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Why are verbal nouns more verbal than finite verbs? New insights into the interpretation of the P200 verbal signature

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Traditionally, languages are assumed to minimally manifest a distinction between nouns and verbs. This assumption has occasionally been debated in the theoretical linguistic literature, in particular in the context of challenging verbal noun constructions that simultaneously manifest nominal and verbal features. From a psycholinguistic perspective, one of the most promising diagnostic criteria for determining whether a given word belongs to the category NOUN or VERB is an event-related brain potential (ERP) component, P200, whose amplitude is larger for verbs than for nouns. So far, a challenge for the interpretation of the P200 has been whether this component reflects verbal (e.g., action) semantics, lexical category or verb-related morphological operation. In the present study we report an ERP experiment whose goal was to contribute to a better understanding of the nature of the “verbal” P200 component by monitoring the comprehension of Polish morphologically related finite verbs, converbs, and verbal nouns. Thereby, we manipulated the syntactic category and morphological complexity of the critical words while keeping their semantics identical. The results show that finite verbs engender a smaller amplitude of the P200 component than less prototypical “verbs” such as verbal nouns and converbs. Based on this observation, we argue that the P200 component reflects the brain activation triggered by the demands of verb-related morphological integration processes performed on the verbal base of derived forms.

Keywords: nominal and verbal categories; verbal nouns; converbs; derived forms; ERP; P200

1 Introduction

It is a traditional assumption that languages minimally manifest a distinction between nouns and verbs (see, for instance, Sapir 1921; Croft 1991; 2003; 2005; Baker 2003; 2015; Borer 2005; Evans & Osada 2005). This assumption has occasionally been debated on the basis of the observation that some languages (e.g., Samoan, Mosel & Hovdhaugen 1992; Riau Indonesian, Gil 2005; 2013; Kharia, Peterson 2006; Nuu-chah-nulth, Braithwaite 2015) do not seem to distinguish between nouns and verbs in a straightforward manner (see Zeijlstra 2016). It appears that no real consensus can be reached as to the universal nature of the noun-verb distinction (see, e.g., Evans 2000 and Bisang 2010; see also Haspelmath 2015) until a good theory-neutral set of criteria can be found for identifying the lexical categories NOUN and VERB. How to clearly define nouns and verbs has been debated by both theoretical linguists and psycholinguists with different degrees of success. In psycholinguistics, or more precisely in the studies using electrophysiological measures of brain reactions to linguistic stimuli, one of the most promising category-related diagnostics is the so-called “verbal signature” P200. This is an event-related brain potential

manifested as a short positive deflection, peaking around 200 ms, thus enhancing the P200 component relative to a baseline. It is thought to signal the processing of verbs as opposed to nouns, both in single word recognition (Preissl et al. 1995; Pulvermüller et al. 1999; Kellenbach et al. 2002) and in a sentence context (Federmeier et al. 2000). However, the nature of the P200 signature is still controversial. The goal of this paper is to provide a significant advance in the understanding of this theory-neutral “verbal” diagnostic. By doing this we also hope to contribute to the discussion related to the organization of the knowledge of the categories NOUN and VERB in the mind.

In order to achieve this goal, we conducted an ERP (event-related brain potentials) study in which we monitored the processing of Polish past tense finite verbs, converses and verbal nouns. Using these three different word types allowed us to tease apart the contributions of noun- and verb-like properties to the processing of the categories NOUN and VERB. In the following, we will give an outline of the definition of the categories NOUN and VERB from the perspective of theoretical linguistics and psycholinguistics before taking up our research question again in more detail.

1.1 Defining the categories NOUN and VERB in theoretical linguistics

In the theoretical literature scholars have usually used semantic/conceptual and formal criteria to define nouns and verbs. Based on semantic criteria, nouns are defined as denoting thing-like concepts which are stable in time, whereas verbs are defined as denoting event-like concepts which are time-unstable (see Givon 1979; Sasse 1993; Croft 2000). These semantic definitions are problematic when confronted with nouns denoting events, such as *a divorce*, *a discussion*, or when confronted with stative verbs which are stable in time, such as *to know* or *to be a human*.

Definitions based on formal criteria make use of the fact that nouns and verbs have different morphological and syntactic distributions. This definition can account for the fact that even such obviously nominal lexical items as *door* can become verbs in some syntactic contexts, e.g., *What happened to you? I was riding down the hill and some yuppie got out of his Porsche and doored me* (see Bisang 2010 for an overview of approaches to nouns and verbs). However, it is not so that any noun can be equally easily used in a verbal frame and any verb in a nominal frame, as evidenced by the differences in the acceptability of the following two examples: *Yesterday I had a drink* vs. **Yesterday I had an eat*. This might suggest that the category of a word results from an interaction of the syntactic frame in which this word is used and its lexical semantics.

Apart from these descriptive criteria used to define nouns and verbs, there are also different theoretical approaches to lexical categories. For example, in the generative tradition there is a long-standing controversy as to the question of whether lexical categories are determined at the level of the lexicon or at the level of the syntax in the human mental grammar. 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 Pesetsky 1982). Rappaport Hovav & Levin (1998) refer to such approaches as projectionist since they assume that the properties of lexical entries are projected onto syntactic units. Quite a different view is assumed in more recent generative approaches. For example, Borer (2005) and Baker (2003; 2015) argue that the lexical category of a given item is determined by syntax. Essentially, Borer (2005) diverges from earlier generative approaches in her assumption that listemes, which have a conceptual content but are not equipped with any information about the

category or argument structure, cannot affect syntactic computations. More specifically, since listemes do not possess any grammatical properties, their grammatical category results from the interaction of their conceptual value and the specific grammatical computation. Baker (2003; 2015) presents a similar view according to which it is a syntactic representation which makes a discrete distinction between the categories NOUN and VERB.

Even this very selective overview of different approaches to grammatical categories shows that the nature of the distinction between the categories NOUN and VERB is still debatable and possibly it can profit from the findings of the related psycholinguistic studies focusing on the processing of the categories NOUN and VERB.

1.2 Defining the categories NOUN and VERB in psycholinguistics

Unlike theoretical linguists, psycholinguists acknowledge the role of the conceptual level for the distinction between nouns and verbs but like theoreticians, they provide evidence in favor of the relevance of the lexical and morphosyntactic level for the distinction between prototypical nouns and verbs. Regarding the conceptual level, nouns and verbs are distinct because nouns denote things while verbs denote events and states. At the lexical level, nouns and verbs are distinct because each lexical entry is tagged for the category that it belongs to. And finally, at the morphosyntactic level, nouns and verbs are distinct because they are subject to different types of morphosyntactic processes in the sentence context. Much of the research on nouns and verbs in psycho- and neurolinguistics pursues the aim of finding out which of these three levels of the difference between nouns and verbs are relevant for processing, i.e., which of the verbal and nominal properties cause processing differences between categories. So far, there is evidence for the relevance of each of these levels for the distinction between nouns and verbs, supporting the view that categories can be defined either at the conceptual level (e.g., Damasio & Tranel 1993; Pulvermüller et al. 1999; Kauschke & Stenneken 2008; Moseley et al. 2013), at the lexical (e.g., Hillis & Caramazza 1995; Perani et al. 1999; Kellenbach et al. 2002; Shapiro & Caramazza 2003a; b; Shapiro et al. 2006; Melinger & Koenig 2007) or at the morphosyntactic level (e.g., Tyler et al. 2001; Tyler et al. 2004; Cappelletti et al. 2008; Finocchiaro et al. 2008; Finocchiaro et al. 2010).

The most consistent experimental results have been reported by researchers who attribute the distinction between nouns and verbs to the conceptual level. For example, neurophysiological and neuroimaging studies provide strong evidence showing that action-related words most strongly activate frontocentral motor areas and visual object-words occipitotemporal cortex regions (see, e.g., Moseley et al. 2013). Additionally, Damasio & Tranel (1993) report three cases of aphasic patients who presented a clear instance of a double dissociation between nouns and verbs at the conceptual level. Two reported patients consistently failed to retrieve nouns in a picture-naming task, while another patient performed worst in the tasks involving verb retrieval. Damasio & Tranel (1993) correlate impaired noun retrieval in the first two patients with a damage in left anterior and middle temporal lobe (which is typically activated by visual object-words), whereas impaired verb retrieval in the third patient was correlated with a damage to the left frontal cortex (which is typically activated by action-related words).

