Swarms and degrees – two experiments on Slavic *swarm* constructions[1]

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Abstract. The paper discusses the results of two experiments on Czech *swarm*-constructions. The results are interpreted in the degree approach to *swarms* (Hoeksema, 2009). Furthermore, some polarity constraints on *swarms* are clarified and described as a special case of degree positive polarity items.

Keywords: *swarm*-constructions, PPIs, experiments, degree semantics, Czech.

1. Introduction

Swarm-construction belongs to the family of argument alternations like active-passive or *spray-load* alternations, but compared to the two previously mentioned, *swarms* attracted a bit less attention from formal linguists (see especially Dowty 2000, 2001; Hoeksema 2009, 2018). We will summarize some of the most influential approaches to *swarms* in section 2, but let us first illustrate the alternation via data patterns. The most widely used predicate (both in the literature and language material) of the alternation is in (1) (from Hoeksema, 2009) and gave name to the whole construction. The variant in (1a) is usually considered as a baseline: the subject of the activity (in many cases repeated movement) is located as a figure in a ground syntactically realized as an object PP. We will call this type A-construction (following the similar naming convention as A-Subject from Dowty 2000). The semantically more loaded (1b) (L-construction) has the ground in the subject position, and the entities executing the activity are syntactically realized as *with*-headed PP. There are many intriguing semantic and pragmatic differences between A- and L- constructions (on top of the mentioned syntactic alternation) but let us now focus on one which will be central for our paper: in the L-construction the ground is totally affected by the activity which seems not to be the case in the A-construction. We will formalize this intuitive difference in a scalar framework, essentially following Hoeksema (2009).

(1) a. Termites are swarming in my kitchen. [A-construction]
b. My kitchen is swarming with termites. [L-construction]

Swarm alternations appear either in A- vs. L-construction demonstrated above, or they can be found in the third sub-type, demonstrated with a German example (from Hoeksema, 2009: ex.6) and Czech data in (2c) and (3c). We will call the third sub-type *es*-construction as in German (and some other Germanic languages where it appears) the subject position is filled with the expletive *es*.

(2) a. Ameisen wimmeln in der Küche.
Ants swarm in the kitchen

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'Ants are swarming in the kitchen'

b. Die Küche wimmelt von Ameisen.
the kitchen swarms with ants
'The kitchen is swarming with ants'

c. Es wimmelt von Ameisen in der Küche.
it swarms with ants in the kitchen
'The kitchen is swarming with ants.'

(3) a. Na té louce bzučely včely.
on the meadow swarmed.3PL bees.PL.NOM
'The bees swarmed on the meadow.'

b. Ta louka bzučela včelami.
the meadow swarmed.3SG bees.PL.INSTR
'The meadow was swarming with bees.'

c. Na té louce to bzučelo včelami.
on the meadow it swarmed.3SG bees.PL.INSTR
'The meadow was swarming with bees.'

In this paper, we discuss two experiments (on Czech data), which (i) show that the intuition of total-affectedness derives from the scalar properties of the L-construction; (ii) probe into the nature and mechanisms behind the polarity constraints on the L-construction.

2. Two approaches to *swarms*

In this section, we discuss two approaches to *swarms* that are dominant in formal linguistic literature. Historically first is Dowty's dynamic texture hypothesis (Dowty, 2000), which is summarized in section 2.1, Hoeksema's scalar approach is introduced in section 2.2. In the last part of this section (2.3), we summarize Solt (2018), one of the most successful attempts to deal with scalar polarity constraints. The scalar nature as a source of positive polarity behavior was previously considered improbable (see especially Szabolcsi 2004), but nowadays, it seems more accepted that scalarity plays a role in the licensing of some PPIs and some NPIs though not all (Rullmann, 1996; Hoeksema, 2018).

2.1. Dynamic texture hypothesis

Let's first start with the "dynamic texture hypothesis" as Dowty himself names it. In the current section, we will summarize the main points of this approach, skipping over intriguing details which are not central for our paper.

As for the empirical coverage, Dowty (2000) lists the following 5 classes of *swarms*:

1) small local movements (repeated): *crawl, drip, buble, dance, foam, rumble, pulsate, ...*
2) animal (and other) sounds (repetitive): *hum, buzz, whistle, resonate, echo, ...*
3) kinds of light emission: *beam, blaze, flame, glow, glitter, ...*
4) smells and tastes: *smell, taste, reek, ...*
5) degree of occupancy/abundance: *brim, teem, be rampant, ...*

He furthermore notices that all the verbs in the five classes are atelic activities but not vice versa:

if an activity does not describe repeated movement/sound/. . . it cannot undergo the swarm alternation; compare ungrammatical attempt to make an L-construction from a predicate denoting directly oriented motion like **The road marched with soldiers.* Some morphological support for Dowty's claim can be found in Slavic languages where *swarm*-predicates are nearly without exception imperfective pluractional verbs (the only exceptions being phase denoting atelic perfectives), compare the morphological paradigm in (4a) (pluractional verb signaled with the stem *-a-*) with (4b) (semelfactive verb with the stem *-nou-*) where only the former aktionsart can participate in the L-construction (5). And note that this constraint cannot be explained as a result of some telicity prohibition on *swarms* since semelfactives are atelic.

(4) a. blýsk-a-t 'glitter' pluractional
b. blýsk-nou-t 'glitter once' semelfactive

(5) a. Jeskyně se blýsk-a-la diamanty.
'The cave glittered with diamonds.'
b. Jeskyně se *blýsk-nu-la diamanty.
'The cave glittered with diamonds #once.'

