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Developmental dyslexia and specific language impairment: distinct syntactic profiles?

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ABSTRACT

Recent work exploring syntax in developmental dyslexia (DD) has identified morphosyntactic deficits, striking parallelisms between children with DD and specific language impairment (SLI). The question remains open if the underlying causes for such deficits are related to difficulties in phonology, which is affected in DD, or to working memory, as has been previously reported for SLI. We focus on the production of third person accusative clitic pronouns (ACC3) and of homophonous definite determiners in French-speaking children with DD and SLI as well as typically developing (TD) controls. If syntactic complexity modulates performance of DD children, as has already been shown for SLI, we predict children with DD to perform significantly worse on ACC3 compared to definite determiners, which are homophonous but syntactically simpler. In addition, if impairment in ACC3 stems from phonology or working memory difficulties, we expect ACC3 performance in both clinical groups to relate to performance on non-word repetition or forward/backward digit spans. We studied 2 groups of 21 children and adolescents, with DD and SLI (7–15 years) and age-matched TD controls. Results reveal significant weaknesses with ACC3 in DD and SLI groups compared to TD controls, but no difficulty for homophonous definite determiners, confirming a deficit relating specifically to syntactic complexity. As for links to phonology and working memory, a single correlation emerged between ACC3 and the backward digit span in SLI, but not in DD, suggesting different underlying sources for syntactic deficits in these populations. Clinical implications of these results are discussed.

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Introduction

Developmental dyslexia (DD) and specific language impairment (SLI) are both developmental disorders affecting between 5% and 10% of children (Tomblin, 1997; Leonard, 1998; Snowling, 2000), running in families (Fisher & DeFries, 2002; Rice, Haney, & Wexler, 1998) and occurring in the absence of any other handicapping condition which may interfere with linguistic development (DSM-V, American Psychiatric Association, 2013). Whereas SLI is characterized by various oral language disorders, DD is associated with persistent and specific difficulties in written word identification, which are hypothesized to result from a deficit in the phonological component of language (Lyon, Shaywitz, & Shaywitz, 2003; Ramus et al., 2003). Individuals with DD are indeed known

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to have poorly specified phonological representations, which manifest in various phonological reading-related skills, such as phonological awareness, non-word repetition as well as rapid automatized naming (Lyon et al., 2003; Melby-Lervag, Lyster & Hulme, 2012; Ramus, Marshall, Rosen, & Van Der Lely, 2013; Ramus et al., 2003; Snowling, 2000; Snowling & Hulme, 1994). Impairments in other areas of oral language such as morphosyntactic deficits are not included in the basic terminology of DD; however, it has been hypothesized that vulnerability in grammar may also relate to reading comprehension difficulties attested in this population (Bentin, Deutsch, & Liberman, 1990; Menyuk & Chesnick, 1997; Scarborough, 1991; Xiao & Ho, 2014). Indeed, amongst 34 young English-speaking children at genetic risk of dyslexia (from 2;6 to 8 years old), those who later became dyslexic produced shorter and less complex sentences at 30–40 months, thus suggesting that syntactic skills at these ages are a strong predictor of reading disabilities (Scarborough, 1990, 1991). In older Hebrew-speaking children with DD (10–11 years), Leikin and Assayag Bouskila (2004) evaluated syntactic processing and found that they were less accurate than age-matched controls on the five syntactic structures tested (including passives and relative clauses). Talli, Sprenger-Charolles and Stavrakaki (2013) also found significant delays in general oral and written morphosyntax in 16 Greek-speaking children with DD (*M* age = 9;2). On more specific constructions, individuals with DD reportedly experience difficulty with tough constructions (Byrne, 1981, for English), relative clauses (Stein, Cairns, & Zurif, 1984; Bar-Shalom, Crain, & Shankweiler, 1993, for English; Sevcenco, Avram, & Stoicescu, 2014, for Romanian; Arosio, Panzeri, Molteni, Magazu & Guasti, 2017, for Italian) and passives (Cardinaletti & Volpato, 2015, for Italian). Vender (2011) showed difficulties in pronoun interpretation in 18 Italian children with DD (*M* age = 9;6) compared to age-matched controls. Still in Italian, Zachou, Partesana, Tenca and Guasti (2013) studied production and comprehension of direct object clitics and definite determiners in 10 children with DD (*M* age = 9). Their overall results revealed subtle difficulties for clitics, with gender errors and production of dative clitics, in contrast to ceiling performance on definite determiners. More precisely, Italian-speaking children with DD produced only 65% clitic pronouns while control children were at ceiling (90%). Similarly, Arosio, Pagliarini, Perugini, Barbieri and Guasti (2016) also reported difficulty in clitic production in another study of 24 children with DD aged 7–12 years and argued that this observed difficulty in grammar underscores the problem of SLI under-identification in DD. Unfortunately these studies did not include a comparison group with SLI; therefore, qualitative and quantitative similarities between DD and SLI require additional investigation.

Other oral-language difficulties in DD have been identified in the realm of morphology, both regarding morphological awareness in English (Siegel, 2008) and verbal agreement (Cantiani, Lorusso, Perego, Molteni, & Guasti, 2015; Joanisse, Manis, Keating, & Seidenberg, 2000; Rispens, Roeleven, & Koster, 2004; Robertson, Joanisse, Desroches, & Terry, 2013). The question remains whether morphological impairments in DD can be related to initial phonological limitations (as suggested by Robertson et al., 2013, amongst others) or if they stem from a more general linguistic delay beyond their phonological disorder (Waltzman & Cairns, 2000). Finally, morphosyntactic weaknesses in DD children are extremely heterogeneous. As some studies from Italian have shown, weaknesses in the production of complex syntactic structures such as *Wh*-questions and relative clauses affect a subgroup equivalent to approximately 20–25% of the population, with others showing intact syntactic profiles (Guasti, Branchini, Vernice, Barbieri, & Arosio, 2015).

To sum up, despite DD being primarily a condition affecting written language, oral language difficulties have been uncovered in the domains of phonology and morphosyntax. This is reminiscent of SLI, a syndrome where oral language deficits in phonology and morphosyntax are a defining characteristic (e.g. Jakubowicz & Tuller, 2008; Leonard, 2014). It is thus not surprising that some studies have specifically compared the language performance of children with DD and SLI in an attempt to elucidate the potential similarities between the language profiles of these populations. Hence, Guasti (2013) compared comprehension of object relative clauses in 15 Italian-speaking children with SLI (*M* age = 9;9) and 15 children with DD (*M* age= 9;0). She found that these groups did not differ on performance with these structures and both groups displayed lower performance than age-matched typically developing (TD) controls. Regarding the production of verbal morphology, Robertson and colleagues (2013) showed that 15 English-speaking children with DD (*M* age = 9;3) displayed difficulties similar to those of 14 children with SLI (*M* age = 9;4). Turning to spoken sentence comprehension, Robertson and Joanisse (2010) compared English-speaking children with DD (*N* = 14, *M* age = 10;6) to those with SLI (*N* = 14, *M* age = 10;4) on a task in which the difficulty increases with successive working memory loads.[1] They found that both groups performed lower than age-matched controls in word reading, non-word repetition, as well as in receptive grammar (assessed by TROG, Bishop, 1989). As for sentence comprehension, SLI children performed lower than those with DD and controls who did not differ from each other. In all groups, performance decreases when memory load increases, the DD group showing a more pronounced effect than age-matched controls. Finally, Cantiani (2011) compared the morphosyntactic abilities of 16 Italian-speaking children with DD (aged 8–13) and 16 other children with DD and an additional diagnosis of SLI (aged 8–13), for grammatical comprehension, grammaticality judgement as well as morphological manipulations of non-words. Group results clearly showed that children with DD display an intermediary level, situated lower than controls but higher than children with co-morbid DD and SLI.

