Nonword repetition by bilingual learners of German: The role of language-specific complexity

Angela Grimm and Julia Hübner

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Abstract

This study examines whether phonological complexity in nonword repetition (NWR) can help to distinguish between bilingual (Bi) typically developing (TD) children and children with Specific Language Impairment (SLI). To control the influence of language-specific knowledge, we constructed quasi-language independent (LI) and language dependent (LD) nonwords which increase systematically in phonological complexity. Monolingual and bilingual learners of German, aged 8-10 years, were tested. Results show equal performances of monolingual TD (MoTD) and BiTD children in both test parts while both SLI groups were outperformed by their TD peers. The TD-SLI-differences are more obvious in the LD part. The results show great promise for using phonological complexity as an indicator of SLI in German monolingual and bilingual language development.

Keywords: nonword repetition, monolingual, bilingual, typical development, SLI, language-independent, language-dependent, language assessment, phonological complexity

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Introduction

Specific language impairment (SLI) is a heterogeneous neurodevelopmental disorder affecting 6 to 8% of children in Germany (Grimm, 2000; Hamann, 2015) as well as in other countries (Leonard, 2014). Children with SLI show difficulties in processing language and building linguistic representations (Leonard, 2014). Most researchers assume that bilingual children are affected by SLI to the same degree as monolingual children (Armon-Lotem, de Jong & Meir, 2015; Bedore & Pena, 2008; Paradis, Genesee & Crago, 2011).

Accurately diagnosing SLI in bilingual children is difficult and high percentages of misdiagnoses have been reported (Crutchley, Botting, &

Conti-Ramsden, 2007; Crutchley, Conti-Ramsden & Botting, 1997; Grimm & Schulz, 2014). Language-based tests can prove to be problematic due to the lower language experience of bilingual children (Paradis, 2005). The identification as SLI should be based on various measures or tasks (e.g., Tuller et al. 2015; Abed Ibrahim, Lein, Hamann, & Rothweiler, this volume for sentence repetition and exhaustivity). Combining different tasks like nonword repetition, sentence repetition, and exhaustivity tasks taps into children's working memory capacities (Archibald & Gathercole, 2006) and their linguistic representations (Snowling, Chiat & Hulme, 1991).

Nonword repetition seems to be particularly useful to identify bilingual children with SLI since, compared to vocabulary-based or morpho-syntactic tasks, nonword repetition is less based on prior language knowledge (Chiat, 2015). In addition, nonword repetition is considered to be culturally fair and no correlations to the socio-economic background of the families have been reported (Engel, Santos & Gathercole, 2008). Some studies found better outcomes for bilingual children in nonword repetition tasks in comparison to monolingual children due to better metalinguistic control (e.g., Bialystok, Craik & Luk, 2012). On the other hand, BiTD children scored similar to MoSLI children in some studies (Messer, Leseman, Boom & Mayo, 2010; Windsor, Kohnert, Lobitz & Pham, 2010). Bilingual children, even TD, seem to be more disadvantaged if word-like items were used (Chiat, 2015). This is related to their lower vocabulary size in one language (Bialystok, Craik, Green & Gollan, 2009; Schaerlakens, Verhagen & Zink, 1995; but see de Houwer, Bornstein & Putnick, 2014); bilinguals often have less lexical support when processing nonwords, compared to monolingual children.

Therefore, a fair assessment of bilingual children could be achieved by using less word-like nonwords. This paper presents results of such a nonword repetition task, the LITMUS-NWR ('Language Impairment in a Multilingual Society'-NWR). The LITMUS-NWR has been developed in joint work within the COST Action IS 0804 (www.bi-sli.org) and focuses on phonological complexity.

The paper is organized as follows: Section 2 summarizes previous findings on nonword repetition and SLI in monolingual and bilingual populations. Section 3 provides an overview of the syllable and word-prosodic structure of German and briefly sketches milestones in the phonological development in German. Section 4 describes the construction of the LITMUS-NWR. The empirical study follows in Section 5. The results of the study and their implications are discussed in section 6.

Nonword repetition as an indicator of SLI

Numerous studies have shown that nonword repetition provides an indicator of SLI in monolingual children (Ellis Weismer et al., 2000; Gathercole, 2006; see Graf Estes, Evans & Else-Quest, 2007 for a meta-analysis of English NWR tests; Schuchardt, Bockmann, Bornemann & Mähler, 2013 for German). In the meta-analysis of Graf Estes et al. (2007), word-like, longer and articulatory complex nonwords proved to distinguish better between TD and SLI than less word-like, short and articulatory simpler nonwords. Also, low phonotactic probability increased the level of difficulty for children with SLI. Furthermore, Graf Estes et al. (2007) found consistently good differentiation of nonword repetition independently of age. They concluded that children with SLI show persistent deficits in nonword repetition. Interestingly, Graf Estes et al. (2007) reported that even short items were sufficient to discriminate between TD and SLI. The effects turned out most distinct in big samples and long item lists. Graf Estes et al. (2007) argued that the short item effect is consistent with the view that nonword repetition not only taps into phonological working memory (contra Archibald & Gathercole, 2006) but also requires linguistic processing such as phonological encoding and representation (in line with Coady & Evans, 2008; Snowling et al., 1991).