The leading idea of Dowty's approach to *swarms* is that in the L-construction, the ground subject is described by predicates of small and frequently repeated events. Because there are many events, there are many corresponding sub-regions where each event is located, and an addressee of L-constructions (according to Dowty) has an intuitive feeling of texture perception (thus the name "dynamic texture hypothesis"). Dowty's theoretical claim then is that there is a transfer of events to locations analogical to aspectual transfers between incremental themes and their predicates. Dowty's reasoning nicely explains the data contrast in (6) (from Dowty 2000: p. 123): the PP objects in L-construction seem to be only indefinites (mostly bare plurals or mass nouns) and any explicit and precise cardinality information leads to an ungrammaticality.

(6) a. The room swarmed with mosquitoes.
b. The room swarmed with a hundred mosquitoes.
c. ??The room swarmed with seventy-three mosquitoes.
d. My philodendron is crawling with dozens of snails.
e. ??My philodendron is crawling with fifty-seven snails.

Dowty explicitly claims that *swarms* are argument alternations similar to middle or conative alternations and for him are derived in the lexicon where (via lexical rules) un-appropriate candidates for L-constructions are filtered out. And analogically to other alternatives, he conceives one pattern as basic, semantically default/un-marked and purely compositional. For Dowty, it is the A-construction (this idea is in some form shared by all other linguists working on *swarms*).

Dowty mentions another important observation concerning an inference distinguishing A- and L-construction, which is the total affectedness inference mentioned in section 1. For Dowty, in accordance with his events to locations mapping, that results in a total impact of the whole location, as demonstrated in (7) from Dowty (2000). Whether total affectedness equals mapping to all sub-regions of the L-subject is a point of controversy, but it seems like a valid observation concerning examples like (7).

(7) a. Bees are swarming in the garden, but most of the garden has no bees in it.
b. #The garden is swarming with bees, but most of the garden has no bees in it.

2.2. Hoeksema's scalar approach to *swarms*

Hoeksema's analysis differs in many important aspects from Dowty's dynamic texture hypothesis. Hoeksema first correctly points out that not all subjects of *swarms* are strictly speaking locative. But they always express a high degree of affectedness. See (8) and (9) from Hoeksema (2009), where neither John nor walls are plausible locations of the *swarming* events.

(8) a. Q: Was John angry?
b. A: He was foaming with fury.

(9) a. Q: Was the crowd loud?
b. A: The walls were vibrating with their cheers.

On the positive side, Hoeksema claims that *swarms* are degree constructions with a causative component, in his words: "the object of *with* causes the subject to exhibit a high degree of some property by completely affecting it" from Hoeksema 2009: p. 20. Let's notice that: i) this concerns just L-construction so that the syntactic derivation would proceed from the non-causative A-construction to the causative L-construction – in accordance with the un-marked status of A-construction; ii) the causative L-*swarm* differs from the usual causative constructions where the causation source is in the majority of cases encoded in the subject position. Whatever the real syntax-semantic analysis of L-constructions turns out to be,[2] Hoeksema's analysis seems to be well supported in its degree approach to *swarms* – a point verified by our experiments too.

Hoeksema supports his claims with the following data: i) L-constructions as in (10) (after Hoeksema 2009: ex. 41) are compatible with high degree modifiers and incompatible with adverbs modifying low degrees (we found this effect in our experiments too); ii) the degree analysis correctly predicts scalarity based inferences concerning affectedness of L-construction subjects, see (11) (after Hoeksema 2009: ex. 40). Let us illustrate the second point intuitively: (11) would be true even in a scenario where e.g., the first half of the book is extremely full of typos, while the second part is totally without them: once some contextually given threshold of high degree is exceeded, the L-construction becomes true. We consider this second observation very compelling, and we are preparing an experiment to test its general validity.

(10) a. The book is literally littered with typos.
b. The yard was absolutely lousy with vermin.
c. ??The book is somewhat littered with typos.
d. ??The yard was a bit lousy with vermin.

(11) The book is littered with typos.

After establishing the degree nature of L-construction *swarms*, Hoeksema (2009) discusses their polarity properties – some short note concerning *swarms*' polarity can be found in Hoeksema 2018 too. Based basically on two reasons, Hoeksema classifies *swarms* as PPIs. The first reason is theoretical: Hoeksema claims that many high degree predicates (as extreme adjectives, some types of idioms, etc.) are PPIs and offers some preliminary reasoning about that concerning very weak information value of such predicates under negation. The second reason is empirical: based on careful investigations of *swarms* natural occurrences and some cross-

[2]We believe that proposals of Gehrke and McNally 2014 where it is hinted at incorporation analysis of *swarms* are maybe more promising.

linguistic corpus evidence (English and Dutch mostly), he shows that L-construction *swarms* avoid negation and downward entailing contexts. He uses Fisher's test to calculate expected frequency (based on non-*swarm* predicates) and compares them with in the corpus observed frequency of positive vs. negated *swarm*-predicates. In the majority of cases, it seems that *swarm*-predicates occur either only in positive sentences or if negated, they appear with statistically significantly smaller frequency than generic types of non-*swarming* predicates. We ran some similar queries in the Czech national corpus (Křen et al. 2015) with similar results.[3]

2.3. Degree constructions and polarity

In recent years linguistic interest in the polarity constraints of degree constructions had arisen. They are studied either from a mostly empirical point of view (Hoeksema, 2018), mostly theoretical perspective (Spector, 2014) or some mixture of both with an experimental approach (Solt, 2018; Solt and Waldon, 2019). The area seems to be less understood than in the case of NPIs as frequently mentioned, so there is nothing like a standard recipe for degree polarity items. But we'll focus now on Solt (2018) and her treatment of approximators, which seem to empirically resemble the polarity effects revealed by *swarms* as we will argue in the following sections.