The only study comparing SLI and DD children in French is that of Talli, Sprenger-Charolles and Stavrakaki (2015). These authors compared 10 children with DD (8–9 years old) to 10 children with SLI of the same age on various measures including reading skills (decoding and comprehension), listening comprehension, oral language expression as well as phonological reading-related skills (phonological awareness, non-word repetition, and rapid automatic naming). They found a predominance of reading problems in DD and, in contrast, difficulties in oral comprehension and expression in SLI. As for performance on non-word repetition, deficits were observed in both groups with a more severe impairment in SLI. Note that for the same phonological reading-related skills, Greek-speaking children with SLI were also more impaired as compared to DD (Talli, 2010; Talli et al., 2013). Similarly, a study in Italian by Guasti (2013) found that 79% of children with SLI obtained low scores (<1.5 SD) in non-word repetition, as compared to 51% of children with DD, both groups producing the same type of phonological transformations (essentially on consonant clusters).

These similarities have led various authors to debate the nature and extent of the overlap between DD and SLI. Mac Arthur, Hogben, Edwards, Heath and Mengler (2000) conducted a large-scale study evaluating oral and written language in samples of children with DD and SLI. Out of 110 children with DD, aged 7–13, 55% also presented impairment in oral language, and out of 102 children with SLI, aged 6–9, 51% displayed additional written language impairment. These results reveal a strong behavioural overlap between DD and SLI, with half the population studied meeting the criteria for the two diagnoses, a proportion also found by Ramus and colleagues (2013). In an epidemiological study, Catts, Adlof, Hogan and Weismer (2005) reported lower proportions of such double diagnoses, with 14–20% of SLI children who also have dyslexia and 17–35% of dyslexic children who also have SLI. In addition, these authors found that children with DD and those with a combination of DD and SLI obtained significantly lower scores in non-word repetition than children with SLI only, which contradicts previously mentioned results (such as those of Talli et al., 2013, 2015). Finally, Ramus et al. (2013) confirmed that SLI and DD do not always co-occur and that some children with SLI do not display a phonological deficit. Moreover, children with SLI do not necessarily encounter difficulties in word reading (Bishop, McDonald, Bird, & Hayiou-Thomas, 2009; Talli, Sprenger-Charolles, & Stavrakaki, 2016).

These different results have led researchers to propose different models attempting to explain the overlap between SLI and DD, while questioning the specificity of each of these disorders and considering the roles of (1) phonological disorders, (2) other language disorders and (3) cognitive factors. The three main models are presented below.

(1) The *severity model* (Kamhi & Catts, 1986; Tallal, 2003) considers DD and SLI as being two manifestations of the same underlying phonological processing deficit, differing only with respect to the severity of the phonological disorder. A lighter phonological disorder will give rise to reading difficulties alone, while a more pronounced phonological disorder will be accompanied by additional oral language difficulties (and thus SLI). Note that this model involves the notion of a continuum and as such does not predict the presence of SLI children without any word reading problems. However, some studies have demonstrated the existence of samples of children 'who read words accurately despite language impairment' (Bishop et al., 2009). This model also disregards the fact that some SLI children do not display severe phonological disorders. Indeed, Gerits and de Bree (2009: 191) revealed that only 50% of their SLI children (aged 4) had problems with speech sound categorization, 'which suggests that SLI cannot primarily be explained by an underlying speech perception deficit'.

(2) The *co-morbidity model* (Catts et al., 2005) assumes two distinct disorders with distinct origins, DD being caused by a phonological processing deficit and SLI by other cognitive deficits, which may co-occur. Phonological deficits would be closely associated with DD, but not necessarily with SLI when the latter occurs without co-morbid DD. This is reinforced by studies claiming that children with 'pure' SLI (without reading difficulties) show milder phonological disorders (Boada & Pennington, 2006; Catts et al., 2005) and would suggest that only SLI accompanied by DD shows significant phonological processing deficits (Ramus et al., 2013). When clear phonological disorders are displayed in individuals with SLI, sometimes identical to those found in DD (see Messaoud-Galusi & Marshall, 2010), these cases are accounted for in terms of co-morbidity, arguably frequent amongst DD and SLI (Pennington & Bishop, 2009). To sum up, this model predicts that phonological

disorders explain reading difficulties in DD children, but not the oral language difficulties encountered in individuals with SLI only.

(3) A third position, the *additional deficit model* (Bishop & Snowling, 2004), does not argue for varying degrees of an underlying phonological deficit (as does the severity model), nor for the specificity of phonological deficits to a DD diagnosis (along the lines of the co-morbidity model). Instead, this approach claims that children with SLI always display a phonological deficit, leading to DD, as well as an additional deficit, affecting other linguistic areas, such as syntax and lexicon. From this point of view, children who are impaired only in the phonological domain would have DD whereas children with more widespread deficits, in both phonological and crucially non-phonological domains as well, would be diagnosed with SLI. Thus, this model predicts the presence of reading problems, hence DD, across the board in SLI, due to phonological disorders, like the severity model, but it considers the source of other language disorders (displayed in SLI) as stemming from a domain outside of phonology. Regarding DD children also experiencing impairments beyond reading not amenable to a single phonological deficit, i.e. in the syntactic realm, this model would explain such cases in terms of under-diagnosis of SLI (Guasti, 2013).

These different models of overlap leave open the following questions: What exactly is the role of phonological deficits in these two disorders? More precisely, do these deficits contribute to the language impairment in SLI, as claimed by the severity model? Or do other factors play a role in the non-phonological disorders exhibited in SLI, as supported by the other two models? Amongst these factors, working memory appears to be a good candidate since deficits in complex working memory have already been linked to syntactic impairment in SLI (Delage & Frauenfelder submitted Delage, 2015; Durrleman & Delage, 2016; Montgomery & Evans, 2009). As for DD, what is the nature and extent of non-phonological language disorders? Are they similar to those found in SLI and possibly due to misdiagnosis? To sum up, more research is necessary so as to determine the grammatical deficit in (subgroups of) individuals with DD, how it may be similar to that found in SLI and whether or not syntactic development is related to phonological impairment or to working memory in both DD and SLI.

Goals of the current study

In order to answer these questions, we propose to evaluate both phonological and grammatical abilities, as well as verbal working memory, in children with DD and to compare their performance to that of SLI children. The first aim is to determine if a subgroup of DD children also meets the criteria for SLI (**Goal 1**), in which case this subgroup should display selective deficits on a non-phonological marker of SLI, such as the production of (third person) accusative clitic pronouns. Indeed, these grammatical items are now recognized as a clinical marker for SLI in various Romance languages (Arosio, Branchini, Barbieri, & Guasti, 2014; Avram, Sevcenco, & Stoicescu, 2013), including French (Hamann, Cronel-Ohayon, Dubé, Frauenfelder, Rizzi, Starke et al., 2003; Jakubowicz, Nash, Rigaut, & Gérard, 1998; Paradis, Crago, & Genesee, 2003; Parisse & Maillard, 2004) where persistent difficulties may be observed even at adolescence (Tuller, Delage, Monjauze, Piller, & Barthez, 2011). The literature on DD is void of studies exploring clitic production in French-speaking children with DD, although some studies have suggested that these clitics may indeed be a vulnerable domain in DD in other languages (see Avram et al., 2013; Zachou et al., 2013; Arosio et al., 2014; for Romanian, Greek and Italian). The current investigation will increase our understanding of the nature and extent of morphosyntactic weaknesses in DD by comparing clitic production in French-speaking children with this diagnosis to their peers with a diagnosis of SLI. If some children with DD present syntactic difficulties similar to those of SLI children, they should display impairment on this particular aspect of grammar.