However, there is also evidence supporting the view that the relevant level at which nouns and verbs are distinguished is the lexical level. One problem for the purely semantic/conceptual distinction between nouns and verbs comes from the study of Hillis & Caramazza (1995), who report a double dissociation in modality specific impairments within a single patient. The patient reported in this study made more errors on nouns than

on verbs in spoken language tasks, and more errors on verbs than on nouns in written language 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, since such a loss should affect both modalities (spoken and written) equally. Neither can it 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. The results of this study support the conclusion that the distinction between nouns and verbs is represented at the lexical level. Additional support for this view comes from a production experiment by Melinger & Koenig (2007) in which they used a part-of-speech priming task. The target word was ambiguous: depending on stress placement it could be a noun or a verb (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 dependent measure was the stress placement (either typical for nouns or for verbs). Melinger & Koenig (2007) show 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. The authors conclude that grammatical category information can influence lexical selection without a syntactic context.

In addition, there is evidence in favour of a distinction between nouns and verbs at the morphosyntactic level. Shapiro & Caramazza (2003a; b) describe two cases of patients with a brain damage. While the first patient was 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*), the second patient (as reported in Shapiro et al. 2000) could produce inflected forms of words and pseudo-words used as verbs (*he judges, he wugs*) but had problems producing inflected forms of words used as nouns (*the judges, the wugs*). As visible in the provided examples, the grammatical category of the lexical item was unambiguously determined by the morphosyntactic frame in which a lexical item was inserted. Both patients had 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.

1.3 Defining the category NOUN and VERB

As outlined above, there are three levels of distinguishing between nouns and verbs that could be assumed to be relevant for processing. The joint evidence from experimental and clinical findings provides a mixed picture in that there is support for an involvement of each of these levels and therefore none of them can be excluded. Importantly, the findings summarized above do not necessarily contradict each other; but neither do they create a global picture of how the knowledge of NOUN and VERB is organized in the brain.

To sum up, both theoretical linguists and psycholinguists attempt to attribute the word category information to one of the levels, be it a lexical or a morphosyntactic level in the theoretical literature, and a lexical, morphosyntactic or conceptual level in the psycholinguistic literature. So far no consensus has been reached that would allow us to choose one of the accounts over the others. However, it has been suggested by Vigliocco et al. (2011) in their comprehensive overview of behavioural, electrophysiological, neuropsychological and imaging studies related to the organization of the knowledge about NOUN and VERB in the brain that it might be the case that “grammatical class information is neither part of our lexical nor procedural knowledge, but rather a property emerging from a combination of constraints” (Vigliocco et al. 2011: 409). Following this approach, what

linguists refer to as a category (NOUN or VERB) seems to be information derived from different sources (see also Błaszczał & Klimek-Jankowska 2015). Such an emergentist view is also supported by the results of the ERP study of Federmeier et al. (2000), who report the “verbal signature” P200 and interpret it as an outcome of an interaction of verb-related semantic and syntactic clues.

1.4 The P200: A verbal ERP signature

As mentioned at the outset of the Introduction, the P200 seems to be a promising category-related diagnostic in the psycholinguistic literature. The first ERP studies in which a stronger early positivity was observed as a response to verbs as compared to nouns were single word studies in which only concrete nouns and action verbs were used (see Preissl et al. 1995; Pulvermüller 1996; Pulvermüller et al. 1999). In these studies, verbs elicited an increased maximal positivity at fronto-central sites relative to nouns, while nouns elicited more incoming current over occipital sites. This finding was taken to indicate that the processing of action verbs involved frontal cortices due to their motor attribute salience, while concrete nouns involved occipital areas due to their visual attribute salience. A number of predictions arise from this interpretation of the findings. 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, it could be expected that nouns denoting manipulable objects should elicit the same ERP effect as action verbs, since both involve salient motoric properties. In order to verify this prediction, Kellenbach et al. (2002) conducted an ERP experiment to investigate whether the distinctions between the processing of NOUN and VERB categories are better explained in terms of their different salience of visual-perceptual and sensimotor characteristics, or in terms of their different grammatical class specifications. Three subclasses of verbs and nouns were used. They were selected on the basis of their semantic attribute composition. For nouns, these were abstract nouns (e.g., *peace*), nouns referring to non-manipulable objects (e.g., *lamppost*) and nouns referring to manipulable objects (e.g., *pliers*). For verbs, these were cognition verbs (e.g., *consider*), motion verbs (e.g., *flow*), and action verbs (e.g., *read*). The main finding was that nouns and verbs produced different ERPs, but that the ERPs were not influenced by semantic attribute types. That is, 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 an enhancement of the P200 component at posterior sites, elicited by verbs relative to nouns. Nouns caused greater negativity than verbs in the time window between 350 and 450 ms. The comparison across the semantic attribute types did not reveal any significant interactions. In view of the fact that the enhancement of the P200 component was observed across three types of verbs, two of which did not have a high motor attribute salience, this P200 effect cannot be understood as a reflection of a higher salience of motoric knowledge of verbs. Relative to verbs, all noun stimuli triggered a larger N400 component. The findings seem to indicate that different ERP signatures elicited for nouns and verbs are not determined exclusively by their semantic (conceptual) content as the same ERP components were obtained for different semantic classes of nouns and verbs. More specifically, Kellenbach et al.’s (2002) results lend support to the idea that the P200 effect is related to the verb lexical category.

The studies reviewed above investigated the processing of nouns and verbs in isolation. In contrast, Federmeier et al. (2000) compared the ERP waveforms of nouns and verbs in sentence contexts. To this end, they used three types of stimuli: (i) word class-ambiguous items, i.e., words that can be used as nouns or verbs depending on context

(e.g., *drink*); (ii) word class-unambiguous items, i.e., words that are unambiguously nouns (e.g., *beer*) or words that are unambiguously verbs (e.g., *eat*), and (iii) pseudowords. These three stimulus types were presented in two types of sentence contexts: 1. noun-predicting contexts (e.g., “John wanted THE [target] but ...”) and 2. verb-predicting contexts (e.g., “John wanted TO [target] but ...”). For unambiguous items, they observed a contrast between nouns and verbs. More specifically, unambiguous nouns triggered more negative responses over centro-parietal sites between 250 and 450 ms (N400) as compared to unambiguous verbs. Unambiguous verbs, but none of the other types of stimuli used in Federmeier et al.’s (2000) experiment, elicited a left-lateralized frontal positivity in the time window from 150 to 250 ms, peaking around 200 ms (i.e., a P200 effect).

The most relevant finding of their study for the present discussion was that only the unambiguous verbs relative to nouns elicited a P200 effect (i.e., a left-lateralized anterior positivity), but only when they were used in verbal contextual frames. In a context which sets up the expectation for a noun, no P200 was elicited. Federmeier et al. (2000) manipulated verbal and nominal morphosyntax. Still, the results of this study do not reveal whether the P200 component is a verbal component in a semantic (conceptual) or in a morphosyntactic sense, since the P200 was found only with unambiguous verbs in a verbal frame. If it were a verbal semantic component, it should potentially be obtained in the case of unambiguous verbs in a nominal frame. Accordingly, if the P200 were a verbal morphosyntactic component, it should be visible in the case of class-ambiguous items used in a verbal frame. None of these two scenarios was supported by the experimental findings. Federmeier et al. (2000) conclude that the category “verb” emerges from the interaction of both conceptual information and morphosyntactic cues.

In sum, the P200 effect has consistently been found for the processing of verbs compared to nouns, both in single word and sentence comprehension studies. However, it still remains unclear which of the levels of the distinction between nouns and verbs – conceptual, lexical or morphosyntactic – the P200 reflects.

