Passive verb morphology: The effect of phonotactics on passive comprehension in typically developing and Grammatical-SLI children

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Abstract

In this study we explore the impact of a morphological deficit on syntactic comprehension. A self-paced listening task was designed to investigate passive sentence processing in typically developing (TD) children and children with Grammatical-Specific Language Impairment (G-SLI). Participants had to judge whether the sentence they heard matched a picture they were shown. Working within the framework of the Computational Grammatical Complexity Hypothesis, which stresses how different components of the grammar interact, we tested whether children were able to use phonotactic cues to parse reversible passive sentences of the form the X was verbed by Y. We predicted that TD children would be able to use phonotactics to parse a form like touched or hugged as a participle, and hence interpret passive sentences correctly. This cue is predicted not be used by G-SLI children, because they have difficulty building complex morphological representations. We demonstrate that indeed TD, but not G-SLI, children are able to use phonotactics cues in parsing passive sentences.

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1. Introduction

Language processing by children, and the manner in which it breaks down in those who have Specific Language Impairment (SLI), is currently a vibrant area of research. A number of studies...
have investigated language processing in typically developing (TD) and/or SLI children (Clahsen et al., 2004; Felser et al., 2003; Fonteneau and van der Lely, 2005; Marinis and van der Lely, under revision; Montgomery and Leonard, 1998; Windsor, 2002; Montgomery, 2005). Such investigations enable us to understand more fully the processing of particular linguistic forms in typical development, and also to characterize how processing can break down.

The present study brings together two aspects of language that children with a particular form of language impairment, Grammatical-SLI, find problematic—syntax and morphology. In this paper we investigate the impact of phonotactics on the processing of passive sentences, something that to our knowledge has not been studied in either typical or atypical development. We begin this introduction with a discussion of the linguistic characteristics of G-SLI, and with an outline of the model that we have proposed can account for G-SLI, the Computational Grammatical Complexity Hypothesis. We then move on to discuss how passive sentences and morphology are acquired in TD and G-SLI children, and outline the motivation for our study.

1.1. Linguistic characteristics of G-SLI

SLI is a deficit in the acquisition of language despite adequate hearing, non-verbal abilities and opportunity, and the absence of any known neurological disorder (see Leonard, 1998, for a review). The incidence of SLI in the preschool population is estimated at 7% (Tomblin et al., 1997), but in some children the disorder persists until adulthood. Within the SLI population as a whole, deficits have been diagnosed in syntax, morphology, phonology, pragmatics and the lexicon. However, the population is also heterogeneous, with considerable variation in both the severity and the linguistic pattern of impairment. Although this phenotypic heterogeneity is widely acknowledged (Bishop, 1997; van der Lely, 2003), there is little consensus as to how it is best described and accounted for, and consequently it is not accommodated within most theories of SLI.

One pattern of impairment that has been characterized in detail is termed ‘Grammatical-SLI’ (for English: van der Lely, 1997, 2005; van der Lely et al., 1998; for Greek: Stavrakaki, 2002; for Hebrew: Friedmann and Novogrodsky, 2004). This subgroup of SLI children is argued to have a relatively homogenous pattern of linguistic deficits. G-SLI children’s language difficulties encompass the core aspects of grammar—syntax, morphology and phonology. In syntax, there are particular difficulties with the production and comprehension of complex syntactic forms, specifically those involving syntactic dependencies characterized by ‘Movement’ (Chomsky, 1995), e.g. tense marking (production of bare stem forms, e.g. *Yesterday he go to school), wh-questions (gap-filling and lack of do-support, e.g. Who Mrs Scarlet saw someone in the lounge?) and passives (incorrect assignment of thematic roles, in, for example, *The elephant was kicked by the mouse) (van der Lely, 1996a,b, 1998; van der Lely and Battell, 2003; van der Lely and Stollwerck, 1997). In morphology, past tense and agreement suffixation are severely affected, and children’s use of regular plurals inside compounds (e.g. *rats-eater) reveals that their knowledge of plurality is unlike that of language-matched TD children (van der Lely, 1998; van der Lely and Christian, 2000; van der Lely and Ullman, 2001). In phonology, children have difficulties repeating non-words that contain complex syllabic and metrical structures, such as consonant clusters and initial weak syllables (Gallon et al., submitted for publication; Marshall, 2004; Marshall et al., 2003). Lexical deficits are reported, but are less severe than the grammatical deficits, and are argued to be secondary to them (van der Lely, 2005). Importantly, the deficit is a persistent one—children are only included in the subgroup if they are at least 9 years old, and so are at an age when they are unlikely to ‘grow out of’ their impairment. Although
the existence of this subgroup is controversial, the approach taken by van der Lely and her colleagues to investigate SLI reduces the phenotypic heterogeneity that besets the majority of studies of SLI, and makes the data more amenable to a coherent psycholinguistic explanation.

