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Accumulation and aspectuality in Polish

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TWO themes are at play *sub rosa* in this paper, informing the analysis of a verbal prefix in Polish. The first is the expression of quantificational notions cross-linguistically, and the second, the character of aspectuality in Polish.

Partee et al. 1987 propose a typological division between D-quantifiers and A-quantifiers to classify the variety of elements that have quantificational meanings. Here 'D' stands for determiner, and 'A', for adverb(ial), auxiliary, and affix. Cross-cutting this classification is the distinction between *quantifiers proper* and *cardinality predicates*. Whereas quantifiers proper denote relations between sets of entities ($\langle\langle e, t \rangle, \langle\langle e, t \rangle, t \rangle\rangle$), cardinality predicates denote sets of entities ($\langle e, t \rangle$). Milsark (1979, 200–201) observes that the determiner *many* is ambiguous between these two interpretations. Thus a sentence like *Many linguists came* means either that many of the linguists came (compared to the linguists that did not come) or simply that linguists came and they were many. On the former interpretation, *many* is a quantifier proper, and on the latter, it is a (vague) cardinality predicate.

In this study, I will analyze the meaning of the verbal prefix known as 'accumulative *na-*' in Polish, an A-quantifier by the aforementioned classification (*formacje akumulatywne*, Grzegorzycowa et al. 1984, 477).¹ Accumulative *na-*, I will argue, is in one respect equivalent to *many* as a vague cardinality predicate. It applies productively to a class of verbs, adding a sense of accumulation to the interpretation of the direct object.²

- (1) a. *łuskać*^I 'shell, hull' > *na-łuskać*^P 'shell, hull a lot of'
- b. *drukować*^I 'print' > *na-drukować*^P 'print a lot of'
- c. *obierać*^I 'peel' > *na-obierać*^P 'peel a lot of'
- d. *opowiadać*^I 'tell' > *na-opowiadać*^P 'tell a lot of'
- e. *rwać*^I 'pick' > *na-rwać*^P 'pick a lot of'

- f. myć^l 'wash' > na-myć^P 'wash a lot of'

The effect of *na-* with the verbs in (1) concerns the quantity of entities denoted by the direct object: there are a lot of them (i.e., they have accumulated) by the time that the event described terminates. The pairs of sentences in (2–4) contrast a verb containing *na-* with its unprefixated counterpart.

- (2) a. Irenka na-łuskała^P orzechów.
Irenka *na*-shelled nuts.GEN
'Irenka shelled a lot of nuts.'
b. Irenka łuskała^l orzechy [ACC].
'Irenka shelled nuts.'
- (3) a. Wydawnictwo na-drukowało^P książek.
publisher *na*-printed books.GEN
'The publisher printed a lot of books.'
b. Wydawnictwo drukowało^l książki [ACC].
'The publisher printed books.'
- (4) a. Dziecko na-rwało^P kwiatów.
child *na*-picked flowers.GEN
'The child picked a lot of flowers.'
b. Dziecko rwało^l kwiaty [ACC].
'The child picked flowers.'

Note that we cannot infer any precise cardinality information about the quantity of shelled nuts, printed books, etc. from the descriptions in (2a, 3a, 4a). Intuitively, the threshold determining what counts as a lot depends on the context of use.

This paper has three sections, organized as follows. In §1, I examine three properties of *na-* and propose an informal treatment. In §2, I provide the necessary technical background for the analysis. Finally, in §3, I present the formal analysis of accumulative *na-* and review three of its consequences.

1 Three properties of *na-*

Accumulative *na-* has three salient properties that any analysis should address. They are (i) perfectivization, (ii) genitive case-marking of bare direct objects, and (iii) accumulation. I will discuss each of these in turn.

1.1 *na-* as a perfectivizer

Property one is that *na-* systematically perfectivizes imperfective verbs, as was already evident from the superscripts in (1). The terms 'imperfective' (*czasownik niedokonany*) and 'perfective' (*czasownik dokonany*) refer to the classification developed for verbs in the Polish grammatical tradition. Most imperfective verbs have standard perfective counterparts that are derived by prefixation. Accumulative *na-* does not apply to these perfective verbs, as shown in (5) for the prefixed perfective forms of the imperfectives in (1):³

- (5) a. ob-łuskać^P 'shell, hull' ✗ *na-ob-łuskać
b. wy-drukować^P 'print' ✗ *na-wy-drukować
c. o-brać^P 'peel' ✗ *na-o-brać

- d. o-powiedzieć^P 'tell' ✗ *na-o-powiedzieć
 e. z[e]-rwać^P 'pick' ✗ *na-z[e]-rwać
 f. u-myć^P 'wash' ✗ *na-u-myć

Other than the aspectual shift from imperfective to perfective, the verbs in the left column of (5) are equivalent to the imperfective ones in the left column of (1). On the basis of these data alone, it would be reasonable to think that the non-existent forms in (5) are ruled out by a morphological constraint against multiple prefixation in Polish. Such a constraint was in fact proposed by Kipka (1990, 31) to curtail all the imaginable and yet unattested combinations of verbal prefixes in Polish. But even if the proposed constraint were not so stipulative (which it is), it would not solve the problem at hand, for there are otherwise perfectly qualified *unprefixed* perfective verbs that do not admit prefixation of *na-*.

- (6) a. dać^P 'give' ✗ *na-dać
 dawać^I 'give' > na-dawać^P 'give a lot of'
 b. rzucić^P 'throw' ✗ *na-rzucić
 rzucać^I 'throw' > na-rzucać^P 'throw a lot of'
 c. pożyczyć^P 'lend' ✗ *na-pożyczyć
 pożyczać^I 'lend' > na-pożyczać^P 'lend a lot of'

Clearly, since the non-existent forms in (6) have a single prefix, they should be ruled out on other grounds—the suggested restriction against multiple prefixation would have nothing to say about them. It is also evident that there is no meaning clash between *na-* and the lexical semantics of the verb, for the imperfective verbs in (6) do allow prefixation of *na-*. Consequently, the restriction appears to be an aspectual one, stated in (7).

