Lexical impairment in Agrammatism

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Abstract

The aim of this paper is to make a survey of the most important studies on lexical damage in agrammatism, reviewing their contributions to describing the mental organization of lexical knowledge; it also reconsiders the relationship between agrammatic lexical and syntactic impairment, and provides evidence of the independent processing of the underlying mental components.

The paper reviews the principal phenomena of lexical disorders in agrammatism reported in the literature, focussing in particular on the disproportionate impairment of content versus function words, verb-noun dissociation, mass/count dimension, processing of morphologically complex words (inflected, derived and compound words) and the lexical knowledge of grammatical gender. An analysis is also made of the principal aspects of morphological and lexical deficits mirroring agrammatic disorders in phonological/deep dyslexia and a discussion of the implications for the mental representation of orthographic lexical knowledge is also provided.

Over the last twenty years both linguists and psycholinguists have focussed on the syntactic aspects of agrammatism. However, agrammatic behaviour is a "symptom complex", in which syntactic impairment interacts with phenomena that arise at the lexical and at the morpholexical level. The importance of this side of the medal is more than evident if one considers that a number of authors have even tried to explain agrammatism entirely as a specific impairment of free and bound grammatical morphemes at lexical level (e.g. Bradley, Garrett & Zurif, 1980; Kean, 1979). In fact, more recent studies of agrammatism have shown that patients may have predominantly lexical and morphological disorders with mild or no syntactic deficits in production or comprehension (Miceli, Mazzucchi, Menn & Goodglass, 1983; Miceli, Silveri, Romani, & Caramazza, 1989; Berndt, Mitchum, & Haendiges, 1996). Indeed, much aphasiological research has been devoted to understanding how the lexical system represents and processes morphologically complex words and grammatically different types of words, reporting patients with selective deficits of lexical components in both production and comprehension. The different types of aphasia may cause deficits in processing content words, like nouns, adjectives and verbs, while generally sparing function words like prepositions, auxiliary verbs and pronouns. Agrammatic aphasic subjects on the other hand may suffer from disproportionate damage to function words, which may involve specific subtypes of open class of words, such as nouns or verbs. These neuropsychological data provide useful evidence that constrain the hypotheses formulated by psycholinguistic investigations on normal subjects. Many mental lexicon models postulate the existence of two separate stages within the lexical store, i.e. the *lemma* and the *lexeme* level (see Levelt, Roelofs & Mayer, 1999). The *lemma* contains the lexical-syntactic features of words and the *lexeme* is where the actual phonological or orthographic

word forms are encoded. The contribution of neurolinguistic studies to this theory is rather important and is reported in this paper as it comes predominantly from cases of agrammatism.

Morpho-lexical damage to free and bound grammatical morphemes can also be observed in reading: this impairment usually appears in deep and phonological dyslexia, a reading deficit that reflects many aspects of agrammatic disorder in spoken output. In deep and phonological dyslexia severe damage to the sub-word level reading procedure is associated with grammatical class effects (better performance on reading nouns than verbs or function words), imageability effects (concrete words are read better than abstract words) and semantic errors (patients may read *dog* instead of *hound* or *tree* instead of *wood*) as shown in Coltheart, 1980c.

One of the accounts given for this pattern of phenomena is that damage to the entire left hemisphere language areas favours the emergence of right hemisphere lexical abilities, which are limited to high-frequency concrete nouns (Coltheart, 1980b, 2000; Saffran, Boygo, Schwartz, & Marin, 1980; Zaidel, 1990). In addition the study of deep dyslexic patients has provided useful information regarding the architecture of the mental lexicon and of the mental representation of morphologically complex words.

This review describes the major neuropsychological data that provide information regarding the operations underlying (i) the processing of content versus function words; (ii) verb-noun dissociation within content words; (iii) mass/count dimension; (iv) the processing of morphologically complex words in the mental lexicon.

Data has been collected from patients speaking different languages. The majority of the early modern studies on agrammatism were carried out with native speakers of English, a language that has a very simple morphological structure. However, over

the last twenty years several studies have been done on patients speaking languages with a much more complex morphology, such as Greek (Tsapkini, Jarema & Kehayia, 2001; Stavrakaki & Kauvava, 2003), Italian (Luzzatti & De Bleser, 1996), German (De Bleser & Bayer, 1990), Polish (Jarema & Kadzielawa, 1990) and Finnish (Laine, Niemi, Koivuselka-Sallinen & Hyona, 1995). See also Menn and Obler (1990) for a cross-language sourcebook of agrammatism.

(i) Content versus function words

Disproportionate damage to function words with respect to content words is a constant of agrammatic behaviour (see Goodglass & Menn, 1985 for a review). This constant phenomenon was the theoretical basis of Bradley et al.'s (1980) suggestion of two independent mechanisms underlying the lexical processing of content and function words (agrammatism would be caused by selective damage to function words), while a different account of selective function word damage was offered by Mary Louise Kean (1979) who interpreted this phenomenon as being caused by an impaired phonological processing of clitic (i.e. not stressed) grammatical morphemes.