1.5 Research question for the current study

The P200 effect allows us to distinguish between the processing of nouns and verbs. However, interpreting these differences remains challenging, because it is still unclear whether this component reflects verbal (e.g., action) semantics, lexical category or verb-related morphological (and linked semantic) integration processes. Our ERP study presented in this paper was aimed to provide further insights into the question of the “proper” interpretation of the P200 component, and to arrive at a better understanding of differences between NOUNs and VERBs in processing.

To this end, we monitored the processing of Polish past tense finite verbs, conversbs and verbal nouns in the context of grammatically and semantically well-formed sentences. This experimental design allowed us to tease apart the contributions of noun- and verb-like properties to processing. Example (1a–c) gives an illustration of past tense finite verbs, anterior conversbs (also referred to as conjunctive participles or gerunds) and verbal nouns in a comparable sentence context. The relevant forms are highlighted in bold.

(1) a. *finite verb*

Po	tym	jak	szybko	wypił	sok,
after	that	how	quickly	drink.PFV.PST.3SG.M	juice.ACC
zjadł				tort.	
eat.PFV.PST.3SG.M				cake.ACC	

‘After he quickly **drank** some juice, he ate cake.’

b. *anterior converb*

Szybko wypi-wszy sok, zjadł tort.
quickly drink.PFV-WSZY.CVB juice.ACC eat.PFV.PST.3SG.M cake.ACC
'Quickly having drunk some juice, he ate cake.'

c. *verbal noun*

Po szybkim wypi-ciu soku
after quick.LOC.SG drink.PFV-CIE.NMLZ.LOC.SG juice.GEN
zjadł tort.
eat.PFV.PST.3SG.M cake.ACC
'After the quick **drinking** of some juice (=after the completed drinking
of juice), he ate cake.'

We will give a detailed outline of the properties of all the three forms before developing the predictions arising from these properties.

The three forms (i.e., the critical words in our stimulus material, see below) express the same action (event) concept, and are derived from the same verbal stem via morphological operations. Converbs remain verbs after adding an anteriority suffix *-wszy*. Verbal nouns, on the other hand, change their category to NOUN after the suffix *-nie/-cie* is added.

In fact, verbal nouns constitute an interesting mixture of nominal and verbal properties (see Rozwadowska 1995; 2006). The verbal properties of Polish verbal nouns are manifested by the fact that:

- just like the verb they are derived from, they refer to events or states:

(2)	a.	pisać	→	pisanie
		'to write'	→	'writing'
	b.	rozumieć	→	rozumienie
		'to understand'	→	'understanding'

- they inherit the event and argument structure from the verbs they are derived from:

(3)	podarowanie	Tomkowi	książki	przez	Jana	wczoraj
	giving		Tom.DAT	book.GEN	by	John
						yesterday

In (3) the verbal noun *podarowanie* is derived from the ditransitive verb *podarować* 'to give something as a present' and just like the verb it takes three arguments: the agent, expressed by means of a 'by'-phrase, the recipient, expressed by the dative nominal phrase and the theme, expressed by the genitive nominal phrase.

- they can be marked for grammatical aspect and co-occur with aspectual or other adverbial modifiers and negation:

(4)	a.	pisać.IPFV	→	pisanie.IPFV		
		'to write'	→	'writing'		
	b.	napisać.PFV	→	napisanie.PFV		
		'to write'	→	'writing'		
(5)	a.	Jan	pisał	list	przez	godzinę.
		John.NOM	write.IPFV.PST.3SG.M	letter.ACC	for	hour
						'John was writing a/the letter for an hour.'

- b. Jan **nie** napisał listu **w godzinę.**
 John.NOM not write.PFV.PST.3SG.M letter.GEN¹ in hour
 ‘John did not write a/the letter in an hour.’
- (6) a. pisanie listu **przez godzinę** przez Jana
 writing.IPFV letter.GEN for hour by John
 ‘the writing of the letter for an hour by John’
- b. **(nie)**pisanie listu **w godzinę** przez Jana
 (not)writing.PFV letter.GEN in hour by John
 ‘the (not)writing of the letter in an hour by John’

The verbal nouns in (6) have the same aspectual forms and co-occur with the same modifiers as the verbs they are derived from; see (5).

Examples of their nominal properties include the following:

- case and number morphology

- (7) a. SINGULAR
- | | |
|-------------------------------|----------------|
| pisanie ‘writing’ | NOM(inative) |
| pisania ‘writing’ | GEN(itive) |
| pisaniu ‘writing’ | DAT(ive) |
| pisanie ‘writing’ | ACC(usative) |
| pisaniem ‘writing’ | INS(trumental) |
| (o) pisaniu ‘(about) writing’ | LOC(ative) |
- b. PLURAL
- | | |
|----------------------------------|----------------|
| pisania ‘writings’ | NOM(inative) |
| pisań ‘writings’ | GEN(itive) |
| pisiom ‘writings’ | DAT(ive) |
| pisania ‘writings’ | ACC(usative) |
| pisaniami ‘writings’ | INS(trumental) |
| (o) pisaniach ‘(about) writings’ | LOC(ative) |

- they can be modified by adjectives

- (8) to **szymbkie** napisanie listu
 this quick writing.PFV letter.GEN
 ‘this quick writing of the letter’

- they can play the function of a subject or an object in the sentence, i.e., they can appear in syntactic positions typically occupied by nouns, including subject, object, object of a preposition and dislocated topic:

- (9) a. [To **szymbkie** **napisanie** listu
 this.NOM quick.NOM writing.PFV.NOM letter.GEN
przez Jana] zdziwiło mnie.
 by John surprised me.ACC
 ‘This quick writing of the letter by John surprised me.’

¹ In example (5b) the direct object is marked for genitive instead of accusative which is caused by the presence of negation. In Polish the direct object of negated transitive verb is obligatorily marked for genitive, a phenomenon which is called “genitive of negation” (see, among others, Przepiórkowski 1997; Witkoś 1998; Błaszczał 2001a; b; 2007 for details).

- b. Maryśia obserwowała [pisanie listu przez Jana].
Mary.NOM watched writing.PFV.ACC letter.GEN by John
'Mary was watching the writing of the letter by John.'
- c. Maryśia mówiła [o napisaniu listu przez Jana].
Mary.NOM talked about writing.PFV.LOC letter.GEN by John
'Mary was talking about the writing of the letter by John.'
- d. [O napisaniu listu przez Jana] mówiła Maryśia.
about writing.PFV.LOC letter.GEN by John talked Mary.NOM
'Mary was talking about the writing of the letter by John.'

Verbal nouns take genitive complements; see (10a). In contrast, finite verbs and converbs take accusative complements; see (10b) and (10c).

- (10) a. wypicie soku
drink.PFV.NMLZ juice.GEN
'(the) drinking of some juice'
- b. wypił sok
drink.PFV.PST.3SG.M juice.ACC
'(he) drank some juice'
- c. wypiwszy sok
drink.PFV.CVB juice.ACC
'having drunk some juice'

It should be noted that verbal and nominal properties can co-occur, as shown in (8) and (9a), where the verbal noun appears in the perfective form contributing to its verbal nature and at the same time is modified by an adjective contributing to its nominal nature. In sum, verbal nouns behave like nouns that denote action concepts and retain some morphosyntactic properties of their verbal stems, while lexically they clearly belong to the category NOUN.

In contrast to verbal nouns, converbs are clearly verbal in Polish; see (11).

- (11) **Starannie** / *stranny napisawszy list w godzinę, Jan
carefully / *careful write.PFV.CVB letter.ACC in hour John.NOM
poszedł na spacer.
go.PFV.PST.3SG.M for walk.ACC
'Having carefully written a letter in an hour, John went for a walk.'

Unlike nouns, they can never be modified by adjectives and they cannot be inflected for case. Like finite verbs, they refer to events and states, they inherit the event and argument structure and aspectual morphology from the verbal bases² they are derived from. Just like verbs, they can co-occur with aspectual or other adverbial modifiers and negation, as indicated in (11).³ However, they differ from finite verbs in that they are non-finite forms and they are temporally anchored participial clauses functioning in a sentence as optional adverbial modifiers. The semantic role of anterior converbs is to create a temporal relation of anteriority between the eventuality they refer to and the main clause eventuality.

