The time course of processing perfective and imperfective aspect in Polish

Evidence from self-paced reading and eye-tracking experiments

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Abstract: This paper is a contribution to a long-standing discussion related to the domain of aspectual interpretation. More precisely, it focuses on the impact of the degree of specificity and morphological complexity on the time course of processing of perfective (prefixed perfective and semelfactive perfective) and imperfective (simple imperfective and iterative imperfective) verbs in Polish. In two experiments, eye-tracking during reading and self-paced reading, we tested a hypothesis based on Frisson & Pickering (1999), Pickering & Frisson (2001), and Frisson (2009) that the interpretation of semantically underspecified verbs should be delayed to the end of a sentence. As predicted, in both of the reported experiments significantly longer reading measures were observed for aspectually underspecified simple imperfective verbs as compared to aspectually more specific perfective verbs in the sentence-final region. Our second major prediction was that morphological complexity of aspectual forms should cause computational cost directly on the verbal region. As predicted, significantly longer reading times were observed on morphologically complex (prefixed) perfective verbs and (suffixed) semelfactive perfective verbs as compared to their morphologically simple imperfective counterparts in the eye-tracking experiment. This effect was not confirmed in the self-paced reading experiment. This difference between the results in the two reported experiments is attributed to the differences between the methods used.

Keywords: perfective and imperfective aspect; iterative and semelfactive verbs; semantic underspecification; morphological complexity; eye-tracking; self-paced reading

1. Introduction

Both psycholinguists and theoretical linguists have recently focused on cross-linguistic differences in the domain of aspectual composition (see Bott & Hamm 2014; Husband & Stockall 2014; Filip & Rothstein 2006; Rothstein 2015). What is at the center of this discussion is the question of whether aspectual meaning is computed on a verb in languages in which aspect is grammaticalized and on a VP in languages in which it is not or whether a complete VP is cross-linguistically needed to trigger the derivation of Aspect Phrase where the aspectual meaning is computed. We would like to contribute to this discussion and ask whether the domain of aspectual interpretation in Polish is the same for perfective and imperfective aspect which differ in the degree of their semantic specificity.

There are reasons to expect that the interpretation of imperfective aspect is delayed to post-verbal regions (possibly to the end of a sentence) because it is semantically underspecified (see Comrie 1976; Dahl 1985; Battistella 1990; Filip 1999; Klein 1995; Paslawska & von Stechow 2003; Willim 2006). Such a delay in the interpretation of a semantically underspecified imperfective aspect is expected on the basis of the findings of recent eye-tracking studies reported in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009), who investigated the role of context in the processing of homonymous and polysemous verbs. They observed that the processor does not select between alternative senses of a semantically underspecified (polysemous) verb but rather it initially activates its underspecified meaning and subsequently homes in on the precise sense for the verb. As pointed out in Frisson (2009, 117), the findings of their experiments suggest that "the end of a sentence is a natural choice point to commit oneself to a specific sense of a polysemous verb in the absence of disambiguating information". Frisson and Pickering (1999) additionally emphasize that the homing-in stage (the time when a specific interpretation is obtained) probably depends on many factors, among them being the requirements of the task (e.g., whether there is time pressure or whether a full understanding of every single word is required), and on the characteristics of the method used (e.g., unlike eye-tracking during reading, self-paced reading does not allow rereading).

With these findings in mind, we would like to investigate the impact of the degree of semantic specificity of perfective and imperfective verbs in Polish on the timing of their interpretation. Based on the model of processing underspecified meanings proposed in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009), our core prediction is that

in contrast to simple perfective verbs, the interpretation of simple imperfective verbs will be delayed potentially to the end of the sentence in neutral contexts and the moment of arriving at the proper interpretation of a semantically underspecified imperfective verb will be associated with computational cost. By contrast, perfective verbs used in our experiments are morphologically more complex and therefore they are expected to be computationally more costly on the verbal region (see Niemi et al. 1994; Hyönä et al. 1995; Laine et al. 1999; Vartiainen et al. 2009; Bozic & Marslen-Wilson 2010; Schuster et al. 2018).

Apart from these key predictions, we will be interested in the time course of computing aspectual meanings of iterative imperfective verbs such as *kichać*[11] 'to sneeze', *mrugać*[I] 'to wink', which refer to a series of atomic subevents happening on a single occasion under their most plausible iterative interpretation[2] as compared to more semantically underspecified simple imperfective verbs such as *szybować*[I] 'to glide', *śpiewać*[I] 'to sing', *płynąć*[I] 'to swim'. Our prediction is that because the dominant (most plausible) "repetition" meaning of iterative imperfective verbs in Polish is specific whereas the meaning of simple imperfective verbs is aspectually underspecified, the parser should delay the interpretation only in the case of simple imperfective verbs. If the dominant "repetition" meaning of iterative imperfective verbs used in our experiment is indeed specific, we should not expect effects of semantic underspecification in another comparison between iterative imperfective and semelfactive perfective verbs in the sentence final regions. What is expected in this comparison, however, is that semelfactive verbs should be computationally more demanding on the verbal region than the corresponding iterative verbs due to their greater morphological complexity.

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[1] In the following the superscript [I] is used to mean imperfective and the superscript [P] is used to mean perfective.

[2] In the rest of this paper we will use the term iterative imperfective verbs not to talk about a natural class of iterative verbs because the dominant iterative reading of these imperfective verbs results from the interaction of their conceptual/lexical properties and imperfective aspect but it can be overridden by context. Moreover, when we used the descriptive label "single occasion" iterative imperfectives, we mean those imperfective verbs which describe a series of atomic subevents happening on a single occasion by default and we distinguish them from other iterative imperfective verbs, e.g., habitual imperfective verbs of achievement or accomplishment predicates which describe iterated events happening on different occasions. Importantly, when we use a counting or quantifying adverb with the "single occasion" imperfective iterative verbs as in *Jan kichał*[I] *trzy razy* 'John sneezed three times' in Polish, we obtain a reading in which John sneezed repeatedly on three occasions or, in other words, that John produced three series of sneezes (see section 2.2.2.).

Another relevant question we would like to ask is methodological in nature. The model of processing semantically underspecified words proposed by Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009) is based on the results of their eye-tracking experiments. However, as mentioned earlier, they point out that the time when a specific interpretation is obtained probably depends on many factors such as, for example, the requirements of the task and the method used. To be able to gain some insights about the influence of the experimental method on the timing of processing perfective and imperfective verbs in Polish and in order to see whether similar processes are reflected in different reading measures in both methods, we conducted both a self-paced reading and an eye-tracking during reading experiment. It is not excluded that the processing system may make the first attempts at resolving the underspecified meaning of imperfective verbs earlier, which may generate some computational cost locally and, in the absence of any contextual support, it may delay the homing-in stage to later regions (possibly the end of the sentence). The process may be manifested differently in our two experiments due to the differences in the methods used (e.g., a self-paced reading method does not allow rereadings and an eye-tracking during reading does).

Taken together, in the reported experiments we are primarily interested in the impact of the degree of semantic specificity of imperfective and perfective verbs in Polish on the timing of their processing. To examine this question, we compare the processing of: (i) simple imperfective verbs such as, for example, *szybować*[I] 'to glide', *śpiewać*[I] 'to sing', *szlochać*[I] 'to sob', and their derived perfective partners *poszybować*[P] 'to start to glide', *zaśpiewać*[P] 'to start to sing', *zaszlochać*[P] 'to start to sob', (ii) simple imperfective verbs exemplified above as compared to iterative imperfective verbs such as *sapać*[I] 'to gasp repeatedly', *tupać*[I] 'to stamp repeatedly', *klikać*[I] 'to click repeatedly', *stukać*[I] 'to knock repeatedly', *gwizdać*[I] 'to whistle', *chrapać*[I] 'to snore', *mrugać*[I] 'to wink repeatedly', (iii) iterative imperfective verbs exemplified above and their semelfactive perfective counterparts, for example, *sapnąć*[P] 'to produce a single gasp', *tupnąć*[P] 'to stamp once', *kliknąć*[P] 'to click once', *stuknąć*[P] 'to knock once', *gwizdnąć*[P] 'to produce a single whistle', *chrapnąć*[P] 'to produce a single snore', *mrugnąć*[P] 'to wink once'.

The structure of this paper is as follows: the introductory sections offer an overview of relevant facts related to grammatical aspect in Polish with a special focus put on the differences in the morphological and lexico-semantic properties of imperfective verbs (including the ones with an iterative meaning) and perfective verbs (including semelfactive perfec-

tive verbs) and the degree of their semantic specificity. In later sections, this overview of essential facts about Polish aspect will be related to a model of resolving semantic underspecification of verbs proposed in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009) and to previous findings related to the processing of morphologically complex words on the basis of which we will formulate our predictions related to the time course of the processing of perfective and imperfective verbs in Polish. This will be directly followed by the description of our self-paced reading and eye-tracking experiments. The paper will conclude with a general discussion related to the results of both experiments.

2. Grammatical aspect in Polish

In Polish, almost all verbs[3] (including infinitives) are either perfective or imperfective, as shown in (1) and (2) respectively.

(1)   Jan   jechał[I].
      Jan.NOM drove
      'Jan drove.'

(2)   Jan   przejechał[P] dziesięć mil.
      Jan.NOM PFV.drove   ten.ACC miles.GEN
      'Jan drove ten miles.'   (Willim 2006, 175)

Additionally, most verbs in Polish have both perfective and imperfective variants. However, there are some cases of the so called *perfective tantum* where the perfective does not have an imperfective counterpart, e.g., *oniemieć* 'to be struck dumb', and there are *imperfectiva tantum*, which cannot be perfectivized, e.g., *mieć*[I] 'to have'. In the coming sections, the focus will be on some facts about Polish perfective and imperfective aspect relevant for our reported experiments.

2.1. The morphology and semantics of perfective aspect in Polish

2.1.1. Uniform criteria for perfectivity in Polish

Perfective verbs do not form a uniform class in Polish in that there are perfective verbs referring to a final boundary of an event, as *dotrzeć* 'to

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[3] With the exception of biaspectual verbs such as, for example, *anulować* 'to cancel' and *aresztować* 'to arrest'.

get to', *przeczytać* 'to complete the event of reading'. There are also initial boundary perfectives such as, for example, *zakwiczeć* 'to start to squeak', *pokochać* 'to start to love', which do not pass standard telicity tests (see Rozwadowska 2012 for a detailed discussion). There are delimitative perfectives with a prefix *po-* as in *poczytać* 'to read for a while', *pośpiewać* 'to sing for a while' which are not prototypical either in that they also do not pass standard tests for telicity but they refer to temporally delimited events (see Filip 2017, 172). There are semelfactive perfective verbs, which are derived from their imperfective bases with the semelfactive suffix *-ną-*, as in *stuknąć* 'to knock once', *mrugnąć* 'to wink once', and they are commonly described as denoting punctual or naturally atomic events (cf. Willim 2006 and Rothstein 2008). According to Filip (2017, 171), semelfactives "entail a change from some initial state of affairs $\neg p$ to p, followed by another change back to the initial $\neg p$". And finally, there are also perfective verbs which either refer to an initial or a final boundary depending on context, for example, *zagrać*[P] 'to play' encodes cessation of a process of playing in *Orkiestra zagrała*[P] *i goście się rozeszli* 'The band stopped playing and everyone left the dance floor' but it encodes inception in *Orkiestra zagrała*[P] *i goście zaczęli tańczyć* 'The band started playing and everyone started dancing'.

This brief overview of different types of perfective verbs in Polish shows that if we want to uniformly describe their semantics, we cannot describe them as telic, quantized, completed or as referring to an end point of an eventuality. What these different perfectives have in common is that they pass a couple of standard tests used to diagnose perfectivity in Polish (and most Slavic languages). More specifically, all these perfective forms cannot be used as complements of phasal verbs: *zacząć* 'to begin', *kontynuować* 'to continue', *skończyć* 'to finish', or as complements of the auxiliary *będzie* in periphrastic future constructions, as shown in (3) (cf. Wróbel 2001; Willim 2006; Filip 2017):

(3)   zacząć/kontynuować/skończyć/będzie; to begin/continue/finish/will:
       czytać[I]/*przeczytać[P] artykuł 'read'/'finish reading an article'
       kwiczeć[I]/*zakwiczeć[P] 'squeak repeatedly'/'start squeaking'
       śpiewać[I]/*pośpiewać[P] 'sing'/'sing for a while'
       stukać[I]/*stuknąć[P] 'knock repeatedly'/'knock once'

All the perfective verbs without exceptions do not form a present participle **przeczytając* 'while reading', **stuknąc* 'while knocking', **poczytając* 'while reading'. The present tense form of perfective verbs always makes reference to a future event as in *przeczyta* 'will read.3SG', *postuka* 'will knock.3SG for a while' *pośpiewa* 'will sing.3SG for a while' (see Filip 2017, 173).

2.1.2. The morphology of perfective aspect in Polish

Most Polish perfective verbs are morphologically marked by means of a prefix or a suffix, as shown in (4a,b) respectively (cf. Bogusławski 1963; Nagórko 1998; Wróbel 1999; 2001; Willim 2006):[4]

(4) a. pisać[I] – **na**pisać[P] 'to write'
     b. błyskać[I] – błys**ną**ć[P] 'to flash'

However, there is no single dedicated perfective or imperfective morphological marker in Polish. For this reason, in Bogusławski (1963); Piernikarski (1969); Grzegorczykowa (1997); Willim (2006); Filip (2017 and her earlier works), among others, Slavic verbal prefixes or suffixes are not treated as markers of perfectivity or imperfectivity. Moreover, the choice of aspectual morphology for the expression of perfective and imperfective aspect is in most cases not predictable. For example, one verbal stem can co-occur with many different aspectual prefixes, e.g., pod***pisać***[P] 'to sign', na***pisać***[P] 'to write down', prze***pisać***[P] 'to copy sth in writing', wy***pisać***[P] 'to prescribe', and one prefix can be attached to many verbal stems, e.g., ***od***skoczyć[P] 'to jump away', ***od***stawić[P] 'to put away', ***od***nieść[P] 'to bring back', ***od***dać[P] 'to give back', ***od***tworzyć[P] 'to recreate'. In both cases, it is evident from the English translations that the verbal stem *pisać*[I] 'to write' can acquire different, sometimes remotely related, readings depending on the prefix it co-occurs with and the prefix *od-* expresses different meanings depending on the verbal predicate it is attached to. In fact, many prefixes used to derive perfective verbs modify the meaning and/or the argument structure of the basic verb, as is shown in (5).[5]

(5) a. pisać[I] 'to write' – **pod**pisać[P] 'to sign'
     b. kupić[I] 'to buy' – **prze**kupić[P] 'to bribe'
     c. gotować[I] 'to cook' – **przy**gotować[P] 'to prepare'
     d. płakać[I] 'to cry' – **wy**płakać[P] awans 'to cry out a promotion' (Willim 2006, 184, 188)

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[4] There are also underived perfective verbs in Polish, for example, *dać*[P] 'to give', *wziąć*[P] 'to take', *kupić*[P] 'to buy'.

[5] In most cases verbs with prefixes modifying their meaning or argument structure have an imperfective partner expressed by means of a suffix *-ywa-* or by means of vowel alternation, as in *przekupić*[P] 'to bribe' – *przekupywać*[I] and *przebić*[P] 'to break through' – *przebijać*[I] 'to be breaking through'. However, see Slabakova (1997; 2003; 2005); Willim (2006); Biały (2012) and Willand (2012), among others, for the discussion related to the division of Slavic prefixes into the so-called internal (lexical) and external (superlexical) prefixes.

