Title: The interplay between phonology and syntax in French-speaking children with specific language impairment

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Running headline: Interplay between phonology and syntax

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Abstract

Background. This study investigated the relationship between phonological and syntactic disorders of French-speaking children with SLI in production.

Aims. This article compares three theories (pure phonological theory, surface theory and mapping theory) of language developmental disorders, all of which view phonological difficulties as the main reason for the children's problems.

Methods and procedures. The linguistic parameters (salience, phonological complexity, syntactic complexity, lexical/functional word, semantic/syntactic weight) that are fundamental to these theories were identified. The validity of these parameters was then tested against the phonological and syntactic results obtained by children with SLI and control children. Nine syntactic categories were tested.

Outcomes and results. Phonological complexity was the only parameter whose importance was confirmed, and this was only for phonological performance. Syntactic complexity did not correlate significantly with children's difficulties. Phonological salience did not correlate with phonological performance but was related to syntactic performance for French-speaking children. Mixed results were obtained for the other parameters, including negative correlations, which may call for different explanations.

Conclusions. No theory fully explained the observed outcomes. Pure phonological theory was the most parsimonious, but could not explain all the results, in particular not the results with respect to grammar.

Key words: specific language impairment, language disorders, children with SLI, phonology, syntax, French

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Introduction

Children with specific language impairment (SLI) very seldom show a homogeneous

delay in language acquisition. Numerous studies have shown that when compared to children

(usually younger) with the same mean length of utterance (MLU) level, specific

morphosyntactic weaknesses can be distinguished (for a review, see Leonard 1998). Similar

observations have recently been made with respect to phonological development. For a given

language development level, children with SLI produce more phonological errors than their

younger control counterparts. The existence of such phonological deficits has been

demonstrated in Italian (Bortolini and Leonard 2000), Hebrew (Owen, Dromi and Leonard

2001), Catalan and Spanish (Aguilar-Mediavilla, Sanz-Torrent and Serra-Raventos 2002), as

well as in French (Maillart and Parisse 2006). Children with SLI mainly have difficulties

related to phonological and morphosyntactic levels, and several theoretical interpretations

have therefore been proposed to account for the observations from a morphosyntactic and/or

phonological viewpoint (see for a review, Bishop 1992).

In this article, we will review several phonological hypotheses which propose that an

initial and/or mainly phonological deficit could explain the morphosyntactic problems

encountered by children with SLI. We will present three phonological theories, review their

interpretations/predictions and compare these with experimental data. The theories account

for the difference in performance between children with SLI and control children. These

theories use weaknesses that are specific to children with SLI to build and support their

theoretical reasoning. For example, to account for difficulties in the morphology of verbs,

these theories investigate all linguistic characteristics that make verbs particularly vulnerable. Since these theories were designed to account for children's performance in verbal morphology, they are all compatible with the existing data on the difficulties encountered by children in the use of verbs. This makes the comparison between these theories more difficult. In order to test these theories, results of experimental studies can be compared with those obtained in other languages (i.e. in languages other than English which is generally the first language to be investigated). This approach, already widely used, has resulted in the reformulation of some theories (e.g. Leonard 1998). Another approach is to extend the analysis to other grammatical categories (nouns, pronouns, determinants, etc.), in order to see if the reasoning still applies. Indeed, even though verbs remain one of the most problematic categories for children, there are significant differences in performance in other categories as well. Considering that the theories are not always tested on all categories (particularly in languages other than English), this can lead to new predictions or to more empirical verifications.

The aim of this study is to test the predictions regarding language difficulties in children with SLI generated by three phonologically-oriented theories to the empirical data. To produce testable predictions, an 'intermediary level' between the principles described in the three theories and the experimental results is used. Analysis of the principles underlying the three theories allows five linguistic 'parameters', the intermediary level, to be identified (see below). These parameters will be tested, and the results will enable to evaluate the three theories indirectly. These parameters have two properties that are fundamental to the current study. First, they interact differently with the theories, so that knowledge of which parameter is valid will enable us to decide which theory is the best. Second, they correspond to clear linguistic principles that are well studied and known, and which enable us to predict how a parameter may facilitate or hinder the processing of syntactic categories by children. Without

these parameters, drawing predictions for each syntactic category would be impossible. This is because the authors of the phonologically-oriented theories do not always elaborate precise predictions for each syntactic category (except those at the core of theoretical thinking, such as verbs, nouns and the categories directly related to them).

The predictions for each linguistic parameter and for each syntactic category are checked against the phonological and syntactic errors produced at word level by children during a spontaneous language production task. Two populations of children are compared, a population of children with SLI and a population of control children matched by level of syntactic development (based on the MLU, as described below and in Maillart and Parisse 2006). The predictions are analysed for each parameter in turn, and the theories are then indirectly evaluated.

The phonological theories

The phonological weaknesses of children with SLI no longer need to be demonstrated (Leonard 1995; Leonard 1998). At the level of perception, numerous studies have demonstrated the existence of poor performances in tasks requiring phonemic identification (Leonard, McGregor and Allen 1992; Sussman 1993), discrimination (Tallal, Stark and Mellits 1985) and/or consistency of phonemes (Bird and Bishop 1992; Bird, Bishop and Freeman 1995). At the level of production, children with SLI have quantitative delays in certain phonological measures such as the size of the phonetic repertory (Eisenwort et al. 2004) and the complexity of the syllabic structure (Roberts, Rescorla, Giroux and Stevens 1998). Several theories (Tallal, Stark and Mellits 1985) have suggested that this deficit may account for the linguistic difficulties encountered by children with SLI. This approach, which we refer to as *pure phonological theory*, has been widely criticized and does not seem to account for all specific language deficits (see Bishop, Carlyon, Deeks and Bishop 1999;

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Rosen 2003). However, the criticism bore mostly on the nature of the perceptual deficit. Since then, deficits other than the proposal from Tallal, Stark, and Mellits (1985) have been suggested; for example, frequency differentiation (Hill, Hogben and Bishop 2005; McArthur and Bishop 2004) and categorical perception (Serniclaes, Van Heghe, Mousty, Carré and Sprenger-Charolles 2004).

Theories do not agree on how the phonological deficit actually impacts on linguistic development, or more specifically the morphosyntactic development. Pure phonological theories suggest that children with SLI suffer from an initial perceptive deficit which hinders their learning of the phonological contrasts and rules of their language, and therefore prevents them from developing phonological representations that are specific enough (Joanisse and Seidenberg 1998). Since some syntactic markers differ from other syntactic markers only in a single phoneme, this could create many morphologic errors, regardless of the syntactic and semantic abilities of the child. Indeed, the morphosyntactic phonemes which cause problems are characterised by a relatively weak perceptual salience which makes them particularly vulnerable. Some of the children's morphosyntactic performances seem to depend more on the phonological characteristic of the item than on some specific syntactic complexity. Thus, children with SLI might, for example, present consonant deletions in the final position for phonological reasons, independently of the grammatical value of this phoneme. In this context, the errors made by children with SLI could be deduced either from the nature of the phonemes they produced, or contingently from the phonemic structure in which they appear, but they should not be influenced by other parameters, either syntactic or semantic. Predictions can be made based on the nature and complexity of the item, or based on the salience of the items to be processed. For a given phonological complexity (or for the same salience), there should be no difference between various syntactic categories. Conversely, for categories with significantly different complexities or saliencies, it might be expected that

children with SLI would perform better in less complex (or more salient) categories. According to Tallal, Stark, and Mellits (1985), who discuss difficulties in the perception of short and non-salient phonemes, children with SLI are predicted to experience difficulties when processing syntactic categories which are marked by such phonemes.