Moreover, to be sure that phonological deficits do not account for potential difficulties on clitics, we will compare performance on the production of third-person accusative clitics to that of definite determiners (**Goal 2**). These two items display the same phonological form in French but have a different degree of complexity, with clitics being more complex. Indeed, while full lexical objects respect the canonical ordering of the language (1), the corresponding cliticized accusative pronouns do not and instead occur pre-verbally (2). Accusative clitic pronouns thus have to undergo what is referred to as 'syntactic movement', an operation that contributes to complicating their acquisition (see Cardinaletti & Starke, 1999). Such overt movement is absent for definite determiners (3), which are simply merged in their canonical position (see Figures 1 and 2, respectively, for definite determiners and accusative clitics).

(1) Jean voit **Marie**
'John sees Mary'
(2) Jean **la** voit
'John sees **her/it**'
(3) Jean voit **la** voiture
'John sees **the** car'

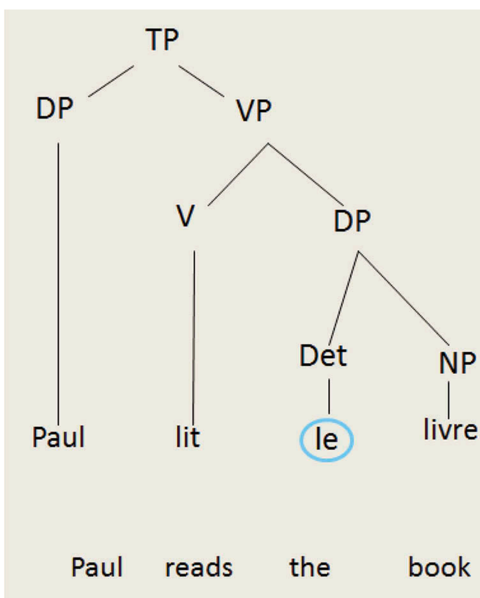

Figure 1. Definite determiner.

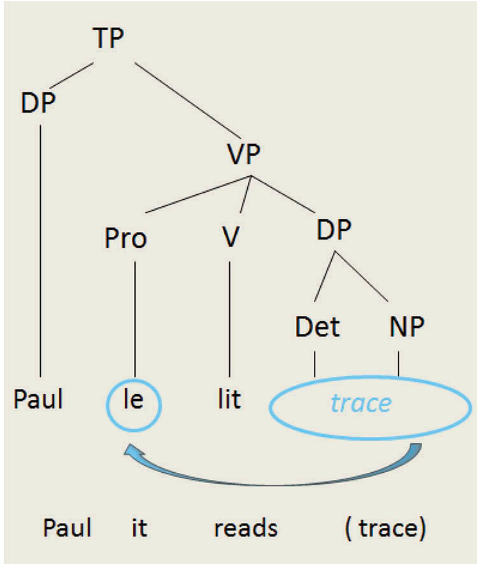

Figure 2. Accusative clitic with syntactic movement.

As a result, third-person accusative clitics such as in (2) emerge relatively late in typical development (Clark, 1985; Delage, Durrleman, & Frauenfelder, 2016; Hamann, Rizzi, & Frauenfelder, 1996; Jakubowicz & Rigaut, 2000). It isn't until around age 6 years that TD children approach ceiling production for these elements (Delage et al., 2016; Zesiger, Chillier-Zesiger, Arabatzi, Baranzini, Cronel-Ohayon, Franck et al., 2010). In contrast, homophonous definite determiners are mastered earlier in typical development, being systematically used at age 2;6 (Prevost, 2009).

It has been proposed that the underlying cause of the difficulty in the acquisition of clitics in young TD and older SLI is that of working memory limitations (Durrleman & Delage, 2016; Grüter, 2006; Jakubowicz, 2011). Clearly, clitic production involves not only phonological parsing but the storing and manipulating of verbal information, and working memory is thus plausibly involved as it is the system temporarily storing and manipulating information via the phonological loop, the central executive and the episodic buffer (Baddeley, 2007). By assessing clitics, homophonous but syntactically simpler articles, phonological and working memory in both SLI and DD, we will determine if syntactic difficulties in these clinical populations relate to a domain outside of phonology, namely working memory (**Goal 3**). Finally, our results on phonological difficulties, working memory and grammar should together shed light on the models previously presented (**Goal 4**), by allowing us to explore to what extent phonological difficulties are more particularly associated with DD (*co-morbidity model*) or SLI (*severity model*) and if a non-phonological deficit such as working memory underlies grammatical impairments (*additional deficit model*).

To sum up, recent work exploring syntax in DD has identified morphosyntactic deficits with some researchers claiming that subgroups with DD have syntactic profiles reminiscent of SLI. The question remains open if these are independent of phonological impairment. With our study, we further investigate the nature of syntactic impairment in DD, its parallelism with SLI and its potential relation to phonology and to working memory. We focus on the production of third-person accusative clitic pronouns in French-speaking children with DD compared to those with SLI. The aim is to contribute to elucidating the nature and extent of overlapping grammatical deficits in these conditions. If a subgroup of children with DD displays similar syntactic difficulties to children with SLI, we expect that the production of accusative clitics will pose a problem for these children, leading to avoidance of this element. If phonological disorders of individuals with DD directly explain their syntactic weaknesses, as suggested by the *severity model*, then we should also expect difficulties with homophonous grammatical items such as determiners as well as clear correlations between results on non-word repetition and syntax. On the other hand, if syntactic deficits cannot be explained by phonological disorders, as suggested by the two other models, and if syntactic complexity modulates performance of DD children, as has already been shown for SLI (Jakubowicz & Tuller, 2008), we predict a subgroup of children with DD to perform significantly worse on the production of third-person accusative clitics compared to the production of definite determiners. Finally, we explore to what extent deficits in phonological abilities as measured by non-word repetition are observable in our clinical groups, as already reported with this task for both SLI (Bishop, North, & Donlan, 1996; De Bree, Rispens, & Gerrits, 2007; Gathercole & Baddeley, 1990) and DD (Catts et al., 2005; Gathercole, Alloway, Willis, & Adams, 2006; Vender, 2011), and further examine to what extent these deficits, or rather deficits with working memory as measured by digit spans, relate to deficits with clitics. A relationship between non-word repetition and performance on clitics would support the *severity model* for which a severe phonological deficit explains grammatical deficits in SLI. On the other hand, a relationship between digit spans and clitics would rather support models of *additional deficit* and *co-morbidity* for which the explanation of syntactic deficits is outside the domain of phonology.

Methodology

Participants

Our participants included 21 individuals with DD aged 8–11 (M = 9;11, SD = 1;0), 21 individuals with SLI aged 7–15[2] with the same mean age (M = 9;10, SD = 2;10) and the same sex ratio, as well as age-matched control children (whose characteristics will be presented for each task). Clinical groups did not differ on non-verbal reasoning (p = 0.8) as measured by The Raven's Progressive Matrices (Raven, Styles, & Raven, 1998), which is a standardized intelligence test.[3] Note that some SLI data in this study have previously been reported in Durrleman and Delage (2016). Characteristics of the two clinical groups are presented in Table 1.

Participants with DD and SLI were diagnosed by speech and language therapists working in private offices in France or Switzerland and were recruited though these therapists, as well as though the 'Réseau Dys/10' in Lyon (France) which is a network specialized in

Table 1. Characteristics of participants with DD and SLI.