For this reason, Bogusławski (1963), Piernikarski (1969), Grzegorczykowa (1997), Filip (1999; 2003; 2017) and Willim (2006), among others, assume that aspectual meanings are conveyed not by aspectual affixes alone, but by the entire perfective or imperfective stems and that lexical prefixes are eventuality description modifiers rather than the markers of grammatical aspect. Following Willim (2006) and Filip (2017), we assume that (many)[6] perfective and imperfective verbs are stored as such in the lexicon based on their systematic interactions with syntax and other grammatical categories. Additionally, we follow Willim (2006) in her assumption that perfective and imperfective aspect represent a lexico-grammatical category and that verbal stems in Polish are indeed specified in the lexicon as perfective or imperfective but their aspectual value is computed in the grammar at the level of AspP (that is, after the formation of VP) (cf. Husband & Stockall 2014). Moreover, following Willim (2006), we would like to point out that some aspectual prefixes and suffixes are much more productive and predictable than others (e.g., the secondary imperfective suffix *-ywa-* and the semelfactive suffix *-ną-*). It is assumed in this study that such aspectual affixes are most probably not encoded as part of a verb's lexical entry but are stored in the lexicon as independent aspectual morphemes and they are computed in the grammar possibly at the level of AspP), where they modify (possibly even override) the aspectual semantics of the verbal stem encoded in the lexicon. This is compatible with independent neurolinguistic evidence coming from Tyler et al. (2002) and Marslen-Wilson and Tyler's (2005) study on the processing of regular and irregular past tense inflection, where the former is computed in the grammar and the latter is claimed to be part of the verb's lexical representation. This shows that the +past value of the same functional category Tense is sometimes computed in the grammar and sometimes it is lexically accessed together with a verbal stem (see footnote 6). Along these lines, we assume that in Polish most verbs are specified as perfective and imperfective in the lexicon but some are composed regularly in the grammar (with the semelfactive verbs containing a productive suffix *-ną-* being such likely examples) (see section 2.1.4. and footnotes 8 and 9 for more details). Notice that when we use the semelfactive suffix *-ną-* with phono-

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[6] We added *many* because there are reasons to believe that some aspectual prefixes (the ones which are very productive) are not stored as part of a verb's lexical entry but rather as separate elements in the lexicon. In fact, we assume so based on some preliminary arguments related to aspectual values of pseudoverbs (discussed later in the paper). We are aware of the fact that this issue is debatable and it remains to be further investigated ideally experimentally (cf. Bozic & Marslen-Wilson 2010).

tactically possible pseudoverbs in Polish such as *mizgnął, gurdnął, fiwnął* the dominant reading of those pseudoverbs is the semelfactive perfective one as they are (according to our native speaker informants) unacceptable in contexts with durative adverbials, as in **Jan mizgnął, grudnął, fiwnął przez godzinę* 'John mizgnął, grudnął, fiwnął for an hour'. They are also unacceptable as complements of phasal verbs **Janek zaczął mizgnąć, grudnąć, fiwnąć* 'John started mizgnąć, grudnąć, fiwnąć'. This indicates that the suffix *-ną-* is productive in Polish under the semelfactive perfective meaning (cf. Merkman 2008).

2.1.3. The meaning of perfective aspect in Polish

As stated in Willim (2006, 202), perfective aspect has a very specific meaning and it is in a vast majority of cases used to refer to a single, well-delimited event occurring on a specific occasion.[7] In spite of the fact that the class of perfective verbs is not uniform, as mentioned earlier, in that there are final boundary perfectives, initial boundary perfectives, delimitative perfectives and semelfactive perfectives, all perfectives in Polish have individuation boundaries, as postulated in Willim (2006) and Filip (2017). Let us explain what this means in more formal terms. First of all, we adopt a standard assumption that verbs have an eventuality description encoded in their lexical entry. The lexical eventuality description of a verb corresponds to Vendler's (1957) states, e.g., *love, admire*, activities, e.g., *run, swim,* achievements, e.g., *notice, find, die,* and accomplishments, e.g., *eat an apple, build a bridge,* or to Bach's (1986) ontology of eventualities comprising states, processes and events, where processes correspond

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[7] Generally, perfective aspect in Polish is strongly dispreferred in habitual contexts and in contexts with adverbs of quantification such as 'always', 'never', 'sometimes' and with frequentative adverbs such as 'often', 'frequently', 'rarely'. The use of perfective aspect in non-episodic (generic) contexts is very restricted. However, there are some exceptional dispositional contexts in which perfective aspect is used, e.g., *Jan pomoże*[P] *ci w potrzebie* 'John PFV.help you (will help you) in need', where the context makes it possible to accommodate John's disposition in virtue of which whenever someone needs help, John will help them. In these special dispositional modal contexts, the generic meaning of the perfective verb results from the universal quantification over possible worlds in which the accommodated "in virtue of" property of the subject holds (see Klimek-Jankowska 2012 for a detailed discussion on the differences in the meaning and distribution of perfective and imperfective verbs in two types of generic contexts in Polish). The meaning of these contexts is not part of the semantics of perfective aspect but rather the semantics of perfective aspect is not incompatible with the semantics of those modal contexts. Informally speaking, in these special contexts perfective verbs impose individuation boundaries on input eventualities in each of the accommodated possible worlds.

to Vendlerian activities and events correspond to Vendlerian accomplishments and achievements. Second, following de Swart (1998), we assume that this lexically encoded eventuality description introduced by a verbal base serves as input to aspectual and tense operators, as schematically shown in (6):

(6)   [Tense [Aspect* [eventuality description]]]   (de Swart 1998, 348)

In de Swart's (1998) formal semantic representation, Tense scopes over grammatical Aspect, which in turn scopes over lexical eventuality description of a verbal predicate. The Kleene star $*$ indicates that there may be more aspectual operators. Tense operator relates the temporal trace of an eventuality with respect to the speech time (see Comrie 1985). In this model, perfective and imperfective aspectual operators act as eventuality description modifiers. Following Filip (2017), we assume that the perfective operator is a maximizing operator MAX_E. As proposed in Filip (2017, 182), MAX_E is applied to an eventuality description in a given context and it "singles out the largest unique event stage [...] in the denotation of P which leads to the most informative proposition among the relevant alternatives". According to Filip (2017, 182) MAX_E is a function that yields a set of singular maximal events, $MAX_E(P)$, relative to P and context. The role of MAX_E is to individuate an eventuality. In that sense, the semantics of perfective aspect is specific.

2.1.4. The meaning of semelfactive perfective verbs in Polish

It is clear how the MAX_E operator interacts with the eventuality descriptions in the case of final boundary, initial boundary and delimitative perfective verbs. It imposes individuation boundaries on the eventuality description provided by a verbal predicate in a given context and these individuation boundaries allow us to focus on the initial, final part of a lexically specified eventuality or on an eventuality in its totality. It is less clear, however, how MAX_E interacts with the eventuality description in the case of semelfactive verbs. As mentioned earlier, semelfactive verbs in Polish such as *stuknąć*[P] 'to knock once', *mrugnąć*[P] 'to wink once' are derived with the suffix *-ną-* from the verbal base. They are usually translated into English by means of a counting adverbial *once*. As stated in Bacz (2012, 109), in popular grammars of Polish, semelfactives are lexically and derivationally related to iterative verbs and in this sense their distribution

is predictable.[8] For example, *pisnąć*[P] 'to squeal once' is related to *piszczeć*[I] 'to squeal repeatedly', *parsknąć*[P] 'to snort once' is related to *parskać*[I] 'to snort repeatedly', *machnąć*[I] 'to wave once' is related to *machać*[I] 'wave repeatedly'.[9] More specifically, semelfactive verbs are related to imperfective base verbs that denote a series of minimal atomic events that happened on a single occasion (e.g., *Zajączek kicał w lesie* 'The baby hare hopped in the forest').

Crucially, not all iterative verbs have semelfactive equivalents. For example, iterative imperfective verbs of achievement predicates such as, for example, *spotykać*[I] 'to meet repeatedly', *gubić*[I] 'to lose repeatedly', *odwiedzać*[I] 'to visit repeatedly' do not have semelfactive counterparts. However, these iteratives are different from the ones lexically related to semelfactives. More specifically, iterative verbs lexically and derivationally related to semelfactives describe a series of iterated atomic events happening by default on a single occasion and the iterative imperfectives of achievement predicates describe iterated events happening on different occasions (habitually).

With this background in mind, let us now focus on the question of how semelfactive verbs with the suffix *-ną-* are lexically related to the "single occasion" iterative verbs. In our attempt to answer this question, we rely on Willim's (2006) approach to semelfactivity. As noted in Willim (2006, 223), in Polish imperfective verbs with an iterative meaning (e.g., *mrugać*[I] 'to wink repeatedly', *błyszczeć*[I] 'to flash repeatedly') describe activities. As such they can co-occur with a prefix *za-* in Polish as in *zamrugać*[P] 'to start winking repeatedly', *zabłyszczeć*[P] 'to start flashing repeatedly'.[10] Willim (2006, 223) suggests that "whether an activity has a derived semelfactive verb depends on whether it conceptually specifies the minimal part or unit of the process it denotes". However, as further pointed out by Willim (2006), not all real-world situations referred to with activity predicates

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[8] There are verbs derived with the homonymous suffix *-ną-* but which are derivationally related to non-iterated activities and they are then described in Bacz (2012) as non-semelfactive perfectives such as, for example, *cofnąć* 'to draw back', *ciągnąć* 'to pull', *ginąć* 'to disappear' and, as stated in Bacz (2012), there are also imperfective verbs with a homonymous suffix *-ną-* indicating a gradual change of state and are usually derived from adjectives as in *blednąć* 'to grow pale', *żółknąć* 'to become yellow', *schnąć* 'to dry'.

[9] While creating the list of verbs to be used in our experiments, we selected all the "single occasion" iterative verbs and their semelfactive counterparts derived with the suffix *-ną-* in Mędak (2013).

[10] The inceptive prefix *za-* in most of its uses co-occurs with activity or state-denoting predicates and it denotes a transition from or to an activity or a state.

that can be decomposed into discrete parts at the conceptual level have a related semelfactive verb. For example, *drgać*[I] 'to twitch/shudder repeatedly' has a related semelfactive verb *drgnąć*[P] 'to twitch/shudder once' but the verb *pulsować*[I] 'to throb/pulsate/pound repeatedly' does not have a semelfactive verb. According to Willim (2006, 223), the asymmetry is not "conceptual, as units of throbbing are not less individuated than the instances of twitching". What Willim (2006) suggests instead is that twitching events are individuated linguistically in the lexical entry of the verbal predicate *drgać* 'to twitch/shudder repeatedly' while throbbing events are not. In this respect, *pulsować* 'to throb/pulsate/pound repeatedly' is similar to the noun *furniture* in English in that *furniture* has discrete elements conceptually but they are lexically not individuated and hence the noun *furniture* cannot be pluralized in English.

This brings us back to the question of how the MAX_E operator interacts with the eventuality description in the case of semelfactive perfective verbs in Polish. Based on the logic presented so far, it appears reasonable to conclude that the MAX_E operator interacts with those activities which have a lexically specified access to atomic units and it grammaticalizes the maximization operation (the operation of imposing individuation boundaries) on such a single atomic unit of the input activity. Now let us turn our attention to imperfective aspect in Polish, which plays a crucial role in our reported experiments as its meaning is underspecified.

2.2. The semantics of imperfective aspect in Polish

What is crucial for our experiments is that imperfective verbs in Polish are consistent with several readings and depending on the context in which they are used they can refer to progressive, iterative, habitual, completed and even resultative eventualities. In that sense imperfective verbs are polysemous and hence, semantically underspecified. In what follows, we will overview some of the readings of imperfective verbs in Polish and in doing that we will rely on Wierzbicka (1967); Comrie (1976); Filip (1999); Smith (1997) and Willim (2006).

2.2.1. Progressive reading

The progressive reading of imperfective verbs in Polish is available in episodic contexts in which the event is interpreted as unfolding in time, e.g., *Anna czytała*[I] *gazetę, kiedy ktoś wszedł*[P] *do domu. Przerwała na chwilę, rozglądnęła się i nadal czytała*[I]. 'Anna read.ɪᴘꜰᴠ (lit. was reading) a newspaper when someone entered the house. She stopped reading for a moment,

looked around and kept on reading'. On the progressive reading, the eventuality denoted by the imperfective verb *czytała* 'read.IPFV.PST.3SG' does not include the endpoint and it is consistent with the continuation *i nadal czytała* 'and she kept on reading'. Willim (2006, 200–201) states that on this reading the initial and the final boundary of the event denoted by the imperfective verb are not included in the reference time and the imperfective verb refers to an event which is incomplete at the asserted interval.

2.2.2. Iterative and habitual reading

Another possible reading of imperfective verbs is the iterative one. On the iterative reading, an imperfective verb in Polish refers to a series of delimited events repeated over an interval on a single occasion, e.g., *Jan pukał*[I] *do drzwi przez pięć minut* 'Jan knocked.IPFV (lit. was knocking) at the door for five minutes' or on several occasions, as in, for example, *Żona Jana prasowała*[I] *jego koszulę i spodnie starannie wieczorami, żeby wyglądał elegancko w pracy* 'John's wife ironed his shirt and his trousers carefully in the evenings so that he could look elegant at work'.[11] The latter type of iterative meaning of imperfective verbs is also referred to as habitual and it is used to describe events repeated over a longer stretch of time on several separate occasions by virtue of one's habits, duties and/or dispositions. The mechanisms of obtaining the habitual meaning of imperfective verbs and the iterative meaning (referring to a series of events happening on a single occasion) are potentially different (but this requires further research). First of all, a verb can obtain both an iterative and habitual reading within a single context, e.g., *W dzieciństwie Janek często kichał*[I] *wiosną z powodu alergii na pyłki traw* 'In his childhood, John sneezed in spring due to his allergy to grass pollen'. In this context, it is clear that John produced a series of sneezes (iterative meaning) on each occasion of being exposed to grass pollen (habitual meaning). There is another difference between "single-occasion" iterative readings of imperfective verbs and the habitual ones. Consider the sentence *Czesząc konia, Jan klepie*[I] *go delikatnie po boku* 'While combing a horse, John pats.IPFV it gently on its side'. In this sentence, on each occasion of John's combing and patting a horse reference

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[11] Unlike English verbs *to wink* or *to flash*, Polish iterative imperfective verbs *mrugać*[I] 'to wink repeatedly', *błyszczeć*[I] 'to flash repeatedly' are not ambiguous between an iterative and semelfactive reading (see Piñango et al. 1999; 2006; Todorova et al. 2000; Pickering et al. 2006; Bott 2010; Paczynski et al. 2014, who assume that iterative meanings of English verbs *to wink* or *to flash* is obtained via aspectual coercion; see also Błaszczak & Klimek-Jankowska 2016 for a discussion of aspectual coercion in Polish).

is made to a potentially different horse. This may indicate that the habitual operator scopes over the whole VP and it possibly quantifies both over the events in the denotation of the verb and the Davidsonian participant subevent introduced by the nominal complement of the verb. By contrast, in a purely iterative use of a verb *klepać*[I] *konia* 'pat.IPFV a horse' each atomic subevent of patting is the event of patting the same horse.

2.2.3. Planned futurate reading

Imperfective verbs in Polish can also be used to talk about events that are planned or that are about to happen but have not started yet as in *Zaraz wysiadam*[I] *z pociągu* 'I am getting off the train in a moment' (see Błaszczak & Klimek-Jankowska 2013 for further discussion).