First, let us start with the basic data patterns and theoretical tools that Solt (2018) uses to deal with them. The most important polarity contrast concerning approximators is illustrated in (12) (after Solt 2018: ex. 20): approximators like English *about* act as PPIs, not tolerating negation if they modify numerals: (12a) vs. (12b). But if the approximator is embedded in comparative quantifiers, they seem to switch to the exactly opposite side and behave as NPIs: (12c) vs. (12d).

(12) a. Lisa has about 50 sheep.
b. *Lisa doesn't have about 50 sheep.
c. *Lisa has more than about 50 sheep.
d. Lisa doesn't have more than about 50 sheep.

The first assumption which Solt makes and which she derives from Katzir (2007) is that the approximator competes with the alternative in which the approximator is deleted. The alternatives for (12a) are then $\{$*about 50 sheep*, *50 sheep*$\}$. The immediate problem then is that unlike the run of the mill polarity effects with *even* and bare numerals (strong NPIs like *even one book* is standardly assumed to evoke alternatives like $\{$*1 book*, *2 books*, *3 books*, $\ldots\}$ – see Crnič 2011; Krifka 1995), the approximators are by definition vague, and in the right context, both bare and approximator-modified numerals are logically equivalent, consequently neither is logically stronger or weaker than the other one.

Solt acknowledges this obstacle and proposes that using approximators is a reasonable conversational turn only in such cases where the speaker signals that imprecision is overtly signaled;

[3]We gathered frequencies of three most common Czech *swarms* in positive and negative sentences and compared them with frequencies of their non-*swarm*-alternating counterparts: *swarms hemžit se* 'swarm', *bzučet* 'buzz', *třást se* 'tremble' and their corresponding verbs *pohybovat se* 'move', *zpívat* 'sing' and *hýbat se* 'move'. We summarized their 2x2 contingency tables and have found a significant association between polarity and the *swarm*/non-*swarm* status: $\chi^2(1) = 56.72, p < 0.001$. The odds of occuing in a negated sentence were 1.9 times higher for non-*swarms* than in the case of *swarms*, $\phi = 0.045$. As the odds ratio and the Cramér's V show, the effect was very weak.

consequently the bare numerals are interpreted exactly (not in the 'at least,' lower bounded way), and approximators denote non-trivial range around the bare numeral denotation.

Simplifying Solt's formalization then yields (13a) as a (contextual) meaning of (12a) and (13b) as the meaning of bare numeral alternative of (12a): k_i denotes the non-trivial range dependent on the context i.

(13) a. $max\{n$: Lisa has n sheep$\}$ = 50
b. $max\{n$: Lisa has n sheep$\} \in [50-k_i, 50+k_i]$

Notice that (13a) is logically stronger than (13b), so the assertion of the approximator-modified numeral yields an implicature that the speaker was not in a position to assert the bare alternative. But such an implicature is, in this case, innocent and, in fact, compatible with the usage of approximator as a signal of exact uncertainty.

But in the case of negated sentences containing approximator-modified numerals the entailment reverses: the negated modified numeral ($\neg\ max\{n$: Lisa has n sheep$\} \in [50-k_i, 50+k_i]$) entails the negated alternative with the bare numeral ($\neg max\{n$: Lisa has n sheep$\}$=50), and corresponding double-negated implicature ($\neg\neg max\{n$: Lisa has n sheep$\}$=50) contradicts the original assertion resulting in blocking and PPI behavior of the approximator-modified numerals.

Notice that in the negated case, the bare alternative is not logically stronger but weaker; thus, at least in the standard neo-Gricean approaches to NPIs, it would not be considered as competing with the assertion. Solt is fully aware of this complication and suggests that there are two factors beyond the proposed concurrence: i) simplicity – partially following Katzir (2007) she considers the bare alternative simpler, as it can be derived from the approximator-modified version via deletion; ii) entailment defined as "definitely stronger than" relation which requires to be true across all possible interpretations (in all contexts). Because qua the relation "definitely stronger than" the two alternatives are logically equivalent (even if in some interpretations one is contextually stronger than the other one) and the bare alternative is always simpler, there is concurrence between the two even if they are (across contexts) logically equivalent. In simple words, to formalize the concurrence between the approximator-modified numeral and the bare-numeral, one has to take into account both the logical and structural properties of the alternatives.

The general recipe then is: if the simpler alternative is logically weaker (in some contexts), its non-assertability leads to a contradiction resulting in the blocking of the asserted sentence (containing approximator modified numerals in the case at hand). If the simpler alternative is logically stronger, its non-assertability is innocent. In the case of approximators embedded in comparative quantifiers, the entailment reverses (against the basic pattern discussed in the current section), and the NPI pattern emerges (see Solt 2018 for details).

We will apply this sort of reasoning to the polarity behavior of *swarms* in section 4 as there are many properties connecting approximators with *swarms*: both are degree constructions that are context-dependent and exhibit patterns of polarity sensitivity depending on the scale standards. Generally, both constructions differ from the more studied and more understood polarity items, so the usual standard polarity frameworks like Krifka (1995) cannot be straightforwardly applied to them.