Group	*N*	Sex	Age range (year; month)	Age: *M* (SD) (year; month)
DD	21	14 M; 7 F	8;4–11;2	9;11 (0;11)
SLI	21	14 M; 7 F	7;2–15;9	9;10 (2;10)

DD: Developmental dyslexia; SLI: specific language impairment.

developmental disorders (such as SLI, dyslexia and autism). Inclusion criteria for these groups included an absence of intellectual retardation (checked with a score superior to the 10th percentile in the progressive matrices of Raven). For DD children, we also ensured that they demonstrated scores inferior to two standard deviations in a standardized task assessing text-reading speed (Alouette-R, Lefavrais, 2005). All participants were monolingual French-speaking or native bilinguals (the latter applying for three DD and four SLI).[4] Different control groups were recruited for the different experiments (for practical reasons). These TD children came from local French and Swiss schools and were matched to the clinical groups on chronological age. All these control children were native speakers of French. In order to be sure that they were indeed TD children, we only included children who had no diagnosis of any sort, who were faring well in typical classrooms, who did not present any particular language difficulty and thus had never received speech or language therapy. Approval for this study was obtained from the Ethics Committee of the Faculty of Psychology of the University of Geneva. Parents of participants provided informed, written consent for their children to participate in the research.

Procedure

All children were tested individually by one experimenter either in the child's home or in the office of their speech and language therapists. Experimental tasks were conducted to evaluate the production of first- and third-person accusative clitics (the latter being considered as a clinical marker of SLI) as well as the production of definite determiners (the latter being homophonous with clitics, but syntactically simpler). We also administered standardized tasks assessing general morphosyntax, phonological processing (non-word repetition), verbal working memory (forward and backward digit-span task) and non-verbal reasoning (Raven's Progressive Matrices). Note that, due to the non-normal distribution of the data (confirmed by the Shapiro–Wilk test), our analyses were conducted with non-parametric tests: ANOVA by ranks (Kruskal–Wallis tests) in order to reveal group effects, Mann–Whitney tests for inter-group comparisons and Wilcoxon tests for intra-group comparisons.

Tasks

Clitic pronoun production

In order to test production of first- and third-person accusative clitics (respectively called ACC1 and ACC3 from here on), we administered a shortened version of the clitic pronoun production task (Tuller et al., 2011). We adapted this task by removing items which require the production of reflexive clitics and by adding fillers in order to avoid that all items required clitics. The final task contains 16 test items preceded by 2 pre-test items and interspersed with 4 fillers which all require a structure with an intransitive verb (see Table 2). Appendix 1 provides the complete list of all target items. The experimenter elicited clitics by asking a

Table 2. Clitic pronouns elicited by the shortened version of the clitic pronoun production task.

2 pretest items		16 test items		4 fillers
1 × ACC1 me	1 × ACC3 la	8 × ACC1 **me**	8 × ACC3 4 masc. **le** 4 fem. **la**	All intransitive verbs Example: il nage—'he's swimming'

Table 3. Clitic pronoun production task: examples of stimuli.

ACC3	*Experimenter* Que fait le monsieur avec sa voiture? 'What's the man doing with his car?' *Expected response* Il **la** lave He her washes 'He's washing it'
ACC1	*Experimenter* Lui, il dit « Hé, Marie, que fait la vache? » Maintenant, toi, tu es Marie, qu'est-ce que tu réponds? '*He* says « Hey, Mary, what's the cow doing?' » 'Now, *you* are Mary, what do you answer?' *Expected response* Elle **me** lèche She me licks 'It's licking me'

question about a drawing appearing on a computer screen, as illustrated in Table 3 (for the two pre-test items).

Accusative clitics elicited in this task were always obligatory; their omission would thus lead to an ungrammatical response. Moreover, whenever the child answered with a structure other than the one expected (i.e. with a verb which does not require an accusative clitic), the experimenter asked the child to reformulate his/her answer by specifying the verb to use. Below is an illustration of how this was accomplished with an example such as that in (4), where the expected response is *Elle me lèche* ('It's licking me') and the child provided an utterance which does not require a clitic (4a) and is prompted to correct the utterance with the appropriate transitive verb (4b).

(4a) La vache est sympa
'The cow is nice'
(4b) Mais comment tu dirais avec lécher ?
'But how could you say it with "lick"?'

Production probe of definite determiners

Definite determiners were elicited with an adapted version of the task created in Italian by Zachou (2013). We adapted the initial task by reducing the number of items (by half) and translating the questions in French. The final task contains 16 test items preceded by 4 pre-test items and interspersed with 5 fillers which require an indefinite determiner. Three variables were manipulated: type of question (subject vs. object) as well as gender and number of the determiners (see Table 4). Appendix 2 provides the complete list of all target items.

The experimenter elicited determiners by asking a question about a drawing appearing on a computer screen, as illustrated in (5) for a singular masculine and in (6) for a feminine singular.

(5) Subject question
Qui regarde la poule? — 'Who is watching the chicken?'
Le loup. — '**The** wolf'
(6) Object question
Le renard regarde qui? — 'The fox is watching who?'
La poule — '**The** chicken'

Table 4. Definite determiners elicited by the adapted version of the task created by Zachou.

	4 pretest items		16 test items			5 fillers
	Singular feminine 'la'	Plural 'les'	Singular masculine 'le'	Singular feminine 'la'	Plural 'les'	Indefinite determiners 'un, une, des'
Subject question	1	1	2	2	4	5
Object question	1	1	2	2	4	

Standardized assessment of expressive grammar

Expressive grammar was assessed using a computerized, sentence completion task called the Bilan Informatisé de Langage Oral 3C (Khomsi, Khomsi, Parbeau-Guéno, & Pasquet, 2007). Different morphosyntactic features were evaluated by this task, such as verbal and nominal inflections, spatial prepositions or passives. As in (7), illustrated in Appendix 3, the child hears an utterance corresponding to a first picture and then has to complete this with a second utterance corresponding to a second picture. Each item is scored 0, 1 or 2 depending on the child's performance and the item's complexity. This test is standardized with children of a large age range, from 5 to 15 years old. The maximum score is 36.

(7) Ici, le garçon est debout; là, la fille… → **est assise**
'Here, the boy is sitting; there, the girl… → **is sitting**'

Non-word repetition

We used an abbreviated version of the non-word repetition BELEC task (Mousty, Leybaert, Alegria, Content, & Morais, 1994), from which we had removed the series of less (phonologically) complex non-words (i.e. those with consonant–vowel structures). Children had to repeat 20 (pre-recorded) non-words, all phonologically complex (with consonant–vowel–consonant structures), organized in five series increasing in length (1–5 syllables, such as *bli, plubro, kragrinblan, fleublifrouklébro*). The task was stopped when children missed three correct repetitions within one series (i.e. within one level of length). The final score was the total number of correctly repeated syllables.

Digit-span tasks

Verbal working memory was assessed through a standardized digit-span task taken from the Wechsler Intelligence Scale for Children (WISC-IV, Wechsler et al., 2003). The task consisted of orally presenting a series of digits increasing in length from 2 to 9, which then had to be repeated by participants either in the same order (giving rise to the forward digit span) or in the reversed order (giving rise to the backward digit span). The length of the longest list participants can remember is their overall digit span. The task was stopped when children missed 2 out of 2 trials within one level.

Results

Table 5 presents the global results of children with DD and SLI as well as those of control children of the same age on the different tasks we used. Main inter-group differences were also noted. These statistical results are detailed in the next sections, presented task by task.

Table 5. Global results for DD, SLI and control groups.

