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Verbs of motion in Polish, I: parts and processes

Ruch to pieniądz.[*]

1. Introduction

Verbs of motion in Slavic languages are a source of many puzzles, but probably the most celebrated of these is the existence of a class of paired imperfective verbs that are very similar in meaning. This is illustrated for Polish in (1): unlike most other imperfective verbs, which lack an imperfective counterpart, many imperfective verbs of motion come in pairs.[1]

(1) a. gotować^i 'cook' (no imperfective counterpart)
     b. biec^i+, biegać^i- 'run' (paired imperfective verbs)

Let us call the category of verbs typified by biec^i+ 'determinate' [zdeterminowany] and the one exemplified by biegać^i- 'indeterminate' [niezdeterminowany], following Forsyth (1970, 319) for Russian.[2] The twelve most common pairs of determinate and indeterminate verbs in Polish are those listed in (2), which is based on Włodarczyk's (1980, 49) inventory.

(2)

Determinate	Indeterminate	
iść^i+	chodzić^i-	'go by foot'
jechać^i+	jeździć^i-	'go by vehicle'
biec^i+	biegać^i-	'run'
lecieć^i+	latać^i-	'fly'
płynąć^i+	pływać^i-	'swim'
pełznąć^i+	pełzać^i-	'crawl'
leźć^i+	łazić^i-	'climb'
nieść^i+	nosić^i-	'carry'
wieść^i+	wodzić^i-	'lead'
wieźć^i+	wozić^i-	'transport'
gnać^i+	ganiać^i-	'chase'
wlec^i+	włóczyć^i-	'haul'

Although it is evident from the list in (2) that determinate verbs bear a strong morphological resemblance to their indeterminate counterparts, Polish doesn't have a productive rule relating the members of the two groups. It is in fact fair to say that imperfectively paired verbs of motion form a closed class in modern Polish. In this connection, note that a number of existing imperfective verbs which denote motion of some kind fall outside of this class, e.g., spacerować^i 'stroll', maszerować^i 'march', podróżować^i 'travel', krążyć^i 'circle, walk around', etc. (cf. Piernikarski (1969, 103–104)). It is doubtful that there is a semantic criterion determining which verbs of motion are imperfectively paired and which are not. The attitude expressed in descriptions of Polish, which I also will adopt, is that the class represented in (2) is a grammatical category of the language, the extension of which is not semantically predictable. Nevertheless, even if we cannot absolutely predict which verbs of motion fall into this class, we may still

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[*] *Motion is money*. From an advertisement for Treasury bills [bony skarbowe] in a Polish weekly.

[1] Superscripts: i = imperfective, p = perfective, + = determinate, − = indeterminate. The +/− distinction plays no role among perfective verbs of motion, but these aren't discussed in this paper. Cases: ACC = accusative, GEN = genitive, LOC = locative, INST = instrumental. The mark # indicates that a sentence is unacceptable on the intended reading.

[2] Less common terms in Polish are determinowany/indeterminowany and docelowy/niedocelowy.

ask—of those that do—what semantic difference underlies the distinction between determinate and indeterminate verbs, given that the pattern doesn't appear to be arbitrary.

The intended scope of this paper is modest. I restrict myself to *actualist* uses of verbs of motion for describing motion in space. Consequently, I don't discuss modal uses, such as those exemplified in (3).

(3) a. Ich dziecko już chodzi$^-$.
their child already walks
'Their child can already walk.'   (ability)

 b. Pociąg jedzie$^+$ sześć godzin z Warszawy do Berlina.
train goes six.ACC hours.GEN from Warsaw.GEN to Berlin.GEN
'It takes six hours for the train to go from Warsaw to Berlin.'   (habituality)

Włodarczyk (1980, 51–52) observes that indeterminate verbs exhibit a wider variety of modal uses than determinate verbs do.3 Piernikarski (1969, 104) remarks that indeterminate verbs are employed in characteristic predications much more often than their determinate counterparts are. While these are puzzling issues, I assume that such problems are best tackled once a better understanding of the actualist uses is achieved.

I also don't treat the *progressive* interpretation of verbs of motion, as in (4), which probably seems like a more serious omission.

(4) a. Kiedy zobaczyłem^P Irenkę, ona pływała$^-$ w basenie.
when saw.I Irenka.ACC she swam in pool.LOC
'When I saw Irenka, she was swimming in the pool.'

 b. Kiedy zobaczyłem^P Teresę, ona biegła$^+$ do biblioteki.
when saw.I Teresa.ACC she ran to library.GEN
'When I saw Teresa, she was running to the library.'

But again, the behavior of verbs of motion in the progressive is also best examined once their behavior in simple actualist contexts is better understood. This is because the progressive interpretation of a sentence is 'built upon' or is derived from its nonprogressive interpretation.4 Thus, if it is unclear how to describe the nonprogressive interpretation of a sentence, it won't be any clearer how to describe its progressive interpretation. For example, the substitution of the indeterminate verb *biegać*$^-$ for *bieć*$^+$ in (4)b results in an unacceptable sentence, as shown in (5), but it is difficult to see how this unacceptability can be accounted for if it is unclear how to represent the meaning of the nonprogressive sentence *Teresa biegała*$^-$ *do biblioteki* in the first place.

(5) # Kiedy zobaczyłem^P Teresę, ona biegała$^-$ do biblioteki.
when saw.I Teresę she ran to library.GEN   (cf. (4)b)

As the title suggests, this paper is the first installment of a series on the semantics of verbs of motion in Polish. When compared with the previous literature on verbs of motion in Polish, my approach is distinctive in that it strives for a formalization of the semantic intuitions involved. Formalization is not an end in itself, but rather an essential way of revealing the successes and shortcomings of a particular analysis. At the same time, however, it is extremely difficult to formalize everything at once, and so one has to concentrate on certain aspects of meaning at the

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3 For example, the determinate verb *iść*$^+$ cannot be substituted for *chodzić*$^-$ in (3)a without a change in meaning. That is, *Ich dziecko już idzie*$^+$ means 'Their child is already walking (somewhere)' and not 'Their child can already walk.'

4 In standard analyses of the progressive (e.g., Dowty (1979)), the contribution of the progressive is represented by the *addition* of a PROG operator to a nonprogressive sentence.

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cost of ignoring others. In the present case, I focus on what seems to be the most salient semantic difference between determinate and indeterminate verbs—roughly, the difference in the types of motion events that they denote.

The paper is structured as follows. In section 2, I review the data and argue that previous approaches to the meaning difference between determinate and indeterminate verbs are inadequate and suggest that we need a better understanding of the domains in which these verbs denote. In section 3, I propose that there are two such domains, one of *coarse processes* and another of *fine processes*.5 I offer a formal characterization of these domains, showing how they are connected by a relation of *refinement*. Finally, in section 4, I use the distinction between two classes of verbs. In a nutshell, whereas determinate verbs denote in the domain of coarse processes, indeterminate verbs denote in the domain of fine processes.

2. Two views on verbs of motion

Although both a determinate verb and its indeterminate counterpart are imperfective, they are not equivalent. Broadly speaking, there are two views in the literature on Polish about how such imperfective pairs differ in meaning: the 'iterative' approach and the 'multidirectional' one.6 While each approach contains a grain of truth, neither alone manages to clarify the meaning difference between determinate and indeterminate verbs.

2.1. Indeterminate verbs as 'iterative'

According to the first view (e.g., Bąk (1977, 261–262)), indeterminate verbs of motion are 'iterative' [*wielokrotny*], whereas their determinate counterparts are 'semelfactive' [*jedno-krotny*].7

The main difficulty with this view is that it is unclear how the intended notion of 'iterativity' [*wielokrotność*] is be characterized. Polish has a class of imperfective verbs—partially listed in (6)—that qualify as 'iterative' in the intuitive sense that they cannot be used to describe specific occurrences of a certain type of process.

(6) mawiać$^-$ 'speak', pisywać$^-$ 'write', czytywać$^-$ 'read', chadzać$^-$ 'walk', siadywać$^-$ 'sit', jadać$^-$ 'eat', ...
(iterative verbs)

Indeterminate verbs of motion do not follow the pattern of these iterative verbs, for they can readily be used to describe specific occurrences of a process, as the divergence between (7)b and (8)b testifies.

(7) a. Irenka często chadzała$^-$ do biblioteki.
Irenka often walked to library.GEN
'Irenka often walked to the library.'

 b. # Irenka wczoraj chadzała$^-$ do biblioteki.
Irenka yesterday walked to library.GEN   (iterative verb)

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5 Henceforth, I will speak of 'processes' instead of 'events', for reasons that would take me too far afield to explain (see Piñón (1995) for discussion of the distinction). Since nothing that I will say here crucially depends on distinguishing processes from events, one could simply think of my processes as 'events' in a broad sense.

6 Since these approaches have never been elaborated formally, my main concern is not with who favors which approach for which reasons. Rather, I am concerned with the intuitions that underlie each approach.