The details of our experiment results and the first steps to formalize them will be described below, but let us shortly foreshadow the patterns and our way of dealing with them theoretically. First, the core pattern which emerged from our experiments (all the details are in the section 3) is demonstrated with English examples below: both positive and negative sentences do allow *swarm* L-construction ((14a) and (14b)). But if the L-construction is modified with *completely* type of degree booster, the modified L-construction becomes unacceptable if it is negated ((14c) vs. (14d)). Second, we take this resemblance between *swarms* and *about* approximators seriously (recall the PPI pattern of approximators in (12)) and in the theoretical part (section 4) apply Solt's reasoning to *swarms*: in case of modified L-construction, the negated bare alternative (the alternative without *completely* modifier) is logically weaker and consequently its non-assertability blocks the realization of the modified L-construction as (14d).

(14) a. Bees are swarming in the garden.
b. Bees aren't swarming in the garden.
c. Bees are completely swarming in the garden.
d. #Bees aren't completely swarming in the garden.

3. Experiments

The question that comes to mind is what is the distinction between Czech A-constructions and L-constructions. For this purpose, we run two experiments to test the various properties of these two *swarm*-constructions. In the first experiment, we asked whether L-construction exhibits high degree properties and whether it behaves as PPIs (Hoeksema, 2018). Based on the results from the first experiment showing that unmodified *swarms* do not behave as PPIs, we conducted the second experiment focusing on L-constructions modified with modifiers of maximality. In this section, we present both experiments, their results, and the consequences. The experiments basically show that modified L-constructions are PPIs, unlike unmodified L-constructions, but they seem to be a different type of PPIs.

3.1. Experiment 1

The first experiment aims to confirm Hoeksema's intuition that L-constructions exhibit a high degree of a predicate's property. We tested both A-constructions and L-construction to show the differences between them. Since L-constructions are supposed to be high degree constructions, A-constructions are considered to have default/semantically un-marked status by both main approaches presented above.

3.1.1. Procedure & Participants

The experiment was run on the IBEX farm, and the participants filled the experiment online. The experiment began with the instructions following with the practice part where it was illustrated in three practice examples of what the participant's task is. Then, participants filled the test part itself. There were two types of sentences in the experiment: (i) tested sentences, so-called items, and (ii) sentences that were supposed to distract and, at the same time, verify that the participants pay attention, so-called fillers. Items alternated with fillers. We used the Latin square design; the experiment was presented in such a way that each item appeared only once in the whole experiment for each subject, whereas individual conditions cycled with the subjects. The order of items and fillers was presented to each participant randomly. 50 Czech

native speakers participated in the first experiment.

3.1.2. Design & Material

The experiment consisted of the acceptability judgment task: we used the 5-point Likert scale from 1 (absolutně nepřijatelná věta "completely unacceptable sentence") to 5 (věta je naprosto v pořádku "completely acceptable sentence"). We tested whether the sentences are acceptable for Czech native speakers or not. There were 32 items and 32 fillers in total in the experiment. We used four conditions, and each condition was varied for L-construction and A-construction; the design of the experiment then was 4x2, eight conditions in total. The sample item for L-construction is in (15). We present here L-construction since this construction is crucial for our following analysis, and it was expected to observe a desirable effect in it. The four conditions were as follows: 1) REF in (15a) – The baseline condition was the reference level; there were bare *swarm* constructions. 2) DEG in (15b) – *Swarm* constructions were modified with a low degree modifier *trochu* 'slightly'. Assuming that L-constructions exhibit high degree properties and behave as PPIs, this condition should be unacceptable for participants, since the low degree modifier is inconsistent with the high degree properties of predicates. 3) NEG in (15c) – *Swarm* constructions were negated to detect avoidance of PPI contexts. *Swarm* constructions were expected to be unacceptable for participants provided *swarms* behave as PPIs, as suggested by Hoeksema (2009). 4) RESC in (15d) – this condition tested the rescuing of *swarms* in iterated DE contexts. Taking into account that *swarms* were suggested to have PPI's properties, this condition should be more acceptable than the condition NEG since *swarm* predicates should be rescued.

(15) a. Ta louka bzučela včelami.
the meadow.SBJ buzz.3SG.PST bee.PL.INS
'The meadow buzzed with bees.' REF

b. Ta louka trochu bzučela včelami.
the meadow.SBJ slightly buzz.3SG.PST bee.PL.INS
'The meadow slightly buzzed with bees.' DEG

c. Ta louka nebzučela včelami.
the meadow.SBJ NEG.buzz.3SG.PST bee.PL.INS
'The meadow didn't buzz with bees.' NEG

d. Jestli dnes louka nebzučí včelami, tak zítra
if today meadow.SBJ NEG.buzz.3SG.PRS bee.PL.INS then tomorrow
bude.
be.3SG.FUT
'If the meadow doesn't buzz with bees today, it will buzz tomorrow.' RESC

3.1.3. Results & Discussion

We analyzed the data statistically. First, we evaluated fillers; they were uncontroversially acceptable or unacceptable Czech sentences, and we checked whether the average of each participant's responses to unacceptable fillers was lower than the average of their responses to acceptable fillers. All the participants successfully passed the fillers; therefore, we kept all of them in the subsequent analysis. Responses in the experiment were modeled by a mixed-effects linear model with subject and item random effects (in R package *ordinal*). Both random-effects

were treated as random intercepts and random slopes. The independent variables were: Conditions (DEG, NEG, RESC, and the reference level REF), and Construction: (A-construction – ACON, L-construction – LCON) and their interaction. The dependent variable was the subject's responses. The Error bars graph nicely summarizes the acceptability of each condition in Figure 1.