2.2.4. Factual imperfective reading

As observed in Śmiech (1971, 44), Szwedek (1998, 414–415) and Willim (2006, 201–202), among others, imperfective aspect in Polish can also be used to talk about culminated events in special contexts in which the culmination is a matter of the so called telic presupposition or factivity. In such telic presupposition or factive contexts, culmination or completion is not asserted by the imperfective verb but the participants accommodate at the time of the utterance that the event in the denotation of the imperfective verb is complete. This happens most often in contexts in which the event denoted by an imperfective verb is clearly part of old information in discourse and some other information about the participant, place, time or location are part of the topic under discussion as in *Kto gotował*[I] *te ziemniaki?* Who cooked these potatoes? or *To van Gogh malował*[I] *Słoneczniki* 'It was van Gogh who painted Sunflowers'.

2.2.5. Universal perfect and resultative perfect reading

As pointed out in Willim (2006, 202), imperfective aspect can be used to translate two types of English present perfect, that is, universal perfect (cf. Pancheva 2003, 277), which describes an eventuality as holding in the past until the moment of speaking as in *Pracuję*[I] *w tej firmie od 20 lat* 'I have been working in this company for 20 years now', and the resultative perfect (cf. Comrie 1976, 59; Smith 1997, 236), which describes a past culminated event, whose results are relevant at the moment of speaking as in *Janek nie może zagrać podczas meczu, bo chorował*[I] 'Jan cannot play at the football match because he was ill'.

2.3. More arguments for the semantic underspecification of imperfective aspect

The above discussion shows that it is very difficult to propose a uniform semantics of the imperfective aspect. Different linguists refer to it as non-aspect, non-perfective, semantically unmarked, semantically underspecified, polysemous (cf. Comrie 1976; Dahl 1985; Battistella 1990; Filip 1999; Klein 1995; Borik 2002; Paslawska & von Stechow 2003; Willim 2006). As stated in Filip (2017, 178), "the general factual use of the Slavic IMPFV constitutes 'the strongest evidence' (Comrie 1976, p. 113) for the unmarked status of the IMPFV in the Slavic PFV/IMPFV opposition, where the PFV is the marked member". We would like to point to two more facts which can be used as arguments for the semantically unmarked (semantically underspecified) status of imperfective aspect in Polish. These facts are related to the observation made in Aikhenvald & Dixon (1998) that languages tend to have fewer aspect choices in negative statements than in positive ones. This results from the strong marked status of negative polarity and from a general tendency in languages not to have too many semantically marked categories within a single sentence. This enforces aspect neutralization in negative statements meaning that languages tend to have unmarked aspect forms with sentential negation. For example, as pointed out in Aikhenvald & Dixon (1998), in Kresh and Pero the distinction between perfective and imperfective aspect is neutralized in negative clauses. In Polish, negation does not always force the use of the unmarked imperfective aspect but certain aspect neutralization effects can be observed in the negative contexts with necessity modals. More precisely, in positive contexts a perfective form has to be used to distinguish between single completed and repetitive events, as shown in (7a) and (8a). By contrast, in negative contexts this distinction is neutralized in the sense that one and the same form, i.e., imperfective is used to describe single completed and repetitive eventualities, as shown in (7b) and (8b). Using perfective aspect in a negative context with a necessity modal sounds much less natural than using the imperfective form; see (7c).

(7) a. Musiałeś   wstać.
         must.PST.2SG.M get_up.PFV.INF
         'You had to get up (once).'

     b. Nie musiałeś   wstawać.
         NEG must.PST.3SG.M get_up.IPFV.INF
         'You did not have to get up (once).'

c. #Nie musiałeś   wstać.
   NEG must.PST.2SG.M get_up.PFV.INF
   'You did not have to get up (once).'

(8) a. Musiałeś   wstawać.
         must.PST.2SG.M get_up.IPFV.INF
         'You had to get up (repeatedly).'

     b. Nie musiałeś   wstawać.
         NEG must.PST.2SG.M get_up.IPFV.INF
         'You did not have to get up (repeatedly).'

Another relevant example of aspect neutralization is observable in negative contexts with imperative mood, as illustrated in (9) and (10). In positive contexts, both perfective and imperfective forms can be used but in negative contexts while imperfective is entirely natural and acceptable, the use of perfective aspect is very constrained; see the contrast between (9b) and (10b).

(9) a. Wstań!
         stand_up.PFV.IMP.2SG
         'Stand up!'

     b. #Nie wstań!
         NEG stand_up.PFV.IMP.2SG
         Intended: 'Don't stand up!'

(10) a. Wstawaj!
         get_up.IPFV.IMP.2SG
         'Stand up'

     b. Nie wstawaj!
         NEG get_up.IPFV.IMP.2SG
         'Don't stand up!'

These facts point to the conclusion that perfective aspect is the semantically marked (semantically specific) member of the aspectual opposition in Polish and imperfective is its semantically unmarked/underspecified counterpart. Being semantically underspecified, imperfective constitutes a good testing ground for the recent psycholinguistic models of processing underspecification proposed in Frisson & Pickering (1999), Pickering & Frisson (2001), and Frisson (2009).

3. On the impact of semantic underspecification
on the processing of verbs

Frisson and Pickering (1999), Pickering and Frisson (2001), and Frisson (2009) are particularly interested in the impact of semantic underspecification on the timing of the influence of context (neutral vs. supportive) on the interpretation of homonymous verbs such as *rule* in *As he had all the power, the sultan ruled this very nice country as he thought best* (dominant meaning) as compared to *By using a fine artist's pencil Max ruled this very nice line on all his papers* (subordinate meaning) and polysemous verbs such as, for example, *disarm* in *After the capture of the village we disarmed almost every rebel and sent them to prison for a very long time* (dominant sense) as compared to *With his wit and humour, the speaker disarmed almost every critic who was opposed to spending more money* (subordinate sense). They report significant delayed effects of context for both homonymous and polysemous verbs but still these effects were more delayed after reading polysemous verbs than homonymous verbs. In the case of homonymous verbs, the effects of context were visible on the argument of the verb and in the case of polysemous verbs they were visible at the end of the sentence. Additionally, preference effects were significant only in the case of a homonymous verb. More precisely, the subordinate sense of homonymous verbs caused more regressions and longer reading times in neutral contexts than in contexts supporting the dominant meaning. No such effect of preference was observed for polysemous verbs. Based on these findings, the authors propose that while interpreting both homonymous verbs with multiple meanings and polysemous verbs with multiple senses, context effects are delayed (but more so in the case of polysemous verbs). Additionally, in the case of polysemous verbs the processor does not select all the alternative senses (if it did so, preference effects would be significant) but rather it initially activates an underspecified (less than fully developed) interpretation of a verb and then a number of factors influence how fast the following "homing-in" stage is obtained (the stage when the processor homes in on the precise sense for the verb). As stated in Frisson (2009), in the case of polysemous verbs the homing-in stage is usually delayed to the end of a sentence in the absence of disambiguating information. However, as stated earlier in the introductory section, Frisson and Pickering (1999) additionally emphasize that the homing-in stage (the time when a specific interpretation is obtained) probably depends on the requirements of the task (e.g., whether there is time pressure or whether a full understanding of every single word is required), and on the

experimental method (e.g., unlike eye-tracking during reading, self-paced reading does not allow rereading). Based on the model of processing semantically underspecified verbs proposed in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009), we predict that the time course of processing perfective and imperfective verb in Polish should depend on the degree of their semantic specificity, with imperfective verbs being underspecified and their interpretation being computational costly on later regions than the interpretation of semantically specific perfective verbs used in our experiment. However, as pointed out above, we might expect differences either in the timing of the homing-in stage in the self-paced reading experiment and in the eye-tracking experiment or in the patterns of results for different measures available in both experimental techniques. In addition, we will investigate the time course of computing aspectual meanings of such imperfective verbs as *kichać*[I] 'to sneeze', *mrugać*[I] 'to wink' which refer to a series of atomic subevents happening on a single occasion and we will compare them with semantically more underspecified simple imperfective verbs such as *płakać*[I] 'to cry', *żeglować*[I] 'to sail' (see Battistella 1990). Since the dominant meaning of our iterative imperfective verbs is semantically specific, we expect that the parser should not delay their interpretation to later regions. By contrast, simple imperfectives being more semantically underspecified are expected to be computationally more costly on later regions. If this prediction is correct, we do not expect any differences in the reading measures on later regions in our third comparison between iterative imperfective verbs (whose dominant iterative meaning is specific) and the corresponding semelfactive perfective verbs (whose meaning is also specific).

4. On the impact of morphological complexity on word processing

As stated in Bozic & Marslen-Wilson (2010, 1063) and Schuster et al. (2018, 2317), considerable research has provided evidence that the human cognitive system is sensitive to the morphological structure of words and that it is sensitive to degrees of morphological complexity of words. Similarly, Vartiainen et al. (2009) in their study on neural dynamics of reading morphologically complex words point out that an increased processing cost as a factor of morphological complexity of words has been shown to affect the comprehension in visual lexical decision (see, e.g., Niemi et al. 1994; Laine et al. 1999), progressive demasking where the exposure time to a word is gradually increased (Laine et al. 1999) and eye movement patterns during reading (Hyönä et al. 1995). These studies suggest that the effects

of morphological complexity of words are possibly caused by the process of morphological decomposition which affects the processing very early.[12]

Based on these earlier findings, we predict that because both simple perfective verbs and (suffixed) semelfactive perfective verbs used in our experiments are morphologically more complex than the corresponding simple imperfective verbs and iterative imperfective verbs, they are expected to be computationally more costly on the verbal region.

In order to test our predictions related to semantic underspecification and morphological complexity, we conducted a self-paced reading and eye-tracking during reading experiment described and discussed in the next sections of this paper.

5. Experiment 1: self-paced reading experiment (SPR)

5.1. Language material and predictions

The language material consisted of 48 sentences per condition. All the sentences were exactly parallel apart from the critical verb, which belonged to one of the following four verb groups: (i) simple imperfective, (ii) iterative imperfective, (iii) semelfactive perfective and (iv) simple (prefixed) perfective. All the sentences began with an introductory statement of the type *Mary said that,* followed by an embedded clause (containing the critical verb), followed by a closing statement of the type *and John said so too.* An example of a typical sentence quartet used in our experiment is given in Table 1.

For these four conditions we planned three comparisons summarized in (11).

(11) Comparison 1: Condition 1 (simple imperfective verbs) vs. Condition 2 (iterative imperfective verbs)
Comparison 2: Condition 1 (simple imperfective verbs) vs. Condition 4 (simple perfective verbs)
Comparison 3: Condition 2 (iterative imperfective verbs) vs. Condition 3 (semelfactive perfective verbs)

The purpose of the introductory statement was to create a discourse background, that of the closing statement was to create an additional spill-over region. Proper names were always female in the introductory statement,

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[12] Whenever the term "simple perfective" is used it means prefixed perfectives. The adjective *simple* is used to distinguish prefixed perfectives from semelfactive perfectives.

Table 1: An example of a stimulus quartet used in the self-paced reading time study. Table columns correspond to Interest Areas, i.e., words appearing together after a button press.

Condition	IA 1	IA 2	IA 3	IA 4	IA 5	IA 6
1: simple imperfective verbs	Maria powiedziała, że Mary said that	nadąsany dzieciak sulky kid	**wył screamed**	głośno loudly	w piaskownicy in sandpit	i Jacek też tak powiedział. and Jack said so too
2: iterative imperfective verbs	Maria powiedziała, że Mary said that	nadąsany dzieciak sulky kid	**tupał stamped repeatedly**	głośno loudly	w piaskownicy in sandpit	i Jacek też tak powiedział. and Jack said so too
3: semelfactive perfective verbs	Maria powiedziała, że Mary said that	nadąsany dzieciak sulky kid	**tupnął stamped once**	głośno loudly	w piaskownicy in sandpit	i Jacek też tak powiedział. and Jack said so too
4: simple perfective verbs	Maria powiedziała, że Mary said that	nadąsany dzieciak sulky kid	**zawył started screaming**	głośno loudly	w piaskownicy in sandpit	i Jacek też tak powiedział. and Jack said so too

and always male in the closing statement. Subjects of the embedded sentences consisted of a common noun modified by an adjective, followed by a verb modified with an adverb and a prepositional phrase. All the words apart from the critical verbs were kept parallel across conditions for each sentence quartet. Subjects of the embedded clauses were animate. Because almost all iterative imperfective and semelfactive perfective verbs in Polish are 1-argument verbs, we used only 1-argument simple imperfective and simple perfective verbs to make sure that all the verbs used in our experiments have the same argument structure. The iterative imperfective verbs used in our experiments describe a series of atomic events happening on a single occasion by default and they were selected based on whether they have semelfactive perfective equivalents in Polish. All the imperfective verbs were bare (with no affixes) and all the perfective verbs were prefixed. We constructed 48 sentence quartets. 40 verbs differed in each of the four conditions and 8 verbs were repeated. Using some verbs more than once was necessary because of the limited number of iterative imperfective and semelfactive perfective verbs in Polish. When verbs were repeated, the remaining words in the sentence were changed to create a new sentence.

To control for the plausibility relation between the subject NP and the verb, we conducted a questionnaire study as a pretest. We collected judgments from 17 native speakers of Polish, who were asked to evaluate how natural the relation between the subject and the verb is on a 1–7 scale, where 1 means 'unnatural' and 7 means 'natural'. The mean values for all the four conditions are summarized in Table 2.

Table 2: The mean values for Conditions 1–4 in the questionnaire testing subject–verb plausibility on the scale from 1–7

Condition	Mean	Condition	Mean
1	5.99	3	6.07
2	6.02	4	6.05

The ratings in the subject-verb plausibility questionnaire did not differ significantly for the planned comparisons in the Ordinal Logistic Regression, package *MASS* (Ripley et al. 2017 function *plor*), as summarized in Table 3.

Table 3: The summary of the subject–verb plausibility ratings for the planned comparisons in the Ordinal Logistic Regression

Comparison 1: Condition 1 vs. Condition 2	$p = .98$
Comparison 2: Condition 1 vs. Condition 4	$p = .99$
Comparison 3: Condition 2 vs. Condition 3	$p = .99$

In all the comparisons, the tested verbs were additionally matched for lemma frequency. The means and standard deviations of the raw lemma frequencies of the critical verbs according to PELCRA NKJP (the PELCRA search tool for the National Corpus of Polish, Pęzik 2012) are summarized for each condition in Table 4.

Table 4: Means and standard deviations of lemma frequencies of verbs per condition, according to PELCRA NKJP

Condition	Mean lemma frequency	Standard Deviation
1	862	827.8
2	979	775.2
3	879	730.4
4	1001	1450.6

In the conducted t-tests for independent measures, the mean logarithmic lemma frequencies did not differ significantly for the planned comparisons, as summarized in Table 5.

Table 5: The results of t-tests for the mean logarithmic lemma frequencies in all the comparisons

Comparison 1: Cond. 1 vs. Cond. 2 t.test log. frequency $= t(93.875) = -.97, \ p = .332$
Comparison 2: Cond. 1 vs. Cond. 4 t.test log. frequency $= t(76.963) = 1.21, \ p = .229$
Comparison 3: Cond. 2 vs. Cond. 3 t.test log. frequency $= t(84.925) = 1.50, \ p = .136$

All the verbs used in Conditions 1–3 consisted of two syllables. All the perfective verbs in Condition 4 were the prefixed counterparts of the imperfective verbs in Condition 1 and they were by necessity one syllable longer. This means that verbs in Comparisons 1 and 3 were matched in terms of the number of syllables. In Comparison 2, imperfective verbs were always one syllable shorter than the corresponding perfective verbs. A full list of verbs used in Experiment 1 and 2 is given in Appendix C.