7 In my usage, a semelfactive verb denotes single occurrences of a certain type of process. Note that these occurrences need not be short.

(8) a. Irenka często chodziła⁻ do biblioteki.
         'Irenka often walked to the library.'
     b. Irenka wczoraj chodziła⁻ do biblioteki.   (indeterminate verb)
         'Irenka walked to the library yesterday.'

(7)b contains an iterative verb and is unacceptable, and contrasts with (8)b, which contains an indeterminate verb and is fine. This shows that indeterminate verbs are clearly not 'iterative' in the same way that the iterative verbs are.

The most likely interpretation of (8)b is that Irenka walked at least twice to the library yesterday, i.e., that she made a series of at least two trips to the library. In fact, it's questionable whether the meaning of (8)b is compatible with a situation in which Irenka walked only once to the library, as the contrast in (9) shows.

(9) a. Irenka wczoraj dwa razy chodziła⁻ do biblioteki.
         'Irenka yesterday two times walked to library.GEN'
         'Irenka walked twice to the library yesterday.'
     b. ? Irenka wczoraj raz chodziła⁻ do biblioteki.
         'Irenka yesterday once walked to library.GEN'
         'Irenka walked once to the library yesterday.'

Whereas (9)a is clearly acceptable, the 'status of (9)b is marginal, though perhaps it is not to be ruled out completely. In any case, the 'singular' reading of (8)b is clearly special, and so any analysis should account for it differently than for the 'plural' reading of the sentence.

What is striking about the meaning of (8)b is that it excludes the possibility that Irenka stayed at the library, regardless of how many times she may have walked there. In other words, use of an indeterminate verb in this context implies that the motion process consisted minimally of two parts: (i) motion to a designated point (e.g., the library) and (ii) motion away from it. Determinate verbs lack this property, as the contrast in (10)–(11) indicate.

(10) a. Irenka wczoraj jechała⁺ do Krakowa.   (10)b ⇒ (10)a
         'Irenka yesterday rode to Kraków.GEN'   (10)a ≠ (10)b
     b. Irenka wczoraj jeździła⁻ do Krakowa.
         'Irenka rode to Kraków yesterday.'

(11) a. Teresa wczoraj biegła⁺ przez park.   (11)b ⇒ (11)a
         'Teresa yesterday ran through park.ACC'   (11)a ≠ (11)b
     b. Teresa wczoraj biegała⁻ przez park.
         'Teresa ran through the park yesterday.'

The meaning of the b-sentences express more than that of the a-sentences. For example, whereas the meaning of (10)b requires that Irenka go to Kraków but not stay there, that of (10)a asserts only that she went in the direction of Kraków (which is intended to leave it open whether she went all the way or not). Clearly, if Irenka went to and away from Kraków, then she went in the direction of Kraków at some point, but crucially the reverse does not hold. That the use of jeździć⁻ in (10)b implies that Irenka left Kraków is evident from the fact that (12)b is contradictory, in contrast to (12)a, which is not.⁸

(12) a. Irenka wczoraj jechała⁺ do Krakowa i tam została⁺.
         'Irenka yesterday drove to Kraków and there remained'
     b. # Irenka wczoraj jeździła⁻ do Krakowa i tam została⁺.
         'Irenka drove to Kraków and stayed there.'

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8 Admittedly, (12)a would be more natural with a perfective verb in the first clause (e.g., with *pojechać⁺* 'go by vehicle'), but the point here is to contrast the acceptability of (12)a with the unacceptability of (12)b.

The same pattern characterizes the pair in (11). The meaning of (11)b asserts that Teresa ran through the park to the other end and then went on (possibly back to where she started). The meaning of (11)a, in contrast, merely asserts that she ran in the direction of the other end of the park (which allows that she may have reached it).

The intuition behind the view that indeterminate verbs are 'iterative' seems to be that the motion processes denoted by indeterminate verbs are 'complex', consisting of two or more parts, whereas those denoted by determinate verbs are 'simple', consisting of just one part (viz., the motion process itself). However, the problem with formalizing this intuition is in knowing which parts to count and which to ignore, because even the motion processes denoted by determinate verbs may be internally 'complex' in an obvious sense. For example, the process of riding described in (10)a is made up of many smaller processes of riding, but these are evidently ignored in assessing its 'simplicity'. Similarly, what makes the process of riding described in (10)b 'complex' is that it consists of at least two processes of riding to and away from Kraków, but any complexity internal to (say) the first one-way ride to Kraków is ignored.

Indeed, the verb's PP-complement can affect how the 'simplicity' or 'complexity' of the process is assessed. In (10)–(11) we saw that the meaning of the PP crucially helped to define what counted as a relevant part of the process in question. With other examples, however, the meaning of the PP leaves the individuation of parts much less determined. Consider, for instance, the sentences in (13) together with the situation depicted in (14). (Cf. Piernikarski (1972,56) for a pair comparable to (13).)

(13) a. Nasz pies dziś biegł⁺ᵢ po ulicy.
         'our dog today ran about street.LOC'
     b. Nasz pies dziś biegał⁻ po ulicy.
         'Our dog ran about the street today.'

(14)

The problem here is that both of the sentences in (13) can describe the situation shown in (14), and yet the use of an indeterminate verb in (13)b no more implies 'iterativity' than its determinate counterpart in (13)a. In both cases the dog's run may be continuous and the path of motion may not repeat itself. Unlike in (10)–(11), in (13) the meaning of the PP doesn't help to individuate the relevant parts of the running.

Nevertheless, the intuitive meaning difference between (13)a and (13)b pertains to whether the run consists of a single part or of several. (13)a implies that there was a single process of running and accordingly tends to suggest that the running was somehow 'directed' towards a destination, even if this destination is not expressed overtly. (13)b, in contrast, implies that the run consisted of many parts and therefore tends to suggest that it was somehow aimless, deprived of a destination, even if it did in fact stop at some location. Other pairs illustrate the same point. Take, for example, the one in (15).

(15) a. Irenka wczoraj szła⁺ po parku.
         'Irenka yesterday walked about park.LOC'
     b. Irenka wczoraj chodziła⁻ po parku.
         'Irenka walked about the park yesterday.'

Again, the intuition is that the truth of (15)a is verified by a process that consists of a single stretch of walking, whereas that of (15)b is verified by one that is made up of a number of

smaller stretches. As in (13), the relative sizes (small or big) of the stretch in (15)a and the stretches in (15)b are left open.

Although (13)a and (15)a are not very natural sentences, they are not unacceptable. The problem seems to be that the linguistic context doesn't provide a way of individuating the single run or walk that the determinate verbs describe. No direction or goal of motion is indicated, and the meaning of the po-PP even suggests that the motion had no intended direction or goal. In other words, (13)a and (15)a require more effort to interpret than (13)b and (15)b precisely because no linguistic clue is provided as to why a clearly 'complex' motion process consisting of many parts should also be construed as a 'simple' motion process without proper parts.

Note that whereas we found a clear entailment pattern among the members of proper parts in (10) and (11), no such pattern is evident among the sentences in (13) and (15). There seem to be two reasons for the lack of an entailment relation in the latter examples. For concreteness, let us focus on the pair in (15).

First, the meaning of (15)b is compatible with Irenka's having interrupted her walk with many breaks, though of course she may also walked continuously without a single break. The meaning of (15)a, in contrast, isn't compatible with her having taken breaks: the single stretch of walking described in (15)a is continuous. Given this difference, it is apparent that the meaning of (15)b doesn't entail that of (15)a, for (15)b may describe a process of walking that is interrupted many times, whereas (15)a may not.

The second reason for the lack of an entailment relation is that the meaning of (15)b implies that at least some of the parts of Irenka's walking differed in their spatial direction, i.e., (15)b doesn't describe a motion process taking place along a straight line. The meaning of (15)a, however, is compatible with Irenka's having walked the whole time in a single direction. Consequently, it is clear that the meaning of (15)a doesn't entail that of (15)b, for (15)a may describe a straight line of motion, whereas (15)b may not.

While there is doubtlessly something right about the idea that indeterminate verbs are 'iterative' in the sense that they denote 'complex' motion processes with at least two parts and that determinate verbs are 'semelfactive' in the sense that they denote 'simple' motion processes without proper parts, the central task is to show how what is seemingly a single motion process can be both 'complex' and 'simple' at the same time. Furthermore, as just noted, other factors such as the presence or absence of interruptions and direction of motion seem to figure in the semantics of the distinction between indeterminate and determinate verbs, and so any approach based solely on the said difference between 'complex' and 'simple' motion processes won't be fully adequate.

2.2. Indeterminate verbs as 'multidirectional'

The second and by far more popular view holds that indeterminate verbs are 'multidirectional' [wielokierunkowy]: they describe motion taking place in many directions. Determinate verbs are said to have the opposite function: they are 'unidirectional' [jednokierunkowy], describing motion that takes place in a single direction. Forsyth (1970), Piernikarski (1972), Grochowski (1973a, b), Laskowski (1979), and Włodarczyk (1980) all espouse this view in one form or another.[9]

The problem with this view is that it turns out that the sense of 'direction' appealed to isn't strictly spatial, and yet it's unclear what else it should be. This can be seen by considering the examples in (16) with respect to the situation depicted in (17).

