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Année Académique 1998-99

Review of a BBS target article
Lexical Entries and Rules of Language:
A Multidisciplinary Study of German Inflection
by Harald Clahsen to appear in *BBS* (1999) 22 (6).

Abstract

Many authors (e.g., Chomsky 1995, Pinker 1984, and Marcus 1998) argue that the architecture of the language faculty contains two separate components: a (structured) lexicon and a computational component. Clahsen presents in a current BBS target article (in press) new empirical evidences in favour of such a dual-mechanism model of language processing based on a multidisciplinary study of German inflection. In the following review, I will summarise and discuss the major points of Clahsen's paper. My focus will be on theoretical, methodological and empirical issues presented and discussed in the paper. An important issue will be the bearing of his empirical findings on the current debate in psycholinguistic modelling. I will as well speculate that at least a part of Clahsen's reasoning seems not to hold in the case of a language closely related to German, namely Luxembourgian.

Preliminary comments

Before reviewing Clahsen's paper, I would like to stress out its general logic. Linguistic descriptions suggest a two components structure of the language faculty (namely, a lexicon and rule-based operations). Empirical evidence from various dissociation studies must be sought to confirm their psycho- and neurolinguistic relevance (cf. the correspondence hypothesis proposed by Miller & Chomsky 1963). And, deficiencies of current (and probably future) single-mechanism models are taken as supportive prove (at least temporarily) in favour of dual-mechanism models.

It is thus assumed, in terms of methodological claims, that dissociations of performances and brain processes directly reflect dissociations of cognitive processes (a claim that will be discussed later). In terms of psycholinguistic modelling, it follows from this reasoning that any valid model in computational linguistics must (somehow) account for the dissociations found in linguistic descriptions and in empirical data (I will return to this claim later on, too). Another major point of Clahsen's claims is that German inflectional systems (for instance, plural noun formation and verb participle formation) are particularly interesting to study for reasons exposed below.

Summary

In a current BBS target article Harald Clahsen, Professor of Linguistics at the University of Essex, presents a wide range of new empirical data collected by himself and his colleagues that aim to 'bear on the controversy between dual and single-mechanism models of language'[1]. They studied German inflection from different disciplines investigating its linguistic structure, how it is produced and comprehended in real time, how it is processed in the brain, how it is affected by language disorders, and, finally, how it develops in child language acquisition. Clahsen presents the results from these studies as impressive converging evidence in favour of a dual-mechanism model of language processing[2].

In the context of inflection[3], this model can be characterised as follows. It postulates 'two qualitatively different clusters of inflectional phenomena, [namely] **lexically-based inflection** versus **inflection based on combinatorial rules**'. This distinction corresponds to what other authors (Pinker & Prince 1991) called the distinction between irregular and regular (default) inflection. Clahsen adopts a model, the Minimalist Morphology introduced by Wunderlich & Fabri (1995) for English inflections, that explicitly makes this distinction.

Lexically-based inflection is assumed to be accounted for by a structured lexicon. Each node in a structured lexical entry corresponds to a pair of its 'category membership' (e.g. N(oun), V(erb)) and of 'idiosyncratic information' about its forms and meaning; and 'each subnode inherits all information of its mother, except for the features it replaces or adds'. Subregularities among irregular forms are 'captured through lexical templates in which stem segments are associated with segments from subnodes'.

On the other hand, processes of affixation (stem+affix) explain inflection based on combinatorial rules. They can easily extend to novel items (this is why it is also called *default* inflection). Based on this dual-mechanism model, Clahsen predicts, in general, that regular and irregular forms should, in terms of processing, exhibit different effects. Indeed, regulars should reflect that they are 'computed via their constituent morphemes', and irregular forms should 'exhibit associative memory effects'. This general prediction will be adapted to different experimental paradigms and thus yields more precise predictions that will be separately exposed below.

