groups. Of these seven, merely Cluster Reduction and Weak Syllable Deletion have also been described in all previous Italian studies (Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012; see also Table 1) with the exception of Bortolini (1995) as well as for all other language where applicable (e.g. Hua & Dodd, 2006). They could thus be considered universal patterns. However, contrary to prior Italian studies cluster reduction was investigated in more depth by differentiating between Initial and Heterosyllabic Cluster Reduction. Interestingly, our findings show that children treat the two types of clusters differently. In contrast to Initial Cluster Reduction, heterosyllabic clusters were only reduced by a very small percentage of children in the first two age groups and only for the lower cut of criterion.

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The remaining structural patterns that occurred with low percentages and only for isolated age groups have only rarely been described as typical for other languages: Syllable Initial Consonant Deletion (SICD), for example, was only described by Grech (1998, in Hua & Dodd, 2006) up to the age of 3;6 for Maltese. Thus, data on younger children need to show whether this is a typical language-specific pattern for Italian. Deletion of /r/ has been reported by Galcerán (1983) for Spanish, Guerreiro and Frota (2010) for Portuguese and for Swiss-German by Fox-Boyer et al. (2020) - although for children aged four to six. For Italian, Viterbori et al. (2018) and Bortolini (1995) mention the pattern 'sound deletion' but do not specify the types of sounds, which limits the comparisons that can be drawn with our data. The different ages of occurrence indicate again that even though patterns might occur across languages, their age of occurrence might still be language-specific. Word initial consonant deletion was also reported for Spanish by Galcerán (1983) for children aged three, similar to our findings, as well as for Maltese (Grech, 1998; Grech & Dodd, 2008). However, since no cut-off criteria for patterns were used but instead every phonological variation was described as a pattern, this might have been an incidental finding as our low numbers might also be.

As for *substitution patterns*, the 13 pattern Types found were in general also reported by the five earlier studies on Italian (Bortolini, 1995; Bortolini & Leonard, 1991; Viterbori et al., 2018; Zanobini et al., 2012; Zmarich et al., 2012; see Table 1). It should be acknowledged however that comparisons remain limited for three reasons. First, pattern descriptions and definitions by the different authors are generally not precise enough to allow direct and reliable comparisons. Second, all studies but Bortolini (1995) only investigated children up to the age of three, resulting in limited comparability regarding the occurrence and disappearance of patterns across a wider age range. Third, our study - despite being more in line with the definition of patterns being a rule-like variation (Kirk & Vigeland, 2015) - differs from all five studies in the applied cut-off criteria. For example, in Bortolini's (1995) data the phonological

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pattern 'fronting' includes velar as well as postalveolar fronting, two subtypes that according to our data do not occur within the same age groups. While velar fronting of /k, g/ did not reach the 10% criterion for the youngest age-group, fronting of /ʃ/ was not resolved by 4;11. Gliding as a 'substitution of a sound by a semivowel' is mentioned by Bortolini up to the age of 2;9, while gliding in our data only occurred for /ʎ/ and again was not resolved by the age of 4;11.

In comparison with data from other Romance languages, an agreement on pattern Types can be found concerning those features that are shared by Italian, Spanish and Portuguese (see supplementary material: Table S1). Interestingly, only three language specific patterns for Italian were found. Gliding of /ʎ/ and the change of heterosyllabic clusters to geminates occurred with a very high percentage across all age groups. Both can be attributed to language-specific features; /ʎ/ as a language-specific phone of Italian and the possibility of geminates as another feature of Italian. Studies in other languages that allow consonants on both ends of syllable boundaries are needed to verify whether this assumption of a language-specific kind of assimilation pattern holds true. Additionally, vowel substitution patterns (e.g. vowel /o/ ↔ /ɔ/) apparent in some age groups are suggested to result from dialectal variations of the Ligurian region. Although other Italian features such as the phoneme /ɲ/ or geminate consonants could have been affected, no relevant language-specific patterns emerged from our data.

Conclusion

The present study investigated phonological development in Italian-speaking children aged 3;0-4;11. Findings showed a steady decrease of phonological variations in form of Tokens and Types (patterns) in line with other cross-linguistic studies. However, the variability (SD) within all age groups was found to be large. At least half of the variations were classified as InfrVar, a measure usually not considered but a potential additional indicator of atypical phonological

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development. Concerning the phonological patterns identified, all but three had also previously been reported by studies on Italian or related languages although the in-depth analysis of patterns highlighted that broad pattern categories such as 'fronting' do not sufficiently explain developmental behaviour and limit comparability across studies.

There were two additional important findings. First, because of the application of two cut-off criteria for patterns (i.e. ≥4 and ≥6) in our analyses, we were able to demonstrate an influence of the cut-off criterion on the identification of patterns in that several Types only occurred when the lower cut-off criterion was applied. This raises the question whether these patterns should actually be considered patterns or chance findings (InfVar). Second, a large group of patterns only occurred with very low frequency and within certain age groups. A reliable interpretation of the quality of these patterns (i.e. chance findings or fading out patterns of typically-developing, younger children) is currently not possible and therefore, highlight the importance of data collections from the age of 2;0.

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Declaration of interest statement

The authors report no conflict of interest.

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Table 1: Overview of previous studies on the occurrence of phonological patterns in Italian-speaking children.

	Viterbori et al. (2018)	Zanobini et al. (2012)	Zmarich et al. (2012)	Bortolini (1995)	Bortolini and Leonard (1991)
Sample	n=88 2;1-2;8	n=30 3;0-3;6	n=30 1;6-3;0	n=? 2;0-4;6	n=9 2;2-2;11
Cut-off Criterion (per child)	≥1	≥1	≥1	?	≥2
Structural 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					
Lateralization of /r/	x	x			
Phonologically plausible substitutions	x	x			
Other substitutions	x	x			
Vowel substitutions	x	x			
Liquid deviation					x
Spirantisation					x

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	Viterbori et al. (2018)	Zanobini et al. (2012)	Zmarich et al. (2012)	Bortolini (1995)	Bortolini and Leonard (1991)
Sample	n=88 2;1-2;8	n=30 3;0-3;6	n=30 1;6-3;0	n=? 2;0-4;6	n=9 2;2-2;11
Cut-off Criterion (per child)	≥1	≥1	≥1	?	≥2
Vowel dissimilation				x	

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Table 2: Age and gender distribution of participants (N=183)

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			

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Table 3. Mean (M), standard deviation (SD), Tokens, Types of phonological patterns, and InfrVar in each age group according to the two cut-off criteria.

	n	Cut-off	Tokens M (SD)	Tokens Range	Types M (SD)	Types Range	InfrVar M (SD)	InfrVar Range	PCC (SD)
3;0-3;5	28	≥4	55.21 (31.08)	6-134	5.39 (3.13)	0-13	19.09 (9.78)	3-47	75,24% (13,27)
		≥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	20.02 (10.70)	3-54	76,88% (15,28)
		≥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	84,86% (9,00)
		≥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	87,27% (7,17)
		≥6			1.83 (1.53)	0-7	15.65 (8.08)	3-38	

Note: Tokens values are not affected by the applied cut-off criterion

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Table 4. Types, age, and percentages of occurrence of developmental phonological patterns presented in at least 10% of children in each age group (cut-off criteria ≥4 or ≥6)

	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
/ˈʃivolo/→[ˈsivolo] (‘slide’)	≥6	50	38	18	28
Fronting of /ʧ, ʤ/ →[ts,dz]	≥4	32	13	17	13
/biʧiˈkletta/→[bitsiˈkletta] (‘bike’)	≥6	29	11	12	13
Gliding of /ʎ/→[j]	≥4	89	85	83	70
/zbaˈdiʎo/→[zbaˈdijo] (‘yawn’)	≥6	89	85	83	70
Lateralisation of /r/ →[l]	≥4	64	31	20	18
/ˈraɲo/→[ˈlaɲo] (‘spider’)	≥6	43	24	15	13
Deaffrication	≥4	25	11	23	13
/ˈtatstsa/→[ˈtassa] (‘cup’)	≥6	25		12	
Affrication	≥4	21			10
/ˈsoffja/→[ˈtsoffja] (‘blows’)	≥6				
Devoicing	≥4		15	22	15
/ˈgomma/→[ˈkomma] (‘rubber’)	≥6			12	
Vowel Substitution /e/↔ /ɛ/	≥4	11		10	
/ˈmela/→[ˈmɛla] (‘apple’)	≥6				
Vowel Substitution /o/↔ /ɔ/	≥4	11	11	17	
/ˈpɔrta/→[ˈporta] (‘door’)	≥6	11		10	
Stopping of Fricatives	≥4	11	13		
/kaˈvallo/→[kaˈballo] (‘horse’)	≥6		11		
Stopping of Affricates	≥4		13		
/ʤeˈlato/→[deˈlato] (‘ice cream’)	≥6				
Assimilation	≥4	18	11		
/ˈsole/→[ˈlole] (‘sun’)	≥6				
Heterosyllabic Cluster → Geminate	≥4	61	49	25	23
/ˈalbero/→[ˈabbelo] (‘tree’)	≥6	57	27	15	13
Structural Patterns					
Initial Cluster Reduction	≥4	50	40	20	10
/ˈtreno/→[ˈteno] (‘train’)	≥6	21	16	10	
Heterosyllabic Cluster Reduction	≥4	11	13		
/ˈalbero/→[ˈabelo] (‘tree’)	≥6				
Deletion of /r/	≥4	11			
/kaˈrɔta/→[kaˈɔta] (‘carrot’)	≥6	11			
Geminate Reduction	≥4		13		
/uʧ͡ʧɛllo/→[uˈʧɛllo] (‘bird’)	≥6				
Weak Syllable Deletion	≥4		15		
/ʤanˈʤara/→[ˈʤara] (‘mosquito’)	≥6				
Word Initial Consonant Deletion	≥4	11			
/ˈnave/→[ˈave] (‘ship’)	≥6	11			
Syllable Initial Consonant Deletion	≥4	11			

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/ˈtrɔttola/→[ˈtrɔttoa] (‘spinning top’)	≥6				
Phonetic distortions					
Distortions of /s, z/[1] (e.g. /s/→ [s̪])	≥4	50	49	33	18
/ˈrosso/→[ˈlos̪s̪o] (‘red’)	≥6	50	45	32	10
Distortions of /r/[2] (e.g. /r/ → [ɾ])	≥4	50	40	40	33
/verˈsare/→[veɾˈsaɾe] (‘pour’)	≥6	43	35	37	33

Note: *All numbers are percentages.

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