In the second theoretical approach, *surface account,* Leonard et al. (1992) discuss the impact of limited processing capabilities on the production of certain phonologically marked grammatical features. At first sight, the deficit does not appear to be primarily phonological, since children with SLI are able to perceive the phonemes, including short and/or non-accentuated ones. However, this theory is based on predictions concerning the phonetic features of such phonemes. Surface theory (Bortolini, Caselli and Leonard 1997; Leonard 1989; Leonard, McGregor and Allen 1992) suggests that the surface form of a given phoneme, its physical properties, in interaction with the need to build a morphological paradigm, could make certain elements more difficult for children with SLI. Indeed, the cognitive load generated by the processing of items with low salience, added to that of the construction of a morphological paradigm, might exceed the cognitive capacity of children with SLI. Therefore, grammatical morphemes with a low phonetic substance will be particularly vulnerable and most often omitted. In English, the grammatical morphemes most affected (-ed, -s, forms of the verb 'to be') are those with the shortest duration. The data from cross-linguistic studies confirms this interpretation: in Italian, tense or gender markings carried by syllabic flexions in the final position are not treated differently by children with SLI than by their control peers (Leonard, McGregor and Allen 1992). On the other hand, young Italians with SLI use significantly fewer articles or direct object clitics. These monosyllabic forms are not stressed, and they are located in initial or median positions (positions which are distinguished from the final one by their short length in French). This theory makes predictions about the perceptive salience of the items being processed: elements

not bearing stress are more likely omitted. The theory relies on the hypothesis of limited processing capacity, which implies that the most complex items (from a phonological or syntactic perspective) will be more difficult to handle. The syntactic categories are thus processed more or less well by children with SLI depending on two main criteria: phonological saliency (similar to the pure isolated phonological theory), and syntactic complexity. Although phonological complexity is not mentioned *per se* in surface theory, it sounds only logical that it should have an effect, so the parameter will also be added to the other two parameters linked with surface theory.

A third theory, *mapping theory*, considers the consequences of an initial phonological deficit on the lexical as well as the syntactic development of children with SLI. According to Chiat (2001), problems in the development of spoken language are due to difficulties encountered during the mapping of the different phonological forms onto their meanings. By definition, this theory predicts interactions between the different linguistic levels. The sensitivity of children with respect to prosodic structure and segmental information plays a critical role in the segmentation of lexical units, their storage, and the semantic or syntactic constructions that use these units. Chiat predicts differences between morphemes and syntactic structures depending on the impact of phonology on the learning process. Concepts that cannot be associated with visual, social or emotional information are learned mainly using data and interactions in a purely linguistic form. Therefore, their acquisition depends on the structure and complexity of the linguistic forms, including the characteristics of their phonological form. This theory predicts an imageability effect. SLI children should perform better on lexical items than on functional ones, and on items with stronger semantic values. Similarly, this theory predicts that verbs should be more vulnerable than nouns because verbs are less concrete items; temporal terms will be less affected that those with perceptive, mental, emotional or social meanings. Chiat's theory can explain isolated phonological

difficulties, as well as certain special characteristics of children with SLI (see for example the fragility of verbs in Conti Ramsden and Jones 1997; Parisse and Le Normand 2002). It can also explain the existence of uneven profiles. For example, 5-year-old children with SLI frequently exhibit a lexical level typical of 4-year-olds, while their grammatical level is closer to that of 3-year-olds (Moore and Johnston 1993).

Theories and linguistic parameters

For each of the three theories, there are linguistic parameters that clearly underlie the processes at work when using language. Some parameters underlie more than one theory, others do not. The relationships between theories and parameters are summarised in Table 1 and explained below. Each column corresponds to a particular theory, and each line to a parameter. Crosses indicate that the line's parameter should have an influence, according to the column's theory. If no relationship is predicted the square is left blank.

Table 1 about here

By definition, the pure phonological theory only considers phonological and phonetic factors to be relevant. Thus, words are produced better if they are of low phonological complexity and/or salient. However, this theory does not predict that their syntactic or semantic characteristics will have any influence. The predictions of the surface theory are related to Leonard's (1998; Leonard, McGregor and Allen 1992) description. According to this theory, children with SLI suffer from a general limitation of their processing capabilities which, combined with the perceptual characteristics of some grammatical morphemes, makes theses morphemes particularly prone to phonological errors. In a model based on the limitation of processing capability, complexity is a parameter that has a direct impact on performance. Effects of phonologic or syntactic complexity (more complex items being less well performed that simpler ones) are therefore expected. Moreover, according to surface

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theory, the perceptive characteristics of the morphemes being processed play a very important role: since accentuated phonemes are stressed, they are easier to perceive and should be performed better than non-stressed ones. Finally, mapping theory (Chiat 2001) specifies that many factors affect the quality of phonological productions. The problem being initially phonological suggests that the children's performance will be dependent on phonological complexity, and on whether the item is stressed or not. Then, there should be a lexical/functional effect, i.e. more phonological errors will be found on functional words than on lexical words. An effect of syntactic complexity (more complex structures being less well performed) should also be observed. Finally, there should be an effect of semantic transparency: essentially semantic categories (nouns, verbs, adverbs, adjectives, prepositions and pronouns) should be processed better than categories with a strong syntactic character (such as determiners and personal pronouns used as subjects).

Predictions by syntactic category

Let us now predict the influence of each of the five parameters on each syntactic category. In order to do so, we have to take into account the phonological, lexical and syntactic characteristics of French, which are sometimes quite different from those of English. In particular, there are some important phonological differences. Prosody is much more regular in French, so French people do not perceive stress differences (Dupoux, Pallier, Sebastian and Mehler 1997). Most functional words are not stressed in French, but they are no more difficult to process than other non-functional unstressed words of the same syllabic length.

Using data from the literature, we attributed values to the various parameters with respect to the degree of difficulty for the children. When no information from the literature was available, we calculated the values for the parameters for the French language ourselves. It is important to note that the calculated values did not come from the theories presented

above. The values take account of the spontaneous characteristics of children's language. Phonological and syntactic forms that are infrequent may be processed by a child in a lexical rather than syntactic way. They are very dependent on the experience of each child, which is a parameter that cannot be adequately controlled (for). For this reason only the categories that the children produced sufficiently often to allow for statistical calculations of significance are used. There are nine such syntactic categories: adverbs, auxiliaries, definite and indefinite determiners, nouns, prepositions, strong pronouns, subject personal pronouns, unmarked lexical verbs, and grammatically marked lexical verbs (see Section 2.4 below for a full description of the categories).