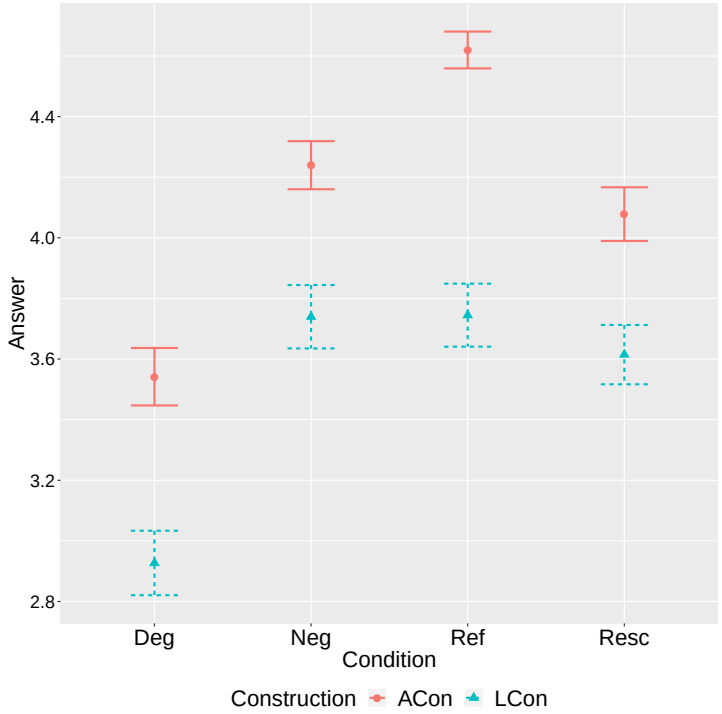


Figure 1. Error bars of responses (means and standard errors).

It is evident from the mere sight of the error bars graph that A-construction was always better in each condition. Moreover, something seems to be happening with the condition DEG. We observe that the condition DEG is less acceptable than all other conditions.

The linear regression model was constructed as follows: i) the response variable was the subjects' answers, the explanatory variable was the condition with four levels (DEG, NEG, RESC, REF); ii) the reference level condition was REF level. The explanatory categorical variable was treated in the R defaults way (treatment contrasts). The 4x2 design was fitted by way of interaction, the subjects' responses were modeled as an interaction between the CONDITION (4 categorical levels) and the construction (2 categorical levels: ACON,LCON). The estimated coefficients in Table 1 show how much the three levels of the variable CONDITION differ on average from the reference condition. As is clear from the z-values and p-values, only the level DEG is significantly different from the reference level.[4]

The model further reported significant effect of CONSTRUCTION and three significant negative interactions: CONSTRUCTION with DEG, CONSTRUCTION with NEG and CONSTRUCTION with

[4]To check the reliability of the interaction model, we fitted the data with another model without interactions and with main effects only. The ANOVA comparison of the two models confirmed that the interaction model was significantly better ($p < 0.001$).

	Estimate	Std. Error	z value	Pr(> |z|)
DEG	-0.724307	0.114374	-6.333	2.41e-10 ***
NEG	0.007611	0.116197	0.066	0.947776
RESC	-0.119997	0.114384	-1.049	0.294145

Table 1. The statistical output.

RESC. Table 2 summarizes the estimated coefficients for the three interactions and hte CONSTRUCTION effect. The *z*-values clearly show that CONSTRUCTION effect was much stronger than the interactions.

	Estimate	Std. Error	z value	Pr(> |z|)
ACON	1.102949	0.131216	8.406	< 2e-16 ***
DEG:CON	-0.578378	0.171478	-3.373	0.000744 ***
NEG:CON	-0.589774	0.177291	-3.327	0.000879 ***
RESC:CON	-0.622380	0.174732	-3.562	0.000368 ***

Table 2. The statistical output: the interaction effects.

Since the Construction effect was much stronger than the interactions, ACON was always better than LCON. The statistical results and descriptive statistics clearly show the overall worse acceptability of LCON, which probably derives from the relative morpho-syntactic markedness of (Czech) L-constructions against ACON. The main negative effect of DEG proves the degree sensitivity of swarms. Technically the interaction of CON with DEG states that L-construction accepts degree modifiers more than A-construction: we would expect bigger decrease of acceptability in the condition DEG (parallel to the condition REF), but both the Figure 1 and the interaction effect in Table 2 show the significant interaction effect.

The results taken together strongly support the degree analysis of *swarms* and falsify their PPI status. These findings are more consistent with Hoeksema's degree analysis. Nevertheless, *swarms* do not show real PPI behavior, which goes against the polarity analysis of them in Hoeksema (2009) (and partially similar notes concerning extreme adjectives in Morzycki 2012).

3.2. Experiment 2

Following the results obtained from the first experiment, we raised the following question: whether a modification of L-constructions with negation may lead to unacceptability. Our research goal was to bring new reliable data about polarity effects of high degree vague predicates as their profile is very different from the more studied and understood the existential type of PPIs (Spector 2014, among others).

3.2.1. Procedure & Participants

The procedure of the second experiment was identical to the first experiment: the experiment was run on IBEX farm again; there were the introduction, the practice part, and the test part. Participants had to judge items and fillers, and the way of the presentation remained similar as in the first experiment, i.e., we used the Latin square design again, but we added context against

which the subjects rated both grammaticality and appropriateness. 38 Czech native speakers participated in the second experiment.