5.2. Predictions concerning both self-paced reading and the eye-tracking experiments

Taking into consideration the facts about Polish aspect discussed in section 2, the model of processing semantically underspecified verbs described in section 3, we formulated the following predictions.

Prediction 1 (concerning Comparison 1 and 2)
Because simple imperfective verbs are semantically more underspecified than iterative imperfective verbs and simple perfective verbs used in our experiment in Comparison 1 between Condition 1 (simple imperfective verbs) and Condition 2 (iterative imperfective verbs) and in Comparison 2 between Condition 1 (simple imperfective verbs) and Condition 4 (simple perfective verbs), the parser is expected to home in on their proper interpretation with a delay. The homing-in stage is expected to generate computational cost manifested in longer reading times on the last region (Interest Area (= IA) 6 in both experiments).

Prediction 2 (concerning Comparison 2 and 3)
Both simple perfective verbs and semelfactive perfective verbs used in our experiments are morphologically more complex than the corresponding simple imperfective verbs and iterative imperfective verbs and therefore

they are expected to be computationally more costly on the verbal region in Comparison 2 between Condition 1 (simple imperfective verbs) and Condition 4 (simple perfective verbs) and in Comparison 3 between Condition 2 (iterative imperfective verbs) and Condition 3 (semelfactive perfective verbs). This additional computational cost should be manifested in longer reading measures in both experiments reported in this paper on the verb (IA 3 in the self-paced reading and IA 4 in the eye-tracking experiment).

Prediction 3 (concerning Comparison 3)

Since the dominant (more plausible) meaning of iterative imperfective verbs used in our experiment in Condition 2 is specific and the meaning of semelfactive perfective verbs in Condition 3 is also specific, the parser is not expected to delay their interpretation to later regions in the comparison with semantically very specific semelfactive verbs. No significant difference is expected between Condition 2 (iterative imperfective verbs) vs. Condition 3 (semelfactive perfective verbs) on the sentence-final region IA 6 in both experiments.[13]

5.3. Participants

Forty eight Polish native speakers (31 female, mean age 19.5 (SD = 0.3, range 19–20 years) were recruited at the University of Wrocław. Participants received partial course credit. They had no known neurological or reading-related problems. Data from two participants were excluded before the final data analysis because they gave wrong answers to more than 40% of the comprehension questions used in the experiment. For the remaining participants, the mean error rate was 13.7% (SD = 5.7) over all conditions.

5.4. Procedure

Participants were tested individually in one session. They were seated 1m in front of a Samsung 22-inch LCD screen. Stimuli were presented in a white courier font, size 48, on a black background using the *Presentation* software (Neurobehavioral Systems, Inc., Version 16.3 Build 12.20.12). Response latencies were recorded via a key press on a Razer keyboard. After having read the written instruction, participants received a practice block with 10 sentences, followed by explicit feedback. The practice session was

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[13] Here we are predicting null results and we do so only because if it is confirmed, it can potentially strengthen Prediction 1 concerning Comparison 2.

followed by the experimental session, during which each participant saw 120 sentences divided into 4 blocks of 30 sentences. 48 of the 120 sentences were critical sentences, the remaining 72 sentences were filler sentences. Each participant saw one sentence of each critical sentence quartet, resulting in 12 sentences of each of the four conditions. Comprehension questions were asked after each sentence in order to give the participants a task and to keep them attentive. For questions concerning critical sentences, the correct answer was 'no' in 24 questions and 'yes' in the remaining 24 questions. Each trial began with a fixation asterisk in the center of the screen for 1500 ms, followed by sentence presentation. Sentences were presented chunk-by-chunk (using a non-cumulative moving window paradigm):

(12) Marysia powiedziała, że | nieznośne dziecko | tupało | głośno| w piaskownicy | i Jacek też tak powiedział.
     Mary said that | sulky kid | screamed | loudly | in sandpit | and Jack too so said
     'Mary said that a sulky kid screamed loudly in a sandpit and Jack said so too.'

The material that was presented as one chunk is separated by a vertical pipe (|). The Interest Areas will be referred to as IA 1, IA 2, IA 3, IA 4, IA 5, IA 6. IA 3 is the critical Interest Area, containing the verbs that differ in semantic complexity and semantic markedness.

5.5. Stimulus presentation

For the experiment, the stimuli were arranged in four different versions. Each version contained 12 items per condition. Each participant saw 48 critical sentences, interspersed with 72 transitive filler sentences, leading to 120 sentences for the whole experiment. We used a Latin Square design to make sure that sentences with the same subjects were equally distributed across the four versions. In other words, only one sentence from each quartet was used in each version. Each version was divided into four blocks, with a pause between them. Each sentence was followed by a comprehension question related to different parts of a sentence.

In each version, experimental sentences and fillers were randomized. Not more than two sentences from the same condition were displayed one after another. Sentences with the same beginnings up to the verb were equally distributed across versions.

5.6. Data preparation and analysis

Reading times shorter than 200 ms or longer than 8000 ms were removed from the dataset. Outliers were defined as values that deviated more than two standard deviations from a participant's mean per condition per position and were removed before the final data analysis. In sum, 7.4 % of all data were removed as outliers.

Data were analyzed in *R* (R Development Core Team 2005) with linear mixed effects models, using the packages *lme4* (Bates et al. 2015, *lmer* function) and *LMERConvenienceFunctions* (Tremblay & Ransijn 2015, *summary* function).

For the planned comparisons, we defined the main effects of CONDITION as fixed effect. PARTICIPANT and ITEM were defined as random effects. CONDITION was defined as a random slope for PARTICIPANT. Effects are reported when they reached statistical significance ($p < .05$) or narrowly missed statistical significance ($p < .06$).

Based on our hypotheses outlined above, we analyzed reading times at the position of the critical verb (IA 3) and on the position directly following the critical verb (IA 4). In addition, we also analyzed reading times at the sentence-final position (IA 6), where wrap-up effects may become visible. Full tables of the fixed effects of all comparisons are given in Appendix A.

5.7. Results of the self-paced reading study

For the self-paced reading experiment, the mean reading times over participants per position are given in Table 6, and the graphs of the mean reading times over participants for all comparisons are given in Figure 1–4. Graphs were made in *R* using the *ggplot2* package (Wickham 2009).

Table 6: Self-paced reading times, mean reading times over participants in ms, standard error in parentheses. Graphs for the planned comparisons are given in Figures 1–4.

Condition	IA 1	IA 2	IA 3	IA 4	IA 5	IA 6
1	1266 (26)	819 (18)	668 (13)	311 (13)	394 (16)	1034 (43)
2	1280 (31)	810 (17)	645 (12)	325 (13)	439 (18)	932 (39)
3	1256 (28)	829 (18)	641 (12)	299 (12)	399 (16)	944 (40)
4	1279 (30)	856 (18)	664 (13)	288 (12)	398 (16)	834 (35)

Logarithmized reading times were compared between Condition 1 and 2 (Comparison 1), Condition 1 and 4 (Comparison 2), Condition 2 and 3 (Comparison 3).

Comparison 1: Condition 1 (simple imperfective verbs) vs. Condition 2 (iterative imperfective verbs). Summaries of the fixed effects for this comparison are given in Appendix A in Table 10. **IA 3:** there was a statistically significant main effect of CONDITION ($t = -2.4$, $p < .05$). Reading times were significantly longer in Condition 1 than in Condition 2. **IA 6:** there was a statistically significant main effect of CONDITION ($t = -2.1$, $p < .05$). Reading times were significantly longer in Condition 1 than in Condition 2 (see Figure 1).
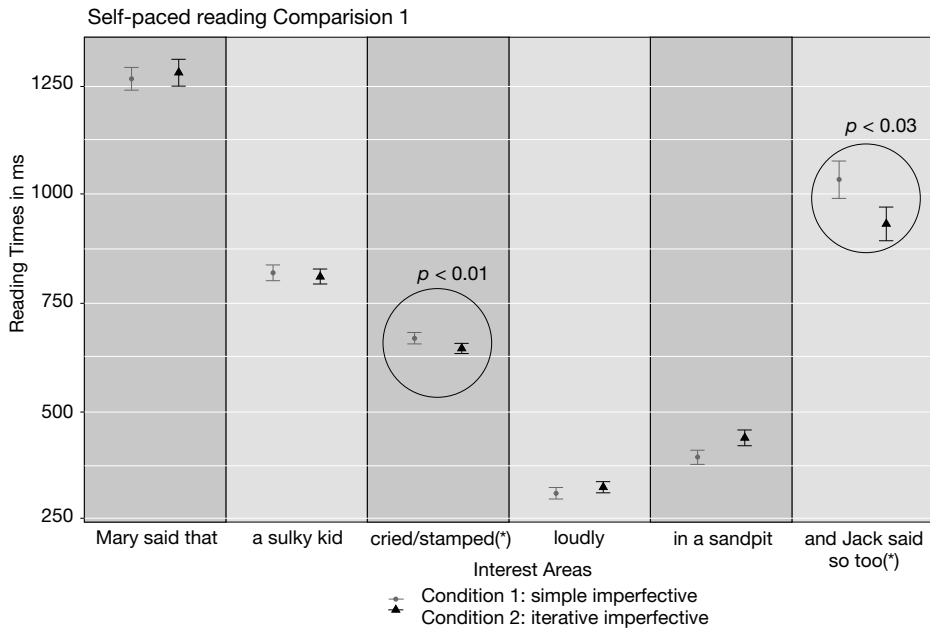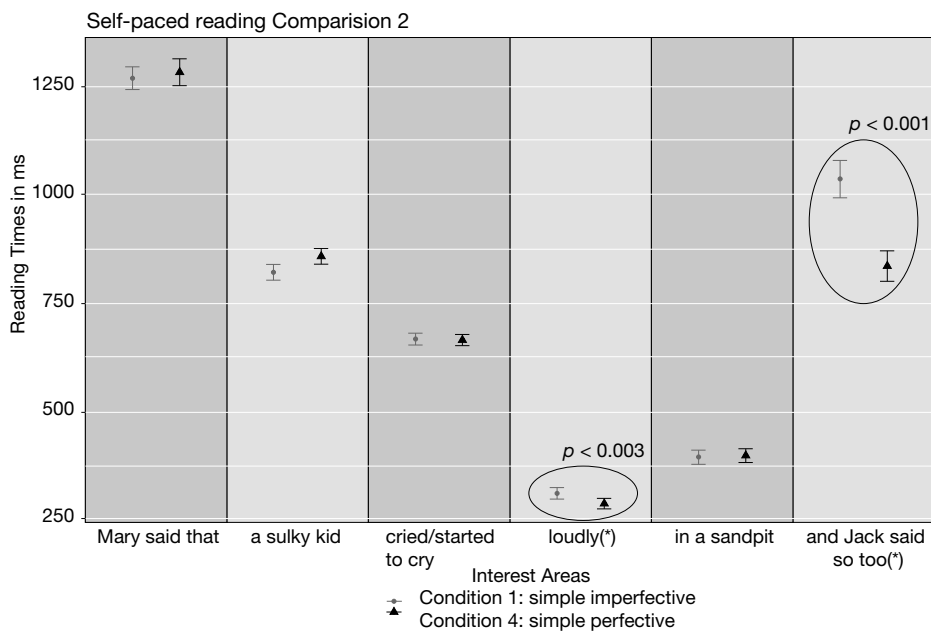

Figure 1: Self-paced reading times in ms, means over participants per condition. Condition 1 is plotted with a circle in the middle of error bars, Condition 2 is plotted with a triangle in the middle of error bars. Interest Areas are indicated by the respective chunks of the experimental sentences translated into English.

Comparison 2: Condition 1 (simple imperfective verbs) vs. Condition 4 (simple perfective verbs). Summaries of the fixed effects for this comparison are given in the Appendix A in Table 11. **IA 4:** there was a statistically significant main effect of CONDITION ($t = -3.1$, $p < .01$). Reading times

were significantly longer in Condition 1 than in Condition 4. **IA 6:** there was a statistically significant main effect of CONDITION ($t = -3.4$, $p < .01$). Reading times were significantly longer in Condition 1 than in Condition 4 (see Figure 2).

Figure 2: Self-paced reading times in ms, means over participants per condition. Condition 1 is plotted with a circle in the middle of error bars, Condition 4 is plotted with a triangle in the middle of error bars. Interest Areas are indicated by the respective chunks of the experimental sentences translated into English.

Comparison 3: Condition 2 (iterative imperfective verbs) vs. Condition 3 (semelfactive perfective verbs). Summaries of the fixed effects for this comparison are given in the Appendix A in Table 12. There were no significant effects for this comparison.

5.8. Discussion

The present study investigated the role of semantic specificity and morphological complexity in the processing of perfective (simple and semelfactive) and imperfective verbs (simple and iterative) in Polish.
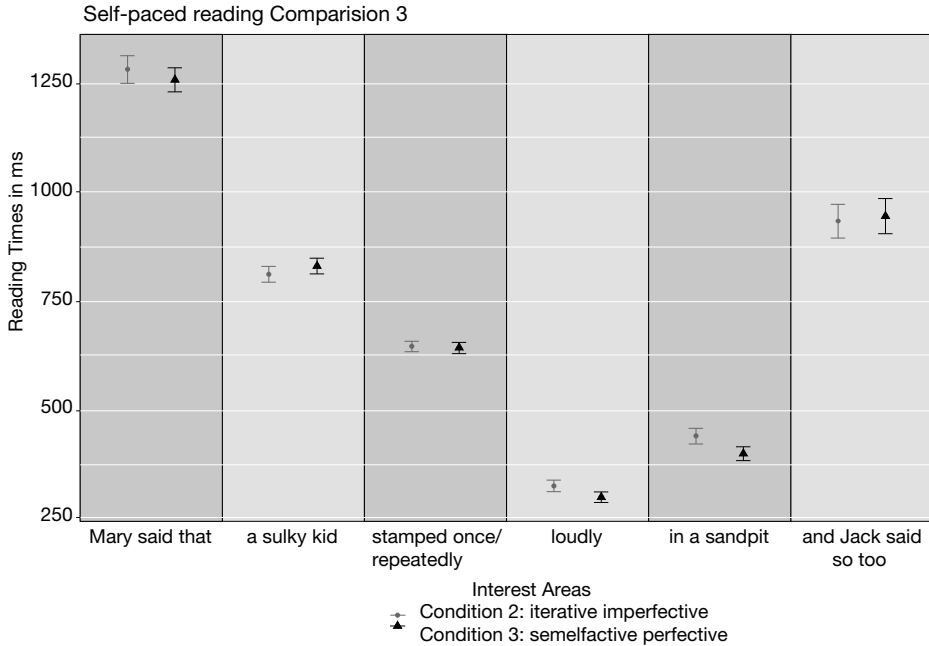
Figure 3: Self-paced reading times in ms, means over participants per condition. Condition 1 is plotted with a circle in the middle of error bars, Condition 2 is plotted with a triangle in the middle of error bars. Interest Areas are indicated by the respective chunks of the experimental sentences translated into English.

The reported self-paced reading study revealed significant effects of CONDITION on different positions for three comparisons: Comparison 1, 2 and 3. The results of the first two comparisons pattern together.

In Comparison 1 between Condition 1 (simple imperfective) and 2 (iterative imperfective), the general pattern was that reading times were significantly longer for Condition 1 (simple imperfective) on the verb (IA 3) and in the last region (IA 6).

In Comparison 2 between Condition 1 (simple imperfective) and Condition 4 (simple perfective), reading times were significantly longer for Condition 1 (simple imperfective) on the area immediately following the verb (IA 4) and in the last region (IA 6).

In Comparison 3 between Condition 2 (iterative imperfective) and Condition 3 (semelfactive perfective) no significant differences were found.

5.8.1. Discussion related to Prediction 1

The results of the analysis of Comparison 1 (between simple imperfective verbs and iterative imperfective verbs) and Comparison 2 (between simple imperfective verbs and simple perfective verbs) confirm our key Prediction 1, which was based on the model of processing semantically underspecified verbs proposed in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009). More specifically, we expected a delay in the parser's homing in on the proper interpretation of semantically underspecified simple imperfective verbs in Condition 1 as compared to semantically more specific iterative imperfective verbs in Condition 2 and simple perfective verbs in Condition 4. This homing-in stage was predicted to be computationally costly and this cost was expected to lead to longer reading times on the sentence-final region. This prediction was borne out. However, additionally, in the self-paced reading experiment we obtained longer reading times already on the verb. This may be due to the characteristics of the self-paced reading method, which does not allow rereading, and therefore, the parser potentially attempts to resolve the underspecified meaning of simple imperfective verbs earlier. More precisely, because the comprehenders are not able to make regressions to earlier elements of the sentence in a self-paced reading study, they choose to spend more time searching for some meaning cues from the previous context in their working memory when they arrive at the verbal region in order to resolve the underspecification of simple imperfective verbs but in the absence of earlier meaning cues in preverbal regions they delay the resolution process to the sentence-final region.[14] This may have generated some computational cost reflected in the observed longer reading times already on the verb.

5.8.2. Discussion related to Prediction 2

In Comparison 2 (between simple imperfective verbs and simple perfective verbs) and Comparison 3 (between iterative imperfective verbs and semelfactive perfective verbs) both simple perfective verbs and semelfactive perfective verbs used in our experiment were morphologically more complex than the corresponding simple imperfective verbs and iterative imperfective verbs and therefore they were expected to be computationally more costly and consequently longer to read on the verbal region. This prediction was not confirmed in our self-paced reading experiment. The lack of effects of morphological complexity in the reported self-paced

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[14] In fact there were no preverbal contextual cues resolving this underspecification in the stimuli used in our experiment.

reading study may be an artifact of the self-paced-reading method. As stated earlier, psycholinguistic and neurolinguistic studies very often attribute the effects of morphological complexity to the underlying process of morphological decomposition inherently associated with word recognition. Given that the underlying process of morphological decomposition happens very early (as evident from earlier studies on morphological processing) and it is followed by morphological and semantic composition and given that reading times in self-paced reading experiments reflect the underlying cognitive processes occurring during and after word recognition (including the time a participant needs to press a button), it may happen so that early effects of morphological decomposition and morphological and semantic composition are reduced or eliminated. To capture such early effects of morphological decomposition, a more time-sensitive method should be used.

5.8.3. Discussion related to Prediction 3

In the analysis of Comparison 3 between Condition 2 (iterative imperfective verbs) and Condition 3 (semelfactive perfective verbs) no significant differences were licensed in the sentence-final region as predicted. According to Prediction 3, the parser is not expected to delay their interpretation to later regions in the comparison between iterative imperfective verbs and semelfactive perfective verbs because their meanings are semantically specific. This was confirmed in our results.

Taken together, Experiment 1 revealed strong effects of semantic underspecification of simple imperfective verbs as compared to semantically more specific perfective and iterative imperfective verbs both on the verbal region and on the sentence-final region. We take it to indicate that due to the characteristics of the self-paced reading method (no rereadings are possible), the comprehenders first attempt to resolve the underspecified meaning of simple imperfective verbs by searching for relevant meaning cues in their working memory and in the absence of such meaning cues, they delay the process of homing in on the proper interpretation of aspectually underspecified verbs to later regions (in our study to the last region).

6. Experiment 2: an eye-tracking during reading experiment

6.1. Language material and predictions

In order to have a more complete picture of how grammatical aspect is processed in Polish, we conducted an eye-tracking experiment. The stimulus material and experimental design for this second experiment was parallel to the first; however, we omitted the spillover region (*and John said so too*) from the stimuli. It has been shown in the study of Magliano et al. (1993, 707) that more wrap-up effects are to be expected in self-paced experiments than in eye-tracking experiments. In addition, the omission of the spill-over region allowed us to present the whole sentence in one line in the eye-tracking study, thereby avoiding line breaks. Avoiding line breaks is important since it has been shown that the layout in which a text is presented may cause differences in reading patterns (see Koops van 't Jagt et al. 2014). We also changed slightly the division of the sentences into Interest Areas (the adjective and the noun were presented separately), so that the critical verb is now displayed in IA 4. An example of a typical sentence quartet with the division into IAs is given in Table 7.

Table 7: Eye-tracking stimuli divided into conditions and Interest Areas

Condition	IA 1	IA 2	IA 3	IA 4	IA 5	IA 6
1: simple imperfective verbs	Maria powiedziała, że Mary said that	nadąsany sulky	dzieciak kid	**wył** **screamed**	głośno loudly	w piaskownicy in sandpit
2: iterative imperfective verbs	Maria powiedziała, że Mary said that	nadąsany sulky	dzieciak kid	**tupał** **stamped** **repeatedly**	głośno loudly	w piaskownicy in sandpit
3: semelfactive perfective verbs	Maria powiedziała, że Mary said that	nadąsany sulky	dzieciak kid	**tupnął** **stamped** **once**	głośno loudly	w piaskownicy in sandpit
4: simple perfective verbs	Maria powiedziała, że Mary said that	nadąsany sulky	dzieciak kid	**zawył** **started** **screaming**	głośno loudly	w piaskownicy in sandpit

The predictions in Experiment 2 were the same as the ones in Experiment 1.

We conducted the same comparisons as in Experiment 1 repeated here for convenience.

(13) Comparison 1: Condition 1 (simple imperfective verbs) vs. Condition 2 (iterative imperfective verbs)
Comparison 2: Condition 1 (simple imperfective verbs) vs. Condition 4 (simple perfective verbs)
Comparison 3: Condition 2 (iterative imperfective verbs) vs. Condition 3 (semelfactive perfective verbs)

6.2. Participants

Forty eight Polish native speakers (35 female and 13 male, mean age 19.5 (SD = 0.3, range 19–20 years) were recruited at the University of Wrocław. Participants received partial course credit. They had no known neurological or reading-related problems. No participant was excluded before the final data analysis. The mean error rate was 8.81% (SD = 9.73) over all conditions. The mean error rates per conditions and fillers were as follows: For Condition 1 it was 13.37% (SD = 10.09), for Condition 2 it was 6.60% (SD = 5.29), for Condition 3 it was 10.07% (SD = 9), for Condition 4 it was 5.21% (SD = 6.86), for fillers it was 5.24% (SD = 0.76).

6.3. Procedure

Participants were tested individually. Eye movements were recorded using an Eye Link 1000 Plus eyetracker by SR Research interfaced with a compatible PC. The sampling rate was 2000 Hz. Viewing was binocular, but only the dominant eye was monitored. We used a paper roll test to determine eye-dominance. All sentences in this experiment were displayed in a single line with a maximum length of 75 characters. Stimuli were displayed on a 24-inch BenqXL monitor. Participants were seated 61 cm from the computer screen. At this distance, 3.6 characters subtended 1° of visual angle; the eye-tracker has a resolution of <0.01° RMS. Before the experiment, participants were asked to sit comfortably in front of the computer screen. A head support and a chin rest were used to stabilize the head.

After the written instruction, participants received a practice block with 10 sentences and questions, followed by explicit feedback to their answers. Participants were asked to read the sentences for understanding and to read at a normal rate. During the practice session and during the actual experimental session, a calibration routine was performed, and its accuracy was checked after each sentence. After reading each sentence, the

participants pressed a button to remove the sentence. Each sentence was followed by a yes-no comprehension question. The whole experiment lasted approximately 30 minutes.

In each version experimental sentences and fillers were randomized. Not more than two sentences from the same condition were displayed one after another. Sentences with the same beginnings up to the verb were equally distributed across versions.

6.4. Data preparation

Each sentence was divided into six IAs as shown below:

(14) Maria powiedziała, że | nadąsany | dzieciak | **wył** | głośno | w piaskownicy.
      Mary said that | sulky | kid | **screamed** | loudly | in sandpit
      'Mary said that a sulky kid screamed loudly in a sandpit.'

The IAs will be referred to as IA 1, IA 2, IA 3, IA 4, IA 5, IA 6. IA 4 is the critical Interest Area, where verbs differed in semantic complexity and markedness (marked in bold in the example above).

Due to coding errors in our stimuli with individual sentences in some randomizations, we had to remove 1.27% of the data. For the remaining data, reading time measures were normalized to percent of total sentence reading time. This means that the total sentence reading time was calculated for each participant and sentence, and reading time measures were converted to the percentage that they contributed individually to the total sentence reading time.

For each reading time measure, data points contributing more than 99% or less than .05% to the total sentence reading time were removed. Outliers were defined as values that deviated more than two standard deviations from a participant's mean per condition per position, and were removed before the final data analysis. The amount of data removed before analysis is given for each reading time measure below in section 6.5.

We calculated results for the following reading time measures for all interest areas starting from the position of the critical verb (i.e., IA 4): *first pass times* (the sum of all fixations in a region prior to leaving the IA for the first time, either to the left or to the right), *regression path durations* (the sum of all fixations from the first fixation in an IA up to but excluding the first fixation to the right of this IA, including any time spent to the left of the IA after a regressive eye movement and any time spent re-reading material in the IA before moving on) and *total reading time* (the sum of all fixations made within an IA, including those fixations made when re-

reading the IA). Additionally, we analyzed regression patterns into and out of all IAs (these two measures show the proportion of sentences in a condition when participants made regressions out of or into a region).

6.5. Results of the eye-tracking study

Average accuracy for the comprehension questions was above 91.19%, with no participant scoring below 70%. Three reading time measures were computed: first pass time, regression path durations and total reading times.

A summary of the mean normalized reading time measures for IAs per condition, and mean regression measures in and out of IAs per condition is given in Table 8. Data were analyzed in *R* (R Development Core Team 2005) with linear mixed effects models, using the packages *lme4* (Bates et al. 2015, *lmer* function for reading time measures, *glmer* function for regressions) and *LMERConvenienceFunctions* (Tremblay & Ransijn 2015, *summary* function).

For the first pass times, 2.6% of the data were removed as extreme values. The condition-based outlier removal procedure led to the removal of 4.7% of the data. First pass times for each Interest Area were analyzed with a linear mixed effects model. CONDITION was specified as fixed effect, and PARTICIPANT and ITEM as random intercepts. In addition, CONDITION was specified as random slope for PARTICIPANT and ITEM.

For regression path times, 2.6% of the data were removed as extreme values. The condition-based outlier removal procedure led to the removal of 5.3% of the data. Regression path times were analyzed with the same model as first pass times.

For total reading times, 2.6% of the data were removed as extreme values. The condition-based outlier removal procedure led to the removal of 3.4% of the data. Total reading times were analyzed with a linear mixed effects model. CONDITION was specified as fixed effect, and PARTICIPANT and ITEM as random intercepts. In addition, CONDITION was specified as random slope for PARTICIPANT. It was necessary to choose a slightly reduced random effects structure for this last analysis because the model would frequently not converge when the random effects structure included CONDITION as a random slope for ITEM.

For regressions into and out of IAs a generalized linear mixed model for binomial data was used. CONDITION was specified as fixed effect, and PARTICIPANT and ITEM as random effect. In addition, CONDITION was specified as a random slope for PARTICIPANT.

Analysis followed the planned comparisons outlined above. Data for individual IAs were analyzed separately. Only statistically significant effects are reported, unless explicitly stated otherwise. We present the results for each of the planned comparisons, and for each investigated reading time measure. Full tables for the fixed effects reported here are given in Appendix B.

Comparison 1: Condition 1 (simple imperfective verbs) vs. Condition 2 (iterative imperfective verbs). Full tables for the fixed effects of the results reported here are given in Appendix B in Table 13 for reading time measures, and in Table 14 for regressions. Total reading time: there was a statistically significant effect of CONDITION in IA 6 ($t = -2.22$, $p < .03$). Total reading times in IA 6 was longer for simple imperfective verbs than for iterative imperfective verbs.
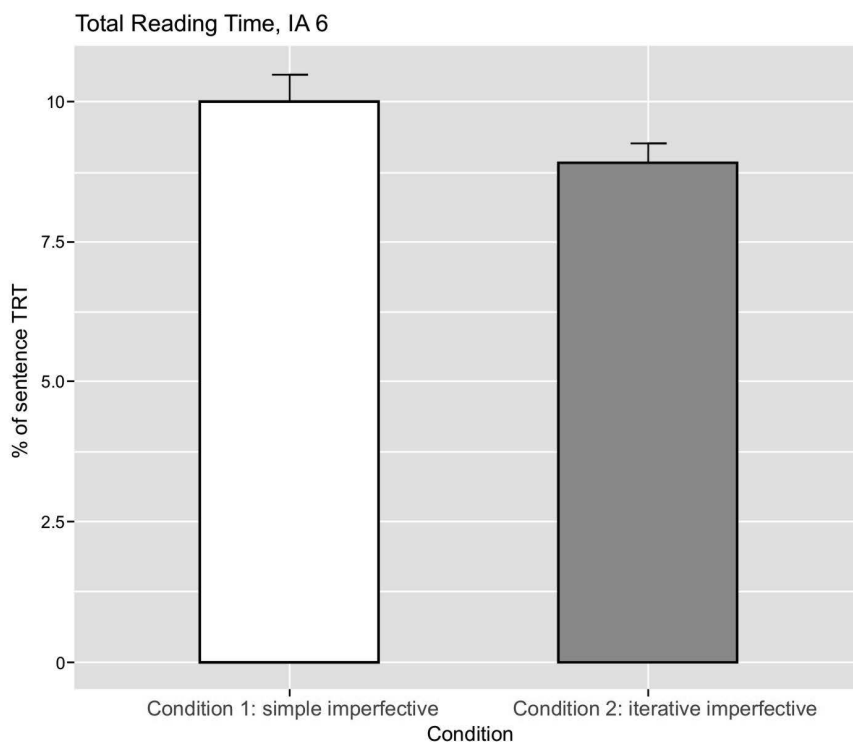
Figure 4: Participants' Total Reading Times in % of Total Sentence Reading Time for IA 6 for Comparison 1 between Condition 1 (simple imperfective) and Condition 2 (iterative imperfective)

Regressions into IA: there was a marginally significant effect of CONDITION for regressions into IA 1 ($z = -1.9$, $p < 0.06$) and IA 3 ($z = -1.9$, $p < 0.06$), and a statistically significant effect of CONDITION for regressions into IA 4 ($z = 2.19$, $p < .05$). More regressions were made into IAs 1 and 3 for simple imperfective verbs than for iterative imperfective verbs, and more regressions were made into IA 4 for iterative imperfective verbs than for simple imperfective verbs.
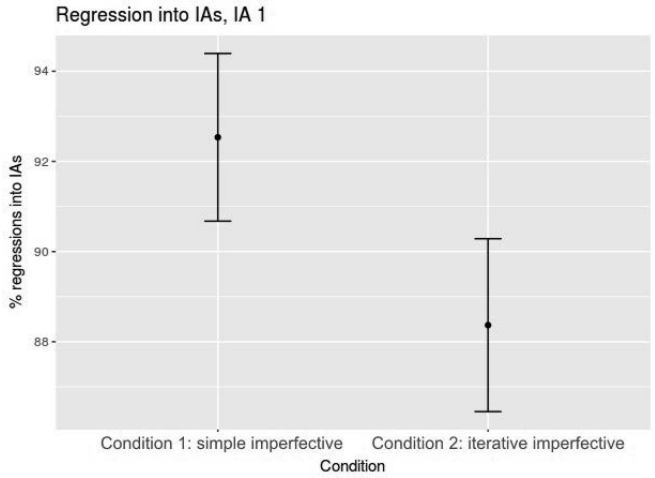

Figure 5: Participants' Regressions into IA 1, i.e., % of sentences in which participants made regressions into IA 1 in Condition 1 and Condition 2
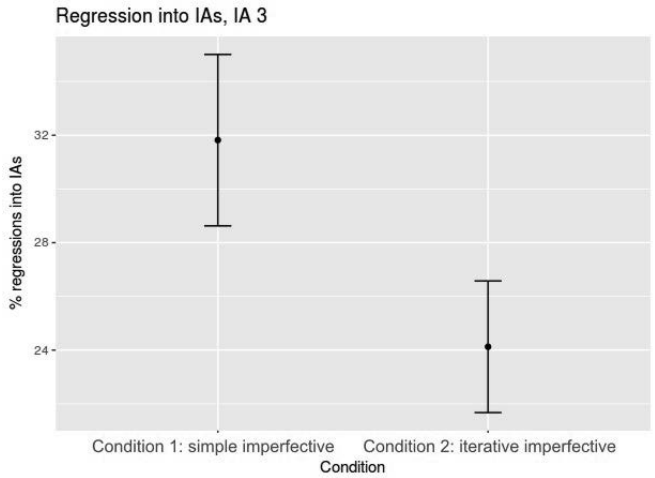

Figure 6: Participants' Regressions into IA 3, i.e., % of sentences in which participants made regressions into IA 3 in Condition 1 and Condition 2
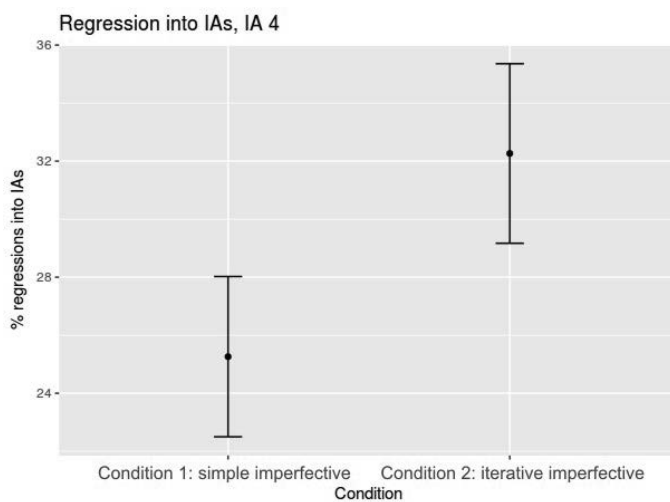
Figure 7: Participants' Regressions into IA 4, i.e., % of sentences in which participants made regressions into IA 4 in Condition 1 and Condition 2

Comparison 2: Condition 1 (simple imperfective verbs) vs. Condition 4 (simple perfective verbs). Full tables for the fixed effects of the results reported here are given in Appendix B in Table 15 for reading time measures, and in Table 16 for regressions. **First pass time:** there was a statistically significant effect of CONDITION in IA 6 ($t = -2.32$, $p < .05$). First pass times in IA 6 were longer for simple imperfective verbs than for simple perfective verbs.
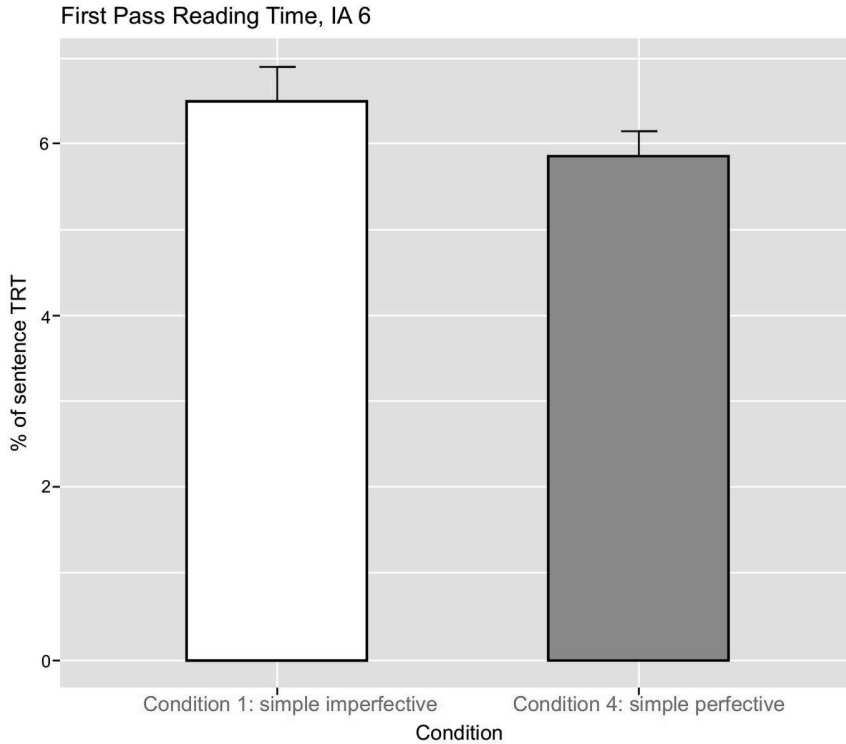

Figure 8: Participants' First Pass Reading Times in % of Total Sentence Reading Time for IA 6 for Comparison 2 between Condition 1 (simple imperfective) and Condition 4 (simple perfective)

Total reading time: there was a statistically significant effect of CONDITION in IA 4 ($t = 2.16$, $p < .05$) and IA 6 ($t = -2.84$, $p < .01$). Total reading times were longer for simple perfective verbs than for simple imperfective verbs in IA 4, and longer for simple imperfective verbs than for simple perfective verbs in IA 6.
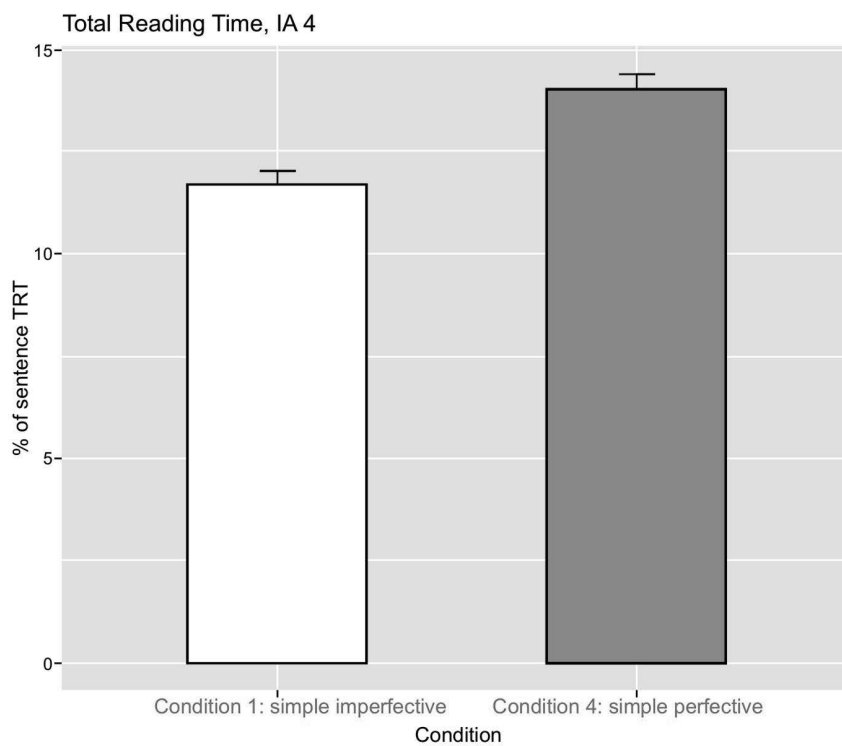
Total Reading Time, IA 4

Figure 9: Participants' Total Reading Times in % of Total Sentence Reading Time for IA 4 for Comparison 2 between Condition 1 (simple imperfective) and Condition 4 (simple perfective)

Figure 10: Participants' Total Reading Times in % of Total Sentence Reading
Time for IA 6 for Comparison 2 between Condition 1 (simple imper-
fective) and Condition 4 (simple perfective)
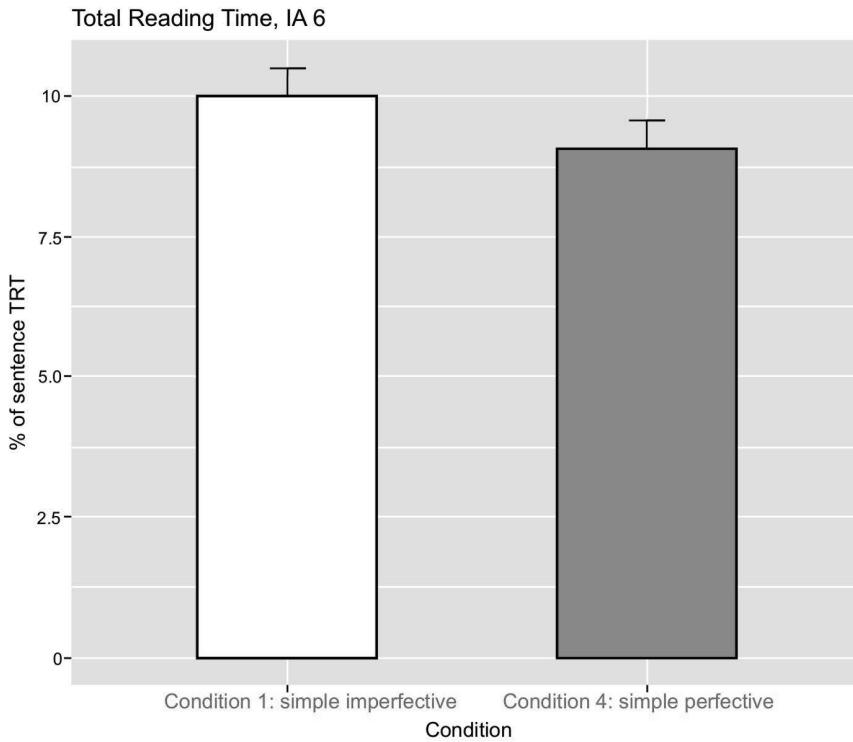
Regressions into IA: there was a statistically significant effect of CONDI-
TION for regressions into IA 1 ($z = -2.20$, $p < 0.03$) and Interest Area 4
($z = 2.70$, $p < .01$). More regressions were made into IA 1 and IA 4 for
simple perfective verbs than for simple imperfective verbs.

Regression into IAs, IA 1

Figure 11: Participants' Regressions into IA 1 i.e., % of sentences in which participants made regressions into IA 1 in Condition 1 and 4

Regression into IAs, IA 4

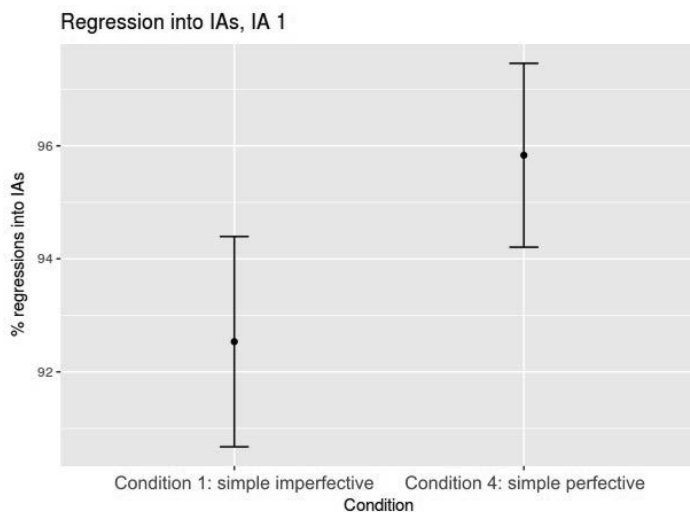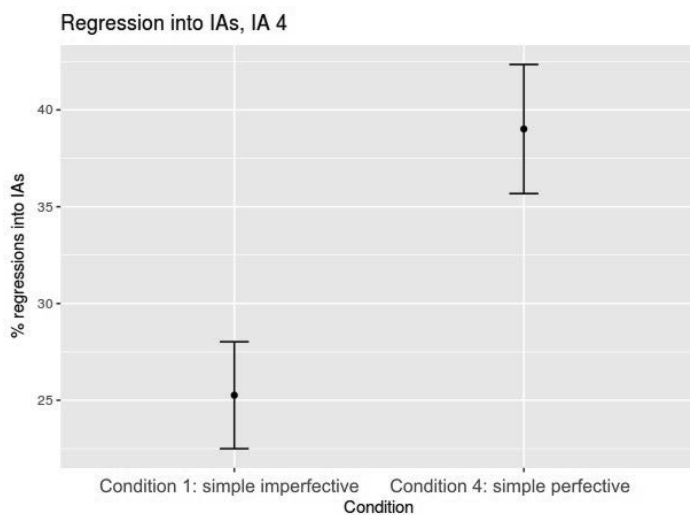**Figure 12:** Participants' Regressions into IA 4, i.e., % of sentences in which participants made regressions into IA 4 in Condition 1 and 4

Regressions out of IA: there was a statistically significant effect of CONDI-TION for regressions out of IA 6 ($z = 2.16$, $p < .05$). More regressions were made out of IA 6 for simple perfective verbs than for simple imperfective verbs.
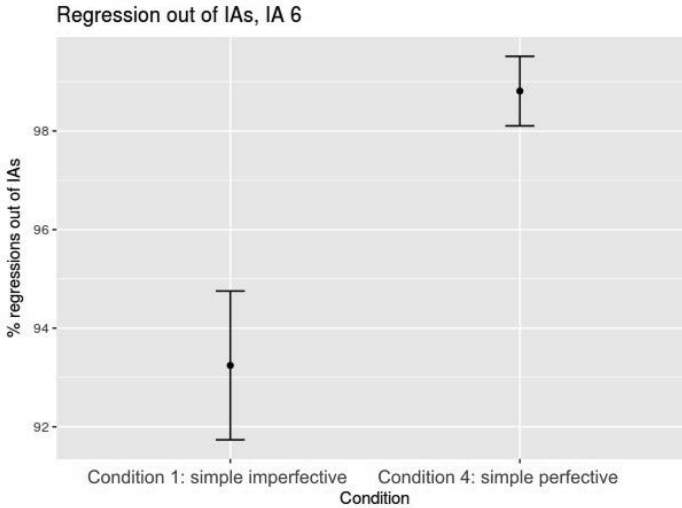
Figure 13: Participants' Regressions out of IA 6, i.e., % of sentences in which participants made regressions out of IA 6 in Condition 1 (simple imperfective) and Condition 4 (simple perfective)

Comparison 3: Condition 2 (iterative imperfective verbs) vs. Condition 3 (semelfactive perfective verbs). Full table for the fixed effects of the results reported here are given in Appendix B in Table 17 for reading time measures (none for regressions). **Total reading time:** there was a statistically significant effect of CONDITION in IA 4 ($t = 2.16$, $p < .05$). Total reading times were longer in IA 4 for semelfactive perfective verbs than for iterative imperfective verbs.
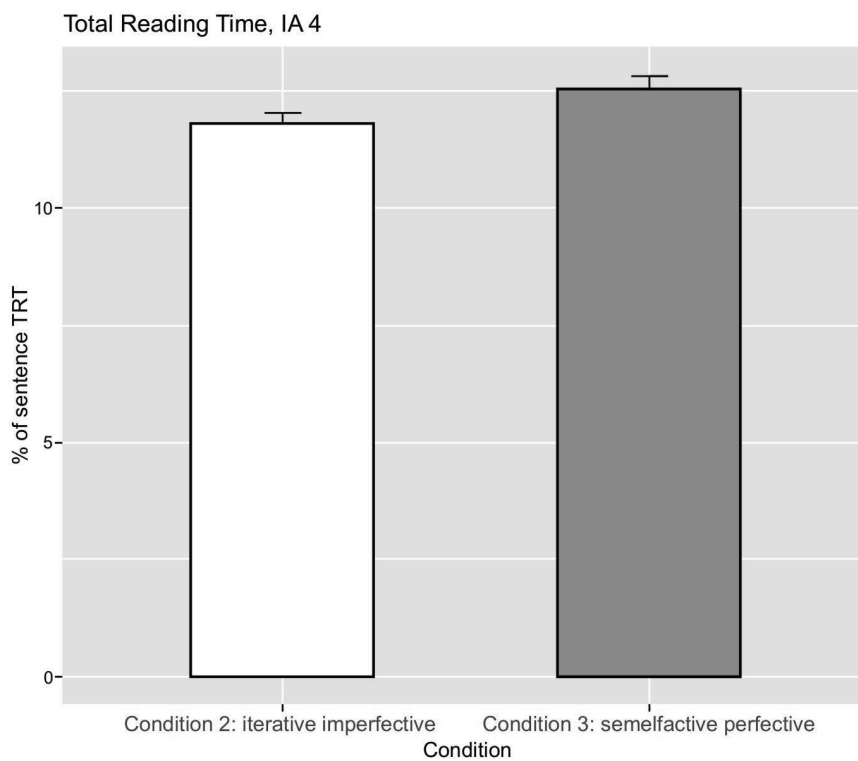
Total Reading Time, IA 4

Figure 14: Participants' Total Reading Times in % of Total Sentence Reading Time for IA 4 for Comparison 3 between Condition 2 (iterative imperfective) and Condition 3 (semelfactive perfective)

Table 8 presents the % of Total Sentence Reading Time as well as the standard errors of the participant means (for each participant and sentence individually).

Table 8: Participant Normalized Mean Reading Times in % of Total Sentence Reading Time (for each participant and sentence individually) for Experiment 2. Standard error of the mean is given in parentheses.

Measure	IA 1	IA 2	IA 3	IA 4	IA 5	IA 6
First pass reading time						
Condition 1	18.01 (0.76)	5.74 (0.19)	4.61 (0.16)	5.46 (0.22)	5.15 (0.19)	6.48 (0.40)
Condition 2	18.34 (0.68)	6.22 (0.26)	5.03 (0.20)	5.17 (0.18)	4.98 (0.22)	6.06 (0.26)
Condition 3	18.32 (0.71)	5.81 (0.24)	4.78 (0.19)	5.25 (0.16)	4.69 (0.18)	6.06 (0.33)
Condition 4	18.37 (0.84)	5.97 (0.23)	4.60 (0.18)	5.82 (0.27)	4.82 (0.26)	5.86 (0.28)
Regression path reading time						
Condition 1	18.01 (0.74)	6.01 (0.22)	5.46 (0.20)	6.65 (0.40)	8.14 (0.94)	58.43 (1.18)
Condition 2	18.60 (0.67)	6.46 (0.25)	5.72 (0.24)	6.09 (0.32)	8.43 (0.94)	57.79 (1.02)
Condition 3	18.30 (0.68)	6.26 (0.24)	5.62 (0.25)	6.55 (0.46)	8.71 (0.87)	58.79 (1.07)
Condition 4	18.61 (0.87)	6.32 (0.26)	5.28 (0.24)	7.01 (0.59)	8.28 (0.84)	58.15 (1.38)
Total reading time						
Condition 1	40.66 (0.84)	15.10 (0.38)	11.25 (0.25)	11.70 (0.32)	10.39 (0.32)	9.99 (0.48)
Condition 2	41.81 (0.75)	15.92 (0.47)	11.52 (0.26)	11.77 (0.25)	9.18 (0.32)	8.89 (0.38)
Condition 3	41.34 (0.69)	15.25 (0.38)	11.37 (0.27)	12.52 (0.27)	9.41 (0.24)	9.26 (0.46)
Condition 4	41.04 (0.78)	15.36 (0.33)	11.46 (0.26)	14.02 (0.37)	8.71 (0.33)	9.05 (0.50)
Regressions out of IAs						
Condition 1	0(0)	4.73(1.02)	10.87 (1.65)	7.03 (1.18)	17.20 (2.25)	93.24 (1.50)
Condition 2	0(0)	4.16 (0.95)	6.79 (1.17)	6.62 (1.19)	17.64 (2.27)	90.99 (1.62)
Condition 3	0(0)	5.62 (1.13)	10.87 (1.65)	7.72 (1.21)	19.62 (2.63)	97.77 (0.79)
Condition 4	0(0)	3.65 (0.87)	10.47 (1.78)	7.00 (1.43)	19.89 (3.13)	98.81 (0.71)
Regressions into IAs						
Condition 1	92.53 (1.86)	47.53 (3.01)	31.81 (3.19)	25.26 (2.76)	29.83 (3.42)	0(0)
Condition 2	88.36 (1.91)	41.26 (2.99)	24.12 (2.45)	32.26 (3.09)	24.50 (3.53)	0(0)
Condition 3	97.69 (1.12)	44.96 (3.10)	28.47 (2.93)	37.60 (2.77)	31.45 (3.68)	0(0)
Condition 4	95.83 (1.62)	50.00 (2.82)	30.47 (2.92)	39.02 (3.33)	27.95 (3.63)	0(0)

6.6. Discussion of the results of the eye-tracking experiment

Table 9 systematizes the obtained results for all the four comparisons and it provides a point of reference for the later discussion.

Table 9: Summary of the results

Comparison 1	*Condition 1: simple imperfective*	*Condition 2: iterative imperf.*
	significantly longer total reading times in IA 6	significantly more regressions into IA 4
	significantly more regressions into IA 1 and IA 3	
Comparison 2	*Condition 1: simple imperfective*	*Condition 4: simple perfective*
	significantly longer first pass times in IA 6	significantly longer total reading times in IA 4
	significantly longer total reading times in IA 6	significantly more regressions into IA 1 and IA 4
		significantly more regressions out of IA 6
Comparison 3	*Condition 2: iterative imperf.*	*Condition 3: semelfactive perf.*
		significantly longer total reading times in IA 4

6.6.1. Discussion related to Prediction 1

In Comparison 1 (between simple imperfective verbs in Condition 1 and iterative imperfective verbs in Condition 2), simple imperfective verbs triggered significantly longer total reading times than iterative imperfective verbs in the last IA (i.e., IA 6). Additionally, there were significantly more regressions in sentences with simple imperfective verbs into IA 1 and IA 3.

In Comparison 2 (between simple imperfective verbs in Condition 1 and simple perfective verbs in Condition 4), simple imperfective verbs triggered significantly longer first pass and total reading times than simple perfective verbs in the last IA (i.e., IA 6).

The results of the analysis of Comparison 1 (between simple imperfective verbs and iterative imperfective verbs) and Comparison 2 (between simple imperfective verbs and simple perfective verbs) confirm our key Prediction 1, which was based on the model of processing semantically underspecified verbs proposed by Frisson and Pickering (1999), Pickering and Frisson (2001), and Frisson (2009). According to their model, while

interpreting a semantically underspecified (polysemous verb) the processor does not select between its alternative senses but it initially activates its underspecified meaning and subsequently homes in on the precise sense for the verb (possibly at the end of the sentence). This model is reflected in our results which seem to indicate that the degree of semantic specificity of perfective and imperfective verbs in Polish has an impact on the timing of their interpretation. More specifically, we expected a delay in the parser's homing in on the proper interpretation of semantically underspecified simple imperfective verbs in Condition 1 as compared to semantically more specific iterative imperfective verbs in Condition 2 and simple perfective verbs in Condition 4. This homing-in stage was predicted to be computationally costly and this cost was expected to lead to longer reading times on the sentence-final region. This prediction is confirmed. The fact that the comprehenders made significantly more regressions in sentences with simple imperfective verbs into IA 1 and IA 3 than in sentences with iterative imperfective verbs in Comparison 1 may indicate that the parser attempted to resolve the underspecified meaning of simple imperfective verbs earlier on the verbal region but in the absence of contextual support in the preverbal regions it delayed the process to the end of the sentence.

6.6.2. Discussion related to Prediction 2

In Comparison 2 (between simple imperfective verbs in Condition 1 and simple perfective verbs in Condition 4), perfective verbs triggered significantly longer total reading times in IA 4, significantly more regressions into IA 1 and IA 4 and significantly more regressions out of IA 6. As expected, perfective verbs turned out to be computationally more costly on the verbal region. We attribute this result to a greater morphological complexity of perfective verbs as compared to their bare imperfective counterparts. In Comparison 3 (between iterative imperfective verbs in Condition 2 and semelfactive perfective verbs in Condition 4), semelfactive perfective verbs triggered significantly longer total reading times in IA 4. This result is compatible with what was predicted; namely, semelfactive perfective verbs turned out to be computationally more costly on the verbal region. We attribute this result to their greater morphological complexity leading to their early decomposition followed by morphological and semantic composition. Since the predicted effect of morphological complexity was not reflected in first pass reading times but in total reading times, we take this to mean that the observed effect reflects either both morphological decomposition followed by morphological and semantic composition or just the second stage, i.e., morphological and semantic composition. The lack of

significant effect for first pass reading times (early measure) would speak in favor of the second option.

6.6.3. Discussion related to Prediction 3

In the analysis of Comparison 3 between Condition 2 (iterative imperfective verbs) and Condition 3 (semelfactive perfective verbs) no significant differences were observed in the sentence-final region IA 6. This expectation was confirmed. This is a null result but it suggests that the meaning of both iterative imperfective verbs and semelfactive verbs is semantically specific hence no delay in their interpretation is licensed in later regions.

6.6.4. Discussion related to additional findings

Two additional effects were licensed in the eye-tracking study; namely, a significantly greater proportion of regressions from the last region to the verbal region for perfective verbs were made as compared to simple imperfective verbs and a significantly greater proportion of regressions were made to iterative imperfective verbs than to simple imperfective verbs from later regions.

A greater proportion of regressions from the last region to the verbal region for perfective verbs in comparison with simple imperfective verbs may suggest that the comprehenders control the contextual fit of the initially chosen individuation boundaries imposed by perfective aspect on the input eventuality. This interpretation is compatible with Filip's (2017) semantics of perfective aspect which is formally represented in form of a MAX_E operator. MAX_E imposes individuation boundaries on an input eventuality (see section 2.1.3. and 2.1.4.). Crucially, Filip (2017) makes the placement of individuation boundaries for perfective aspect (MAX_E) dependent both on the lexical properties of the predicate and context. We suggest the following mechanism of processing perfective aspect: the comprehenders make an early commitment to the placement of individuation boundaries while computing the semantics of perfective aspect on the verbal region and then at the end of the sentence they verify whether their initial choice is compatible with the sentential context. This procedure was reflected in more regressions for perfective verbs to the verbal region and to the sentence-initial region (from which they probably started to read the sentence again to make sure that the initial choice of individuation boundaries for perfective verbs fits the sentential context). This interpretation deserves to be verified in further experiments.

An additional unexpected effect was observed in Comparison 1 between Condition 1 (simple imperfective verbs) and Condition 2 (iterative

imperfective verbs), namely, a significantly greater proportion of regressions was made to iterative imperfective verbs than to simple imperfective verbs from later regions. This finding may be tentatively related to the fact that there is a number of such iterative imperfective verbs in Slavic which are ambiguous between an iterative reading and a "slow-motion camera" reading focusing on a single protracted atomic unit. Most of the iterative imperfective verbs used in our experiments are divisible into very short-lasting discrete units; consider, e.g., *kichać*[I] 'to sneeze repeatedly', *mrugać*[I] 'to wink repeatedly', *mlaskać*[I] 'to slurp repeatedly', *klikać*[I] 'to click repeatedly', *tupać*[I] 'to stamp repeatedly', *stukać*[I] 'to knock repeatedly' and their iterative meaning is strongly dominant (most plausible) (the "slow-motion camera" reading focusing on a single unit of sneezing, winking or clicked perceived as a continuous activity is not easily available without any strongly supporting context) but there were some (though not many) instances of iterative imperfective verbs used in our experiment such as, for example, *łykać*[I] 'to swallow', *dmuchać*[I] 'to blow', *trąbić*[I] 'to trumpet', *ryczeć*[I] 'to roar', which are decomposable into conceptually longer discrete units and these instances may have created an ambiguity between an iterative meaning and a simple activity reading referring to a single protracted unit of swallowing, blowing or trumpeting understood as an activity. It is questionable, however, whether those few more ambiguous iterative imperfective verbs may have contributed to a larger proportion of regression to iterative verbs than to simple imperfective verbs. This cannot be conclusively answered based on the findings of our study. Another possible interpretation of this result is that there may have been some differences in the plausibility between iterative imperfective vs. simple imperfective verbs and their modifiers. Since this factor was not systematically studied in our experiments, it remains to be investigated in later experiments related to this topic. Concerning a related question of why such possible effects of plausibility observed in the eye-tracking experiment were not found in post-verbal regions in the self-paced reading experiment, this can be attributed to the fact that in the self-paced reading experiments the comprehenders very often make use of a buffering strategy and the potential effects of plausibility (observed in the eye-tracking study) may have been delayed to the final region in the self-paced reading study. If so, they may have been suppressed by significant effects of resolving underspecification of simple imperfective verbs also manifested in the sentence-final region in Comparison 1. This interpretation is to be taken with caution.

7. Global discussion

The main goal of this study was to investigate the time course of processing perfective and imperfective verbs in Polish depending on the degree of their semantic specificity and morphological complexity. In order to obtain this goal, two experiments were conducted (using a self-paced reading and an eye-tracking method), both focusing on three comparisons: (i) simple imperfective verbs and simple perfective verb; (ii) simple imperfective verbs and iterative imperfective verbs; (iii) iterative imperfective verbs and semelfactive perfective verbs. In testing the impact of the degree of semantic specificity on the processing of aspect in Polish we formulated our predictions based on the model of processing semantically underspecified verbs proposed by Frisson and Pickering (1999), Pickering and Frisson (2001), and Frisson (2009) and based on the findings of earlier psycholinguistic and neurolinguistic studies providing evidence that the cognitive system is sensitive to the morphological complexity of words. In the model of processing semantic underspecification proposed in Frisson & Pickering (1999), Pickering & Frisson (2001) and Frisson (2009) it is assumed that while interpreting a semantically underspecified (polysemous) verb, the processor does not select between its alternative senses but it initially activates its underspecified meaning and subsequently homes in on the precise sense for the verb (possibly at the end of the sentence). This model is reflected in our results which indicate that the degree of semantic specificity of perfective and imperfective verbs in Polish has an impact on the timing of their interpretation. More specifically, we observed a delay in the parser's homing in on the proper interpretation of semantically underspecified simple imperfective verbs at the end of the sentence as compared to semantically more specific iterative imperfective verbs and simple perfective verbs. The homing-in stage on the last region triggered computational cost and this cost led to longer reading times on the sentence-final region both in the self-paced reading and in the eye-tracking experiment. However, our additional prediction was that the parser should attempt to resolve the underspecified meaning of simple imperfective verbs earlier (potentially already on the verbal region), which was expected to generate some computational cost reflected in either longer reading measures in the verbal region or a greater proportion of regressions to preverbal regions depending on the method used. This prediction is compatible with what was suggested by Frisson and Pickering (1999). They claim that the homing-in stage (the time when a specific interpretation for a semantically underspecified word is obtained) depends on many factors, among them

being the requirements of the task (e.g., whether there is time pressure or whether a full understanding of every single word is required), and on the characteristics of the method used (e.g., unlike eye-tracking during reading, self-paced reading does not allow rereading). Such a methodological difference between our self-paced reading experiment and the eye-tracking experiment was observed. Early attempts to resolve the semantic underspecification of simple imperfective verbs manifested themselves in longer reading times in the verbal region in the self-paced reading experiment and more regressions to preverbal regions possibly from the verbal region in the eye-tracking study. Additionally, in both experiments no significant differences were observed in the sentence-final region in the comparison between iterative imperfective verbs and semelfactive verbs, which suggests that their meaning is specific and hence no delay in their interpretation is licensed in later regions.

Effects of morphological complexity were observed in the eye-tracking study both in the comparison between simple imperfective verbs and their prefixed counterparts and between iterative imperfective verbs and their suffixed semelfactive counterparts. Longer reading times were obtained on morphologically complex verbal forms, which may be attributed to the underlying process of morphological decomposition followed by morphological and semantic composition. The effects of morphological complexity were not confirmed in our self-paced reading experiment. This may be an artifact of the self-paced-reading method, which is less time-sensitive than the eye-tracking method. Given that reading times in self-paced reading experiments reflect the underlying cognitive processes occurring during and after word recognition (including the time a participant needs to press a button), it may happen so that the effects of early morphological decomposition and the following morphological and semantic composition are reduced or eliminated. Since there was no significant effect of morphological complexity for first pass reading times (early measure) but there was a significant effect of morphological complexity for total reading times (late measure) in the eye-tracking experiment, it is more likely that the observed effect reflects the second stage, i.e., morphological and semantic composition of morphologically complex words used in our experiment.[15]

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[15] As pointed out by an anonymous reviewer, morphological complexity was positively correlated with word length in Comparison 2 between simple perfective verbs and simple imperfective verbs (the former being one syllable longer). Given this, the observed effect of morphological complexity in Comparison 2 could have more than one source. We agree that this may be a potential problem. However, in Comparison 3 between semelfactive perfective verbs and iterative imperfective verbs we also report

Two additional effects were licensed in the eye-tracking study; namely, a greater proportion of regressions from the last region to the verbal region for perfective verbs were made as compared to simple imperfective verbs and a significantly greater proportion of regressions were made to iterative imperfective verbs than to simple imperfective verbs from later regions.

A greater proportion of regressions from the last region to the verbal and sentence-initial region for perfective verbs in comparison with simple imperfective verbs may suggest that the parser controls whether the initially assumed individuation boundaries for perfective verbs are compatible with the sentential context. This interpretation is in line with Filip's (2017) context-dependent formal semantics of perfective aspect.

A significantly greater proportion of regressions to iterative imperfective verbs than to simple imperfective verbs from later regions may be tentatively related to the fact that it is more difficult to integrate post-verbal modifiers with iterative verbs which are conceptually decomposable into discrete units. Another interpretation may be that some (though not many) of the iterative imperfective verbs in our experiment such as, for example, *łykać*[I] 'to swallow', *dmuchać*[I] 'to blow', *trąbić*[I] 'to trumpet', *ryczeć*[I] 'to roar' were decomposable into conceptually longer discrete units and these instances may have created an ambiguity between an iterative meaning (very dominant) and a "slow-motion camera" reading referring to a single protracted unit of swallowing, blowing or trumpeting understood as an activity.

To sum up, both experiments confirm our key prediction that the degree of semantic specificity and morphological complexity of aspectual forms of verb have an impact on the time course of their processing.

Acknowledgements

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an effect of morphological complexity but in this case word length cannot be the confounding factor as both types of verbs consisted of two syllables. This analogy between Comparison 2 and 3 weakens the possibility that it was the word length and not morphological complexity that is reflected in the reported results.

Appendix A: Summaries of the fixed effects for the analysis of self-paced reading times

Table 10: Summary of the fixed effects for the analysis of reading times – Comparison 1

	Estimate	Std. Error	Df	t value	Pr($>$|t|)
Position 3					
(Intercept)	6.42	−0.05	47.36	169.34	$<$ 2e−16 ***
CONDITION	−0.05	0.02	221.58	−2.40	0.0174 *
Position 4					
(Intercept)	6.49	0.05	47.62	128.05	$<$ 2e−16 ***
CONDITION	−0.03	0.02	45.04	−1.34	0.187
Position 6					
(Intercept)	7.78	0.037	61.40	211.71	$<$ 2e−16 ***
CONDITION	−0.04	0.02	43.75	−2.13	0.0388 *

Table 11: Summary of the fixed effects for the analysis of reading times – Comparison 2

	Estimate	Std. Error	Df	t value	Pr($>$|t|)
Position 3					
(Intercept)	6.40	0.04	48.91	169.21	$<$ 2e−16 ***
CONDITION	−0.01	0.02	118.79	−0.63	0.532
Position 4					
(Intercept)	6.49	0.05	47.97	126.07	$<$ 2e−16 ***
CONDITION	−0.06	0.02	46.49	−3.13	0.00303 **
Position 6					
(Intercept)	7.78	0.04	52.10	223.71	$<$ 2e−16 ***
CONDITION	−0.07	0.02	43.88	−3.40	0.00143 **

Table 12: Summary of the fixed effects for the analysis of reading times – Comparison 3

	Estimate	Std. Error	Df	t value	Pr($>$|t|)
Position 3					
(Intercept)	6.36	0.05	47.60	142.75	$<$ 2e−16 ***
CONDITION	0.02	0.02	721.60	1.15	0.25
Position 4					
(Intercept)	6.47	0.05	49.50	122.30	$<$ 2e−16 ***
CONDITION	0.02	0.02	980.60	1.19	0.23
Position 6					
(Intercept)	7.74	0.04	61.70	211.45	$<$ 2e−16 ***
CONDITION	0.02	0.02	998.20	1.15	0.249

Appendix B: Summaries of the fixed effects for the analysis of eye-tracking measures

Table 13: Summary of the fixed effects from the analysis of reading time measures – Comparison 1

	Estimate	Std. Error	Df	t value	$Pr(>|t|)$
Total reading times, IA 6					
(Intercept)	2.16	0.052	58.96	41.71	$< 2e−16$ ***
CONDITION	−0.12	0.05	41.11	−2.22	0.0322 *

Table 14: Summary of the fixed effects from the analysis of regressions – Comparison 1

	Estimate	Std. Error	z value	$Pr(>|t|)$
Regressions into IA 1				
(Intercept)	4.79	0.56	8.51	$< 2e−16$ ***
CONDITION	−0.82	0.43	−1.92	0.0543
Regressions into IA 3				
(Intercept)	−0.86	0.14	−6.28	3.45e−10 ***
CONDITION	−0.28	0.14	−1.93	0.0541 .
Regressions out of IA 6				
(Intercept)	−1.01	0.14	−7.20	5.98e−13 ***
CONDITION	0.29	0.14	2.03	0.0422 *

Table 15: Summary of the fixed effects from the analysis of reading time measures – Comparison 2

	Estimate	Std. Error	Df	t value	$Pr(>|t|)$
First pass times, IA 6					
(Intercept)	1.71	0.06	62.02	73.05	$< 2e−16$ ***
CONDITION	0.07	0.04	38.17	−2.32	0.0259 *
Total reading times, IA 4					
(Intercept)	2.37	0.03	62.02	73.05	$< 2e−16$ ***
CONDITION	0.07	0.03	44.14	2.16	0.0361 *
Total reading times, IA 6					
(Intercept)	2.16	0.05	58.37	41.27	$< 2e−16$ ***
CONDITION	−0.14	0.05	39.84	−2.84	0.00709 **

Table 16: Summary of the fixed effects from the analysis of regressions
– Comparison 2

	Estimate	Std. Error	z value	$Pr(>|t|)$
Regressions into IA 1				
(Intercept)	4.99	0.60	8.33	$< 2e{-}16$ ***
CONDITION	−0.88	0.40	−2.20	0.0279 *
Regressions into IA 4				
(Intercept)	−0.99	0.13	−7.87	3.65e−15 ***
CONDITION	0.4194	0.1554	2.699	0.00695 **
Regressions out of IA 6				
(Intercept)	3.46	0.33	10.42	$< 2e{-}16$ ***
CONDITION	0.86	0.40	2.16	0.0308 *

Table 17: Summary of the fixed effects from the analysis of reading time measures
– Comparison 3

	Estimate	Std. Error	Df	t value	$Pr(>|t|)$
First pass times, IA 4					
(Intercept)	2.37	0.03	62.02	73.05	$< 2e{-}16$ ***
CONDITION	0.07	0.03	44.14	2.16	0.0361 *

Appendix C: Verbs used in both experiments

Condition 1: lecieć 'to fly', mamrotać 'to mumble', kpić 'to mock', wirować 'to swirl', skomleć 'to whine', błądzić 'to wander about', psocić 'to misbehave', bełkotać 'to stammer', chichotać 'to chuckle', szydzić 'to jeer', rechotać 'to croak', śpiewać 'to sing', gulgotać 'to gobble', harcować 'to caper', imprezować 'to party', szybować 'to glide', wyć 'to yell', płakać 'to cry', pełzać 'to crawl', wiosłować 'to paddle', żeglować 'to sail', pluć 'to spit', pląsać 'to frolic', beczeć 'to bleat', bębnić 'to drum', rechotać 'to chortle', pędzić 'to race', mknąć 'to speed', piać 'to crow', psioczyć 'to curse', hasać 'to caper', biadolić 'to kvetch', nucić 'to hum', łazić 'to slouch around', kroczyć 'to pace', tańczyć 'to dance' szaleć 'to rave', trajkotać 'to chatter', szybować 'to glide', mknąć 'to canter', nurkować 'to dive', gnać 'to gallop', wędkować 'to fish', plotkować 'to gossip'.

Condition 2: łykać 'to gulp repeatedly', prychać 'to cough repeatedly', klikać 'to click repeatedly', kwiczeć x2 'to sqeal repeatedly', tupać 'to stamp repeatedly', syczeć 'to hiss repeatedly', kaszleć 'to cough repeatedly', migać 'to flash repeatedly', mlaskać 'to squelch repeatedly', pluskać 'to splash repeatedly', kichać 'to sneeze repeatedly', mrugać 'to blink repeatedly', fikać 'to gambol repeatedly', dmuchać 'to blow repeatedly', klaskać 'to clap repeatedly', ryczeć 'to roar repeatedly', brykać 'to frisk repeatedly', pukać 'to knock repeatedly', trąbić 'to honk repeatedly', warczeć 'to snarl repeatedly', błyszczeć 'to flash repeatedly', chrapać 'to snore repeatedly', szurać 'to shuffle repeatedly', bzyczeć 'to buzz repeatedly', chuchać 'to puff repeatedly', kaszleć 'to cough repeatedly', szczekać

'to bark repeatedly', ziewać 'to yawn repeatedly', huczeć 'to hoot repeatedly', machać 'to wave repeatedly', parskać 'to snort repeatedly', chlapać 'to splash repeatedly', mruczeć 'to purr repeatedly', ćwierkać 'to chirp repeatedly', siorbać 'to slurp repeatedly', jęczeć 'to moan repeatedly', stukać 'to knock repeatedly', sapać 'to gasp repeatedly', klękać 'to kneel repeatedly', drgać 'to tremble repeatedly', gwizdać 'to whistle repeatedly', stękać 'to moan repeatedly', pstrykać 'to flick repeatedly', piszczeć 'to trill repeatedly'.

Condition 3: plusnąć 'to splash once', fiknąć 'to gambol once', szarpnąć 'to jerk once', klasnąć 'to clap once', ryknąć 'to roar once', bryknąć 'to frisk once', puknąć 'to knock once', mrugnąć 'to wink once', kwiknąć 'to squeal once', błysnąć 'to flash once', mrugnąć 'to wink once', kichnąć 'to sneeze once', bzyknąć 'to buzz once', chuchnąć 'to puff once', walnąć 'to bang once', mlasnąć 'to slurp once', przytaknąć to nod once', klęknąć 'to kneel once', błysnąć 'to flash once', parsknąć 'to snort once', chlapnąć 'to splash once', pisnąć 'to squeak once', szurnąć 'to shuffle once', huknąć 'to hoot once', machnąć 'to wave once', czknąć 'to hiccup once', jęknąć 'to moan once', stuknąć 'to knock once', szczeknąć 'to bark once', sapnąć 'to gasp once', ziewnąć 'to yawn once', drgnąć 'to jerk once', gwizdnąć 'to whistle once', stęknąć 'to moan once', kwiknąć 'to squeal once', dmuchnąć 'to blow once', łyknąć 'to swallow once', pstryknąć 'to flick once', ziewnąć 'to yawn once', siorbnąć 'to slurp once', tupnąć 'to stamp once', drgnąć 'to jerk once', kaszlnąć 'to caugh once', mignąć 'to flash once'.

Condition 4: przylecieć 'to arrive by air', wkroczyć 'to step in', odpłynąć 'to swim away', zawyć 'to start to bellow', przemówić 'to start to speak', zaśpiewać 'to start to sing'/'to finish singing', poszybować 'to start to glide', pognać 'to start to canter', zanurkować 'to dive in', odskoczyć 'to leap away', zatańczyć 'to start to dance'/'to finish dancing', wtargnąć 'to burst in', pofrunąć 'to fly away', ponarzekać 'to complain for a while', zakpić 'to start to mock', zawirować 'to start to swirl', zaskomlać 'to start to whine', zabłądzić 'to get lost', zaszaleć 'to pain the town red', zabełkotać 'to start to mumble', zachichotać 'to start to giggle', dobrnąć 'to arrive', popędzić 'to start galloping', podleźć 'to approach', zagulgotać 'to start to goggle', poszybować 'to glide away', zawyć 'to start to scream', zaszlochać 'to start to sob', dopłynąć 'to arrive by swimming', pożeglować 'to sail away', poćwiczyć 'to start to exercise'/'to exercise for a while', zabębnić 'to start to drum', zabuczeć 'to start to boo', powędrować 'to wander away', zabeczeć 'to start to bleat', zatrąbić 'to start to honk', zarechotać 'to start to croak', pomknąć 'to canter away', zapiać 'to start to crow', dojechać 'to arrive by car/bike/bus', dolecieć 'to arrive by air', zanucić 'to start to hum', pomknął 'to start to speed'.

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