9 Laskowski (1979, 165):"[Die nichtzielgerichteten Verben zeigen an,] daß die Bewegung in verschiedenen Richtungen verläuft. ... [Die zielgerichteten Verben geben] die Bewegung in einer bestimmten Richtung [an]." Laskowski speaks of 'non-goal-directed' (nichtzielgerichtet) and 'goal-directed' (zielgerichtet) verbs, which is misleading, for as Forsyth (1970, 320) rightly points out, "it is essential to define 'direction' clearly, and not to confuse it with the more concrete factor of destination or purpose [...]."

(16) a. Irenka dziś jechała+ drogą Krętą.
Irenka today drove road.INST winding.INST
'Irenka drove along Winding Road today.'

b. Irenka dziś jeździła- drogą Krętą.

(17)
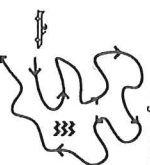
Imagine that droga Kręta is a winding road around a lake. If Irenka drives along it, she heads in many different directions (although in at most one direction at any time, of course). Since this appears to be a good example of 'multidirectional' motion, the second view straightforwardly predicts that use of a determinate verb should be unacceptable. However, as (16) demonstrates, and contrary to the prediction, (16)a (with a determinate verb) is completely acceptable. In fact, it is the acceptability of (16)b (with an indeterminate verb) that is at first glance less obvious. The interpretation of (16)a is that Irenka drove some unspecified distance along droga Kręta today. Her drive was basically uninterrupted, disregarding negligible stops. The interpretation of (16)b, in contrast, is either that she drove several times along droga Kręta today or that her one drive along it was broken up by a number of stops, as though she had been sightseeing. This kind of contrast stands in the way of any simple-minded account of indeterminate and determinate verbs in terms of direction.[10]

Even so, other facts suggest that there is a role for spatial direction to play, as we already hinted at in the previous section. For example, if we force the interpretation of unidirectional motion with the adverb prosto 'straight', then use of an indeterminate verb is ruled out:

(18) a. Teresa jechała+ prosto przez dziesięć minut.
Teresa drove straight through ten.ACC minutes.GEN
'Teresa drove straight for ten minutes.'

b. # Teresa jeździła- prosto przez dziesięć minut.

(18)b is unacceptable if it means that Teresa drove in a straight line for ten minutes, which is the reading of (18)a. The problem here seems to be that even if the motion process described is complex, consisting of at least two parts, none of its parts differ in their spatial direction.

It should be noted that (18)b also has an acceptable (though less obvious) interpretation, viz., that Teresa drove in various directions for ten minutes, but each time in a straight line, e.g., as depicted in (19).

(19)

In this case, straightness is not asserted about the motion process as a whole (which would be the unacceptable interpretation), but rather of each part of the motion process. Note that (18)a lacks this second interpretation.

10 Although Piernikarski is a proponent of the directional approach, he seems to be aware of this problem. He stresses (1972, fn. 10) that "[b]eing marked for unidirectionality does not mean that the motion takes place on a straight line or along the shortest road (idzie+ okrężną drogą 'he is taking an indirect road'), but nevertheless some very generally understood direction is always established". [,,Nacechowany co do kierunkowości" nie znaczy, że ruch odbywa się po linii prostej lub najkrótszą drogą (idzie okrężną drogą niemniej jakiś najogólniej) pojęty kierunek jest zawsze wyknięty]. But it is precisely this elusive notion of direction that needs to be explained if the directional approach is supposed to account for the data.

Although an appeal to direction seems necessary to rule out the unacceptable reading of (18)b, the crucial point is that direction alone can't account for either the acceptable reading of (18)b or why (18)a lacks this reading. Rather, spatial direction appears to interact with the distinction between 'simple' and 'complex' motion processes already described: (18)a describes a motion process without proper parts that proceeds in a straight line, whereas on the acceptable reading of (18)b there is a motion process with proper parts at least two of which proceed in straight lines in different directions.

Another way in which direction might be said to play a role is seen in the following contrast:

(20) a. # Teresa przed chwilą szła↓ w kółko.
    Teresa before while.NST walked in circle.
    'Teresa walked in a circle a while ago.'
   b. Teresa przed chwilą chodziła↓ w kółko.
    'Teresa walked in a circle a while ago.'

If it is asserted that Teresa walked in a circle, as in (20), then use of a determinate verb is unacceptable. The unacceptability of (20)a suggests that determinate verbs may be 'unidirection-al', for walking in a circle surely requires 'multidirectional' motion. The admissibility of (20)b, which contains an indeterminate verb, would support this conclusion.

However, the factor at play simply cannot be reduced to one of spatial direction, to repeat my point above. Imagine that there is a circle sketched on the ground and that Teresa walks along its perimeter. In this case, either a determinate or an indeterminate verb may be used:

(21) a. Teresa dziś szła↓ po okręgu.
    Teresa today walked about circle.LOC
    'Teresa today walked about the circle today.'
   b. Teresa dziś chodziła↓ po okręgu.

The truth of (21)a obviously requires circular motion despite the fact that the sentence contains a determinate verb. The difference between (21)a and (21)b turns on whether there was a single stretch of walking or several. In (21)a, Teresa walked some distance along the circle's perimeter without stopping. In (21)b, she either walked several times around the circle or walked some distance along the circle's perimeter, but probably with stops. Clearly, the pair in (21) is analogous to the one in (16).

What such considerations indicate is that the data cannot be accounted for solely in terms of direction. Consequently, we shouldn't assign to direction a role that it can't bear. I suggest that indeterminate verbs are 'multidirectional' in the sense that at least two parts of every motion process in their denotations differ in spatial direction, which has the effect of ruling out simple straight motion. Clearly, however, this requirement has to be combined with the hypothesis that indeterminate verbs always denote 'complex' processes with at least two parts in the first place, as I proposed in the previous section. Direction alone is insufficient. Determinate verbs, in contrast, denote motion processes that are 'simple' in the sense that they are single uninterrupted stretches of motion. In this case, no additional requirement of 'unidirectionality' is called for.

In the next section, I will ignore the role of direction and will focus on the distinction between 'simple' and 'complex' processes. The resulting analysis, although free of any notion of direction, can always be supplemented by one. As a first attack on the problem, it is useful to leave direction out of the picture, for things are tricky enough as they stand.

3. An analysis: the role of granularity

The guiding intuition behind the analysis to be presented is that the meaning difference between determinate and indeterminate verbs resides in how the motion processes denoted are *structured*. A typical motion process is made up of smaller motion processes—these are its *parts*. For example, a process in which Irenka runs to the library is made up of a whole collection of

smaller runnings. Were it not, it would be difficult to see how Irenka could ever successfully run to the library. However, although a motion process typically has many parts, these parts may not always be 'represented', i.e., reality may be structured in such a way that at a 'lower' level the parts of a motion process are accessible but that at a 'higher' level they are not. Let us call such a level a 'grain'. The idea, then, is that determinate and indeterminate verbs denote motion processes at different grains. Determinate verbs denote motion processes at a *coarse* grain—at this level the motion processes have no parts (such processes are *coarse-grained*). Indeterminate verbs, in contrast, denote motion processes at a *fine* grain—at this level the motion processes may have many parts (such processes are *fine-grained*).[11]

A partial analogy with the distinction between 'object-oriented' and 'non-object-oriented' computer graphics might help to clarify the notion of granularity that I have in mind. In an object-oriented graphic, the image in question is stored as a whole object. Since the image is stored as a whole, none of its parts can be edited independently of the others. All that can be edited is the entire object itself, its size, position, color, etc. In a non-object-oriented graphic, in contrast, the image in question is stored as a series of pixels, thereby making it possible to edit any of its parts independently of the others. Indeed, the only way to edit an entire non-object-oriented image is to edit one or more of its pixels. These two ways of storing images parallel the difference between representing motion processes at coarse and fine grains, respectively.[12]

Yet another way to cast the proposed distinction is to think of coarse processes as *singular* processes and of fine processes as *pluralities* of singular processes. It must, however, be emphasized that singular processes are not always small and short, and plural processes are not always large and long—duration is a purely relative matter. Furthermore, processes—unlike most physical objects—generally don't 'come' 'prepackaged' as singular or plural. As we will see, many processes can be represented at either grain.