3.2.2. Design & Material

The experiment consisted of a truth-value judgment task: the subjects had to judge both the grammaticality and contextual appropriateness of one of the conditions (for each item) in the context. We used the 5-point Likert scale from 1 (věta je naprosto negramatická a neodpovídá kontextu "the sentence is completely ungrammatical, and it is not appropriate in the context") to 5 (věta je naprosto gramatická a odpovídá kontextu "the sentence is completely grammatical, and it is appropriate in the context"). There were 16 items and 16 fillers in total in the experiment.

We tested various types of L-constructions with modifiers of maximality *úplně* 'completely'. The sample item is in (16). Due to the lack of space, we present a context only for the first condition since contexts for the other three conditions were slightly modified, e.g., to ensure that *úplně* 'completely' is interpreted as scoping over negation. The four conditions were as follows: 1) REF in (16a) – The baseline condition was the reference level; there was a positive verb. 2) DE in (16b) – The tested sentences contain the downward entailing expression *málokdy* 'rarely'. 3) NEG in (16c) – *Swarm* constructions were negated. 4) RESC in (16d) – We used negated questions for testing of eventual rescuing.

(16) The context: A human rights march is held regularly every month in the town. On average, about 180 human rights activists participate in the march. Today, exactly 180 participants met on the square. Policeman Ales calls his superior and says the following sentences:

a. Dnes se náměstí úplně rojí bojovníky za lidská
today SE square.SBJ completely swarm.3SG.PRS activist.PL.INS for human
práva.
right.PL
'Today, the square is completely swarming with human rights activists.' REF

b. Minulý rok se náměstí málokdy úplně rojilo
last year SE square.SBJ rarely completely swarm.3SG.PST
bojovníky za lidská práva.
activist.PL.INS for human right.PL
'Last year, the square was rarely completely swarming with human right activists.' DE

c. Dnes se náměstí úplně nerojí bojovníky za
today SE square.SBJ completely NEG.swarm.3SG.PRS activist.PL.INS for
lidská práva.
human right.PL
'Today, the square is not completely swarming with human rights activists.' NEG

d. Nerojí se dnes náměstí úplně bojovníky za
NEG.swarm.3SG.PRS SE today square.SBJ completely activist.PL.INS for
lidská práva?
human right.PL
'Isn't the square today completely swarming with human rights activists?' RESC

Based on our intuition, we expected that only both negation and modification by maximality modifier *úplně* 'completely' lead to unacceptability. The non-technical explanation is such that the use of maximality modifiers (or eventually intensifiers), e.g., *úplně* 'completely,' fix the high degree of *swarm* constructions. Still, the negation causes that the high degree is not valid anymore, which goes against the expected high degree properties of *swarms*. The condition NEG was supposed to be unacceptable since the negation is rarely compatible with intensifiers (Castroviejo and Gehrke, 2019).

3.2.3. Results & Discussion

The procedure of analyzing data was identical to the analysis of the first experiment. First, we evaluated fillers, and since all the participants successfully passed the fillers, we kept all of them in the subsequent analysis. The responses were modeled by a mixed-effects linear model (in R package NLME). The random effects were subjects and items, and the fixed effects were four conditions REF, DE, NEG, RESC. Participants' answers were modeled as functions of the fixed effect. The descriptive statistics show the statistically significant effects and their *t.ratio*s: the pairwise differences using Tukey's honestly significant adjustment is in Table 3.

contrast	estimate	SE	df	t.ratio	p.value
NEG − DE	-0.3982	0.130	643	-3.069	0.0120
NEG − REF	-1.1595	0.129	643	-9.002	<.0001
NEG − RESC	0.0676	0.129	643	0.523	0.9537
DE − REF	-0.7613	0.128	643	-5.954	<.0001
DE − RESC	0.4658	0.129	643	3.617	0.0018
REF − RESC	1.2271	0.127	643	9.626	<.0001

Table 3. The pairwise differences of Conditions.

The statistically significant effect was between almost all pairs of conditions listed in Table 3. The only statistically non-significant effect was between NEG and RESC. The error bar graph representing the means and standard errors is in Figure 2.

The statistical results and descriptive statistics (visualized in Figure 2) show that L-constructions of *swarms*, when modified by *completely*-type of a modifier, are degraded in downward monotonic and antimorphic environments. In this respect, the experiment confirms Hoeksema's claims (2009; 2018) about the polarity sensitivity of *swarms*. But contrary to standard types of PPIs, *completely*-modified *swarms* seem not to be rescuable. To our ears, the polarity question was the best possible rescuing candidate from PPI rescuing environments. However, even here, the modified *swarms* were not acceptable.

On the other hand, there is a difference between *swarm* constructions and previously studied degree predicates modified with intensifiers (see Castroviejo and Gehrke 2019), which allow being embedded in downward entailing environments which is not true for the *completely*-modified *swarms* as the statistically significant difference between REF and DE shows. To account for the data, we propose a partially semantic and pragmatic theory of *swarm*'s polarity behavior discussed in the following section.