Disproportionate damage to function words is also one of the salient lexical aspects of phonological (Andreewski & Seron, 1975) and deep dyslexia (e.g., Coltheart, 1980a). According to the classical dual-route reading model, the emergence of this symptom would suggest partial damage to the lexical semantic route. A classical example is the French agrammatic patient MD described by Andreewsky & Seron (1975), who could read the string *CAR* when it appeared in a sentence context as a noun (the bus) but not when it appeared in its homograph function word counterpart (because): *le car ralentit car le moteur chauffe* (the bus slows down because the motor overheats) is

read "*car ralentit moteur chauffe*". Thus the authors suggested that sentence reading is not a concatenation of words but depends on an implicit, context sensitive analysis.

Bird, Franklin and Howard (2002) on the other hand, basing their proposal on data from fluent and nonfluent aphasic patients and semantic dementia, suggested that disproportionate damage to function words does not reflect a different representation of grammatical class, but a different rate of imageability. The authors analysed the different performance on spontaneous speech, repetition and in reading, on nouns and function words and the results showed that differences disappeared when imageability was controlled, emphasising the role of abstractness of function words. On the other hand, Druks and Froud (2002) argued against an explanation of the grammatical class effect in terms of imageability. These authors described the performance of a patient (MC) with Broca's aphasia and agrammatism who showed selective deficits in reading nonwords, function words and morphologically complex words while his reading of abstract nouns was well preserved.

(ii) Verb-Noun dissociation and agrammatism

A form of lexical dissociation that is almost always found in agrammatic patients is the predominant impairment of verbs with respect to nouns. A disproportionate verb impairment suggests that the grammatical categories of verbs and nouns must be distinctly represented in some manner in the organisation of the mental lexicon.

Early reports of verb-noun (V-N) dissociations conceived verb retrieval to be more impaired in agrammatic patients, while anomic patients had greater difficulty with nouns (McCarthy & Warrington, 1985; Zingeser & Berndt, 1988, 1990; Chen & Bates, 1998; Bates, Chen, Tzen, Li & Opie, 1991; Daniele, Giustolisi, Silveri, Colosimo & Gainotti, 1994). However, it soon appeared that this generalization was

untenable, since several cases of *verb retrieval damage* in *non-agrammatic* patients were described (e.g. Williams & Canter, 1987; Kohn, Lorch, & Pearson, 1989; Berndt, Mitchum, Haendiges & Sandson, 1997), and other studies found that disproportionate verb impairment emerges at an almost identical rate in fluent aphasic patients (Basso, Razzano, Faglioni & Zanobio, 1990; Zingeser & Berndt, 1990; Luzzatti, Raggi, Zonca, Pistarini, Contardi & Pinna, 2002). For instance, Luzzatti et al. (2002) reported data on the rate of dissociation on a sample of fifty-eight aphasic patients, which demonstrated noun superiority in five out of six agrammatic patients (the sixth agrammatic case showed a strong trend in the same direction that did not reach a two-tailed significance level), but also in nine fluent patients. The opposite phenomenon (i.e. verbs better than nouns) emerged in six fluent aphasic patients.

The mechanisms underlying V-N dissociation are still not completely clear. Bird and coworkers (Bird, Franklin & Howard, 2000; 2003) explained the phenomenon in terms of the different weights of the underlying lexical-semantic and perceptual features. Fundamentally, knowledge of verbs would be predominantly functional, while knowledge of (concrete) nouns predominantly visual. The lower rate of imageability that habitually distinguishes verbs from concrete nouns in picture naming tasks would therefore be an indirect expression of this phenomenon and therefore accounts for a dissociation with disproportionate verb impairment (V<N). Word class effect reported in naming, reading and writing disappeared when assessed with imageability-controlled lists. However, when lexical-semantic variables such as imageability or word frequency were ruled out, V-N dissociation disappeared in most but not all patients (Luzzatti et al., 2002; Crepaldi, Aggujaro, Arduino, Zonca, Ghirardi, Inzaghi, Colombo, Chierchia & Luzzatti, 2006). Thus, disproportionate

verb-impairment is closely related to a decrement in imageability, but cannot be completely explained by this factor.

Furthermore, a strong semantic account cannot explain *all cases* of V-N dissociations since Noun- and Verb-superiority was found in *single* oral or written input or output modalities. For instance, some patients were able to name a depicted action orally, but were not able to do so in writing (Caramazza & Hillis, 1991); other patients made several errors on nouns in a spoken naming task, but showed greater impairment on verbs in written word comprehension (Hillis & Caramazza, 1995) or alternatively on nouns in spoken naming, but on verbs in written naming tasks (Rapp & Caramazza, 2002).