- (7) Accumulative *na-* applies to imperfective verbs, perfectivizing them.

Since (7) also accounts for the non-existent forms in (5), it is superior to the proposed morphological constraint on multiple prefixation, and so we are now able to dispense with the latter.

I know of one exception to (7), given in (8). The form *na-kupić^P* is predicted not to exist, because *kupić^P* is perfective.

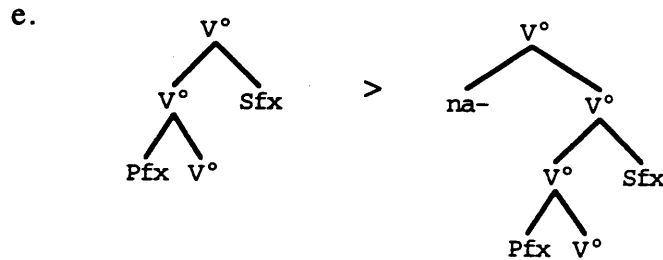
- (8) kupić^P 'buy' > na-kupić^P 'buy a lot of'
 kupować^I 'buy' > na-kupować^P 'buy a lot of'

Since accumulative *na-* regularly does not apply to perfective verbs, it is more reasonable to condone *na-kupić^P* as an exception than to invent reasons for why the relevant forms in (6) are ruled out. But this means that *na-kupić^P* will not be formally relatable to *kupić^P* in my analysis, which is a bit unfortunate since Polish speakers judge it as equivalent to *na-kupować^P* (the latter form is expected, of course). This disadvantage notwithstanding, much more is gained by postulating the restriction in (7) than by giving it up, hence I will keep it.

Polish also has *derived* imperfective verbs, viz., imperfective verbs derived from perfectives by means of suffixation or vocalic changes in the stem. The imperfective verbs in (1c–d) are actually related (via vocalic changes) to the perfective verbs *o-brać^P* and *o-powiedzieć^P* in (5c–d), respectively. In (9), I provide further

examples of derived imperfectives, their forms with *na-*, and the standard perfective verbs from which they are derived.⁴

- (9) a. w·pis-yw-ać^I > na·w·pis-yw-ać^P (w·pisać^P)
 ‘enroll, register’ > ‘enroll, register a lot of’
 b. za·bi-ja-ć^I ‘kill’ > na·za·bi-ja-ć^P ‘kill a lot of’ (za·bić^P)
 c. z·r-y-wać^I ‘pick’ > na·z·r-y-wać^P ‘pick a lot of’ (ze·rwać^P, cf. (5e))
 d. po·prawi-a-ć^I > na·po·prawi-a-ć^P ‘correct’ > ‘correct a lot of’ (po·prawić^P)



The morphological structures that I assume for the verbs in (9a–d) are shown in (9e): *na-* perfectivizes an imperfective verb that is itself derived via suffixation from a prefixed perfective verb. It is apparent that these are not exceptions to the constraint in (7), because *na-* is directly prefixed to the imperfective and not the perfective verb, and the latter is represented by the most deeply embedded branching V° .

In sum, any analysis of accumulative *na-* should account for the fact that it perfectivizes imperfective verbs. But this will mean elucidating in semantic terms what (im)perfectivization should even involve in the first place.

1.2 *na-* and genitive case-marking

Property two of accumulative *na-* is that it demands genitive case on a *bare* direct object, despite the fact that the imperfective verb to which it is prefixed systematically governs accusative case. Note that the genitive case-marking has nothing to do with perfectivity *per se*, because standard perfective prefixes do not require genitive case on bare direct objects.

- (10) a. (ob·)łuskać orzechy [ACC] / *orzechów [GEN] ‘shell, hull nuts’
 na·łuskać^P *orzechy [ACC] / orzechów [GEN]
 b. (wy·)drukować książki [ACC] / *książek [GEN] ‘print books’
 na·drukować^P *książki [ACC] / książek [GEN]
 c. obierać^I / o·brać^P ziemniaki [ACC] / *ziemniaków [GEN] ‘peel potatoes’
 na·brać^P *ziemniaki [ACC] / ziemniaków [GEN]
 d. opowiadać^I / o·powiedzieć^P bzdury [ACC] / *bzdur [GEN] ‘tell nonsense [plural]’
 na·opowiadać^P *bzdury [ACC] / bzdur [GEN]
 e. (ze·)rwać kwiaty [ACC] / *kwiatów [GEN] ‘pick flowers’
 na·rwać^P *kwiaty [ACC] / kwiatów [GEN]

The pattern in (10) notwithstanding, I want to claim that verbs with *na-* actually do *not* govern genitive case. This is because the head noun in other types of

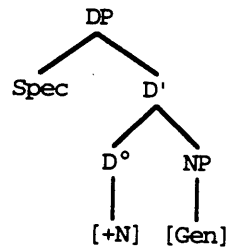
noun phrases does not (and indeed cannot) appear in genitive case. To my knowledge, the relevance of these data has not been pointed out in this connection.⁵

- (11) a. Irenka *na-łuskała*^P **stu* / *sto* orzechów.
 Irenka *na*-shelled hundred.GEN hundred.ACC nuts.GEN
 'Irenka shelled a hundred nuts.'
- b. Irenka *na-łuskała*^P **koszyka* / *koszyk* orzechów.
 Irenka *na*-shelled basket.GEN basket.ACC nuts.GEN
 'Irenka shelled a basket of nuts.'
- c. Irenka *na-łuskała*^P **trzech* *koszyków* / *trzy*
 Irenka *na*-shelled three.GEN baskets.GEN three.ACC
koszyki orzechów.
 baskets.ACC nuts.GEN
 'Irenka shelled three baskets of nuts.'
- d. Irenka *na-łuskała*^P **stu* *koszyków* orzechów /
 Irenka *na*-shelled hundred.GEN baskets.GEN nuts.GEN
sto *koszyków* orzechów.
 hundred.ACC baskets.GEN nuts.GEN
 'Irenka shelled a hundred baskets of nuts.'