		DD group	SLI group	Control groups (CTRL)	*Inter-group differences*
	% ACC1	**97.1%** (9)	**92.9%** (23)	**98.2%** (6)	Ø
Clitic pronoun production (%)	*% ACC3*	**72.6%** (21)	**60.1%** (32)	**88.5%** (11)	*DD < CTRL*** *SLI < CTRL***
Definite determiners production (%)		**97.9%** (5)	**94%** (10)	**96.3%** (8)	Ø
Standardized assessment of expressive grammar (mean SD)		**−1.4 SD** (1.7)	**−2.2 SD** (1.8)		
Non-word repetition (N correctly repeated syllables)		**36** (6)	**22** (7)	**44** (6)	*DD < CTRL**** *SLI < CTRL**** *SLI < DD****
Digit-span tasks	*Forward digit span*	**7.2** (2)	**5.6** (2)	**8** (2)	*SLI < CTRL**** *SLI < DD***
	Backward digit span	**6.3** (1)	**4.9** (1)	**6.9** (2)	*SLI < CTRL**** *SLI < DD****

All the main results is in bold.
** : p <.01; *** : p <.001

Clitic pronoun production

ANOVA by ranks (Kruskal–Wallis tests) revealed a group effect for third-person accusative clitics 'ACC3' ($H(2, 70) = 12.8$, $p = 0.002$) but not for first-person accusative clitics 'ACC1' ($p = 0.88$). More precisely, results obtained by each clinical population in producing ACC3 display clear deficits on this clinical marker (of SLI) since performance of both DD and SLI groups differed from that of control participants of the same age[5] ($N = 28$, age range = 7;9–11;9, $M = 9;7$) who showed significantly better performance (controls > DD: $U = 162.5$, $p = 0.006$; controls > SLI: $U = 141.5$, $p = 0.002$). On the other hand, performance of DD and SLI did not significantly differ for this item ($p = 0.3$) even though performance is visibly lower in the SLI group. Results are different for ACC1 for which there was no significant difference between groups (p values between 0.7 and 0.9).

Notice that the production rates for ACC3 only concern items that were entirely correct, without any gender errors. If we now want to determine whether rates are statistically different for ACC1 and for ACC3 for each population, we have to take into account the production rate of ACC3 including gender errors because ACC1 is neutralized for gender, i.e. it implies the same form regardless of the gender of the referent and thus cannot be confusing for children in this respect. Therefore, we compared, via Wilcoxon tests, production rates of ACC1 and of ACC3 with gender errors. This comparison is not relevant ($p = 0.13$) for the control group since these children performed at ceiling levels for the two variables (98% for ACC1, 95% for ACC3).[6] On the other hand, ACC1 was produced more than ACC3 by the DD and the SLI groups ($T = 1.5$, $p = 0.002$ and $T = 8$, $p = 0.005$, respectively). Figure 3 illustrates these different results.

Concerning unexpected answers produced by the two clinical groups instead of ACC3, Table 6 presents their number and respective rates. The groups displayed the same patterns since they tended to produce a DP (8, 10) rather than produce an objectless sentence (9). Gender errors were also produced by both groups at equal rates, as illustrated in (11).

(8) Experimenter: Que fait le médecin avec le bébé. 'What is the doctor doing with the baby?'

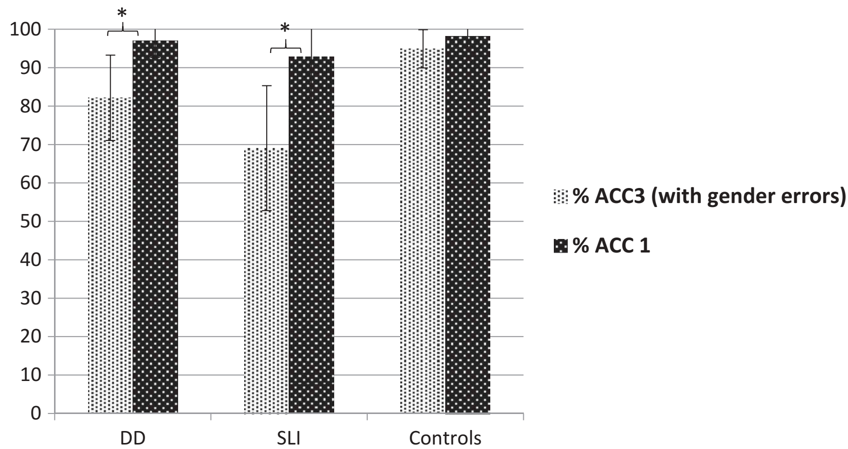

Figure 3. Rates of production of ACC3 (including gender errors) and ACC1 in each group.

Table 6. Unexpected answers produced instead of ACC3.

	Unexpected answers	DD group	SLI group
ACC3	***N* total**	**46**	**75**
	Omissions	13 (28%)	17 (23%)
	DP production	18 (39%)	29 (39%)
	Gender errors	13 (28%)	19 (25%)
	Reflexive clitics	2 (4%)	2 (3%)
	Others (inappropriate and non-response)	0	8 (11%)

Expected answer: il le pèse. 'He is weighing him'
DD (10; 11): il pèse le bébé. 'He is weighing the baby'
(9) Experimenter: Que fait Thomas avec l'argent? 'What is doing Thomas with money?'
Expected answer: il le cache 'He is hiding it [+masc]'
DD (8; 10): il cache 'He hide'
(10) SLI (5; 10): il cache l'argent 'He is hiding money'
(11) SLI (9; 8): il la cache 'He is hiding it [+fem]'

Production probe of definite determiners

The two clinical groups were compared to 32 control children aged 7;2 to 12;1 (*M* = 9;9).[7] ANOVA by ranks (Kruskal–Wallis tests) revealed no group effect for the total amount of definite determiners ($p = 0.13$). In addition, no group effect was observed specifically for masculine ($p = 0.80$) or feminine ($p = 0.59$) or plural ($p = 0.06$). Figure 4 indeed illustrates the high production rates (all superior to 93%) demonstrated by the three groups for these determiners.

Standardized assessment of expressive grammar

Standard deviations obtained by the DD group show a mean score of −1.4 (SD = 1.7), which did not significantly differ from that of the SLI group (*M* = −2.2, SD = 1.8, $p = 0.14$). This could be explained by the large inter-subject variability in performance

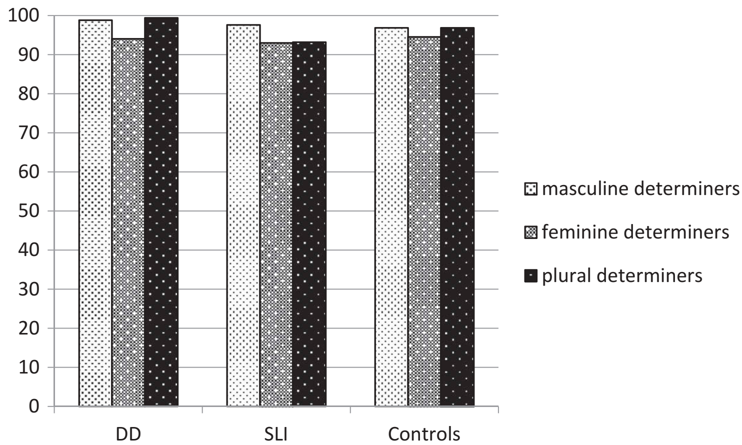

Figure 4. Rates of production of masculine, feminine and plural definite determiners in each group.

of the two groups with scores ranging from −5.1 to 1.7 SD in the DD group and from −6.8 to −0.1 SD in the SLI group (see Table 7 for individual results). More specifically, it is interesting to note that eight participants with DD obtained a score superior to −1 SD, which is also the case for 5 participants with SLI.[8]

Non-word repetition

ANOVA by ranks revealed a strong group effect for the score of correctly repeated syllables (H (2, 80) = 50.18, $p < 0.001$). Both participants with DD and SLI show lower performance than that of controls of the same mean age ($N = 38$, age range = 6;2–12;9, $M = 9;10$,[9] controls > DD:

Table 7. Individual results (SD) for the standardized assessment of expressive grammar (BILO-3C).