The postulation of a granularity distinction in the domain of motion processes has the immediate advantage of clarifying the intuitions behind the two traditional views reviewed in section 2. If determinate verbs denote motion processes at a coarse grain, then these processes are partless wholes or *atoms* at that grain. This helps account for the impression that determinate verbs are 'semelfactive' (section 2.1) and 'unidirectional' (section 2.2). As atoms, the motion processes in question are singular (whence semelfactivity); and if we suppose that a motion process is calculated to be multidirectional only if its parts vary in direction, then an atomic motion process will effectively be unidirectional, because its only part is the whole process itself.[13]

Similarly, if indeterminate verbs denote motion processes at a fine grain, then these processes have parts and aren't atoms at that grain. This helps account for the feeling that indeterminate verbs are 'iterative' (section 2.1) and 'multidirectional' (section 2.2). If 'iterativity' is taken to mean that the motion process in question is composed of two or more parts, as I suggested earlier, then indeterminate verbs are indeed 'iterative' and determinate verbs are not. Further-

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11 Although I adopt a realist perspective, nothing here crucially depends on this choice. It would be possible to recast my proposal in terms of how a motion process is 'viewed' or 'conceptualized' in different ways, but that would call for a domain of interpretation different from the (real) world. In a realist perspective, if a motion process may be 'viewed' in different ways, then that is because different things or aspects of a thing in reality are being 'viewed' in the first place.

12 The analogy is not perfect, because it ignores the fact that object-oriented images are calculated mathematically and therefore have a sharper resolution than non-object-oriented images, which are not. Moreover, as far as fine-grained processes are concerned, the 'pixels' may differ in size.

13 This is reminiscent of Forsyth's (1970, 320) claim that "[t]he meaning of determinate verbs can thus be defined as expression of motion taking place at a specific moment and therefore in one direction." However, it isn't clear how we should understand "expression of motion taking place at a specific moment": on the contrary, as we have seen (e.g., (18)a), determinate verbs are often used to express motion that takes place over an *interval*, so Forsyth can't be literally right.

more, if a motion process is calculated to be multidirectional only if its parts vary in direction, as just proposed, then only motion processes at a fine grain stand a chance of being multidirectional, because it is only at that grain that they have two or more parts.[14]

In speaking of a 'granularity distinction', I acknowledge a certain resemblance between the notion that I am after and a more general notion of granularity that is applied by authors such as Hobbs (1985), Eschenbach (1994), and Habel (1995) to characterize aspects of commonsense reasoning. While the lack of space prevents me from making comparisons, it should be borne in mind that I am primarily concerned with a semantic difference between two classes of verbs. Nothing turns on my calling this particular difference a 'granularity distinction', even if I believe that it is useful and relevant to do so.

3.1. The formal language

I will formulate the essential details of a theory of parts and processes with a granularity distinction in a formal language J_1 (cf. Polish język 'language').[15] J_1 is based on classical first-order predicate logic with equality, lambda abstraction, and proper ι-descriptions—it is first-order in the sense that although second-order variables are employed, they are never bound by the quantifiers ∃ and ∀. Unlike classical predicate logic, J_1 is *many-sorted*, i.e., J_1 employs different types of variable symbols to denote objects of different types. Specifically, there are two main sorts of individual variable symbols:

• *physical object variables* x, y, z ... are used to denote physical objects
• *process variables* p, q, r, ... are used to denote processes

In addition, two subsorts of process variables are used:

• *coarse-grained process variables* p_c, q_c, r_c, ... are used to denote coarse-grained processes
• *fine-grained process variables* p_f, q_f, r_f, ... are used to denote fine-grained processes[16]

Since J_1 has three basic sorts of variable symbols (viz., physical object, coarse process, fine process), we could also introduce three equality symbols, one for each sort. But it's simpler to do without this complication of the syntax and to allow the basic sorts to be 'mixed' in equations. Instead, we will set up the semantics so that any equation with mixed sorts is interpreted as false in all models. Thus, whereas we allow both x=y and x=p to be well-formed expressions, the latter is evaluated as false in all models. Note, however, that equations such as p=p_c and p_f=p don't involve mixed sorts, precisely because every coarse or fine process variable is also a process variable (the basic sorts aren't mixed in this case). The semantics just hinted at presupposes that the three basic domains over which the three sorts of variables of J_1 range are *pairwise disjoint*. Each of these domains is a *set* of objects; they are designated by O (physical objects), P_c (coarse processes), and P_f (fine processes). The domain of processes, P, is just the set union of P_c and P_f. While the pairwise disjointness of the three basic domains is probably obvious for physical objects with respect to processes, given that no physical object is a process, it is less obvious for coarse processes in relation to fine processes. Is no coarse

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14   Of course, by this criterion it doesn't follow that all motion processes at a fine granularity *are* multidirectional—it is simply that some *can* be, which is sufficient to distinguish them from motion processes at a coarse level, which *cannot* be.

15   Although I presuppose a basic acquaintance with model-theoretic semantics, I try to explain the relevant details as clearly as possible. Readers unfamiliar with formal semantics are nevertheless encouraged to read the prose and skip the symbols in order to get a feel for the scope and limitations of the analysis.

16   Henceforth, I will use 'coarse' and 'fine' for 'coarse-grained' and 'fine-grained', respectively.

process also a fine process? In the framework of assumptions that I adopt, the answer is provably no (see (42)b).

The special nonlogical symbols of J_1 are {<_f, △}; <_f is a binary relation symbol whose intended reading is 'be a (fine) proper part of'. △ is a binary relation symbol whose intended interpretation is 'be refined by'. As with the equality symbol, we impose no sortal restrictions on the *syntax* of these symbols.

A *model M* for J_1 is a tuple ⟨O, P_c, P_f, ⊑, <, [[ ]]⟩, where [[ ]] is the interpretation function that maps the expressions of J_1 to the structure ⟨O, P_c, P_f, ⊑, <⟩. The symbols <_f and △ of J_1 correspond to ⊑ and <, respectively, i.e., [[<_f]] = ⊑, and [[△]] = <. ⊑ is a strict partial order (i.e., irreflexive, asymmetric, and transitive) on P_f, which already implies that it is irreflexive, asymmetric, and intransitive (hence not an order). Any pair consisting of a coarse process that is refined by a fine process belongs to this relation. Intuitively, refinement should be understood as the 'exhibition' or 'revealing' of otherwise hidden structure: if a coarse process is refined by a fine process, then the latter 'exposes' or 'reveals' the proper parts of the former.

3.2. Parts and processes

I will now discuss the structure of P, the domain of processes, in some detail. The initial strategy is to define a part structure with coarse processes as the 'bottom' elements and with fine processes as constructed from two or more coarse processes.

To begin with, let us require that all processes be either coarse or fine, i.e., there is no third sort of process. In other words, coarse and fine processes together *exhaust* the domain of processes:[17]

(29) *Exhaustiveness:* ∀p[∃p_c[p=p_c] ∨ ∃p_f[p=p_f]]

The next step is to *restrict* the second (external) argument of <_f to fine processes. Effectively, this guarantees that <_f is the proper part relation of fine processes. Consequently, any assertion involving <_f to relate proper parts to a coarse process will be false.

(30) *Restriction:* ∀q∀p[q<_f p → ∃p_f[p=p_f]]

Note, however, that Restriction doesn't restrict the first (internal) argument of <_f to fine processes. Thus, nothing prevents coarse processes from being (fine) proper parts of fine processes.

The relations 'be a fine (improper) part of' and 'be (finely) disjoint from' can be defined on the basis of <_f in the standard manner:

(31) a. ≤_f := λqλp[q<_f p ∨ q=p]   (fine part)
     b. ʃ_f := λqλp[¬∃r[r≤_f q ∧ r≤_f p]]   (fine disjointness)

Since ≤_f allows for identity, every coarse or fine process is automatically a fine (improper) part of itself. If two processes aren't disjoint, then they overlap in either a coarse or fine process. Note that since ʃ_f is ultimately based on ≤_f, we can't use ʃ_f for determining whether two coarse processes are disjoint. Rather, we need another relation for this purpose, to be introduced in the next section.

The *Witness* axiom in (32) states that if a process is a proper part of a fine process, then there is always a third process disjoint from the first that is also a proper part of that fine process. This means that no fine process can have a single proper part:

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17   Expressions of J_1 are given in this font.

(32) *Witness:* $\forall q\forall p[q\mdsmallwhite_f p \to \exists r[r<_f p \wedge q\mid_f r]]$

If two processes are not disjoint, then they evidently have at least one part in common. The *Maximality* axiom asserts that in such cases the two processes will always have a maximal part in common, i.e., no overlap of processes without a process that maximally fills that overlap. For example, if two processes in which Irenka runs for five minutes overlap each other by three minutes, then it is certain that there is a process of running in the overlap that lasts three minutes.

(33) *Maximality:* $\forall q\forall p[\neg q\mid_f p \to \exists q'\forall p'[p'\leq_f q \wedge p'\leq_f p]]$

Maximality rules out a model like that shown in (34) because there is no maximal process containing just p_2 and p_3 in the overlap between p' and p. (The lines connecting processes in (34) represent the relation of (fine) proper part.)

(34)

p' p

p_1 p_2 p_3 p_4
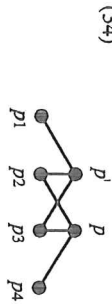
Again, since f_f doesn't tell us whether two coarse processes are disjoint, Maximality reveals nothing about cases in which two coarse processes partially overlap.