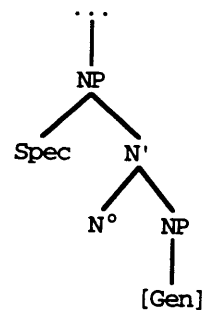
In each sentence of (11), the head of the object noun phrase appears obligatorily in accusative case. If *na-* simply changed the case-marking property of the imperfective verb from accusative to genitive, as the pattern in (10) would suggest, then it would be inexplicable why the head nouns of the object noun phrases in (11) do not also bear genitive case in this environment. Consequently, I reject the hypothesis that *na-* changes the case-marking property of the imperfective verb and thereby turn the problem around: if verbs with accumulative *na-* still govern accusative case, then why should genitive case show up obligatorily in (10)?

Let us understand the examples in (11) better. The genitive marking of *orzechów* has nothing to do with *na-*; rather, *orzechów* appears in genitive because it is the complement of a nominal head. This is obvious in (11b–c), but is less so in (11a, 11d). It is well-known, however, that the numeral expressions for 5 and higher in Polish take their complements in genitive case.⁶ If we make a distinction in Polish between nominal determiners ([+N], e.g., *sto* 'hundred') and non-nominal determiners ([–N], e.g., *trzy* 'three'), then the genitive case-marking in (11a, 11d) can be assimilated to that in (11b–c).⁷ Specifically, nominal complements of nominal heads appear in structural genitive case, regardless of whether these heads are nominal determiners or nouns (e.g., *koszyk* 'basket'). In (12), I adopt the DP approach to noun phrase structure, in which all noun phrases are really determiner phrases (Abney 1987). (12a–b) show the configurations in which genitive case is structurally assigned, and (12c–f) give the structures that I assume for the direct objects in (11).

(12) a.



b.



- c. [DP [D' [D° *sto*] [NP [N' [N° *orzechów*]]]]] (cf. (11a))
 d. [DP [D' [D° \emptyset] [NP [N' [N° *koszyk*] [NP *orzechów*]]]]] (cf. (11b))
 e. [DP [D' [D° *trzy*] [NP [N' [N° *koszyki*] [NP *orzechów*]]]]] (cf. (11c))
 f. [DP [D' [D° *sto*] [NP [N' [N° *koszyków*] [NP *orzechów*]]]]] (cf. (11d))

Thus, on this view, the genitive case-marking of an NP inside an accusative case-marked DP is independent of *na-*. The object DPs in (11) bear accusative case precisely because the verb prefixed with *na-* assigns them accusative case. The simplest assumption to be made about the bare genitive objects in (10) is that they are also accusative case-marked DPs that contain a genitive case-marked NP. In order to ensure that the objects in (10) exhibit the structure in (12a), I postulate the existence of a phonologically null [+N] determiner ' δ ' in Polish. Compare the two bare direct objects from (10a), the first in accusative case, the second in genitive case:

- (13) a. [DP [D' [D° \emptyset] [NP [N' [N° *orzechy*]]]]] (nuts.ACC, cf. (10a))
 b. [DP [D' [D° δ] [NP [N' [N° *orzechów*]]]]] (nuts.GEN, cf. (10a))

Crucially, δ is a [+N] determiner, whereas \emptyset is no determiner at all. The genitive case-marking of the NP in (13b) is therefore taken to be structural, falling under (12a), whereas δ is in accusative case. This is not so in (13a), where the NP directly bears the accusative case assigned by the verb.

The postulation of δ , although useful in accounting for the genitive case-marking in (10), is not unproblematic. The practical difficulty is in constraining its distribution. There are two sides to this difficulty. First, it is unclear why δ *must* be the head of the object DP of a verb with *na-* if no other nominal determiner or head noun is chosen. In other words, how are the bare accusative objects in (10) ruled out with *na-*? Second, it is puzzling why δ *may not* be the head of the object DP of an imperfective verb. If the DP in (13b) bears accusative case, as I claim, and if an imperfective verb like *łuskać* assigns accusative case (cf. (10a)), then it is not apparent why the combination of these two should be ungrammatical.

A similar problem arises in preventing δ from appearing in other environments, e.g., as the head of the subject DP of the copula. This contrasts with the overt heads exemplified in (11), which are permitted in this position.

- (14) a. *Sto orzechów jest / *są na stole.*
 hundred nuts.GEN is are on table.LOC
 'A hundred nuts are on the table.'

- b. Trzy koszyki orzechów *jest / są na stole.
'Three baskets of nuts are on the table.'
- c. *Orzechów jest / są na stole.
- d. Orzechy są na stole.
'Nuts [NOM] are on the table.'

In (14a), the nominal determiner *sto* is grammatically singular and therefore triggers singular agreement on the verb, but in (14b), the non-nominal determiner *trzy* is grammatically (as well as semantically) plural and consequently triggers plural agreement. As shown in (14c), no matter whether we take δ to be grammatically singular or plural, it may not head the subject DP of the copula. (14d), on the other hand, demonstrates that a bare nominative DP is fine in subject position. The lesson is that the postulation of δ does not automatically resolve the issue of its distribution.

I will propose a morphosyntactic solution to this problem, doubting that a purely semantic one is available. This decision is also driven by the intuition that the co-occurrence of accumulative *na-* with a bare accusative object (cf. (10)) is in fact ungrammatical and not simply semantically anomalous. My proposal is to introduce [m], a privative morphosyntactic feature that is mnemonic for *measure*. [m] is semantically motivated, a feature of determiners or nouns that denote measures.⁸ In addition, δ is specified for [m].

- (15) a. Elements with [m]: *sto* 'hundred', *trzy* 'three', *koszyk* 'basket', δ , ...
b. Elements without [m]: \emptyset , *orzech(y)* 'nut(s)', demonstratives, ...