In order to support the hypothesis of the dual-mechanism model of the language faculty, Clahsen first of all reviews some familiar arguments from linguistics, psycholinguistics, neurolinguistics, neuro-imaging and developmental studies in its favour. I will not elaborate on these arguments but rather on the new evidences presented in the target article. Clahsen also reviews some recent attacks of the dual-mechanism model by researcher from the field of connectionism (e.g., Elman et al. 1996, Rumelhart & McClelland 1986, Seidenberg 1993). Associative single-mechanism models are designed to 'make without the machinery of internally-represented, symbol-manipulating combinatorial operations'. The claim of connectionism is that of parsimony and of neural-based implementation of cognitive processes. But Clahsen thinks that there is still vast evidence for their 'severe deficiencies', for instance, their failure to correctly master syntax, as shown by Fodor et al. (1974) and their failure to handle inflectional systems, as remarked by Pinker & Prince (1988), Marcus et al. (1995), and Marcus (1998).

[1] All quotations are, by default, taken from Clahsen (1999) if no other author is mentioned.

[2] Although Clahsen presents the general idea of a dual-mechanism model three times in his paper (in the introduction and later on in sections 3 & 4.1), I will describe it only once in order to avoid overloading the present review.

[3] As said above, I will not extend on Clahsen's general description of the dual-mechanism model for language as such, but merely concentrate on the particular model of inflectional system.

According to Clahsen the main point of interest in this current connectionist-symbolist debate is to turn to empirical evidences that might bear on the controversy.

Before presenting the studies on German inflections he and his colleagues performed, he argues for their relevance by situating them in the general context of studies on inflectional systems, namely studies on English past-tense formation, as well as in the context of the acknowledged need for cross-language confirmation studies. He reports on studies that have shown double dissociations between regular and irregular past tense forms in English using the paradigm of cross-modal priming. Studies on developmental disorders, as well, showed similar dissociations for English speaking children (children with William Syndrome are contrasted with those with Selective Language Impairment). Moreover, some of these results seem to replicate in German-speaking aphasics.

Clahsen also points out that several attempts to simulate the properties of English past-tense formation (in adults and in children) with the help of connectionist models remain flawed in some important ways. He especially stresses the false assumptions about the nature of linguistic input and about correlations between vocabulary development and overgeneralization errors, as well as the unconstrained ability of neural networks to learn any arbitrary input-output mapping - 'even linguistically impossible ones'.

On the other hand, Clahsen argues that English past-tense formation itself presents certain problems that render it an unfavourable object of studies aiming to distinguish between single-mechanism and dual-mechanism models. English is a basically inflectionally poor language and there is a certain confusion of regularity (of inflections) with both the presence of an affix and with its frequency - regular forms are more frequent than irregular forms and only regular forms take affixes.

German inflectional systems are better suited to Clahsen's project for two reasons: they are inflectionally richer and they do not confound frequency of regular forms with the presence of an affix. Indeed, German noun plurals and verb participles can take several endings (two for verbs and four for nouns), where one of them can be considered to be regular and the other(s) to be irregular. Moreover, regular forms are far from being the most frequent forms. Processing of regular forms can thus, according to Clahsen, not be explained by mere associative learning mechanisms, since here it cannot be that the more a network encounters such a form, the more it tends to generalise it to new (or nonsense) words. Therefore the author proposes a dual-mechanism approach to German inflection. The general features of this model have been presented above. Since Clahsen and colleagues have chosen to examine the 'phenomenon of grammatical inflection […] focusing on noun plurals and participle formation […] a linguistic analysis of this inflectional system [is] presented which makes use of two kinds of linguistic representations, affixation and structured lexical entries'.

German participle formation involves two endings, the irregular one being -n, and the regular one being -t. As already mentioned above, the regular (or default) 'suffix applies to words for which lexical entries are not readily available' (e.g., nonsense words).[4] This is not the case for the irregular suffix, which furthermore, by contrast to the regular suffix, 'co-occurs with phonologically unpredictable stem changes'.[5] As stated before, this regular/irregular distinction is supposed to be linked to a distinction of cognitive processes. German noun plurals are constructed using five endings (-n, -s, -er, and -0) along with possible vowel changes. None of these suffixes is 'statistically predominant, and the use of these endings with specific nouns is not readily captured by standard inflectional rules'. But the German plural system provides a default process which 'applies when irregular forms are not accessible'.[5] Affixation of -s applies 'when the phonological environment does not permit any other plural allomorph'. It also readily generalises to a range of derived nouns (e.g., rootless or headless nouns,

[4] This precisely is the method proposed to determine default inflection.