Unfortunately, no comparable meta-analysis has been published for bilingual children, and it is unclear if Graf Estes et al.'s (2007) findings can be transferred to bilingual children. Studies provide increasing evidence that nonword repetition serves as an adequate tool for distinguishing BiTD and BiSLI (Gibson et al. 2014; Girbau & Schwartz, 2008; Gutierrez-Clellen & Simon-Cereijido, 2010; Kohnert, Windsor & Kim, 2006; Windsor et al., 2010; all for Spanish-English bilinguals; Ferré, dos Santos & de Almeida, 2015 for French and different first languages). However, there is a great variability within bilingual populations due to the prior experiences in two languages. For example, bilinguals normally have lower vocabulary sizes and lower phonotactic knowledge compared to monolinguals (Messer et al., 2010; Sorensen Duncan & Paradis, 2016). Studies comparing MoTD and BiTD children with regard to nonword repetition showed mixed results (Barac, Bialystock, Castro & Sanchez, 2014; Chiat, 2015 for recent reviews). Some studies found similar performances of the two groups or even better scores for BiTD children (e.g., Bialystok et al., 2012, for simultaneous bilinguals), yet other studies reported significantly poorer performances of BiTD children; in some cases BiTD children scored like MoSLI children (Windsor et al., 2010; Sorensen Duncan, Tessier & Paradis, 2011; Sorensen Duncan & Paradis, 2016, for successive bilinguals). Based on these results, researchers argued for separate norms for bilinguals and monolinguals in nonword repetition tasks (Gutierrez-Clellen & Simon-Cereijido, 2010).

A further possibility is to use less word-like nonword repetition tasks. In the last years, several attempts have been made to construct a (quasi-) language-independent nonword repetition task (Armon-Lotem & Chiat, 2012; Boerma et al. 2015; Ferré et al., 2015; see Mottier, 1951 for older attempts). The Mottier-Test, for example, used CV sequences increasing in length (Wild & Fleck, 2013 for actual norms in German). CV syllables correspond to the simplest syllable type and do not tap into phonological knowledge. CV sequences are not dependent on effects of phonological complexity; they are particularly useful if phonological working memory or phonological short-term memory has to be assessed. However, children with (phonological) SLI may also show difficulties with phonological complexity (Edwards & Lahey, 1998; Barlow, 2001; Marshall, Ebbels, Harris & van der Lely, 2002 for English; Fox-Boyer, 2009; Fox & Dodd, 2001 for German). Therefore, using CV sequences bears the risk of underdiagnosing children with phonological deficits. Hence, another line of research was to construct nonwords increasing systematically in phonological complexity (Marshall et al. 2002; Ferré et al., 2015). The present study is also based on nonwords which vary systematically in the complexity of their syllabic constituents.

Representation and acquisition of phonological complexity in German

Complexity at the syllable- and word-level

This section summarizes syllable and prosodic word level characteristics in German relevant for the analysis (e.g. Féry, 2001; Wiese, 1996 for more information).

Since German is a trochaic language, the left syllable in bisyllabic words is stressed (e.g., /ˈʀeːgən/ 'rain', see Figure 1(a)). Trisyllabic words can contain an unfooted syllable (e.g. /toˈma:tə/ 'tomato'; see Fig. 1(b)). Unfooted syllables cannot be integrated into a trochaic foot, and cannot create a foot of their own either. Most analyses of German propose that extrametrical syllables are adjoined to the prosodic word (Wiese, 1996;

Féry, 2001). If three-syllable words bear penultimate stress, the extrametrical syllable is adjoined to the left of the trochaic foot (see Figure 1(b)).

1(a) 1(b)

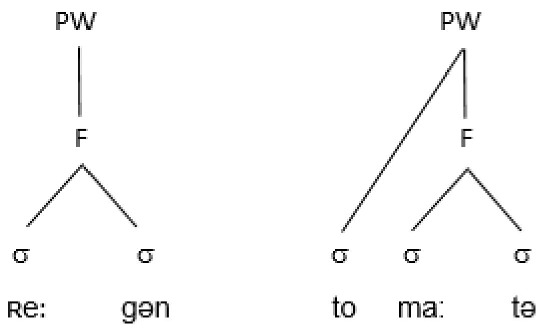

Figure 1. Word-prosodic structure of bisyllabic trochees (a) and trisyllabic words with penultimate stress (b) in German. Abbreviations: PW = prosodic word, F = foot, σ = syllable.

At the syllable level, phonological complexity is realized by consonant clusters in syllable-initial (onset) and syllable-final (rhyme) position. In syllable-initial position, obstruents combine with most liquids (except */tl/, */sl/). Except /kn/, sequences of obstruent and nasal are restricted to loanwords (e.g., pneu- in ‘pneumothorax’). Three-member onset clusters such as /ʃpʀaːxə/ ‘language’ or /sklaːvə/ ‘slave’ are possible, however, /s/ or /ʃ/ + obstruent combinations are limited to word-initial position (see below for more details).

Syllable-final positions are less restricted with regard to consonant sequencing than syllable-initial position. For example, homorganic nasal and obstruent sequences (e.g. /mp/, /nt/) are permitted, and the coronal obstruents /t/ and /s/ can follow liquids (e.g. /rt/, /lt/, /rs/, /ls/). The rhyme can be very complex as illustrated by the word [hɛɐpsts] 'autumn'-GENITIVE.