The next step is to adopt a notion of syntactic subcategorization that is (at least partially) independent of semantic valency (Krifka 1989, Parsons 1990). I assume that syntactic subcategorization frames specify categorial and idiosyncratic case information, and distinguish external from internal arguments. Accumulative *na-* requires that the object DP bear [m]:

- (16) For all verbs of the form [*na-* [V°] v°]^P with accumulative *na-*:
{..., DP[Int, m], ...}
(Int = internal argument. *na-* does not require an external argument, as we will see in §3.)

Given (15–16), it is evident that a bare accusative object will be ungrammatical with *na-* (cf. (10)). This follows because a bare accusative object has an empty D° head (viz., \emptyset), which lacks [m], and therefore the subcategorization requirement in (16) is not satisfied. As a rule, if the object DP is not specified for [m], it will not be grammatically compatible with *na-*. If no overt element bearing [m] is chosen, this accounts for why δ must be used with accumulative *na-*.

In my analysis, [m] is not semantically interpreted, but it is with one exception always semantically motivated. δ is exceptional in this regard: it is a nominal determiner that bears [m] but which is not interpreted as a measure term (in contrast to the other expressions that have [m] in (15a)). This means that the accusative and genitive forms in (13), for example, are semantically equivalent. Nevertheless, since they differ with respect to the presence or absence of δ , they are clearly not morphosyntactically equivalent.

If δ is not interpreted, then a *blocking* solution for the distribution problem of δ suggests itself. In order to eliminate δ from environments in which it should not appear (e.g., in object DPs of imperfectives and standard perfectives, in subject DPs of the copula), the simple idea is that δ is not used unless the environment calls for [m] and no overt measure term is chosen. Since there is a morphosyntactically simpler form without δ that is semantically equivalent (viz., \emptyset), blocking demands that we use it in environments where [m] is not required.

- (17) For all DPs in all environments: δ is blocked iff \emptyset is grammatical.⁹

Consider how (17) rules out an example like (14c). The fact that the bare genitive subject *orzechów* is in genitive case indicates that δ is the head of the DP. But in this position, as subject of the copula, \emptyset would also be grammatical (the copula does not subcategorize for [m]), hence by (17) δ is blocked. The same reasoning applies to the other environments in which δ is blocked.

The feasibility of the blocking solution depends on our not interpreting [m], because if [m] is interpreted, then pairs like the one in (13) will not be semantically equivalent. Blocking compares morphosyntactic complexity, keeping the semantic dimension constant. As an alternative, suppose that we decide to interpret [m] (and thereby δ): does that automatically solve the distribution problem? The answer is clearly no—an example like (14c) is not automatically ruled out just because δ is interpreted. Thus there appears to be a morphosyntactic component governing the distribution of δ that is not fully reducible to interpretation.¹⁰

1.3 *na-* and accumulation

Property three of *na-* is that it asserts the *accumulation* of entities referred to by the object DP. While it is not straightforward to characterize accumulation in model-theoretic terms, the notion is reasonably clear on intuitive grounds. Entities accumulate in the course of an event iff their quantity gradually increases in the course of that event. This informal definition leads us to expect that *na-* is incompatible with transitive verbs that do not entail an internal argument whose referent is subject to accumulation. This expectation is borne out, as (18–19) show.

- (18) a. *Piotr *na*-kochał kobiet. **na*-kochać / kochać¹
 Peter *na*-loved women.GEN 'love a lot of' / 'love'
 'Peter loved a lot of women.'
- b. *Irenka *na*-umiała języków. **na*-umieć / umieć¹
 Irenka *na*-knew languages.GEN 'know a lot of' / 'know'
 'Irenka knew a lot of languages.'
- (19) a. *Bożena *na*-jadła jabłek. **na*-jeść / jeść¹
 Bożena *na*-ate apples.GEN 'eat a lot of' / 'eat'
 'Bożena ate a lot of apples.'
- b. *Irenka *na*-czytała artykułów. **na*-czytać / czytać¹
 Irenka *na*-read articles.GEN 'read a lot of' / 'read'
 'Irenka read a lot of articles.'

The imperfective verbs in (18–19) are not verbs of accumulation, hence *na-* cannot apply to them. Since stative verbs do not have internal arguments that are

entailed undergo any change (let alone gradual accumulation), the prefixed forms in (18) are prohibited. Verbs of consumption also do not entail accumulation—in fact, just the contrary. Bożena's eating of apples, for example, clearly removes apples from the context, even if we acknowledge that the consumed apples accumulate inside her in a somewhat different form. (19a) and its analogues are consequently ruled out. (19b), which does not exhibit a verb of consumption, is a bit trickier: if Irenka reads a lot of articles, her knowledge may accumulate, but the articles surely do not (nor, of course, are they necessarily removed from the context). I claim therefore that the crucial ingredient of 'accumulation of entities' is consistently missing from the examples in (18–19).¹¹

The proper subset relation holds between verbs of creation and verbs of accumulation—specifically, the set of the latter properly includes the set of the former. If we take verbs of creation to entail 'effected' entities, i.e., entities that come into existence during the course of an event, then it is evident that many verbs of accumulation are not verbs of creation. Of the imperfective verbs in (1), for example, *łuskać* 'shell, hull', *obierać* 'peel', *rwąć* 'pick', and *myć* 'wash' do not entail 'effected' entities *sensu stricto*. For example, it is not the case that there are no nuts before a shelling event (there are), but rather that the number of shelled nuts gradually increases in the course of a shelling event. More generally, entities that accumulate in the course of an event acquire a salient property that is constitutive of the event described.

Let us suppose that the syntactic arguments of a verb are associated with different thematic role types (Krifka 1989, Parsons 1990). The study of accumulative *na-* offers evidence in support of an 'accumulative patient' role type. Specifically, accumulative *na-* asserts the existence of entities that are of the 'accumulative patient' role type. I will designate this role type as 'Patient_A': semantically, it is a relation that holds between events and ordinary entities (cf. §2).

- (20) Accumulative *na-* asserts the existence of entities that stand in the Patient_A relation to the event described by the verb.

