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Past-tense inflection of non-verbs: a potential clinical marker of developmental language disorder in Swedish children

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ABSTRACT

Aim: In this paper, we explore the performance of past-tense inflection of non-verbs (NVI) in children with developmental language disorder (DLD) and in typically developing controls, to investigate its accuracy as a clinical marker for Swedish-speaking children with DLD. Further, we investigate the relationship between NVI, nonword-repetition, and family history.

Methods: The sample consists of 36 children with DLD (mean age 9;5 years) and 60 controls (mean age 9;2 years).

Results: The DLD group performed significantly lower than the controls on the NVI task, with a large effect size of the difference ($d = 1.52$). Analysis of the clinical accuracy of NVI resulted in 80.6% sensitivity and 76.6% specificity. NVI was significantly and moderately associated with nonword-repetition in the controls, but not in the DLD group. A positive family history, 80.6% in the DLD group and 6.9% in the controls, was associated with lower performance on NVI. When controlling for group (DLD and controls), a non-significant association between family history and performance on the NVI task was found.

Conclusions: NVI is a potential clinical marker of DLD in Swedish school-aged children, but the current NVI task does not reach the level of being acceptable. Further development of the NVI task is warranted to improve its accuracy.

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Developmental language disorder; clinical marker; past tense inflection; nonword repetition; family history

Background

The focus of this paper is on past-tense inflection as a clinical marker for developmental language disorder (DLD) in Swedish school-aged children. Individuals with DLD experience deficient language development in the absence of other clinical explanations, e.g. acquired brain injury or hearing impairment, and without any general developmental delays. DLD, previously labelled specific language impairment [1], is characterized by deficits in aspects of language production, comprehension, and communication. Similar to other neurodevelopmental disorders, a strong genetic component underlies the aetiology of DLD [2–6]. For some children, speech, language, and communication deficits are parts of conditions such as autism spectrum disorder, Down syndrome, or intellectual disability. Here, following a consensus agreement on terminology [7], we use the term DLD when referring to children with developmental language problems that do not co-occur with autism spectrum disorder, hearing impairment, or intellectual disability.

Identifying clinical markers is of importance for the correct identification of a condition [8]. A clinical marker is a measurable deficit characterizing a disorder or a condition [9]. It should reliably distinguish between those individuals who have the condition in question and those who do not. For DLD, mainly three potential clinical markers have been evaluated: nonword repetition (NWR), sentence recall, and past-tense inflection. Most studies of clinical markers in DLD are based on English-speaking populations, with the majority focusing on NWR [see e.g. 10–13]. It is, however, crucial that evaluations of clinical markers of DLD are performed for each language, as the measures suggested as clinical makers are all language-dependent. For example, research on bilingual children indicates that performance on NWR is influenced by both the phonotactic structure of the target language as well as by the child's familiarity with the language [14,15]. Moreover, the rather large variation in sensitivity (i.e. the percentage of those who have the condition in question correctly identified as such by the marker) and specificity (i.e. the percentage of those without the condition in question correctly identified as such by the marker) of a potential clinical marker can be attributed to methodological differences such as different tests, different scoring principles, and different cut-offs, as well as

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differences in the ages of the participants and different degrees of DLD severity. For example, the sensitivity for NWR as a clinical marker in English-speaking children with DLD ranges between 52% and 94%, while the specificity ranges between 88% and 99% [see, e.g. 16,17]. The first study of the accuracy of a clinical marker in Swedish DLD [18] evaluated the performance of NWR in school-aged children. The authors found a sensitivity of 90.2% and a specificity of 97.7% and concluded that NWR is a potential clinical marker of Swedish DLD.

