

Noun and verb in the mind. An interdisciplinary approach^{*}

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Abstract In this paper we intend to provide a unified picture of the organization of knowledge about nouns and verbs in the mind emerging from the results of recent foundational studies that use a variety of different experimental techniques and research methods ranging from processing experiments, language acquisition and aphasia studies to more advanced neurophysiological and neuroimaging studies. Each of the authors of the articles discussed in the present paper attempts to show that the distinction between nouns and verbs originates only (or mainly) at one of the following levels: the conceptual-semantic, the lexical or the morphological level. Our overview points to a conclusion that the knowledge about verbs and nouns in the mind cannot be attributed to a single level, but rather it seems to be the case that it is organized in the form of a distributed network of specialized functions in which many processes related to noun or verb processing may happen in a parallel fashion. Even though in some respects the presented studies do not entirely lead to a coherent picture of what happens in the brain when people process nouns and verbs, it is still possible to find overlapping results. For example, nominal and verbal concepts of objects or actions are processed in the vicinity of the visual and motor cortex respectively. Lexical (orthographic and phonological) representations of nouns and verbs are stored in mid temporal and left frontal cortex respectively. Noun- and verb-dependent morphological operations happen in left anterior occipitotemporal gyrus and prefrontal/frontotemporal cortex respectively.

1. Introduction

1.1. Theoretical approaches to nouns and verbs. An overview

Within the grammar of natural language, linguists distinguish certain groups of words or morphemes which share a set of properties and hence form natural classes of grammatical items. Such natural classes of grammatical items are commonly referred to as grammatical categories which are further subdivided into functional or lexical categories. Within the set of functional categories we can distinguish, for example, TENSE, ASPECT, MOOD, NUMBER, GENDER, and within the class of lexical categories the generally accepted division is into NOUNS, VERBS, and ADJECTIVES. In this paper we contribute to a discussion related to the status of two lexical categories, to wit: nouns and verbs. In traditional school grammars a noun is defined as referring to a person, thing or phenomenon, while a verb is defined as referring to an action or state. Such semantic definitions are also postulated by many linguists such as, for instance, Sasse (1993), who claims that nouns are thing-like concepts and verbs are event-like concepts, Croft (2000), who suggests that nouns refer to objects and verbs express predication of an action, Dixon (2004), who argues that there are certain semantic types that are always associated with nouns only, e.g., people, parts, flora, etc., whereas motion, speaking are always verbs. According to Givon (1979), nouns represent ontological categories that are stable in time, unlike verbs, which are time-unstable. These semantic definitions are not unproblematic when confronted with nouns such as *a divorce*, *a discussion* which refer to events or when confronted with stative verbs such as, for instance, *to know* or *to believe* which are stable in time. What are nouns and verbs then? An overview of approaches to nouns and verbs is proposed by Bisang (2010), where apart from semantic criteria, he mentions discourse and formal criteria used by different authors to distinguish between nouns and verbs. According to discourse criteria, nouns introduce participants whereas verbs assert the occurrence of an event, while according to formal criteria, nouns and

^{*} This research has been supported by a *Focus* grant received from the Foundation for Polish Science.

verbs have a different morphological and syntactic distribution and even such obviously nominal lexical items as *door* can in some syntactic contexts become verbal, e.g., *What happened to you? I was riding down the hill and some yuppie got out of his Porsche and doored me*. It seems then that even though most of us seem to know what nouns and verbs are, it is not easy to come up with a precise definition of these two lexical categories. This apparently trivial question has recently gained a lot of attention in typological, theoretical and neurolinguistic studies. In typological studies, many researchers test whether the distinction between nouns and verbs is universal across languages (see, e.g., Evans 2010 for an overview). Some linguists such as, for instance, Swadesh (1939), Kinkade (1983), Shkarban (1992), Gil (1994), Jelinek and Demers (1994), Broschart (1997), and Gil (2013) question the universality of noun and verb by pointing to a lack of this distinction in such languages as Salish, Tagalog, Tongan, Nootka,¹ Riau Indonesian. Given this typological variation even in the use of such apparently trivial categories as nouns and verbs, Haspelmath (this volume) postulates that pre-established (universal, innate) categories do not exist. He claims that categories are language-particular and he bases his reasoning on the observation that cross-linguistic evidence is not converging even on the smallest number of universal categories and similar categories in languages are never identical. Haspelmath advocates the view that we should adopt a non-aprioristic approach to categories. Like other functionalists (Dixon 1982; Givon 1984; Hopper and Thompson 1984; Langacker 1987; Croft 1991), Haspelmath treats lexical categories as prototype notions with fuzzy boundaries. Under such an approach, one does not have to strive to set up a set of criteria distinguishing unambiguously between nouns and verbs.

It follows from this brief overview that typologists do not use strict criteria of classifying nouns and verbs but rather they treat them as prototypical notions and with such an approach they aim at proving the cross-linguistic universality of the distinction between nouns and verbs. Quite a different set of questions concerning the status of nouns and verbs is asked by formal generative grammarians, who are interested in the architecture of the human mental grammar. In the generative tradition there is a long-standing controversy as to the question of whether lexical categories are determined at the level of lexicon or syntax. Early generative approaches used to assume that lexical categories are determined already in the lexicon, i.e., they are assigned to each lexical root. What was assumed to be part of a lexical entry was the grouping of its phonological representation, its meaning and the information about its lexical category connected with a particular syntactic insertion frame (see Grimshaw 1979 and Pesetksy 1982). Rappaport Hovav and Levin (1998) refer to such approaches as projectionist: they are endocentric in that they construct the properties of larger units from the properties of some central lexical entry. Borer (2005) calls such approaches endoskeletal, capitalizing on the metaphor of the listeme as a skeleton around which the syntax is constructed. All these approaches share the assumption that there is a level of representation, with well-defined formal properties that can be computed directly from the information in the lexical entry. Quite a different view is assumed by Borer (2005) and Baker (2003, and this volume). They both share the assumption that the lexical category of a given item is determined by syntax. Borer claims that words are polysemous; a word like “stone” can be used as a noun (*three stones*) or as a verb (*to stone a bird*) or as an adjective (*to be stoned*). Borer uses the notion of listemes (which corresponds to roots) and assumes that they feed structure only with some underlying conceptual content but listemes as such cannot affect the structure. She describes listemes as conceptual packages which operate at the interface between the conceptual system and the linguistic computational system. Essentially, Borer diverges from earlier generative

¹ See Braithwaite (this volume), who provides new morphological evidence – based on the distribution of bound and free allomorphs of certain roots – in favour of the categorical distinction between nouns and verbs in Nuuchah-nulth (Nootka).

approaches in her assumption that listemes are not equipped with any information about the category or argument structure. Since listemes do not possess any grammatical properties, they are able to impose any structural conditions on their distribution. Any restrictions are the result of the compatibility between the conceptual value and the interpretation returned by the specific grammatical computation. Baker (2003) presents a similar view according to which it is a syntactic representation which makes a discrete distinction between noun, verb and adjective. The distinction is discrete when a lexical entry used, for example, as a verb in a verb-predicting syntactic contexts has all the properties of a verb (it never has half the properties of one category and half of the other). Baker takes it as evidence that the verb-noun distinction is discrete as it concerns syntactic nodes. He develops his own theory of grammatical categories which is similar in spirit to Chomsky's (1970) treatment of categories defined in terms of two binary distinctions ($\pm N$, $\pm V$), where $[+N, -V]$ = noun, $[-N, +V]$ = verb, $[+N, +V]$ = adjective, $[-N, -V]$ = preposition. In his own system, Baker defines nouns as having a referential index, verbs as having a specifier, adjectives as neither having a referential index nor a specifier, whereas prepositions are not lexical but functional categories.

1.2. Outlook

Even this very selective overview of different typological and theoretical approaches to the question of the nature of grammatical categories seems to show that the individual accounts are not necessarily compatible with each other. Thus, it seems to be quite hard to integrate them into a coherent theory of grammatical categories. This is so because theoretical linguists usually see grammatical categories as exclusively belonging either to the domain of morphology or morpho-syntax, or to the conceptual or lexical system. A similar tendency can be observed in psycho- and neurolinguistic studies focusing on the question of how grammatical categories are organized in the brain. Psycholinguists and neurolinguists also try very hard to find evidence supporting the view that categories can be defined either at the conceptual or the lexical or the morphological level (see Shapiro and Caramazza 2003b for an overview). While in the case of theoretical accounts it is difficult to decide which of them is the right one, many psycholinguistic discussions seem to provide strong empirical evidence which may lead one to the conclusion that there are different levels at which grammatical categories play an important role. The emerging picture of categories is such that they are assembled at different levels and different linguistic modular systems representing them are located in different cortical regions of the brain. What linguists refer to as a CATEGORY (NOUN or VERB) is actually information derived from different sources. Since neuropsychological studies show that the distinction between nouns and verbs is reflected either at the conceptual (semantic), morphological or lexical level, the discussion in this paper will be organized along these three levels. That is, in section 2.1. we will look at the semantic or conceptual factors such as the existence of distinct cortical areas storing concepts of objects vs. activities, concrete vs. abstract entities which – when impaired – may result in partial inability to produce or understand nouns or verbs. Additionally, we will discuss studies which focus on the cross-linguistic similarities and differences in the processing of nouns and verbs where again concreteness is claimed to be the decisive factor.