The sonority sequencing principle is violated if /s/ or /ʃ/ precede an obstruent in syllable-initial position and if /s/ or /ʃ/ follow an obstruent in syllable-final position (Selkirk, 1984; Wiese, 1988). In these contexts, /s/ and /ʃ/ are analysed as extrametrical (Wiese, 1996; Féry, 2001). Due to the violation of the sonority sequencing principle, these word-final Cs-Clusters cannot be integrated into the syllable (in the following called 'extrasyllabic'). Researchers analyse word-final /s/ and /ʃ/ in German as appendix to the prosodic word (Wiese 1996) or to the syllable (Féry, 2001) because they do not count for the assignment of word stress. In word-initial position, /s/+consonant clusters are analysed as prefix to the syllable (Fery 2001) or as extrametrical consonant (Wiese 1988). Figure 2(a) illustrates the representation of /s/-clusters in syllable-initial position for the first syllable /ʃpʀaː/ in /ʃpʀaːxə/ 'language' according to Wiese (1988); Figure 2(b) in syllable-final position for the example /huːts/ 'hat'-GENITIVE. A similar representation of extrasyllabic consonants is presumed for Dutch (Fikkert, 1994), English (Kenstowicz, 1994), as well as other languages (see Barlow, 2001 for a summary). It is important to note that the structural representation of /s/ + consonant differs cross-linguistically (Fikkert & Freitas, 2004; Goad & Rose, 2004).

2(a) 2(b)

Figure 2. Representation of extrasyllabic consonants in syllable-initial position (a) and in syllable-final position (b). Abbreviations: PW = prosodic word, F = foot, σ = syllable, O = onset, R = rhyme.

Acquisition of complex phonological structure in child German

During the acquisition of German, children show several phonological processes such as syllable omission, reduction of consonant clusters and substitution of consonants (e.g., Fox & Dodd, 1999 for an overview). Omission of unfooted syllables (/baˈnaːnə/ 'banana' → [ˈnaːnə]) is a frequent process in the acquisition of German (Grimm, 2008; Lleó, 2002) which disappears around the age of 3;6 (Fox & Dodd, 1999). Additionally, German children tend to omit consonants in consonant clusters for a certain period of time (e.g. /bluːmə/ 'flower' → [buːmə]. The majority of word-initial two-member onset clusters is acquired up to the age of 4;5 with /s/+obstruent clusters being among the latest ones (Fox & Dodd, 1999; 90% correct realizations). In the study of Fox and Dodd (1999), three-member clusters have been acquired in word-initial position up to the age of 4;11, whereas complex codas are acquired somewhat earlier by German children (Lleó & Prinz, 1996). As a phoneme, /s/ is mastered at the age of 2;11 and /ʃ/ at 4;11 (Fox & Dodd, 1999), however, the correct phonetic realization of /s/ often takes much more time (Fox & Dodd, 1999).

There is evidence that children treat /s/+consonant clusters differently from other onset clusters (Fikkert & Freitas, 2004 for Dutch and Portuguese; Goad & Rose, 2004 for German and various other languages). A study of language-delayed German children by Ott, van de Vijver and Höhle (2006) supported this view. Ott et al. (2006) analysed the error patterns in singleton onsets (e.g. /ku:/ 'cow', /ʃa:f/ 'sheep') and in clusters like /knɔpf/ 'button' and /ʃlaŋə/ 'snake'. Fronting (/ku:/ 'cow' → [tu:]) was found significantly more frequent in words with singleton onsets compared to words containing onset clusters. Apparently, the children prevented illegal sound sequences in onset clusters (/knɔpf/ 'button' →*[tnɔpf]). With regard to the process of stopping (/ʃa:f/ 'sheep' → [ta:f]), no difference was found between singleton onsets and consonant clusters. Ott et al. (2006) attribute the different error patterns to the representation of the respective onset clusters (p. 329). Evidence for a different representation of /s/-clusters and other onset clusters comes also from children with SLI acquiring English (Barlow, 2001) and Turkish (Yavaş, 2009).

With regard to bilingual phonological acquisition, most studies have concentrated on transfer effects as a possible source of acceleration or deceleration (e.g., Lleó, 2002 for word prosody; Kehoe & Lleó, 2003; Lleó & Demuth, 1999 for syllable structure in Spanish-German simultaneous bilinguals; Gunter, 2010 for consonant clusters in Russian-German and Turkish-German successive bilinguals; Tessier, Sorensen Duncan & Paradis, 2012 for consonant clusters in Punjabi-English and Chinese-English successive bilinguals; see Fabiano-Smith & Barlow, 2010 for an overview of cross-linguistic findings). However, these studies often considered small samples of children and focused on specific language combinations. Therefore, it is still an open question whether typically developing bilingual children generally show more difficulties than age-matched monolinguals producing phonologically complex structures. In addition, it is still debateable whether phonological complexity can be used as indicator of SLI in bilinguals.