Studies investigating past-tense inflection as a clinical marker have reported mixed results in English-speaking children with DLD. Conti-Ramsden et al. [19] reported a sensitivity of 71% and a specificity of 93%, while Conti-Ramsden and Hesketh [20] found even lower sensitivity (52%) and specificity (29%) for past-tense inflection. Christensen and Hansson [21] reported a sensitivity of 100% and a specificity of 81.2% for past-tense inflection in Danish-speaking children with DLD. All these studies elicited regular and irregular past-tense forms of known verbs using a sentence completion task. Since it may be the case that a grammatical form could be more or less accurate as a clinical marker at different ages (e.g. early acquired forms at earlier ages and later acquired forms, such as past-tense, at later ages), it should be pointed out that the age groups investigated in these studies differed. The participants in the study by Conti-Ramsden et al. [19] were around age 11, the participants in Conti-Ramsden and Hesketh [20] were 4;4 to 5;10, and the participants in Christensen and Hansson [21] were 5;2 to 7;11. In a review of results from different Germanic languages, Krok and Leonard [22] concluded that past-tense inflection is a potential clinical marker not only for English but for all languages included in the review. The conclusion is based on findings of large combined effect sizes in comparisons of past-tense production between children with DLD and both age- and language-matched controls, though neither sensitivity nor specificity was reported in the review.

In some studies, composite measures of tense or finiteness marking have been created as potential clinical markers for DLD, consisting of past-tense together with other verb measures. For example, Eisenberg and Guo [23] found 100% sensitivity and 88% specificity for the measure of percentage of verb tense usage. Bedore and Leonard [24] found >85% sensitivity and 100% specificity of a verb morphology composite (consisting of regular past-tense, regular 3rd pers. sing. –s, copula, and auxiliary be-forms). Using the same measure as Bedore and Leonard [24], Moyle et al. [25] found much lower results for clinical accuracy (50% sensitivity and 86% specificity), whereas Souto et al. [26] reported both sensitivity and specificity above 90%. Again, one possible factor to explain the different figures is that the age of the participating children differed. The participants in Eisenberg and Guo [23] were 3;0 to 3;11, the participants in Bedore and Leonard [24] were 3;6 to 5;9, the participants in Souto et al. [26]were 4;0 to 5;10, and the participants in Moyle et al. [25] were older, i.e. 5;5 to 9;8.

Several earlier Swedish studies have shown that regular past-tense inflection of verbs is a vulnerable form in the language production of 4- to 7-year-old children with DLD [27–30]. In particular, the production of the past-tense inflection of *non-verbs* (i.e. made-up verbs) causes difficulties for Swedish children with DLD [27,29]. Past-tense inflection has not yet been evaluated as a clinical marker for DLD in Swedish. The main aim of the present study is to explore the performance of the past-tense inflection of non-verbs in Swedish school-aged children with severe DLD and in typically developing controls, to investigate its potential as a clinical marker.

Difficulties with past-tense inflection are part of the predictions of several theoretical accounts of the underlying deficit in DLD. The Extended Optional Infinitives (EOIs) account [31] predicts difficulties with finiteness marking (e.g. 3rd person singular –s, regular past-tense inflection and use of copula in English). According to the EOI, children with DLD treat finiteness marking as optional, due to lack of grammatical knowledge. According to the surface account [1], children with DLD have difficulties processing grammatical elements with low phonetic salience. The surface account predicts difficulties with a range of morphological forms in several languages, among them regular past-tense inflection. Gathercole and Baddeley [32] proposed that the difficulties seen in children with DLD, e.g. difficulties with morphological forms, are caused by a deficient phonological short-term memory. Thus, Gathercole and Baddeley's theory accounts for both the findings that children with DLD have significant difficulties with the NWR task (a task that relies on, among other things, phonological processing) and difficulties with regular past-tense inflection. Using a task requiring past-tense inflection of non-verbs could thus be considered extra taxing, since it requires both processing of a new phonological form, i.e. a nonsense word, and transforming it into the required morphological form.

In their study of NWR as a clinical marker of Swedish DLD, Kalnak et al. [18] found an association between NWR and a family history of language and literacy difficulties. Children with DLD with a positive family history performed significantly poorer on NWR than did children with DLD with no family history; the effect size of the difference was large in their intra-DLD comparison. A study of the genetic influence of NWR and verb tense inflection in DLD [2] found that both measures distinguished between children with high and low risks for language disorders but that the phenotypic and etiological overlap between the two deficits was minimal. Thus, the two measures seem to be associated with different genetic mechanisms. The second aim of the present study is to investigate the association of the past-tense inflection of non-verbs with NWR and family history.

Aim

In the present study, we investigate the past-tense inflection of non-verbs as a clinical marker for Swedish DLD and how it is related to performance on NWR and a family history of language and literacy difficulties.

Specific research questions

1. Do children with DLD differ from controls on a non-verb inflection task? If so, what are the sensitivity and specificity values of the non-verb inflection task?
2. How is performance on the non-verb inflection task associated with NWR performance?
3. Does performance on the non-verb inflection task differ between children with and children without a positive family history of language and/or literacy difficulties?

Methods

Participants

Participants with DLD were 36 children – eight girls and 28 boys – recruited from school language units in Stockholm, Sweden. Their mean age was 9;5 (8;0 to 11;8). At the time of inclusion in our study, the children were in school years 1–5. The assessment required for admission to these schools is made by a clinical assessment team, usually consisting of a speech-language pathologist, a psychologist, and a teacher, when the child is at the age of 6–7 years. The school language units are for children with severe DLD, i.e. children whose language difficulties have been judged by the clinical assessment team to risk negative effects on learning and social participation. These children's need to attend a special school is annually evaluated by the special school staff, who decides if, and when, the child is ready to transfer to a mainstream school. Only children for whom the schools confirmed that DLD was still the primary developmental problem were recruited. All participants with DLD were monolingual Swedish-speaking children with normal hearing according to parental reports. The mean nonverbal IQ, assessed using Raven's Coloured Matrices [33], was 99.7 (SD 13.8). Parents' highest level of education was categorized according to whether the parents had at least three years of higher education, i.e. university studies (in total, 15 years or more) or not, i.e. parents who had an education level of maximum secondary school (maximum 12 years). For 42% of the participants with DLD, at least one of their caregivers had a higher education, while for 58% of the participants, neither parent had higher education.

Seventy-seven children were recruited to the control group, though 17 children did not fit the study inclusion criteria. The control group consisted of 60 children – 40 girls and 20 boys – and was collected from mainstream schools in the south of Sweden. Their mean age was 9;2 (6;9 to 11;2). The controls had no developmental difficulties, including language and learning development, and no hearing impairments, according to parental reports. Six children in the control group were multilingual, with Swedish as their first language. The remaining 54 were monolingual speakers of Swedish. The mean nonverbal IQ of the children in the control group was 107.7 (SD 15.2), as measured using Raven's Coloured Matrices [33]. For the control group, we have no individual information about individual caregivers' highest levels of education. Instead, we rely on official statistics for the schools from which the control children were recruited (https://www.skolverket.se/skolutveckling/statistik/sok-statistik-om-forskola-skola-och-vuxenutbildning). About half of the control group ($n = 32$, 53%) attended schools where around 90% of the pupils had at least one parent with higher education, while the other half ($n = 28$, 47%) attended schools where around 45% of the pupils had at least one parent with higher education.

Table 1. Gender distribution and means (standard deviations) for age and non-verbal IQ for each of the groups, with p values from group comparison.

	DLD ($n = 36$)	Controls ($n = 60$)	p[a]
Gender (girls:boys)	8:28	40:20	<.001
Age (months)	112.6 (13.4)	110.1 (13.7)	.389
Nonverbal IQ[b]	99.7 (13.8)	107.7 (15.2)	.012

[a]Comparison of gender distribution was based on chi-square analysis. Comparison of age and non-verbal IQ was based on t-tests.
[b]Standard score.

In Table 1, we present DLD and control group comparisons of gender distribution, age, and nonverbal IQ. There was no statistically significant difference in mean age between the DLD group ($M = 112.6$ months, SD = 13.4) and the control group ($M = 110.1$ months, SD = 13.7; $t(94) = -.865$, $p = .39$). There was a difference in gender distribution between groups, with a boys:girls ratio of 3.5:1 in the DLD group and 1:2 in the control group ($Chi^2 = 16.04$, $p = <.001$). Both groups performed within the norm average on nonverbal IQ, although the controls' average performance was significantly higher ($t(94) = 2.563$, $p = .01$).

The projects followed the Helsinki Convention and ethical approvals for the research projects were given by the local ethics committees in Stockholm (ref. nos. 2008/543-31/3; 2012/1938-32) and Lund (2009/383).

Materials

All children performed an NWR task (NWR) consisting of 24 nonwords based on three or four syllables [34]. The majority of the words (18/24) followed Swedish phonotactic rules, whereas six contained consonant clusters not permitted in Swedish. The nonwords were presented via a computerized test platform using a female voice. The children's performance was quantified as the number of correctly produced nonwords, judged online. The maximum score was 24. The participants' responses were audio-recorded and transcribed for a reliability check. Reliability for the scoring of the correct or non-correct production of the nonwords was carried out on all participants with DLD. Agreement (calculated as the percent of items that two independent judges scored identically regarding whether the child's response was correct or not correct) was 100% in the DLD group. Reliability (checked on a random selection of 50% of the controls and calculated in the same way as for the DLD group) was 96.8%.

All participants with DLD were required to perform below −2 SD from the norm mean on the NWR task. The controls were required to perform above −1.5 SD from the norm mean on the NWR task as part of the study inclusion criteria. This criterion is based on the NWR task being a

clinical marker for Swedish DLD in school-age children, with a sensitivity of 90.2% and specificity of 97.7 for binary scoring of nonwords [18]. Also, in younger Swedish-speaking children (4-year olds), NWR has been found to be the best single predictor of language outcome [35].

The main measure was a past-tense elicitation task based on eight non-verbs – that is, made-up verbs that the child could never have heard, i.e. past-tense inflection of non-verbs [29]. We used test items that have previously been published based on samples of younger Swedish-speaking children with typical language development, with language disorder and with hearing impairment [29,36,37] showing a large variation. Here, we investigate the performance with the same items in older children. Non-verbs were used instead of known, real verbs to avoid the influence of lexical frequency and lexical knowledge [38]. Past-tense forms in Swedish can be regular or irregular. The regular past-tense consists of the stem form (the imperative) of the verb to which one of the inflections (*–de* or *–te*) is added. If the stem ends with a vowel or a voiced consonant, *–de* is used (as in the example below). If the stem ends with a voiceless consonant, *–te* is used. Irregular past-tense forms involve a vowel change relative to the stem; no inflection is added.

For each item in the past-tense inflection of non-verbs task, the child was shown a picture that was presented in the following way: "This girl/boy likes to [non-verb in infinitive form]. Look, here she/he [non-verb in present-tense form]. She/he did it yesterday too. What did she/he do yesterday, she/he … ?". The child's task was to complete the final sentence with a past-tense form.

The children's responses in the past-tense inflection of non-verbs task were transcribed and scored as correct if the form given was a plausible Swedish past-tense form of that verb. The maximum score was 8 (1 score per item). Forms ending with *–de* or *–te*, as well as irregular forms made in analogy with one of the existing vowel change patterns for Swedish irregular verbs, were accepted as past-tense forms in this task. For example, for the verb *flipa*, both *flipade* and *flipte*, as well as the irregular form *flep*, were accepted. In order to control for reliability, scoring of the children's responses to the non-verb items was done by two independent judges for all children. For the children with DLD, the two judges scored the same (whether the response was correct or incorrect) in 96.5% of the children's responses. For the controls, the two judges scored identically in 98.5% of the children's responses.

Family history data were collected from the parents of all 36 children with DLD and the parents of 29 of the controls. For the remaining 31 control children, no information about family history was available. The parents of the 36 children with DLD participated in a larger family history interview [39], in which the prevalence of several language-related diagnoses and problems was investigated in relatives of children with DLD ($n = 61$) and in a control group of 100 typically developing children (not the same controls as in the present study). The parents were asked if they had a history, or current difficulties within several categories, of language-related diagnoses and problems, such as e.g. autism spectrum disorder, attention deficit hyperactivity disorder (ADHD), cleft palate, specific learning disorders, and social communication difficulties. In the present study, we classified family aggregation into two categories based on whether or not the child with DLD had a parent or parents with language and/or literacy problems. Information about family history in the 29 controls was collected in a questionnaire, in which the parents were asked if their child had any parents who had speech, language, and/or literacy difficulties.

Statistical analyses

The assessment of normality indicated that only the results for NWR in the control group were normally distributed. (For all other scores, the Shapiro–Wilk test was significant.) Therefore, we used parametric tests only for group comparison of NWR results; for all other analyses, we used non-parametric tests. An independent *t*-test was used to compare NWR scores between the two groups; a Mann–Whitney *U*-test was used for a group comparison of past-tense inflection of non-verbs scores and Spearman's Rho was used to investigate correlations between past-tense inflection of non-verbs, NWR, family history, and background variables. The chosen level of significance was .05. According to Cohen's convention (Cohen, 1988), correlations from .10 to .29 were considered weak, correlations from .30 to .49 were considered moderate, and correlations of .5 or above were considered strong. Effect size was measured using Cohen's *D* (0.2 small; 0.5 moderate; 0.8 large).

Results

We first report the performance and group differences on the past-tense inflection of non-verbs task for the 36 participants with DLD (DLD group) and the 60 typically developing controls (control group). Thereafter, we present associations with background data such as gender, age, and nonverbal IQ before investigating whether past-tense inflection of non-verbs shows diagnostic accuracy for children with DLD. Further, in the DLD group, we examine the association of past-tense inflection of non-verbs with NWR and family history.

Group comparison

We found a lower mean average raw score on the past-tense inflection of non-verbs task in the DLD group ($M = 3.83$, SD 2.64, min–max 0–8) as compared to the control group ($M = 7.08$, SD 1.47, min–max 1–8). The difference was significant ($t(48) = 6.789$, $p = <.001$) with a large effect size ($d = 1.52$, $r = 0.61$).

The age span was fairly large (although similar in both groups). Gender distribution and nonverbal IQ differed significantly between the two groups and there was a possible difference between groups in the distribution of parental level of education. Therefore, we investigated the impact of these background factors on the children's performance in

Table 2. Correlations between background variables and the non-verb inflection task for the DLD group and control group.

	DLD group ($n = 36$)		Control group ($n = 60$)	
Variables	*r*	*p*	*r*	*p*
Gender	.363	.030[a]	-.023	.861[a]
Age (months)	.283	.094	.099	.450
Non-verbal IQ	-.158	.357	.269	.159
Parental education level	.041	.812[b]		.297[b]

[a]Spearman's Rho.
[b]Analysis of variance (ANOVA).

Table 3. Diagnostic accuracy for cut-offs 6 and 7 (of max 8 scores) on the non-verb inflection task.

Cut-off	DLD group (sensitivity)	Control group (specificity)	LR+[a]	LR–[b]
7	80.6% (29/36)	76.7% (46/60)	3.45	0.25
6	63.9% (23/36)	85.0% (51/60)	4.26	0.42

[a]Positive likelihood ratio.
[b]Negative likelihood ratio.

the past-tense inflection of non-verbs task. Correlation analysis between the variables of gender, age, nonverbal IQ, and past-tense inflection of non-verbs was performed for the DLD group and the control group, respectively. As can be seen in Table 2, no significant association was found between age or nonverbal IQ with past-tense inflection of non-verbs, in either group. We found a significant and moderate association between gender and performance on the past-tense inflection of non-verbs task in the group with DLD ($r_s = 0.363$, $p = .030$), though not in the control group ($p = .861$). This result originated from a higher mean score for the DLD girls ($n = 8$, $M = 5.5$) than for the DLD boys ($n = 28$, $M = 3.36$); the difference was significant ($t(34) = 2.128$, $p = .041$) and large ($d = .85$, $r = .39$). This association with gender in the DLD group cannot be explained by a difference in age between girls and boys in this group ($p = .426$). Correlation analysis between past-tense inflection of non-verbs and parental level of education could be performed only in the DLD group for which we had individual data. We found no statistically significant correlation between past-tense inflection of non-verbs and parents' levels of education ($p = .812$). As described in the method, for the controls, we lack *individual* data on parents' levels of education. However, at the time of data collection, we had access to official statistics (https://www.skolverket.se/skolutveckling/statistik/sok-statistik-om-forskola-skola-och-vuxenutbildning) regarding parents' levels of education in the schools from which the controls were recruited. An analysis of variance showed that the effect of school on past-tense inflection of non-verbs performance was not significant ($F(14,24) = 1.297$, $p = .297$).

Clinical accuracy of the past-tense inflection of non-verbs task

Following our aim to investigate the accuracy of past-tense inflection of non-verbs as a potential clinical marker of Swedish DLD, we calculated sensitivity and specificity. We inspected different cut-off values on the past-tense inflection of non-verbs task (Table 3). The analysis resulted in a sensitivity of 80.6% and a specificity of 76.7% with a cut-off value at 7 scores, i.e. a maximum of one non-approved response allowed. The positive likelihood ratio was 3.45 (CI 2.1–5.6) and the negative likelihood ratio was 0.25 (CI 0.1–0.5). Lower cut-off values resulted in a loss of sensitivity and a gain in specificity (Table 3).

Table 4. Means and standard deviations for NWR raw score and *z*-score with *p* values from *t*-test.

	DLD ($n = 36$)	Controls ($n = 60$)	*p*
NWR raw score	7.31 (5.52)	14.58 (2.99)	<.001
NWR (*z*-score)	−9.89 (8.64)	0.011 (.88)	<.001

Associations between past-tense inflection of non-verbs and NWR

As expected, given the criteria for the groups, a group comparison confirmed that the children with DLD scored significantly lower than the control group on the NWR task (Table 4). As there was a significant correlation between age and NWR performance in the control group, but not in the DLD group, raw scores were converted into *z*-scores based on norm references [18]. Group comparison based on *z*-scores still showed a significant difference between the groups; the DLD group scored on average −9.89 standard deviations below the norm; meanwhile, the control group performed within the norm average (Table 4). Pearson's correlation analysis showed that performance on the NWR task was significantly and moderately associated with performance on the past-tense inflection of non-verbs task in the control group ($r = .41$, $p = .001$) but not in the DLD group ($r = .22$, $p = .197$).

Is family history associated with lower performance on the past-tense inflection of non-verbs task?

The number of children with a positive family history of language and/or reading-related difficulties was 29 of the 36 children in the DLD group (80.6%); in 16 cases both parents had difficulties, while in 13 cases one of the parents had difficulties (mothers $n = 6$; fathers $n = 7$). Two of the controls (6.9%) had a positive family history (in both cases the fathers) with language and/or literacy-related difficulties.

In the entire population for which information about family history was available (36/36 in the DLD group; 29/60 in the control group; in total $n = 65$), we found a moderate correlation between family history and performance on the past-tense inflection of non-verbs task ($r = –.513$, $p < .001$). This means that a positive family history of language and/or literacy difficulties in the parents was associated with lower performance on the past-tense inflection of non-verbs task. Participants with a positive family history ($n = 31$) scored lower on the past-tense inflection of non-verbs task than those with no family history ($n = 34$), ($m = 3.87$ and 6.65, respectively), and the difference was significant ($t(63) = 4.605$, $p < .001$, equal variance assumed). The effect size of the difference was large ($d = 1.14$, $r = .49$). Nota bene, 29 of 31 participants with a positive family history were from the DLD group. When controlling for group (DLD and controls), we found a

non-significant association between family history and performance on the past-tense inflection of non-verbs task.

Discussion

Group comparison

In this study, we investigated whether past-tense inflection of non-verbs can be used as a clinical marker for DLD in Swedish-speaking school-aged children. We found a large and significant difference ($d = 1.52$) in the average performance on past-tense inflection of non-verbs between the DLD group and the control group. Moreover, in a study of 3- and 5-year-old Swedish-speaking children with typical language development, Göransson and van der Pals [36] found that Swedish-speaking 3-year-olds scored an average of 3.65 (SD = 2.66) and that 5-year-olds scored 4.8 (SD = 2.33), using the same task as in the present study. This means that the children with DLD in the present study in the age range 8;0 to 11;8 years, with a mean past-tense inflection of non-verbs score of 3.83 (SD = 2.64), perform, on average, at a level similar to 3-year-olds with typical language development.

Clinical accuracy

Next, we measured the sensitivity and specificity of the past-tense inflection of non-verbs task to investigate its clinical accuracy as a marker for DLD. Based on a cut-off score of 7 (out of a maximum of 8), we found 80.6% sensitivity and 76.7% specificity. The sensitivity value is at a fairly acceptable level [40], while the specificity value is not acceptable because it risks the over-identification of DLD. Lowering the cut-off score from 7 to 6 increases specificity but lowers sensitivity, i.e. risking the under-identification of DLD. The likelihood ratios with the cut-off score 7 indicate moderate validity for correct identification. Sensitivity and specificity in the present study are considerably higher compared to the findings by, e.g. Conti-Ramsden and Hesketh [20] but slightly lower compared to Conti-Ramsden et al. [19] for English and considerably lower than what Christensen and Hansson [21] found for Danish. All studies used the same elicitation method, though an important methodological difference between the present study and the cited studies is that the present study used non-verbs whereas the cited studies elicited the past-tense forms of known verbs, both regular and irregular. Moreover, the cited studies contained more test items (30 or more vs. eight items in the present study). The relatively few test items in the present study, implies that getting one item wrong has a large effect, which may over-indicate problems. A further difference is the age of the participants. However, we cannot conclude that age is the determining factor based on the findings in the present study. Interestingly, of the studies using composite finiteness measures, cited in the background, those with younger English-speaking children [23,24,26] revealed higher sensitivity and specificity than the study with older children [25]. Possibly, a clinical marker for DLD could have different strengths of clinical accuracy at different ages, but the results from previous studies are too methodologically diverse to support any conclusions in that direction. There is also the issue of language. Most of the cited studies are based on English, while the Christensen and Hansson [21] study is based on Danish and the present study is based on Swedish. Although research results indicate that past-tense production presents significant difficulties for children with DLD in all three languages, there are important cross-linguistic differences to consider when one is comparing the clinical accuracy of past-tense inflection of non-verbs as a clinical marker of DLD in these languages. For example, a cross-linguistic comparison between English-speaking and Swedish-speaking children with DLD [30] found that the English-speaking children had a significantly lower use of past-tense inflection than Swedish-speaking children [30]. Swedish and Danish are closely related languages, though Danish-speaking children typically master past-tense inflection later than Swedish-speaking children do [41]. To summarize, comparisons to previous studies investigating the clinical accuracy of past-tense inflection of non-verbs are difficult to make due to both methodological and cross-linguistic differences. However, despite being based on a different language, using a different type of verb, and having fewer test items, the present study has produced results that are in line with findings in previous studies. Importantly, the clinical accuracy (i.e. sensitivity and specificity values) for the past-tense inflection of non-verbs task in the present study is lower than for NWR in [18], also based on Swedish school-aged children with DLD. This indicates that NWR is, so far, the most reliable clinical marker of DLD in Swedish school-aged children.

Family history

The association between the presence of a family history of language-related difficulties and the past-tense inflection of non-verbs score was moderate and significant for the subgroup for which information about family history was available ($n = 65$). The group of children with a positive family history ($n = 31$) performed significantly lower than those without a positive family history ($n = 34$) on the past-tense inflection of non-verbs task. However, the majority of the children with a positive family history (29/31) belonged to the DLD group. When controlling for group, the association between positive family history and past-tense inflection of non-verbs score was no longer significant, and, thus, reflects a difference between children with and without DLD. In the present study, we found a positive family history of language and literacy problems in 6.9% of the control group, which is in line with Kalnak et al. [39] based on a comparable sample of 100 Swedish-speaking control families.

The application of past-tense inflection on non-verbs requires knowledge of a productive morphological rule regarding how to create a past-tense form given another form of the verb (in this case, both an infinitive and a present-tense form). Additionally, it is dependent on the ability to process a new phonological form, which is also the case

in the NWR task. In the control group, past-tense inflection of non-verbs and NWR scores were significantly and moderately associated, whereas in the DLD group, there was no significant association between NWR and past-tense inflection of non-verbs. This could indicate that the past-tense inflection of non-verbs and NWR tasks measured different underlying skills, at least in the group with DLD. In a British study [2], both NWR and verb inflection were investigated as phenotypic markers of DLD. The authors found that performance in these measures is heritable but that the phenotypic and etiological overlap between the two measures is small. They concluded that different genes may be involved in difficulties with the two measures. In our study, all children with DLD had significant difficulties with NWR, whereas 80% performed below the cut-off on the past-tense inflection of non-verbs task. Thus, despite a larger overlap, some of the children with DLD have significant difficulties with NWR without having difficulties with past-tense inflection of non-verbs. It should be pointed out that the children in the present study differ in age and degree of severity of DLD from the English speaking children in Bishop et al.s' study [2] who were at risk for DLD based on parental report at age 4, assessed at age 6. The children in the present study were older and all had severe DLD, at the time of participation in the study. One possible explanation of the non-significant correlation between NWR and past-tense inflection of non-verbs in the participants with DLD, could be an effect of a restriction of range, i.e. the participants with DLD representing an extreme sample.

Methodological considerations

Possible influencing factors must be taken into account when one is interpreting the results. The participating groups are fairly small, although they are larger than the groups in several other studies examining past-tense as a clinical marker. The DLD sample is restricted to children with severe DLD, which could imply a higher sensitivity value of past-tense inflection of non-verbs and explain the high prevalence of a positive family history in the DLD group. More importantly, the clinical accuracy of the past-tense inflection of non-verbs task needs to be increased, possibly by developing more items. Furthermore, we did not check how similar the non-verbs were to known verbs nor the phonological complexity of the non-verbs. These are factors that should be controlled for. Thus, a larger population, including children representing a wider range of severity of DLD, with more diverse backgrounds, and more test items controlled for phonological complexity and word-likeness are needed for a more definite evaluation of past-tense inflection of non-verbs as a clinical marker of DLD in Swedish.

Conclusions

Past-tense inflection of non-verbs is a potential clinical marker of DLD in Swedish school-aged children, but as measured here, it does not yet reach the level of being an reliable clinical marker. To improve its accuracy further development of the past-tense inflection of non-verbs task is warranted, e.g. more items controlled for similarity with known verbs and phonological complexity and increasing the complexity of the task. To answer the question regarding an association between family history and past-tense inflection of non-verbs, larger samples are needed, with more variation of family history. As we found an almost complete overlap of a positive family history and the DLD group (which is interesting in itself), this question could not be answered.

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