The nine categories have different characteristics according to the phonological, syntactic and semantic parameters presented in Table 1. Table 2 summarises how those parameters apply to each syntactic category, using values from 0 to 10. High values (close to 10) are used when a parameter should not generate any problem for children with SLI. Conversely, the lower the value, the more difficulties children are expected to have, because of this parameter. For example, 'saliency' helps for the categories of adverbs, nouns, strong pronoun, etc. and therefore these categories should not create problems for children with SLI (score of 10). On the other hand, determiners, prepositions, subject pronouns and auxiliary verbs weakly accentuated are expected to create problems for children with SLI, and are therefore given a lower score of 5. To define the values of the parameters, we have taken into account the number of levels that the parameters can have. By definition, 10 is the highest possible value; the possible values for each parameter are obtained by dividing the grading range by the number of possible states. Thus, the parameters that are binary (only two possible options, e.g. accentuated or not, etc.) can take the values 10 and 5 (=10/2). When there are three possible states, the possible scores are 3.3, 6.6 and 10. When there are four, the values are 2.5, 5, 7.5, and 10 and for five possible states they are 2, 4, 6, 8, and 10.

Table 2 about here

As mentioned above, the predictions for each parameter are extracted from the literature or calculated directly using the data available for French. The detail for each of the five parameters is described below.

Stress

In French, the last syllable of a phrase or a rhythmic group (e.g. a verbal or nominal group) carries the stress (Wioland 1991). This stress consist of a lengthening of the syllable duration. Several syntactic categories rarely or never end a rhythmic group. For instance, a determiner must be followed by a noun, subject pronouns and auxiliary verbs by a verb etc. So these syntactic categories were considered as non salient. In Table 2, a value of '10' was applied to salient categories while a value of '5' was applied to non salient ones.

Phonological complexity

No data about phonological complexity in French was available, so we had to compute it from scratch. We chose to define phonological complexity as a combination of length and syllabic structure. Phonological complexity was calculated from the number of syllables plus a complexity index calculated for each syllable of the word. The canonical syllabic structure 'CV' (consonant/vowel) received an index of 0, the structures 'V' and 'CVC' an index of 0.5, 'CCV', 'CVV', 'CYV' (consonant/vowel glides /vowel) an index of 1 and 'CVCC' or others an index of 1.5. This complexity hierarchy of syllabic structure was issued from Paradis and Beland (2002). For example, the words 'canard' (duck; /kanaR/; CV-CVC), 'trois' (three; /tRwa/; CCYV) and 'toboggan' (slide; /tobogã/; CV-CV-CV) received phonological complexity values of 2.5 (2 syllables + 0 for CV + 0.5 for CVC); 2.5 (1 syllable + 1.5 for CCYV) and 3 (3 syllables) respectively.

The indexes were calculated for each syntactic category using the Lexique database (New, Pallier, Ferrand and Matos 2001) Unfortunately, this database was generated using a written corpus. To avoid our estimates being modified by rare written forms, we kept only lexical entries that corresponded to child directed speech. This was done by keeping only the 4,062 different forms in the Lexique database which also occurred in a corpus of 91,878 words (Suppes, Léveillé and Smith 1974) from the CHILDES database (MacWhinney 2000).

The mean phonological complexity of words was computed for each syntactic category. The results were 1.21 for determiners, 1.21 for subject pronouns, 1.92 for strong pronouns, 1.99 for preposition, 2.21 for auxiliary verbs, 2.61 for nouns, 2.57 for adverbs, 2.66 unmarked verbs, and 3.03 for marked verbs. These scores were grouped into four different levels of complexity: level 1 = determiners, strong pronouns, subject personal pronouns; level 2 = prepositions, auxiliary verbs; level 3 = adverbs, nouns, unmarked verbs; level 4 = marked verbs. This led to the use of four values in Table 2 (2.5, 5, 7.5, and 10).

Lexical/functional and semantic/syntactic

Functional morphemes tend to be omitted by young children when they produce their first words and their first multi-word utterances (Valian, Hoeffner and Aubry 1996). This is also true for children with language impairments. These children sometimes continue to produce few functional morphemes even when their vocabulary is well developed. These behaviours have led several authors to postulate the existence of various properties that make the perception, comprehension, and production of functional morphemes more difficult. This is particularly true for free grammatical morphemes such as English determiners and pronouns, but also for bounde morphemes such as the 3rd-pers-sing-s for verbs in English.

Chiat (2001) attributes the existence of difficulties with bound morphemes, not only to their phonological weakness, but also to the fact that they do not relate to non-verbal

experience. Instead they relate to linguistic properties such as tense, argument structure, use of non-canonical structures, expression of co-reference (see Chiat 2001, p. 131). For this reason, they are dependent on phonology to trigger the access to semantic-syntactic contexts. Chiat also proposes that categories of words can be contrasted by their degree of semantic transparency. This is especially true for nouns vs. verbs. Black and Chiat (2003, p. 231) explain that: 'Semantically, a number of factors load differently for verbs and nouns: their conceptual range (with 'things' always mapping onto nouns and 'relations' typically mapping onto verbs); their semantic complexity in terms of the occurrence and number of entities they connect (their 'argument structure'); and the closeness of the mapping between their meanings and non-linguistic concepts (something similar to but not identical with the concrete/abstract distinction).'

It is not easy to make a summary of Chiat's predictions using only a few parameters. However, the general idea is that words can be rated as more difficult when they have a heavy syntactic weight (meaning they are important for determining pure syntactic relationships) and less difficult when they have a clear semantic mapping onto non-verbal elements. However, for some categories of words (see below), the opposition between syntactic and semantic weight is not clear cut. Some categories (such as, for example, strong pronouns) have easy semantic mapping properties but also bear a lot of information of a syntactic nature. This is also the case for a category such as prepositions, which have quite high imageability (and thus have a high semantic weight) but clearly have a functional role in grammar. In order to produce more specific predictions, the opposition described by Chiat was split in two dimensions although these dimensions are often related: function word vs. lexical word (which means low or high syntactic weight); and syntactic vs. semantic (which means low or high semantic weight).

Some categories are clearly functional in nature and do not allow easy semantic mapping: it is the case for determiners, subject pronouns and auxiliary verbs. These three categories have the value of 3.3 in Table 2 for both the functional/lexical dimension and the syntactic/semantic dimension. The noun category is completely opposed to these three categories. It is both lexical and semantic, and it has the maximum value of 10 in both dimensions. Unmarked verbs and marked verbs are both lexical (as nouns), but they have a lower semantic transparency and cannot be rated as high as nouns are in the syntactic/semantic dimension. For these reasons, both categories have a value of 10 for the functional/lexical dimension, but only an intermediate value of 6.6 on the syntactic/semantic dimension. Adverbs usually offer no easy mapping to non-verbal experience and they sometimes relate to tense, but they do not relate to argument structure, non-canonical structures, or co-reference. For these reasons, they are in the middle of both dimensions and have a value of 6.6 on both dimensions. Prepositions and strong pronouns refer to non-verbal knowledge, which gives them a high semantic weight (even though the use of prepositions can be arbitrary, which makes them more difficult to remember). On the other hand, they are used to express argument structure, non-canonical order, and co-reference. For these reasons, both categories have a low lexical weight but a high semantic weight, so that they are valued at 3.3 on the functional/lexical dimension, and at 10 on the syntactic/semantic dimension.