² In what follows, while talking about inflectional and derivational processes, we use the term "base" to remain theory-neutral.

³ Compare also (i). The genitive marking on 'letter' is due to the presence of negation; see footnote 1.

- (i) Nie napisawszy listu, Jan nie mógł iść na spacer.
not write.PFV-WSZY.CVB letter.GEN John.NOM not could go.IMP for walk.ACC
'Not having written a letter, John could not go for a walk.'

To sum up, all the three forms used in our experiment have the same verbal bases and refer to the same eventualities; thus, they are not distinct at the conceptual level. Converbs and finite verbs are lexically verbal categories; in contrast, verbal nouns are lexically nominal categories. The latter fact allows us to disentangle the conceptual and lexical levels as being responsible for distinguishing the categories NOUN and VERB. In addition, the three forms differ in the difficulty of the morphological integration processes performed on the verbal base. In fact, all the three forms contain a suffix, as illustrated in (12a–c).

- (12) a. **wypi-ł**_[participle ending]
 b. **wypi-wszy**_[anteriority morpheme]
 c. **wypi-cie**_[nominalizing morpheme]

However, these overt suffixes impose different demands on the comprehension system. In (12a) the suffix *-ł* just creates a participle form (Fisiak et al. 1978; Spencer 2001; see Migdalski 2006 for an extensive discussion) and the past time interpretation comes from a covert (null) past tense auxiliary (Dornisch 1997: 188; see also Witkoś 1998: 75, who states that the [+past] tense feature is not represented lexically). In the third person singular masculine past tense verb forms (i.e., in the forms used in the current experiment) person is not expressed overtly (there is no inflectional ending). This makes these forms syncretic with singular masculine *l*-participle forms in Polish also used as complements of the future auxiliary (*będzie pił* ‘be.AUX.3SG drink.PTCP.IPFV.SG.M’ ‘he will be drinking’/‘he will drink’ and the conditional auxiliary (*piłby* ‘drink.PTCP.IPFV.SG.M + COND’ ‘he would drink’) and in subjunctive contexts (e.g., *Maria chce, żeby on więcej pił* ‘Mary wants that + SBJV he more drink.PTCP.IPFV.SG.M’ ‘Mary wants that he would drink more.’/‘Mary wants him to drink more.’). However, note that in the examples used in the experiment (see (1a) Condition 1), past tense verbal forms are clearly finite forms with the morphologically unrealized past tense functional category. In order to minimize the impact of syncretism, we made sure that none of the experimental sentences contained any periphrastic future, conditional or subjunctive contexts. It is not so uncommon in world’s languages to find functional categories which are not expressed morphologically (see Spencer 2001: 282).

In contrast, the morphological composition of the verbal base and the anteriority morpheme is accompanied by a more demanding semantic composition: it creates a relation of temporal anteriority with the main clause eventuality. With regard to verbal nouns, they are created by changing a verb, which is prototypically a predicate (or whose primary propositional act function is that of predication), into a noun, which is prototypically a referential category (or whose primary propositional act function is that of reference) (see Croft 2003: 185).

This control over the manipulation of different levels of the NOUN-VERB distinction in turn creates a good setting to investigate which level of verbal processing is reflected in the P200 component. Recall that the P200 could be a reflection of the activation triggered by verbs in response to i) verbal (e.g., action) semantics, ii) lexical category (word class) or iii) verb-related morphological integration processes. The properties of the three different forms described above lead to the following predictions with respect to the P200 effect:

Prediction 1: If the P200 is a response to verbal semantics, i.e., of action concepts in contrast to object concepts, there is no reason to expect differences in the strength of this component in the processing of finite verbs, verbal nouns and converbs, as they all share the same action concepts.⁴

⁴ This prediction will be formulated as the null hypothesis in the following sections, however, we have chosen to develop the predictions in a parallel wording upon their first mention for the sake of readability.

Prediction 2: If the P200 effect reflects the recognition of the lexical category VERB in contrast to NOUN, it should arise in response to finite verbs and converbs, since they are verbal categories, when compared to verbal nouns, which become nouns after the category-changing operation of adding a nominalizing suffix to a verbal base has taken place.

Prediction 3: Finally, if the P200 reflects the difficulty of morphological integration processes performed on a verbal base, we might expect more processing difficulties for temporally anterior converbs and verbal nouns than for finite verbs.⁵ Temporally anterior converbs are semantically less prototypical and more demanding (due to their specific anterior temporal meaning) than finite verbs, hence the operation of adding the anteriority suffix performed on the verbal base might be expected to be more difficult for the parser than the operation of adding finiteness morphology. Likewise, verbal nouns should be more difficult to comprehend than finite verbs. This is due to the fact that by creating a verbal noun we change a verb, which is prototypically a predicate, into a noun, which is prototypically a referential category (see Croft 2003: 185). If this reasoning is correct, then we would expect a stronger P200 for anterior converbs and verbal nouns than for finite verbs.

2 The current ERP study

2.1 Participants

Twenty eight Polish native speakers (19 females, mean age 20, range 19–21 years) were recruited at the University of Wrocław.⁶ Participants received partial course credit. All participants were right-handed according to the Edinburgh Handedness Inventory (Oldfield 1971) and had normal or corrected vision. None reported neurological or psychiatric disorders or traumas.

2.2 Language material

In our experiment we compared the processing of finite verbs, converbs and verbal nouns all derived from the same verbal base. All forms were presented in sentential contexts. This was motivated by the fact that ERP signatures to grammatical class information are reported to be stronger in sentence context than in isolation (see, e.g., Vigliocco et al. 2011: 422), suggesting that access to grammatical class is enhanced during integration processes. All conditions were maximally similar apart from the (de)verbal form. They also differed in the linear position in which the word of interest was used and the number of words in the sentence. The stimuli were parallel to the sentences given in example (1), and are repeated here as an example of a stimulus triplet for the sake of readability.

Condition 1: FINITE VERB

- (13) Po tym jak szybko wypił sok,
after that how quickly drink.PFV.PST.3SG.M juice.ACC
zjadł tort.
eat.PFV.PST.3SG.M cake.ACC
'After he quickly drank some juice, he ate cake.'

⁵ Given the evidence outlined in Reid & Marslen-Wilson (2003) and Marslen-Wilson (2007) for productive derivational processes, we assume that the recognition of converbs and deverbal nouns includes access to the verbal base.

⁶ There are no ethical issues raised by the reported research. The study is in compliance with the EU legislation on ethics Charter of Fundamental Rights of the EU (2000/C 364/01) and ECHR and Declaration of Helsinki (2013).

Condition 2: CONVERB

- (14) Szybko wypi-wszy sok, zjadł tort.
quickly drink.PFV-WSZY.CVB juice.ACC eat.PFV.PST.3SG.M cake.ACC
‘After quickly having drunk some juice, he ate cake.’

Condition 3: VERBAL NOUN

- (15) Po szybkim wypi-ciu soku
after quick.LOC.SG drink.PFV-CIE.NMLZ.LOC.SG juice.GEN
zjadł tort.
eat.PFV.PST.3SG.M cake.ACC
‘After the quick drinking of some juice, he ate cake.’

Following this pattern, we constructed 60 stimulus triplets, leading to 180 experimental sentences. All the sentences started with a (clausal or phrasal) temporal modifier creating an anteriority relation between two eventualities (here: between the ‘drinking some juice’ and the ‘eating a cake’ eventualities). The main clause had the same structure across all the conditions and consisted of a finite transitive past tense verb in 3rd person singular masculine (with a null subject) and an inanimate object nominal phrase. In all the conditions the eventuality was described by a form derived from the same transitive perfective verbal base, followed by the same inanimate masculine object and preceded by the same manner modifier. All the experimental sentences were grammatically and semantically well-formed. The 180 experimental sentences were interspersed with 180 filler sentences. The fillers corresponded lexically and structurally to our experimental sentences, except for the fact that their temporal modifiers were incorrectly derived from imperfective verbal action stems, making them ungrammatical. This was to distract participants from the experimental data. However, we decided to use a probe detection task and not a grammaticality judgement task since we did not want the participants to perform a conscious analysis of the grammar of the sentences during the processing.