Next, in section 2.2. the discussion will focus on experimental approaches which provide evidence in favour of the view that the distinction between nouns and verbs is made in the lexicon. The evidence discussed there, coming from four independent investigations: (i) aphasia study, (ii) priming study, (iii) a Positron Emission Tomography (PET) experiment, and (iv) an Event Related Potentials (ERP) study, shows that the information about a lexical category is defined for all items belonging to a given lexical class independently of possible semantic differences between its different members.

Whereas the studies presented in section 2.2. emphasize the role of the lexical level as a level feeding the category-dependent morphological transformations, in section 2.3. we will look at studies using Functional Magnetic Resonance Imaging (fMRI) and Transcranial Magnetic Stimulation (TMS) techniques that argue that the observed brain activation in category-related morphological tasks is caused not by the lexical selection of a lexical item belonging to the category noun or verb but by the very verb- or noun-related morphosyntactic operation. Finally, we will discuss Kauschke, Lee, and Pae's (2007) study which – on the basis of cross-linguistic differences in the order of acquisition and in the ease of processing of nouns and verbs – also stresses the importance of morphosyntax for distinguishing nouns and verbs. The overall discussion will be presented in section 3.

2. Psycholinguistic approaches to noun and verb

While theoreticians interested in the distinction between nouns and verbs focus their attention on establishing a set of formal criteria that can be used to distinguish between nouns and verbs or to determine their role within the grammar, psycholinguists are mainly interested in answering the question about the origin of the distinction between noun and verb in the brain. There is quite a lot of evidence coming from research related to aphasia which indicates that distinct cortical areas are involved in the processing of nouns and verbs. However, it is still debatable what underlies problems with the production and perception of nouns and verbs. Is the distinction between nouns and verbs reflected at the conceptual (semantic) level, the morphological level or at the lexical level? It may also be the case that categories consist of a set of underlying semantic features and the inability to produce or comprehend one category or another results from the selective damage to cortical regions supporting the representation of a specific semantic feature such as, for instance, animacy or concreteness/imageability.

In the following section we will look at the examples of studies showing that the distinction between nouns and verbs exists at the conceptual level.

2.1. Distinction between nouns and verbs at the semantic/conceptual level

2.1.1. Online processing studies

In their recent study Kauschke and Stennken (2008) contribute new experimental evidence from online processing supporting earlier findings from numerous studies showing that nouns are processed faster than verbs. For example, category effects, namely an advantage of nouns over verbs, and of intransitive over transitive verbs, have been reported in German on the basis of picture naming experiments with children, aphasics and unimpaired adults. One possibility of accounting for this noun advantage is that prototypical nouns denote concrete, individuated, and highly imageable objects while verbs tend to be more abstract. However, it should be pointed out that when less prototypical items are considered, for example, abstract nouns or more concrete verbs, there may be substantial overlap between the categories.

Kauschke and Stennken (2008) in their two experiments address the question of whether noun advantage in German visual lexical decision relies purely on the semantic distinction in terms of concreteness, and whether the word category effect persists independent of contributions from morphological complexity of a given category. The purpose of the visual lexical decision task experiment was to establish the noun advantage in German, and therefore to compare the processing of prototypical object and action words using uninflected forms of the two stimulus categories. The following subcategories were included: man-made objects, biological objects, transitive verbs, and intransitive verbs. Their experiment confirmed a significant noun advantage. Additionally, the comparisons of

subcategories showed significantly faster responses to intransitive verbs than to transitive ones. However, there was no significant difference in the responses to biological and man-made nouns. Since all stimuli were controlled for word length, as well as for age of acquisition and frequency these findings cannot be attributed to either of these parameters alone. Rather, semantic, morphological, and syntactic factors should be taken into account. Since this experiment consisted of nouns referring to concrete objects and verbs referring to actions, semantic and syntactic properties inevitably overlap in the stimuli. On the basis of the category effect found in this experiment, Kauschke and Stennken (2008) conclude that this may be attributed to object and action properties or to syntactic factors such as argument structure. That syntactic aspects play a role is reflected in faster processing of intransitive verbs compared to transitives. On the other hand, the fact that no subcategory effect has been observed for nouns suggests that the semantic influence in lexical decision is not strong.

Since there was a morphological imbalance between the nominal and verbal stimuli in the first experiment in that nouns were morphologically unmarked (to be precise, singular, nominative case is not morphologically overtly specified on nouns), e.g., *Nelke* ‘pink’, whereas the verbal stimuli used in the first experiment were infinitives, which in German require a suffix (-en), e.g., *rupfen* ‘to pick’, the authors conducted a second experiment to exclude the possibility that noun advantage observed in the first experiment was caused by the fact that nouns had a simpler morphological structure. In the second experiment Kauschke and Stennken (2008) investigated whether the word category effect persists independent of contributions from morphological complexity. To this aim they used inflected word forms of nouns and verbs with orthographically identical suffixes: nouns marked for plural and verbs marked for person, e.g., *Nelken* ‘pinks’ and (*wir/sie*) *rupfen* ‘we/they pick’. This manipulation led to an equivalence of the stimuli on the word form level and decreased the morphological differences considerably as compared to Experiment 1. The prediction was that if in this case the noun advantage was still present, it should not be due to morphological differences. This prediction was corroborated in that the noun advantage found in Experiment 1 persisted, thus suggesting that nouns are processed faster than verbs, even when there is considerable form identity and similar morphological complexity.

Taken together, the findings from these two experiments allowed the authors to conclude that the observed differences in the processing of nouns and verbs cannot be reduced to a higher morphological complexity of verbs or to word form aspects. The category effect was evident for both unmarked nouns and verbs which represent prototypical object- or action labels and for inflected word forms. The overall results suggest that nouns are processed faster than verbs, probably due to conceptual differences between these two categories.

2.1.2. ERP studies

The processing of nouns and verbs in German was also a subject of the study by Pulvermüller, Lutzenberger, and Preissl (1999). In their study they used stimulus-triggered event-related potentials (ERP) and high-frequency electrocortical responses in the gamma band to investigate the processing of German nouns and verbs in a lexical decision task. The material consisted of 50 nouns and 50 verbs presented together with 100 matched pseudo-words. The latter were generated from word stimuli by exchanging letters within or between words. The participant task was to decide whether a given string of letters was a real word or non-word in German. The most important result was that verbs elicited more ingoing activity above premotor and motor cortices than nouns. In contrast, nouns elicited more ingoing (less outgoing) activity at occipital recording sites. As soon as 200 ms after stimulus onset event-related potentials disclosed electrocortical differences between nouns and verbs over widespread cortical areas. In a later time window (500–800 ms) after stimulus onset, there

was a significant difference between high-frequency responses in the 30 Hz range. Different maps obtained from both event-related potentials and high-frequency responses revealed strong differences in signals between categories recorded above motor and visual cortices. These data suggest that different physiological responses are related to semantic associations (motor or visual) elicited by verbs and nouns.

2.1.3. Aphasia studies

The conclusion that the difference between nouns and verbs is anchored at the conceptual level was also earlier reached in a seminal study by Damasio and Tranel (1993). In this study, Damasio and Tranel report three cases of aphasic patients who presented a clear instance of a double dissociation between nouns and verbs at the conceptual level. The first patient, Boswell, consistently fails to retrieve the concepts behind the pictures of different classes of entities whereas he has no problems retrieving the concepts behind the pictures of actions. The second patient, AN-1033, can access all classes of concepts for which he has been investigated but has a selective defect in lexical retrieval of relevant nouns. Finally, the third patient, KJ-1360, shows the opposite deficit to that of AN-1030 in that in spite of the intact conceptual system he has problems with the lexical retrieval of verbs. These observations were made in a series of picture-naming tasks in which the patients were presented with slides depicting: (i) concrete entities from various lexical categories (animals, fruits, vegetables, tools), (ii) faces of famous people, and (iii) pictures of actions. In the first two cases, noun retrieval was stimulated by a question *What is it?* or *Who is it?*. In the third case, verb retrieval was stimulated by the question *What is happening?*. Both Boswell and AN-1033 performed significantly worse than both KJ-1360 and control non-aphasic subjects in the tasks involving noun retrieval. By contrast, KJ-1360 performed significantly worse than both Boswell and AN-1033 and control non-aphasic patients in the tasks involving verb retrieval. Since in both patients Boswell and AN-1033 left frontal cortices are intact whereas this region is damaged in KJ-1360, Damasio and Tranel (1993) correlate impaired verb retrieval in KJ-1360 with a damage in left frontal cortex. Accordingly, since in both Boswell and AN-1033 left anterior and middle temporal lobe are damaged, Damasio and Tranel (1993) conclude that this sector of left hemisphere is responsible for the retrieval of nouns that denote concrete entities. The implication of these findings is that there are specific neural systems supporting the retrieval of concepts of actions and objects. These findings, however, do not allow us to conclude that there are specific neural systems supporting the retrieval of different grammatical categories since the objects used in the tasks described above were prototypical nouns and, accordingly, the actions depicted in the experimental material were prototypical verbs. The possible implication of this finding is that the neural systems that support the retrieval of concepts of actions and relations are not the same as those that support the retrieval of concepts of objects.