Syntactic complexity

In order to assess the syntactic complexity of a syntactic category, the number of different syntactic features expressed was taken into account. The syntactic features which are marked in the nine categories analysed are gender (male or female), number (singular or plural), person (first, second, third), and tense. Some particularities of French constrain its syntactic complexity:

(1) many contrasts are marked in written language but not in oral language, except for irregular words (e.g. the noun plural marker 's' is not pronounced, except in liaisons);

(2) numerous syntactic structures (or features) are not frequently used in modern oral French;

(3) a number of syntactic structures (or features) are infrequent in the language in general, whether oral or written, or are infrequent among children of the age of those in the present study.

If a syntactic feature shows patterns (1) or (2) it is ignored in our syntactic complexity measure. If it shows the (3) pattern, it is given half the weight (as opposed to the full weight for other features). For instance, we considered that number is never expressed orally in nouns, although it is expressed in a few irregular words (case 1). This is only true for oral language. Written language requires the number of nearly all nouns to be marked. Gender is not usually marked on nouns, the exceptions being specific words, notably nouns corresponding to human beings. However, most nouns have a fixed gender that cannot be changed. A frequency analysis would show that there are many cases of nouns in which no syntactic feature could be expressed (case 3). By applying the (1) and (3) rules described above, we attributed only a half-weight to the syntactic complexity of nouns. A second example concerns the person of verbs. First, there is no oral distinction between the first, second and third person singular and the third person plural in most common regular verbs (see case 1). For nearly all other verbs, except auxiliaries (which form a specific category), the third person singular is a homophonous form (case 1). The first person plural is produced in oral language with a specific 'on' sound that agrees with the third person singular. Therefore, number marking on verbs is not taken into account (case 2). All the other plural forms of verbs are rare (case 3). For all these reasons, we attributed only the tense feature plus

a half-weight for the number feature to the verb category (no feature for the person, this feature being considered as exclusively marked by the personal pronoun). The linguistic features carried by the categories are listed in Table 3. From our analysis, it appears that only determiners and personal pronouns carry syntactic features that are traditionally (in written language at least) also attributed to nouns and verbs.

Table 3 about here

Purpose of the paper

Three phonologically-oriented theories will be tested indirectly. Linguistic parameters (salience, phonological complexity, functional vs. lexical, syntactic complexity, syntactic vs. semantic) are used to categorise each theory (see Table 1). The theoretical weights each parameter has on the processing of nine syntactic categories is estimated (see Table 2). Correlations will be computed between the theoretical weights for each parameter and the performances (on phonology and syntax) of children with SLI and typically-developing children. Significant correlation will show that a parameter is important to explain the performances of children with SLI and control children. The theories that are underlied by 'important' parameters will be indirectly validated.

Methods

All the language data used in this study was produced spontaneously. This allowed us to obtain phonological and syntactic data that was close to the actual performance level of the children. In this situation, the differences between children with language disorders and control children are minimised, as children can choose to use words and constructions they are more at ease with. Significant results obtained using these data collection procedures are more likely to be reproducible than results obtained using experimental elicitation.

Twenty-four children participated in the study: twelve children with SLI and twelve control children with typical language development. All participants were French native speakers. Children with SLI and control children were matched for MLU. The average age of the children with SLI (10 boys, 2 girls) was 7;7 and their average MLU was 3.82. The average age of the control children (4 boys, 8 girls) was 4;0 and their average MLU was 3.70 (see Table 4). All children had comparable phonemic inventories.

Table 4 about here

MLU was computed in words, without taking into account word morphology. This is the most useful way of computing MLU for young French children for three reasons: first, the results obtained are comparable with those from other languages which used the same measure (Aguilar-Mediavilla, Sanz-Torrent and Serra-Raventos 2002; Bortolini and Leonard 2000); second, the most common morphological markings pronounced in French are made redundant by the use of an article, a pronoun or an auxiliary (and vice versa), so using MLU computed in words means that the same morphological information is not counted twice; third, most of the noun forms and verb forms are homophones, and it is only the use of an article, a pronoun or an auxiliary that allows the difference between various morphological markings to be heard.

The children with SLI were chosen randomly among children being followed for language remediation in special education classes for language disorders. These children had previously been diagnosed as language impaired by a multidisciplinary team. The diagnosis included a medical examination (hearing and vision), as well as neuropsychological and speech–language investigations. All the children satisfied the classical exclusion criteria for an SLI diagnosis (Stark and Tallal 1981). They scored within the average range on the Leiter

International Performance Scale (Roid and Miller 1993) and the non-verbal scale of the Wechsler Intelligence Scale for Children (WISC III) (Wechsler 1996). They also demonstrated hearing and oral motor functioning within normal limits and showed no signs of emotional disturbance.

Children with normal language development served as controls. These children were recruited at kindergartens. The selection procedure for control children was done in two steps. In the first step, the average MLU of the SLI group was computed, which gave a level of language development (according to MLU) of around age four. The second step consisted of selecting a set of control children aged 4;0, each matched for MLU with one child from the group of children with SLI.

An analysis of variance was carried out to check the group matching, with MLU as the dependent variable and group (SLI vs. Control) as the between-subject independent variable. As expected, no group effect was found (F(1,22) = .068, p = .80).

Data collection

All the data was gathered in spontaneous language production settings. Questions were asked to all the children in order to initiate language production. For the younger children, the setting was a play situation, using the '*Bain des poupées*' (dolls' bath time) procedure from a standardised language-testing tool (Chevrie-Muller, Simon, Le Normand and Fournier 1997). The older children were asked questions by a professional speech therapist following the procedure described by Evans and Craig (1992). In both situations, although the questions were not the same, the same procedure was followed, so that in all cases the children had to choose their own words and phrasing. This was necessary to ensure that children used words that they felt quite comfortable with.

Phonemic transcription

Most of the transcriptions were done by the two authors. For some recordings, the transcription was first carried out by trained specialists and later extensively checked by the authors. All cases of disagreement between transcriptions were carefully checked until full agreement was reached. Most cases of disagreement were in the tagging of vowels subject to regional variations. The other problems were mostly about the transcription of codas (/l / and /ʀ/), which are often difficult to perceive. Where there was any doubt, the child was considered to have produced the standard expected adult pronunciation. Transcription was done using a phonemic rather than a phonetic approach to allow a certain leeway in the pronunciation. Achieving a 100% success rate in phonetically tagging a large corpus is undeniably a highly challenging task. The CHAT format (MacWhinney 2000; MacWhinney and Snow 1985) was adopted for transcription, and the SAMPA phonetic alphabet (employing the full set of French phonemes, which includes 18 consonants, 3 semivowels, and 16 vowels) was used for the phonemic transcription. As some of the contrasts between vowels are becoming obsolete in modern French pronunciation and are subject to regional variation, four pairs and a triplet of vowels were reduced to single phonemes for all subsequent analyses. This left a set of ten different vowels, including three nasal vowels. The full set of phonemes used in the transcripts can be found in Maillart and Parisse (2006).

