The regular-irregular dissociation in non-native English past tense

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Abstract: The present article investigates Pinker's (1991) Dual Mechanism model in non-native (and native) morphology. Adult Greek learners and English natives produced the past tense of English pseudo-verbs varying in their similarity to existing verbs. Results seem problematic for Dual Mechanism and indicate no qualitative difference between L1 and L2 regarding the representation of regular/irregular morphology.
Key words: Dual Mechanism, English past tense, second language acquisition

1. Introduction: Dual Mechanism and contrasting theories

A central issue in linguistic debates concerns the mental representation of regular and irregular morphology. In the Dual Mechanism (DM) model (e.g. Pinker 1991), irregular words are stored in the mental lexicon, while regular ones are computed by a symbolic rule. To test this theory, the present study focuses on the English past tense.

In DM, an irregular word bearing the feature [PAST] is linked with the entry of its stem form through association (1), while regular past forms are produced by the grammatical operation of merging two constituents, such as a V-stem + a morpheme with the feature [PAST] (2). Phonological rules determine whether the past tense affix is spelled out as /d/, /id/ or /t/, as in *played*, *started* and *walked*, respectively. Moreover, a stored inflected form blocks the application of a rule (Marcus et al. 1995), (3).

(1) hold ~ held$_{PAST}$

(2) walk + affix$_{PAST}$ ⟶ walked

(3) hold ~ held$_{PAST}$ ⤫ holded

In this theory, 'regular' refers to 'default'. A default rule is one that applies freely in new words and in nonsense words, as well as in cases where memory is blocked (Pinker 1999: 214). While, in English, addition of the *-ed* affix to a verb stem is both the most common *and* default rule for past tense, in other languages the default may be a minority rule, as the rule for the affixation of plural nouns in German (Marcus et al., op. cit.).

DM contrasts with two main alternative theories. According to the first one, both regular and irregular forms are generated by abstract rules. For example, in Halle & Marantz's (1993) model of Distributed Morphology, all past forms have the abstract representation V-[$_{PAST}$][1] and this structure is realized overtly at the Spell-out level through the application of phonological rules (cf. Chomsky & Halle 1968). The affix -Ø$_{PAST}$ applies on certain lists of verb stems. If it is the list with stems such as *burst*, *hit*,

[1] In Distributed Morphology, the abstract form of words is computed in the syntactic module, while in other theories (e.g. Di Sciullo & Williams 1987), this occurs in the morphological module. For instance, in Yang (2002) word-formation is a morphological process and rules for irregulars, which are non-productive or less productive than rules for regulars, are 'morpholexical'. However, the issue of whether rules for words are syntactic or morphological will not concern us here.

cost, *cut*, *hurt*, one operation is necessary to yield *burst-Ø*$_{PAST}$, *hit-Ø*$_{PAST}$ etc. If it applies on a list with stems such as *sling*, *sink* etc., or a list with stems such as *feed*, *hold* etc., readjustment rules apply to render the phonological changes following the stem affixation yielding, for example *slung-Ø*$_{PAST}$ or *fed-Ø*$_{PAST}$. Likewise, the affix *-t*$_{PAST}$ forms the past tense through one operation when it applies on the list of verb stems containing *burn*, *learn* etc., yielding, e.g. *burn-t*$_{PAST}$. Should it apply on a list with stems such as *think*, *bring,* or a list with stems such as *sleep*, *deal*, an additional operation is required to yield the forms *though-t*$_{PAST}$, *slep-t*$_{PAST}$ etc. Last, if neither *-Ø* or *-t* applies, the abstract [past] morpheme is realized by the default affix *-ed*, according to the Pāninian principle of most specific to least specific. In this theory, only suppletive forms, like *go* → *went*, are stored unanalysed.