In addition to the postulated distinction between nouns and verbs as reflecting a conceptual difference in terms of objects and actions, there is also another possible approach according to which the distinction between nouns and verbs reflect a semantic distinction between concrete and abstract concepts respectively. This is correlated with the observation that selective impairments may arise for either abstract or concrete concepts (Marshall et al. 1996a, 1996b; Bird, Howard, and Franklin 2000). The conclusion would be then that noun deficits result from an inability to access information about the meaningful features of concrete words (usually nouns), whereas verb deficits result from an inability to access information about the meaningful features of abstract words (usually verbs). This kind of approach may give rise to an important question related to the observation that the feature [$\pm$ abstract] does not allow us to draw a definite line between nouns and verbs where all

[−abstract] lexical items should be understood as belonging to the grammatical class of nouns and all [+abstract] lexical items should be classified as verbs. This seems to be implausible since within the class of nouns one can make a division between those that denote more abstract concepts such as *freedom*, *love* as compared to nouns referring to more concrete objects (*ball*, *stone*, etc.). Accordingly, also within the class of verbs there are more or less abstract verbs. On the one hand, there are stative verbs like *think*, *feel* which evoke abstract concepts, and, on the other hand, there are activity verbs evoking more imaginable (more concrete) concepts, e.g., *kick*, *kiss*, etc. In other words, this kind of research suffers from an important limitation, namely it remains silent on how abstract nouns such as *idea*, *intelligence* and abstract verbs such as *inspire*, *think* are represented. The question is whether abstract nouns would pattern with those nouns that denote concrete entities or whether they rather would be stored in the same cortical locations as verbs. It should be observed that not all verbs can be defined as describing activities involving motion. Certainly, verbs like *like*, *hate*, *admire* would be difficult to be perceived as motion concepts.²

The study by Damasio and Tranel (1993) shows that the distinction between nouns and verbs might indeed have a conceptual nature and be related to the semantic contrast between objects and activities. However, it does not exclude the lexical account, meaning that it is still possible that it is not the concepts of objects and activities that constitute a problem for the patients reported by Damasio and Tranel (1993), but rather that these patients have problems with retrieving the phonological representation of the specific lexical class, e.g., nouns or verbs. This possibility is discussed in the next section.

2.2. Distinction between nouns and verbs at the lexical level

2.2.1. Aphasia studies

One problem for the purely semantic/conceptual distinction between nouns and verbs comes from the study of Hillis and Caramazza (1995), who report a double dissociation in modality specific impairments within a single patient. The patient reported in this study makes more errors in nouns than in verbs in spoken language tasks and more errors in verbs than in nouns in written language tasks. To identify the modalities of output that were affected by the patient's brain damage, a set of black and white pictures showing objects and actions was presented for oral naming, oral reading and word/picture matching. In various oral naming and reading tasks as well as in the corresponding written tasks the patient revealed a striking dissociation between the ability to process the meaning of nouns and verbs, which was relatively unimpaired and her ability to retrieve the phonological form of nouns and orthographic form of verbs, which was severely impaired. In other words, the patient's oral naming and reading was significantly more accurate for verbs than for nouns. By contrast, in the written naming tasks, the patient did significantly better for nouns than for verbs. Interestingly, several of the patient's erroneous responses in the reading task revealed that a specific phonological form might be available for use as a verb but not as a noun (*a comb* → *it is used to comb your hair*). On the basis of this evidence Hillis and Caramazza (1995) conclude that phonological and orthographic representations of nouns and verbs are processed

² In addition, there are reports of semantic category-specific deficits, the most prevalent being the selective damage for 'living things' category (Hart, Berndt, and Caramazza 1985; Basso, Capitani, and Laiacina 1988; Farah et al. 1989, among others). For example, certain brain lesions can affect the ability to retrieve the meaning of animal names but not names of artifacts, or can have the reverse effect (Hillis and Caramazza 1991). This would indicate that either the representations of meanings are processed by discrete brain mechanisms for different semantic categories of words, or that certain aspects of meaning pertain to some categories more than others.

by independent neural mechanisms. Since the patient performed almost flawlessly in word comprehension tasks, this impairment cannot be attributed to the loss of the conceptual/semantic distinction between objects and activities stored in the semantic component of lexical processing because then the expectation would be that such a loss should affect both modalities (spoken and written) equally. The problem cannot also be generalized to phonological or orthographic deficits for all word classes since the patient did not have any other phonological and orthographic problems with solving any other tasks requiring the articulation of complex phonemic sequences or testing the ability to write. On the basis of these observations one may draw a conclusion that nouns and verbs must be organized at a lexical level. It is not enough to have just a conceptual distinction for nouns and verbs (along the lines of, e.g., objects and actions) since the patient described above did not have problems with semantic tasks. Given the fact that his overall phonological and orthographic abilities were unimpaired, one cannot attribute his problems with producing nouns in an oral task and verbs in a written task to a general loss of orthographic and phonological knowledge. Rather what seems to be at issue is his loss of phonological representations of a specific word (grammatical) class, namely nouns, and accordingly, the loss of orthographic representations of a distinct specific word class, namely verbs. This selective impairment suggests that the information of the lexical category noun and verb is part of the lexical information. In other words, the information about word classes seems to be relevant for the manner how this information is mapped onto their corresponding phonological and orthographical representations.

2.2.2. Priming studies

Another important piece of evidence in favour of the claim that the noun-verb distinction is psychologically real and relevant at the lexical level comes from a priming study by Melinger and Koenig (2007). In this study they investigate whether grammatical category information influences the lexical selection of single words or whether such information is determined on the fly while inserting single words into larger syntactic units. Within the mental lexicon phonological, semantic and syntactic information about words is not stored as a single whole, but rather represented in different strata. Each type of this information can be accessed independently. There is ample evidence showing that phonological and semantic information influence lexical selection of single words (see, e.g., Meyer and Schvaneveldt 1971; Underwood 1976; Fischler 1977; Neely 1977; Rosinski 1977; Lupker 1979; Tanenhaus, Flanagan, and Seidenberg 1980; Briggs and Underwood 1982; Lupker 1982; Glaser and Dünghoff 1984; Underwood and Briggs 1984; Rayner and Springer 1986; La Heij 1988; Lupker 1988; Neely 1991; Shelton and Martin 1992; Kroll and Stewart 1994; McRae and Boisvert 1998). This is accounted for by referring to the idea that words are organized in the mental lexicon in form of a network consisting of phonologically and semantically related nodes. When one word is retrieved (activated) in this network, the activation spreads to the closest phonologically and semantically related nodes. The important question is whether the third component of the lexical knowledge – morphosyntactic features – also influences lexical access or lexical selection. There are several studies which suggest that syntactic information in fact exerts such influence but only when an accessed word is integrated into an unfolding syntactic representation (see, e.g., Fromkin 1971; Garrett 1975; Marx 1999; Ferreira and Humphreys 2001; Vigliocco et al. 2004, and further references cited in Melinger and Koenig 2007). For example, speech errors are subject to grammatical category constraints. This means that in word substitutions or exchanges the interacting words commonly come from the same syntactic category: nouns exchange nouns and verbs exchange verbs, but seemingly this influence of grammatical category on lexical selection is only present when a given lexical

candidate is to saturate some slot in the unfolding syntactic derivation. Given these observations, there is an inclination in the experimental studies related to lexical selection to assume that syntactic information has a different status from semantic and phonological information within the mental lexicon. Unlike in the case of phonological and semantic activation of words, in the syntax-driven lexical selection activation spreads from the active slots within a syntactic tree which is currently under construction to the lexicon.

In an alternative explanation proposed by Melinger and Koenig (2007) it is assumed that grammatical category information is available whenever needed irrespective of whether a single word, a phrase or a whole sentence is produced. This makes a prediction that the effect of syntactic information should be observable even if there are no combinatory processes involved. The evidence for this assumption comes from three experiments reported by Melinger and Koenig (2007). In the first of them they used a part-of-speech priming task in which the target word was a syntactically ambiguous word which could be a noun or a verb depending on stress placement (e.g., REcord vs. reCORD) and it was preceded by a prime word which was either a syntactically unambiguous noun or a syntactically unambiguous verb. The independent measure was not the reaction time but the type of utterance: (i) the stress placement typical of nouns or (ii) the stress placement typical of verbs. The primes were controlled for orthographic, phonological and semantic relatedness to the target words. The main finding was that targets preceded by noun primes were produced as nouns more often than when preceded by verb primes. Similarly targets preceded by verb primes were produced more often as verbs than as nouns. On the basis of this finding, Melinger and Koenig (2007) conclude that grammatical category information can influence lexical selection without a syntactic context.