Research questions and hypotheses

The present study provides a quantitative analysis of the influence of phonological complexity in nonword repetition. We asked 8- to 10-year-old monolingual and bilingual children, TD and SLI, to repeat nonwords. The bilingual groups started to acquire German before age 5 (see below for more details). Two sets of phonologically complex nonwords were constructed: The (quasi-)language-independent nonwords (LI) were composed of cross-linguistically frequent sounds and sound combinations. An additional set of nonwords was composed of /s/ and /ʃ/ in extrasyllabic positions in addition to the universal sounds of the LI part. We call this second set of items language-dependent items (LD) because extrasyllabicity of consonants is rather infrequent in the world's languages. The study addresses the following research questions:

(1) Do 8-to 10-year-old MoTD and BiTD children differ in the repetition accuracy of (quasi-)language-independent (LI) and language-dependent (LD) nonwords?

(2) How do children with SLI perform in the LI and LD parts, compared to their TD peers?

In this study, we analysed whole-word accuracy. The following predictions were stated: With regard to question (1) we expected BiTD children to perform like MoTD children. No differences between the two groups were expected in the LI part due to the (quasi-)universal phonological structure of the items, since there is low similarity to existing words. Furthermore, at the age of 8 to 10, simultaneous and early successive BiTD learners were exposed to German for several years and therefore should have acquired extrasyllabic consonants. With regard to question (2), we expected significant differences between TD children and their SLI peers in both test parts. The repetition accuracy should be significantly lower in the SLI groups because children with SLI struggle with complex phonological structures.

The LITMUS-NWR (German, pre-version)

The LITMUS-NWR task focuses on phonological knowledge rather than on working memory (see Chiat, 2015; Ferré et al., 2015). The NWR test includes consonant clusters which are known to be problematic for children with (phonological) SLI (Barlow, 2001; Leonard, 2014). Due to the focus on bilingual children, language-specific phonological properties had to be considered as far as possible. This implies a) that nonwords should be maximally distinct from existing words of German and b) that cross-linguistically and widely attested sounds had to be used. To reduce the phonological working memory load, the length of the nonwords does not exceed three syllables.

The present test contains a (quasi-)language-independent (LI) and a language-dependent (LD) part. In both parts, a trochaic 'CVCV shape forms the base and varies systematically in complexity. For the LI part, the 'CVCV shape is expanded by one or more consonants and/or by an additional syllable. Consonants are added in word-initial ('CVCV→'CCVCV), word-medial ('CVCV→'CVCCV), word-final position ('CVCV→'CVCVC) or in a combination ('CVCV→'CCVCCV) of them. A syllable is added to the right ('CVCV→'CVCVCV), resulting in antepenultimate stress and the trisyllabic

'CVCVCV shape is expanded further by consonants in word-initial ('CVCVCV→'CCVCVCV), word-final 'CVCVCV→ 'CVCVCVC) or word-medial position ('CVCVCVC →'CVCVCCV, 'CVCCVCV). The nonwords are composed of the vowels /a/, /i/, /u/ and the consonants /p/, /k/, /f/, and /l/ which are distributed equally. The LI part consists of 23 test items and 7 additional items serve as controls to examine the ability to produce singleton consonants (e.g., /'faku/, /paf/).

The language-dependent (LD) items are constructed according to the same principles plus extrasyllabic /s/ in word-initial and word-final position (e.g. 'sCCVCV; 'CCVCVCs). We chose extrasyllabic /s/ in order to focus on children’s language-specific phonological representation rather than their phonetic or articulatory abilities (see section 3 for theoretical and cross-linguistic considerations on extrasyllabicity). The LD part consists of 32 test items and 4 controls (e.g. /'sapi/, /kas/). The entire list of items is given in the appendix.

Studies on the German pre-version

The pre-version of the LITMUS-NWR was conducted with 168 monolingual learners of German between 3 and 14 years of age (M = 6;8, SD = 2;3) and 199 bilingual children between 3 and 14 years of age (M = 7;2, SD = 1;10; age of onset in years: M = 2;0; SD = 1;5). The sample included 9 MoSLI and 24 BiSLI children who were diagnosed by paediatricians. The data collection took place between 2011 and 2015 in different German cities, primarily in Frankfurt, Berlin, Erfurt, Bremen and Oldenburg. Conducting the pre-version (66 items) required approximately 8-10 minutes. No problems were reported regarding instruction and procedure.

The following analyses are based on whole word accuracy. Statistical comparisons of 5- to 10-year-old children confirmed our predictions (see section 3.3). No significant differences between MoTD and BiTD children were found in the LI part. In the LD part, BiTD children were outperformed by MoTD children. In all age groups, SLI children were outperformed by their TD peers (Grimm, 2012, 2013; Grimm, Ferré, dos Santos & Chiat, 2014; dos Santos, Ferré & Grimm, 2011). As the results of the pre-version were very promising, we ran a discriminant analysis to examine the degree of selectivity.

Degree of selectivity

A discriminant analysis was calculated from the data of the 3- to 14–year-old children (monolinguals: n = 168; bilinguals: n = 199). For the LI items, the corrected item-total correlation revealed a mean item discrimination of .291 (SD = .072). For the LD items, the mean item discrimination is .355 (SD = .103). With Cronbach's α =.902, the reliability of the scale is very good. The subscales are very reliable as well, with Cronbach's α = .774 for the LI subscale and Cronbach's α = .861 for the LD subscale.