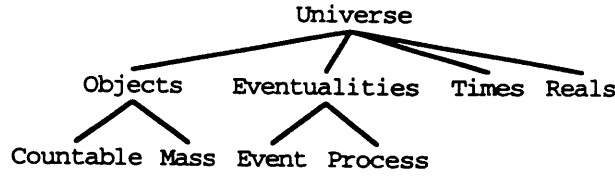
The characterization in (20) will be made more precise in §3.

2 Sorts and structures

In this section, I give technical formulations of the semantic notions that are assumed in my analysis of accumulative *na-*. For lack of space, I cannot fully convey the intuitions behind these notions, and so the relevant literature is useful in this regard.

I adopt the idea that the *universe of discourse* contains *sorted* domains of entities. The sorts that I postulate are *objects*, *eventualities*, *times*, and *real numbers*, all of which are mutually disjoint. The first two of these sorts, objects and eventualities, each contain two non-overlapping subsorts, viz., *countables* and *mass-objects*, and *events* and *processes*, respectively.¹² Intuitively, events differ from processes in that they culminate, whereas processes do not. The full inventory of sorts is depicted in (21).

(21)



For convenience, sorted variables range over entities in each domain, along with the standard unsorted variables x, y, z , which are domain-independent. Each set is abbreviated and shown with its designated variables in (22).

(22) B (objects):	V (eventualities):	T (times):	R (real numbers):
u, u', u''	v, v', v''	t, t', t''	r, r', r''
C (countables):	E (events):		
c, c', c''	e, e', e''		
M (mass-objects):	P (processes):		
m, m', m''	p, p', p''		

The next assumption is that each sort—with the exception of R —has the structure of a *mereology*. A mereology is a kind of algebra (technically, a semilattice) that represents a part-theoretic partial ordering on a set of entities.¹³ Let X be any basic set in (22), except for R . The *operation* of the mereology is the (primitive) binary *join* operation (\oplus) satisfying the axioms of *closure*, *idempotency*, *commutativity*, and *associativity* on any non-empty subset Y of X (\oplus is a total mapping from $Y \times Y$ to Y).¹⁴ Importantly, \oplus can only apply to entities of the same sort. Thus two countables may be joined to yield a complex countable individual, but a countable may not be joined with a mass-object, for example. This restriction is ensured by the following axiom:

$$(23) \quad \forall x \forall y \exists z [x \oplus y = z \rightarrow \exists Y [x, y \in Y \wedge Y \subseteq X \wedge X \in \{C, M, E, P, T\}]]$$

(\oplus is restricted to apply to entities of a single sort)

The *relations* of the mereology characterize the intuitive notion of part. They are *part* (\triangleleft), *proper part* (\triangleleft), and *overlap* (\circ), defined in terms of \oplus in (24).

$$(24) \quad \begin{array}{ll} \text{a. } \forall x \forall y [x \triangleleft y \leftrightarrow x \oplus y = y] & \text{(part)} \\ \text{b. } \forall x \forall y [x \triangleleft y \leftrightarrow x \triangleleft y \wedge \neg x = y] & \text{(proper part)} \\ \text{c. } \forall x \forall y [x \circ y \leftrightarrow \exists z [z \triangleleft x \wedge z \triangleleft y]] & \text{(overlap)} \end{array}$$

The most complex entity of a non-empty subset Y of X is known as the *supremum* of Y —it has as its parts all the other elements of Y . Operationally, the supremum of Y is found by applying \oplus pairwise to all the elements (simple and complex) of Y . Introducing P as a one-place predicate variable (type $\langle e, t \rangle$) whose extension in a model is Y ($\llbracket P \rrbracket = Y$), the supremum of P ($\sigma(P)$) is defined as follows:

$$(25) \quad \begin{array}{l} \text{Assume: } \forall P \exists x [P(x)]. \text{ Then:} \\ \forall P [\sigma(P) = \iota x [P(x) \wedge \forall y [P(y) \rightarrow y \triangleleft x]]] \end{array} \quad \text{(supremum of } P \text{)}$$

For example, if $Y = \{x, y, z\}$, then $\sigma(P) = x \oplus y \oplus z$. In this framework, the referent of a definite description is the supremum of the set in question.

The mereologies $\langle C, \oplus \rangle$, $\langle E, \oplus \rangle$, and $\langle T, \oplus \rangle$ are *atomistic*, i.e., every entity

in these structured domains is the join of atoms. An atom is an entity that has no proper parts:

$$(26) \quad \forall x \forall y [\text{at}(x) \leftrightarrow \neg \exists y [y \angle x]] \quad (\text{atom})$$

As emphasized above, \mathbf{R} is not structured as a mereology. The operations on \mathbf{R} are the standard binary ones of addition (+), subtraction (−), multiplication (•), etc., and the relations on \mathbf{R} are the familiar ones of *greater-than-or-equal* (\geq), *less-than-or-equal* (\leq), etc.

With a view to analyzing accumulative *na-*, we want to be able to count or *measure* objects of various complexity. An *additive measure function* for objects is one that maps non-overlapping objects into the positive real numbers, thereby preserving an empirical relation in an arithmetical relation (Lønning 1987). Let μ vary over the class of such measure functions:

$$(27) \quad \mu: \mathbf{B} \mapsto \mathbf{R}^+ \quad (\text{additive measure functions}) \\ \forall u \forall u' [\neg u \circ u' \rightarrow \mu(u) + \mu(u') = \mu(u \oplus u')]$$

The function that counts the atomic parts of countable objects is an additive measure function. This function, called **quantity** (Eschenbach 1993), is defined in (28a) and figures in the logical translation of *three* in (28b).

$$(28) \quad \text{a. } (\mu =) \text{ quantity: } \mathbf{C} \rightarrow \mathbf{Z}^+ \quad (\text{countables into positive integers}) \\ c \mapsto \text{card}(\{c' \mid \text{at}(c') \wedge c' \angle c\}) \quad (\text{card} = \text{cardinality}) \\ \text{b. } \textit{three} \Rightarrow \lambda P \lambda c [P(c) \wedge \text{quantity}(c) = 3] \quad \langle \langle e, t \rangle, \langle e, t \rangle \rangle$$

More generally, measure terms such as *kilogram*, *loaf*, *koszyk* ‘basket’, etc. are interpreted as additive measure functions μ in this approach.