The critical words were checked for frequency to be able to discuss our findings also with respect to alternative explanations. In the neurolinguistic literature, it has been shown that ERP amplitudes are reduced for high-frequency compared to low-frequency words. This has been most consistently shown for the N400 amplitude, but also for earlier time windows (see Barber & Kutas 2007 and Penolazzi et al. 2007 for comprehensive overviews; most of the cited studies manipulated lemma frequency or lemma and word form frequency in parallel). Importantly, the P200 amplitude has not been shown to be sensitive to frequency yet.

Checking the frequency of the underlying stem (corresponding to the lemma frequency) was not necessary, since the verbal stems were identical in all three conditions. The surface frequencies of finite verbs, converbs and verbal nouns used in our experiment were checked in *Narodowy Korpus Języka Polskiego (podkorporus zrównoważony)*, IPI PAN “Balanced National Corpus of Polish”, 300 M segments (Przepiórkowski et al. 2012). The mean surface frequency of finite verbs was 1290 hits, the mean surface frequency of verbal nouns was 199 hits and the mean surface frequency of converbs was 12 hits. Data analysis and preparation was performed in R (R Development Core Team 2005), using The R Stats package. Since the corpus frequencies for the compared forms were not parametrically distributed, we decided to square-root-transform them to improve the distribution. Although the distribution was closer to the normal distribution, the data were still not parametric, as shown by Shapiro-Wilk normality test (Condition 1 [finite verbs]: $W = 0.736, p < 0.0001$, Condition 2 [converbs]: $W = 0.7386, p < 0.0001$, Condition 3 [verbal nouns]: $W = 0.758,$

$p < 0.0001$). Therefore, to determine the differences between the conditions, Kruskal-Wallis rank sum test was conducted. The result of the test was statistically significant ($\chi^2(2) = 61.4038, p < 0.0001$). Accordingly, comparisons between the conditions were calculated using a pair-wise Wilcoxon Rank Sum test with Bonferroni correction. The obtained results were as follows. There was a statistically significant effect for the Comparison 1 between Condition 1 [finite verbs] and Condition 2 [converbs] ($p < 0.0001$). There was also a statistically significant effect for Comparison 2 between Condition 1 [finite verbs] and Conditions 3 [verbal nouns] ($p = 0.002$), and for Comparison 3 between Condition 2 [converbs] and Condition 3 [verbal nouns] ($p < 0.0001$). This means that all the three forms differ significantly in terms of their surface frequency, with converses being the least frequent, verbal nouns being more frequent, and finite verbs being the most frequent of the forms. (We will discuss the potential contribution of these differences in surface frequency to our findings in the Discussion, Section 2.5.3.)

To assess the acceptability of our stimuli, and also to monitor whether the difference in surface frequency of the different forms led to dispreferences for one of the conditions, we performed an acceptability rating study. We conducted this study as a pen-and-paper study in which we used all the experimental sentences from our ERP study (180 sentences) plus 60 filler sentences in a randomized order as part of a course assignment. Twenty seven native speakers of Polish took part in the acceptability study. The participants were students from the University of Wrocław (mean age: 21); none of them participated in the reported ERP study. The participants were asked to rate the acceptability of sentences on a scale from 1–5, where 1 was ‘unacceptable’ and 5 was ‘acceptable’. Data analysis and preparation was performed in R (R Development Core Team, 2005), using the Hmisc package (Harrell Jr. 2017). The mean acceptability values were as follows: for sentences with finite past tense verbs: 4.67 ($SD = 0.69$), for sentences with anterior converses: 3.95 ($SD = 1.24$), for sentences with verbal nouns: 4.49 ($SD = 0.87$). Since the acceptability judgement data were not parametrically distributed, as shown by Shapiro-Wilk normality test (Condition 1 [finite verbs]: $W = 0.526, p < 0.0001$; Condition 2 [converbs]: $W = 0.795, p < 0.0001$; Condition 3 [verbal nouns]: $W = 0.628, p < 0.0001$), a robust repeated measurement Anova (RManova) was conducted using the WRS2 package (Mair 2017). The test revealed no statistically significant differences between conditions ($W(1.81, 27.2) = 1.954; p = 0.164$). This means that even though the surface frequencies of the forms differ, the acceptability of all the three stimulus conditions is not measurably different, and any effect found in the study is unlikely to be caused by dispreferences for one condition over the others.

For the sake of readability, we repeat the predictions for the P200 effect for the three stimulus conditions here, in a slightly reworded form. We predict the following results for the processing of the three forms outlined in (13)–(15) (see Section 1.5 for the motivation of the following predictions):

- **Prediction 1:** Our null hypothesis predicts no measurable differences between the stimulus conditions with respect to the P200 amplitude. This finding would fit the assumption that the P200 reflects the semantic-conceptual contribution to verbal processing.⁷
- **Prediction 2:** If the P200 reflects the lexical class contribution to verbal processing (i.e., the recognition of the grammatical category VERB), we expect

⁷ Importantly, this finding would not conclusively prove that the P200 reflects distinctions at the conceptual level; this could only be proven with an additional condition containing nouns denoting concrete objects. In the current study, this is impractical, given that it would be impossible to maintain the strict parallelism of the three experimental conditions with nouns like that.

a difference between verbal forms (finite verbs and converbs) and verbal nouns, i.e., (13) *wypił* ‘he drank’ vs. (15) *wypicie* ‘(the) drinking’ and (14) *wypiwszy* ‘having drunk’ vs. (15) *wypicie* ‘(the) drinking’, but not between the two verbal forms: (13), a finite verb *wypił* ‘he drank’, vs. (14), a converb *wypiwszy* ‘having drunk’.

- **Prediction 3:** If the P200 reflects the difficulty of morphological integration processes performed on a verbal base, it should be more difficult to process an anterior converb, (14) *wypiwszy* ‘having drunk’, than a finite verb, (13) *wypił* ‘he drank’. Likewise, verbal nouns should be morphologically and semantically more difficult to comprehend than finite verbs.

2.3 Procedure

Participants were tested individually in one session. The whole experiment (including the application of electrodes) lasted for approximately 90 minutes. Following the application of the EEG electrodes, participants were seated 1m in front of a Samsung 22” LCD screen in an electrically and acoustically shielded EEG chamber. Stimuli were presented in a white courier font, size 48, on a black background using the Presentation software by Neurobehavioral Systems Inc. (software package 16.3 12.20.12).

The experimental session was preceded by oral and written instructions and a practice session. Participants were instructed to avoid blinks or movements during sentence display, and to provide their answers to questions as fast as possible. After the written instruction, participants received a practice block with 10 sentences, followed by explicit feedback. The practice session was followed by six experimental blocks containing 60 sentences each. After each block there was a break.

Each trial began with a fixation asterisk in the center of the screen for 1500 ms, followed by sentence presentation. Sentences were presented word-by-word, only the prepositional phrases were presented as chunks:

Po szybkim | wypiciu | soku | zjadł | tort.

Each segment appeared in the center of the screen for 500 ms, followed by a short 100 ms blank screen. Sentence-final words appeared with a full stop, and were followed by a 100 ms blank screen. Probes were presented for 500 ms. After that, the words TAK (‘yes’) and NIE (‘no’) were presented on the screen for 3000 ms, as a prompt for the probe detection task. After 3000 ms, the presentation of the next trial began with the presentation of the new asterisk.

The language material was outlined in the preceding section. We use 60 stimulus triplets supplemented by 180 fillers. 10% of all the sentences including experimental and filler sentences were followed by a probe detection task. In the remaining 90% of the trials, the participants did not do anything except for reading silently. The probe words were equally distributed across conditions. There was an equal number of probes semantically or phonologically corresponding to objects in main clauses and temporal modifiers. The probes were balanced for the expected YES and NO answers. The mean answer accuracy in the probe detection task was 96% (SD = 3.9%).

