The Computation and Representation of Past-Tense Morphology in Specifically language impaired and Normally Developing Children

Heather K. J. van der Lely & Michael Ullman
Birkbeck College, University of London,
& Massachusetts Institute of Technology

1. Introduction

The mental representation and acquisition of regular *(look-looked)* and irregular *(give-gave)* past tense inflection has become the topic of a central debate in cognitive science. The debate focuses on whether a single mechanism or a dual mechanism accounts for the representation and acquisition of past tense morphology.

According to the dual mechanism view (Pinker and Prince, 1988; Pinker, 1991), regular past tense forms are computed by application of a grammatical -ed-suffixation rule, while irregular past tense forms are learned in and retrieved from associative memory. This dichotomy attempts to capture the predictability of regulars, and the fact that new ones are constantly being added (e.g., *moshed*), and the unpredictability of irregulars (e.g., *sing-sang, fling-flung, bring-brought*), and the fact that new ones are very rarely added.

In contrast, the single mechanism view (Rumelhart and McClelland, 1986; MacWhinney and Leinbach, 1991; Plunkett and Marchman, 1993) posits a single representational mechanism: a connectionist pattern-associator memory, with rules eliminated, and both regular and irregular forms produced as generalizations from previously learned similar verbs. This unified approach attempts to capture the probabilistic patterns found among the irregulars (*ring-rang, sing-sang, drink-drank, sit-sat*), as well as the predictability of the regulars.

Several lines of evidence suggest a dual mechanism in adults, including the following: First, higher frequency irregular past tense forms (*gave*) are produced significantly faster (Prasada, Pinker, Snyder, 1990), and judged significantly more acceptable (Ullman, 1993) than lower frequency irregular past tense forms (*dug*). In contrast, such frequency differences do not significantly affect reaction times or acceptability ratings for regular pasts (*looked* vs *stalked*). Because forms stored in memory are expected to show frequency effects, these results have been taken to support the dual mechanism. Second, greater phonological similarity of a novel (e.g., *spling*) or real verb stem (e.g., *spring*) to other real irregular verb stems (*sing, ring*) increases the likelihood of production and the acceptability ratings of irregular pasts (*splang, sprang*, c.f. *sing-sang, ring-rang*). In contrast, phonological similarity to regular verbs has no significant effects in the production or rating of novel or real regular verbs (Bybee and Moder, 1983; Prasada and Pinker, 1993;

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Ullman, 1993). Third, double dissociations between regular and irregular past tense production in several populations of brain-damaged adults suggest that distinct brain systems subserve the computation of the two types of past tense forms (Ullman et al., 1993).

In this paper we address the debate by examining the elicited production and judgment of real and novel regular and irregular verbs in normally developing children and in a group of Grammatically specific language impaired (SLI) children. Grammatical SLI children have a persisting language impairment with a disproportionate deficit in grammatical abilities. Van der Lely (1995, 1996) has hypothesised that this is a particular sub-group of SLI children that has a modular language deficit, affecting only grammatical abilities (syntax, morphology, and phonology). Investigations of these children's language may therefore shed light on the debate between the single and dual mechanisms for inflectional morphology.

If a dual mechanism accounts for past tense inflection in normally developing children, they should show frequency effects and phonological neighborhood effects for irregular, but not regular past tense forms. In contrast, if a single mechanism accounts for their past tense inflection, frequency effects and phonological neighborhoods might be found for regular as well as irregular past tense forms.

If SLI children are indeed afflicted with a developmental deficit that disproportionately affects grammar, then we can make the following predictions. If normal children have a dual mechanism, the SLI children's grammatical deficit should preclude a functional rule, and therefore regular past tense forms might be learned in the associative system alongside the irregular pasts. Thus the two past tense types should be similarly produced and similarly judged by the SLI children, but not necessarily by the normal children. In addition, we should find frequency effects for the regular pasts as well as the irregular pasts for the SLI children, but only for irregular pasts for the normal control children.

If normal children have a single mechanism, it is unclear what results a grammatical deficit would have. However, if we assume a separate component for non-past-tense grammar (i.e., the syntax underlying past tense morphology), SLI children and normal children should have similar production and judgment patterns over the two past tense types, although both past tense types may be impaired in SLI because of underlying syntactic deficits. There should be no difference in frequency effects between the SLI children and their control children.