Based on the discrimination analysis, the NWR has been reduced to 16 test items for the LI and 16 test items for the LD part, including only items with a discrimination value higher than .3 (see Appendix). The reliability of the reduced scales is very good with a total Cronbach's α =.862, Cronbach's α = .714 for the LI subscale and Cronbach's α = .819 for the LD subscale. The results described below are based on the new item lists (LITMUS-NWR German, short version) and represent the findings for the groups of 8- to 10-year-old children.

The present study: LITMUS-NWR (German, short version)

Method

Recruitment

The sample included 92 children assigned to four groups: MoTD, BiTD, MoSLI and BiSLI. The children participated in different research projects across Germany: MILA ('The role of migration background and language impairment in children's language achievement; PI: Petra Schulz), BiLAD ('Bilingual Language Development: Typically Developing Children and Children with Language Impairment'; PI's: Laurie Tuller & Cornelia Hamann) and GIF ('How can a teacher tell if a bilingual child has language impairment: A study of the language of Russian-Hebrew and Russian-German migrant children in preschool and school years' PI's: Sharon Armon-Lotem, Naama Friedmann, Solveig Chilla, & Natalia Gagarina).

Among other objectives, all projects aimed at determining indicators of SLI in bilingual children. The projects have been conducted in different German cities: Frankfurt (MILA), Berlin (GIF), Erfurt (GIF, BiLaD), Bremen (BiLaD) and Oldenburg (BiLaD).

Background information

Information about children’s and their parents’ language background was assessed via parental questionnaires. Different questionnaires have been used by the projects; however, all questionnaires were adopted from the ALDEQ (Paradis, Emmerzael & Sorenson Duncan, 2010). The projects GIF and BiLaD used the PABIQ (Tuller, 2015) whereas in MILA, a project-internal questionnaire has been developed. In all projects, comparable information about the language(s) spoken by parents and, in multilingual families, the usage of the child's, parents' and peers' first and second languages has been collected. Socio-economic background was operationalized based on the parents' years of schooling. The age of onset was consistently defined as the age of the first systematic contact to German.

Inclusionary criteria

Paediatricians diagnosed the children with SLI according to the diagnostic regularities in Germany. At the time of testing, all children diagnosed with SLI regularly visited speech-language intervention which was conducted in schools or in additive interventions after school. Children could only participate in the study if they showed no history of hearing impairment, no age-inappropriate cognitive or motor development and no social or emotional difficulties (according to parental information).

Participants

Monolingual TD children (MoTD): The Mo-TD group consisted of 14 girls and 14 boys with a mean age of 9;4 (SD = 0;1). All children were born in Germany and except for four families, both parents were also born in Germany. In three families, one parent was not born in Germany; two parents were born in Iran and one in Poland. In one family, both parents were born in Morocco. For all children, German was the only language used by the family.

Bilingual TD children (BiTD): The BiTD group consisted of 26 girls and 18 boys with a mean age of 9;4 years (SD = 0;8). Their mean age of onset was at 2;3 years (SD = 1;5, range 0-53 months). At the time of testing, they had a mean length of exposure to German of 7;0 years (SD = 1;8, range 54-125 months). The sample covers 15 cross-linguistically different first languages, among others Russian (n = 18), Turkish (n = 5), Urdu (n = 4), Arabic (n = 2), Japanese (n = 2) and Tamil (n = 2). 42 of the 44 children were born in Germany. Two children were born in Russia. In 37/44 families, both parents were born outside Germany. In six cases, one parent was born in Germany and in one family both parents were born in Germany. For 16 children, parents indicated German to be the dominant language and for the remaining children, information on language dominance is lacking. All children have visited German primary schools for at least two years at the time of testing. In all likelihood, German is the dominant language of the BiTD children.

Monolingual SLI children (MoSLI): The MoSLI group consisted of 3 girls and 5 boys with a mean age of 9;3 years (SD = 0;6) who were all born in Germany. In most cases, the parents were also born in Germany; in only one case, the father was born in Yugoslavia and in another case, both parents were born in Poland. According to parental information, German has been used as the only language in the families.

Bilingual SLI children (BiSLI): The BiSLI group consisted of 4 girls and 8 boys with a mean age of 9;6 years (SD = 0;10), whose first contact with German was at the mean age of 2;10 years (SD = 1;3; range 0-52 months). At the time of testing, they had a mean length of exposure to German of 6;8 years (SD = 1;5; range 62-118 months). One child was born in Kazakhstan, all other children were born in Germany. The children acquire 8 different first languages, among them Arabic (n = 4), Urdu (n = 2) and Russian (n = 1). In two families, one parent was born in Germany, in all other families, the parents were born outside Germany. Like in the Bi-TD sample, German is assumed to be the dominant language because the children are visiting German primary schools.

Group comparisons (t-tests) revealed no significant age differences, neither for the MoTD vs. MoSLI groups ($t(18.648) = .772$, $p = .450$) nor the MoTD vs. BiTD ($t(70) = .895$, $p = .374$), the BiTD vs. BiSLI ($t(54) = -.714$, $p = .479$) and the MoSLI vs. BiSLI ($t(18) = -.579$, $p = .569$) groups. Likewise, there were no significant differences between the BiTD and the BiSLI group in their age of onset ($t(54) = -1.140$, $p = .259$) and length of exposure to German ($t(21.251) = .962$, $p = .347$).