After phonemic transcription, a phonemic model line (%mod tier in the CHAT format) was added for each phonemic line that contained the correct phonemic adult target. This information was thoroughly checked by the two authors as it was used for automatically computing the results of the data analysis. All types of contractions were considered as correct, as well as some consonant reductions in words beginning with a vowel, as this represents standard oral French language (Blanche-Benveniste 1990). For example, forms

such as 'pti' for 'pəti' (petit=small), contractions such as 'ja' for 'ilija' (il y a = there is), and consonant reduction such as 'i tõb' for 'il tõb' (il tombe = he falls).

Syntactic analysis

The whole corpus was automatically tagged for part of speech, using the POST tool (Parisse and Le Normand 2000a) of the CHILDES software (MacWhinney 2000). This resulted in a line where each word was coded for syntactic category (%pos tier in the CHAT format). A manual check was then performed to remove the remaining tagging errors. As discussed in Section 1.3 above, the analyses in this article used a set of nine categories: adverb, auxiliary, determiner, noun, preposition, strong pronoun, subject preverbal pronoun, marked lexical verb, and unmarked lexical verb. The two categories 'marked lexical verb' and 'unmarked lexical verb' correspond to the most frequently used lexical verbs in the French language. Unmarked verbs correspond to the present tense (first, second and third person singular and third person plural) and imperative (second person singular). In all these cases, the verb is reduced to its most simple bare root form. For the purposes of this article, marked verbs were limited to lexical verbs with non-finite tense markings (past particle and infinitive) both of which take the same marker (the single vowel /e/ for the most frequent regular verbs). In normal language use, these two forms are used in finite constructions with an auxiliary to produce the past and periphrastic future tenses.

Table 5 about here

This subset does not cover all the categories produced by children. Infrequent categories (for example adjectives, conjunctions and object preverbal pronouns) were not used to compute results because their low frequency did not allow the computation of meaningful statistical values on phonological mismatches. Categories that do not allow clear syntactic predictions were not used either. The subset of nine categories covered an average of 50.5%

of all the children's words (48.4% for children with SLI, 52.5% for control children). Table 5 gives details on the average number of words actually produced in each category for children with SLI and control children, and the percentage of words in each category. For all categories, the average number of words produced is sufficient to compute the statistical differences between SLI and control children. Only one significant difference was found: SLI children produced more auxiliary verbs than control children ($F(1,22) = 5.02$, $p=.035$). In two cases (strong pronouns and auxiliary verbs for control children), the number of words produced was low and these results must therefore be taken with some caution, as low word production is usually correlated with high variability in word production.

After this first coding, a second model line (%mds tier) was manually created from the phonemic model line by correcting the syntactic errors. The different codings used for the analyses can be illustrated as follows:

*CHI: sait pas nager[‡] (cannot swim; transcription of the child's production)

%pho: se pa laʒe (child's phonetic production)

%mod: se pa naʒe (adult's phonetic target without correction of syntactic errors)

%mds: il se pa naʒe (adult's phonetic target with correction of syntactic errors: i.e. addition of the obligatory subject pronoun 'il' (he))

Experimental variables

Analyses were conducted on two variables, corresponding to two different types of errors: phonological errors and syntactic errors.

Phonological errors

The analyses consisted of comparing the %pho tier and the %mod tier to count the number of words which exactly matched the phonemic model. Analyses were conducted at the word level to compare with the syntactic errors. Words that could be understood but belonged to a partially intelligible utterance were taken into account. A word was considered correct if all the phonemes matched the model. If the pronunciation of a word followed an adult variant, it was considered as correct. Hesitations and rephrasings were not counted as errors.

Syntactic errors

The analyses consisted of comparing the %mod tier and the %mds tier to count the number of words which exactly matched the syntactic model. The addition, omission or modification (e.g. gender errors) of words were considered as errors.

Correlations between theoretical prediction and error rates

The analysis summarized above in Table 2 presents the theoretical impact of five linguistic parameters (saliency, phonological complexity, lexical/functional category, syntactic complexity and semantic/syntactic weight) on the processing of seven syntactic categories. For example, for the parameter saliency (see Table 2, column 2), adverbs are easy to process (value 10), auxiliary verbs are difficult (value 5), determiners are difficult (value 5), nouns are easy (value 10), etc. If these values (the set of nine values corresponding to the nine categories: 10, 5, 5, 10, 5, 10, 5, 10, 10) are highly correlated with the children's error rates for each of the nine categories, then the theoretical parameter 'saliency' will be a good predictor of the children's results while a weak correlation would indicate that the parameter is not a good predictor. This evaluation can be done separately for both the phonological

errors and the syntactic errors, and for each theoretical parameter. Also, this can be done for children with SLI and control children.

Results

Error rates for French-speaking SLI and control children

The percentages of correct responses for each experimental parameter (phonology and syntax) were computed for each child for each of the nine syntactic categories. Table 6 summarises the children's correct use of each syntactic category, phonetically and syntactically. The statistical difference between SLI and control children is also given. For each grammatical category, the two groups were compared by means of analysis of variance, using arc-sine transformations of the percentage data.

On the phonological comparison, significant differences between SLI and control children were found for all syntactic categories except auxiliary verbs. Interpretations of the results for auxiliaries should remain tentative because of the low number of items produced. Control children performed better than SLI children in all categories. The results differ greatly from one syntactic category to another, even among control children, with the proportion of correct utterances ranging from 69% for marked verbs to over 95% for the phonetically easiest categories.

Table 6 about here

In the syntactical comparisons, significant differences emerged in only two categories: control children performed significantly better than SLI children on determiners and prepositions (see Table 6). Further analysis revealed that, for both SLI and control children, 59% of the determiner errors and 58% of the preposition errors were omissions. Among the other errors on determiners, there were 34% gender errors, 7% number errors, 20% wrong uses of the

indefinite or finite article, and 39% errors of unknown type. For prepositions, the other errors were mainly the use of the wrong preposition.

Predictions by linguistic parameters

The correlations between prediction for the five linguistic parameters (saliency, phonological complexity, lexical/functional, syntactic complexity and semantic/syntactic) and the children's error rates can be computed by combining the predictions presented in Table 2 and the results presented in Table 6. More precisely, 5 x 4 correlations are computed between each column of Table 2 and the four columns of Table 6 that correspond to correct production rates (column 2, 3, 5 and 6). The correlations are presented in Table 7. Three linguistic parameters had significant correlations, but phonological complexity was the only one for which only positive significant correlations were found. Salience and lexical/functional parameters also had significant negative correlations.