2. Method

2.1 Subjects

The performance of 12 Grammatical SLI children (age 9;3 - 12;10) was compared with three groups of 12 language ability (LA) matched control children, who were developing normally. The LA1 controls (5;5 - 6;4) were matched to the

SLI children on a test of sentence comprehension (TROG, Bishop, 1983) and on a test of expressive morphological ability. The LA2 controls (6;5 - 7;4) and LA3 controls (7;5 - 8;9) were matched on tests of single word expression and comprehension. (See van der Lely, 1995; and van der Lely & Stollwerck, in press for further details of the subjects and the selection and matching procedure.)

2.2 Materials

We presented each subject with a total of 60 verbs in Experiment 1, the production task, and 64 verbs in Experiment 2, the judgment task. The verbs, which were selected from the set used by Ullman (1993), belonged to four classes. There were 32 real verbs, comprised of 16 irregular verbs (*give-gave*) and 16 regular verbs *(look-looked)*; half in each class had high past tense frequencies (e.g., *gave, looked*) and half had low past tense frequencies (e.g., *dug, stalked*), according to the Francis and Kucera (1982) and COBUILD (developed by the University of Birmingham) frequency counts. The stems of the regular verbs (*look*) were selected to be phonologically distant from the stems of all irregular verbs. In addition, there were 16 "novel irregular verbs" (e.g., *crive-crove, frink-frank/frunk, cleed-cled*), whose stems were phonologically similar to the stems of irregular verbs (c.f., *drive-drove, drink-drank, cling-clung; feed-fed, lead-led*). Finally, there were 12 "novel regular verbs" (*prass-prassed*) in the production task, and 16 in the judgment task; their stems were phonologically distant from the stems of irregular verbs. The verbs were randomized for presentation purposes. See Ullman, 1993, for further details on the verb classes.

3. Experiment 1: Production Task

3.1 Presentation

The task was explained to the child. Each verb was presented in the context of two sentences, which were spoken by the experimenter. In the first sentence (see (1) a.) the child heard the real or novel verb. The child had to repeat the sentence. This was followed by the test sentence (the past tense context sentence) ((1) b.). The child was encouraged to repeat the test sentence from *yesterday* and to fill in the missing word.

(1) a. Every day I **spling** around London
b. Just like every day, yesterday I _____ around London.

The child was told to say the first thing he thought of which sounded right to him. He was told that in some of the sentences he may not know some of the words but he was to do the best he could. The experimental sessions were recorded using a high quality DAT recorder and were later transcribed.

3.2 Coding of Responses

Each response to the missing verb in each second sentence was assigned to one of three categories: unmarked form (e.g., *look, give, crive, prass*), -ed-suffixed past tense form (*looked, gived, crived, prassed*), and irregularized past tense form (*look-leck, give-gave, crive-crove, prass-pruss*). Categorization as an irregular past for verbs other than real irregulars was made by the experimenter.

3.3 Results and Discussion

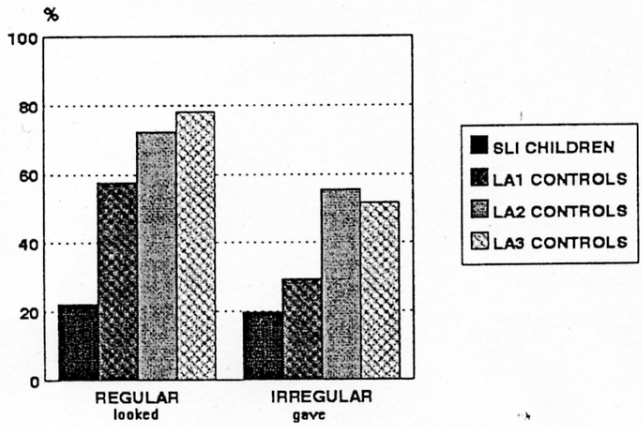

Figure 1. Experiment 1, Production Task. Real regular and irregular verbs: Mean percentage of correct responses for the subject groups.