Finally, Friedmann, Wenkert-Olenik & Gil (2000) suggested that the verb retrieval deficit observed in agrammatic patients "shall not be explained as a selective lexical impairment, but as a syntactic impairment causing inability to move verbs to the relevant functional categories, and to inflect them correctly". However, a strong syntactic account of verb impairment in agrammatism is at odds with the possible verb impairment in fluent aphasic patients as well as with the opposite dissociation in noun impaired aphasic cases.

Thus, verb-noun dissociation cannot be explained *exclusively* as an artefact of unbalanced lexical material; in some cases, at least, it provides evidence of a genuine grammatical class effect. On the other hand the grammatical class of verbs does have internal differences. Once again, the observation of agrammatic patients provides evidence of this aspect. De Bleser and Kauschke (2000), for example, found that transitive verbs were more impaired than intransitive verbs, which was explained by Thompson, Lange, Schneider & Shapiro (1997; see also Thompson, Fix & Gitelman, 2002) as a specific sensibility in agrammatic patients to the number of arguments

taken by verbs. The argument structure effect has been considered aspecific for a single grammatical class (verbs) since it also occurs related to nouns (Collina, Marangolo, Tabossi, 2001). There are of course some very particular types of nouns that are, in a certain sense, argument taking: e.g. *"relational nouns"*, such *neighbour*, *enemy*, *mother*, etc. and *"deverbal nouns"*, such as *arrival, emergence*. Deverbal nouns (e.g. *destruction)* simply inherit the thematic structure of the related verbs (e.g. *destruct*). Tabossi et al. argued that damage to the thematic structure would affect nominals in much the same way it affects verbs. However, even if some kind of thematic structure is present, it is also clear that the way in which nouns can be said to be argument taking is very different from that in which verbs take arguments. The clearest piece of evidence in this connection is that nouns, as opposed to verbs, do not take arguments obligatorily. A second caveat regarding Collina et al.'s hypothesis is that deverbal nouns are almost without exception highly abstract, thus making it difficult to disentangle any possible differences between argument-taking and non-argument-taking nouns from the imageability effect. Furthermore, when dividing intransitive verbs into the two major underlying classes, unaccusative (ergative) verbs were found significantly more impaired than unergative verbs (Luzattti et al., 2002; Thompson et al., 2003).

As in the case of the dissociation between content words and function words in the agrammatic spontaneous speech, V-N dissociation has also been described in the reading performance obtained from several cases of phonological or deep dyslexia (e.g. Coltheart,1980a; Holmes, Marshall & Newcombe 1971, Luzzatti, Mondini & Semenza, 2001a; Toraldo, Cattani, Zonca, Saletta & Luzzatti, 2006).

(iii) The mass/count dimension

An important example of information linked to a noun at the lexical level is whether it belongs to the count or the mass category; indeed, the grammatical information about the mass or count status of a noun is a pivotal example of lexical syntax. These two classes do in general have semantic differences: mass nouns (e.g., *milk*) refer to substances or sets of items while count nouns (e.g. *bottle*) refer to individual objects. However, the clearest distinction between mass and count nouns lies in their morpho-syntactic features: mass nouns do not take the plural (e.g., *milks**) and in the singular form cannot be modified by enumerating quantifiers (e.g., *a milk**). Count nouns, on the other hand, do have a plural form (e.g., *bottles*) and in the singular form can be modified only by enumerating quantifiers (e.g., *a bottle, each bottle*). An important issue of the mass/count distinction is the relatively idiosyncratic distribution of the two classes. In fact, the same concept may correspond to either a mass or a count homonym in the same language (e.g. the Italian term $pasta_{[Mass, Singular]}$ *al sugo* (pasta with tomato sauce) is mass but $spaghetti_{[Count, Plural]}$ *al sugo* is count (pasta/spaghetti with tomato sauce) or may be translated by either a mass or a count term in different languages (e.g. *hair* is mass in English and count in Italian: he went to cut his $hair_{[Mass, Singular]}$ = *è andato a tagliarsi i* $capelli_{[Count, Plural]}$). In Chinese an extreme condition prevails: all nouns are mass. Therefore it can be deduced that the mass/count knowledge must be lexical and has to be stored at the lemma level.

The interplay between lexical-semantic and lexical-syntactic features have made these word categories particularly interesting in neuropsychology. Semenza, Mondini and Cappelletti (1997) reported the first extensive study of an anomic patient (FA) who, across a series of tasks, showed a selective deficit in using the grammatical properties

of mass nouns. The reverse pattern of damage has also been found in another fluent aphasic patient (GA) suffering from a general syntactic impairment, but whose performance on tasks requiring an implicit mass/count distinction was flawless (Mondini, Jarema & Liguori, 2004). In other words, despite his impairment in applying the major syntactic rules, GA was aware of the grammatical properties that distinguish mass and count nouns. These findings showed that the morpho-syntactic features of these two classes of nouns could be selectively impaired or spared in aphasia. Recently, Herbert and Best (2005) described an agrammatic patient with a naming deficit that was more severe for mass nouns and impaired lexical-syntactic knowledge of the mass/count distinction (over-generalization of the "count" solution). They concluded that access to lexical syntactic knowledge at the lemma level is crucial for lexical retrieval and that any discrepancy between categories in word finding may arise from lexical syntactic damage. On the other hand, a patient with anomic aphasia reported by Semenza, Mondini and Marinelli (2000) showed selective deficit in retrieving count nouns with spared retrieval of mass nouns, despite perfect performance on both semantic and syntactic tasks with the same items. Thus, at least in some cases, a word retrieval deficit may emerge at a more peripheral level (the lexeme) and with relative sparing of mass nouns.