Stimuli were pseudo-randomized in two versions (with descending and ascending order) and distributed over six blocks containing 60 critical sentences each. All participants saw all of the 360 sentences. 14 participants saw the first and 14 participants saw the second randomization version. Additionally, each version was further subdivided into two variants differing in the coding for YES and NO buttons to avoid any potential effects of lateralized readiness potential.

2.4 EEG recordings and data processing

2.4.1 Recording

The EEG-activity was measured with 24 Ag/AgCl-electrodes which were attached to the scalp using the Easycap system at Fz, FCz, Cz, CPz, Pz, POz, FC1, F3, C3, P3, O1, FC5, CP5, F7, P7, FC2, F4, C4, P4, O2, FC6, CP6, F8, P8. The ground electrode was positioned at AFz. Electrode positions were chosen in accordance with the international 10/20 system (Jasper 1958). Signals were referenced to the A1 electrode (left mastoid) during recording and re-referenced to the average of left (A1) and right (A2) mastoids before data processing. Horizontal eye activity was measured by placing two electrode 2 cm lateral to the right (EOGR) and the left (EOGL) canthus. Vertical eye activity was measured by placing two electrodes 3 cm above (EOGU) and below (EOGD) the pupil of the right eye. Electrode impedances were kept below 5 kΩ. All electrophysiological signals were digitized with a frequency of 250 Hz.

2.4.2 Data processing

Data were processed using the Brain Vision Analyzer 2 software (Brain Products, Gilching). Raw data were inspected visually. Time windows including strong, visible artifacts (like pauses or periods of strong movement) were manually removed before proceeding. An ICA blink correction was performed for the remaining data, using the Slope Algorithm for blink detection. After the blink correction, remaining artifacts were removed based on a semi-automatic Raw Data Inspection (maximal allowed voltage step: 50 µV/ms; maximal allowed difference: 200 µV/200 ms; lowest allowed activity: 0.5 µV/100 ms). The remaining data were segmented into time windows time-locked to the onset of the critical verb. Time windows began at -200 ms before the onset of the critical verb, and ended at 1000 ms after the onset of the critical verb. A baseline correction was performed for the 200 ms before the onset of the critical verb. Averages were calculated per participant for all three conditions. The mean rejection rate over participants was 6.7% of the segments ($SD = 0.8\%$). Mean rejection rates per condition were: 7.4% ($SD = 10.8\%$) for Condition 1: FINITE VERB, 6.9% ($SD = 9.9\%$) for Condition 2: CONVERB, and 5.8% ($SD = 10.0\%$) for Condition 3: VERBAL NOUN. For visual presentation, grand averages were filtered with a 10 Hz low-pass filter.

2.5 Results and discussion

2.5.1 Data analysis

The time windows for the analysis were selected on the basis of visual inspection of Grand Average wave forms, and with reference to the literature (i.e., 150–250 ms for the P200 time window, as reported in Federmeier et al. 2000, and 250–500 ms for the N400 time window; Federmeier et al. reported the time window from 250–450 ms).

We defined the following regions of interest (ROIs): left-posterior (C3, CP5, P3, P7), right-posterior (C4, CP6, O2, P4, P8), right-anterior (F4, F8, FC2, FC6), left-anterior (F3, F7, FC1, FC5). These regions of interest were chosen based on visual data inspection and previous studies. Federmeier et al. (2000) and Kellenbach et al. (2002) report ERP results related to the processing of verbs and nouns for frontal, posterior and central sites; Federmeier et al. (2000) report P200 effects in left-anterior sites.

Based on our predictions, we tested the following comparisons:

- **Comparison 1:** Condition 1: FINITE VERB vs. Condition 2: CONVERB (cf. (13) vs. (14)).
- **Comparison 2:** Condition 1: FINITE VERB vs. Condition 3: VERBAL NOUN (cf. (13) vs. (15)).

- **Comparison 3:** Condition 2: CONVERB vs. Condition 3: VERBAL NOUN (cf. (14) vs. (15)).

For the statistical analysis of the ERP data, we used mean amplitude values per time window per condition (Condition 1: FINITE VERB, Condition 2: CONVERB, Condition 3: VERBAL NOUN) in five regions of interest (ROIs).⁸ Data were prepared and analyzed in R (R Development Core Team 2005), using the packages reshape (Wickham 2007), plyr (Wickham 2011) and ezANOVA (Lawrence 2011). Mean voltages for the single ROIs were calculated from the participants' condition mean of all electrodes in a ROI.

We calculated a repeated measures ANOVA of the mean voltages per condition for the chosen time windows in all five ROIs. Analyses were performed in a hierarchical fashion, i.e., only statistically significant interactions were resolved. Interactions between CONDITION and ROI were pursued following the planned comparisons outlined above. Comparisons between conditions inside the single ROIs were performed using a paired *t*-test of the mean voltages per condition. Greenhouse-Geisser corrections (Greenhouse & Geisser 1959) were applied when the degrees of freedom in the numerator were > 1 , for which original degrees of freedom and corrected probability levels are reported. Only statistically significant effects are reported, unless specifically stated otherwise.

2.5.2 Results

P200: 150–250 ms

Voltage difference maps and examples of curves are given in Figure 1. We report the outcomes of the statistical analyses, followed by a short description of the results.

There was a statistically significant main effect of ROI ($F(3, 81) = 13.0, \epsilon = .58, p < .001$), and a statistically significant interaction of CONDITION and ROI ($F(6, 162) = 3.6, \epsilon = 0.58, p < .05$).

Comparison 1 (finite verbs vs. converbs): There was a statistically significant main effect of CONDITION ($F(1, 27) = 4.9, p < .05$), ROI ($F(3, 108) = 11.3, \epsilon = .70, p < .001$) and a statistically significant interaction of CONDITION and ROI ($F(3, 81) = 5.4, \epsilon = .74, p < .01$). The difference between conditions was statistically significant at left-anterior positions ($t(27) = 3.6, p < .01, d = -.60$). Waveforms for converbs were more positive-going than waveforms for finite verbs at left-anterior positions. (In the voltage difference maps, there is also a visible negativity at right electrode sites. In contrast to the left-anterior P200, this negativity did not reach significance in the P200 time window.)

Comparison 2 (finite verbs vs verbal nouns): There was a statistically significant main effect of ROI ($F(3, 81) = 8.9, \epsilon = .52, p < .01$) and a statistically significant interaction of CONDITION and ROI ($F(3, 81) = 4.6, \epsilon = .74, p < .05$). The difference between conditions was statistically significant at left-anterior positions ($t(27) = -2.6, p < .05, d = -.33$). Waveforms for verbal nouns were more positive-going than for finite verbs at left-anterior positions.

Comparison 3 (converbs vs. verbal nouns): There was a statistically significant main effect of ROI ($F(3, 81) = 16.2, \epsilon = .60, p < .001$). No main effects or interactions of CONDITION reached statistical significance. While descriptively, curves for converbs were more negative-going than for verbal nouns, this difference was less pronounced than for the other two comparisons.

⁸ We chose to analyse mean amplitudes to keep our findings comparable to the literature regarding the distinction of nouns and verbs via P200 amplitude (see Preissl et al. 1995; Pulvermüller et al. 1999; Federmeier et al. 2000; Kellenbach et al. 2002).

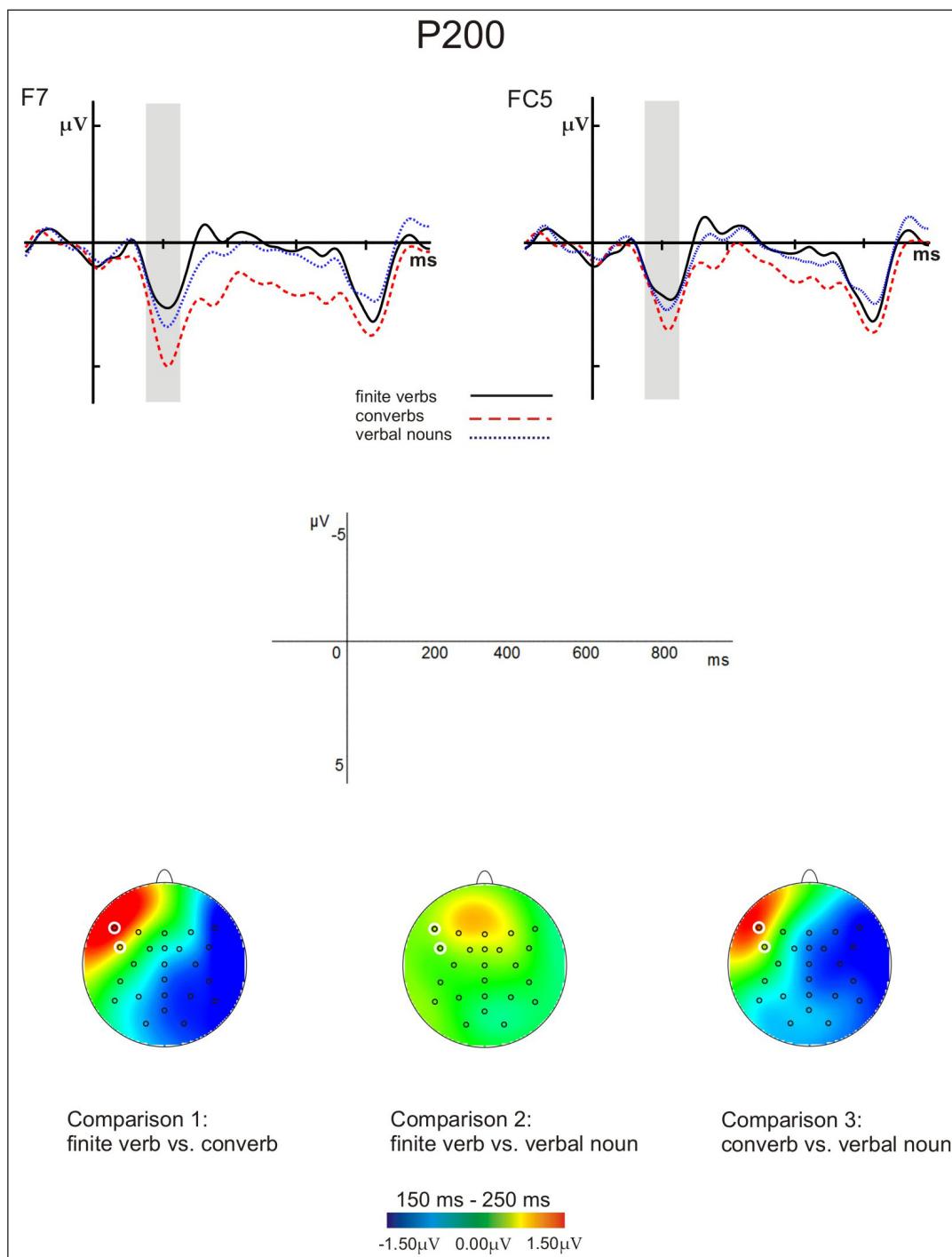


Figure 1: In the upper part: Grand-average ERP pattern for the observed P200 effect on two selected electrode sites: F7 and FC5. In the lower part: Mean voltage difference maps (CONVERB minus FINITE VERB, VERBAL NOUN minus FINITE VERB, CONVERB minus VERBAL NOUN) for the time window from 150–250 ms.

2.5.3 Discussion

In the time window 150–250 ms we observe a P200 in the left-anterior ROI (see Figure 1). The amplitude of this P200 is significantly stronger in converbs and verbal nouns than in finite verbs, while there is no statistically significant difference between converbs and verbal nouns. Our results do not match the null hypothesis leading to **Prediction 1**. Recall from Section 2.2 that in Prediction 1 the P200 effect reflects the processing of action concepts relative to object concepts. Hence there should be no differences in

the strength of the P200 between the three conditions since all the critical words in our experimental triplets were derived from the same verbal bases denoting an action concept. Importantly, this null result has to be interpreted with caution and needs further experimental support; while our findings do not support a contribution of the semantic-conceptual level of the verb-noun distinction in explaining the P200, they do not conclusively prove that this level of distinction does not play a role at all (since we did not manipulate the semantic concept denoted by the different forms). However, what our results show is that there is some variability in the amplitude of P200 when holding the action concept constant; hence, it is warranted to conclude that verbal action concepts are not the only contributor to the verbal P200 effect. This interpretation matches findings from the literature which provide preliminary support for the conclusion that the P200 is not a response to the verbal action concepts. Kellenbach et al. (2002) manipulated the semantic classes of verbs (abstract, e.g., *consider*, visual, e.g., *flow*, visual and motor, e.g., *sit*) and observed no modulation of the P200. Kellenbach et al. (2002) interpret the P200 component as a response to a verbal category at the lexical level, but not at the semantic-conceptual level. This conclusion is also compatible with Federmeier et al. (2000), who did not elicit a P200 signature for unambiguous verbs inserted in nominal syntactic frames. If the P200 was the exclusive response to the semantics of a verb (at the semantic-conceptual level), it should not be sensitive to the syntactic frames. Our findings also do not match **Prediction 2**. According to this prediction, if the P200 indeed reflects the processing of the lexical category VERB, this component should be enhanced for finite verbs and converbs as compared to verbal nouns, since the former belong the lexical category VERB and the latter (after derivation) belong to the lexical category NOUN (recall the discussion in Section 1.5). This prediction is not fulfilled, as there is no statistically significant difference in the P200 for converbs (a verbal category) and verbal nouns (a nominal category). In addition, the P200 is more positive-going for verbal nouns than for finite verbs, thus making it highly unlikely that a P200 effect reflects the processing of lexically verbal as compared to lexically nominal forms. Importantly, this does not mean that the information about lexical category NOUN/VERB is irrelevant in sentence processing. Recall from Section 1.2 that there are studies showing that the lexical-level distinction between NOUNs and VERBs matters. Especially strong evidence is provided by Hillis & Caramazza (1995), who report double dissociations of errors for verbs and nouns in spoken and written language tasks; and also by Melinger & Koenig (2007) who report lexical priming in healthy participants. Notice that the results of our ERP experiment and the results reported in Hillis & Caramazza (1995) do not necessarily contradict each other. It could be that in the case of productive category-changing operations such as the one involved in the formation of *-nie/-cie* verbal nouns in Polish, only the information about the lexical category of a stem (and not of the whole derived form) is stored in the mental lexicon, but this is only a tentative idea to be further investigated. In fact the relevant literature on the derivation of verbal nouns in Polish points to this conclusion. Verbal nouns are productive and treated in the literature as syntactically derived (see Rozwadowska 2006 for discussion). This conclusion is supported by the fact that P200 effect was stronger for verbal nouns than for finite verbs. This fact may indicate that the P200 is sensitive to the amount of work performed on the verbal stem (see the discussion related Prediction 3 below).

Our results for the P200 match **Prediction 3**. Based on the results of our experiment, we are inclined to interpret the obtained P200 (treated as “the verbal signature” in the literature) as reflecting the complexity of online morphological integration processes related to the verbal category of the base. We found an enhanced P200 for converbs as compared to finite verbs, and also for verbal nouns when compared with finite verbs. In

other words, this component was elicited in the comparison of prototypical cases of verbal categories (finite verbs) with less prototypical verbal categories such as verbal nouns and converbs whose morphological derivation is more demanding for the comprehension system. Recall from Section 1.5 that in the case of converbs a very specific anterior temporal meaning of the suffix is involved, and in the case of verbal nouns we have a change of the lexical category from VERB to NOUN. In the case of past tense finite verbs, the *-l* suffix morphologically flags a participial form and the past tense interpretation comes from a covert (null) past tense auxiliary. We interpret the larger P200 in the case of converbs and verbal nouns as compared to finite verbs as reflecting the enhanced processing load caused by more demanding morphological semantic integration operations performed on the verbal base.