Many processes are composed of smaller ones; such complex processes are *fine aggregates* of their parts. The fine aggregate of a set of processes is the smallest process which contains all of the processes in that set among its parts (the set is denoted by the predicate variable F in (35)).[18]

(35) $\mathrm{agg}_f := \lambda F_f \forall q[p\leq_f q \leftrightarrow \forall r[F(r) \to r\leq_f q]]$ (fine aggregate)

Although every set of processes has a unique fine aggregate, a particular process may be the fine aggregate of more than one set of processes. To see this, observe that process p is the aggregate of both $\{p_1, p_2\}$ and $\{p_1, p_2, p_3\}$ in the following model:

(36)

p

p_1 p_2 p_3
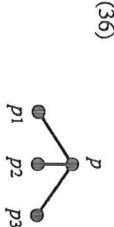
The definition in (35) tells us what the fine aggregate of a set of processes is, assuming that it exists, but nothing yet requires aggregates to exist, i.e., nothing requires every set of processes to have an aggregate. The existence of aggregates is guaranteed by the *Aggregate Principle*, which states if a set of processes is nonempty, then there is a process that is the aggregate of that set:

(37) *Aggregate Principle:* $\exists p[F(p)] \to \exists p[p=\mathrm{agg}_f(F)]$

The Aggregate Principle rules out models in which there are 'stranded' processes, i.e., in which there are processes that are not proper parts of a larger process. For example, it rules out the model shown in (38) (cf. (36)):

18   Mathematically, the aggregate of a set of processes is the *least upper bound* of that set.

(38)

p
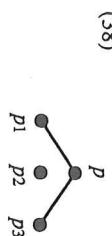
p_1 p_2 p_3

Note that the set $\{p_1, p_2, p_3\}$ in (38) lacks an aggregate, a condition which is prohibited by the Aggregate Principle. Intuitively, the Aggregate Principle guarantees that every process is part of a *universe* of processes.[19]

A *fine atom* is a process all of whose parts are identical to it:

(39) $\mathrm{at}_f := \lambda p[\forall q[q\leq_f p \to q=p]]$ (fine atom)

Since fine processes in our conception have proper parts, it should be the case that they are not fine atoms, as postulated in (40).

(40) *Fine processes are not fine atoms:* $\forall p[\neg \mathrm{at}_f(p)]$

Finally, a *minimal process* is a process with exactly two fine proper parts:

(41) $\mathrm{min}_f := \lambda p[\exists q\exists r[q<_f p \wedge r<_f p \wedge \neg q=r \wedge \forall p'[p'<_f p \to p'=q \vee p'=r]]]$ (minimal process)

I point out that the facts stated in (42) follow straightforwardly in this approach:

(42) a.   *Fact:* $\forall p_c[\mathrm{at}_f(p_c)]$ (coarse processes are fine atoms)
b.   *Fact:* $\forall p_c\forall p_f[\neg p_c=p_f]$ (coarse and fine processes are distinct)
c.   *Fact:* $\forall p[\mathrm{at}_f(p) \to \exists p_c[p=p_c]]$ (fine atoms are coarse processes)
d.   *Fact:* $\forall p[\mathrm{min}_f(p) \to \exists p[p=p_f]]$ (minimal processes are fine)
e.   *Fact:* $\forall p_f\forall p[p<_f p_f \to \exists p_c[p_c\leq_f p]]$ (fine processes are built up from coarse processes)

3.3. Refinement

Since we know from (42)a that coarse processes are fine atoms, $<_f$ is useless for determining whether a coarse process is internally complex or not. Recall the intuition that a coarse process may be internally complex even if its structure isn't directly represented or accessible. We will make use of *refinement* ($\lhd$) in order to determine the structure of a coarse process:

(43) *Refinement holds between coarse processes and fine processes:*
$\forall q\forall p[q\lhd p \to \exists p_c[p_c=q \wedge \exists p_f[p_f=p]]]$

Clearly, since the point of refinement is to reveal structure, it would make no sense to allow a coarse process to be refined by another coarse process, as that would simply trade one fine atom in for another. Observe that (43) doesn't require all coarse processes to be refined by fine processes —it simply states that refinement is a relation between coarse processes and fine processes. In fact, the smallest coarse processes aren't refined by fine processes (see (48)a).

19   The part structure on processes determined by Witness, Maximality, and the Aggregate Principle is rich, but not as rich as a classical mereology. This is because the notion of aggregate is weaker than that of *sum* (all sums are aggregates, but not all aggregates are sums). For example, the model depicted in (36) is inadmissible as a model of a classical mereology because the set $\{p_1, p_2\}$ lacks a sum. See Simons (1987, chap. 1) for a discussion of mereological strength.

The next axiom guarantees that every fine process refines a coarse process. In other words, given a fine process, we can always find a coarse process that it refines.

(44) *Correspondence*: $\forall p \exists q[q \triangleleft p]$

Intuitively, the content of Correspondence is that we can always choose to ignore the structure of a fine process and represent it as a coarse process.

Given a coarse process that is refined by some fine process, is the fine process in question the *unique* refiner of that coarse process? If it were, then that would mean that there is a unique way of analyzing the internal structure of a coarse process. But this is improbable, because it is unclear which way that would be. Take, for example, a process in which Irenka runs for ten minutes. What are its parts? On the face of it, there are many ways of analyzing such a process into its parts. We could break it down into a long series of smallest possible motions of running, but we could also analyze it as (any one of) a shorter series of larger motions of running. Since any of these ways could count as a 'correct' analysis of the process in question, it would be wrong to insist on the priority of one analysis over the others. In short, it appears that there is in general no unique way of refining a coarse process into its parts.

We therefore say that two fine processes are *similar* if there is a coarse process that they both refine:

(45) $\approx := \lambda q \lambda p[\exists r[r \triangleleft q \wedge r \triangleleft p]]$ (similarity)

It is evident that $\approx$ is an equivalence relation (i.e., reflexive, symmetric, and transitive). Using $\approx$ we can partition the set of fine processes into disjoint subsets, according to whether they refine the same coarse process or not.

With the help of $\triangleleft$ it is possible to define a part structure on coarse processes. The definitions are set out as follows (cf. (31), (35), (39)):

(46) a. $<_c := \lambda q \lambda p[\exists r[p \triangleleft r \wedge q <_f r]]$ (coarse proper part)
    b. $\leq_c := \lambda q \lambda p[q <_c p \vee q = p]$ (coarse part)
    c. $\int_c := \lambda q \lambda p[\neg \exists r[r \leq_c q \wedge r \leq_c p]]$ (coarse disjointness)
    d. $agg_c := \lambda F \lambda p \lambda q[p \leq_c q \leftrightarrow \forall r[F(r) \rightarrow r \leq_c q]]$ (coarse aggregate)
    e. $at^{+}_c := \lambda p[\neg \exists q[q <_c p]]$ (coarse atom)

Since the definition of $<_c$ is based on $\triangleleft$ and $<_f$, the analogues of Fine Witness, Fine Maximality, and the Fine Aggregate Principle for coarse processes are now theorems (cf. (32), (33), (37)):

(47) a. *Fact*: $\forall q \forall p[q <_c p \rightarrow \exists r[r <_c p \wedge q \int_c r]]$ (Coarse Witness)
    b. *Fact*: $\forall q \forall p[\neg q \int_c p \rightarrow \exists q \forall p'[p' \leq_c q \wedge p' \leq_c p]]$ (Coarse Maximality)
    c. *Fact*: $\exists p[F(p)] \rightarrow \exists p[p = agg_c(F)]$ (Coarse Aggregate Principle)

Moreover, the following four facts are also straightforward to prove in this system:

(48) a. *Fact*: $\forall p[at^{+}_c(p) \rightarrow \neg \exists q[q \triangleleft p]]$ (coarse atoms are not refined by a fine process)
    b. *Fact*: $\forall p_c[\neg at^{+}_c(p_c) \rightarrow \exists q[p_c \triangleleft q]]$ (coarse processes that are not coarse atoms are refined by a fine process)
    c. *Fact*: $\neg \exists p[at^{+}_c(p_c)]$ (no fine process is a coarse atom)
    d. *Fact*: $\forall q \forall p \forall r[q \triangleleft p \wedge r \triangleleft p \rightarrow q = r]$ (fine processes refine a unique coarse process)

The fact in (48)d guarantees that if a fine process refines a coarse process, then that coarse process is the only coarse process that it refines. In other words, $\triangleleft$ is functional with respect to

its first (internal) argument. This is consistent with the intuition that we can't get two different coarse processes by 'concealing' or 'collapsing' the structure of a fine process, i.e., there is only one way to 'conceal' the structure of a fine process. On the basis of (45) and (48)d, it follows immediately that similar fine processes refine one and the same coarse process.