Table 7 about here

Discussion

Error rates for French-speaking SLI and control children

A major result is that the control children performed better overall than the children with SLI. To be more specific, the control children tended to perform better on some syntactic variables (5/9) and significantly only on two, but the two groups differed on all phonological variables. These results confirm previous reports by Maillart and Parisse (2006), Bortolini and Leonard (2000), and Aguilar-Mediavilla et al. (2002), and provide a clear illustration of the difficulties which children with SLI have with language.

A second major result is that the rate of phonological errors was much higher than the rate of syntactic errors. It is difficult to compare the two results as the higher error rate will

tend to blot out the lower one. Also, there is an interdependency between phonology and syntax so some errors may be related to both domains. The percentage of phonetically correct words was 71% for children with SLI and 90% for control children, while the percentage of syntactically correct words was 91% for children with SLI and 95% for control children. This large difference could stem from certain syntactic categories (e.g. adverbs, nouns, verbs, strong pronouns) for which it is difficult to produce syntactic errors but easy to produce phonological ones.

Phonological errors were found in nearly all categories, whereas syntactic errors were found only in specific categories. For children with SLI, only one category out of nine was phonologically correct in more than 90% of utterances, but this level of success was reached syntactically in six out of the nine categories. The control children showed a similar trend, but with higher success rates. Both groups of children displayed similar weaknesses. Phonologically, marked verbs was the worst category for both groups. The second and third worst categories (nouns and unmarked verbs) were also the same, but in reverse order. Syntactic categories which were the most difficult for children with SLI (subject pronouns, prepositions and determiners) were also the most difficult for control children.

It is impossible to compare our results directly with those in the literature because phonology and syntax have not been studied in this way before. Elicitation paradigms are much more common than approaches involving spontaneous speech. This leads to worse results for children with SLI, because they cannot avoid forms that are difficult for them. However, some studies in English, French and Italian have used spontaneous language. Their authors have reported error rates in obligatory contexts, but without any information about the phonological quality of the productions. Le Normand et al. (1993) compared the percentage of determiners use in obligatory contexts for English-speaking, French-speaking, and Italian-speaking children with SLI. They found that French-speaking children produced 91.5% of

required determiners, which was much higher than the percentage for English-speaking (46.4%) or Italian-speaking (45.6%) children. Our result (88%) is very comparable with theirs. This confirms that French-speaking children have a good mastery of determiners. The difference between our study and Le Normand et al.'s is that they did not find a significant difference between SLI and control children. This could result from the differences in age groups between the two studies. Both Le Normand et al.'s groups were younger than both of ours, and the difference between SLI and control children tends to grow with age (see also Maillart and Parisse 2006).

The results for the noun syntactic category (99%) confirmed the results from English-speaking children, which were that children with SLI have good results on nouns. Black and Chiat (2003) found ceiling effects for the use of plural in nouns for children with SLI as well as control children, with no significant difference between the two groups (93% and 97% respectively). Our results were slightly higher but this could be explained by the fact that plural is often not marked orally on French nouns.

In our study, auxiliaries were very well produced by children with SLI (95%), as well as by control children (99%). This result was markedly different from that of English or Italian speakers. In English, Leonard (1995) found only 34% correct use of the auxiliary verb *to be* and 21% correct use of *to do* among children with SLI. The values were 59% and 46% respectively for control children. The results for Italian, were in between those for English and French: 55% correct use for children with SLI and 90% for control children (Leonard and Bortolini 1998). For Leonard and Bortolini, Italian-speaking children's difficulties with auxiliaries and determiners were explained by the non-accentuated character of these morphemes, and their absence from clause-final positions. The authors stressed that the length of the morphemes appeared to be an important factor, but their results did not allow them to choose between two opposing hypotheses: limitations linked to prosodic constraints, and

limitations in processing the input. If the low number of production errors for French can be explained by the simple form of the auxiliaries (a single vowel most of the time), it is surprising not to find more omission errors. This might be explained by the syllable-timed structure of French, with very regular accentuation, or by the high frequency of auxiliaries.

Third person singular verb markers were correctly produced 59% of the time by English-speaking children with SLI and 71% by control children (Moore 2001). These problems with verbal morphology have frequently been described in the literature. We did not find any difference between SLI and control children in our study, either for marked or unmarked verbs, but it should be stressed that obligatory person marking for verbs is relatively infrequent in French.

Predictions by linguistic parameters

For each parameter, four correlations were computed between the predictions for the parameter and the children's error rates (see Table 7). A strong correlation should indicate that the parameter is a good predictor of the children's results while a weak correlation should indicate that the parameter is not a good predictor. However, differences can be found between the results for phonology and for syntax error rates, and between children with SLI and control children. Also, significant negative correlations should be discussed because predictions had only been made for positive correlations.

Salience

This acoustic property produced highly contrasting results. Significant results were obtained for children with SLI only, but the correlation was negative for phonology whereas it

was positive for syntax. None of the theories under consideration can explain the negative result in phonology for salience. Stress always has a facilitating effect, not the opposite, as numerous studies of the beginnings of children's language have shown. The existence of an adverse effect seems unlikely.

However, the specific properties of the French language could explain this surprising result. For salience the negative correlation with phonological correctness is a consequence of lexical words (in particular nouns and verbs) having high salience (they are often longer than one syllable and they often carry stress). But since they are longer, they often are more phonologically complex. This makes them more difficult to produce with respect to correctness on the phonemic level. For the lexical/functional parameter (see below), the same argument applies. So, for phonological correctness, salience has no facilitating effect. However, the positive correlation between salience and syntax in the SLI group can be taken to indicate that salience has a facilitating effect for grammatical correctness.

What could be surprising is that the correlation of syntactic results with salience is higher than the correlation with the lexical/functional parameter. This might be linked to properties of the young children's language. In French, salient syntactic categories can also be used to produce single-word utterances, by children and by adults. These categories are the first that French-speaking children learn (Parisse and Le Normand 2000b). These structural and developmental properties could explain the results in two ways: 1) all these categories have a strong semantic weight, which, according to mapping theory at least, gives them an advantage; 2) the processes that underlie the use of these words are the first to be acquired during the development of language, and may therefore be more robust than processes acquired later.

Phonological complexity

As phonological complexity explained the phonological results very well for all children, this means that complexity is a very important factor. It was the only positive and significant parameter for phonology. However, it did not provide good results for syntax. The syntactical results were not significant but they displayed a negative trend. This suggests that the categories that were syntactically difficult were those that were phonologically easy, which would rule out phonology as an explanation for syntactic deficits.

Phonological complexity was the linguistic parameter that produced the best results. It was the only one that predicted more difficulties for verbs than for pronouns, and for nouns than for determiners. It was also a good predictor for auxiliaries, and was in fact the only parameter to do this. However even for phonology only, the predictions were not perfect. A comparison between Table 2 (predictions) and Table 6 (results) shows that no difference was predicted between subject pronouns or determiners for both SLI and control children, but that in fact subject pronouns lead to more errors than determiners. Strong pronouns were estimated to have the same level of relative difficulty as prepositions and auxiliaries, but in practice turned out to be considerably more difficult for children with SLI. The difficulty of adverbs was overestimated in comparison with that of nouns and unmarked verbs. Finally, although the two groups of children were predicted to exhibit good performances for auxiliaries, the results were even better than predicted. Auxiliaries were in fact the category on which both groups of children performed best.