At first glance, the fact that we obtained a stronger P200 for verbal nouns than for finite verbs seems to be incompatible with the idea that the P200 is a “verbal signature” and it is not clear in what sense verbal nouns should be “more verbal” than the prototypical verbs. However, this paradox may be explained if we adopt a position postulated in Vigliocco et al. (2011: 423), according to which “grammatical class effects emerge or become stronger”, when the brain performs operations related to underlying grammatical class membership. The more demanding such tasks are and the more category-related integration processes are involved, the stronger category-related effects are expected to emerge. Following this view, it is no longer surprising that we obtained a stronger “verbal” component P200 for verbal nouns as compared to finite verbs and also for converbs as compared to finite verbs: both verbal nouns and converbs as categories derived from a verbal base impose greater processing demands for the brain than straightforward verbs. Such an increased category-related integration cost is reflected in a stronger P200 for the two derived categories.

In addition, the topography of the obtained ERP effects can serve as evidence for the verbal nature of the P200 component. The ERP effects obtained in our study have a left-anterior distribution. This is consistent with Moseley et al.’s (2013) recent findings according to which action-related words most strongly activate frontocentral motor areas. It is also known from the literature that verb-related morphological operations are performed in prefrontal and frontotemporal cortex (see, e.g., Shapiro et al. 2006; Longe et al. 2007; Cappelletti et al. 2008; Finocchiaro et al. 2008).

Could the pattern of our results be explained by different reasons, namely, effects of frequency or acceptability? Although the P200 has not been linked to the processing of frequency differences yet, and (mostly lemma) frequency differences have been described as influencing either earlier or later time windows (see Barber & Kutas 2007 and Penolazzi et al. 2007 for overviews), it is worthwhile to discuss this idea. As outlined above, the frequency of the underlying stem cannot be a candidate for explaining the results because the underlying stems were identical for all three conditions. However, the different forms differ statistically in the surface frequency, with finite verbs being more frequent than verbal nouns, and verbal nouns being more frequent than converbs (this difference reaches statistical significance in all pairwise comparisons, see the subchapter on Language material, Section 2.2). However, if the observed variability in the strength of the P200 component in the reported ERP experiment was directly caused by surface frequency of the different forms, we would expect a significant P200 effect for all the three comparisons and it should be the strongest in Comparisons 1 and 3. Contrary to this expectation, in our ERP experiment we obtained a significantly stronger P200 for Comparisons 1 and 2, but importantly there was no significant P200 effect in Comparison 3. This makes it unlikely that the P200 effect we find for verbal nouns and converbs relative to finite verbs directly and exclusively reflects a confound of our experimental conditions with surface

frequency. The conclusion that the P200 is probably not a direct response to surface frequency is additionally supported by the fact that Pulvermüller et al. (1999), Federmeier et al. (2000), and Kellenbach et al. (2002) all found P200 effects with stimuli that were controlled for the frequency of the used nouns and verbs. It could be potentially the case that although the P200 component is not a direct response to surface frequency, the low frequency enhances the processing load caused by morphological integration operations performed on the verbal base. In other words, it is possible that surface frequency of the derived forms is correlated with the frequency/productivity of the morphological operations involved in the creation of such forms and by doing so it can indirectly have an effect on how easy or difficult it is to perform a given operation on a verbal base. Still, in this case we would also expect a difference in the amplitude of the P200 in Comparison 3 between Condition 2 [converbs] and Condition 3 [verbal nouns] (where converbs feature a significantly lower surface frequency).

3 Concluding remarks and open questions

The overall goal of the present paper was to contribute to our understanding of the nature of the “verbal” P200 component. In the reported ERP study, we used finite verbs, converbs and verbal nouns which all share the same verbal bases and express the same action concepts, for example, a finite verb: *wypił* ‘(he) drank.PFV’, a verbal noun: *wypicie* ‘drinking.PFV’, a converb: *wypiszy* ‘having drunk.PFV’. This gave us the opportunity to keep the semantics (the conceptual level) constant while manipulating the lexical (word class) level and the morphosyntactic processing load. With this setting it was possible to investigate which level of verbal processing is reflected in the P200 component. Our findings reveal an enhanced P200 for converbs and verbal nouns as compared to finite verbs which led us to the conclusion that this component might reflect the difficulty of verb-related morphological integration processes. The operation of adding the anteriority suffix (with specific temporal semantics) performed on the verbal base is morphologically and semantically demanding for the parser. Likewise, given the fact that by creating a verbal noun we change a verb, which is prototypically a predicate, into a noun, which is prototypically a referential category, verbal nouns are morphologically and semantically more difficult to comprehend than finite verbs. At first glance, it might be surprising that it is converbs and verbal nouns that give rise to an enhanced “verbal signature” P200 when compared to finite verbs. Given that finite verbs can be argued to be the “most verbal” of the three conditions compared, they might be expected to engender the strongest P200 component. However, if we take the line of reasoning presented above regarding the degree of difficulty involved in the morphological integration processes performed on a verbal base, our finding receives a natural explanation. In fact, the results of our ERP experiment can shed a new light on the interpretation of the verbal P200, namely that this component is not simply “a verbal signature” per se, that is, it does not simply signal the processing of verbs as opposed to nouns. Rather, it reflects the demands of morphological integration processes for derived words with underlying verbal bases.

This finding provides new insights into the question of how “in-between” categories such as verbal nouns are processed online. It seems that the parser is sensitive to the lexical category of the verbal base and the demands of morphological operations performed on it. This is reflected in the increased amplitude of the P200 elicited for verbal nouns and converbs as compared to finite verbs.

A number of questions arise from our findings. One question is whether the parser is generally sensitive to the verbal category of the base in all kinds of deverbal nominalizations such as, for example, *informacja* ‘information’, *decyzja* ‘a decision’, *stuk* ‘a

knock'. Such nominalizations are treated in the literature as being more nominal than verbal on the lexicalization continuum from VERB to NOUN. They cannot be marked for grammatical aspect and do not co-occur with aspectual modifiers and negation (see, e.g., Rozwadowska 2006 and the references cited therein). By contrast, the verbal nouns used in our experiment have a special status since they inherit a lot of verbal properties (argument structure, the possibility of adverbial modification, event structure; see Rozwadowska 1995) from their verbal bases. Furthermore, deverbal nominalizations are not productive, meaning that they cannot be derived from a verbal base in real time. By contrast, verbal nouns of the type used in our experiment are derived productively from any verbal base on the fly (online), as supported by the experimental findings in Reid & Marslen-Wilson (2003). What requires further research is the question of whether the P200 will be enhanced by such strongly nominal deverbal nominalizations to the same extent as by verbal nouns like the ones used in our stimuli.

Moreover, it would be interesting to test whether the P200 effect would be elicited for denominal verbs, that is, verbs with nominal bases such as, for example, *idioćieć* (idiot. INF) 'to become confused', *fotografować* (photograph.INF) 'to take a picture'. These forms have nominal bases and they only become verbal after the addition of an infinitival suffix to them. Another possibility is that the parser is generally sensitive to the lexical category of the base of the derived forms. Recall that we obtained a verbal component P200 in the case of verbal nouns suggesting that the parser reacted to the verbal category of the stem. However, it is also possible that the productivity of the derived forms plays a role in that the parser may react to the category of the stem in the case of highly productive forms (created online), such as verbal nouns derived by means of the *-nie/-cie* suffix, and the category of the derived form in the case of less productive (more lexicalized) forms, such as deverbal nominalizations. Previous studies related to the processing of categories NOUN and VERB have mainly investigated simple verbs and nouns. The interaction between the productivity of derived forms and the reaction of the parser of their category has a potential to start a new discussion.

Abbreviations

3 = third person, ACC = accusative, AUX = auxiliary, COND = conditional, CVB = converb, DAT = dative, ERP = event-related brain potential, GEN = genitive, INF = infinitive, INS = instrumental, IPFV = imperfective, LOC = locative, M = masculine, NMLZ = nominalizer/nominalization, NOM = nominative, PFV = perfective, PL = plural, PST = past, PTCP = participle, ROI = region of interest, SBJV = subjunctive, SG = singular

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Competing Interests

The authors have no competing interests to declare.

Authors' Contributions

The authors made equal contribution to the paper.

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