Real regular and irregular verbs

The SLI children showed a low level of correct past tense marking for both regular and irregular verbs (*looked, gave*) (see Figure 1), with unmarked forms (*look, give*) comprising the majority of their responses, i.e. 78% and 80% of their regular and irregular verb responses, respectively. A 4 x 2 ANOVA, Group x Verb class (regulars and irregulars), was carried out by subject (analysis 1) and by item (analysis 2). The interaction was significant at the .05 level by item ($F2(3,136) = 18.46$, $p < .001$) and approached significance by subject ($F1(3,43) = 2.51$, $p = 0.07$). Follow-up tests revealed that in the production of regular past tense forms (*looked*), the SLI children performed significantly worse than both the young, morphologically-matched LA1 controls ($F(1,43) = 15.42$, $p < .001$) and the older, vocabulary-matched LA2 and LA3 controls ($F(1,43) = 44.99$, $p < .001$). In contrast, in the production of irregular pasts (*gave*), the SLI children were not significantly worse than the LA1 controls ($F(1,43) = 1.07$, $p = .31$), although their disadvantage in comparison to the older LA2 and LA3 controls was significant ($F(1,43) = 8.48$, $p < .01$). While the three LA control groups were significantly better at regular than irregular verbs (*looked* vs *gave*) (for all three analyses, ($t(30) > 2.2$, $p < .050$), the SLI children's response rates for regular and irregular verbs were not significantly different ($t(30) = 0.31$, $p = .76$) (see Figure 1). Thus the SLI children produced regular and irregular pasts at similar success rates, which were in

turn similar to the young normal controls' production rate for irregular pasts, but not regular pasts.

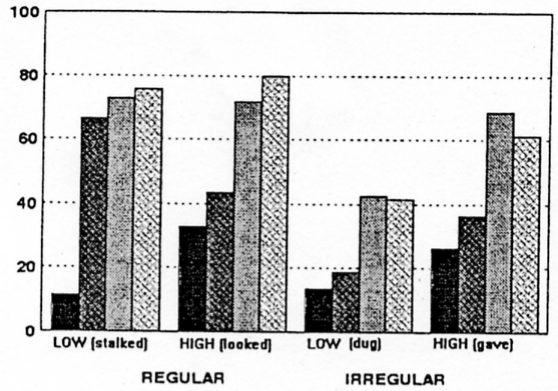

Figure 2. Experiment 1, Production Task: Mean percentage of correct respones for the high and low frequency regular and irregular verbs.

The effect of high and low frequency on the regular and irregular verbs was considered (see Figure 2). The Group x Verb class x Frequency ANOVA revealed an interaction approaching significance ($F(3.84) = 2.36$, $p = 0.07$). All three LA control groups showed a frequency effect for irregular verbs, producing more correct responses for high-frequency than for low-frequency items (*gave* vs *dug*) (LA1 controls, $F(1,28) = 4.17$, $p = 0.05$; LA2 controls, $F(1,28) = 6.52$, $p = 0.05$); LA3 controls, $F(1,28) = 5.61$, $p = 0.05$); however, no such differences were observed for regular verbs (*looked* vs *stalked*) (LA1 controls, $F(1,28) = 3.01$, $p = 0.094$; LA2 controls, $F(1,28) < 1$; LA3 controls $F(1,28) < 1$). This pattern suggests that the normally developing children retrieved the irregular past tense forms (*gave, dug*) from memory, while the regular past tense forms (*looked, stalked*) may have been produced by other means. In contrast, the SLI children showed a frequency effect for regular verbs ($F(1,28) = 5.00$, $p < .05$), and a similar, though non-significant trend for irregulars ($F(1,28) = 1.68$), $p = 0.2$) This pattern suggests that the SLI children retrieved the past tense forms for regular and irregular verbs from memory. This contrast between the normally developing and SLI children further supports the dual mechanism: If the normally developing children had a single mechanism, why would they fail to show frequency effects for regular verbs, while SLI children do show such effects?

Novel regular and irregular verbs

Two types of past tense responses to novel regular (*prass)* and novel irregular *(crive)* verbs were found: Regular (*prassed, crived*) and irregular (e.g., *pruss* or *pross, crove* or *criv*) past tense forms (see Figure 3). The Group x Past Tense type interaction was significant by subject and item analyses ($F1(3,43) = 14.03$, $p < .001$; $F2(3,78) = 14.02$, $p < .001$). Each of the three LA control groups produced

more regular past tense responses (*prassed, crived*) than irregular past tense responses (*pruss, crove*) (for the three analyses, $t(11) > 3.38$, $p < .01$), while this difference was not significant for the SLI children ($t(11) = 1.44$, $p = 0.18$).

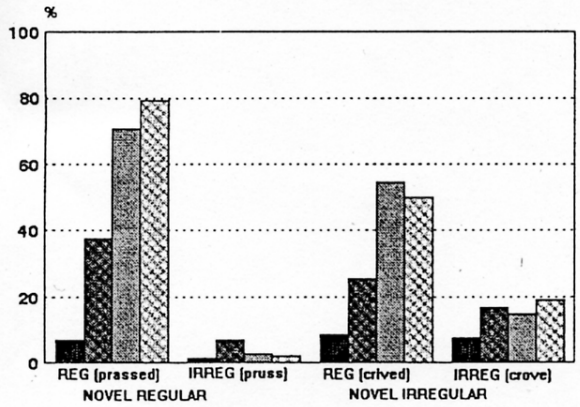

Figure 3. Experiment 1, Production Task: Mean percentage of regular and irregular responses to the novel regular and novel irregular verbs.

For regular responses (*prassed, crived*), an ANOVA revealed a significant main effect of Group ($F(3,43) = 17.31$, $p < .001$), which reflected the SLI children's lower production rate of regular responses than the LA1 controls ($F(1,43) = 7.36$, $p < .05$) and the LA2 and LA3 controls ($F(1,43) = 53.36$, $p < .001$). A significant interaction between Group (SLI, controls) and Verb class (*prassed, crived*) ($F(3,43) = 3.54$, $p < .05$) revealed that while the LA2 and LA3 control groups produced significantly more regular responses for the novel regular verbs (*prassed*) than for the novel irregular verbs (*crived*) ($t(11) > 2.27$, $p < .05$ for both analyses), this difference was not significant for the LA1 controls ($t(11) = 1.52$, $p = 0.16$) or the SLI children ($t(11) = 1.17$, $p = 0.27$). However, whilst the difference for the LA1 controls was not significant, they showed a similar trend as the older LA controls to produce more regular past tense forms for the novel regular verbs. In contrast, the SLI children showed no such trend, producing slightly fewer regular past tense forms for the novel regular verbs than the novel irregular verbs.

A different pattern of results emerged from analysis of the irregular responses to novel regular verbs (*prass-pruss*) and novel irregular verbs (*crive-crove*). There was no significant main effect of Group ($F(3,43) = 1.41$, $p = 0.14$) and no significant interaction between Group (SLI, controls) and Verb class (*pruss, crove*) ($F(3,45) < 1$) indicating that the three control groups and the SLI children had similar response patterns. However, the four groups produced significantly more irregular responses to the novel irregular verbs (*crove*) than to the novel regular verbs (*pruss*) ($F(1,43) = 91.69$, $p < .001$), indicating that they were sensitive to the phonological characteristics of the novel verbs.

Thus, in the production task for novel verbs, the SLI children were impaired at the production of regular past tense responses (*prassed, crived*), but not irregular

past tense responses (*pruss, crove*), compared to normal control children. Moreover, the SLI children produced the regular and irregular past tense responses at similar rates, while their normal controls produced more regular responses. The normal controls produced more regular responses for novel regular verbs (*prassed*) than for novel irregular verbs (*crived*), while the SLI children did not show this difference. In contrast, the SLI children were like their controls in producing fewer irregular responses for novel regulars (*pruss*) than for novel irregulars (*crove*).

These results for the novel verbs support the dual mechanism model for normally developing children, with the rule component impaired in the SLI children, resulting in their reliance on the associative component for the computation of regular as well as irregular past tense forms: The SLI children were similar to the control children at the production pattern of irregular pasts (*pruss, crove*), but not at the production pattern of regular pasts (*prassed, crived*). Indeed, the SLI children, but not the control children, produced the regular and irregular past tense types at similar rates, suggesting that the SLI children, but not the controls, computed them by the same mechanism. The higher response rates in normal and SLI children for irregular forms like *crove* than for irregular forms like *pruss* suggests an underlying associative mechanism for irregulars such as that discussed in Pinker (1991), Prasada and Pinker (1993), and Ullman (1993).

However, the results from this production task indicate that the SLI children's language impairment is not restricted to problems with the rule component for marking tense. In this study the SLI children showed a general impairment in marking tense for both the regular and irregular real and novel verbs. The majority of the SLI children's responses were unmarked forms or infinitival verb forms. Thus, it appears that SLI children use stem or infinitival verb forms for verbs presented in past tense context in elicitation tasks as well as in spontaneous speech (Rice, Wexler, & Cleave, 1995). However, the different pattern of past tense marking found for the SLI children indicates that their production of the past tense is not merely worse than the younger LA control children but qualitatively different.

4. Experiment 2: Morphological Judgements

4.1 Method

The morphological judgment task used the same set of verbs as the elicitation task, with 4 additional novel regular verbs. The control and SLI children were asked to judge whether the verb form presented in each past tense context sentence (the second sentence in each sentence pair) was "good" or "bad". Each verb was presented three times. In one of the presentations the verb in the past tense context sentence was marked with a regular inflection (*looked, gived, prassed, crived*), in another with an irregular inflection (*leck, gave, pruss, crove*), and in the third it was unmarked (*look, give, prass, crove*). Thus for the real and novel regular verbs, plausible irregular past tense forms were constructed. The verb forms were

randomized for presentation and then checked to ensure that different forms of the same verb did not occur sequentially. The same random order was given to all of the children.

4.2 Results

Real regular and irregular verbs

Analyses of correct past tense forms for real regular (*looked*) and irregular (*gave*) verbs (see Figure 4) revealed significant main effects of Group (SLI, controls) ($F(3,44) = 2.95$, $p < .05$) and Verb class (*looked, gave*) ($F(1,44) = 9.88$, $p < .005$). The significant main effect of Verb class reflected the generally better performance for regular verbs than irregular verbs. No significant interaction was found ($F(3,44) = 1.01$, $p = 0.40$). Planned comparisons revealed that the SLI children and the LA1 controls did not differ in their acceptance of correct forms (*looked, gave*) ($F(1,44 < 1)$. However, the SLI children and the LA1 controls accepted significantly fewer correct forms than the LA2 and LA3 controls (respectively, $F(1,44) = 4.53$, $p < .05$, and $F(1,44) = 5.55$, $p < .05$). It should be noted, however, that all the groups accepted the correct forms at least 73% percent of the time.

The SLI children accepted overregularizations (*gaved*) (65% of responses) at a higher rate than the LA controls (43%); this difference approached significance for the LA1 controls ($F(1,44) = 3.41$ $p = .07$), and was significantly different when compared with the LA2 and LA3 controls' acceptance of overregularizations

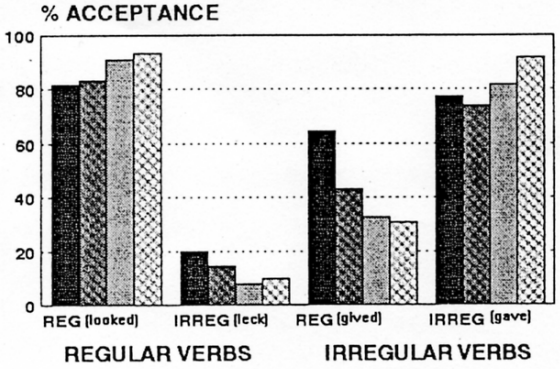

Figure 4. Experiment 2, Judgement Task: Acceptance of regular and irregular past tense forms for the regular and irregular verbs.

($F(1,44) = 10.75$, $p < .005$) (see Figure 4). In contrast, both the SLI children and their LA controls rejected irregularized past tense forms for regular verbs (*look-leck*). Analyses also revealed no significant difference between the groups for these irregular forms ($F(3,44) = 1.02$, $p = 0.39$).

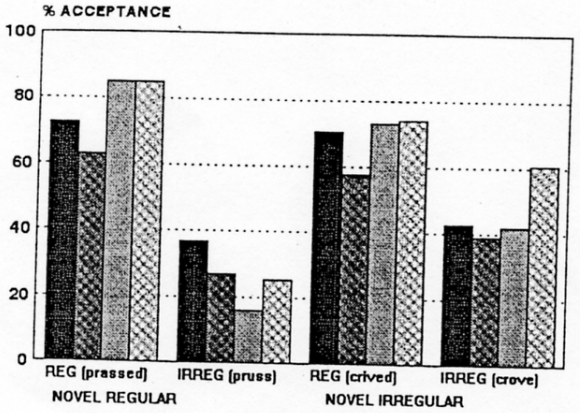

Figure 5. Experiment 2, Judgement Task: Acceptance of regular and irregular forms for the novel regular and novel irregular verbs.

Novel regular and irregular verbs

Over all four groups, regularized past tense forms (*prassed, crived*) were accepted significantly more often than irregularized past tense forms (*pruss, crove*) ($F(1,47) = 124.28$, $p < .001$) (see Figure 5). This preference for regularized past tense forms held even for the novel irregular verbs (*crived* vs *crove*) ($F(1,11) = 17.17$, $p < .005$, for the SLI children; $F(1,11) = 12.64$, $p < .01$ for the LA1 controls; $F(1,11) = 15.88$, $p < .005$, for the LA2 controls).

The children's sensitivity to the phonological characteristics of the novel verbs is also revealed by their lower level of acceptance of irregular past tense forms for the novel regular verbs (*pruss)* than the novel irregular verbs (*crove*) (see Figure 5). Analysis revealed that this difference was significant for the LA1 controls ($F(1,11) = 7.04$, $p < .05$), the LA2 controls ($F(1,11) = 10.93$, $p < .01$) and the LA3 controls ($F(1,11) = 129.76$, $p = .001$). Whilst a similar trend is evident for the SLI children the difference was not significant ($F(1,11) = 1.22$, $p = 0.2$).

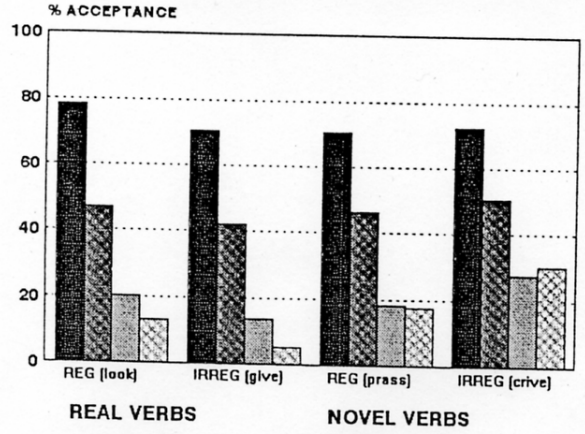

Figure 6. Experiment 2, Judgement Task: Mean percentage of unmarked forms accepted for the four verb classes by the subject groups.

Unmarked forms

We also analysed the acceptance rates of unmarked forms (*look, give, prass, crive*) in the past tense context sentences (see Figure 6). There were significant main effects of Group ($F(1,47) = 17.14$, $p < .001$) and Verb class ($F(3,132) = 7.40$, $p < 0.001$). There was no significant interaction ($F(9,132) = 1.57$, $p < 0.13$). The SLI children accepted the majority (70% to 78% of responses) of unmarked forms for all four verb classes (*look, give, prass, crive*). This acceptance rate was significantly higher than that of the LA1 controls (42% to 50%) ($F(1,44) = 8.61$, $p < .01$), which in turn was significantly higher than that of the LA2 and LA3 controls ($F(1,44) = 13.25$, $p < .005$). Thus the SLI children accepted more unmarked forms than all their controls, and within these normal controls there was a developmental trend, with fewer unmarked forms accepted by the older children.

5. General Discussion

The normally developing children produced high frequency irregular pasts (*gave*) more successfully than low frequency irregular pasts (*dug*), but showed no such frequency effects for high- and low-frequency regular pasts (*looked* vs *stalked*). In contrast, the SLI children showed frequency effects for regular as well as irregular pasts. This contrast suggests that the normally developing children retrieve irregular but not regular pasts from memory, while the SLI children retrieve both past tense types from memory.

The consistent advantage of regular past tense forms over irregular past tense forms in production and acceptance in the normally developing children, but not the SLI children, suggests that the two groups had qualitatively different inflectional systems. The SLI children produced irregular and regular pasts of real and novel verbs at a similar rate, which was also similar to the production rate of the irregular but not regular pasts for the normal children. This suggests that the SLI children used the same mechanism to produce regular and irregular pasts as the normal children did to produce irregular pasts, but not regular pasts.

The SLI children's high percentage of irregular and regular unmarked verb forms in past tense contexts in production and acceptance indicates that their impairment extends to the syntactic representation of tense. Thus, the data from this study support the findings of Rice et al. (1995) and further indicates that an underlying syntactic deficit is a major component of Grammatical SLI in children (van der Lely, 1995).

We conclude that the data is best accounted for by a dual mechanism in the normally developing children. The SLI children appear to be impaired in the grammatical mechanism underlying regular past tense formation, and also in the syntactic representation underlying past tense inflection, but not in the associative system underlying irregulars. Finally, these findings for the Grammatical SLI children appear to concur with the data reported for Familial SLI subjects (Gopnik

& Crago, 1991; Ullman & Gopnik, 1994), who also show frequency effects for regular as well as irregular past tense forms.

Endnotes

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