3.4. Taking stock

Since the battery of definitions and principles introduced in the previous two sections may appear bewildering, let us now consider in less technical terms what has been accomplished. Recall that the guiding intuition behind an analysis of the data was that (what is seemingly) a single motion process can be represented both as a partless whole and as made up from smaller motion processes. In order to formalize this intuition, I have defined two parallel but at the same time incompatible part structures on processes. The first structure characterizes the parts of fine processes; the second does the same for coarse processes. The structures are incompatible because the two domains of coarse and fine processes are disjoint. Consequently, fine processes have fine but not coarse proper parts, and coarse processes may have coarse but not fine proper parts. What connects the two domains is refinement: every fine process refines a unique coarse process, and every coarse process that isn't a coarse atom is refined by at least one fine process.

This situation may be depicted as in (49). Given a set of coarse processes (e.g., $\{p_c, q_c, r_c\}$), the Aggregate Principle in (37) together with Restriction in (30) guarantee that the set has a unique fine aggregate, viz., p_f. Correspondence in (44) and the fact in (48)d ensure that p_f refines a unique coarse process, designated by p_c'. Accordingly, each of the fine proper parts of p_f (viz., p_c, q_c, r_c) is a *coarse proper part* (see (46)) of p_c'. Since the fact in (42)a states that coarse processes are fine atoms, p_c' lacks fine proper parts, as shown. Furthermore, since it cannot be shown that refining processes are unique, nothing prevents the coarse structure of p_c' from being analyzed in more than one way. Thus, another fine process, p_f', may also refine p_c'. Note that p_f as depicted doesn't overlap with p_f', for it is the aggregate of an entirely different set of coarse processes, viz., $\{p_{c1}, q_{c1}, p_{c2}, q_{c2}\}$. Although disjoint, p_f' and p_f are similar, because they both refine the same coarse process (see (45)). Of course, p_c can in turn be combined with one or more coarse processes to create another fine process which will then refine another unique coarse process, and so on, but these further possibilities aren't exhibited in (49).

(49)

p_c' p_c q_c r_c
Δ Δ
p_f' p_f
p_{c1} q_{c1} r_{c1} p_{c2} q_{c2}
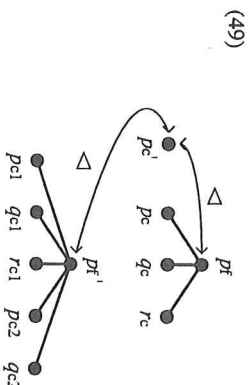
Coarse atoms (see (46)e) are the most minimal of the coarse processes: they are not refined by fine processes (see (48)a), because there is nothing to refine. Intuitively, they correspond to the smallest motion processes in terms of which all other motion processes are ultimately analyzable.

4. From Polish to J_1

Now that I have characterized the domain of processes P with the help of J_1, the next step is to apply J_1 in an analysis of verbs of motion in Polish. Since determinate verbs are the most

straightforward to treat, let me begin with them. I analyze determinate verbs as relations between coarse processes and physical objects, as in (50).[20]

(50) a. iść[+] ⇒ $\lambda x \lambda p_c[\text{walk}(p_c) \wedge \text{agent}(x)(p_c)]$
b. jechać[+] ⇒ $\lambda x \lambda p_c[\text{go-by-vehicle}(p_c) \wedge \text{agent}(x)(p_c)]$
c. biec[+] ⇒ $\lambda x \lambda p_c[\text{run}(p_c) \wedge \text{agent}(x)(p_c)]$
d. płynąć[+] ⇒ $\lambda x \lambda p_c[\text{swim}(p_c) \wedge \text{agent}(x)(p_c)]$

Observe that nothing excludes some of the coarse processes in these denotations from being coarse atoms, which by (48) aren't refined by fine processes. However, we know from (48)b that any coarse process that isn't a coarse atom is refined by a fine process and from (48)a that a fine process always refines a coarse process that isn't a coarse atom. The constraints in (51) specify, for each type of coarse process figuring in (50) that isn't a coarse atom, what kind of fine process it is refined by.

(51) a. $\forall p_c[\neg\text{at}(p_c) \wedge \text{walk}(p_c) \leftrightarrow \exists q_f[p_c \triangle q_f \wedge \text{walk}(q_f)]]$
b. $\forall p_c[\neg\text{at}(p_c) \wedge \text{go-by-vehicle}(p_c) \leftrightarrow \exists q_f[p_c \triangle q_f \wedge \text{go-by-vehicle}(q_f)]]$
c. $\forall p_c[\neg\text{at}(p_c) \wedge \text{run}(p_c) \leftrightarrow \exists q_f[p_c \triangle q_f \wedge \text{run}(q_f)]]$
d. $\forall p_c[\neg\text{at}(p_c) \wedge \text{swim}(p_c) \leftrightarrow \exists q_f[p_c \triangle q_f \wedge \text{swim}(q_f)]]$

For example, (51)a asserts that every nonatomic coarse process of walking is refined by a fine process of walking and (conversely) that any coarse process that a fine process of walking refines is a nonatomic coarse process of walking. Since a nonatomic coarse process may be refined by more than one fine process, we can't conclude that a particular coarse process of walking is refined by a unique fine process of walking, but only that if it is refined by two or more fine processes of walking, then they are similar. The remaining constraints given in (51) for the coarse processes introduced in (50) are analogous.

Since it is beyond the scope of this paper to analyze the compositional structure of PPs, I will simply assume what would be a plausible result of such an analysis. Directional PPs are analyzed as modifiers of predicates of coarse processes:

(52) a. do Krakowa ⇒ $\lambda F \lambda p_c[\text{to-kraków}(p_c) \wedge F(p_c)]$
b. przez park ⇒ $\lambda F \lambda p_c[\text{through-the-park}(p_c) \wedge F(p_c)]$

The intended interpretation of *do Krakowa* is that it is an modifier that restricts the set of coarse processes denoted by the verbal predicate to those that are spatially located on paths leading from some unspecified location to Kraków. Similarly, the interpretation of *przez park* restricts the set of coarse processes to those that are spatially located on paths leading from one end of the park to the other. Intuitively, the reason for stipulating that these modifiers apply to predicates of coarse processes (as opposed to fine processes) is that the meaning of a directional PP individuates coarse processes of motion, which are precisely what I have reconstructed as coarse processes.

The sentences in (10)a and (11)a then receive the analyses in (53)a and (53)b, respectively (ignoring tense):

(53) a. Irenka wczoraj jechała[+] do Krakowa ⇒   (= (10)a)
$\exists p_c[\text{go-by-vehicle}(p_c) \wedge \text{agent}(x)(p_c) \wedge x=\text{irenka} \wedge \text{to-kraków}(p_c) \wedge \text{yesterday}(p_c)]$

---

20   For perspicuity, I represent thematic roles as relations between processes and physical objects (see Krifka (1989) for an event semantics with thematic relations), but this isn't essential. Notice that I don't assume that PP-complements of verbs of motion are among the verbs' semantic arguments, because it simplifies the treatment of optionality, but here too another implementation would be possible.

b.   Teresa wczoraj biegła[+] przez park ⇒   (= (11)a)
$\exists p_c[\text{run}(p_c) \wedge \text{agent}(x)(p_c) \wedge x=\text{Teresa} \wedge \text{through-the-park}(p_c) \wedge \text{yesterday}(p_c)]$

In order to derive these representations compositionally, I assume that the PP-modifiers in (52) first combine with their respective V°-predicates in (50) by functional composition. The resulting predicates then combine with their external arguments by functional application. Finally, default existential binding of the coarse process variable applies.[21]

The meaning of the sentence in (53)a asserts the existence of a coarse process of going by vehicle to Kraków by Irenka that took place yesterday. For concreteness, let's say that it was a process of driving. As a coarse process, the drive is represented as a single stretch lacking fine proper parts. Any internal complexity to the drive is ignored. Although the constraint in (50)b allows us to infer that this coarse process of driving is refined by a fine process of driving, we cannot use the verb *jechać*[+] to describe any such fine process, because its meaning is restricted to coarse processes. The representation in (53)b should be understood similarly.

I analyze indeterminate verbs as relations between fine processes and physical objects:

(54) a. chodzić[+] ⇒ $\lambda x \lambda p_f[\text{walk}(p_f) \wedge \text{agent}(x)(p_f)]$
b. jeździć[+] ⇒ $\lambda x \lambda p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f)]$
c. biegać[+] ⇒ $\lambda x \lambda p_f[\text{run}(p_f) \wedge \text{agent}(x)(p_f)]$
d. pływać[+] ⇒ $\lambda x \lambda p_f[\text{swim}(p_f) \wedge \text{agent}(x)(p_f)]$

We know from (42)b, e that although no fine process is a coarse process, fine processes are built up from coarse processes. The constraints in (55) state that the kinds of fine processes introduced in (54) are composed of coarse processes of the same type.