DM also contrasts with 'usage-based' models, according to which both regular and irregular words are learnt in a piece-meal fashion and stored as lexical units (e.g. Bybee 1985). One strand within this camp are 'connectionists', such as Rumelhart and McClelland (1988) who implemented a computer network so that it could link the phonetic representation of the stem of an English verb with its past tense form. This mechanism 'learned' past tense forms through repeated trials, in which connections were readjusted and strengthened between the stem and the past form of each verb. Moreover, it made overgeneralization errors and exhibited a U-shape performance, similar to what happens in the acquisition of past tense by young English children (see Section 2). Connectionists claim that such results indicate non-necessity of symbolic rules in language acquisition. Yet, Pinker and Prince (1988) have argued convincingly against this view, pointing out important differences between the connectionist model's output and human language performance. These differences were shown to be due to the model's inability to parse words into symbolic categories (Vstem, affix$_{PAST}$) and use rules. Namely, the model generated past-tense forms in regulars, such as *squat* → *squakt* and *mail* → *membled* (: 124), never attested in natural language. Similar problems have appeared in more recent connectionist models (Pinker 1998: 240).

Since DM is proposed as a universal language acquisition mechanism, the present study investigates its validity in interlanguage. In what follows, first, I briefly review relevant research (Section 2), next I present the hypotheses and the method of testing these hypotheses (Section 3) and last I discuss implications of the results for theories regarding storage and computation in native and non-native grammars (Section 4).

2. Dual Mechanism in language acquisition research

When young English children produce the past tense of English pseudo-verbs, they do so mainly by adding the affix *-ed* (Berko 1958), as in *spling* → *splinged*, a process described as 'overregularization'. Furthermore, overregularization accounts for 10% of the erroneous past tense forms in young English children's spontaneous speech, while errors of overirregularization (e.g. *wipe* → **wope*) and misirregularization (e.g. *bring* → **brang*) together occur only at 0.2% (see references in Yang 2002: 60). These data indicate the existence of a grammatical operation such as the default symbolic rule, which supports DM. Moreover, populations with language disorders but intact cognitive functions perform better in irregular than regular English past tense, while the opposite pattern occurs in populations with impaired memory but relatively unimpaired language functions (Pinker 1999: 259-262). Additionally, experiments show that while regular English past forms prime their stems, irregular ones do not (see references in Stockall and Marantz 2006: 88). These studies may support DM, as they indicate a difference in the mental representation between regular and irregular words, with the former related to a rule-based language system and the latter related to memory-based language skills.

In an online task with adult native English speakers, Prasada et al. (1990, cited in Pinker 1999: 129) found frequency effects on reaction times concerning the production of irregular, but not of regular past tense forms. Also, in Prasada and Pinker (1993), native English adults produced the past tense of English pseudo-verbs categorized as 'prototypical', 'intermediate' and 'distant' depending on whether they were very similar, moderately similar or dissimilar to real verbs (respectively). Results showed that that there were considerably more suffixed than non-suffixed responses and that the more the pseudo-verbs resembled existing irregular verbs, the less they were affixed with the past-tense morpheme. On the other hand, there was no significant similarity effect on regulars. Given that similarity relates with associative memory but not with the ability to compute words by rule, these results may support DM's claim about the difference in the mental representation between regulars and irregulars.

Nevertheless, there are also empirical data against DM. For instance, Marchman (1997) explained English children's overregularization errors in past tense in terms of phonological constraints and frequency effects, which supports usage-based models. On the other hand, Allen and Badecker (2002) showed that when there is no high orthographic overlap between an irregular past tense form and its stem, for example *teach* → *taught* (cf. *give* → *gave*), irregulars prime their stems as much as regulars. This indicates that both regulars and irregulars have an analyzable V-[$_{PAST}$] structure, in favour of models that suggest abstract rules for both regulars and irregulars.

Studies in the non-native acquisition of the English past tense also seem to disprove DM. Specifically, Beck (1997) found frequency effects on reaction times in the production of both regulars and irregulars, while in Murphy & Buwal's (2004) study frequency did not affect reaction times in the production of either regulars or irregulars. Moreover, using a subset of the pseudo-verbs from Prasada and Pinker's (1993) study, Murphy (2004) found similarity effects on elicited past tense forms of both irregulars and regulars. In addition, there were no significant differences between native and non-native performance in any of the above studies. Yet, Silva and Clahsen (2008) showed that non-native speakers (NNS) demonstrated no priming effect for English past forms, unlike native speakers (NS).

Level of language proficiency may also affect dissociative performance between regular and irregular English past tense. For instance, in Brovetto & Ullman (2001, in Birdsong 2004: 96), where learners had a mean of six years exposure to English, frequency effects in produced forms were found on both regulars and irregulars. Yet, in Birdsong and Flege (2001), where learners had a mean of ten to sixteen years of exposure to English, frequency effects were attested only on irregulars. The equivocal evidence discussed above indicates that the validity of DM in native and in non-native language acquisition deserves further empirical consideration.

3. The Present Study

To avoid the confound of verb type (that is, regular/irregular) with token frequency, the present experiment employed English pseudo-verbs as its test items. Details are provided in Section 3.2. For now, it suffices to recall that, according to DM, the degree of similarity of a pseudo-verb to a real English verb should affect the application of the default rule on pseudo-irregular items but not on pseudo-regular ones.

The Hypotheses were the following.

(A) If DM is correct, in the past tense formation of English pseudo-verbs, regulars should be suffixed more than irregulars and similarity should affect the suffixation of irregulars only.

(B) If the predictions in (A) hold for the NS but not for the NNS, assuming that the latter know the rule for regular past-tense formation in English, DM may be valid only in native language acquisition.
(C) If there is developmental effect with respect to the predictions in (A), the discussed dissociation in English past tense may be experience-based, contra DM.

3.1 Participants
There were three groups of participants, each consisting of twenty-two adults. All NNS were Greek and had started learning English through instruction between the ages of eight to ten. They were grouped into two levels of proficiency, namely advanced to very advanced (ADV) and lower intermediate to upper intermediate (INT), according to their scores in the paper and pencil Quick Placement Test (UCLES, 2001). In the NS control group, five came from US, two from South Africa and fifteen from UK. Male participants were a minority, namely nine NS, four ADV and one INT. Table 1 presents further information.

Table 1. Participants

Groups	Number	Mean Age	Age range	Mean QPT score*	Score range
NS	22	32.2	18-61	-	-
ADV	22	19.2	17-33	50.6	48-56
INT	22	19	18-25	39	31-47

* Quick Placement Test, maximum score = 60

3.2 Materials & Procedure
The pseudo-verbs used as stimuli to elicit past tense forms were the same as those used by Murphy (2004), which constituted a subset of the verbs in Prasada and Pinker (1993, P&P). Out of the thirty verbs employed, half were regular and half irregular, and each category had an equal number of prototypical, intermediate and distant verbs, depending on their similarity to existing English verbs. Note that 'similarity' regards the extent to which a verb rhymes with existing verbs. According to P&P, for example *spling* rhymes with many existing irregular verbs, thus it is in the 'prototypical' category, while *ning* is in the 'intermediate' category because it rhymes with fewer existing irregulars and *keeb*, which does not rhyme with any irregulars, is in the 'distant' category. Also, *plip* rhymes with many existing regulars and so on. Table 2 presents the stimuli.

Table 2. Verbs used in the experiment

Verb type	Regular	Irregular
Prototypical	*greem, plip, brip, gloke, slace*	*spling, sprink, cleed, plare, cloe*
Intermediate	*brilth, glinth, plimph, ploab, smaig*	*Fring, ning, grare, preek, cleef*
Distant	*frilg, smairg, trilb, ploamph, smeelth*	*blip, trisp, keeb, flape, goav*

The procedure was the same as in Murphy (2004). The informants simultaneously read and listened to sentences containing each of the critical verb once in its infinitive form and once in its *-ing* form and had to complete a sentence requiring the respective past form (e.g. Lucy knows how to smeelth. She is smeelthing. Yesterday she ____). Each set of sentences was on a different page of a booklet, accompanied by a picture of a 'weird' action (see Appendix I). Prior to the test, participants had practice with real verbs, one regular and one irregular (*dance* and *sing*). Last, a post-test with real English

verbs ensured that the learners had no problem in the formation of the regular past tense. Most did very well in irregular past-tense forms too.

3.3 Results

Following Pinker and Prasada's method, I scored as suffixed all verbs ending (a) in *-ed* (e.g. *smeelth → smeelthed*), (b) in *-d* (e.g. *cloe → cloed*) and (c) in *-t* if the final stem consonant was [-voice] (e.g. *brip → bript*). All other responses, as well as those in which the affix *-ed* was attached to an altered stem (e.g. *smeelth → smalthed*) were scored as non-suffixed. Moreover, for the statistical analysis of results I employed multiple comparisons ANOVAs with the three levels of groups as a between-group factor and other variables, such as verb type (regular/irregular or suffixed/unsuffixed) or level of similarity (prototypical, intermediate, distant) as within-group factors.