Material

The children participated in the short version of the German LITMUS-NWR. To test basic auditory processing, a pre-test on auditory discrimination preceded the NWR. The auditive discrimination task included 24 nonword pairs (12 similar, 12 distinct pairs of nonwords) and focused on nasals and liquids in word-initial (e.g., 'luba-'ruba, 'niwa-'miwa) and word-medial positions (e.g., 'sone-'some, 'banu-'bamu). Nasals and liquids were chosen because they are particularly difficult to discriminate by hearing-disabled and cochlear implanted persons (Raphael, 2008). Good performances in auditory discrimination have been taken as evidence of age-appropriate hearing abilities at the time of testing (in addition to parents' information in the questionnaire). Children were considered in this study if they correctly responded to at least 18/24 (75%) nonword pairs.

Procedure

Testing took place individually in a quiet room in school. The items were presented via notebook and headphones in a pseudo-randomized order. The children were told that they would now hear unknown and funny words.

They were asked to listen carefully and to repeat the funny words. In case of misperceptions, items were repeated once and were not considered in the later analysis. The sessions were recorded by voice recorder and a SONY ECM-MS 907 microphone for later transcription. Children's productions were transcribed by a student assistant trained for phonetic transcriptions who had no contact to the participants.

Data coding

The present analysis is based on whole word accuracy. A repetition was considered correct if vowels and consonants and their ordering corresponded to the target form. Changes in voicing of consonants (/ˈpifakʊp/→[ˈbifakʊp]) were not considered as errors. Likewise, replacements of extrasyllabic /ʃ/ by [s] or interdental realization of extrasyllabic /s/ have not been considered as errors since, in this position, the opposition is not phonemic in German. Null reactions were counted as mistakes. Data lacking due to technical errors or due to experimental errors were coded as missings. Missings affected approximately 3% of the overall data. In these cases, overall accuracy was calculated on basis of the reduced number of items presented to the child.

Data analysis

Due to the missing data in the recordings, we calculated the proportion of incorrect repetitions relative to the overall number of items passed by the child. The proportions are given in %. The data was not distributed normally, so we ran Mann-Whitney-U tests. Group comparisons were performed separately for the LI and LD part because the test parts are not comparable due to their inherent complexity.

Results

Language-independent (LI) part

Figure 3 depicts the proportion of incorrect repetitions in the LI part. The MoTD group outperformed the MoSLI group ($U = 38$, $Z = -2.888$, $p = .004$). Likewise, the BiTD children outperformed the BiSLI children ($U = 128.5$, $Z = -2.746$, $p = .006$). There are medium effect sizes (MoTD vs. MoSLI: $r = .481$; BiTD vs. BiSLI: $r = .367$) and no significant differences emerged between the MoTD and BiTD groups ($U = 496$, $Z = -1.422$, $p = .155$) as well as between the MoSLI and BiSLI groups ($U = 37$, $Z = -.859$, $p = .390$).

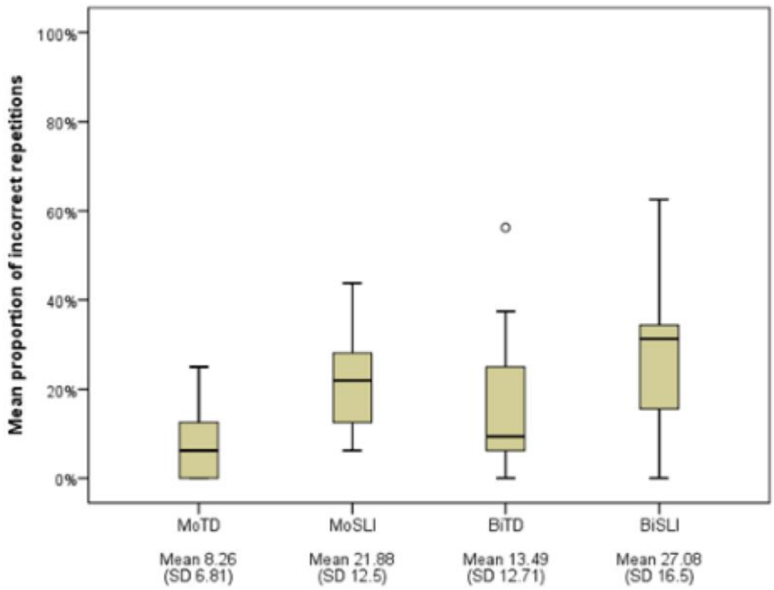

Figure 3: Mean percentage of incorrect realizations in the LI part for the German LITMUS-NWR by group.

Language dependent (LD) part

The results of the LD part are shown in Figure 4. Again, the MoTD children performed significantly better than the MoSLI children (U = 19.5, Z = -3.545, p < .001) and the BiTD children showed significantly better performances than the BiSLI group (U = 47, Z = -4.364, p < .001). The effect sizes are large, both for MoTD vs. MoSLI (r = .591) and BiTD vs. BiSLI (r = .583). No significant differences were found between the MoTD and BiTD groups (U = 551, Z = -.758, p = .449) and between the MoSLI and BiSLI groups (U = 33.5, Z = -1.139, p = .255).