I analyze verbs as one-place predicates of eventualities or times. This is essentially a richly sorted ‘neo-Davidsonian’ approach to verb meaning; see Krifka 1989 and Parsons 1990 for less richly sorted applications of this idea. In analyzing Polish, I propose that perfective verbs be analyzed as predicates of events, non-stative imperfective verbs as predicates of processes, and stative imperfectives as predicates of times. The latter, however, do not play an essential role in the analysis of accumulative *na-*.

$$(29) \quad \text{a. } \textit{wy-drukowa}^{\text{P}} \Rightarrow \lambda e [\textit{wy-drukowa}^{\text{C}}(e)] \langle e, t \rangle \quad \text{‘print’ (cf. (5b))} \\ \text{b. } \textit{łuska}^{\text{C}} \Rightarrow \lambda p [\textit{łuska}^{\text{C}}(p)] \langle e, t \rangle \quad \text{‘shell, hull’ (cf. (1a))} \\ \text{c. } \textit{kocha}^{\text{C}} \Rightarrow \lambda t [\textit{kocha}^{\text{C}}(t)] \langle e, t \rangle \quad \text{‘love’ (cf. (18a))}$$

Thematic role types are reconstructed as *thematic relations* between eventualities and objects. Accordingly, $\text{Agent}(u)(v)$ is read as ‘the agent of eventuality v is object u ’. Note that I assume *thematic uniqueness* for all thematic relations: no two distinct objects may bear the same thematic relation to a single eventuality.

Since we know that eventualities stand in certain relations to objects, which is knowledge that we have independent of the particular language that we speak, the requisite thematic relations can be guaranteed by meaning postulates or constraints on possible models (Parsons 1990). For example, all processes referred to by $\textit{łuska}^{\text{C}}$ ‘shell, hull’ entail the Patient_A thematic relation (cf. (20)):

$$(30) \quad \forall p[\text{łuskać}'(p) \rightarrow \exists u[\text{Patient}_A(u)(p)]]$$

The final notion that we need is the (primitive) *constitution relation* (\gg). Link 1983 introduces the constitution relation for the nominal domain in order to relate mass-objects to the countables that they materially constitute (e.g., gold that constitutes the ring). I propose extending this relation to the domain of eventualities, in the spirit (but not the letter) of Bach 1986. Thus, in a parallel fashion, processes are taken to constitute events. Constitution now holds between mass-objects and countables or between processes and events:

$$(31) \quad \forall x \forall y [x \gg y \rightarrow \langle x, y \rangle \in M \times C \vee \langle x, y \rangle \in P \times E] \quad (\text{constitution})$$

The constitution relation crucially figures in my analysis of (im)perfectivization.

3 Analyzing accumulative *na-*

In order to model the fact that *na-* is a perfectivizer, we should first make better sense of what it means to (im)perfectivize a verb in Polish. My proposal is to define two mappings between the sets of events and processes. Recall from (21) that these two sets are disjoint. The *process function* (ρ) maps events onto the processes that constitute them, and the *event function* (ε) maps processes onto the events that they constitute. The following definitions make this clear:

$$(32) \quad \begin{array}{ll} \text{a. } \rho: E \mapsto P & (\text{process function}) \\ \quad \forall e[\text{at}(e) \rightarrow \rho(e) = \iota p[p \gg e]] & \\ \text{b. } \varepsilon: P \mapsto E & (\text{event function}) \\ \quad \forall p[\varepsilon(p) = \iota e[\rho(e) = p]] & \end{array}$$

The aspectualization functions ρ and ε have overt morphological correlates in Polish. Recall from (9) that suffixes can imperfectivize perfective verbs. This means that such suffixes denote the value of ρ as applied to the events in the denotation of the perfective verb. The imperfectivization of *w·pisać^P* ‘enroll, register’ is given in (33).

$$(33) \quad \begin{array}{ll} \text{a. } w \cdot \text{pisać}^P, V^0 & \text{'enroll, register' (cf. (9a))} \\ \quad w \cdot \text{pisać}^I \Rightarrow \lambda e[w \cdot \text{pisać}'(e)] & \langle e, t \rangle \\ \text{b. } -yw, [[\alpha V^0] _ V^0] & \\ \quad -yw \Rightarrow \lambda P \lambda p [\exists e [P(e) \wedge \rho(e) = p]] & \langle \langle e, t \rangle, \langle e, t \rangle \rangle \\ \text{c. } w \cdot \text{pis-yw-ać}^I \Rightarrow \lambda P \lambda p [\exists e [P(e) \wedge \rho(e) = p]] (\lambda e [w \cdot \text{pisać}'(e)]) = & \\ \quad \lambda p [\exists e [w \cdot \text{pisać}'(e) \wedge \rho(e) = p]] & \langle e, t \rangle \end{array}$$

The perfectivization of imperfective verbs is achieved via prefixation. Analogously, such prefixes denote the value of ε as applied to the processes in the denotation of the imperfective verb. The perfectivization of *drukować^I* ‘print’ is shown in (34).

$$(34) \quad \begin{array}{ll} \text{a. } \text{drukować}^I, V^0 & \text{'print' (cf. (1b, 5b))} \\ \quad \text{drukować}^P \Rightarrow \lambda p [\text{drukować}'(p)] & \langle e, t \rangle \\ \text{b. } wy-, [V^0 _ [V^0 \alpha]] & \\ \quad wy- \Rightarrow \lambda P \lambda e [\exists p [P(p) \wedge \varepsilon(p) = e]] & \langle \langle e, t \rangle, \langle e, t \rangle \rangle \\ \text{c. } wy \cdot \text{drukować}^P \Rightarrow \lambda P \lambda e [\exists p [P(p) \wedge \varepsilon(p) = e]] (\lambda p [\text{drukować}'(p)]) = & \\ \quad \lambda e [\exists p [\text{drukować}'(p) \wedge \varepsilon(p) = e]] & \langle e, t \rangle \end{array}$$

This modelling of (im)perfectivization in Polish has a benefit that is worth emphasizing. As noted in §1.1, multiple prefixation of verbs is prohibited in Polish. Intuitively, the reason for this is that a prefix cannot (or should not be able to) perfectivize a verb that is already perfective, whether the latter is prefixed or not. But if perfectivization involves the application of ϵ , as I claim here, then perfectivization of a perfective verb is simply undefined (i.e., the domain values of ϵ are taken only from P). Similarly, imperfectivization of imperfective verbs is predicted not to be an option in Polish, as is indeed the case.