To exclude the interpretation of the results in terms of semantic priming (in the sense that it is not the grammatical category that does the priming but rather that the semantics of nouns (objects) and verbs (events) is relevant), they conducted a second experiment in which they manipulated the primes by choosing semantically non-prototypical nouns (such as abstract nouns, e.g., *fact*) instead of concrete nouns. If the observed effects are due to semantic priming, it must be priming at a very general semantic level: 'thing' rather than 'object'. And accordingly, if semantic priming is crucial, it should be present independently of the grammatical category also in the case of state-denoting adjectives (used as primes) and verbs (used as targets) as they share a very general semantics of eventualities. The prediction is that if it is not grammatical category but semantics that caused priming effects in the first experiment, abstract nouns should bias speakers to produce nouns, and state-denoting adjectives should bias speakers to produce verbs. However, in the second experiment Melinger and Koenig (2007) found out that speakers are significantly more likely to produce nouns following a noun and state-denoting adjective failed to bias speakers to produce verbs. That is, adjective primes bias speakers to produce nouns. This second result is interpreted by the authors as reflecting a syntagmatic rather than a paradigmatic effect.

Finally, to completely exclude any effect of semantic priming, Melinger and Koenig conducted a third experiment in which they used abstract nouns and stative verbs as primes. Also in this experiment targets preceded by nouns were pronounced as nouns and targets preceded by verbs were produced as verbs. This shows that part-of-speech information influences lexical selection processes even when they are not part of larger syntactic integration processes. Speakers' pronunciation preferences (corresponding to either nouns or verbs) were sensitive to the part-of-speech of prime words. These three experiments thus provide evidence that syntactic features such as grammatical category are encoded in words stored in the mental lexicon and as such they can influence lexical processes or selection in the absence of syntactic combinatory processes.

Further evidence supporting the reasoning that it is the lexical level which matters for the noun vs. verb distinction was provided by a series of neuro- and neurophysiological studies. We discuss the results of these studies in the following section.

2.2.3. Neuro- and neurophysiological studies

2.2.3.1. PET studies

Perani et al. (1999) use Positron Emission Tomography (PET) to measure the activity involved in the processing of concrete and abstract nouns and verbs. More specifically, the subjects were presented with four categories of words in Italian: (i) concrete verbs, related to object manipulation (e.g., 'to cut'), (ii) abstract verbs, related to psychological states (e.g., 'to hope'), (iii) concrete nouns (manipulable tools, e.g., 'hammer'), (iv) abstract nouns ('justice'). Subjects were asked to read each word silently and when a pseudo-word appeared on the screen to press the button. Perani et al. (1999) found out that several areas were significantly more active when processing verbs. More concretely, only verbs activated the dorsolateral frontal, superior parietal, anterior temporal, middle temporal and occipital areas. Interestingly, the reverse comparison (nouns vs. verbs) did not show any areas which were significantly more active during noun processing. In addition, they found out that there was a difference in the processing of abstract and concrete words. The former selectively activated right temporal pole and amygdala, bilateral inferior frontal cortex. There were no brain areas which were more active in response to concrete words. Perani et al. (1999) did not find any significant interaction effects between word class and concreteness. On the basis of these findings, they concluded that brain activations caused by verbs may be associated with the automatic access of syntactic information. This may be due the fact that verbs are in general richer in structural information of nouns, including the information about the number of arguments and thematic roles which must be directly mapped on the surface syntactic structure of the sentence. Because the stronger activation of verbs was the same both for concrete and abstract verbs, this difference in activation cannot be explained in purely semantic terms (along the lines of 'concreteness'). Additionally, since the task was purely lexical, the results cannot be explained in terms of different category-dependent morphological operations. Thus, these findings seem to indicate that the information about the grammatical category is lexically encoded.

2.2.3.2. ERP studies

A similar design based on a semantic manipulation within the class of nouns and verbs but with a different experimental technique, namely Event Related Potentials (ERP), was used by Kellenbach et al. (2002). They contribute to the previous ERP studies by Preissl et al. (1995) and Pulvermüller (1996), Pulvermüller, Lutzenberger, and Preissl (1999) in which distinct ERP effects were found for concrete nouns and action verbs. Verbs elicited an increased frontal-centrally maximal positivity relative to nouns while nouns elicited more incoming current over occipital sites. This finding was taken to indicate that action verbs involved frontal cortices due to their motor attribute salience while concrete nouns involved occipital areas due to their visual attribute salience. Altogether these data suggest that the different ERP results for nouns and verbs reflect semantic factors rather than lexical class differences. If correct, these findings make a number of predictions. For instance, abstract nouns which are less concrete and hence harder to visualize should not elicit the same ERP effect as concrete nouns. Similarly, verbs which do not involve actions and therefore do not have a high motor attribute salience (e.g., state-denoting verbs) should not elicit the same ERP effect as typical action verbs. In addition, we should expect that nouns denoting manipulable objects should elicit the same ERP effect as action verbs since both involve salient motoric properties.

In order to verify these predictions, Kellenbach et al. (2002) designed an ERP experiment to investigate whether the distinctions between the noun and verb categories can be accounted for by their different salience of visual-perceptual and sensorimotor attributes or whether they result from their different grammatical class specifications. They used three subclasses of nouns and verbs which were selected on the basis of their semantic attribute composition: abstract nouns (e.g., *peace*), cognition verbs (e.g., *consider*), nouns referring to non-manipulable objects (e.g., *lamppost*), motion verbs (e.g., *flow*), nouns referring to manipulable objects (e.g., *pliers*), and action verbs (e.g., *read*). The main finding was that nouns and verbs elicited different ERPs but they were not influenced by semantic attribute types. In other words, the effect of semantic attribute class was equivalent for each grammatical class. The earliest grammatical class effect observed in the time window between 250 and 300 ms was a posteriorly maximal enhancement of the P2 component elicited by verbs relative to nouns. Nouns elicited greater negativity than verbs in the time window between 350 and 450 ms. This effect was centrally maximal, statistically robust over lateral sites. The comparison across the attribute types did not show any significant interactions. Given that the P2 component was obtained across three types of verbs, two of which did not have a high motor attribute salience, this component cannot be attributed to a higher salience of motoric knowledge of verbs. Relative to verbs, all noun stimuli elicited a larger N400 component. Kellenbach et al. (2002) interpret these results as being compatible with lexical-semantic knowledge being organized in a manner that takes into account both category-based and attribute-based distinctions between nouns and verbs. Even though no definite conclusion is allowed as to whether the distinction between nouns and verbs is reflected at the conceptual or lexical level, the findings seem to indicate that different ERP components elicited for nouns and verbs are not exclusively determined by their semantic (conceptual) content as the same ERP components were found for different semantic classes of nouns and verbs.

2.2.3.3. fMRI studies

A different perspective onto the relevance of lexical information was taken in later studies in which event-related functional MRI (Magnetic Resonance Imaging) was used. The question asked there was whether the distinction between nouns and verbs is present in the lexicon and if so, whether it determines the category-dependent morphological operations.

Shapiro, Moo, and Caramazza (2006) conducted a study in which they used event-related functional MRI to identify brain regions that were active when English-speaking subjects produced nouns and verbs aloud. Previous functional imaging studies of noun and verb processing often confounded semantic and grammatical categories (by using pictures of objects and actions in picture-naming tasks), thus making impossible to ascertain whether the observed difference in noun and verb processing has to do with the difference in grammatical category or rather whether it has to be attributed to different aspects of meaning: perceptual properties of objects or sensorimotor properties of actions. According to Shapiro, Moo, and Caramazza (2006), true noun-verb differences should emerge in word production tasks in which on-line access to grammatical category information plays a crucial role. This is why in their event-related functional MRI study they manipulated noun or verb-related morphological inflection. Nouns and verbs were produced in context of short phrases or sentences, like *many doors* and *he weeps*. In order to control for confounding grammatical and semantic factors in word production, the study was divided into several experiments.

In the first experiment, subjects produced nouns, verbs and pseudo-words used as nouns or verbs. If real words and pseudo-words of a given category activated certain cortical regions in a similar manner, and given that pseudo-words do not have stored semantic features, such commonalities in patterns of cortical activation could be taken to exclude areas responsive to specific perceptual or sensorimotor properties associated with word meaning.

However, activation during pseudo-word trials could still be taken to reflect a process of retrieving information related to some very generic semantic categories such as ‘objects’ and ‘actions’. In other words, one could still argue that pseudo-words like *the wug* and *he wugs* are automatically interpreted as naming unknown (generic) objects and actions.

To exclude this possibility, in the second experiment both abstract and concrete nouns and verbs were used. If a brain region was selectively active for concrete nouns, abstract nouns and pseudo-nouns, one would assume that such a region is responsive to properties shared by items of the grammatical category noun since the other option, namely that such a region is involved primarily in processing features of objects is less likely, as Shapiro, Moo, and Caramazza (2006: 1645) point out.