DD children		SLI children	
Age	Expressive grammar (SD)	Age	Expressive grammar (SD)
8;4	−2.67	7;0	−1.34
8;6	−3.92	7;0	−1.47
8;10	−4.33	7;2	−1.97
9;0	−1.19	7;4	−1.47
9;0	−2.67	7;4	−2.05
9;1	0.25	7;6	−0.59
9;2	0.25	7;9	−1.76
9;5	−5.06	8;2	−5.17
9;10	−2.48	8;6	−0.17
9;11	−1.52	8;10	−6.83
9;11	−1.5	9;4	−3.12
10;0	1.71	9;6	−4.33
10;1	−1.19	9;7	−4.74
10;7	−1.6	9;9	−2.16
10;7	−0.51	10;1	−3.13
10;10	0.57	10;3	−0.78
10;11	−1.33	12;1	−1.74
10;11	0.57	12;10	−1.3
11;0	−2.13	14;11	−1.56
11;2	0.03	15;9	−0.3
11;2	−0.3	15;9	−0.1

$U = 152.5$, $p < 0.001$; controls > SLI: $U = 7$, $p < 0.001$). If we then look at performance across groups, it appears that the SLI group displays the most pronounced deficit since these children performed behind the group with DD ($U = 29.5$, $p < 0.001$).

Digit-span tasks

ANOVA by ranks also showed group effects for both forward ($H(2,80) = 19.9$, $p < 0.001$) and backward digit spans ($H(2,80) = 17.4$, $p < 0.001$), but in fact only the SLI group displays poor performance in these working memory tasks. Indeed, the group with SLI obtained scores lower than those of controls[10] and of DD children in forward digit span (SLI < controls: $U = 134$, $p < 0.001$; SLI < DD: $U = 104$, $p = 0.003$) as well as in backward digit span (SLI < controls: $U = 162$, $p < 0.001$; SLI < DD: $U = 91$, $p < 0.001$). On the other hand, performance of the DD group did not significantly differ from that of control children for these two tasks ($p = 0.1$ and $p = 0.3$).

Subgroups

Group performance must be interpreted with caution, because upon closer inspection, a significant subgroup of children with DD showed relatively intact grammatical skills. Indeed, a subgroup of 10 children with DD (i.e. nearly half of the group) obtained scores within the norm for their age on the standardized assessment of expressive grammar (>−1.5 SD), associated with ACC3 production rates equal or superior to 75%, corresponding to SD > −1.5 (standard deviations were calculated as compared to control children). The other children had low performance (<−1.5 SD) on at least one of the two syntactic scores. Table 8 presents individual results of children with DD, with low performance in bold.

Performance on the group with normal scores did not statistically differ from control children on ACC3 (87.5% for this subgroup of DD vs. 88.5% for controls, $p = 0.8$) and outperformed SLI for both ACC3 ($U = 53$, $p = 0.03$) and standardized assessment of grammar ($U = 34.5$, $p = 0.002$). When this subgroup is compared to the other 11 participants with DD, the two subgroups do not differ on nonverbal reasoning ($p = 0.8$), age ($p = 0.4$), performance on non-word repetition or digit span (with p values between 0.2 and 0.7) or scores on accuracy and speed of reading, assessed by the Alouette-R test (Lefavrais, 2005) ($p = 0.3$ and 0.8). Native bilingualism and gender do not appear to influence performance of these two groups either, given that the 'normal' group included 1/10 bilingual child and 7/10 boys and the impaired group 2/11 bilinguals and 7/11 boys.

Links with phonology and working memory

One aim of our work was to explore links between phonological processing, working memory and syntax in children with DD and SLI. In order to accomplish that, we ran correlations between these different components. Since non-verbal reasoning may obscure the results of these analyses, we controlled for the effect of non-verbal reasoning by means of partial Pearson's correlations. Different correlations emerged in both groups. For the DD group, one correlation was found between general expressive grammar (BILO-3C) and non-word repetition ($r = 0.45$, $p = 0.04$). In the SLI group, no correlations emerged with non-word repetition and the only correlation found was between production of third-person accusative clitics (ACC3) and backward digit span ($r = 0.51$, $p = 0.02$).

Table 8. Individual results (SD) of DD children for non-word repetition, expressive grammar (BILO-3C), ACC3 production and digit spans.

Age	Non-word repetition	Expressive grammar	ACC3 production	Forward digit span	Backward digit span
8;4	−0.50	**−2.67**	−1.23	−0.1	0.0
8;6	−1.19	**−3.92**	**−2.36**	−1.4	−1.4
8;10	**−4.12**	**−4.33**	**−5.77**	−1.4	−1.0
9;0	**−2.40**	−1.19	−0.09	−1.4	−1.0
9;0	**−1.53**	**−2.67**	1.05	−1.1	−1.0
9;1	**−2.05**	0.25	−1.23	−1.1	−0.5
9;2	−0.33	0.25	−0.09	−0.1	−0.5
9;5	**−1.53**	**−5.06**	**−2.36**	0.5	−0.5
9;10	**−1.71**	**−2.48**	**−2.36**	−1.1	−0.5
9;11	**−2.57**	**−1.52**	−0.09	−0.1	−0.5
9;11	**−1.71**	**−1.5**	**−4.64**	−0.1	0.9
10;0	−0.67	1.71	−1.23	−0.6	−0.5
10;1	0.53	−1.19	−0.09	1.0	−0.5
10;7	−0.16	**−1.6**	−0.09	1.5	0.4
10;7	−1.19	−0.51	−0.09	1.0	−0.5
10;10	0.36	0.57	**−2.36**	−1.1	0.0
10;11	**−1.53**	**−1.33**	**−3.50**	−0.1	0.4
10;11	−0.33	0.57	**−3.50**	−1.1	0.0
11;0	−1.02	**−2.13**	**−2.36**	−0.6	−0.5
11;2	−1.36	0.03	1.05	−1.1	0.0
11;2	−1.36	−0.3	1.05	−0.6	−0.5

Bold: performance < 1.5 SD.
Red: children with deficits in both phonology and syntax (in one or two of the syntactic tasks).
Green: children with deficits only in syntax (in one or two of the syntactic tasks), but not in phonology.

In DD children, we wanted to be particularly attentive to the potential link between syntax and phonological processing. Results reported above seem to indicate a slight link with general grammatical performance. In order to investigate this further, we decided to take a specific look at the performance of DD children in the non-word repetition task. We then considered their individual results compared to those of control children. We calculated standard deviations as compared to control children and identified a subgroup of nine DD children with low performance, inferior to 1.5 SD. When we compared performance of these children to those of the other children, on all our measures of syntax as well as on measures of working memory (digit spans), no difference emerged. Table 8 presents individual results for all these tasks; they illustrate that low performance in non-word repetition (in bold) does not systematically co-occur with low performance in syntax. Indeed, we identified not only seven children who displayed deficits in both domains (in red) but also six children with deficits only in syntax (in green). We also added results for digit spans showing the absence of pathological scores on these tasks.

Discussion

Our study had four main goals: (1) to investigate the nature and the extent of grammatical deficits in children with DD and if they are similar to those of children with SLI, (2) to determine if grammatical deficits in these clinical populations are the result of phonological impairments, (3) to explore whether grammatical deficits relate to another deficit to phonology, namely working memory, and (4) to assess how these combined results shed light on the models put forth to explain the overlap between SLI and DD.