The meaning assignment that I propose for accumulative *na-* is in (35). Observe that it asserts ϵ (the event function), Patient_A (the thematic relation), and μ (an additive measure function).

- (35) $na-$, [v° __ [v° α]], $\langle \dots, DP[\text{Int}, m], \dots \rangle$;
 $na- \Rightarrow$
 $\lambda P \lambda e [\exists p [P(p) \wedge \epsilon(p) = e] \wedge \exists u [\text{Patient}_A(u)(e) \wedge \mu(u) > \text{Exp}(\mu(u))]]$
 (Type $\langle \langle e, t \rangle, \langle e, t \rangle \rangle$; μ is a free variable over additive measure functions, and $\text{Exp}(\mu(u))$ is the expectation value of μ as applied to u , both determined by the context of use.)

The first conjunct of the formula accounts for the role of *na-* as a perfectivizer of imperfective verbs, as required by (7). Given the aforementioned comments about ϵ , it follows that *na-* will not apply to perfective verbs. The second conjunct asserts the existence of an object u that bears the Patient_A relation to the event (cf. (20)) and requires that the value of μ when applied to u be greater than its expected value. This is modelled after the vague cardinality interpretation of *many* (Westerstahl 1985).

I will conclude with three correct consequences of this semantics for *na-*. First, the measure of the object bearing the Patient_A relation has to be large enough to count as many or much in the context of use. Examples in which the measure of the object is too small will be semantically anomalous. For example, if we describe Irenka's shelling of nuts with *na-*, then there should be many shelled nuts as a result. In this light, compare the data in (36).

- (36) a. Irenka *na-łuskała*^P dużo / wiele orzechów.
 Irenka *na-shelled* many.ACC / many.ACC nuts.GEN
 'Irenka shelled many nuts.'
 b. #Irenka *na-łuskała*^P mało [few.ACC] orzechów.
 'Irenka shelled few nuts.'
 c. #Irenka *na-łuskała*^P (jeden [one.ACC]) orzech [ACC] / (jednego [one.GEN]) orzecha [GEN].
 'Irenka shelled a / one nut.'
 d. ?#Irenka *na-łuskała*^P trzy [three.ACC] orzechy.
 'Irenka shelled three nuts.'
 e. Irenka *na-łuskała*^P sto [hundred.ACC] orzechów.
 'Irenka shelled a hundred nuts.'
 f. ?#Irenka *na-łuskała*^P tych [these.GEN] orzechów.
 'Irenka shelled these many nuts / #many of these nuts.'

In (36b), the meaning of *małto* ‘few’ requires that the measure of the object be *less* than the expectation value (see (38)), which clashes with the positive requirement of *na-*. Taking the expectation value for *na-* to be a positive number, a single shelled nut will always fail to be many, as (36c) indicates. In (36d), the question of three nuts is less clear, but in most contexts they will also not be many. (36f) crucially lacks a partitive (i.e., a quantificational proper) reading, which supports the analysis of *na-* as a vague cardinality predicate. Even on the latter interpretation, though, (36f) is judged to be difficult, perhaps because the demonstrative lacks the feature [m] and yet still competes with δ for the D° position (cf. (15b)). The English sentence is also awkward for a reason that I do not quite understand.¹⁵

The semantic derivation of the VP in (36a) is given in (37). It shows how information coming from the object DP serves to specify the value of μ and in fact converges with the requirement of *na-* that the measure of the object be large.

- (37) a. $na\text{-}\acute{t}uska\acute{c}^p \Rightarrow \lambda P \lambda e [\exists p [P(p) \wedge \varepsilon(p) = e] \wedge \text{‘na-shell’}$
 $\exists u [\text{Patient}_A(u)(e) \wedge \mu(u) > \text{Exp}(\mu(u))]] (\lambda p [\acute{t}uska\acute{c}'(p)]) =$
 $\lambda e [\exists p [\acute{t}uska\acute{c}'(p) \wedge \varepsilon(p) = e] \wedge \exists u [\text{Patient}_A(u)(e) \wedge$
 $\mu(u) > \text{Exp}(\mu(u))]]$
- b. $[du\acute{z}o\ orzech\acute{o}w\ DP] \Rightarrow$ ‘many nuts’
 $\lambda P \lambda e \exists u' [P(e) \wedge \text{Patient}_A(u')(e) \wedge \text{orzechy}'(u') \wedge$
 $\mathbf{quantity}(u') > \text{Exp}(\mathbf{quantity}(u'))]$
- c. $[na\text{-}\acute{t}uska\acute{c}^p\ du\acute{z}o\ orzech\acute{o}w\ VP] \Rightarrow$ (cf. (36a))
 $\lambda e \exists u' [\exists p [\acute{t}uska\acute{c}'(p) \wedge \varepsilon(p) = e] \wedge \exists u [\text{Patient}_A(u)(e) \wedge$
 $\mu(u) > \text{Exp}(\mu(u))] \wedge \text{Patient}_A(u')(e) \wedge \text{orzechy}'(u') \wedge$
 $\mathbf{quantity}(u') > \text{Exp}(\mathbf{quantity}(u'))]$

Re (37c): We infer $u = u'$ by thematic uniqueness. With no information to the contrary, we set $\mu = \mathbf{quantity}$, because the latter is a linguistically specified function measuring the same object. But then the two expectation values become identical, and the formula expresses a true proposition iff Irenka shells many nuts.