The model proposed to account for the linguistic deficits in children with G-SLI is the Computational Grammatical Complexity (CGC) Hypothesis (Marshall, 2004; Marshall and van der Lely, in press; Marshall and van der Lely, submitted for publication; van der Lely, 2005). The CGC Hypothesis claims that children with G-SLI have difficulty comprehending and producing complex linguistic structures in three components of the computational grammar: syntax, morphology and phonology. Furthermore, it stresses the cumulative and interactive effects that these deficits have on linguistic constructions such as the English regular past tense, where linguistic complexity in all three components of grammar is required (Marshall, 2004; Marshall and van der Lely, submitted for publication; van der Lely, 2005). In this paper we investigate the interaction between syntactic and morphological complexity in passive constructions.

1.2. Acquisition of the passive

Full passives include a by-phrase, e.g. *The elephant was kicked by the mouse*. Short passives lack the by-phrase, e.g. *The elephant was kicked*. TD children acquire short passives before full passives (Horgan, 1978; Mills, 1986). Early acquired passives represent after-the-fact observations about states, i.e. they describe a state, not an event (e.g. *The tree is broken* can be interpreted similarly to *The tree is green*). Such passives are hence adjectival rather than verbal. Furthermore, Maratsos et al. (1985) found that 4–5 year old children have more difficulties in the comprehension and production of non-actional passives (e.g. with verbs such as *hear* and *see*) than actional passives (e.g. with verbs such as *comb* and *touch*).

Verbal passives involve a more complex syntactic structure than adjectival passives. Whereas adjectival passives are considered to be base-generated and not to involve any type of movement, in verbal passives the object of the active verb (*The mouse was kicking the elephant*) becomes the subject of the passive verb (*The elephant was kicked by the mouse*). This happens through movement of the noun phrase from the object to the subject position, as illustrated in (1) below.

(1)  [The elephant] was kicked \( _{t_i} \) by the mouse.

This movement leaves a silent copy (‘trace’) behind, that is co-indexed with the moved constituent and is assigned a thematic role by the verb. The moved constituent (*the elephant*) and the trace (\( _{t_i} \)) form an (A)rgument-chain, i.e. they are both in argument positions of the same verb and they share some syntactic features. According to Borer and Wexler (1987), young children cannot comprehend and produce verbal passives because they are unable to form A-chains, and thus they cannot assign the thematic role to the moved constituent. In contrast, they do not make errors with adjectival passives because these do not involve movement and A-chains. Borer and Wexler suggested that the formation of A-chains is subject to maturation, and the mechanism responsible for the formation of A-chains does not mature until at least the age of 5 or 6.

It has long been known that children with SLI have difficulty interpreting reversible passives (Bishop, 1979). A series of studies by van der Lely and colleagues have characterised this deficit in G-SLI children. G-SLI children have problems interpreting passive sentences when general semantic and world knowledge cannot be used to facilitate comprehension, and where the child
has to rely instead on abstract syntactic knowledge. This is the case when the event is improbable, reversible, and when a novel verb is used (van der Lely, 1994, 1996a,b; van der Lely and Dewart, 1986). Moreover, in short but unambiguously verbal passive sentences (e.g. *The fish is being eaten*), G-SLI children choose the syntactically simpler adjectival (stative) interpretation on a substantial number of occasions. This pattern is emphasized for short passives that are ambiguous between a stative and a verbal reading (e.g. *The fish is eaten*)—G-SLI children are more likely to choose the stative reading than the verbal reading.

1.3. Morphology and phonotactics

One of the most severe and widely-reported deficits in SLI affects verb morphology, and in particular the use of suffixes that mark tense and agreement (see review in Leonard, 1998). In English the pattern is one of variable suffix omission, e.g. *Yesterday I play_/played football, He always watch_/watches television*. One topic of very lively debate concerns the underlying cause of the morphological deficit. According to some researchers, it reflects an impairment in auditory processing, which affects the perception of suffixes of low perceptual salience and rapid duration at the end of verbs (Joanisse and Seidenberg, 1998; Karmiloff-Smith, 1998; Marchman et al., 1999). For others, however, the morphological deficit reflects an impairment in a grammatical component of the language, although the nature of this impairment is likewise subject to vigorous debate. It is variously proposed to be due to the child persisting in an extended optional infinitive stage (Rice and Wexler, 1996), an inability to construct grammatical rules (Ullman and Gopnik, 1999), an inability to set up agreement relations (Clahsen et al., 1997) or an inability to construct hierarchically branching complex morphological forms (Marshall and van der Lely, 2006; van der Lely, 2005). This debate is theoretically relevant in that it relates to whether suffixation is carried out using a single route, analogical mechanism, or whether it is instead a rule-based process carried out by a separate component of the grammar (dual mechanism model). Those who claim that morphological impairments stem from an auditory processing deficit interpret the SLI data as supporting a single mechanism model (Joanisse and Seidenberg, 1998), whereas those who claim that they stem from a linguistic deficit interpret the data as supporting a dual mechanism model (Pinker and Ullman, 2002).

In order to probe whether the past tense difficulties demonstrated by English-speaking G-SLI children best support a single or a dual mechanism model of morphology, Marshall and van der Lely (2006) investigated the impact of verb final phonotactics on past tense production. Because regular verbs stems frequently end in a consonant, suffixation often produces clusters. Two kinds of clusters exist with regards to phonotactics—legal clusters, which also occur in monomorphemic words (e.g. the /st/ at the end of past tense *missed* is also found in monomorphemic *mist*), and illegal clusters, which only occur in suffixed forms (the /gd/ of *hugged* does not occur at the end of any monomorphemic word of English). Illegal clusters, because they occur only in suffixed forms, are less frequent than legal clusters, which occur in both suffixed and non-suffixed forms. This frequency difference formed the basis of Marshall and van der Lely’s study.

Marshall and van der Lely (2006) hypothesized that if G-SLI children are impaired in forming complex morphological forms, and are having to remember them by rote (van der Lely and Ullman, 2001), then cluster frequency should impact on performance, with lower suffixation rates for phonotactically illegal compared to legal inflected forms. In contrast, if typically developing children are creating past tense forms using a suffixation rule, then the frequency of the cluster formed by suffixation should not impact on performance in a past tense elicitation task. Performance should therefore be equivalent on both phonotactically legal and illegal
inflected forms (e.g. *missed* as compared to *hugged*), when past tense frequency and lemma frequency (i.e. the sum of the frequencies of all morphological forms of the verb, e.g. *miss, missed, missing* and *misses*) are controlled. This was indeed the case—whereas two groups of G-SLI children were revealed to be less likely to mark tense on a verb when the cluster would have been illegal, there was no impact of phonotactics on six groups of typically developing children or on a group of individuals with Williams Syndrome.

Is phonotactics a phenomenon relevant only to tense or does it affect other morphemes with a syntactic function, and if so, what can it reveal about linguistic processing in TD and language-impaired children? For example, it might be the case that typically developing children are able to use illegal cluster phonotactics to parse morphologically complex forms, but that this cue is not available to children who have a morphological deficit, such as those with G-SLI. In this paper we investigate the past participle, which for English regular verbs has same phonological form as the past tense form of the verb. This enables us to investigate further the grammatical deficit in G-SLI: compared to past tense forms, participles are syntactically different, but the phonology is the same as for past tense forms. Past participle forms are lexically affixed, and so clearly involve morphology. Hence we can investigate suffixed forms that are morphologically and phonologically similar to tensed forms, but that participate in a different syntactic construction—the passive.

2. Method

2.1. Participants

Fourteen children and teenagers with G-SLI (11 boys) aged between 10;11 and 15;3 years participated in this study. All have a professional diagnosis of SLI and are attending specialist language schools or language units, but demonstrate non-verbal cognitive abilities in the normal range (mean non-verbal IQ was 93.9 as measured by a composite of the Ravens Progressive Matrices, Raven, 1998, and the Block Design subtest of the British Ability Scales, Elliott, 1996), normal hearing, no articulation difficulties and appropriate emotional and social behaviour.

Furthermore, all participants meet the criteria for G-SLI (van der Lely and Batell, 2003; van der Lely et al., 1998; van der Lely and Ullman, 2001), in that they have persistent problems with grammatical aspects of language in production and comprehension, as evinced by their performance on a range of standardised and non-standardised tests. Their mean $z$-score on a test of sentence comprehension (Test for the Reception of Grammar, TROG, Bishop, 1989) is $-1.8$, with an equivalent age of 6;5, while their mean $z$-score on a measure of single word comprehension (British Picture Vocabulary Scales, BPVS, Dunn et al., 1997) is $-1.5$, with an equivalent age of 7;8. In addition to these standardized tests, the G-SLI children were assessed on a series of non-standardised tests that tap into the aspects of grammar that are particularly problematic for them. These include the Verb and Agreement and Tense Test (VATT, van der Lely, 2000) and the Test of Active and Passive Sentences (TAPS, van der Lely, 1996a,b). Each participant made 20% or more errors on each of these tests (see van der Lely, 2005).

It is important to compare the performance of the G-SLI group to that of a wide age range of TD children, in order to determine whether the pattern of performance in G-SLI children is shown by TD children too. Three control groups of typically developing (TD) children participated in this study (see Table 1). Two matched the G-SLI children on measures of sentence comprehension or vocabulary. The youngest group, TD1, was a group of 14 children with a mean

\[2\] Unlike the tensed form of the verb, past participles show no V to I movement (Grimshaw, 1990).
This control group was matched to the G-SLI group (on raw score) on the TROG (Bishop, 1989). There was no significant difference between the two groups' scores on the TROG ($t(27) = 0.934, p = 0.358$). The second group, TD2, comprised 19 children with a mean age of 8;7 (range 7;9–8;11). This control group was matched to the G-SLI group on the BPVS (Dunn et al., 1997). There was no significant difference between the two groups' scores on the BPVS ($t(32) = 1.686, p = 0.101$). The third group, TD3, consisted of 14 children with a mean age of 10;1 (range 8;9–10;9). The sentence comprehension and vocabulary abilities of these children were significantly higher than those of the G-SLI group (TROG: $t(27) = 4.733, p < 0.001$; BPVS: $t(27) = 2.09, p < 0.05$), and so they will not be directly compared to the G-SLI group, but they are included in this study so that we can investigate typical development over a wide age range.

### 2.2. Design and material

In this study we used a novel task that combines a picture-verification and a self-paced listening or auditory moving window technique (Ferreira et al., 1996). In a picture verification task participants typically see a picture, listen to a sentence, and have to decide whether the sentence matches the picture. In a self-paced listening task, subjects listen to sentences in a word-by-word or phrase-by-phrase fashion, and press a button to receive successive words or phrasal segments. This task provides a segment-by-segment measure of processing time. In our experiment, participants first saw a picture on the computer screen. Then they listened to a sentence segment-by-segment while the picture remained on the screen. We recorded how fast participants processed each segment. After hearing each sentence, participants had to decide whether the sentence they heard matched the picture. It is this judgment measure that concerns us in this present paper—the reaction time data are presented separately for reasons of space (Marinis and van der Lely, in preparation).

The material for our task comprised 135 sentences, including 15 practice sentences, 80 experimental sentences and 40 filler sentences. The experimental sentences were reversible.
active and passive sentences, whereby both the agent and the patient were animals, as illustrated in (2) and (3) below:

(2) I think that the squirrel with the gloves was bathing the tortoise at his house last weekend.
(3) I think that the squirrel with the gloves was bathed by the tortoise at his house last weekend.

The pictures either matched the event in the sentence or they showed the event with the agent and patient reversed.$^3$

We included 20 different verbs, and each verb was used 4 times during the experiment. All verbs were monosyllabic and had a regular past tense form. Half had an inflected form that ended in a phonotactically legal cluster, whereas half had an inflected form that ended in an illegal cluster (the full list of verbs is provided in Appendix A).

There are eight experimental conditions of interest, as shown in (4) below, which allow us to explore the effects of sentence type (active versus passive), verb type (legal versus illegal cluster phonotactics$^4$) and picture type (match or mismatch to sentence):

(4) Experimental conditions
Active sentence – phonotactically legal verb – matching picture
Active sentence – phonotactically legal verb – non-matching picture
Active sentence – phonotactically illegal verb – matching picture
Active sentence – phonotactically illegal verb – non-matching picture
Passive sentence – phonotactically legal verb – matching picture
Passive sentence – phonotactically legal verb – non-matching picture
Passive sentence – phonotactically illegal verb – matching picture
Passive sentence – phonotactically illegal verb – non-matching picture

The auditory materials were spoken by female native speakers of English at a normal speaking rate. We recorded the sentences in an anechoic room on a Sony digital tape recorder, and we used CoolEdit software (Syntrillium) to edit the tapes. Four different experimental sets were created, each containing one version of the experimental sentences and one of the two pictures. Each participant encountered only one of those four sets containing 20 sentences of each condition. Thus, each participant heard only one version of each experimental sentence, and saw only one of the two pictures.

2.3. Procedure

The experiment was carried out at the children’s home or at school, and consisted of two 20–30 min sessions. Participants were seated in front of a laptop and a push-button box, and were

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$^3$ The prepositional phrases are relevant only for the on-line effects. They were used to separate possible on-line effects at the first NP from effects at the verb, and to avoid conflating an effect related to the assignment of theta roles and a wrap up effect at the end of the sentence.

$^4$ Note that cluster phonotactics, and the distinction between phonotactically legal and illegal clusters, is only relevant in passive sentences, where the past participle form of the verb occurs.
instructed to look at the picture on the computer screen and listen carefully to the pre-recorded sentences over headphones. In the first session, each child received a fixed set of instructions, first from the experimenter, and then through the headphones. They were taught how to press the button to hear the sentences, and they were given 10 practice sentences in order to familiarise themselves with the task. These practice sentences could be repeated if necessary. The second session took place on a different day or after a sort break, and was preceded by a further 5 practice sentences that could be repeated if necessary.

In each trial, the child saw a picture on the computer screen. After 1000 ms, the presentation of the sentence began. After listening to each segment, the child had to press a button on a push-button box as quickly as possible in order to receive the next segment. The end of the sentence was indicated by a tone. The computer recorded the time between the onset of each segment and the button press. Presentation of the stimuli and the recording of the reaction times were controlled by the software package E-Prime (Psychology Software Tools). After hearing the entire sentence, the child had to then decide whether it matched the picture. This was recorded by the experimenter on a separate form. Participants did not receive feedback as to whether they had answered accurately.

2.4. Predictions

Our hypothesis concerns parsing: we predict that TD children will be able to use illegal cluster phonotactics as a parsing cue, to aid them in interpreting passive sentences. In contrast, G-SLI children will be unable to use phonotactics as a cue, because of their morphological deficit—they have difficulty building up an abstract representation of stem + suffix, and are therefore not able to use cues in speech stream that indicate the presence of a stem + suffix structure. We therefore predict that TD children will be more successful at interpreting passive sentences when the participle ends in a phonotactically illegal cluster. For G-SLI children, however, whether the participle ends in a phonotactically legal or illegal cluster will have no effect. Hence we predict that G-SLI children's deficit in interpreting passive sentences, which has hitherto been interpreted as a syntactic deficit, may have a partly morphological cause as well.

3. Results

The scores from one child in the TD1 group and one in the TD2 group were more than 2 standard deviations below the mean for their own group, and so these data were excluded from further analyses. Table 2 shows the accuracy of the remaining participants in each group. In our analysis, we first compare data from the three control groups. We performed a 3 (participant group: TD1, TD2, TD3) × 2 (sentence type: active, passive) × 2 (verb type: phonotactically legal, illegal) × 2 (picture type: match, mismatch) ANOVA. There are significant main effects of sentence type and picture type. Passive sentences are significantly harder than active sentences, \( F(1,42) = 4.643, p = 0.037 \), and performance is significantly lower when the picture and sentence do not match, \( F(1,42) = 30.884, p < 0.001 \). The lack of significant interactions with group indicates that all groups behave in the same way with respect to the factors of interest. However, there is a significant main effect of group, \( F(2,42) = 6.189, p = 0.004 \). Post hoc \( t \)-tests (Bonferroni-corrected) indicate that the only significant difference is between the TD1 and TD3 groups, \( p = 0.004 \).

Note that there is no significant main effect of verb type. This is important because it indicates that neither set of verbs (phonotactically legal or illegal in the past participle form) is intrinsically
more difficult than the other, due to differences in properties unrelated to phonotactics, such as imageability. However, verb type enters the picture when we consider higher order interactions. There is a significant three-way interaction between sentence type, verb type and picture type, \( F(1,42) = 6.072, p = 0.018 \), and there are significant two-way interactions between sentence type and verb type, \( F(1,42) = 6.628, p = 0.014 \), and between verb type and picture type, \( F(1,42) = 8.733, p = 0.005 \).

Our hypothesis concerned a particular comparison—we predicted better performance on passive verbs ending in a phonotactically illegal cluster, although we did not make a prediction according to picture type. Therefore, in order to reduce the number of pairwise comparisons carried out and to maintain sensitivity, we compare passive legal match with passive illegal match, and passive legal mismatch with passive illegal mismatch (we are not justified in collapsing across picture type because of the three-way interaction). We reduce the alpha level to 0.025 to compensate for multiple comparisons. There is no significant difference between passive illegal match and passive legal match, \( t(44) = 0.514 \), but performance is significantly better for passive illegal mismatch compared to passive legal mismatch, \( p = 0.001 \). In other words, performance is better for passive sentences containing a phonotactically illegal cluster, but only in the mismatch condition.

Now we consider the performance of the G-SLI children compared to that of the TD1 controls only, as these two groups were matched on general sentence comprehension and performed at similar levels on this task.\(^5\) A 2 (participant group: TD1, G-SLI) \( \times \) 2 (sentence type: active, passive) \( \times \) 2 (verb type: phonotactically legal, illegal) \( \times \) 2 (picture type: match, mismatch) ANOVA reveals a significant main effect of match, \( F(1,25) = 29.879, p < 0.001 \), but no other significant main effects. The lack of main effect of group indicates that we are justified in comparing the relative pattern of performance of these two groups: qualitatively different performance by the G-SLI children cannot be attributed to their being at a different level of active/passive comprehension.

Again, our hypothesis concerns a particular comparison—we predicted that while the typically developing children would perform better on passive verbs ending in a phonotactically illegal cluster, G-SLI children’s impairment in morphology would render them insensitive to phonotactics, and they would show no difference between passive sentences with illegal cluster phonotactics compared to passive sentences with legal cluster phonotactics (we did not make a

\(^5\) Note that the results are very similar when we compare the G-SLI group to the vocabulary-matched LA2 controls.
prediction according to picture type). The four-way interaction is not significant, but there is a significant three way interaction between group, sentence type and verb type, $F(1,25) = 4.261$, $p = 0.050$. To unpack this interaction we compare passive sentences with a phonotactically legal verb to passive sentences with an illegal verb, first for the TD1 group and then for the G-SLI group. For the TD1 group, $t(12) = -2.084$, $p = 0.059$, and for the G-SLI group, $t(13) = 0.723$, $p = 0.482$.

The results of the $t$-test within the TD1 group are approaching significance, and together with the highly significant difference between passive legal and illegal sentences when the three control groups are considered together, we conclude that the G-SLI group show a qualitatively different pattern of performance to typically developing children. While typically developing children show an advantage for passive sentences whose past participles contain phonotactically illegal clusters, the G-SLI children show no such advantage. This qualitatively different pattern of performance suggests that G-SLI children process the verb in passive sentences in a different way to TD children. We explore possible reasons for this in the discussion in section 4.

4. Discussion

In this study we investigated whether typically developing (TD) and Grammatical-SLI (G-SLI) children are able to use phonotactic cues to parse passive sentences. The performance of TD children shows an improvement up to the age of 10. All groups show the same pattern of performance with regards to whether or not the sentence they hear matches the picture they see—they are more accurate in the match conditions. They are also more accurate at interpreting active sentences than passive ones. However, the TD and G-SLI groups differ with respect to the impact of phonotactic legality at the end of the past participle. TD children are more accurate in interpreting a passive sentence when the participle has illegal cluster phonotactics. For G-SLI children, however, cluster phonotactics has no impact. In this section we first discuss the effects of match and phonotactics, and what they reveal about the processing of passive sentences in TD and G-SLI children. We then discuss how these results contribute to our understanding of the language deficit in SLI.

We first tackle the finding that all children are less accurate in interpreting a sentence when that sentence does not match the picture they see, be that sentence active or passive. We hypothesise that children make an initial assignment of thematic roles very early in the sentence, before they encounter the verb and the second argument of the verb. For example, when the picture shows a squirrel bathing a tortoise, and they listen to the mismatch sentence I think / that / the squirrel / with the gloves / was bathed / by the tortoise / at his house / last weekend, the actor in the picture is the subject of the sentence. We hypothesise that after listening to the segment the squirrel, children make an initial assignment of the thematic role Agent to the first noun phrase of the sentence, and expect to hear an active sentence. Then, when they encounter the segment was bathed, they have to re-analyse the sentence, and assign the thematic role Patient/Theme to that noun phrase. This re-analysis phase is prone to error in all the populations we tested. In order to give the correct judgement, i.e. that the sentence does not match the picture, the child has to pay special attention to the morphology of the verb if he/she is not to interpret the sentence as being consistent with the picture.

As for the effect of cluster phonotactics in passive sentences, our explanation is as follows. In order to interpret the sentence as a passive, and to assign thematic roles correctly, the child needs to parse the participle into stem + suffix and interpret the aspectual feature of the suffix in relation
to the tense marker (the auxiliary). We hypothesise that TD children are able to represent a morphologically complex form as stem + suffix. Illegal phonotactics provide a cue as to the existence of a stem + suffix boundary. This is because forms such as hugged and touched can only be suffixed, because those final clusters cannot occur in monomorphemic forms. Participles such as kissed and called are, however, potentially ambiguous between a suffixed and monomorphemic form (as in the pairs missed/mist, billed/build, wrapped/rapt, tacked/tact etc.).

For TD children, the effect of phonotactic illegality is only significant in the mismatch condition—presumably performance in the two match conditions is too close to ceiling for any difference to be apparent. Why are G-SLI children unable to make use of phonotactic cues in the mismatch condition? We hypothesise, consistent with a series of studies of morphology in G-SLI children (Marshall and van der Lely, 2006; van der Lely and Christian, 2000; van der Lely and Ullman, 2001), that G-SLI children have difficulties parsing and creating morphologically complex forms, and therefore to build a representation of stem + suffix. Therefore, G-SLI children are unable to use the clue to morphological structure provided by the illegal clusters to parse past participles in passive sentences.

These results are theoretically important because they challenge single mechanism models of morphology. Such models reject the existence of a separate morphological component of the grammar and hold that frequency is critical, with high frequency patterns being acquired earlier and being available for analogy more readily than low frequency patterns. And yet here we have an example of TD children experiencing greater success with lower frequency patterns (phonotactically illegal clusters) than higher frequency patterns (phonotactically legal clusters).

Furthermore, our results also challenge the hypothesis that G-SLI children have difficulties perceiving the –ed suffix—these children do no worse than their language matched controls on the match sentences, where their performance is actually near to ceiling. Hence we have further evidence against the auditory processing theory of SLI, at least for this particular subgroup of children (see also van der Lely et al., 2004).

Instead, our results provide further evidence that G-SLI children process certain aspects of language differently to TD children (see also Fonteneau and van der Lely, 2005; Marshall and van der Lely, 2006; van der Lely and Christian, 2000; van der Lely and Ullman, 2001). Most parsimoniously for the results in this paper, is an explanation whereby G-SLI children have a deficit in building morphologically complex forms, within a cognitive model of language in which TD children have a dual route system for morphology. In G-SLI children the rule-based morphological component of the grammar, responsible for building representations of stem + suffix, is impaired. We have previously shown this for regular past tense and plural formation (van der Lely and Christian, 2000; van der Lely and Ullman, 2001; Marshall and van der Lely, 2006), and now we have shown that this deficit impacts on syntax too, in the parsing of passive sentences.

5. Conclusions

The evidence we have presented from this study supports the Computational Grammatical Complexity (CGC) account of G-SLI (Marshall, 2004; Marshall and van der Lely, in press; van der Lely, 2005). The CGC Hypothesis provides a novel viewpoint for considering the deficit in SLI. Rather than searching for a single locus for the deficit, e.g. in lower level sensory processing or a deficit affecting tense, the CGC Hypothesis considers independent deficits in the different components of grammar and their cumulative and interactive effects on different linguistic structures. We have previously shown that for tense, syntactic, morphological and phonological deficits all impact on tense, because regular past tense formation in English requires syntactic,
morphological and phonological complexity. In this paper we have shown that for passive comprehension, a linguistic structure that is already vulnerable in G-SLI because of its syntactic complexity, the morphological deficit also has an impact. Furthermore, we suggest that studies of typical language acquisition also need to consider the interaction between different levels of linguistic representation.

**Acknowledgements**

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**Appendix A. List of verbs**

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<th>Word</th>
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<td>called</td>
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<td>licked</td>
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<td>pulled</td>
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<td>stopped</td>
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**References**