Finally, to exclude that any such selectively active brain region merely reflected processing of some specific property shared by nouns in their task, but was not necessarily diagnostic of category membership, in their third experiment Shapiro, Moo, and Caramazza (2006) let subjects produce nouns and verbs with both regular inflectional endings (*ducks*, *played*) and irregular inflections (*geese*, *wrote*). If a region associated with noun production in their first and second experiment showed the same activation in the case of regular and irregular nouns (but not verbs of either type), this could be taken as an additional argument in favour of the claim that this region distinguishes nouns from verbs at the lexical level before the specification of particular morphological transformations.

In their study, which comprised the three experiments mentioned above, Shapiro, Moo, and Caramazza (2006) identified four brain regions whose patterns of activation correlated selectively with the production of words of one grammatical category. More specifically, three regions showed significantly greater activity which was associated with the production of verbs than nouns. These regions were the following: the left prefrontal cortex, left superior parietal lobule, and left superior temporal gyrus. In one region, namely the left anterior fusiform gyrus, the activity for nouns was greater. The most important finding was that for all of these areas (with the exception of the left superior temporal gyrus), event-related responses were indistinguishable for real words and pseudo-words, abstract and concrete words, and regular and irregular morphological transformations within a given category. Shapiro, Moo, and Caramazza (2006: 1646) point out that “[s]uch consistent patterns of activation over words with different semantic and morphological properties can be taken as signatures of cognitive processes specific to noun and verb production.” They also observe that the fact that activation in the left superior temporal gyrus was not consistent across experimental manipulations but rather seemed to reflect the difficulty of producing words with different morphological and semantic properties is actually consistent with the postulate that the superior temporal gyrus may be involved in lexical word form retrieval in production. In other words, the activation elicited in the left superior frontal gyrus may be affected by the degree of difficulty involved in the production of specific word forms. For example, the past-tense forms of verbs involve different semantic, morphological and phonological operations than those involved in computing the plural form of a noun. These two sets of operations differ in complexity and this in turn may affect the amount of time it takes speakers to produce words of each type and this may also have an influence on the amount of activation in the cortical region at hand. However, as Shapiro, Moo, and Caramazza emphasize, none of the other cortical regions identified by them in their 2006 study were sensitive to probable “difficulty” effects (reflected in reaction times). They take this finding to strongly support their conclusion that these areas are specifically involved in computations related to the grammatical categories of noun and verb (Shapiro, Moo, and Caramazza 2006: 1647).

In a later related study, Finocchiaro et al. (2010) used an event-related functional MRI to identify cortical regions which were active when a subject produced nouns or verbs in short

phrases. In their study they used Italian because in this language verbs may belong to different conjugational classes and verb forms differ substantially depending on which tense, person and number they express. They expected that verb-specific activations might be observed especially in those languages which have a rich verbal paradigm. This is so because higher degrees of morphophonological complexity in such a language will necessarily engage a greater variety of morphophonological operation (ibid., p. 555). The material used in their study consisted of regular verbs, regular nouns and pseudo-words used as nouns or verbs. Real verbs and nouns were divided into two semantic categories: “action” and “non-action.” Subjects were presented with either verb or noun phrases containing real nouns with a determiner (*uno* ‘a/one’, *molti* ‘many’) and verbs (in the first *io* ‘I’ or *tu* ‘you’ second person singular) or pseudo-words used as nouns or verbs. The phrases were displayed for one second, then a cue stimulus *uno .../molti ...* for nouns and *io .../tu ...* for verbs appeared for one second. The task was to read the phrase silently and to produce a correct noun or verb form according to the cue. 50% of the trials required the subject to make a morphological transformation of the stimulus and the 50% did not require any transformation. They found that as compared to verbs and pseudo-verbs, nouns and pseudo-nouns elicited a greater activation bilaterally in visual areas and no significant activation was observed using the opposite contrast. In addition, they also observed a greater activation for verbs in a small left-frontal area located in the posterior portion of the middle frontal gyrus and the dorsolateral portion of the right superior frontal gyrus. More interestingly, when a transformation was required, in all areas nouns and pseudo-nouns are associated with greater activity with respect to verbs and pseudo-verbs. However, when no transformation was required, it was verbs and pseudo-verbs that elicited greater activation compared to nouns and pseudo-nouns.

The finding that there are verb- and noun-specific areas is consistent with previous observations from a repetitive Transcranial Magnetic Stimulation (rTMS) study by Tyler et al. (2004), Shapiro, Moo, and Caramazza (2006), and Cappelletti et al. (2008). The new observation by Finocchiaro et al. (2010) is that no increase in the activation of a verb-specific region has been found in the correlation with an increased complexity of verbal morphology. The opposite pattern was observed for nouns, that is, an increased complexity of nominal morphology was correlated with an increased activation of those regions which are responsible for the processing of nouns. Moreover, pseudo-verbs did not lead to any activation of the verb-specific cortical region. This might be surprising given that pseudo-nouns activate noun-specific cortical regions. On the basis of these observations, the authors admit that the grammatical category may be an important organizational principle of language in the brain. However, at the same time they point out that their findings may shed light on the issue of what the origin of the verb-specific and noun-specific activation elicited in their study is. Finocchiaro et al. (2010) suggest that the contrasts observed in their study may be attributed to the fact that in Italian a verb always belongs to some specific conjugation class which determines the set of its possible forms and which may become activated when they should serve as an input to some morphological operation. Given that a pseudo-verb in Italian per definition cannot belong to any conjugational class and hence does not have any specific forms which would be determined on the basis of its non-defined conjugational class, it does not trigger any activation in verb-specific cortical regions.

In the last two experiments reported in this section Shapiro, Moo, and Caramazza (2006) and Finocchiaro et al. (2010) used morphological category-dependent tasks and they concluded that the distinction between nouns and verbs is established at a level prior to morphological transformations, hence most likely at a lexical level. However, they did not entertain the possibility that it is morphology, more precisely, the type of morphosyntactic frame in which a lexical item is inserted, which unambiguously determines the grammatical category of this lexical item. This line of reasoning is undertaken in the following section.

2.3. Distinction between nouns and verbs at the morphological level

2.3.1. fMRI studies

Longe et al. (2007) in an event-related functional magnetic resonance imaging (fMRI) study tested the hypothesis that activations for noun and verb stems (*snail*, *hear*) would not differ, whereas inflected verbs (*hears*) would generate more activation in left frontotemporal areas than inflected nouns (*snails*). In their experiment subjects were presented with one word at a time and asked to make a timed semantic valence judgment to each word, where they judge each word to be either pleasant or not. This task as such required accessing a word's meaning in order to make the valence decision. Equivalent cognitive demands should be involved in the processing of single uninflected words irrespective of grammatical class or form. However, the prediction was that nouns and verbs would be differentiated by virtue of the morphological processes that they invoke rather than by intrinsic differences in their representation. More specifically, they expected no differences in the patterns of activation for noun and verb stems, but inflected verbs should generate greater activation over inflected nouns. It should be pointed out that even though the task did not require overt morphological manipulation, morphological processing was expected to occur because many studies had shown that complex words are automatically segmented into their constituent morphemes during processing (Allen and Badecker 1999; Rastle et al. 2000).

The 2007 experiment by Longe et al. was intended to complement the authors' previous neuroimaging studies in which both lexical decision and semantic categorization tasks were used and which showed that nouns and verbs activate the same left-lateralized regions (inferior frontal gyrus (IFG) and temporal cortex), when they are presented as uninflected stems (*desk*, *sing*). In contrast, when an inflectional affix is added to the stem (*desks*, *singing*), inflected verbs differentially activate left inferior frontal cortex compared with inflected nouns (Tyler et al. 2001, 2004). In this experiment they conclude that grammatical category per se does not influence the processing of a word when it is encountered as a stem. Thus, it might be the case that nouns and verbs may be represented within an undifferentiated cortical system which is not divided into different categories or domains (Tyler et al. 2001, 2004). This however does not have to mean that grammatical category information does not constitute part of the lexical representation of the word. It seems instead that category is not a first-order organizing principle of lexical representation in the brain. This observation leads to the expectation that while uninflected noun or verb stems may readily access lexical representations, the presence of an affix in inflected verbs may place additional demands on this access process. This expectation has been corroborated in their 2007 experiment. They found that, as hypothesized, activations for noun and verb stems do not differ while inflected verbs generate more activation in left frontotemporal areas than inflected nouns. These findings are in line with later studies on morphological processing showing that the left middle temporal gyrus (LMTG) appears to be coactivated with the left inferior frontal gyrus (LITG) when morphologically complex words are processed. More specifically, LMTG and LITG activation is found for regularly inflected words (*jumped*) compared with past tense forms that do not have any overt morphological structure (*slept*). For example, Finocchiaro et al. (2010) in their event-related functional MRI study show that higher degrees of morphophonological complexity may engage a greater variety of morphophonological operations, thus enhancing the possibility of activations specific for a given grammatical class.

Longe et al. (2007) conclude that their results are largely incompatible with the claim that nouns and verbs are represented and/or processed in distinct neuronal regions on the basis

of the category per se. For this to be the case, noun and verb stems should have activated distinct neural regions in this study, which they did not. Additionally, they suggest that their results rule out a neural organization of nouns and verbs based on their differing semantic properties (Gentner 1981; Bock and Miller 1991) because this would also predict differences in activation for noun and verb stems. Instead, they interpret these findings as supporting the view “that nouns and verbs are represented and processed within the same distributed neural language system, which is modulated as function of the processing that different types of linguistic inputs entail” (Longe et al. 2007: 1817). This can be taken to mean that grammatical category information is encoded within the language system at the lexical level but accessing this information does not inevitably give rise to differential activations for nouns and verbs. Activation is observed only in cases in which there are structural implications to grammatical category knowledge. A similar conclusion is also reached by Finocchiaro et al. (2008).

2.3.2. TMS studies

In their Transcranial Magnetic Stimulation (TMS) study, Finocchiaro et al. (2008) focus on the neural correlates of verb and clitic processing. They used pronominal clitic pronouns in Italian (e.g., *portala* ‘bring it[feminine]’) which have both nominal and verbal characteristics. They have nominal characteristics since clitics have nominal referents and are specified for nominal features (e.g., gender). They have verbal properties since they attach to verbs and depend syntactically and phonologically on their verbal hosts. The motivation for their study was the observation from previous research (Shapiro et al. 2001; Cappelletti et al. 2008) that low-frequency TMS targeted at a portion of the left prefrontal cortex along the midfrontal gyrus, anterior and superior to Broca’s area led to an impairment of both verb and pseudo-verb production. In Shapiro’s et al. (2001) experiment, the participants produced singular or plural noun forms (e.g., *a car/some cars*) and 3rd person singular or plural verb forms (e.g., *they jump/he jumps*) in response to specific cues. This task involved both real words and pseudo-words (e.g., *a wug/some wugs* and *they wug/he wugs*). The same pattern of results was obtained for real words and pseudo-words. These findings suggest that left prefrontal cortex is sensitive to the grammatical distinction between nouns and verbs independently of their conceptual-semantic properties. Finocchiaro et al. (2008) extended this research to clitics in Italian with the goal to establish their category status (recall that investigated Italian clitics have nominal and verbal properties). The experiment consisted of two conditions: verb+clitic (e.g., *guardalo* ‘look at it[masculine]’) vs. verb+det+noun (e.g., *guarda il tavolo* ‘look at the table’). The expectation was that if the presence of a clitic (but not that of det+noun) increases the morphosyntactic complexity of the verb, one should observe the involvement of the brain region devoted to verb morphosyntax. If, however, clitics only have a syntactic function, there should be no difference between the two conditions. They found that left TMS but not right TMS interfered with the production of both verb+clitic and verb+det+noun, but the magnitude of the interference was significantly stronger for the verb+clitic task. This supports the view that clitics increase the morphosyntactic complexity of verbs and that it is the left prefrontal cortex that plays a crucial role in processing of verb morphosyntax.

Cappelletti et al.’s (2008) study is an extension of Longe et al. (2007) and Finocchiaro et al. (2008)’s studies in that it investigates the processing of singular or plural noun forms and 3rd person singular or plural verb forms not only for regular but also for irregular verbs and nouns in English. The aim of Cappelletti et al.’s (2008) study is to find out whether any of the targeted areas in the prefrontal cortex is important in distinguishing regular from irregular morphological computations. The question is whether one will obtain the same patterns of activation for regular rule-based morphological transformations as well as for irregular noun-

and verb-related morphological transformations. The experimental task consisted in a simple completion task in which subjects saw stimulus phrases of the form ‘today, I walk’, followed by cue phrases like ‘Yesterday, I ...’. In the case of nouns, subjects were presented with stimulus phrases such as ‘one child’, followed by the cue ‘many ...’. The experimental material contained 20 regular verbs, 20 irregular verbs, 20 regular nouns and 20 irregular nouns. Cappelletti et al. (2008) found out that the left anterior midfrontal region is more strongly involved in the morphological processing of verbs than nouns. More importantly, they show that the effect of stimulation on response latency applies to both regular and irregular morphological transformations with verbs.

The above neuroimaging studies stress the involvement of the left frontal and temporal regions in processing of verbal inflection. This observation is very strong since it was confirmed in three independent experimental studies using very reliable neuroimaging techniques. In what follows we will additionally report a study in which similar results are obtained. The study to be reported concerns verb- and noun-related morphological impairments which are attributed to the damage to the left inferior frontal cortex (including Broca’s area).

2.3.3. Aphasia studies

Shapiro and Caramazza (2003a) describe a case of a brain-damaged patient who is more impaired at producing inflected forms of words and pseudo-words used as verbs (*he judges, he wugs*) than of the homophonous inflected forms of words used as nouns (*the judges, the wugs*). They compare this impairment with the impairment of another patient reported by Breedin, Saffran, and Coslett (1994), who shows the opposite pattern of difficulties in that the patient can produce inflected forms of words and pseudo-words used as verbs (*he judges, he wugs*) but has problems producing inflected forms of words used as nouns (*the judges, the wugs*). Both patients have no difficulty naming object or action pictures or solving lexical decision tasks, which indicates that their impairments are not caused by the loss of conceptual knowledge necessary for the production of nouns or verbs, but rather they had a difficulty in a morphological task in which they were asked to complete sentence fragments using the appropriate spoken inflected forms of nouns and verbs such as ‘These people judge, this person ...’, ‘This is a judge, these are ...’. Both fragments require the use of phonologically identical base words but the first fragment elicits the use of appropriate verbal morphology at the end of the base word while the second fragment elicits the use of appropriate nominal morphology. One patient had a problem with producing correct verbal morphology in this task and the second patient had a problem with producing correct nominal morphology in the same task. Since both patients have a damage to the components of the left inferior frontal cortex, the authors conclude that these cortical areas are involved in processing of verb- and noun-related morphology.

The first four studies presented in this section are concerned with identifying the neural cortical regions in the brain whose which are involved in processing of nominal and verbal morphology. In the remainder of this section we would like to focus on the studies which contribute additional evidence pointing to the importance of morphosyntax for distinguishing of nouns and verbs but which do so by taking a different perspective. More precisely, they discuss different cross-linguistic patterns of acquisition of nouns and verbs.

2.3.4. Language acquisition studies

In earlier studies related to this question (see Kauschke, Lee, and Pae 2007 for a detailed discussion) there was a tendency to assume that nouns in general are acquired earlier than

verbs because they denote concepts which form “cohesive packages” and which as such can easily be mapped onto words. Hence, there was an expectation that nouns should always (i.e., in all languages) be acquired before verbs and they should outnumber the verbs in the early stages of lexical development. However, there are findings showing that verbs are not necessarily preceded by nouns, but rather they are acquired simultaneously; for example, in Chinese (see Tardif 1996), in Korean (see Gopnik and Choi 1995; Choi 1998), in Tzeltal (see Brown 1998) or in Turkish (see Türkay 2005). Also regarding the second point, namely the higher frequency of nouns relative to verbs, there are findings showing that it is not so that nouns outnumber verbs in absolute terms. For example, it has been shown for German and French that nouns prevail in spontaneous speech until the age of two, but thereafter verb frequency exceeds noun frequency (Bassano, Maillochon, and Eme 1998; Bassano 2000; Kauschke and Hofmeister 2002). There is a similar finding regarding Japanese (Ogura et al. 2006). Similar findings also come from studies using spontaneous speech data. Such studies show that verbs might be roughly equivalent to nouns or even outnumber them. This has been argued, for example, for Chinese (see Tardif 1996) and Korean (see Gopnik and Choi 1995; Choi 1998). In addition, there is evidence that the proportion of verbs acquired by children learning languages like Korean or Chinese is higher than that of children learning certain Indo-European languages, for example, English or Italian (Tardif, Shatz, and Naigles 1997; Kim, McGregor, and Thompson 2000).

The emerging picture related to the order of acquisition of nouns and verbs in different languages seems to be a little bit “patchy.” In their recent work, Kauschke, Lee, and Pae (2007) attempt to systematize this knowledge by relating the findings from different languages to some common structural properties of these groups of languages which have the same pattern of noun and verb acquisition. They focus on three languages, namely German, Korean and Turkish. Korean and Turkish have often been described as “verb-friendly” because of (i) the possibility of subject omission, (ii) the use of a regular morphology for verbs, and (iii) the consistent occurrence of verbs in the salient sentence-final position due to the canonical SOV word order. In contrast, German is characterized as a “noun-friendly” language due to (i) its clear noun-verb distinction, (ii) the consistent use of nouns with articles, (iii) the lack of subject drop, and (iv) various positions for verbs, i.e., verb-second in main clauses and verb-final in subordinate clauses. In addition, while in German the noun-verb distinction is generally considered to be clear-cut, the noun-verb distinction in Turkish seems to be less evident (Broschart 1991). Based on these distinctions between German on the one hand and Korean and Turkish on the other hand Kauschke, Lee, and Pae (2007: 1050f.) put forward the following hypotheses: (i) given that Korean and Turkish being “verb-friendly” languages share structural features, the performance of Korean and Turkish children will be similar and both distinguishable from the German children’s performance; (ii) children acquiring “verb-friendly” languages (Korean or Turkish) will perform better at processing verbs than German children; conversely, children acquiring German, a “noun-friendly” language, will be better than Korean or Turkish children at noun processing; (iii) a possible noun advantage will be more pronounced in a language with a clear noun-verb distinction, namely German, and less pronounced in a language in which the noun-verb distinction is less evident, e.g., Turkish.

Kauschke, Lee, and Pae (2007) verified the first two hypotheses.³ They observed that German children performed better at noun naming, while Korean children were better at verb

³ The participants in the German naming study were 240 German children between 2;6 and 8 years of age, with an equal distribution of boys and girls. They were distributed over five semi-annual age groups, each comprising 30 children aged between 2;6 and 4;11 years old, and three annual age groups, each comprising 30 children aged between 5;0 and 8;0 years old. For the Korean study, 240 Korean children were tested, matching exactly the German age groups, resulting in 30 children per age group. The Turkish naming study comprised 60 Turkish

naming. Turkish children applied a higher level of error strategies in verb naming than German children. Kauschke, Lee, and Pae (2007: 1066f.) link these cross-linguistic differences to structural characteristics of the languages concerned. The third hypothesis also seems to be supported by Kauschke, Lee, and Pae's (2007) finding that although nouns were mostly named with greater accuracy than verbs, the size of this discrepancy differed across languages, and it was most distinct in German. According to Kauschke, Lee, and Pae (2007), this observation can be linked to the fact that German is a language with a clear distinction between nouns and verbs.

To sum up, even though undeniably there are conceptual-semantic differences between nouns and verbs (at least the prototypical ones), the study by Kauschke, Lee, and Pae (2007) clearly shows that we have to be careful in drawing general conclusions regarding the status of nouns as having a general advantage over verbs in language acquisition and in the processing tasks. In other words, before one postulates a universal claim which is bound to apply to all languages, one should look at the structural properties of the particular (tested) languages since it might turn out that all of the tested languages have similar structural properties which significantly facilitate the acquisition of a given lexical category. For example, languages similar to German in that they have determiners, obligatory subjects but different verb positions, might be expected to show noun-advantage in language acquisition, while languages similar to Turkish or Korean with a possibility of omitting subjects and a uniform verb position in the sentence due to the SOV word order are expected to show verb-advantage in language acquisition. Note that in both groups of languages nouns are of course usually conceptually more concrete than verbs in that they in general refer to clearly definable objects. If it was only the conceptual semantics that determines the process of lexical acquisition, we would expect that there are no exceptions to the "noun-bias" pointed out above. The findings discussed in this section seem to suggest that even though semantics is important, the morphosyntax plays the final determining role in distinguishing nouns and verbs. It is the syntactic structure which clearly defines the category of a given lexical entry.

3. Discussion and conclusions

In section 2 we presented a selection of neuro- and psycholinguistic studies which in our opinion all provide – when taken together – very strong evidence in favor of the claim that categories are assembled at different levels and different linguistic modular systems represented in different cortical regions of the brain.

In section 2.1. we discussed a study by Kauschke and Stenken (2008), who provide experimental evidence showing that in German visual lexical decision tasks there is a strong noun advantage and they attribute this result to a higher concreteness of nouns at the conceptual level. Next, Pulvermüller, Lutzenberger, and Preissl (1999) use stimulus-triggered event-related potentials (ERP) and high-frequency electrocortical responses in the gamma band to investigate the processing of German nouns and verbs in a lexical decision task and observed that verbs elicited more activity in premotor and motor cortices whereas nouns elicited more activity in visual cortices. These findings are intuitively very convincing, given that in noun processing we "concentrate" on such properties as color, shape, size, whose perception relies very much on the visual area of the brain. In contrast, in verb processing we create concepts of events which mostly involve dynamicity, movement, temporal change, hence properties perceived in the motor area of the brain. Strangely, in Damasio and Tranel

monolingual and unimpaired children with equal numbers of boys and girls. This sample was split over three age groups: 20 children aged 3;0–3;11, 20 aged 4;0–4;11, and 20 aged 5;0–5;11 (Kauschke, Lee, and Pae 2007: 1051–2).

(1993), who report three cases of aphasic patients, the conclusion was that those patients who have problems in naming pictures of objects by using nouns there was a damage of the middle temporal lobe while in those patients who have problems in naming pictures of actions by using verbs there was a damage of the left frontal cortex. Even though both studies, Damasio and Tranel (1993) and Pulvermüller, Lutzenberger, and Preissl (1999), conclude that the origin of the noun-verb distinction is at the conceptual level, they point to different brain regions which are involved in noun and verb processing. However, this apparent disagreement may be attributed to the different tasks used in the two studies at hand. Pulvermüller, Lutzenberger, and Preissl (1999) used a lexical decision task in which the participant had to decide whether a given string of letters was a real word or a nonword. In Damasio and Tranel's (1993) study the participant's task was to name pictures showing objects or activities. This means that in the first study there was a mapping from the orthographic representation to corresponding concept, whereas in the second study there was a mapping from a given concept to a corresponding lexical (phonological) representation. This allows us to postulate a very preliminary hypothesis that the category as such is distributed between the conceptual representation located in the occipital region of the brain in the case of nouns and in the motor cortex in the case of verbs and their corresponding lexical representations are probably stored in the regions identified by Damasio and Tranel (1993), that is, in the middle temporal lobe in the case of nouns and left frontal cortex in the case of verbs. Using a category as such thus involves at least a mapping between a conceptual representation and its corresponding lexical representation.

Section 2.2. discussed a number of experimental approaches which provide evidence in favour of the view that the distinction between nouns and verbs is made in the lexicon. This means that there is a level, which is clearly separate from the conceptual/semantic level, in which, next to the information about the phonological and orthographic representation of a given word,⁴ also the information about its lexical category is specified. More importantly, the information about a lexical category is defined for all items belonging to a given lexical class independently of possible semantic differences between its different members. Evidence for this view comes from four independent studies: (i) aphasia study, (ii) priming study, (iii) a PET experiment, and (iv) an ERP study. In the first of them, Hillis and Caramazza (1995) report a case of double dissociation within one aphasic patient, who makes more errors in nouns than in verbs in spoken language tasks and more errors in verbs than in nouns in written language tasks. If the problem of the patient with producing nouns and verbs was caused by his inability to name objects or actions, we would expect this problem to persist across both modalities (written and spoken). This shows that the information about word classes is relevant for the mapping of nominal and verbal lexemes onto their corresponding phonological and orthographical representations.

An additional argument in favour of the claim that the noun-verb distinction has its origins at the lexical level comes from the second study discussed in section 2.2., namely a priming study by Melinger and Koenig (2007). In their experiment, Melinger and Koenig wanted to determine whether unambiguous nominal and verbal primes would influence the production of ambiguous words (e.g., REcord vs. reCORD) in which one could apply either a nominal or verbal stress placement. The main finding was that targets preceded by noun primes (both concrete and abstract) were produced as nouns more often than when preceded by verb primes. Similarly, targets preceded by verb primes (both concrete and abstract) were produced more often as verbs than as nouns. These results suggest that grammatical category information can influence lexical selection.

⁴ This does not necessarily have to mean that the phonological and orthographic representations are stored in the same place in the brain. See, for example, Price (2012).

Next, we discussed two experiments, one by Perani et al. (1999) and one by Kellenbach et al. (2002), in which the authors used PET and ERP techniques to elicit specific responses of different areas of the brain for nouns and for verbs. Crucially, they manipulated the semantic classes of nouns and verbs (by using, for example, abstract and concrete nouns and verbs). The elicited responses remained constant for different semantic classes of nouns and verbs. This indicates that the distinction between nouns and verbs does not have its origins at the semantic/conceptual level. Perani et al. (1999) found out that only verbs – independently of their semantics – activated the dorsolateral frontal, superior parietal, anterior temporal, middle temporal and occipital areas. Because the stronger activation of verbs was the same both for concrete and abstract verbs, this difference in activation cannot reside in the conceptual distinction between nouns evoking the concepts of objects and verbs evoking the concept of actions. They treat their findings as evidence for the claim that the grammatical category (noun vs. verb) is lexically encoded. In a similar vein, Kellenbach et al. (2002) found out that nouns and verbs elicited different ERPs, but they were not influenced by their semantic attribute types. These findings seem to indicate that different ERP components elicited for nouns and verbs are not exclusively determined by their semantic (conceptual) content as the same ERP components were found for different semantic classes of nouns and verbs.

Already these four studies mentioned above provide solid evidence for the existence of a separate lexical level which is independent of the conceptual level and at which the distinction between nouns and verbs is established. Interestingly, there are also studies which prove the significance of the distinction between nouns and verbs at the lexical level by showing that since the distinction between nouns and verbs is established at a level prior to morphological transformations, it must happen at the lexical level.

Both Shapiro, Moo, and Caramazza (2006) and Finocchiario et al. (2010) used an event-related functional MRI in category-dependent morphological transformation tasks. In the experiments concrete nouns and verbs, abstract nouns and verbs and pseudo-nouns and pseudo-verbs, as well as nouns and verbs with regular and irregular inflections were used. Shapiro, Moo, and Caramazza (2006) identified the following brain regions which showed a significantly greater activity associated with the production of verbs: the left prefrontal cortex, the left superior parietal lobule, and the left superior temporal gyrus. In one region, namely the left anterior fusiform gyrus, the activity for nouns was greater. The most important finding was that for all of these areas (with the exception of the left superior temporal gyrus), event-related responses were indistinguishable for real words and pseudo-words, abstract and concrete words, and regular and irregular morphological transformations within a given category. This indicates that there are specific regions responsible for selecting lexical items belonging to the category noun or verb and inserting them into category-dependent morphosyntactic frames.

Finocchiario et al. (2010) found no increase in the activation of a verb-specific region in response to an increased complexity of verbal morphology. The opposite pattern was observed for nouns, that is, an increased complexity of nominal morphology was correlated with an increased activation of those regions which are responsible for the processing of nouns. Taken together, the authors conclude that the information about the lexical category feeds the morphological level, hence the category distinction must be made prior to the morphological level.

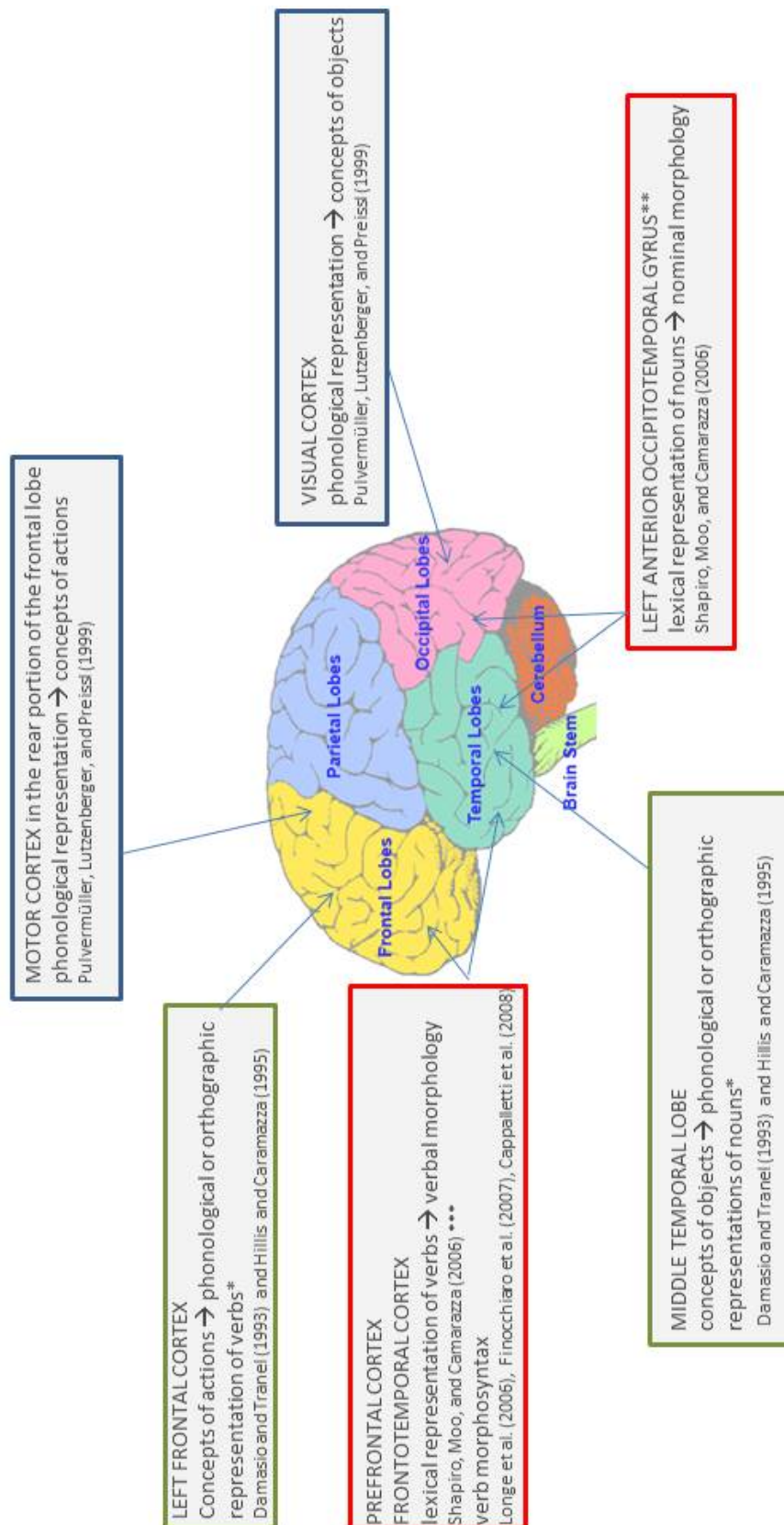
Whereas the studies presented in section 2.2. emphasize the role of the lexical level as a level feeding the category-dependent morphological transformations, it might be the case that the brain activation elicited in these studies was caused not by the lexical selection but by the very morphosyntactic operation. The evidence for the latter view was presented in section 2.3. We discussed there fMRI and TMS studies which were concerned with identifying the

neural cortical regions in the brain whose activation increases proportionally to the increase in the morphological complexity of nouns and verbs. For example, Longe et al. (2007) show that there is no difference in the pattern of activations for noun and verb stems (*snail*, *hear*), but inflected verbs (*hears*) generate more activation in the left frontotemporal areas than inflected nouns (*snails*). In the light of these findings, Longe et al. (2007) claim that nouns and verbs are not necessarily represented and/or processed in distinct neuronal regions on the basis of the category *per se*, but rather different pattern of activation for nouns and verbs elicited in their experiment is caused by category-dependent morphological transformations. Similarly, Finocchiaro et al. (2008) in their TMS study show that clitics increase the morphosyntactic complexity of verbs and that it is the left prefrontal cortex that plays a crucial role in processing of verb morphosyntax. Furthermore, Cappelletti et al. (2008) observe that the prefrontal cortex is also more activated by irregular morphological operations on verbs than on nouns.

The importance of morphosyntax for distinguishing nouns and verbs is also stressed in the paper by Kauschke, Lee, and Pae (2007), who show that against the usually assumed hypothesis that nouns are universally acquired before verbs and they outnumber the verbs in earlier stages of lexical acquisition there are crosslinguistic differences in the order of acquisition and in the ease of processing of nouns and verbs which might be correlated with some structural language-specific characteristics. For example, children performed better at noun naming in German, which is characterized as a “noun-friendly” language due to (i) its clear noun-verb distinction, (ii) the consistent use of nouns with articles, (iii) the lack of subject drop, and (iv) various positions for verbs, i.e., verb-second in main clauses and verb-final in subordinate clauses. By contrast, children were better at verb naming in Korean, which is characterized as a “verb-friendly” language because of (i) the possibility of subject omission, (ii) the use of a regular morphology for verbs, and (iii) the consistent occurrence of verbs in the salient sentence-final position due to the canonical SOV word order. Given these findings, one might have doubts about the conceptual semantics as the only factor determining the process of lexical acquisition. On the contrary, the findings discussed in section 2.3. seem to suggest that even though semantics is important, the morphosyntax plays the final determining role in distinguishing nouns and verbs.

This overview of the major studies using a variety of different experimental techniques and research methods ranging from processing, language acquisition, aphasia studies to more advanced neurophysiological and neuroimaging studies points to a conclusion that the knowledge about verbs and nouns in the mind cannot be attributed to a single level, either conceptual, lexical or morphosyntactic, but rather it seems to be the case that it is organized in form of a distributed network of specialized functions in which many processes related to noun or verb processing may happen in a parallel fashion. Even though many issues still remain to be clarified, in the concluding section of this paper we attempt to provide a coherent and unified picture of the organization of the knowledge about nouns and verbs in the mind which emerges from the studies discussed in the preceding sections and which is schematically presented in Fig. 1. As shown in Fig. 1, there are brain areas specialized more in the processing of nominal or verbal categories at three levels: conceptual (described in green boxes), lexical (described in blue boxes) and morphological (described in red boxes).

The final conclusion resulting from the presented overview of the findings about the organization of the knowledge about NOUNS and VERBS in the brain is that in spite of this very rich and complex matter and in spite of the plethora of existing experimental methods which may often lead to conflicting results or interpretations, when it turns out that we find overlapping results, we may treat this as constituting a strong and solid basis for further investigations.



- * It follows from Hillis and Caramazza (1995) that the mapping from concepts of actions to their orthographic representations can be selectively impaired independently of the mapping from concepts of actions to their phonological representations.
- ** Occipitotemporal gyrus is also referred to as fusiform gyrus.
- *** Shapiro, Moo and Caramazza (2006) additionally identified left superior parietal lobule as involved in the processing of verbal morphology. Note that this area is responsible for spatial orientation and receives sensory input from one's hand. This might indicate that it is related to motor functions which are also controlled by the neighboring motor cortex storing action concepts.

Fig. 1: A schematic representation of the knowledge about nouns and verbs in the mind

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