Goals 1 and 2: determining if a subgroup of DD children meet the criteria for SLI, and if their grammatical deficits relate to their phonological impairments

We will first consider global results before turning our attention to those of subgroups. Regarding results on clitics and determiners, difficulties with third-person accusative clitics are attested in the group of children with DD, who on the whole score similarly to children with SLI and significantly below control children. The overall language profile of children with DD is further reminiscent of that of children with SLI in their accurate performance on definite determiners, which are homophonous with third-person accusative clitics. In light of this, the grammatical difficulties attested in children with DD, just as in SLI, cannot be solely attributed to their phonological challenges. If this were the case, we would expect the same pattern of performance across ACC3 and definite determiners. Instead, increased morphosyntactic complexity associated with ACC3 renders this element an excellent marker for specific difficulties in the realm of grammar, explaining why it is vulnerable also in children with SLI (Jakubowicz et al., 1998), in children with moderate-to-severe hearing loss (Jakubowicz, Tuller, Rigaut, 2000; Tuller & Delage, 2014), as well as in children with ASD (Durrleman & Delage, 2016; Terzi, Marinis, Kotsopoulou, & Francis, 2014). Moreover, difficulties in ACC3 in children with DD do not carry over to ACC1, as attested by their ceiling performance with this latter element, which parallels that in SLI. Again, the level of morphosyntactic complexity selectively associated with ACC3 can explain this asymmetric performance, given that the type of movement involved in ACC3 as well as its gender marking is not associated with the simpler ACC1 (Delage et al., 2016; Tuller et al., 2011). Children with DD are thus clearly sensitive to grammatical complexity. Finally, the error patterns observed in DD when ACC3 is elicited, in particular the predominance of lexical DPs, as well as omissions and gender errors, strike a clear parallelism between DD and SLI groups.

Therefore, we have shown that children with DD display difficulties on ACC3 production, which is a subtle clinical marker of syntactic impairment (Paradis et al., 2003; Tuller et al., 2011). However, their difficulties emerge not only with this marker but also with standardised tasks assessing grammar which are used by speech and language pathologists. This was clearly revealed on one such task used in this study, the BILO 3C, where DD children scored on average −1.4 standard deviations, an average which was not significantly different from that of children with SLI. Specifically in the DD group, general grammatical abilities related to phonological abilities as assessed by non-word repetition. Beyond group results, we further observe that some children with DD, on an individual level, show striking deviations from the norm: Recall that seven children with DD obtain scores inferior to 2 standard deviations from the mean, oscillating in some instances to −4 and −5 standard deviations, scores also obtained by those participants with SLI with the most marked syntactic deficits (see Table 7).

Goal 3: exploring whether grammatical deficits with clitics relate to working memory

We have thus confirmed that a non-negligible proportion of children with DD are particularly affected in grammar, with low performance on both ACC3 production and expressive grammar. Could this subgroup in fact be children with undetected SLI? In this case, we would expect them to show specific deficits not only in morphosyntax but also in working memory, as measured by digit-span tasks, and as has already been elucidated for SLI (Archibald & Gathercole, 2006; Montgomery & Evans, 2009; a.o.). However, when children of this subgroup with DD and marked grammatical difficulties are compared to the other children with DD, they do not specifically differ on forward or backward digit spans. Moreover, working memory difficulties are not revealed across all assessments, as the performance on digit-span tasks of children with DD was on a par with control children. In contrast, children with SLI perform significantly below those with DD on digit spans, underscoring a difference between these clinical profiles regarding verbal working memory.

The relevance of working memory for syntax has been highlighted by an increasing body of work identifying links between these components in instances of delayed and impaired language development, in SLI (Montgomery & Evans, 2009; Montgomery et al., 2010; Frizelle & Fletcher, 2015; Delage & Frauenfelder, submitted and in ASD (Durrleman & Delage, 2016; Schuh & Eigsti, 2012). With syntactically complex items such as accusative clitics, the computational system must maintain in memory morphosyntactic information such as gender and number while linking this information to two positions, namely the preverbal position where the clitic surfaces, and the canonical, post-verbal position where it is first merged. Limited memory resources would affect this cognitive manipulation (Delage et al., 2016; Durrleman & Delage, 2016; Tuller et al., 2011). As expected by this view, links between complex working memory (backward digit span) and ACC3 clearly emerge in our SLI group yet are absent in the DD group. This finding underscores the role of ACC3 as a subtle marker of deficits and delays in language development even in groups without working memory difficulties (see e.g. studies on bilingual children revealing problems with ACC3, Grüter, 2005; Pérez-Leroux, Cuza, & Thomas, 2011; Tuller et al., 2014; a population without working memory delays and with some working memory advantages, Calvo, Ibáñez & Garcia, 2016). This finding also highlights the fact that DD and SLI appear to differ regarding the source of their syntactic difficulties. Further research is needed to elucidate the underlying cause of the challenges in complex grammar that may emerge in DD and in other groups displaying ACC3 delays in the absence of working memory impairments.

One possibility which comes to mind is that difficulties in reading associated with DD may have cascading effects on their syntax. Indeed, it has been proven that lack of exposure to written text would have repercussions on IQ and vocabulary (with the well-known Matthew effects defined by Stanovich, 1986), so pursuing this line of thought, could syntax also be affected? It does seem plausible that children with DD who are most impaired for reading would be those least likely to be exposed to complex syntactic structures which are more frequently conveyed in writing. Despite these considerations, various observations suggest that the grammatical difficulties attested in DD cannot be clearly attributable to their reading impairment. First, accusative clitic pronouns are very frequent in spoken Romance languages (Varlokosta, Belletti, Costa, Friedmann, Gavarró, Grohmann et al., 2016). Second, while the standardized test of morphosyntax indeed contains certain constructions which are more often found in written than oral language (such as sentences involving double clitic sequences[11] and passivization[12]), the subgroup of children with DD and marked syntactic difficulties does not differ from the other DD children regarding their speed and precision of reading, nor regarding their IQ.

In sum, over half of the group with DD (11/21) present scores which are indicative of syntactic deficits, characterized by performance inferior to −1.5 SD for the standardized assessment of expressive grammar, combined with a rate of ACC3 production equal or inferior to 62.5%. Thus, 53% of the participants with DD face real challenges in oral language, a proportion very similar to the 50–55% previously reported by Mac Arthur et al. (2000) and Ramus et al. (2013). However, the source of syntactic weaknesses attested in this population remains to be determined, in light of the observed dissociations between their syntactic scores and their working memory, reading and IQ scores.

Goal 4: assessing the explanatory adequacy of the severity, co-morbid and additional deficit models

Here, we briefly recapitulate our global findings in light of the different models tapping into the overlap between SLI and DD and explain how our findings argue for or against these models. First, recall that the **severity model** postulates that the two conditions are two manifestations of the same underlying phonological processing deficit, differing only with respect to the severity of this phonological disorder. This approach seems at first sight to be coherent with our data, given that our population with DD is always situated in an intermediate position between TD and SLI children, in particular for performance on non-word repetition.[13] However, this model does not predict the two subgroups of children with DD which emerged here, one with impaired syntax and the other with preserved syntax, subgroups which are not distinguishable by their phonological profiles. In this same vein, if grammatical difficulties were clearly linked to phonological difficulties, we should have identified (a) deficits for both ACC3 and homophonous definite determiners and (b) correlations between the task of non-word repetition and syntactic tasks. For neither clinical group did we observe difficulties with homophonous definite determiners nor did we obtain a correlation between non-word repetition and ACC3 production, and the link emerging between non-word repetition and general grammatical abilities was only attested in DD. Consequently, the current results do not support the severity model. Second, the **co-morbidity model** assumes two distinct disorders with distinct origins and would explain a subgroup with DD and syntactic difficulty in terms of high co-morbidity between DD and SLI. As such, it postulates the existence of 'pure SLI' children, without phonological or reading difficulties. If we closely inspect performance by the SLI group on non-word repetition and convert their results on this task into z scores (compared to the 38 age-matched control children), we can see that all children with SLI, without exception, show low scores between −1.4 and −6.4 SD (M = −3.8) and thus clearly display impairment in this area. This result replicates that of De Bree et al. (2007) who found that all their preschool SLI children (M age = 4;5) scored significantly below the mean of age-matched controls on non-word repetition. To complete the puzzle, we would ideally like to have reading measures for our SLI group, which we recognize is a limitation of the current study, but already the generalized deficit in non-word repetition in our SLI sample does not uphold this model. Finally, the **additional deficit model** claims that DD and SLI are both associated with a phonological deficit, but that there is a supplementary (cognitive) impairment in SLI which leads to additional deficits in syntax and lexicon. Our findings confirmed phonological difficulties across both populations, as predicted by this model. Moreover, as highlighted by much psycholinguistic research