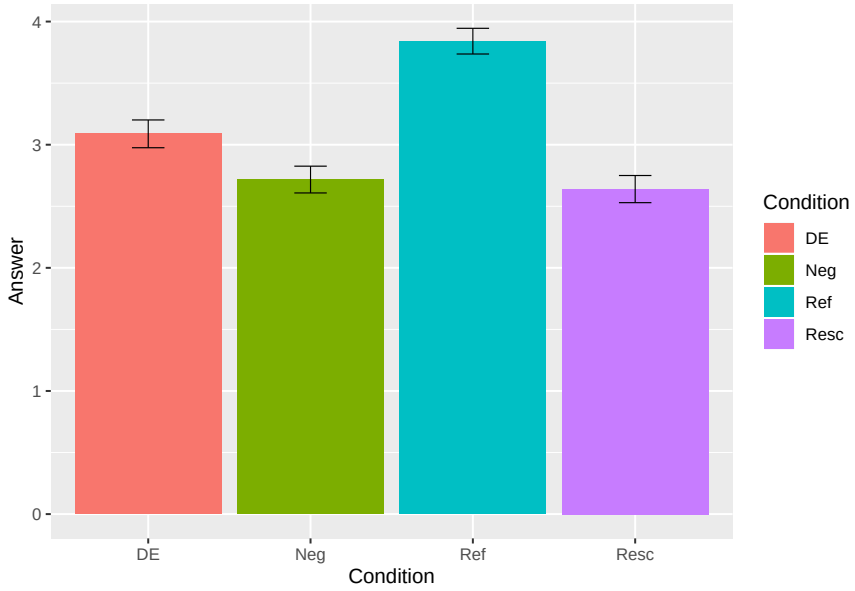
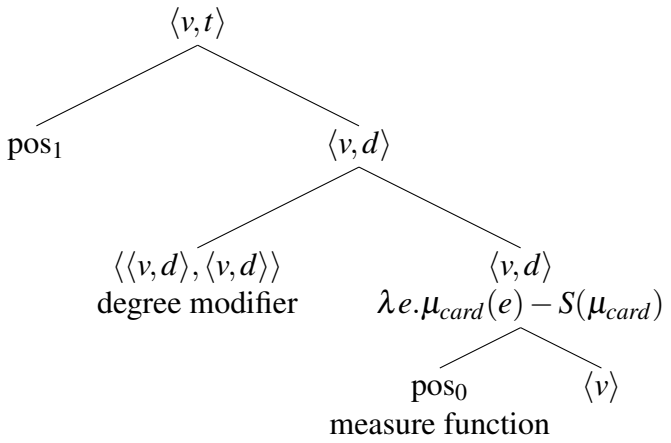


Figure 2. Error bars of responses (means and standard errors).

4. Analysis

Based on the results from the experiments and observations from the *swarm* literature, we suggest that L-construction lexicalizes a degree argument, unlike A-construction. And since both current formal theories of *swarms* (Hoeksema 2009, 2018; Dowty 2000) of *swarm* constructions lack real formalization, we propose the following event formalization (in the style of Champollion 2015) extended with a degree semantics for L-constructions. In formalizing this idea, we follow Umbach's (2011) and Sæbø (2010) in using split positive formative to encode the high degree inferences, the inferences of L-constructions in our case. The proposed syntactic tree with semantics for L-construction is as follows: the pluractional meaning of L-construction is a set of events at type $\langle v \rangle$, it is converted via pos_0 into a function from events to degrees, namely such events exceeding in the appropriate scale (cardinality of events in prototypical *swarms* but also intensity) a contextual standard S. The contextual standard is, in fact, maximum standard, as is clear from the baseline REF acceptability (experiment 2) and independently verified by two experiments on Slovak *swarms* in Vlášková (2020), we will elaborate on this point a bit further. But what is important type-wise is that L-construction is in this phase of semantic composition open for degree modifiers (of the right type). After adding the degree modifier, the second part of split positive formative (pos_1) is added, and the verbal projection is interpreted as a set of events.

(17)



Via this formalization, we argue that L-construction lexicalizes a degree argument, and therefore, it is accessible for degree modification. We will illustrate our reasoning on the formalization of a schematic L-construction sentence *The hillside swarmed with skiers.* The formalization steps are the following: the inner box in (18) denotes a measure function (pos_0); at this point, the degree modifier can be added. The second part of positive formative (pos_1), i.e., the outer box in (18), shifts the measure function into a predicate of events. The semantics is motivated by the fact that L-constructions are compatible with degree modifiers, unlike A-constructions that do not lexicalize a degree argument and cannot be modified with them, see (19) as a formalization of A-construction version of the discussed sentence (empirical support comes from the interaction effects in the experiment 1 which pointed out better acceptability of degree modification with L-constructions).

(18) $\exists X \subseteq \textbf{skiers} \wedge \exists e[\textbf{swarm}(e) \wedge \boxed{(\boxed{\mu_{card}(e) - S(\mu_{card}(e))}) > 0} \wedge \textbf{loc}(e) = \iota(\textbf{hillside}) \wedge \textbf{ag}(e) = X]$

(19) $\exists X \subseteq \textbf{skiers} \wedge \exists e[\textbf{ag}(e) = X \wedge \textbf{swarm}(e) \wedge \textbf{loc}(e) = \iota(\textbf{hillside})]$

The next step is to try to formalize the results from the second experiment, where degree semantics and polarity interact. We describe each condition step by step. We basically claim that the modified version of swarms with *completely*-type modifiers is blocked by a non-assertability of its unmodified version in downward entailing environments. In other words, the unmodified version is, at least in some contexts, logically stronger than the modified version. Still, a speaker is not in a position to assert it in downward entailing environments, which results in the blocking of the modified version too. In this way, we follow Krifka's (1995) neo-Gricean approach to PPIs and, more particularly, Solt's (2018) application of Katzir's (2007) theory of structurally derived alternatives to PPIs introduced in section 2.3. In case of the *swarms* and their polarity sensitivity, we believe that both bare *swarms* (BS) and *completely*-modified swarm (CMS) are vague, as the maximum standard is computed from the mapping between the location denoting subject (Dowty, 2000) and the set of events denoted by the verb. Nevertheless, the point of adding a 'completely' modifier is to fix the contexts (C) to those where CMS expresses the degree of swarms exceeding or being equal to the maximum standard. Let's apply the reasoning to the results from the second experiment.