The above studies highlight the importance of investigating mass/count dimension in aphasia and agrammatism where the interaction between lexical-semantic and lexical-syntactic properties can be disentangled. In fact, data from aphasic patients show that mass/count syntax can be selectively spared/impaired independently of other syntactic rules.

(iv) The processing of morphologically complex words

As already mentioned, not all languages have the same morphological richness: for example, Italian and German are very rich with respect to English, while agglutinative languages like Finnish represent extreme cases of complexity.

Words can be either morphologically simple (a single morpheme like *dog* or *walk*) or complex (two or more morphemes like *dog-s, walk-ed, walk-er-s, dog-house, dog-catch-er-s*). Most complex words follow lexical rules that transform the original base form into inflected or derived words, simply by adding a specific suffix according to the rules of the language. However, as far as inflection is concerned, some words may not follow these rules as they are irregularly inflected (e.g., the plural of *child* is *children*, not *childs**, or the past form of *speak* is *spoke,* not *speaked**). Obviously, an irregular word form must be stored in the lexicon and retrieved as such. On the other hand, the fundamental question regarding regularly inflected words is whether they are taken as whole-words from the lexicon or whether their parts are processed by mean of rules. Indeed, inflectionally related words like *explain – explained* share a pool of lexical information (e.g. morpho-syntactic features and meaning) and it is crucial to understand if this shared information is represented in the lexical system and if so, at what level of the process.

The following chapters will provide an analysis of the major studies on morpho-lexical disorders in agrammatism, revealing their relevance in discriminating between theories of the mental lexical organization.

Some of the models have proposed an exclusively non de-compositional processing (*full-listing* accounts, e.g. Bybee, 1988) and assume that each morphologically complex word is represented in the lexicon as an independent orthographical and phonological lexical unit. In *full-parsing* models, on the other

hand, the components of multi-morphemic word forms are represented and processed separately, i.e. in decomposed form. The locus of parsing processes differs across theories. For example Drew and Zwitserlood (1995) claimed that shared morphological representation is not expressed at the phonological form level, but may exist at the form-independent lexical level (e.g. decomposition at the lemma level). Other theories posited morphological decomposition at the lexeme level so that complex words are transparently parsable into their constituents from their surface representation (e.g., the Augmented Addressed Morphology model in Caramazza, Laudanna & Romani, 1988). On the other hand, parallel dual route models suggest the interplay of (de)composition and full-listing procedures for morphologically complex words on the basis of their surface word frequency (see Bayen, Dijkstra & Schreuder, 1997).

Ullman, Corkin, Coppola, Hickok, Growdon, Koroshetz and Pinker (1997) collected data on patients with lesions in specific anatomical sites: anterior aphasic (mostly agrammatic) patients, posterior aphasic patients, patients with Parkinson's disease and with Alzheimer's dementia. Their performance on a verb production task supported the view that the left frontal cortex (together with the basal ganglia) is involved in rule-based language processing (i.e. the production of regular past tenses) but not in the retrieval of irregular verb forms, while temporal lobe areas are necessary for the retrieval of stored irregular verb forms (Declarative/Procedural model). On the other hand, some agrammatic patients showed a better performance on regular as opposed to irregular past tenses (e.g. the English-speaking patient RC described by Shapiro & Caramazza, 2003; the Italian-speaking patient MR described by Laiacona & Caramazza, 2004; the bilingual Spanish/Catalan patients JM and MP described by Balaguer, Costa, Sebastian-Galles, Juncadella & Caramazza, 2004; the case series of

German-speaking patients reported by Penke, Janssen & Krause, 1999). These agrammatic patients suffered from left frontal lesions, but were able to produce regular past tense forms better than irregular form. Thus data indicate left inferior frontal involvement in processing morphosyntactic information and not only in rule-based language transformations. Agrammatic production would therefore be caused by damage to various processes including those responsible for the retrieval, interpretation and integration of grammatical features, e.g. tense, person and number agreement of verb forms (Balanguer et al., 2004). The deficit would thus concern the morphosyntactic mechanism, independently of the regularity of the verb form.