[5] In order to simplify reading I will speak of regular vs. irregular suffixes in the rest of this review.

eponyms, product names, nominalised VP) and nonsense words. Again, the description of regular vs. irregular plurals is supposed to be paralleled by a difference in morphological processing.

In the following, I will report on the various empirical results found in different studies based on the linguistic considerations and the Minimal Morphology model presented above. These studies involved as well psycholinguistic laboratory experiments, as neuro-imaging studies and developmental studies. The general structure of argumentation has been presented above and remains essentially the same throughout all these studies. Consequently, I will briefly describe the paradigms used and the results obtained, for each study.

In adults, Clahsen and colleagues examined three different major effects on regular vs. irregular inflections, namely those found in generalisation of inflectional processes, visual lexical decision, and cross-modal morphological priming.

Effects of generalising inflectional processes were examined with three tasks comprising generalisation to nonsense words, matching sentences containing nonsense participles and judging for acceptability participle and plural forms of unusual words. Generalisation to nonsense words involved (1) that subjects filled-in in sentences with participles of nonsense verbs provided their infinitive and past tense forms (the past tense forms indicated whether nonsense verbs followed regular or irregular inflection patterns); and (2) that they judged the acceptability of regularly vs. irregularly derived plurals of nonsense nouns that were either rhymes or non-rhymes of existing German nouns. For the participle condition (1), it was predicted that subjects would preferentially produce regular participles, except when the nonsense verbs were similar to existing irregular ones, corresponding to inflection by analogy. This pattern of results was indeed observed. For the plurals condition (2), predicted results (namely that irregular plurals should be 'judged better for nouns that rhymed with existing [irregular] nouns than for non-rhymes', whereas regular plurals should be 'judged worse in the rhyme condition than in the non-rhyme condition') were found too.

In the visual lexical decision study, effects of word-form frequency were investigated. Indeed, it follows from the dual-mechanism model that irregularly inflected forms are more likely to produce word-form frequency effects than regularly inflected ones, since the latter are supposed not to be represented in the lexicon as such. On the contrary, they are derived from default affixation processes applied to existing word-stems. Irregularly inflected forms, themselves, are supposed to be stored in memory and can thus present frequency effects in lexical decision tasks. The predicted asymmetry in frequency effects was produced with German participles: reaction times for irregular participles, but not for regular participles, are affected by their word-form frequencies, suggesting that only irregularly inflected participles have lexical entries (whose differential frequencies can act on reaction times).

In the cross-modal morphological priming study three different conditions, involving auditory primes and visual targets, were created: identical primes and targets, morphologically related primes and targets (e.g. *walked* - *walk*, respectively *taught* - *teach*[6]), and unrelated primes and targets. Note that priming effects are generally assumed to result from activation of lexical representations. In this study, priming effects were predicted to be different for regularly inflected words than for irregularly inflected words. For regular participles and nouns, full priming was expected, i.e. same facilitation (on target decisions) by morphological primes as by identical primes, but no facilitation by unrelated primes. For irregular participles and nouns, on the other hand, partial priming should occur, i.e., only identical primes should produce facilitation, but not morphologically related primes. The reasoning of these predictions goes as follows: regular forms are decomposed into stem+affix, which both have lexical entries of their own, hence the repetition of the same stem (which occurs both with identical

[6] I took English verbs for mere convenience of presentation, although the original material involves German verbs, of course.

primes and with morphologically related primes) produces facilitation on the target decision. Irregular forms, however, are represented on subnodes of lexical representations. Consequently, they activate their corresponding entries only *indirectly*, via subnodes. They should thus produce less facilitation than identical primes. The expected results were produced for both plural nouns than for participles. Note that, with plurals, irregular forms produced overall shorter reaction times than regular forms related to the frequency differences between these two classes of nouns.