In the condition REF (sentences like *Today, the square is completely swarming with human rights activists)*, we claim that the CMS competes with a structurally more simple BS. Follow-

ing the previous discussion, we formalize the degree inferences of the bare *swarm* construction via a split positive formative introduced above in (18) as follows:

(20) $\lambda e.[^{*}swarm(e) \wedge (\#e - max(S_{\#})(C)) = 0)]$

Such a set of swarming events where the degree of the relevant scale, e.g., cardinality, intensity, measuring the events is equal to the maximum-standard in the context C (remember, *swarms* behave as maximum standard degree constructions). On the other hand, CMS enforces the degree to lie in the interval starting at the maximum-standard in the particular context C and to exceed it by contextually given variable $k(C)$. The formalization of CMS is the following, boosting, in fact, the maximum standard:

(21) $\lambda e.[^{*}swarm(e) \wedge (\#e - max(S_{\#})(C) \in [0, k(C)])]$

Recall that unlike the modified L-construction, its negated version was unacceptable. The contrast was introduced intuitively in (14) and then confirmed experimentally with the significant difference between the referential and NEG conditions of experiment 2. Now we will discuss the technical explanation of the contrast. The competition between BS and CMS leads to an epistemic inference concerning the non-assertability of BS, see (22), which is compatible with the meaning of CMS, where the degree exceeds the maximum-standard. In prose: speaker uttering CMS signals that the degree of *swarming* exceeded the maximum standard, and it's not true that he believes that it is equal to the maximum standard, plausible interpretation for CMS.

(22) $\neg Bel_s(\lambda e.[^{*}swarm(e) \wedge (\#e - max(S_{\#})(C)) = 0)])$

In the condition NEG, we assume that the negation scopes over the split positive. The negated BS and CMS meanings are in (23a) and (23b), respectively.

(23) a. $\lambda e.[^{*}swarm(e) \wedge \neg(\#e - max(S_{\#})(C)) = 0)]$
b. $\lambda e.[^{*}swarm(e) \wedge \neg(\#e - max(S_{\#})(C) \in [0, k(C)])]$

The negated CMS characterizes the degree of *swarms* to lie under the maximum-standard, but the negation of BS, especially if strengthened, clashes with the negated meaning of BS. The formalization of the negation of BS is in (24). The assertion of CMS claims the degree of *swarming* to be under the maximum standard. Still, the double negated BS alternative in (24) contradicts the assertion as it equals the degree of *swarming* with the maximum standard. Consequently, the CMS is blocked by the structurally defined alternative. Notice, that BS is logically weaker than CMS in negated sentences, so we have to work with simplicity as a tool for deriving alternatives as Solt (2018).

(24) $\neg Bel_s(\lambda e.[^{*}swarm(e) \wedge \neg(\#e - max(S_{\#})(C)) = 0)]))$

In prose: CMS is logically weaker than its bare alternative, consequently the epistemic implicature of the bare L-construction falsity is still compatible with the assertion of CMS (similarly to a simple propositional logic analogy: $p \vee q$ is logically weaker than p and eventual falsity of p is compatible with the assertion of $p \vee q$). But if the modified L-construction is negated, CMS becomes logically stronger than its bare alternative and the epistemic implicature of BS falsity is devastating as claiming both (stronger) $p \wedge q$ and negating (weaker), p would lead to a contradiction ($\bot : (p \wedge q) \wedge \neg p$)). Next, we introduce the technical explanation of other experimental results, but all of them are built upon the same core reasoning discussed in the

current paragraph.

In the condition DE, we assume the competition between BS and CMS again. The downward entailing frequency adverb under negated believe operator of BS alternative can be strengthened, as is schematically formalized in (25): the improbability comes from the diverging claims of the assertion (the maximum standard was rarely reached), and the negated alternative (which claims that rarely the maximum standard wasn't achieved). Even if BS is still compatible with CMS, it is very improbable to get both assertion and its implicature true. As such, it can explain why, in the experiment, the condition DE is more acceptable than the condition NEG.

(25) $Bel_s(rarely > \neg > swarm_{max})$

In the last condition RESC, we explain the polarity question's inability to rescue CMS as a remaining clash between the non-assertability of BS, which results in blocking of CMS. The same recipe we described for NEG: questioning the polarity of REF still requires the computation of its sentence-radical meaning first.

In this section, we made the first step in formalizing *swarm* constructions. We propose the formalization of basic types of *swarm* constructions. Moreover, we extended the formalization for more complex *swarm* constructions, i.e., for the *swarms* with *completely*-type of modifiers. Our formalization is based on the results from two experiments in Czech. We are aware that our proposed semantics is work in progress and definitely not a final description of *swarm* constructions. Still, we are the first one to come up with a real formalization explaining both the scalar behavior of L-construction *swarms* and their polarity constraints.

5. Conclusions

In this paper, we report the results of two experiments on Czech *swarms*. Empirically their results are the following: i) L-construction shows clear signs of scalarity like the acceptability of degree modification by expressions targeting the maximum standard of scales; ii) there is a complex pattern of L-construction polarity behavior; namely, it resembles other degree polarity sensitive constructions as approximators. Theoretically, both experiments support the degree approaches to *swarms* (like Hoeksema 2009) and the degree-polarity interaction work like Solt (2018). As for the novel insights, we bring new independent empirical evidence for the PPI behavior of degree constructions.

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