Agrammatism and morphological deficit in deep/phonological dyslexia

As previously mentioned, agrammatic patients usually suffer from deep or phonological dyslexia, a reading disorder which closely mimics morphological and lexical agrammatic impairment with part of speech effects (impaired reading of grammatical words) and impaired reading of bound morphemes (i.e. of the affixed components of morphologically complex words). However, an analysis of errors (i.e. omissions versus substitutions of bound morphemes) is required before they can be interpreted unambiguously as morphological disorders. Errors, in fact, could also be caused by phonological, semantic, or visual causes. Luzzatti et al. (2001a) described an Italian deep dyslexic, agrammatic patient (MB) suffering from a specific deficit in reading morphologically complex words. His reading abilities were tested with a series of tasks, which compared singular words, regular (stem + plural suffix) and irregular (not parseable) plurals. Repeated reading sessions showed that the patient was systematically more impaired in reading regular morphologically complex words than simple words. His reading performance on nouns was better than on verbs, and

on irregularly inflected words than on regularly inflected words; his performance on singular nouns was better than on plural nouns and he made fewer errors on irregular plurals than regular plurals. His reading of marked inflected verbs and adjectives was also more impaired than the corresponding base forms. These data demonstrated an impairment of the (de)compositional mechanisms that are required for the processing of regularly inflected words. However, when asked to read aloud plural nouns such as *CUCINE*, kitchens, MB said *"cucina .... tante"!,* ("kitchen ... many"!), showing that he was aware of the meaning of the plural suffix, which however he could not retrieve. A phenomenon that indicates impaired retrieval of inflectional affixes from the phonological output lexicon.

MB was also tested with words altered by an evaluative suffix (e.g. *-ino, -ello, –one,* etc. - for example, *lettino,* small bed*,* is composed of *letto*, bed, + *ino* (diminutive suffix) and pseudo-suffixed words (i.e. simple nouns ending with an orthographic string which is homograph and homophone to an evaluative suffix; e.g. *cervello,* brain, is not a little *cervo*, deer, and *CARBONE*, coal, is not a big *carbo** [nonword]). In the case of suffixed words MB simplified the structure of the target word by either stripping the evaluative suffix or paraphrasing it semantically (e.g. *LETTINO*: *"letto, si, ... piccolo"!* "bed, yes, ... small"!) but it is interesting to note that he never made omissions or substitutions with pseudo-suffixed words.

Cases of semantic paraphrasing of grammatical morphemes had been previously reported by De Bleser and Bayer (1990) and Lecours, Lupien and Bub (1990) in a German agrammatic patient (HJ) and a French-speaking patient respectively. In a reading task HJ paraphrased the diminutive endings -*CHEN* with the free morpheme *klein*, small, and the negative prefix *UN-* with the free morpheme *nicht*, not.

It has been seen that the agrammatic patients described above were impaired in retrieving the phonological form of the grammatical (bound) morpheme, although they were able to access the semantic information of the suffix; these findings could be explained by the dual stage model of lexical processing (Levelt et al., 1999) where the amodal abstract *lemma* level containing the semantic and morphosyntactic information is activated, while the *lexeme* level, where the phonological word form is stored, cannot be accessed.

Luzzatti et al. (2001a) demonstrated the existence of a clear interaction between morphological markedness and lexical frequency of morphologically complex word forms inspired by the experiment developed by Baayen, Dijkstra and Schreuder (1997), in which a lexical decision task with normal subjects showed that the recognition of singular dominant nouns (like *NOSE*) has shorter reaction times (RT) than the corresponding morphologically complex plural word forms (*NOSES*), but that plural dominant nouns (like *EYES*) have the same RT as their corresponding singular forms (*EYE*). This result was interpreted as evidence that plural dominant nouns are stored in the lexicon as a whole and that two determinant variables (word frequency and word complexity) interact (*dual-route hypothesis*). Similarly, the agrammatic patient MB was impaired in reading regular plural nouns with respect to singular nouns, but this difference did not appear in plural dominant nouns. Luzzatti et al.'s (2001a) results therefore confirmed the dual-route hypothesis, i.e. that high frequency word forms (i.e. plural dominant nouns) are also represented in a non-decomposed format in the mental lexicon.

Further studies on deep dyslexia concerned the "semantic" explanation of the part of the speech effects observed in agrammatic patients (Bird et al., 2002) receive little support from the data derived from the Broca's aphasic patient MC reported by Druks

and Fround (2002). MC's ability to read abstract nouns and verbs was well preserved, but he had difficulty in reading non-words, function words and morphological complex words and, in particular, he made affixation errors (both omissions and substitutions) on affixed words, but not on pseudo-affixed words. Thus, the authors suggested that reading (free and bound) grammatical morphemes, abstract words and non-words are independent processes and cannot be explained by their low imageability and low semantic content.

The dissociation between inflectional and derivational morphology

A further issue to be discussed is the relationship between inflectional and derivational morphology. For instance, Miceli and Caramazza (1988) described a patient (FS) who could repeat derived words better than inflected words. They interpreted the results as evidence of independent processing of derivational and inflectional morphology, and of full-listing storage of derived words versus full decomposition of inflected words. However, as the authors admit, FS's reported dissociation is not clear-cut, rendering any calculation of the extent of preservation of derivational morphology rather difficult. On the other hand, there have been no reports to date on the complementary dissociation, i.e. selective deficit of derivational morphology.