These converging results, suggesting that different cognitive mechanisms are involved in processing of regular and irregular inflections are supported by data obtained in neuro-imaging studies on German inflection. Clahsen and colleagues, for reasons of temporal resolution, 'applied the ERP[7] method to examine the brain structures involved in morphological processing and representation'. Previous studies with this method showed that the most promising paradigm for research on language involves violations of linguistic regularities. In the context of research on inflection this implies that violations of regular affixation elicit similar ERP effects than other morpho-syntactic violations in specific brain structures (P600 and LAN[8]). Two studies have been conducted using the ERP method: one on noun plurals and one on participle formation. For each of these studies four groups of stimuli were created by the intersection of two variables: regular vs. irregular and misapplication vs. correct application. There were thus two types of stimuli that potentially corresponded to morpho-syntactic violations: those resulting from irregularisation and those from regularisation. The prediction was, however, that only misapplication of regular inflections would indeed elicit the typical ERP effects signalising real morpho-syntactic violations. It would surely surpass the scope of this review to describe the results in details that are reported for the two ERP-studies. Let me just briefly cite Clahsen when he says that 'in sum, [for plural nouns and participles] regularizations were associated with a negative waveform with a focal left anterior temporal distribution [the LAN effect], that occurs when affixation is incorrectly applied. […] Irregularizations [on the other side] do not involve violations of affixation, but may rather be conceived of as unexpected or anomalous words. The ERP-results support this interpretation [since] the central negativity found for […] irregularizations does […] resemble [an ERP-effect] which occurs [with] pronounceable non-words'. Clahsen concludes that the neuro-imaging results correspond to the linguistic distinction made between regular and irregular inflections.[9]

Based on all those converging results which suggest the psycho- and neurolinguistic relevance of the dual-mechanism model, one question seems to inevitably pop up: how does this dual structure emerge in child language acquisition? At present, there seem to be two ways to address this question, 'Neo-Constructivism' and 'The Continuity Hypothesis'. Clahsen (rather rapidly) concludes with Marcus (1998) that 'connectionism cannot save constructivism' (for reasons exposed above). Consistent with the general framework within which Clahsen's thinking is to be placed, he strains the 'claims that the structure of the language faculty does not change over time but that development results from other factors [such as] increases in the child's lexicon'. The correct use of inflections emerges as soon as the child 'picks up [the inflectional affixes] from the input, […] which can then become effective, though they were (latently) available [before]. For reasons of perceptual non-salience, lack of stress and

[7] An ERP-study provides a real time measure of cognitive processing. The method is very sparsely described in the target article.

[8] P600 corresponds to a positive latency of about 600 ms and LAN means left anterior frontal negativity. For further details on the current status of these ERP effects please refer to Clahsen (1999) and references indicated there.

[9] Instead of following the structure of Clahsen's paper (at this place, he discusses some associative models), I will continue to present empirical data on children and then finish by presenting his discussion of current models of German inflection. This will give a more global picture of the dissociations that computational psycholinguistic models will have to account for.

absence of isolated utterance, affixes are hard to grasp for children, and thus, they only gradually become lexical entries in themselves.

Based on 'evidence for continuity and lexical learning' coming from studies on the acquisition of syntax, Clahsen proposes to study the development of inflection from this point of view. Two main observations have been made in child inflection acquisition that support the dual-mechanism model, namely observations about overgeneralisations of inflections and those about constraints on word formation processes related to inflections.

Concerning overgeneralisations, German verb participle formation and plural noun formation have been studied in experiments designed to elicited speech production of children. For participle formation, children's speech productions showed (1) a clear preference for default affixation-based participles; and (2) a clear effect of token frequency among overregularisations; and (3) that by default, children apply the regular suffix to verbs that have no lexical entries. For plural nouns, children, faced with pictures denoting low-frequency nouns, tended to produce overregularised plural forms, which they were even more likely to produce if the nouns were unfamiliar to them. This furthermore stressed the 'default' nature of the regular affixation process. In order to control for similarity-based generalisations Clahsen and his colleagues designed an acceptability judgement task, in which children were to choose between regular and irregular plural forms when presented either with nonsense words that were rhymes or non-rhymes of existing nouns. They found that children preferred regular form to irregular forms only in the non-rhyme condition, whereas in the rhyme condition no difference in preference existed. Overall, children even preferred regular forms to irregular ones in both rhyme and non-rhyme conditions. These results taken together suggest that the dual structure of language is in place early on and that it closely maps that of adults.

Concerning constraints on word formation processes, Clahsen and his colleagues investigated the relationship between compounding and inflection. The predictions of their dual-mechanism model are quite clear-cut. 'Lexical compounding is a process that concatenates lexical entries. It follows that irregular plurals (because they have lexical entries) can be fed into the compounding process, whereas affixation-based forms […] (which do not have lexical entries) cannot be included in the compounding process'. This results, probably, from a grammatical ordering constraint present in children to some extent at least. What Clahsen predicts is a correlation between plurals-inside-compounds and overregularisation. Indeed, 'plural forms that are used in overgeneralizations should be omitted from the non-head elements of compounds. This would mean that even though the children's plural forms might be incorrect in terms of adult grammar, the ordering constraint on plurals-inside-compounds would be operative in the child's linguistic system'. According to a morphological theory children should tend to omit regulars but maintain irregulars inside compounds. Two findings, based on the analysis of spontaneous speech sample and on an elicited production task, strongly suggest that German children never use regular plurals in compounds, and that they specifically restrict default plural inflection from compounds significantly more than they restrict non-default inflection. The observed interaction between compounding and inflection is said 'to follow from the internal organization of children's language faculty' which is essentially the same as that of adults.

Let us finally turn to Clahsen's discussion of associative models of German inflection. He presents three ways [sic] in which associative schemas could cope with German inflection. The first attempt made by Nakisa et al. (1998) used a pattern associator network to implement the German plural formation system. The performance of this simple associative has been compared with a simulation 'in which the regular plural was removed from the pattern associator and was only applied to singular items that were phonologically distant from other singular items in the sample (in order to implement a dual-mechanism model). They found that the second model did not outperform the first and concluded

that a single-mechanism model was sufficient to model German plural formation. However, Clahsen does not agree with their reasoning for several reasons. Their model does not so well as they claim, since it produced as much as 20-30% errors. The fact that their model had the regular plural hard-wired to apply to phonologically distant nouns can barely be considered a satisfying solution, for this does not correspond to a legal claim about German plurals. What is more, their model simply failed to generalise the regular plural in cases where no lexical entries can be accessed (e.g., nonsense words). Clahsen refutes their model as a descriptively inadequate 'model of linguistic and psycholinguistic properties of German noun plurals'.

According to Clahsen, Westermann & Goebel's (1995) model seems to be more attractive. It implements two separate components (a combinatorial system and an associative phonological lexicon). He rather briefly states that this model correctly reproduced some results that he has reported on. It seems that it somewhat correctly generalises to participles of novel items, as a function of similarity.

He cites another model from the same research group (Goebel & Indefrey 1998) that was designed to account for German plural formation. He also rapidly stresses the authors' concern about the essential difficulties of their model to learn to apply, by default, the extremely rare regular affix.

Schema-based approaches to inflection are confronted with the same problem as associative connectionist pattern associators, as long as they do not account for the linguistic and experimental differences between regular and irregular inflection.

Most importantly, the 'default nature of regular affixes does not necessarily follow from their frequency distribution'. This, according to Clahsen, 'makes it even hard to imagine how any conventional single-mechanism pattern associator could ever get the facts of German inflection right'.