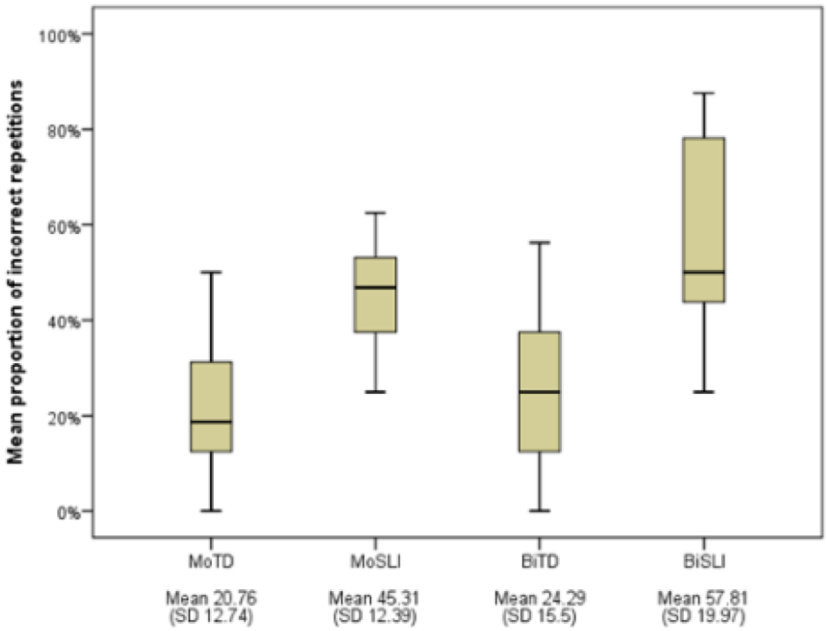

Figure 4: Mean percentage of incorrect repetitions in the LD part for the German LITMUS-NWR by group.

Discussion

The purpose of the present study was to determine if phonological complexity can serve as an indicator of SLI in bilingual learners of German. Monolingual and bilingual learners of German aged 8-10 years repeated short nonwords of one to three syllables. Phonological complexity has been operationalized by consonant clusters and/or a right-adjoined unfooted syllable. Previous studies reported difficulties with consonant clusters and other phonologically complex structures for monolingual learners with language delay or SLI (Barlow, 2001; Ott et al., 2006; Leonard, 2014). A number of studies examined nonword repetition by bilingual learners of German (Grimm, 2016 for an overview). However, no study examined if phonological complexity in nonwords can be used as an indicator of SLI in bilingual learners of German, yet. Therefore, this study fills a gap in current research. We followed the assumption that SLI has similar underlying deficits in monolingual and bilingual development (Paradis, Genesee & Crago, 2011). Thus, we expected that monolingual and bilingual children with SLI show difficulties repeating phonologically complex nonwords. Our results confirm this prediction: There were significant differences between MoTD and MoSLI and between BiTD and BiSLI in both test parts.

Interestingly, TD and SLI children show differences even in the one-to three-syllable nonwords of the LITMUS-NWR. This is remarkable as earlier studies reported reliable discrimination between TD and SLI for three-syllable or longer nonwords (Graf-Estes et al., 2007 for an overview of monolingual children; Girbau & Schwartz, 2008; Windsor et al., 2010; Gibson et al., 2014 for bilingual children). The effect of word length has been attributed to increasing phonological short-term memory load required to process longer nonwords (Gathercole, 2006; Gibson, et al., 2014 for cross-linguistic effects). The present study, however, is based on one-to three-syllable nonwords. The poor results of MoSLI and BiSLI children for these short items are consistent with Graf Estes et al.'s (2007) meta-analysis who also found discrimination by short items. Moreover, the present results support the view that phonological short-term memory deficits are not the unique source of (phonological) deficits in SLI (Edwards & Lahey, 1998; Snowling et al., 1991). The children in this study struggled with the phonological complexity of the nonwords.

Our findings expand previous research in several respects. First, the findings suggest that phonological complexity provides an indicator of SLI in monolingual and in bilingual SLI. With regard to the comparison of monolingual and bilingual children, similar effect sizes in the LI part (MoTD vs. MoSLI: r = .481; BiTD vs. BiSLI: r = .367) and the LD part (MoTD vs. MoSLI: r = .591; BiTD vs. BiSLI: r = .583) suggest comparable difficulties when processing phonologically complex structures. In other words, phonological complexity affects both groups of SLI children to a similar extent.

Secondly, the NWR task administered in this study considered (quasi-) language-independent and language-dependent phonological structures. In previous studies with monolingual children, word-like nonwords discriminated better than less word-like nonwords between TD and SLI (Graf Estes et al., 2007). Word-like nonwords are near to existing words, therefore lexical knowledge supports their processing. Since children with SLI often have lower vocabularies than TD children, they lack the lexical support to process these nonwords (Gathercole, 2006 and replies). BiTD children also possess a smaller lexicon in one language (Bialystok et al., 2009), in particular if they acquire the second language sequentially (Windsor et al., 2010; Schaerlakens et al., 1995). In consequence, bilinguals can be disadvantaged if word-like nonwords are used (Chiat, 2015; Grimm, 2016). In fact, some studies found overlapping performances of (sequential) BiTD learners with MoSLI children even after several years of exposure to their second language (Kohnert et al., 2006; Windsor et al., 2010; Sorensen Duncan et al., 2011; Sorensen Duncan & Paradis, 2016). Therefore, assessing bilingual children with word-like nonwords can lead to overdiagnosing TD children as SLI (Guiterrez-Clellen & Simon-Cereijido, 2010; Grimm, 2016).