(55) a. $\forall p_f[\text{walk}(p_f) \leftrightarrow p_f=\text{agg}_f(\lambda q_c[q_c \leq p_f \wedge \text{walk}(q_c)])]$
b. $\forall p_f[\text{go-by-vehicle}(p_f) \leftrightarrow p_f=\text{agg}_f(\lambda q_c[q_c \leq p_f \wedge \text{go-by-vehicle}(q_c)])]$
c. $\forall p_f[\text{run}(p_f) \leftrightarrow p_f=\text{agg}_f(\lambda q_c[q_c \leq p_f \wedge \text{run}(q_c)])]$
d. $\forall p_f[\text{swim}(p_f) \leftrightarrow p_f=\text{agg}_f(\lambda q_c[q_c \leq p_f \wedge \text{swim}(q_c)])]$

For example, (55)a asserts that a fine process of walking is the fine aggregate of the set of coarse processes of walking that are its fine parts. This captures the intuition that a larger process of walking is composed of smaller processes of walking. The remaining constraints in (55) do the same for the other types of fine processes.

It is immediately clear that we cannot combine a V°-predicate in (54) with a PP-modifier in (52) by functional composition, as we did with determinate verbs, because indeterminate verbs aren't analyzed as relations between coarse processes and physical objects. Suppose, in particular, that we want to derive the meaning of (10)b the predicate in (54)b cannot functionally compose with the PP-modifier in (52)a.[22]

But isn't this problem simply an artefact of our particular analysis of directional PPs? If would be easy enough to resolve the sortal mismatch by analyzing directional PPs as modifiers of process predicates *simpliciter*, without requiring that they also be predicates of coarse processes. If we were to do this, we could combine an indeterminate verb with a directional PP, which would yield the representation in (56) for (10)b.

(56)   Irenka wczoraj jeździła[+] do Krakowa ⇒   (!)
$\exists p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f) \wedge x=\text{irenka} \wedge \text{to-kraków}(p_f) \wedge \text{yesterday}(p_f)]$

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21   I also analyze *wczoraj* 'yesterday' as a modifier but have left this part of the analysis implicit.
22   Technically, it can, but the set of processes in the denotation of the resulting predicate will be empty.

However, the problem is that the formula in (56) just doesn't express the content of the Polish sentence. This formula asserts that there was a fine process taking place yesterday in which Irenka goes by vehicle to Kraków, which is compatible with her having gone there only once and having stayed there. All that we require is that the process of driving there have at least two parts (since it is fine). However, the intuitive meaning of the Polish sentence is that there is no Op_1.

In order to approximate the actual meaning of (10)b, we need to modify the representation of an indeterminate verb so that it can apply to a directional PP-predicate to yield the desired result. The first operator (Op_1) applies to the meaning of an indeterminate verb and yields a formula that can functionally apply to a PP-predicate of coarse processes, as seen in (57)a.

(57) a. $Op_1 := \lambda R\lambda x\lambda p_f[R(x)(p_f) \wedge \min(p_f) \wedge \exists p_c[F(p_c) \wedge p_c \leq p_f]]$

b. jeździć⁻¹ ⟹
$Op_1(\lambda x\lambda p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f)]) =$
$\lambda x\lambda p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f) \wedge \min(p_f) \wedge \exists p_c[F(p_c) \wedge$
$p_c \leq p_f]]$

c. jeździć⁻¹ do Krakowa ⟹
$\lambda x\lambda p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f) \wedge \min(p_f) \wedge \exists p_c[\text{to-kraków}(p_c) \wedge$
$p_c \leq p_f]]$

In (57)b the result of applying Op_1 to the analysis of *jeździć⁻¹* in (54)b is shown, and in (57)c the result of applying the formula in (57)b to the PP-predicate in (52)a is given. In prose, the predicate in (57)c denotes a relation between *minimal* processes of going by vehicle and physical objects such that each minimal process has a fine part that is a coarse process of going by vehicle to Kraków. Recall from (41) and (42)d that a minimal process is a fine process with exactly two proper parts (both of which are coarse processes, of course: see (42)e). The meaning represented in (57)c asserts that one of the two coarse processes is a going by vehicle to Kraków. But what about the other coarse process? From (55)b we at least know that it is a process of going by vehicle, but nothing constrains its location. However, the intended reading of (57)c, even if it is left implicit, is that the other coarse process is a going by vehicle *away from Kraków*. In a more thorough treatment, we would at least need to state (i) that the process of going by vehicle to Kraków precedes the other process and (ii) that the other coarse process is a going by vehicle originates in Kraków. For present purposes, however, I will simply assume that such restrictions have been added to the semantic representation, because they aren't my main concern here. Thus, granting the intended reading, each fine process in the denotation of (57)c is a trip to and away from Kraków.

We can depict each of the fine processes in the denotation of (57)c as in (58) (recall that such diagrams don't depict temporal precedence). Since each process is minimal, it has exactly two (coarse) processes as its proper parts. Moreover, since each fine process is a going by vehicle, each of the two coarse processes is also a going by vehicle. It is further asserted that one of them is a going by vehicle to Kraków.

(58)

go-by-vehicle(pf)

pc   qc   go-by-vehicle(pc)

go-by-vehicle(qc) ∧ to-kraków(qc)

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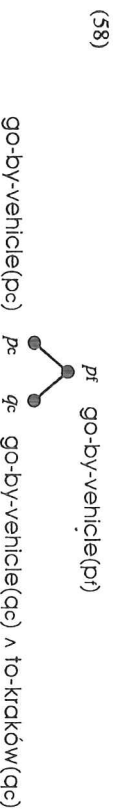
23   If we assume that to-kraków distributes over all the parts of the fine process, then the formula in (56) would assert the existence of at least two one-way drives to Kraków. But this would still be incorrect, because such an interpretation would be compatible with Irenka's remaining in Kraków after (say) the second one-way trip, which isn't what the meaning of (10)b actually allows.

The formula in (57)c represents the reading in which there is one trip to and away from Kraków. Recall, however, that just as for (8)b (cf. (9)b), which is like (10)b in the relevant respects, it is questionable whether this reading is acceptable. What I point out is that it is treated as a special case in my analysis, viz., as the result of applying Op_1. If we should decide that sentences like (8)b and (10)b don't admit of a 'singular' reading, then that would mean that there is no Op_1. Nevertheless, there is a clear sense in which the 'plural' reading of these sentences can be derived from the 'singular' one, and so I assume that the latter isn't excluded in principle.

The second operator (Op_2) also applies to the meaning of indeterminate verbs to yield a formula that can apply to a directional PP-predicate. Op_2 is defined in (59)a, and the result of applying Op_2 to the predicate in (54)b is shown in (59)b. Finally, the result of functionally applying the formula in (59)b to the PP-predicate in (52)a is given in (59)c.

(59) a. $Op_2 :=$
$\lambda R\lambda x\lambda q_f[q_f=\text{agg}_f(\lambda p_c[p_c\leq q_f \wedge \exists p_f[p_c \triangleleft p_f \wedge R(x)(p_f) \wedge \min(p_f) \wedge$
$\exists p_c[F(p_c) \wedge p_c \leq p_f]]])]$

b. jeździć⁻¹ ⟹
$Op_2(\lambda x\lambda p_f[\text{go-by-vehicle}(p_f) \wedge \text{agent}(x)(p_f)]) =$
$\lambda x\lambda q_f[q_f=\text{agg}_f(\lambda p_c[p_c\leq q_f \wedge \exists p_f[p_c \triangleleft p_f \wedge \text{go-by-vehicle}(p_f) \wedge$
$\text{agent}(x)(p_f) \wedge \min(p_f) \wedge \exists p_c[F(p_c) \wedge p_c \leq p_f]]])]$

c. jeździć⁻¹ do Krakowa ⟹
$\lambda x\lambda q_f[q_f=\text{agg}_f(\lambda p_c[p_c\leq q_f \wedge \exists p_f[p_c \triangleleft p_f \wedge \text{go-by-vehicle}(p_f) \wedge \text{agent}$
$(x)(p_f) \wedge \min(p_f) \wedge \exists p_c[\text{to-kraków}(p_c) \wedge p_c \leq p_f]]])]$

Although the formula in (59) looks exceedingly complex, the meaning that it expresses is quite straightforward. Each fine process in its denotation is an aggregate of coarse processes such that each coarse process is refined by a minimal process that has a coarse process of going by vehicle to Kraków as one of its two parts. More plainly, each fine process in the denotation of (59)c is an aggregate of at least two trips to and away from Kraków. Suppose that we consider one such fine process, viz., one that is built out of three coarse processes. The diagram in (60) depicts the internal structure of this fine process. Note that the fine processes p_{f1}, p_{f2}, p_{f3} are of the same type as the one shown in (58), viz., a trip to and away from Kraków.