Responses in all groups involved significantly suffixed than non-suffixed verbs $F(1,63)=232,03$, $p<0.001$ (NS: 70.61%, ADV: 76.36%, INT: 72.12%), while there was no significant group effect or group x verb type interaction. An item analysis showed that of the 30 pseudo-verbs, there were fewer suffixed than non-suffixed responses for two of the prototypical irregulars (*spling*, *sprink*) and two of the intermediate irregulars (*fring*, *ning*), in all groups. In addition, the NS and the ADV produced fewer suffixed than non-suffixed responses for the prototypical irregular *cleed* and both NNS groups did so for the distant irregular *keeb*. Last, the ADV produced an equal number of suffixed and non-suffixed responses for the prototypical irregular *cleef*. These results differ from P&P's (: 25), where there were no items with fewer suffixed than non-suffixed responses and where only *spling* had an equal number of suffixed and non-suffixed responses, while in the present study this verb was not suffixed by any NS.

Moreover, regulars were suffixed more than irregulars (Table 3). This difference was highly significant, $F(1,63)=175.77$, $p<0.001$, $\eta^2=0.74$ (partial eta squared), with no significant group x verb type interaction or between-group difference.

Table 3. Means of suffixed regular and English irregular pseudo-verbs

	Regular	Irregular
NS (n=22)*	84.24 (12.9)**	56.97 (12.8)
ADV (n=22)	88.79 (11.3)	63.94 (21.2)
INT (n=22)	80.91 (16.3)	63.33 (15)

*=Number of participants, ** =Standard deviation

Next, the analysis of the irregular items (Table 4) revealed a strong similarity effect $F(2,126)=51.07$, $p<0.001$, $\eta^2=0.45$, a group x similarity interaction $F(4,126)=2.82$, $p<0.05$, $\eta^2=0.08$ but no group effect. Further analysis showed that the similarity effect was due to that distant irregulars were suffixed significantly more than the other two categories (post-hoc Bonferonni, $p< 0.01$ for all groups) and that the group x similarity interaction was due to that the NS had suffixed significantly fewer prototypical verbs than had either of the other two groups (post-hoc Scheffé, $p<0.01$).

Table 4. Means of suffixed English irregular pseudo-verbs

	Prototypical	Intermediate	Distant
NS (n=22)	42.73 (11.2)	49.09 (17.2)	79.09 (20.9)
ADV (n=22)	58.18 (23)	56.36 (30)	77.27 (20.7)
INT (n=22)	58.18 (23)	57.27 (24.1)	74.55 (18.7)

The next analysis included the three categories of pseudo-regulars. Note in Table 5 that similarity affected regulars in a way reverse to that in irregulars, since distant regulars were suffixed less than prototypical ones. Also note that in both of the two NNS groups suffixation declined from prototypical to intermediate to distant verbs and more so for the INT than for the ADV. On the other hand, the NS suffixed intermediate verbs the most and prototypical verbs slightly more than distant ones. Yet, the analysis revealed a significant similarity effect, $F(2,126)=4.22$, $p=0.017$, $\eta^2=0.063$, but no significant group effect ($p=0.169$) or group x similarity interaction ($p=0.223$).

Table 5. Means of suffixed English regular pseudo-verbs

	Prototypical	Intermediate	Distant
NS (n=22)	82.73 (21.6)	88.18 (14.7)	81.82 (17.3)
ADV (n=22)	92.73 (13.1)	89.09 (18.2)	84.55 (16.3)
INT (n=22)	87.27 (17.6)	80.09 (19.5)	75.45 (21.3)

The vast majority of non-suffixed responses in all groups (see Appendix III) involved a stem-internal vowel change (e.g. *smeelth → smelth*, *spling → splang*). Other non-suffixed responses included the addition of *-t* (a) to a [+voice] stem-final consonant, sometimes combined with an internal vowel change (e.g. *greem → greemt, gremt*), (b) to a [-voice] stem-final consonant combined with a stem-internal vowel change (e.g. *clef → cleft*) and (c) with deletion of a stem-final consonant (e.g. *trilb → trilt, smeelth → smelt*). In some responses there was no change, while in others there was an internal vowel change combined with either the change of a stem-final consonant or consonant cluster (e.g. *preek → prought*, *fring → frought*), or with the addition of a stem-final vowel (e.g. *cleed → clode*). Also, rare cases involved the deletion or change of a stem-final vowel (e.g. *cloe → clo*, *cloo*). Moreover, there were three responses with a stem-internal consonant deletion. In one of them this was combined with the deletion of a stem-final vowel, and in another one with a stem-internal vowel change (e.g. *smaig → smaing*, *gloke → glock*, *preek → preck*, respectively). Additionally, in the NS group there was one response with an altered stem-final consonant + vowel orthographic cluster (*grare → grang*), and two responses with more radical changes, namely *cloe → clang* and *goav → gent*. Last, there were also forty-one responses with the affix *-ed* and a stem change, e.g. *smeelth → smalthed*[2] (Appendix II).

4. Discussion and concluding remarks

Results in this study showed that the default past tense affix was extensively applied to English pseudo-verbs so that overregularization was significantly larger than overirregularization, and more so in regulars than in irregulars. These results may confirm the first part of Hypothesis A, in favour of DM. However, the similarity effect attested on the suffixation of both irregulars and regulars disconfirms the second part of the same hypothesis and may disprove DM. Only one difference was found between the groups, namely that the NS suffixed prototypical irregulars more than the NNS did. This

[2] In P&P (: 27) there were only six similar responses (out of 144), found exclusively in the distant regular category. In Murphy (: 456, En. 7) there were only two such responses, one in the prototypical regular category and one in the distant regular category, both produced by English children. In the present study most were produced by the NS. Specifically, nine NS, one ADV and three INT produced 71.4%, 2.4% and 26.2% of these responses respectively. In Murphy such responses were categorized as suffixed, unlike in P&P and here. Let us note that an analysis of the present data with the discussed responses scored as suffixed yielded similar statistical significances.

is expected, if storage has a role in the representation of irregulars. Additionally, both the NS and the NNS produced more suffixed than non-suffixed responses and more so in regulars than in irregulars. Furthermore, the similarity effect was significant for all groups. Thus, results indicate no qualitative difference between the native and the non-native representation of the English past tense, which disconfirms Hypothesis B and renders Hypothesis C irrelevant.

Results here generally replicate Murphy's results but not P&P's. This discrepancy may be due to methodological differences between the studies (see also Murphy: 451). Namely, in P&P participants saw six of the pseudo-verbs on each page and had to complete analogous sentences based on the definition provided for each of the pseudo-verbs. As semantic context may bias the suffixation of pseudo-verbs (reference in Murphy, ibid.), results here and in Murphy seem more reliable. The issue is what kind of theory for the mental representation of words these data may support.

In the recent version of DM, called "Words and Rules" (WR), it is pointed out that "WR does not posit that regulars are *never* stored, only that they do not *have* to be" (Pinker & Ullman 2002: 458, italics in the original). Still, while this may allow for frequency effects on some existing regulars of high token frequency, one has to wonder whether it may also justify similarity effects on pseudo-regular words. In addition, an item analysis of the NS responses raises some issues. In the irregular class, some of the non-distant items were suffixed as much as or even more than some of the regulars. Namely, *plare* was suffixed more than ten and as much as five of the regulars (95.45%), and *cloe, grare*, *cleef* were suffixed more than the regulars *greem*, *plip*, *smaig*, *frilg*, *smeelth* and as much as the regular *brip* (81.8%). Furthermore, the mean suffixation of distant irregulars was not significantly different from the mean suffixation of any of the regular categories and two of the distant regulars (*frilg*, *smeelth*) were suffixed less than any of the distant irregulars[3]. Thus, either the test validity of the specific pseudo-verbs is dubious or the regular/irregular dissociation is not so categorical.

Additionally, an individual data analysis revealed that the similarity effect for irregulars was not as predicted by DM for 68.2% (15/22) of the NS. Specifically, three NS suffixed prototypical irregulars more than intermediate ones, ten suffixed prototypical and intermediate irregulars to the same extent and two suffixed irregulars in all categories equally. Another issue is the marked differences found between irregulars within the same categories. Namely, in the prototypical category, while two verbs (*plare*, *cloe*) were mostly suffixed (see above), *sling* was not suffixed at all and *cleed*, *sprink* were suffixed at 13.6% and 22.7% respectively. Similar discrepancies occurred within the intermediate irregular category between three of the verbs (*grare*, *cleef*, *preek*), which were mostly suffixed and two of the verbs (*fring, ning*), which were mostly unsuffixed. Now, recall that the reliable similarity effect on irregulars was due to that the distant category differed from both the prototypical and the intermediate categories, while there was no difference between the latter. However, as Murphy (2004: 454) also notes, the distant irregulars included items such as *blip,* which is very similar to items in the prototypical regular category, such as *brip*. It is then possible that, if some of the distant irregulars were not like regular ones, the similarity effect on this verb type would be less reliable. On the one hand, this could lessen the difference between regulars and irregulars, in support of usage-based models. On the other hand, a less reliable similarity effect on irregulars (probably at $p< 0.05$), instead of the one found here ($p<0.001$), could support a theory in which the role of memory in irregulars

[3] Unlike in P&P, where irregulars had a mean suffixation of 4.1, 5.4, 6.3, and regulars a mean suffixation of 9.5, 9.2, 8.9 in the prototypical, intermediate and distant categories respectively (: 25-26).

is important but not to the extent proposed by DM and usage-based theories. This could favour a theory like Halle and Marantz's (1993) discussed in Section 1, where, except suppletives, storage in irregulars is limited to lists of stems on which rules operate. Although the above is based on speculation, next I discuss some research in favor of Halle and Marantz (op. cit., hereafter 'generative model').

In Ullman et al. (2005), non-fluent aphasics, assumed to have unimpaired memory but problems with rule-formation, produced fewer correct regulars than irregulars, like *kept*. According to the researchers, these results support DM and disprove the generative model, because if both regulars and irregulars had a V+stem$_{PAST}$ structure, participants should have produced forms such as *kep*, omitting the affix –t, which they did not. However, Embick & Marantz (2005, E&M) remark that the total lack of these forms support the generative model, which predicts that phonological readjustment applies only after the stem is concatenated with the affix *-t* (see Section 1). Further support for the generative theory may come from Allen and Badecker (2002) discussed in Section 2, as well as Stockall and Marantz (2006) who showed that irregular past tense forms prime their roots as much as regulars in magnetoencephalographic priming experiments.

The preceding discussion showed that the similarity effect on irregulars here could be still significant but less strong, if the distant items were not like regular ones. It also showed that the similarity effect on regulars was less reliable than the one in irregulars (and probably an artefact of the test items). Crucially, the least suffixed category in regulars was the distant one, while the opposite similarity effect was found in irregulars. This effect could be accounted for by results in other studies, which show that processing difficulty in regular past forms is related to stem frequency, while in irregulars it is related to past form frequency (E&M: 245). According to E&M (ibid.), this is due to that a V-ed form does not require any listing information. On the other hand, when encountered with an irregular past form such as gave-Ø, one has to "up the tally for *give*, for -Ø and *gave*-Ø since the zero past tense ending has *give* on its list and the combination of *give* and past tense is an instantiation of the relation encoded by having *give* on the list". Given the above, I tentatively suggest that results here could accommodate a generative model, where regulars are not stored, contra usage-based theories, and where storage in irregulars has a more limited role than the one suggested by DM (and usage-based theories). Given the small role of analogy in language acquisition (e.g. Guasti 2002), I consider a model which minimizes storage more plausible than models that maximize storage.

Although the present study may not decisively support a specific theory, research in languages typologically different from English may be more enlightening. For instance, Agathopoulou & Papadopoulou (to appear) investigated overregularization of the default perfective morpheme in the past tense form of Greek pseudo-verbs categorized as similar or dissimilar according to native speaker's judgements. Results showed a significant difference between regulars and irregulars, but no significant similarity effect on any of the two verb types. This was accounted for by assuming that non-suppletive irregular forms in Greek are represented by abstract rules that are less productive than the default rule.

To conclude, results in the present study indicate no qualitative difference between the native and the non-native mental representation of the English past tense but leave open the nature of this representation for further empirical consideration.

References

Agathopoulou, E. & D. Papadopoulou (to appear). *Morphological dissociations in the L2 acquisition of an inflectionally rich language*. To appear in *EUROSLA Yearbook 9*. Amsterdam: John Benjamins.

Allen, M. & W. Badecker (2002). "Inflectional regularity: Probing the nature of lexical representation in a cross-modal priming task". *Journal of Memory and Language* 46(4): 705-722.

Beck, M. L. (1997). "Regular verbs, past tense and frequency: Tracking down a potential source of NS/NNS competence differences". *Second Language Research* 13(2): 93-115.

Berko, J. (1958). "The child's learning of English morphology". *Word* 14: 150-177.

Birdsong, D. (2004). "Second language acquisition and ultimate attainment". In A. Davies and C. Elder (eds), *Handbook of applied linguistics*. London: Blackwell, 82-105.

Birdsong, D. & J. E. Flege (2001). "Regular-irregular dissociations in L2 acquisition of English morphology". In A. H.-J. Do, L. Domínguez and A. Johansen (eds.), *Proceedings of the 25th Annual Boston University Conference on Language Development*. Boston, MA: Cascadilla Press, 123-132.

Bybee, J. (1985). *Morphology*: *A study of the relation between meaning and form*. Amsterdam: Benjamins.

Chomsky, N. & M. Halle (1968). *The sound pattern of English*. New York: Harper and Row.

Di Sciullo, A-M. & E. Williams (1987). *On the definition of word*. Cambridge, MA: MIT Press.

Embick, D. & A. Marantz (2005). "Cognitive neuroscience and the English past tense: Comments on the paper by Ullman et al.". *Brain and Language* 93(2): 243-247.

Guasti, M. T. (2002). *Language acquisition: The growth of grammar*. Cambridge, Mass: MIT Press.

Halle, M. & A. Marantz (1993). "Distributed morphology and the pieces of inflection". In K. Hale and S. Keyser (eds), *The view from building 20: essays in honor of Sylvain Bromberger*. Cambridge, MA: MIT Press, 111-176.

Marchman, V. A. (1997). "Children's productivity in the English past tense: The role of frequency, phonology, and neighborhood structure". *Cognitive Science* 21(3): 283-303

Marcus, G., U. Brinkmann, H. Clahsen, R. Wiese & S. Pinker (1995). "German inflection: The exception that proves the rule". *Cognitive Psychology* 29: 189-256.

Murphy, V. A. (2004). "Dissociable systems in second language inflectional morphology". *Studies in Second Language Acquisition* 26: 433-459.

Murphy, V. A. & S. Buwal (2004). *Frequency effects in L2 inflection.* Paper presented at EUROSLA 14.

Pinker, S. (1991). "Rules of language". *Science* 253: 530-535.

Pinker, S. (1998) "Words and rules". *Lingua* 106: 219-242.

Pinker, S. (1999). *Words and rules: The ingredients of language*. New York: Basic Books.

Pinker, S. & A. Prince (1988). On language and connectionism: Analysis of a parallel distributed model of language acquisition". *Cognition* 28(1-2): 73-193.

Pinker, S. & M. Ullman (2002). "The past and future of the past tense". *Trends in Cognitive Science* 6(11): 456-463.

Prasada, S. & S. Pinker (1993). "Generalisation of regular and irregular morphological patterns". *Language and Cognitive Processes* 8(1): 1-56.

Rumelhart, D. & J. McClelland 1986. "On learning the past tenses of English verbs. Implicit rules or parallel distributed processing?. In J. McClelland, D. Rumelhart and the Pdp Research Group (eds), *Parallel distributed processing: Explorations in the microstructure of cognition*. Cambridge, MA: MIT Press.

Silva, R. & H. Clahsen (2008). "Morphologically complex words in L1 and L2 processing". *Language and Cognition* 11(2): 245-260.

Stockall, L. & A. Marantz (2006). "A single route, full decomposition model of morphological complexity". *The Mental Lexicon* 1(1): 85-23.