(38) shows the derivation of the VP in (36b), which is anomalous. The anomaly stems from the fact that *małto* ‘few’ demands that the measure of the object be less than the expectation value, whereas the opposite is required by *na-*.

- (38) a. $[ma\acute{l}to\ orzech\acute{o}w\ DP] \Rightarrow$ ‘few nuts’
 $\lambda P \lambda e \exists u' [P(e) \wedge \text{Patient}_A(u')(e) \wedge \text{orzechy}'(u') \wedge$
 $\mathbf{quantity}(u') < \text{Exp}(\mathbf{quantity}(u'))]$
- b. $[na\text{-}\acute{t}uska\acute{c}^p\ ma\acute{l}to\ orzech\acute{o}w\ VP] \Rightarrow$ (cf. (36b))
 $\lambda e \exists u' [\exists p [\acute{t}uska\acute{c}'(p) \wedge \varepsilon(p) = e] \wedge \exists u [\text{Patient}_A(u)(e) \wedge$
 $\mu(u) > \text{Exp}(\mu(u))] \wedge \text{Patient}_A(u')(e) \wedge \text{orzechy}'(u') \wedge$
 $\mathbf{quantity}(u') < \text{Exp}(\mathbf{quantity}(u'))]$

Re (38b): As before, $u = u'$ by thematic uniqueness. With no information to the contrary, set $\mu = \mathbf{quantity}$, for the latter is a linguistically specified measure function. But now we derive a contradiction, as the value of the same measure of u cannot be both greater than and less than the same expectation value.

The second consequence of (35) is that *na-* allows the measured entity to be a mass-object. This shows very clearly that plurality *per se* has nothing to do with

the meaning of *na-* (cf. (36c)). The following examples contain singular mass DPs:

- (39) a. Piotr *na-piekł*^P chleba.
Peter *na*-baked bread.GEN SG
'Peter baked a lot of bread.'
b. Bożena *na-rąbała*^P drzewa.
Bożena *na*-chopped wood.GEN SG
'Bożena chopped a lot of wood.'

Finally, the third consequence is that the meaning of *na-* may apply to unaccusative predicates, as long as the Patient_A relation is entailed, as shown in (40). Recall from (16) that *na-* does not require the imperfective verb to subcategorize for an external argument. I analyze these DPs as subjects, no doubt controversially, and I assume that the verb agrees with δ , the head of the DP.

- (40) a. *Na-padało*^P deszczu.
na-fell.NEUTER SG rain.GEN
'A lot of rain fell.'
b. *Na-marzło*^P ptaków.
na-froze.NEUTER SG birds.GEN
'A lot of birds froze.'

Notes

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¹Śmiech (1977, (1986, §5)) insightfully discusses the range of meanings that *na-* exhibits in Polish. Russell 1985 classifies the meanings of *na-* in Russian with aspectual considerations in mind, but her theoretical aim is quite different than mine, which is to focus on accumulative *na-* alone from a formal syntactic and semantic perspective.

²Conventions: V^I = imperfective verb, V^P = perfective verb, NOM = nominative, ACC = accusative, GEN = genitive, LOC = locative, SG = singular, Pfx = prefix, Sfx = suffix. For clarity, a dot (·) separates a prefix from its stem.

³The *e* of *ze-rwać*^P in (5e) is epenthetic.

⁴In each example, I surround the derived imperfective allomorph by two hyphens. The final suffix is the infinitive marker.

⁵Thus Śmiech (1986, 45) stresses that the complement of a verb prefixed with accumulative *na-* "must appear in genitive case" [*musi występować w dopełniaczu*], apparently failing to notice that this crucially depends on the form of the direct object. His remarks on accumulative *na-* are otherwise quite informative.

⁶This is a feature of many Slavic languages. See the articles by Leonard H. Babby and Steven Franks in Brecht and Levine 1986 for extended discussion of case-marking and noun phrases in Russian.

⁷The [\pm N] feature is intended to distinguish these two classes of determiners.

⁸A noun like *koszyk* 'basket' is ambiguous between a measure and a concrete object reading. In (15a), the former is the relevant reading.

⁹Blocking is akin to a 'minimalist' principle (Chomsky 1992), which states that the simpler structure (derivation) is grammatically favored over the more complex one, *ceteris paribus*.

¹⁰If [m] is interpreted, an alternative morphosyntactic solution would require two bivalent features, the first to distinguish the measure terms from others ([\pm m]), the second to distinguish δ from other measure terms ([\pm d]). Not interpreting [m], I will not pursue this alternative here.

¹¹The verbs *na-jeść*^P *się* 'eat enough of' and *na-czytać*^P *się* 'read enough of' (with the obligatory

reflexive pronoun *się*) do exist, however. Intuitively, such verbs make reference to the experience of the agent, who by eating something comes to feel full enough, or who by reading something comes to feel that s/he has read enough. Although *na...się* is clearly related to accumulative *na-*, the two are both morphosyntactically and semantically distinguishable. In this paper, I leave open the question of how the former should be analyzed.

¹²Unlike Bach 1986, I do not treat states as eventualities. Stative verbs are instead analyzed as predicates of times, though nothing in the paper critically depends on this choice.

¹³Representative of current algebraic approaches to nominal or temporal semantics are Link 1983, Bach 1986, Krifka 1989, Ojeda 1993, and Eschenbach 1993.

¹⁴Formally, these axioms are: $\forall x\forall y\exists z[x\oplus y = z]$ (closure), $\forall x[x\oplus x] = x$ (idempotency), $\forall x\forall y[x\oplus y = y\oplus x]$ (commutativity), $\forall x\forall y\forall z[x\oplus(y\oplus z) = (x\oplus y)\oplus z]$ (associativity).

¹⁵Alternatively, if *na-* requires an *indefinite* DP, then (36f) is unacceptable because the DP is definite. It is not obvious, however, how to build this requirement into the semantics of *na-*. The assumed analysis of definite descriptions as denoting suprema (cf. (25)) is not incompatible with the existential assertion contributed by *na-*. Filip (1993, 152) observes a similar effect in Czech.

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