Some errors in the predictions could not be explained easily by phonological properties. These include the differences between nouns and verbs, and between determiners and subject pronouns. Some differences may have resulted from other linguistic properties such as lexical knowledge or syntax. Some of the predictions might be improved if phonological complexity

was computed on the words actually produced by the children (or at least targeted by the children) rather than on the words addressed to the children. Also, the phonological properties of auxiliaries may have been erroneously interpreted. Auxiliaries usually consist of a single initial vowel, a V structure that was considered more difficult than a CV structure. It is possible that the initial position of the vowels, which have a form similar to phonomorphological fillers produced by children, were in fact easy for them to remember and pronounce. A re-evaluation of the complexity of auxiliaries, taking into account these ideas on their phonological and lexical properties, may explain the results.

Lexical/functional

The lexical/functional parameter correlated negatively with the phonological results, for both SLI and control children. Positive correlations were obtained for syntactic results, but these were not significant. This pattern was similar to that of salience, although the significant results were different. The negative correlation for phonetic errors means that lexical words were phonologically more difficult than functional words, which is evident from the ratings in table 2. Thus this result was part of the predictions. The difficulty of functional words with regard to syntactic processes was confirmed. A comparison with the results for salience shows that the two categories which explained that result for syntax (adverbs and strong pronouns) did not reach significance for the lexical/functional dimension. Syntactic errors did not usually occur in these two categories, although children made a lot of phonological errors with them. This behaviour suggests that they are closer to lexical than functional categories (as does their considerable semantic value). This calls for a better adjustment of the lexical/functional opposition to the French language.

Syntactic complexity

Syntactic complexity was the less predictive of the parameters used, with no significant correlations with children's performance. This came as a surprise because phonological complexity appeared to be a good predictor, and the importance of syntactic complexity is hinted at by many theories (including theories that ignore the role of phonology). This surprising result may arise from the importance attributed by this parameter to verbs (and all categories connected to the verb), and the low importance of the noun (and categories related to the noun). This opposition between verbs and nouns was not found in the results. Instead, an opposition between nouns and verbs on one side, and subject pronouns and determiners on the other side was found. This result may be specific to the French language and call for a redefinition of the locus of syntactic complexity in French. One other explanation might be that syntactic complexity can not be caught at the word level, since syntax is basically about the relation between words.

We predicted that nouns were syntactically much less complex than determiners, due to the fact that few gender or number markers are orally marked on nouns. This prediction was confirmed by the results. Another explanation (which was not taken into account) is that the lexical gender or number on nouns may be handled by semantic processing only. The characteristics of nouns, because they are lexical, may generate some syntactic complexity and hinder the use of the determiner, but they do not generate processing errors on the noun itself. This would explain why so few errors were made with nouns, as only semantic errors could be made, and these are difficult to identify in a spontaneous language production task.

No such prediction was made for verbs, as they are marked for tense and sometimes for number. Our results showed that in fact verbs exhibited a pattern similar to that of nouns. Few errors were made in the verbs themselves, but many errors were made in pronouns. The small

importance of person in verbs may be explained by the fact that person and number markers on verbs are infrequent, so that in fact all the weight of person and number fall on personal pronouns (contrary to a language such as English, whose morphosyntax is simpler than French in principle, but where person marking on the verb is in fact more frequent than in French).

Semantic/syntactic

The opposition between syntax and semantics as we defined it above did not seem to affect the children's performances. Only a small insignificant effect was found for syntax. The opposition between nouns and verbs suggested by Black and Chiat (2003) on the basis that nouns are semantically less abstract than verbs was confirmed, as was a related result with the determiners leading to fewer errors than subject pronouns. However, these effects were not strong enough to generate significant results. The result for prepositions may also be explained by a semantic effect, as around half the syntactic errors for prepositions were of semantic origin. The low level of errors in strong pronouns may also be explained by their semantic weight.

The absence of correlation effects for the semantic/syntactic parameter may be explained by a poor interpretation of this parameter. We based our analysis on an opposition between syntactic categories, but better results might have been obtained by using more fine-grained categories.

Consequences for phonologically-oriented theories

The three phonologically-oriented theories of SLI presented in this paper differ in the linguistic parameters that underlie them (see Table 1). So it should have been possible, using

the results discussed above, to make an indirect evaluation of these theories. As the study included a relatively small number of subjects (2 x 12 subjects), negative results should be taken with caution, especially when results were close to statistical significance. Unfortunately, only one parameter (phonological complexity) was really confirmed as clearly correlated with the performance of children with SLI, and this parameter had no significant effect on syntactic results. All the other parameters were either non-significantly or negatively correlated with performance. Since all the theories posited that phonological complexity is important in SLI, this cannot help us decide between theories. Pure phonology theory might be preferred on grounds of parsimony. However, the poor results obtained for syntax cannot easily be explained by phonological characteristics. Indeed, the three syntactic categories on which children had the most syntactic errors (subject pronouns, prepositions and determiners) were phonologically relatively error-free when they were produced, but they were often omitted.

Two theories were suggested to explain how phonology interacts with other linguistic elements in children's linguistic performances and difficulties. Surface theory involves the principle of complexity and mapping theory involves both complexity and the lexical/ functional and semantic/syntactic oppositions. Contradictory results were obtained for the surface theory, as complexity was found to be important for phonology but not for syntax. Saliency, on the contrary, had an effect on syntax but not on phonology. An explanation of this could be that syntactic complexity as defined in this article was inadequate, either in principle, or in its adaptation to French. Mapping theory did not fare much better. Some results showed that the lexical/functional opposition could be interesting, but the stronger correlations for salience in syntax suggests that the lexical/functional divide was not optimally established. In a similar way, the opposition between semantics and syntax was only marginally supported, and needs to be better tailored to the properties of the French language.

It remains to be seen whether the mapping principle itself should be rejected and a different origin for this effect established.

Conclusion

Three theories that put the existence of a phonological deficit at the core of the difficulties encountered by children with SLI were studied. It was found that five linguistic parameters could be used to differentiate one theory from another. Predictions for these parameters were made and tested against the results of SLI and control children with the same language age in phonology and syntax. The hope was that this would allow the theory that best explained the results to be identified.

However in practice no theory stood out. For no theory were all the predictions confirmed. The best theory appeared to be pure phonological theory, but one parameter of this theory was not validated (salience) and the results obtained could not be fully explained by the phonological properties of the French language (especially the differences between categories linked to verbs and those linked to nouns). Nonetheless, this stresses the importance of taking phonological difficulties into account in any theory about specific language impairment. It also means that, if better results could be expected from more adequate analysis of grammatical deficits, the analysis of phonology presented above is an efficient one.

Many results appeared to be dependent on the properties of the children's mother tongue. To explain the results it appears to be necessary to redefine the notions of syntactic complexity, lexical/functional opposition, and semantic/syntactic opposition. This redefinition will have to be done taking into account the interdependencies between the parameters, not on a parameter by parameter basis.

For example, in French, auxiliaries are marked for tense, number and person so they were considered as the most complex category. However they displayed a very low error rate in syntax. This could be explained by a lexicalisation effect: young children do not have a clear mastery of verb marking, which in French appears at the end of words. This is attested by the low number of erroneous verb markings. It is possible that at this age the auxiliary is also lexicalised. From a morphological point of view, this would mean that past and periphrastic future tenses are created by adding a vowel or a syllable to the beginning of the verb and by modifying the vowel at the end of the verb (for example, for the verb *danser* (to dance), present tense *danse* /dãs/, past tense *a dansé* /adãse/, periphrastic future *va danser* /vadãse/). The use of the determiner and the personal pronoun could also be lexicalised at some point in language development, which could explain the low number of gender errors on nouns, especially for young children.

The most original aspect of our study is that it takes into account results for all syntactic categories, and not only those known to be weak in children with SLI. The results show the limits of recent phonologically-based theories. These limits are not related to the phonological part of the theories, but to the syntactic part. Phonological complexity is clearly a good predictor of children's performance. It is the syntactic part of the theories that appeared to be lacking. For example, for French, a parameter such as saliency has a facilitating effect for syntax but not for phonology, at least for children with SLI. This type of result was not included in theories based on observations from other languages. Our proposal is that the properties of the syntactic system should be redefined to take into account the properties of the system displayed by the children at each point in their development and not the properties of the input to the children. This applies especially to the interrelations between semantic, lexical and syntactic knowledge. After such a redefinition, it remains to be seen

which theory (surface, mapping or some other theory) best describes the children's difficulties.

The results obtained in this work give several directions that could be tested in remediation studies. First, for phonology, complexity is a fundamental factor. It would be useful to train the children on complex words, but not especially on syntactic words as they are phonetically correctly produced. Second, for syntax, stress appears to be a facilitating parameter. So it is indeed useful to put more stress on words which are a target for remediation, as it is often done. Also, the absence of syntax complexity effects could mean that children use grammatical features in a lexical way before developing grammatical competence. Production would be thus more advanced than comprehension. It would be interesting to use children's very productions and help them to understand better what they produce. This could help them to start using functional words with their true grammatical function, at least for some specific items. More generic knowledge would then develop later.

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Table 1. The influence of each parameter on the theories being tested

Theory Parameter	Pure phonological	Surface	Mapping
Salience (+)	X	X	X
Phonological complexity (–)	X	X	X
Function word (–) / Lexical word (+)			X
Syntactic complexity (–)		X	X
Syntactic (–) / Semantic (+) (imageability)			X

Note: The parameters that are relevant for each theory are indicated with crosses. The effect expected from the nature of the parameter is indicated between brackets: '+' means that this parameter should make the children's task easier (facilitation effect), while '–' means that it should hinder their performance.

Table 2. The predicted influence of each parameter by category

Parameter Category	Salience (+)	Phonological complexity (−)	Lexical (+) / Functional (−)	Syntactic complexity (−)	Semantic (+) / Syntactic (−)
Adverb	10	5	6.6	10	6.6
Auxiliary verb	5	7.5	3.3	2	3.3
Determiner	5	10	3.3	4	3.3
Noun	10	5	10	8	10
Preposition	5	7.5	3.3	10	10
Strong pronoun	10	7.5	3.3	4	10
Subject pronoun	5	10	3.3	4	3.3
Marked verb	10	2.5	10	6	6.6
Unmarked verb	10	5	10	6	6.6

Table 3. Syntactic complexity by syntactic category

	Feature	Number of features	Value
Adverb	None	0	10
Auxiliary verb	Tense, number(1/2), person	2.5	2
Determiner	Gender, number	2	4
Noun	None (number and gender for some nouns)	0.5	8
Preposition	None	0	10
Strong pronoun	Gender, person	2	4
Subject pronoun	Gender, person	2	4
Unmarked verb	Tense (non-pronounced), number (1/2)	1.5	6
Marked verb	Tense (pronounced), number(1/2)	1.5	6

Note: The second column shows the features which are relevant for each category, while column four gives the value used in the statistical analysis.

Table 4 : General characteristics of the participants

Group	Age	MLU	Phonological inventory (number of phonemes produced)
SLI (n=12)			
Mean (S.D.)	7;7 (1;5)	3.8 (1.2)	32.8 (1.34)
Range	5;5 –11 ; 11	2.3 – 6.1	30–35
Controls (n=12)			
Mean (S.D.)	4;0 (0)	3.7 (0.8)	34.8 (1.95)
Range	4;0-4;0	2.0-5.6	31–38

Table 5. The average number and percentage of words produced in each syntactic category by SLI and control children

	No. of words		% of words	
	SLI	Control	SLI	Control
Adverb	16 (11)	14 (9)	3.7 (1.5)	3.2 (1.4)
Auxiliary	10 (9)	4 (2)	2.0 (1.2)	1.2 (0.4)
Determiner	45 (14)	53 (15)	10.7 (3.1)	13.5 (3.1)
Noun	62 (23)	62 (16)	14.3 (4.1)	15.9 (4.2)
Preposition	18 (8)	20 (7)	3.9 (104)	4.8 (1.0)
Strong pronoun	12 (15)	7 (6)	2.7 (2.8)	1.7 (1.2)
Subject pronoun	47 (34)	40 (20)	9.5 (4.8)	9.1 (3.4)
Marked verb	20 (8)	19 (8)	4.8 (1.6)	4.5 (1.1)
Unmarked verb	17 (13)	21 (8)	3.5 (2.3)	4.6 (2.1)

Note: Figures within brackets are standard deviations.

Table 6. The percentages of phonologically (phonology) and syntactically (syntax) correct words recorded among SLI and control children

	Phonology			Syntax		
	SLI	Control	p value	SLI	Control	p value
Adverb	67%	92%	0.0003	99%	99%	0.92
Auxiliary	92%	98%	0.15	95%	99%	0.18
Determiner	89%	96%	0.018	88%	95%	0.005
Noun	62%	84%	0.0001	99%	100%	0.095
Preposition	81%	94%	0.024	84%	94%	0.0012
Strong pronoun	69%	95%	0.002	97%	96%	0.94
Subject pronoun	73%	91%	0.004	73%	81%	0.27
Marked verb	48%	69%	0.025	93%	95%	0.20
Unmarked verb	56%	88%	0.0001	96%	97%	0.46

Table 7. The correlations between the predictions for each linguistic parameter and the results for children with SLI and control children

	Salience (+)	Phonological complexity (−)	Lexical (+) / Functional (−)	Syntactic complexity (−)	Semantic (+) / Syntactic (−)
SLI phono	−0.84**	0.79*	−0.85**	−0.34	−0.41
Control phono	−0.55	0.76*	−0.78*	−0.22	−0.19
SLI syntax	0.73*	−0.56	0.51	0.18	0.40
Control syntax	0.48	−0.63	0.39	0.25	0.38

Note: * indicates a value of $p < 0.05$, ** a value of $p < 0.01$.