The results of this study show that phonological properties should be considered when constructing nonwords (see Ferré et al., 2015 for similar results on the French LITMUS-NWR). Consistent with our expectations, MoTD and BiTD children showed similar performances in the LI and LD part. The bilingual children administered in this study subsumed simultaneous and successive bilinguals with a length of exposure of minimally 54 months. Although individual analyses are needed to examine how age of acquisition and length of exposure are related to the individual performances, our results suggest that after approximately 50 months of exposure, BiTD children have acquired enough knowledge about German syllable and prosodic word organization to perform the LD task.

As expected for the LD part, effect sizes and standard deviations were higher compared to the LI part, suggesting that language-specific phonological complexity poses a challenge for both groups of SLI children (Boerma et al., 2015 for similar results on Dutch). This finding is not surprising given the higher inherent complexity of the LD part. Note that three-member clusters like /skl/ occur only in the LD part. For a correct repetition, children have to acquire the representation of extrasyllabic consonants. Language-delayed monolingual children show difficulties with this type of structure (Ott, van de Vijver & Höhle, 2006).

Interestingly, BiTD children also showed lower accuracy rates in the LD part compared to MoTD children in the pre-version of the LITMUS-NWR (see above). This finding stands in contrast to the results of the short version, where BiTD and MoTD performed equally well. We attribute the differences between MoTD and BiTD in the pre-version to the younger age and shorter exposure to German of the BiTD group (pre-version: M = 7;2 years; age of onset: M = 2;0 years; short version: BiTD: M = 9;4 years; age of onset: M = 2;3 years). Mastering extrasyllabicity seems to require considerable exposure to German even in typical bilingual acquisition. It is a topic for future research to investigate how much exposure time is needed and to what extent additional factors (e.g. first language, age of onset) influence the acquisition of extrasyllabic consonants.

In sum, the LITMUS-NWR provides a promising tool for assessing bilingual children since it considers language-specific phonological knowledge. The results suggest that the test is fair to bilingual children. To reduce the risk of misdiagnoses, we nevertheless suggest to consider the language biography if bilinguals are assessed by NWR tests (Gutierrez-Clellen & Simon-Coreijido, 2010; Sorensen Duncan et al., 2011).

Conclusion and directions for future research

This study provides evidence that phonological complexity is an indicator of SLI in monolingual and bilingual acquisition of German. In the 8- to 10-year old groups, language-dependent nonwords better discriminated between TD and SLI than language-independent nonwords. More research is necessary to evaluate how children perform at different age ranges and with different first languages.

Despite these promising results, the study obviously has its limitations. Firstly, standard deviations indicated overlapping performances of BiTD and BiSLI children in the LD and the LI part. This implies a risk of misdiagnosing children if no additional measures are taken. Further analyses of the individual data are required to explain the variation in the bilingual groups. Children's first language, chronological age, their exposure to German and/or the individual profile of SLI could have influenced the outcome in the NWR. Secondly, the study leaves open the question if the groups differ qualitatively. We found no difference between MoTD and BiTD children in their overall repetition accuracy; however, the groups could still differ in the rate and types of errors. Likewise, their error patterns could highlight further differences between BiTD and BiSLI children. An error analysis could show if specific errors are more frequent in BiSLI children. Qualitative data would nicely complement the present quantitative results; in combination they can contribute to a more accurate diagnosis of BiSLI children.

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Appendix

Item	**Item Type**	**Item**	**Item Type**
pilu	LI control	**sapi**	LD control
kapi	LI control	**Saku**	LD control
lafi	LI control	**kiS**	LD control
faku	LI control	**kas**	LD control
pli	LI	Spaklu	LD
kla	LI	**sfupli**	LD
flu	LI	**Spluki**	LD
kip	LI	**sklifu**	LD
paf	LI	**Splaklu**	LD
fuk	LI	**sklaplu**	LD
paklu	LI	**skifup**	LD
fupli	LI	Spukif	LD
fluka	LI	**skifapu**	LD
plifu	LI	**Spafika**	LD
plaklu	LI	**sfikupla**	LD
flaplu	LI	skupifla	LD
kafip	LI	**sklipafu**	LD
pukif	LI	sflipuka	LD
kifapu	LI	Spiklafu	LD
pufaki	LI	**skaflipu**	LD

fikupla	LI	**skapifuk**	LD
kupafli	LI	**Spifakup**	LD
klipafu	LI	kafipS	LD
flipuka	LI	**pukifs**	LD
piklafu	LI	kapifaps	LD
kuflapi	LI	**fikapuks**	LD
kapufip	LI	pafluS	LD
pifakup	LI	kuflas	LD
flukif	LI	fikuspa	LD
klifak	LI	**kufiski**	LD
		pafiklas	LD
		fapuplaS	LD
		kluspi	LD
		plisfu	LD
		pusfa	LD
		faspi	LD

Table 1: List of items of the LITMUS-NWR German. Items selected for the short (final) version are given in bold letters.