(60)
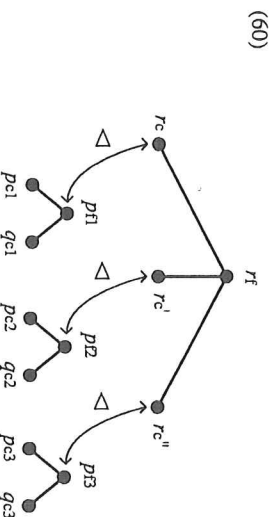
It may not be immediately obvious why refinement was used in the definition of Op_2. In other words, looking at the diagram in (60), why can't we define the aggregate of the set of fine processes $\{p_{f1}, p_{f2}, p_{f3}\}$ directly? Is it really crucial to determine the coarse processes that these fine processes refine before the aggregate is defined? The reason for making use of refinement here is that it allows us to represent each trip to and away from Kraków as an atom whose internal structure is hidden at the level of the fine process r_f. If we instead defined the higher aggregate on the basis of the set $\{p_{f1}, p_{f2}, p_{f3}\}$ directly, then it would be identical to the aggregate of the set $\{p_{c1}, q_{c1}, p_{c2}, q_{c2}, p_{c3}, q_{c3}\}$, in which the trips to and away from Kraków are

not represented as distinguishable wholes but rather as a collection of one-way drives. And this would miss the point: what is being aggregated are whole trips to and away from Kraków and not simply one-way journeys.

I noted in section 2.1 that the proposition expressed by (10)b entails the one expressed by (10)a but not conversely. This entailment is valid in the present analysis, as one can see by inspecting the formulas in (61). (For simplicity, I ignore the contribution of *wczoraj* 'yesterday'.)

(61)　(Irenka jeździła[i] do Krakowa (= (10)b))
$$\exists q_f[q_f = agg_f(\lambda p_c[p_c \leq q_f \wedge \exists p_f[p_c \triangleleft p_f \wedge go\text{-}by\text{-}vehicle(p_f) \wedge agent(x)(p_f)}$$
$$\wedge\, x = irenka \wedge min(p_f) \wedge \exists p_c[to\text{-}kraków(p_c) \wedge p_c \leq p_f]]])]$$
　　(Irenka jechała[i] do Krakowa (= (10)a))
$$= \exists p_c[go\text{-}by\text{-}vehicle(p_c) \wedge agent(x)(p_c) \wedge x = irenka \wedge to\text{-}kraków(p_c)]$$

The proof is essentially as follows. The first formula asserts the existence of a fine process in which Irenka goes by vehicle. From (55)b we know that a fine process of going by vehicle is built out of coarse processes of going by vehicle. If we make the additional assumption that the agent of a fine process is also the agent of going by vehicle. Hence there is a coarse process of going by each of the coarse processes that make it up, then we know that Irenka is the agent of any of these coarse processes of going by vehicle. But note that we have now inferred the content of the second formula, coarse process to Kraków. Finally, the first formula asserts the existence of a viz., that there is a coarse process in which Irenka goes by vehicle to Kraków.[24]

To what extent can the other contrasts discussed be accounted for in my approach? The strategy that I pursued in the case of directional PPs was to make their semantics sensitive to the distinction between coarse and fine processes. This made it necessary to 'adjust' the meaning of indeterminate verbs so that they could combine with a directional PP to yield the desired interpretation. But there is no reason to think that only directional PPs are sensitive to this distinction. In (20), we found that *w kółko* 'in a circle' couldn't combine with a determinate verb. This suggests that *w kółko* should be analyzed as a modifier of predicates of fine processes. In (16) and (21), on the other hand, we saw that adverbials such as *drogą Krętą* 'along Winding Road' and *po okręgu* 'along the circle' are compatible with both determinate and indeterminate verbs. This indicates that they should be analyzed as modifiers of predicates of processes *simpliciter*.[25] Similar to directional PPs, the adverb *prosto* 'straight' in (18) would be represented as a modifier of predicates of coarse processes. Naturally, these suggestions are enlightening only to the extent that we can understand why a given PP selects the one sort and not the other. Ideally, this ought to follow from a more careful look at the semantics of PPs and the interaction of direction with the coarse/fine distinction.

My analysis makes an interesting correct prediction. If determinate verbs denote coarse processes and coarse processes are fine atoms, without proper parts, then modifiers that 'count' parts should be incompatible with determinate verbs. Since indeterminate verbs denote fine processes and fine processes have proper parts, it also follows that such modifiers should be compatible with indeterminate verbs. In this light, consider the following contrasts:

(62)　a.　# Irenka wczoraj dużo biegła[i]+.
　　　　　　Irenka yesterday much ran
　　　b.　Irenka wczoraj dużo biegała[i]-.
　　　　　　'Irenka ran a lot yesterday.'

24　This is a constraint that we need anyway—I just haven't formally stated it.

25　Consider (16)b. In order to capture the reading on which Irenka drove several times along *drogą Krętą*, the meaning of the indeterminate verb should be 'adjusted' via an operator so that it can apply to the meaning of *drogą Krętą* as a modifier of predicates of coarse processes. In other words, the two readings of (16)b cannot both be derived by analyzing *drogą Krętą* as a modifier of predicates of fine processes.

(63)　a.　# Teresa dziś mało płynęła[i]+.
　　　　　　Teresa today little swam
　　　b.　Teresa dziś mało pływała[i]-.
　　　　　　'Teresa swam little today.'

If we make the reasonable assumption that the meaning of adverbs like *dużo* 'much' and *mało* 'little' asserts that a motion process has relatively many or few parts, then the motion processes that they measure should have at least two proper parts to begin with, for otherwise there is nothing to 'count'. Coarse processes lack proper parts, but fine processes have at least two. Therefore, we expect that sentences such as (62)a and (63)a will be unacceptable, precisely because determinate verbs denote coarse processes. Observe that purely temporal modifiers don't exhibit this behavior:

(64)　a.　Irenka wczoraj długo biegła[i]+.
　　　　　　Irenka yesterday long ran
　　　b.　Irenka wczoraj długo biegała[i]-.
　　　　　　'Irenka ran for a long time yesterday.'

(65)　a.　Teresa dziś krótko płynęła[i]+.
　　　　　　Teresa today short swam
　　　b.　Teresa dziś krótko pływała[i]-.
　　　　　　'Teresa swam for a short time today.'

Given that *długo* 'for a long time' and *krótko* 'for a short time' are perfectly compatible with determinate verbs, we are led to conclude that the semantics of these modifiers measure duration without requiring access to the proper parts of a motion process.[26]

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Запись русских глагольно-именных словосочетаний в модифицированном Толково-комбинаторном словаре

Проект Толково-комбинаторного словаря (ТКС), который был задуман в середине 60-ых годов в Москве (в самом начале А. К. Жолковским, И. А. Мельчуком, позднее Ю. Д. Апресяном), на данный момент воплощен в четырех томах-словарях экспериментального характера – с одной стороны, в вышедшем в 1984 г. в Вене фрагменте словаря русского языка, собравшем прежние материалы московской группы лингвистов, а с другой стороны, в трех томах французских словарных статей, составленных по тем же принципам монреальской группой под главе с Мельчуком и Л. Иорданской в Канаде (третий том вышел в 1992 г.).

1. Привлекательность концепции комбинаторной части ТКС прежде всего объясняется концепцией лексических функций. С их помощью должно охватываться большинство слов-партнеров (слов-замен и слов-добавлений) данного слова, в первую очередь идиоматичных, но и чисто ситуативно связанных выражений.

Термин «функция» заимствован из математики. Видоизмененное определение (см. Wirth (1991)) гласит: Значение (или пире: содержание) какой-либо лексемы-партнера («коррелята») данной исходной лексемы может описываться в символах лексических функций, если оно отвечает следующим критериям:

а) Значение в парадигматическом или синтагматическом плане сочетается со *многими* исходными лексемами («аргументами») и имеет относительно *много зависящих* именно от этих исходных лексем (идиоматичных) выражений («значений») в математическом смысле) (ср. Mel'čuk (1996, 41-42)) и / или

б) удобно употребляется в качестве элемента описания в относительно большом количестве комбинаций с другими ЛФ или с самой исходной лексемой.

Значение 'очень' соответствует первому критерию и изображается символом 'magn'. См. следующие наречия (Adv):

(1)   крепко = ЛФ (*спать*);   твердо = ЛФ (*обещать*);   ЛФ = Adv_{magn}

Значение 'не' (non) не удовлетворяет первому условию, но его все-таки удобно использовать в составе других ЛФ:

(2)   пробел = ЛФ (*знание*)   ЛФ = $S^{\subset}_{sing2}$ non

Надо расшифровать: существительное со значением 'отдельный квант (= sing), о котором (= 2) нет [знания]'. Знак $\subset$ указывает на дополнительное значение: $\equiv$ '[... о котором] желательно [знание]'.

В общей сложности в модифицированном списке ЛФ именно в силу второго критерия числятся около 150 символов, в том числе и символы-сокращения.

Не уточняющиеся в записи семантико-синтаксические отношения между следующими друг за другом символами должны явствовать из аппарата определений ЛФ. См. следующий сложный пример с краткими объяснениями: