Regularity and Irregularity in an Inflectionally Complex Language: Evidence from Polish

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Abstract

We report two experiments which address the question of whether there is support for single or dual mechanisms in the processing of Polish regular and irregular nouns and verbs. The data from an immediate cross-modal priming experiment (verbs and nouns) revealed that there was significant priming, irrespective of regularity, for both verbs and nouns. The results for verbs were replicated in a second experiment using delayed repetition auditory-auditory priming. The outcome from both experiments is in line with the results reported from research on Italian and French but not with English and German, and suggest that Polish regulars and irregulars are processed by a single underlying cognitive system.

Introduction

There has been a long lasting debate as to the implications of English regular and irregular verbs for the universal properties of human cognitive mechanisms (Marslen-Wilson & Tyler, 1998; Pinker, 1999). The protagonists of a dual mechanism approach (Pinker & Prince, 1991) have claimed that English regular past tense forms are processed by a symbolic rule, which concatenates allomorphic suffixes (*-ed* or *-d* or *-t*) to the verb stem, while the irregular past tense forms are processed as whole forms in an associative memory. In contrast, the proponents of the single mechanism (Plunkett & Marchman, 1993; Rumelhart & McClelland, 1986) claim that regular and irregular English verbs are processed and represented in the same way, by a distributed connectionist system, operating without symbols and syntax.

We focus here on the experimental work probing the on-line processing and representation of regular and irregular forms in the adult mental lexicon. Much of this work has of course focused on English, chiefly using a variety of priming paradigms. In early work, for example, Stanners, Neiser, Hernon and Hallet (1979) tested the representation of regular and irregular verbs using visual priming with a delay. The authors found that regular inflected verbs primed their bases as effectively as identity primes. In contrast the irregular past tenses primed their bases significantly less than identity primes. Marslen-Wilson, Hare and Older (1995) investigated the representation of English regular and irregular verbs using a cross-modal lexical decision paradigm. The authors contrasted regular verbs (*jumped/jump*), with

irregular verbs which fell into two classes: semi-weak verbs (*burnt/burn*) with irregular alveolar inflection, and vowel change verbs (*gave/give*). The results showed that there was significant priming for the regulars, but no priming for either sub-class of irregular verbs.

Evidence for behavioural differences of this type, suggesting asymmetries in the underlying systems supporting the processing of regular and irregular forms, can be interpreted as support for a dual mechanism approach. It is important, however, to apply these techniques cross-linguistically, to develop a broader perspective on the processing consequences of regularity and irregularity, and to evaluate the universality of the claims being made.

Cross-linguistic behavioural studies

Although cross-linguistic research is in its early stages it has already suggested interesting contrasts between English and German as opposed to Italian and French.

Sonnenstuhl, Eisenbeiss and Clahsen (1999) probed the representation of regular and irregular German verbs as well as regular and irregular noun plurals, using the cross-modal paradigm. Significant priming for both regulars and irregulars was obtained. The regulars were as effective as identity primes, whereas the irregulars were significantly less effective than identity primes. The authors argued that these data, consistent with English, provide support for the dual mechanism where the regulars are processed as a stem and an affix, generated by a rule, whereas irregulars are processed as full lexical items.

Both English and German belong to the same West Germanic language family and share many similarities. In additional research we have begun to look at languages from different sub-families which show different distributions of regulars and irregulars as well as of inflectional suffixation.

Significant cross-modal priming has been found for Italian regular and irregular verbs (Orsolini & Marslen-Wilson 1997). For regular verb pairs, the prime was typically a first or third conjugation past definite form, paired with either an infintive target (as in ***gioc**-a-rono/**gioc**-are* 'they played/to play') or with a past participle target (as in ***am**-a-rono/**am**-a-to* 'they loved/loved'). These conditions were contrasted with irregular verb pairs, such as *sce-s-ero/scend-ere* 'they got down, past definite'/to get down, infinitive', with idiosyncratic alternations, comparable to English irregular alternations, but occurring in a much more constrained and predictable morphological environment. Significant priming

was found across the board, with no differences between conditions in the magnitude of priming. There was no evidence here, or in an accompanying study using elicitation techniques, to suggest underlying differences in the processing and representation mechanisms evoked by regular and irregular forms.

Comparable results were obtained for French, where Meunier and Marslen-Wilson (2000) investigated the processing of French verbs with regular and irregular alternations in both cross-modal priming and masked priming experiments. They distinguished three levels of irregularity, ranging from phonologically triggered alternations such as *sème/semer* 'I sow/to sow', through sub-regularities such as *teignent/teindre* 'they dye/to dye', to highly idiosyncratic alternations such as *iront/aller* 'they will go/to go. As in Italian, these irregularities are linguistically embedded in extensive, primarily regular inflectional paradigms. Again, strong priming, without significant differences in the effects for regulars and irregulars, was found across the board. These results, similar to those from Italian, provide no support for the view that different mechanisms handle the processing of regulars and irregulars.

The aim of this paper is to extend these cross-linguistic investigations to Polish, a representative of the Slavonic language family, where very little behavioural research has been conducted. A striking characteristic of Polish is the great richness of its inflectional systems and the wide distribution of phonological and morphophonological alternations, varying considerably in regularity. In addition, note that in Polish, as in French and Italian, but in contrast with English, both regular and irregular verbs are inflected by concatenation of an inflectional suffix with a stem. In English, this is true for regular past tenses, e.g. *jump/jump-ed*, but not for irregular past tense forms, e.g. *give/gave*. The distinction between Polish regular and irregular forms is made on the basis of a vowel or consonant change (an alternation) in inflected forms. Regular inflected forms have morphophonological alternations which are predictable from Polish morphophonology. Irregular forms have morphophonological alternations which are idiosyncratic and are not predictable from the rules of Polish morphophonology.

We report two preliminary studies which probe the processing of Polish regular and irregular verbs and nouns (Experiment 1) and verbs (Experiment 2). Before moving on to the experiments, a description of the relevant characteristics of Polish is necessary.

Polish inflectional morphology and alternations

Almost every word in Polish exists within a very extensive morphological paradigm: declensional for nouns, adjectives, numerals and pronouns and conjugational for verbs. Every verb in Polish is inflected according to one of the three conjugational paradigms (Laskowski, 1998). The basis of the division of verbal themes into conjugations is their ability to concatenate with the complex morpheme of the present tense. The themes which are members of conjugation I take in the present tense the endings *'-ę', '-e-sz', '-e', '-e-my', '-e-cie'* and *'-ą'* for the 1st, 2nd and 3rd person

SG[1] and the 1st, 2nd and 3rd person PL, respectively. The themes which are members of conjugation II take the endings: *'-ę', '-i-sz', '-i', '-i-my', '-i-cie', '-ą'*. The verbs which belong to conjugation III have the endings: *'-m', '-sz', '-0', '-my', '-cie'* and *'-ą'*. Every conjugation is divided into classes, depending on the ending of the verbal theme. For instance, conjugation I consists of five classes and the fifth class consists of verbs which exhibit unproductive, idiosyncratic alternations.

Every Polish noun is inflected according to an extensive declensional paradigm. Each paradigm consists of seven cases. There are three declensional groups for SG nouns: masculine, feminine and neuter and two for PL nouns - nonpersonal and personal (Zagórska-Brooks, 1975).

Fully two-thirds of words in Polish exhibit changes which are consonantal and/or vocalic. Broadly speaking there are two sources of alternations in Polish: phonological and morphophonological (Zagórska-Brooks, 1975; Kowalik, 1998). Our focus here is on the second type, the morphophonological alternations. This type of alternation is caused by an interaction between morphology and phonology during concatenation of morphemes with other morphemes (e.g. in conjugation or declension). There are two kinds of morphophonological alternations in Polish verbs and nouns: regular and irregular. The regular alternation is predictable and usually productive. For instance, the postalveolar consonants - [ʃ] and [ʒ] in *prosz-ę* [prɔʃ-ɛ̃] 'I ask' and *woż- ę* [vɔʒ-ɛ̃] 'I transport' alternate with the palatal consonants - *ś* [ɕ] and *ź* [ʑ] when the stem is concatenated with the vowel - *i-*, as in *prosi-ć* [prɔɕi-t͡ɕ] 'to ask' and *wozi-ć* [vɔʑi-t͡ɕ] 'to transport'. The reason for this is that the alveolar place of articulation in the inflected forms (1st person SG, present tense) changes to the palatal place of articulation, because of the following front vowel *i*. In contrast, the irregular alternations cannot be predicted and are usually unproductive. For instance, the stem *trze-ć* [t͡ʃɛ-t͡ɕ] 'to grate' alternates with the stem *tr-ą* [tr-ɔ̃] 'they grate'. There are two kinds of alternation here: the consonantal and the vocalic, where the vocalic alternation e : 0 is an idiosyncratic one, which is unpredictable from the morphophonology of contemporary Polish.

The fact that the morphophonological alternations in Polish verbs have a different distribution to those found in English is worth emphasising. In English, alternations in verbs occur between the present and past tense forms, for instance *give/gave*. In Polish, on the other hand, there can be several different alternations in verbs in the same and different tenses, depending on person, number and so forth. For the verb *wieś-ć* [vɛɕ-t͡ɕ] 'to lead', there are two types of alteration: consonantal and vocalic. There are three consonantal alternants: *wieś-ć* [vɛɕ-t͡ɕ]: *wiod-ą* [viod-ɔ̃]: *wiedzie-sz* [vied͡ʑɛ-ʃ] 'to lead: they lead: you lead'. And there are also three vocalic alternants, two in the present tense: *wieś-ć: wiod-ą* and the third in the past tense: *wiód-ł* [vud-w] 'he led'.

The alternations in Polish have a more even distribution than in English. All classes, despite regular or irregular alternations, concatenate with the same conjugational endings, which are characteristic for a given conjugation. Polish is very similar to French in this respect. This does not occur in English, where the concatenative process applies to regular past tense forms but not to irregular ones. Neither does it happen in Italian, where the irregular forms conjugate using a different set of endings than the regular forms.

Experiment 1

The aim of Experiment 1 was to investigate processing of Polish verbs and nouns with regular and irregular alternations. We chose cross-modal priming as a starting point because most cross-linguistic and English data come from this paradigm. The question that we asked was whether the pattern of results for Polish items with no alternations, regular alternations, and irregular alternations would be comparable with the Italian and French or with the English and German results. In contrast to all of these languages, Polish also provides an opportunity to investigate the processing of regular and irregular nouns which are inflectionally suffixed; the suffix occurs in both singular and plural and denotes case, gender and number. Taking advantage of this characteristic of Polish nouns, we contrasted verbs and nouns. This served firstly, to test whether the representation of verb and noun alternants in Polish correspond to each other, and secondly, to obtain a broader picture of the representation of alternants cross-linguistically.

Irregularity in Polish verbs is defined on the basis of the alternation which occurs in the stem and not on the basis of which conjugational morphemes are selected for a given verb. The difference between regular and irregular verbs lies in that regular verbs exhibit an alternation in the stem which can be derived by the phonological rules of contemporary Polish or is conditioned by a specific morphophonological context. For irregular verbs, the alternations in the stems cannot be predicted. All Polish nouns belong to one of the declensional paradigms and their membership depends on the gender of a noun and on the last consonant of the theme. Irregularity and regularity in Polish nouns is defined in the same way as for Polish verbs[2].

To test the processing of words with alternation we co-varied regular and irregular alternations in verbs and nouns and contrasted them with verbs and nouns without alternations. Conditions 1 to 3 were concerned with verbs, while conditions 4 to 6 were concerned with nouns. **Condition 1** consisted of verbs with no alternations, such as *czyt-a-sz/czyt-a-ć* 'you read/to read'. The aim here was to select as homogenous a group of items as possible, to serve as a baseline for verbs. **Condition 2** consisted of verbs with regular alternations, which can be predicted from the morphophonological rules of contemporary Polish, as in *nosz-ę/nos-i-ć* 'I carry/to carry'. The alternation involved dental consonants, such as *c, dz*; postalveolar consonants, such as

sz, ż; and palatal consonants - *ć, dź, ś, ź*. The reason for selecting this particular type of alternation is that it is regular and occurs in verbal stems which belong to a productive conjugation. This contrasts with the verbs in **Condition 3** with irregular alternations, as in *trz-e-ć/tr-ą* 'to grate/they grate'. Six types of irregular alternation were included in this condition[3]: **1)** a : e, **2)** ą : n' and ą : m', **3)** a : 0, **4)** o : e, **5)** ą : ę and **6)** e : 0. The motivation for selecting these types of alternation was that they could not be predicted from the morphophonological rules of Polish. These alternations are peculiar to a specific group of verbs, which belong to the unproductive classes of conjugation I.

Conditions 4 to 6 concentrated on nouns. **Condition 4** consisted of nouns with no alternation, e.g. *plac-u/plac* 'a square, GEN, LOC, VOC/a square, NOM, ACC' and served as a baseline for the other noun conditions. **Condition 5** was designed to investigate the representation of nouns with regular alternations. It consisted of nouns with three types of alternation, all of which are predictable from the context. These included the alternation of hard labials to soft labials, as in *chłop/chłop-i* 'peasant/peasants', the alternation of coronals, as in *studenci-e/student* 'a student, LOC, VOC/a student, NOM', and the alternation of velars, as in *nodz-e /nog-a* 'a leg DAT, LOC/a leg, NOM'. **Condition 6**, in contrast to Condition 5, concentrated on alternations which are not fully predictable from the morphophonological rules of Polish. Three types of irregular alternation were included: **1)** a : e, **2)** ę : ą and **3)** o : ó. All three alternations exist nowadays as fossilised historical remnants. The alternations ę : ą and o : ó are based on a very old phonetic change.

Finally **Condition 7** consisted of words with phonological overlap, without semantic or morphological relationship, e.g. *kotlet/kot* 'cutlet/cat'. This was designed to test whether priming could be due just to pure phonological overlap between the prime and the target.

Procedure

We used the cross-modal immediate lexical decision task. The participants heard binaurally an auditory prime, at the offset of which they immediately saw a visual target (for 500 ms) and had to decide, by pressing an appropriate button, whether a target word was a real word or a non-word. The subjects were allowed 2500 ms from the onset of the target for their response.

Targets were preceded either by a related prime or by an unrelated control prime. The control prime was matched for lemma frequency and number of syllables to the related prime. The priming effect was measured as a difference in the reaction time to the target word when preceded by the control prime as opposed to the related prime. Each target only occurred once in the experiment, and two experimental versions were run, alternating control and related primes for each target.

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[2] There is also a second type of irregularity in Polish nouns which originates from the fact that nouns which are for instance masculine, e.g. *mężczyzn-a* 'a man' are inflected in SG according to one of the feminine declensional paradigms. This type of irregularity was not the focus here.

[3] The vocalic alternations were in some cases accompanied by consonantal alternations. For instance an alternation of *rz : r* co-occurs with *e : 0* in *trz-e-ć/tr-ą* 'to grate/they grate'. Pairs of this type were included here, because there are very few verbs with an irregular alternation which are not accompanied by the consonantal alternation.

The experiment was run in Kraków using DMASTR/VMASTR software[4]. A 486/33 NIMBUS PC was used for running the experiment and collecting participants' RTs and error rates. A Digital Audio Tape Corder TCD-D3, Sony Walkman was used to present the auditory primes.

Results

Three subjects from version 1 and one subject from version 2 were discarded from the analyses because of a high error rate in the lexical decision task. This gave 21 subjects per version. All participants were Polish native speakers who were studying in Kraków. The majority of them were in their twenties and some were in their thirties. Out of the total of 580 items per version, 5 experimental pairs had to be discarded from the analyses; two because of high error percentage, two because they were erroneously classified as having a certain type of alternation, and one item because of homophony. Every data point has been inversely transformed to reduce the influence of outliers. (see Table 1 for details of the descriptive statistics).

Table 1. Priming effects and error rates in Experiment 1.

Condition	N	Prime (Mean RT)	Control (Mean RT)	Priming
1 No Alternation Verb	20	527 (1.0)	610 (5.5)	83***
2 Regular Alternation Verb	26	534 (0.8)	622 (3.4)	88***
3 Irregular Alternation Verb	26	542 (1.1)	615 (4.2)	73***
4 No Alternation Noun	20	512 (0.5)	573 (3.3)	61***
5 Regular Alternation Noun	30	518 (0.5)	580 (3.5)	62***
6 Irregular Alternation Noun	30	503 (0.7)	549 (1.5)	46***
7 Phonological Overlap	20	581 (6.5)	571 (3.5)	-10

*** denotes p<0.01; Reaction Times are in ms; Error rates in percentages (in parentheses).

An overall ANOVA with Prime (2 levels), Condition (7 levels) and Version (2 levels) was run, separately for subjects (F1) and items (F2), and revealed that there was a facilitatory effect of Prime $F_1(1, 40)=160.22$, p<0.001, $F_2(1, 153)=200.94$, p<0.001. There was a main effect of Condition $F_1(6, 240)=35.52$, p<0.001, $F_2(6, 153)=3.94$, p<0.01, and a two-way interaction of Condition and Prime $F_1(6, 240)=160.22$, p<0.001, $F_2(6, 153)=8.67$, p<0.001.

Subsequently an analysis of the simple effects of Prime at each level of the Condition was run. There was a consistent facilitatory effect of Prime at all levels of Condition with the exception of the Phonological Overlap Condition (p<0.001 throughout). To explore whether there were any differences in the magnitude of priming between no alternation, regular

alternation and irregular alternation, planned comparisons were run separately for verbs and nouns. Regarding verbs, there was no significant difference in the magnitude of priming between No Alternation and Regular Alternation (F1<1, F2<1), No Alternation and Irregular Alternation, (F1<1, F2<1), and Regular Alternation and Irregular Alternation, $F_1(1, 40)=2.866$, p=0.098, $F_2(1, 46)=1.31$, p=0.258. The results for the nouns paralleled those of the verbs. There was no significant difference between the magnitude of priming for No Alternation and Regular Alternation, (F1<1, F2<1), No Alternation and Irregular Alternation, [$F_1(1,40)=1.281$, p=0.264, F2<1] and Regular Alternation and Irregular Alternation, $F_1(1, 40)=1.208$, p=0.278, F2<1.

Discussion

Significant priming was found for regulars as well as for irregulars, and no differences were found in the magnitude of priming between all verb conditions compared together, and all noun conditions compared together. Although there was a slight numerical decline in the amount of priming for the irregular alternations, this was not statistically significant in any analyses.

These results suggest, first, that the representation and processing of verb and noun forms is comparable in Polish. The only difference here is the significantly larger amount of priming for verbs overall compared with nouns. A possible explanation for this is that nouns in the oblique cases (all noun primes had this characteristic) are less effective primes than conjugated verbs (all the verb primes were conjugated forms). Nouns in the oblique case typically occur in a specific prepositional context, and they may be more difficult to process out of context, in contrast to conjugated verb forms, which can frequently occur without further context.

More generally, there is again no evidence here that the processing of Polish regular and irregular verbs and nouns invokes distinct underlying processing. This finding groups Polish data together with the data on Italian and French, but not with the English and German results. However, before proceeding further, we need to put these results on firmer ground.

The absence of priming for the pairs with pure phonological overlap indicated that the effects cannot be attributed just to phonological overlap. We cannot, however, exclude an account purely in semantic terms, since all of the verb and noun test pairs were strongly related not only morphologically but also semantically. It is possible, for example, that the preserved priming for the irregular alternants reflects a strong semantic input, compensating for reduced morphological priming. To address this concern, we ran a subset of the items from Experiment 1 (the verb materials) in a second experiment designed to separate morphological and semantic effects.

Experiment 2

This experiment uses the delayed repetition auditory-auditory priming task. In this task, where several items intervene between prime and target, we generally see no effects of pure semantic relatedness but robust effects of morphological relatedness (e.g., Marslen-Wilson & Tyler,

1998). If the priming effects for the alternation conditions are primarily morphological in character, then these should survive the change in task.

Materials

Because of the requirements of the task, the inclusion of all the materials from Experiment 1 would have made the experiment infeasibly large. We therefore used only the verb materials, which can be linked most directly to the research in other languages.

108 prime-target pairs were selected for 5 experimental conditions. Three of these were the Verb conditions from Experiment 1, with 20 pairs in the No Alternation condition, 24 in the Regular Alternation condition, and 24 in the Irregular Alternation condition. A further 20 pairs were selected from the Phonological Overlap condition (*kotlet/kot* 'cutlet/cat'). The fifth, new condition consisted of 20 pairs of words that were Semantically but not Morphologically Related [+Sem, -Morph] (*banan/kokos*, 'banana/coconut'). This was to check whether purely semantic priming could be observed.

Procedure

Standard delayed auditory-auditory priming was used. The subjects heard binaurally a string of words, one every 3 seconds, which were a mixture of primes, controls, targets and fillers. Their task was to make a lexical decision by pressing an appropriate button on a response box to every heard item. The task was designed in such a way that primes and targets were separated by 12 intervening items (approximately 35 seconds). The experiment was run in Kraków using DMASTR/VMASTR software. The same experimental equipment as in Experiment 1 was used.

Results

4 participants from version 1 and 3 from version 2 were discarded from the analysis on the same criteria as in Experiment 1. Additionally 1 participant from version 1 and 1 from version 2 were excluded, because of technical problems. A total of 19 subjects per version was entered into the analysis. Further details on participants were the same as in Experiment 1. Two experimental items were removed from the analysis, because of high error percentages. A total of 106 items were entered into the analysis. (See Table 2 for the details of the descriptive statistics).

The analyses are based on the Target reaction times only. The inversely transformed data were analysed in a repeated measures ANOVA. The overall analysis for all 5 conditions revealed that there was a main effect of Prime, $F_1(1, 36)=40.14$, $p<0.001$, $F_2(1, 96)=16.17$, $p<0.001$. There was also a main effect of Condition, $F_1(4, 144)=67.80$, $p<0.001$, $F_2(4, 96)=4.24$, $p<0.01$ and a two way interaction of Condition and Prime $F_1(4, 144)=7.26$, $p<0.001$, $F_2(4, 96)=3.50$, $p<0.05$.

Subsequently, the simple effects of Prime on each level of the Condition were investigated. There was significant priming in all the verb conditions as predicted: No Alternation Verb: $F_1(1, 36)=11.05$, $p<0.01$, $F_2(1, 16)=5.69$, $p<0.05$; Regular Alternation Verb: $F_1(1, 36)=25.97$,

$p<0.001$, $F_2(1, 22)=12.69$, $p<0.01$; Irregular Alternation Verb: $F_1(1, 36)=28.99$, $p<0.001$, $F_2(1, 22)=9.56$, $p<0.01$. No significant priming was found either in the Phonological Overlap condition [$F_1(1, 36)=1.41$, $p=0.242$, $F_2<1$], or in the Semantically Related and Morphologically Unrelated condition [$F_1(1, 36)=1.83$, $p=0.184$, $F_2<1$].

To explore whether there were differences in the magnitude of priming between the three verb conditions the appropriate planned comparisons were made. There were no significant differences in the magnitude of priming in any of the comparisons between the No Alternation, Regular Alternation, or Irregular Alternation conditions ($F_1<1$, $F_2<1$ throughout).

Table 2. Priming effects and error rates in Experiment 2.

Condition	N	Prime (Mean RT)	Control (Mean RT)	Priming
1 No Alternation Verb	20	718 (0.6)	748 (0.9)	30*
2 Regular Alternation Verb	24	743 (1.1)	781 (1.8)	39**
3 Irregular Alternation Verb	24	753 (3.7)	785 (3.7)	32**
4 Phonological Overlap	20	816 (8.9)	803 (7.4)	-14
5 [+Sem, -Morph]	20	810 (2.6)	819 (1.8)	9

* denotes $p<0.05$; ** denotes $p<0.01$; Reaction Times are in ms; Error rates in percentages (in parentheses).

Discussion

The results indicate that the priming effect observed in all the verb conditions is morphological in nature and not semantic. As in Experiment 1, the effects are equally strong across the alternation sets. There is no trace of a semantic effect under these testing conditions, but there is robust priming between all morphologically related pairs, indicating that both prime and target map onto the same underlying morpheme at the level of the lexical entry. The absence of significant priming for the Phonological Overlap condition confirms that any facilitatory priming here cannot be attributed to the pure phonological overlap between primes and targets.

General Discussion

The question asked at the beginning of this paper was whether a dual or single mechanism can best account for the results from Polish. The data we report, with no difference in the magnitude of priming for regulars and irregulars, seems to group with earlier findings on Italian and French (Meunier & Marslen-Wilson, 2000; Orsolini & Marslen-Wilson, 1997), and indicates that a uniform set of processing procedures and representations are applied to Polish regular and irregular verbs and nouns.

We suggest that the explanation for these properties of Polish, and its similarities with French and Italian, lies in the fact that every verb and noun in Polish functions within similar inflectional paradigms which requires suffixation. All verbs and nouns, despite having regular or irregular vocalic or consonantal alternations, are inflected using con-

catenative processes which link verb roots to a series of inflectional suffixes. This is in contrast to English, where the regularity/irregularity distinction is confounded with a contrast in type of morphological process. The regular past tense inflection involves concatenative suffixing morphology, whereas the irregular forms have no overt inflectional structure, and have to be both stored and processed as unanalysable full forms. The sequence *jumped* can be broken down into the pair {jump} + {-ed}, but no such analysis can be applied to forms like *bought* or *gave*.

The consequences of this, in English, is that regular and irregular inflected forms do partially involve separable underlying cognitive and neural systems, with the regular inflected forms requiring the involvement of specialised systems supporting processes of morphophonological assembly and disassembly. These systems, that can be selectively damaged following stroke and other injuries to the brain, are not required for the access and processing of the irregular forms, which are not phonologically decomposable (Marslen-Wilson & Tyler, 1998). The same distinction does not apply, of course, to Polish (or French and Italian) irregulars, all of which are morphophonologically complex, and which invoke the same range of processing mechanisms as the regular forms.

These considerations suggest that further progress in elucidating the properties of the mechanism underlying the processing of regular and irregular forms will require more attention to the neural underpinnings of these mechanisms. A start has been made in this direction in the study of English and German inflection. For instance, Marslen-Wilson, Csibra, Ford, Hatzakis, Gaskell and Johnson (2000) examined the processing of English regular and irregular past tenses using an immediate cross-modal priming experiment during which ERPs were recorded. The results revealed differences in the pattern of scalp activity for regulars and irregulars and provide support for the claim that partially different mechanisms underly the processing of each type of material. Two other ERP studies reported by Clahsen (1999) on the representation and processing of German regular and irregular plurals and participles, using a violation paradigm, claim that regularisations elicit signals which are characteristic for violations of a morpho-syntactic rule, whereas irregularisations elicited signals which are typical of anomalous words and can be regarded as support for a distinction between rule-based and lexically based inflectional processes (Pinker, 1999).

Thus, if Polish regular and irregular nouns and verbs are indeed processed by a uniform underlying mechanism, as suggested by the data presented in this paper, then one would not predict significant differences in ERP recordings for the regulars and irregulars, nor in neuro-imaging studies using techniques such as fMRI, allowing a greater degree of spatial localisation. But whatever the outcome, input from studies of this sort are likely to be an essential component of any future resolution of the kinds of questions raised here.

Acknowledgements

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