Laine et al. (1995) described a Finnish speaking agrammatic and deep dyslexic patient who made a number of morphological errors with inflected nouns in oral reading, repetition and production, but obtained a better performance in reading and repetition of both base form and derived nouns. This single-case study supports the distinction between inflectional (impaired) and derivational (spared) processing, a position which however does not find empirical support in most studies of deep and phonological

dyslexia as no dissociation between the two types of affixation has been reported. In the case of the deep dyslexic patient HJ, mentioned earlier, De Bleser and Bayer (1990) tested the reading performance of inflected and derived nouns and verbs, revealing severe impairment both of inflected and derived words characterized by the constant omission of the inflectional and derivational affix. MB, the Italian agrammatic patient described by Luzzatti et al. (2001a), suffered from severe impairment in reading inflectional and derivational bound morphemes, with inflected words being more affected than derived words (18%, vs. 43%; $\chi^2(2) = 16.08$, p<.001) when all word categories were computed (including adjectives and verbs); however, no difference emerged between affix types when only inflected nouns (47% correct) and derived nouns (43% correct) were compared ($\chi^2 < 1$; ns).

The independence of derivational rules from the retrieval of the whole phonological form has been demonstrated by studies of neologistic jargonaphasia: in this condition neologisms were found to be affixed with a full repertory of correct derivational rules (Semenza, Butterworth, Panzeri & Ferreri, 1990).

Finally, neuroimaging data on the processing of derivational morphology in normal subjects (Marangolo, Piras, Galati & Burani, 2004) showed activation of left frontal areas, while derivational processing relative to both nouns and verbs caused a further fronto-parietal activation. However, independent processing of inflected and derived morphology was not confirmed by a further fMRI study with normal subjects (Vannest, Polk & Lewis, 2005), in which the same pattern of activation was found when participants were required to recognize inflected and derived words.

Grammatical gender of nouns

In languages such as German, French and Italian, in which all nouns have a grammatical gender, gender knowledge must be stored at lexical level (*lemma*). Luzzatti and De Bleser (1996) assessed gender assignment of common nouns in two Italian agrammatic patients asking them to produce the corresponding definite article (*il* for masculine nouns; *la* for feminine nouns). The Italian gender system is complex: when nouns refer to living entities the grammatical gender is usually determined by the semantic natural gender; for neutral entities a phonological/morphological rule prevails (masculine nouns usually have an *-o* ending; feminine nouns usually have an *-a* ending), but in some cases there is a conflict between the natural gender and the phonological/morphological ending. In these conflicting cases either the semantic criterion (e.g., *il*[M] *pirata*, the pirate) or the phonological ending (e.g., *la*[F] *guardia,* the policeman) may prevail to determine the grammatical gender of the noun.

There are also nouns with an opaque ending *–e,* which can be either masculine or feminine (e.g., *il padre*[M], the father; *la madre*[F], the mother; *il ponte*[M], the bridge; *la* torre[F]*,* the tower). In those cases in which the gender cannot be attributed on the basis of semantic information or of a morpho-phonological rule, gender knowledge has to be entirely lexicalized.

Of the two agrammatic patients described by Luzzatti and De Bleser (1996), gender assignment was almost fully preserved in MG, while the other patient (DR) tended to over-generalize the phonological/morphological rule (e.g., *il*[M]* mano*, instead of *la*[F], *mano*[F], the hand; also he attributed masculine gender to feminine nouns with the opaque ending *–e (e.g., il*[M]* torre* instead of *la*[F] *torre,* the tower*)*. DR performed better on derived nouns, in which gender is determined by the derivational suffix,

while he was unable to parse pseudo-derived non-words and judged the gender on the basis of the final vowel rather than on the derivational ending.

Mondini, Luzzatti and Semenza (1999) described another Italian agrammatic patient (MB), who showed a pattern of performance similar to that described for DR. He assigned gender perfectly on the basis of semantic knowledge and made no errors in applying and generalizing the major ending rules, but was impaired in the case of lexically based gender assignment, i.e. with nouns lacking natural gender and with conflicting or opaque final vowels.

These data are complementary to those reported by Badecker, Miozzo and Zanuttini (1995) who investigated the performance of an Italian anomic patient (Dante) and interpreted the results obtained within the frame of the dual-stage model of lexical access (e.g., Level et al., 1999). The authors assessed Dante with a series of pictures whose grammatical gender could not be determined semantically. When the patient was in an 'anomic state' (i.e. in a tip-of-the-tongue condition and thus unable to retrieve the phonological form of the noun) he was asked to specify the grammatical gender of the noun. Throughout a detailed investigation with picture naming tasks and sentence completion tasks, the authors interpreted Dante's naming impairment as a deficit in retrieving stored lexical phonology (*lexeme* level information); on the other hand, his ability in assigning the correct grammatical gender indicated that access to information at the *lemma* level was preserved. Vigliocco, Antonini and Garrett (1997) also reached similar conclusions from experiments with the tip-of-the-tongue phenomenon in neurologically intact subjects.

Compound nouns

Compounding is a grammatical process that allows a content word to be modified by means of another content word; it is based on a set of lexical rules that determine

word order and in some instances the agreement between constituents. Once again, the question arises whether a compound element is processed as a whole or (de)composed in its individual constituents, and it is possible that the answer could be found in the reading performance of agrammatic and deep dyslexic patients. The study of these patients has contributed to the knowledge of the representation and processing of compound words, at least as much as has experimental psychology. Converging evidence from formal linguistic analyses, laboratory data and clinical/experimental observations on brain-damaged patients is seldom so equally balanced and convincing as it is on this topic (see Semenza & Mondini, 2006, for a review). The main contributions from studies on compounds in aphasia can be summarized as follows:

a) Evidence that aphasic subjects who were not able to retrieve the phonological word form of a given item were nonetheless aware of its compound status, comes from the fact that the compound words were mostly substituted with other compounds bearing the same morphological structure (e.g. a noun-noun or a verb-noun or an adjective-noun nominal compound), while simple words were substituted with other simple words. On the whole, despite their inability to retrieve a given compound word, aphasic subjects have been shown to respect, in their errors, language-specific (de)compositional rules (Badecker, 2001; Hittmair-Delazer, Andrée, Semenza, De Bleser, & Benke, 1994; Semenza, Luzzatti, & Carabelli,1997).

b) The study of aphasic patients has shown (de)compositional processes even for opaque compounds (Badecker, 2001; Chiarelli, Menichelli & Semenza, 2005; Hittmair-Delazer et al., 1994; Mondini, Luzzatti, Zonca, Pistarini, & Semenza, 2004; Semenza et al., 1997). Moreover, errors consisting in the substitution of one or both

components are *prima facie* evidence of (de)composition. Once again, the most convincing empirical evidence of (de)compositional processes comes from research on agrammatism. As already discussed, patients suffering from this type of language impairment are much less efficient in retrieving verbs than nouns. Studying the production of verb-noun compounds, a very productive type of compound noun used in Italian (e.g., *il cacciavite,* the screwdriver, lit. the drive[verb] screw), aphasics with disproportionate verb deficit were shown to omit the verb component much more often than the noun component (Semenza et al., 1997; Mondini et al., 2004). This phenomenon cannot be attributed to a simple position effect since the omission of the first component does not prevail in noun-noun compounds. Taken together, the findings provide a strong indication that compound words are parsed into their components in the course of lexical retrieval.

c) In noun-noun compounds grammatical gender depends on the morphological structure and the position of the head. Contrary to the Germanic languages where the compound head is always the left-most element, Italian noun-noun compounds can be either left (e.g., *la*[F] ***casa***[F] *albergo*[M], boarding house or *il*[M] ***bagno***[M]*schiuma*[M], bubble bath) or right headed (e.g., *la ferrovia, la*[F] [[*ferro*][M][***via***][F]][F], the railway or *il viadotto, il*[M] [[via][F][**dotto**][M]][M], the viaduct) and they take the gender of the head. Verb-nouns are, instead, exocentric and their gender is, with very few exceptions, always masculine independent of the gender of the end noun (e.g. *il portacenere: il*[M] [[*porta*][verb][*cenere*][F]][M], the ashtray, lit., carry ash). Luzzatti and De Bleser (1996) and Mondini et al. (1999) studied the ability to retrieve gender knowledge in compounds by agrammatic patients. In contrast with their unimpaired ability to apply the major ending rules in simple nouns, they were impaired in assigning grammatical gender to noun-noun compounds, in which a morphosyntactic

analysis is required. Patients over-generalized right-headedness also to left-headed noun-noun compounds and thus applied the gender of the last constituent to compounds in which the semantic and grammatical head was the first constituent (e.g. $il_{[M]}$ instead of $la_{[F]}$ **$casa_{[F]}albergo_{[M]}$**, boarding house, lit. the hotel-house).

In the case of the verb-noun compounds, agrammatic patients once again over-generalized the "right-head" rule of compounds and succeeded in assigning gender correctly only when the rightmost element was masculine. Thus, the patients showed a dissociation between preserved rule-based gender assignment and impaired full-listing lexical processing of nominal compounds.