(Montgomery & Evans, 2009; Montgomery et al., 2010; Frizelle & Fletcher, 2015; Durrleman & Delage, 2016; & Frauenfelder, submitted), limitations in working memory in SLI explain much of their syntactic immaturity as links emerged between ACC3 production and working memory (as measured by backward digit span) in the group of participants with SLI. However, the subgroup of participants with DD who showed deficits in syntax and who, according to this model, would be undiagnosed children with SLI do not show any relation between their syntactic and working memory scores, which is unexpected according to this model. In sum, none of the three models previously proposed adequately accounts for the current findings, which suggest that difficulties in grammar arising in DD may stem from another source to that of grammatical impairments in SLI. Global morphosyntactic weaknesses relate to weaknesses in phonological memory as measured by non-word repetition specifically in the DD group; however, it is as yet unclear what might cause specific difficulties in the area of complex grammar, such as indicated by deficits with third person accusative clitics.

Conclusion

In closing, grammatical difficulties emerged in over half of our participants with DD, as detected by a standardized assessment of morphosyntax, as well as by deficits with ACC3, a clinical marker of SLI. The predominant difficulty with grammar in DD may be the result of SLI under-identification in this population, as already proposed by Arosio et al. (2016). However, our findings also show a divergent pattern regarding weaknesses in phonology and working memory between DD and SLI children, as well as how these relate to grammar, which casts doubt on this being the entire story. Our results confirmed that phonological memory skills are affected in DD children, while both verbal and phonological working memory skills are affected in SLI. In line with a growing body of work, the current study also highlighted a significant relation between complex working memory and syntactically complex ACC3 in SLI. The DD group, in contrast, did not show any such link, while a link did emerge between non-word repetition and general morphosyntax in this group. In light of this, it appears that the underlying difficulty hypothesized to trigger (global and specific) grammatical deficits may differ between these populations. Alternatively, the lack of correlation between ACC3 and working memory in the DD group could be the result of a limitation of the current study. For example, the age range was more extended in the group with SLI (7–15 years) than in the one with DD (8–11 years). Moreover the more homogenous ages of the DD participants also possibly interfered with the amount of variability in working memory and diminished chances of identifying the relation between complex working memory and syntax. Future research, including larger groups of a more tightly similar age range, should attempt to determine if a comparable link between working memory and syntax between DD and SLI can be identified and, if not, to shed light on what could be specifically impacting grammatical development in DD.

Another limitation of the current study relating to age range distinctions is that the population with SLI included five adolescents aged between 12 and 15 years who clearly confirmed the persistence of grammatical deficits, in particular with ACC3 production, along the lines of previous reports (Tuller et al., 2011). As children of the same age were absent from the DD sample, we are not in a position to ascertain if grammatical delays in this population show the same degree of persistence or if delays disappear by adolescence. Future work should also seek to elucidate the evolution of syntactic performance in DD.

As for the clinical implications of the current study, it seems crucial that speech and language pathologists remain attentive to the possibility that children with DD present deficits in morphosyntax. Indeed, as DD is classically associated with difficulties in written text, challenges in the realm of oral language may go undetected and consequently could impact their academic performance. Thus, more careful attention to diagnosing and treating grammatical morphosyntactic deficits in DD is of utmost importance.

Notes

1. Memory loads were manipulated by presenting the sentences after or before the pictures to select, the last case being intended to increase working memory demand.
2. We chose to include adolescents in the SLI group since we know that they may display persistent difficulties in both working memory and accusative clitic production (Montgomery, Magimairaj, & Finney, 2010; Tuller et al., 2011).
3. The particularity of this measure is that it is essentially non-verbal, including 36 items focusing on visual problem solving.
4. It is worth noting that there were no statistical differences between the monolingual and bilingual children for performance on accusative clitics (p = 0.4 for DD; p = 0.3 for SLI), definite determiners (p = 0.2 for DD; p = 0.9 for SLI), non-word repetition (p = 0.7 for DD; p = 0.2 for SLI) or digit-span tasks (p = 0.5 and 0.9 for DD; p = 0.5 and 0.9 for SLI).
5. We ensured that these controls did not differ from our clinical groups for chronological age (p = 0.4 for DD and p = 0.7 for SLI).
6. Note that the difference between ACC1 and ACC3, in favour of ACC1, has been shown in younger typically developing children, aged 4–6, by Tuller and collaborators (2011) and Delage et al. (2016).
7. We ensured that these controls did not differ from our clinical groups for chronological age (p = 0.6 for DD and p = 0.2 for SLI).
8. This result can seem unexpected but a series of observations may be relevant here. First, we only included participants for which speech and language therapists had confirmed expressive language disorders, as assessed by French standardized tests. Second, all participants with SLI had a level of language difficulty that continued to justify their being included in remediation programs, which is where they were recruited. Third, the 'BILO' standardized test comprises items which are very frequently used by speech therapists during their language evaluations and remediation programs. Due to this, participants with SLI may have received a little 'training' on these items, thus boosting their performance. However, amongst the five participants with SLI who managed to perform well on the BILO, two present difficulties on ACC3 production (with scores <2 SD compared to age-matched controls) and the other three display severe phonological disorders (with SD between −4 and −5 on non-word repetition).
9. We ensured that these controls did not differ from our clinical groups for chronological age (p = 0.9 for DD and p = 0.7 for SLI).
10. Our clinical groups were compared to the same control children as in the previous section (N = 38, Age range = 6;2–12;9, M = 9;10).
11. Ex: *Il les lui donne*: 'He is giving them to him/her'.
12. Ex: *Il est poussé par la fille*: 'He is pushed by the girl'.
13. This is in line with other reports claiming that the phonological deficit associated with DD is milder than that attested in children with SLI (Guasti, 2013; Talli, 2010).

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Declaration of interest

The authors report no declaration of interest.

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Appendix 1. List of target items for the shortened version of the clitic pronoun production task

ACC1	
Il me lèche	'He is licking me'
Elle me mord	'He is biting me'
Elle me lèche	'She is licking me'
Elle m'éclabousse	'She is splashing me'
Il m'écrase	'He is crushing me'
Il me pique	'He is biting me'
Il me poursuit	'He is chasing me'
Elle me pique	'She is stinging me'
ACC3	
Il le pèse	'He is weighing him'
Elle la regarde	'She is looking at her'
Il la coiffe	'He is combing her (hair)'
Il la réveille	'He is waking her (up)'
Elle le coupe	'She is cutting it'
Elle le lave	'She is washing him'
Il le cache	'He is hiding it'
Elle la maquille	'She is making her up'

Appendix 2. List of target items for the production probe of definite determiners

Les moutons	Sheep
Le loup	The wolf
Une fleur	A flower
Le chien	The dog
La vache	The cow
Les lapins	Rabbits
Des fraises	Strawberries
La poule	The chicken
Les moutons	Sheep
Les tortues	Turtles
Une poupée	A doll
Les grenouilles	Frogs
La poule	The chicken
Les lapins	Rabbits
Une danseuse	A dancer
Le loup	The wolf
La vache	The cow
Le chien	The dog
La panthère rose	The pink panther
Les tortures	Turtles
Les grenouilles	Frogs

Appendix 3. Illustration taken from the BILO-3C (Khomsi et al., 2007)

Ici, le garçon est debout; là, la fille… → **est assise**
'Here, the boy is sitting; there, the girl… → **is sitting**'