Discussion

Clahsen's paper is particularly interesting for several reasons. First of all, it presents empirical evidences from various disciplines. This multidisciplinary nature of his study clearly reinforces the strength of its claims. Second, it is about German. This is interesting in itself, since cross-language confirmation studies are necessary to test for the genuinely general characteristics of human language. What is more, Clahsen convincingly argues that German is better suited than English to test for the dual-mechanism model. Third, the various empirical data converge. This is also, by itself, quite impressive. Fourth, Clahsen's studies represent a more or less convincing attempt to defend the "language-is-special-claim". The nature of language, the knowledge that underlies its use and its acquisition are currently "hot issues". In no other domain of cognitive science, is the clash between the "classicists" and the "connectionists" so tangible. The whole discussion is about whether cognition, and especially language, can do without rules or not. Clahsen and his colleagues aimed to contribute to this controversy by providing empirical evidences in favour of the claim that language cannot be explained by simple associative learning mechanisms, but ˇhat combinatorial rules really are indispensable to account for human cognition. At first sight, their converging results do seem to render the dual-mechanism model of language quite plausible, regular inflection seems to imply rule-based combinatorial operations. Clahsen even finds it rather difficult to imagine how simple associative mechanisms could ever account for the empirical data found with German inflections. Yet, this is precisely were Clahsen's argumentation is essentially flawed. Indeed linguistic analyses suggest a distinction between a lexicon and combinatorial operations. Psycholinguistic experiments and developmental studies suggest that this distinction has some functional reality: different cognitive processes seem to underlie regular and irregular inflections. Different brain areas seem to be involved in lexical and combinatorial processes too. All these data are clearly consistent with a dual-mechanism

model of the language faculty. Yet, consistent with a dual-mechanism model does not necessarily mean implying such a model.

The 'dissociation/transparency' fallacy

Indeed the methodological claim on with Clahsen's study is based, namely the (double) dissociation method, has recently come under serious attack, which Clahsen altogether seem to ignore. David Plaut (1995), for instance, has shown that double dissociations of performance do not necessarily imply modularity. I other words, 'the functional specialization in the network that gives rise to the double dissociation is not *transparently* related to the network's structure, as modular theories assume' (Plaut 1995, emphasis added). This critique applies, a fortiori, to Clahsen's experimental data, since they do not even show a double dissociation, but a simple dissociation of performances on regular and irregular inflections in German. Yet, although these experimental data are not really conclusive, one could argue in favour of Clahsen's study that it presents data, which indicate that the brain represents regular and irregular inflections in a different way. Indeed, he showed that misapplications of regular inflections yielded ERPs different to those yielded by misapplications of irregular inflections, and these potentials were generated in different areas of the brain. Now this, would a proponent of the dual-mechanism model say, really shows that affixation-based inflection is different from lexicon-based affixation. But I will argue in the following that, even if these results could be described and explained in terms of different cognitive processes, nothing implies that this implies, neither different processes (see above) nor rule-based combinatorial operations.

The 'description-equals-explanation' fallacy

Indeed, Clahsen seems to assume, because this seems more straightforward and parsimonious to him, that there is a *direct* mapping between high-level descriptions and low-level mechanisms, which is fundamental to the classical metaphor of the mind. '[S]tructural properties of inflected and (derived) words should converge with their processing properties, a sensible prediction if our ultimate goal is an integrated theory of brain and mental functions underlying language.' Still, models that are based on this kind of claims fundamentally do not represent integrative theories of brain and mental functions but reductionist theories. They assume that the neural level puts little constraints on the implementation of cognitive processes, which can therefore be described in terms of classical symbol-processing operations. These combinatorial rules are not taken to be convenient descriptions of linguistic entities and cognitive processes, but they are assumed to provide us with explanatory models of psychological mechanisms. Yet, it has also been shown that rule-like behaviour (or behaviour according to rules) does not necessarily imply that this behaviour follows these rules. This reasoning is quite clear if we consider the motion of planets. They do move in accord with Kepler's laws, but nobody would presume that they actually, and explicitly apply Kepler's laws. In the same vein, I find it hard to imagine that individual neurons (or even groups of neurons) apply some linguistic rules in order to directly produce the dissociation between regular and irregular inflections. It may be convenient to describe a language in terms of rules. But applying this description in a top-down fashion seems to inevitably lead to untreatable paradoxes, since it would imply that their is no level of emergence where neural processes take together produce rule-like behaviour. Instead, neurons would have to directly implement rules. Compare this with recent findings in the domain of Artificial Life. Take, for instance, the swarm behaviour of birds. A classicist would start describing the general rules that (seem) to govern this group behaviour and would be inevitably lead to suppose that each and every individual of the group follows these rules, granted that the correspondence hypothesis is straightforward and parsimonious. Nevertheless, this is quite unnecessary and even wrong. Individuals do not know the rules that govern coherent swarm behaviour and, moreover, it is absolutely not necessary to explain the emergent