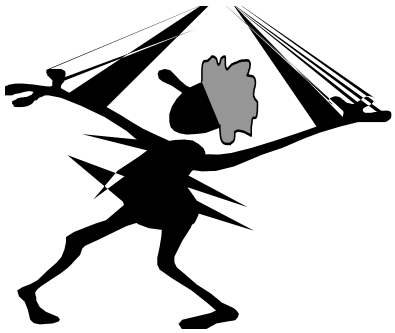
Yang, C. (2002). *Knowledge and learning in natural language*. New York: Oxford University Press.

UCLES (2001). *Quick placement test*. Oxford: Oxford University Press.

Ullman, M. T., R. Izvorski, T. Love, E. Yee, D. Swinney & G. Hickok (2005). "Neural correlates of lexicon and grammar: Evidence from the production, reading and judgment of inflection in aphasia". *Brain and Language* 93(2): 185-238.

APPENDIX I

Example of a test item



Mary knows how to **brilth**.
Mary is **brilthing**.
Yesterday she _____.

APPENDIX II

Suffixed responses with a stem-internal change (Numbers in parentheses indicate frequency of occurrence)

VERB TYPES	NS	ADV	INT
REGULAR			
Prototypical	plapped (4), plupped, brepped, brapped	-	gremmed, brapped
Intermediate	plamphed (2)	glunthed	glanthed, smaged
Distant	fralged (2), frelged, plumphed, smalthed (2), smoolthed, smulthed	-	smelthed (2)
IRREGULAR			
Prototypical	-	-	spranked
Intermediate	nanged, preked, praked, pruked, clafed, cloofed, cloffed	-	clefed
Distant	blapped (2), bleeped, trasped, trusped, keebled	-	blapped, trasped, kebbed

APPENDIX III

Non-suffixed responses (Numbers in parentheses indicate frequency of occurrence)

VERB TYPES	NS	ADV	INTERMEDIATE
REGULAR			
Prototypical			
greem	gram (3), grem, grum, grame, greemt	grem, greamt, greemt	grem (2)
plip	plap	plip	plap (3)
brip	brap (3)	brap (3)	brap (2), brapp, brip
gloke	glock	-	gluke, glake
slace	sloce	sloce	slace
Intermediate			
brilth	broth, brilt	bralth, brilt	broulth
glinth	glanth (2)	glanth (3)	glanth (3), glunth (3), glenth (2)
plimph	plumpht	plumph (3), plamph	plumph (5), plamph
ploab	ploabt	plub	ploab
smaig	smag (4), smug, smaing	smaigt	smag (3)
Distant			
frilg	fralg (3), frelg, frolg	fralg (2), frulg	fralg (4), frulg (3)
smairg	-	smurg	smarg (2), smurg
trilb	trulb	tralb, trolbe, trilb	tralb (4), trulb, trilt
ploamph	-	-	-
smeelth	smelth (2), smealth, smolth, smeelt (2)	smelth (9), smoulth	smelth (10)
IRREGULAR			
Prototypical			
spling	splang (15), splung (4), splong, splought	splang (12), splung (2)	splang (9), splung (8), splought
sprink	sprank (13), sprunk (2), sprought	sprank (10), sprunk (5)	sprank (11), sprunk (4), sprought (2)
cleed	cled (11), clad (3), clood, clud, clod, clead	cled (11), clad, clod (2), clode	cled (8), clad
plare	plore	-	-
cloe	clo, clang, cloo, clooe	-	-
Intermediate			
fring	frang (13), frung (3), fringt	frang (12), frung (2)	frang (9), frung (4), frought (2)
ning	nang (15), nung (4), nong	nang (10), nung (3), ningt	nang (10), nung (7), noung
grare	grore, grang, grad	grore (3), grar	-
preek	prak (2), preak, prack, prook, prought (2)	prek (2), proke (2), prack, prekt	prek (6), prought, prekt
cleef	cleft (6), claf, clove	cleft (5), clef (4), clofe (2), claf	cleft (4), clef (4), cluf
Distant			
blip	blap, blipt	blap	blap (3), blup (2), blop, bleap, blip
trisp	trasp, trosp	trasp (3)	trusp (2), trasp
keeb	keb (2), kebt (4), keebt (2)	keb (6), kebt (4), koab (2), keebt	keb (7), kebt (8)
flape	flope, flept	flope (5), flop, flap	flope, flapt
goav	goav, goave, guv, gent	-	-