A further productive type of compound in Italian is noun modification by means of an adjective. The modifying adjective may be placed (obligatorily) either to the right or to the left of the noun heading the compound. Italian adjectives have to agree in gender and number with the modified noun; agreement is also required within the adjective-noun (AN, e.g. *$bianca_{[F]}neve_{[F]}$*, snow-white) and noun-adjective (NA, e.g. *$croce_{[F]}rossa_{[F]}$*, red cross) nominal compounds. Mondini, Jarema, Luzzatti, Burani and Semenza (2002) described the case of two Italian agrammatic patients who were able to inflect adjectives within an AN or NA compound noun properly, but were less effective when processing gender agreement in a standard noun-adjective phrase (e.g. *la $torre_{[F]}$ $bianca_{[F]}$*, the white tower). Thus, it would appear that NA and AN compounds are processed, with respect to gender agreement, as whole-words. The data obtained from the two agrammatic patients supports the distinction between the processing of syntactic agreement that is impaired and lexical agreement that is spared. This conclusion contrasts with the fact that compounds may be processed otherwise in decomposed form, and therefore Mondini et al. (2002) argued that access

is at play through both whole-word and morphological parsing; access to the undecomposed lexical item helps patients in partially circumventing problems with adjective suffixation.

d) Prepositional compounding is a further condition in which the mental processing of compounds was tested in agrammatic patients (Mondini, Luzzatti, Saletta, Allamano, & Semenza, 2005). The authors described the production of this type of compound noun in a group of Italian agrammatic patients, then analyzed a single case to obtain greater detail. Prepositional compounds are a type of compound in which the modifying element is a prepositional phrase. The morphological structure of these items is noun-preposition-noun, where the linking preposition is not always transparent with respect to the meaning of the whole compound (e.g., *film **in** bianco e nero*, black and white movie, lit. film in black and white, but *film **a** colori*, colour movie, lit. film on colours). Moreover, in some cases, the preposition also takes an article, whereas in other cases it does not [e.g., *mulino **a** vento*, windmill, lit. mill on wind, vs. *pasta **al**[prep+art] forno,* baked pasta, lit. pasta at the oven]. In the authors' study, patients were tested with a series of reading, repetition, naming and completion tasks. It is well known that agrammatic patients have difficulty with prepositions and often omit articles, and in fact this pattern of impairment was present in Mondini et al.'s patients, also when they attempted to retrieve the phonological form of fully lexicalized compounds containing syntactically and semantically opaque (i.e. fully lexicalized) prepositional links. The data suggest that these lexical elements are (de)composed at some level of processing and that the agrammatic deficit can thus - and only thus - damage the retrieval of the linking preposition. On the other hand, the opaqueness of the linking preposition makes the whole form representation of prepositional compounds necessary. Mondini et al. (2005) took this example as

evidence of the fact that both the whole-word form and the de-composed form of constituents have to be available before the phonological representation of complex words can be accessed. Therefore, once again, the aphasic performance described so far can only be explained by the existence of a dual route model.

Conclusions

This review summarises the major contemporary neurolinguistic studies on the issue of lexical impairment in agrammatism. Data are discussed from several perspectives ranging from the clinical aspects of the agrammatic language disorder to their relevance in verifying contemporary theories describing the mental architecture of the lexicon.

Firstly, data were reported on the disproportionate damage of function words with respect to content words and, within the category of content words, of verbs with respect to nouns. In this frame, the confounding effect of grammatical class and concreteness has been discussed.

Although the number of studies that have taken into consideration the lexical knowledge underlying the nominal mass/count status in agrammatic brain-damaged patients is limited, the crucial role of neurolinguistic studies in this field has clearly emerged.

Further morphosyntactic phenomena were discussed with regards the processing of morphologically complex nouns such inflected, derived and compound words and to the assignment of grammatical gender.

Finally, a number of aspects regarding deep dyslexia were described, focussing on the importance of neurolinguistic studies in describing the architecture of the

orthographic lexicon.

The data show very clearly that the lexical impairment, which usually emerges in agrammatism is a complex pattern of phenomena that cannot be reduced to the mere disorganization of syntax. In fact, agrammatism necessarily also involves specific lexical abilities, which may be impaired in isolation (i.e. without syntactic damage; e.g. Miceli et al, 1983; see Luzzatti et al., 2001b for a review), but it usually appears in spontaneous speech output, in picture naming and in reading.

Similarly to Coltheart's (1980b; 2000) account of *deep dyslexia,* the variegated association of phenomena that emerges in agrammatic patients is difficult to explain in a strict cognitive frame, but could be explicated as the emergence of right hemisphere lexical-semantic abilities. Indeed, large perisylvian lesions causing total damage to the left hemisphere language areas would allow the "rough" right hemisphere linguistic abilities to surface and to cause the cluster of symptoms characterising the agrammatic "symptom complex" (i.e. reduced syntactic abilities, impaired retrieval of function words, difficulty with morphologically complex words, etc.).

In conclusion, research carried out on agrammatism has highlighted the extraordinary complexity of the mental lexical architecture. The findings confirmed data collected on normal subjects in psycholinguistics, as for example the two-stage distinction of the lexical representations (lemma and lexeme levels) proposed by Levelt and co-workers (1999), and the dual-route model describing the mental processing of morphologically complex words (Baayen et al., 1997). The data also contributed to shed light on the neural organization of the mental lexicon and its re-organization after brain damage.

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