properties of swarm behaviour. Individual birds rather behave in accord with a set of rules implemented in their neural system without having to follow these rules explicitly, in a traditional computer-like fashion.

The 'evidence-of-absence' fallacy

Another weak point of Clahsen's general argumentative structure is that he takes the severe deficiencies of current connectionist networks as clear evidence in favour of the correspondence hypothesis. This reasoning is by no means valid. In fact, even if no current connectionist account for the differential processing of regular and irregular inflections exists, this does not at all imply that the dual-mechanism model represents more than a convenient description of the cognitive and brain processes underlying language comprehension and production. Just as, absence of evidence does not mean evidence of absence, failure of current models does not mean that this failure cannot be overcome in the future. Ultimately, psycholinguistic modelling will have to account for the empirical data presented by Clahsen, but in a way that is neurally plausible and that respects the low-level constraints on the implementation of rule-like high-level processes.

The misunderstanding of connectionism

In sum, I seems to me, and this is confirmed by the fact that Clahsen keeps on referring to Marcus' (1998) critics of connectionism, that he is prone to a fundamental misunderstanding of the connectionist programme. Indeed, Marcus (1998) realised a neural network simulation with localist input units and showed that the network could not generalise to new, untrained stimuli. Since very young infants were able to generalise the underlying rule to new stimuli, Marcus concluded not only that the network has severe deficiencies, but also that babies extract and apply abstract rules. Yet, his simulation results are by no means surprising to the informed reader. Using localist input units alone was sufficient to predict Marcus' simulation results. How could the network ever generalise to stimuli, which are feed-in through untrained connections? However, no connectionist would claim that this is possible. The proper way to simulate the empirical findings on supposed rule abstraction by babies is rather to use parallel distributed processing, which allows the internal representations of the network to capture the regularities inherent to the input and eventually behave in the desired rule-like fashion. I conjecture that this fundamental misunderstanding of the connectionist framework stems not from the authors' ignorance but rather from the general theoretical framework which they embrace, namely the classical metaphor of the mind, which understands the mind as a symbol-processing computer. Connectionism truly represents a more interesting alternative to classicism than Clahsen wants the reader to believe. It remains that the case of German default plural formation seems hard to be accounted for by current connectionist models due to their low frequency as well in terms of type as token. It may be speculated that since default affixation, in German, applies to low-frequency words, an adequate neural network model could generalise in an affixation-like way to any other low-frequency word, like nonsense words for instance.

Furthermore, the model he presents is far from being more precise than current neural network models. Take, for instance, his description of how children are assumed to extract and use the affixes for noun plurals and participles: 'Once separate lexical entries for [...] affixes have been *created*, the affixation component can become effective' (my emphasis). I think this statement is symptomatic for the whole theoretical programme that underlies Clahsen's study. Cognition equals symbol-processing and new symbols are created (or give by the programmer). There is no room for auto-organisation of internal representations. The increase in behavioural mastery of language does not yield from a better representation of the multiple statistical constraints that exists in a language, but rather from an increase of the lexicon ('gradual acquisition of new lexical and morphological items').

A lack of real implications

In sum, Clahsen's empirical evidences can hardly be said to have any real implications on the current controversy between single and dual-mechanism models of the language faculty. For reasons of scientific fairness I would like to stress out that current single-mechanism accounts of linguistic performance are far from being satisfying. Even if they could entirely account for the observed dissociations this would not necessarily imply that the functional or neural architecture could (pr would) not contain separate processing mechanisms. In biological sciences, parsimony is not always an ultimate principle, since natural selection rarely 'cares' about optimality. If we grant that the mind/brain's functional architecture is a product of natural selection, than we should not be surprised to find multiple specialised problem-solving devices within our mind and brain. Still, against classicism, I claim that any computational account of these devices, and language seems to be one of them, needs to thoroughly consider neural-level constraints. On the other hand, in favour of classicism, I would like to stress out that even if our brain processes imply simple associative mechanisms, we are nevertheless able to behave in a rule-based way. I can, for instance, follow rules when I cook a certain meal for instance. Rule-like behaviour need not imply rule-based processes. But genuinely rule-based processes and behaviour, and I think they exist, need to be explained nevertheless. After all linguists can 'extract' rules from any language and use them to create new combinations of words or morphemes, even if this is not the natural process by which we normally do it.

The case of Luxembourgian

Finally, I would like to show that Clahsen's model could yield some rather specific and testable predictions. In section 5.2, Clahsen defines compounding as resulting from the concatenation of lexical entries, and since regular plurals have no (or need not have any) lexical entries they cannot be included in this compounding process. It follows that if we can find a language where regular plurals can enter the compounding process, at least one of the two basic assumptions is refuted. Either compounding does not act on lexical entries - and this would mean that Clahsen's results on word formation constraints would have to be reviewed -, or regular plurals do have lexical entries - rendering the distinction between processing of regular and irregular inflections at least superfluous. In the following, I report on an informal analysis of plural formation in Luxembourgian, which I performed together with Anne Schiltz. Of course, this informal linguistic analysis would have to be confirmed as well by formal linguistic analyses as experimental evidence. Still, in terms of the general logic, it clearly follows Clahsen's argumentation. Indeed, first of all, we determined the default plural ending for Luxembourgian, just as Clahsen did for German. We observed that the plurals of nonsense words were formed by affixation of -en (e.g., 'een galup' - 'zwee galup-en'). It should be noted here that, due to the informal nature of our analysis, we do not have any information about the frequency distributions of the various plural affixes that are possible in Luxembourgian. Still, the default affixation has be reliably determined, and it applies to proper nouns and the like too ('een Otto' - 'zwee Otto-en'). Second, we formed various compounds, especially looking for what happens with -en plurals (remember that this corresponds to the German default -s plurals), and found large amounts of exemplars with -en plurals as non-head parts of compounds. This precisely is the critical test of Clahsen's hypothesis on word formation constraints. Take, for instance, the Luxembourgian word for cat, 'eng Kaatz'. Its plural is 'Kaatz-en' and it can enter, as a non-head, many compounds, like for instance the homologue of 'cat-eyes', Kaatz-en-aan. And this holds for many other nouns whose plural is regularly formed. It even holds for nonsense words, which can enter the compounding processes in their affixation-based (regular) plural form: 'een galup' - 'zwee galup-en' leads to a possible compound, 'een galup-en-aascht' ('a galup-branch'). In Luxembourgian we thus find the homologues of compounds that are not legal in

English, like ‘a *bananas-tree’ or ‘a *cats-eye’. This either suggests that regular plurals have lexical entries, or that compounding does not act on (structured) lexical entries as such. Furthermore, in Luxembourgian we find some oddities with compounds not encountered in German or English. While the plural of ‘een Büro’ (a desk) is naturally formed by the default affixation process to yield ‘zwee Büro-en’, we do not hesitate to say ‘een Büro-s-stuhl’ (a desk-chair). It thus seems, that even irregularised plurals, although they are never used as such in Luxembourgian, do enter the compounding process, and should, according to Clahsen’s model, have lexical entries. Although the present findings are very informal, they nevertheless indicate that Clahsen’s dual-mechanism model of language processing needs not to be valid across various, closely related, languages and that further experimental and linguistic research might even favour a lexicon-based, single-mechanism model. This also reveals a fundamental flaw of general models of cognitive processing based on linguistic descriptions of specific languages. Indeed they might be good descriptions of the language in question but neither of the linguistic properties of human language as such, nor of the underlying cognitive mechanisms.