Long-distance cumulativity asymmetry: experimental evidence from Czech [1]

Mojmír DOČEKAL — *Masaryk University*
Michaela HULMANOVÁ — *Masaryk University*

Abstract. This paper explores conjunctions and the phenomenon of cumulative asymmetry with respect to the subject and object position. The tested conjunction is the Czech *i*, which is postulated to be a D-conjunction. The aim of this paper and the experiment carried out is to test whether Czech speakers observe cumulativity asymmetry at long-distance in ECM constructions and whether monoclausal and long-distance configurations differ in interpretations.

Keywords: conjunction, d-conjunction, c-conjunction, distributivity, cumulativity, cumulativity asymmetry.

1. Introduction: universal quantifiers, distributive conjunctions, and distributivity

Singular universal DPs in subject position, like English *every* in (1a), always allow the distributive reading (formalized under (1a)), therefore would make a sentence true in a distributive context like (1). The same is true for indefinite descriptions (prototypically numerical NPs) in the same syntactic configuration: (1b).

(1) Context (distributive): Alex planted a spruce and a birch, and Bart planted a maple and a walnut.
   a. Every boy planted two trees. true
   $\forall x[\text{BOY}(x) \rightarrow \exists Y[^*\text{TREE}(Y) \wedge \#Y = 2 \wedge \text{PLANT}(x,Y)]]$
   b. Two boys planted two trees. true

On the other hand, universal quantifiers in the same syntactic configuration (subject position) are not prone to the cumulative interpretation, unlike indefinite descriptions: (2a) would be false in a cumulative context, (2), while the numerical NP, (2b) is well acceptable there.

(2) Context (cumulative): Alex and Bart planted a spruce and a birch.
   a. Every boy planted two trees. false
   b. Two boys planted two trees. true
   $\exists X \exists Y[^*\text{BOY}(X) \wedge \#X = 2 \wedge {}^*\text{TREE}(Y) \wedge \#Y = 2 \wedge \text{PLANT}(X,Y)]$

Nevertheless, in a different syntactic position, for example the object of a transitive verb in (3a), the same universal quantifier is allowed to be interpreted cumulatively, as witnessed by the context (3), which is not surprising in case of the indefinite description in (3b).

[1]We would like to express our deepest gratitude to Nina Haslinger for her help with not only the whole experiment, but mainly the theoretical part of this paper and the thesis on which this paper is based. Also thanks to the audiences at Sinn und Bedeutung 27, FASL 31 and Psycholinguistics of Slavic Languages 2022 for relevant comments.

(3) Context (cumulative): Alex and Bart watered a spruce and a birch (the only trees around).
   a. Two boys watered every tree. true
   b. Two boys watered two trees. true

This instance of subject-object asymmetry is well known in the theoretical literature as Schein (1993); Kratzer (2000); Champollion (2010) a.o. and is usually named **asymmetry of cumulative readings**. In this article, we bring new empirical material concerning this asymmetry of cumulative readings. In this respect, we contribute to the growing interest in asymmetry, which until recently was mainly theoretical. Our research focuses on distributive conjunctions. Namely, we follow Dočekal et al. (2023), where it was established that universal quantifiers and distributive conjunctions form a natural class with respect to the asymmetry of cumulative readings. Dočekal et al. (2023) report experimental work on Czech and German distributive conjunctions. The distributive conjunctions in the subject position, like German *sowohl* NP *als auch* NP in (4a) or Czech NP *i* NP in (4b), are obligatorily interpreted distributively: (4).

(4) a. Sowohl Ada als auch Bea haben genau vier Bücher gelesen.
   PRT Ada PRT also Bea have exactly 4 books read
   'Ada and Bea each read exactly four books.'
   b. Aleš i Bedřich přečetli přesně čtyři knihy.
   Alex *i* Fridrich read exactly 4 books.
   'Alex and Fridrich read exactly four books each.'
   c. cumulative scenario: A read 2, B read 2 false
   d. distributive scenario: A read 4, B read 4 true

However, if distributive conjunctions are in the scope of plural denoting NP (in the object position, e.g., outscoped by a plurality denoting NP in a subject position), the cumulative reading for them starts to be available. This shows that both, universal quantifiers and distributive conjunctions, share an important meaning component making their behavior parallel to the asymmetry of cumulative readings. Additionally, it also shows that approaches where obligatory distributivity is an integral part of the distributive conjunctions meaning, like Szabolcsi (2015); Mitrović and Sauerland (2016) or Gruet-Škrabalová (2004) for Slavic, are at least partially wrong.

(5) a. Heute haben die zwei Deutshcen sowohl die Abfahrt als auch den Slalom
   today have the two Germans PRT the downhill PRT also the slalom
   gewonnen.
   won
   'Today, the two Germans won both the downhill and the slalom.'
   b. Dva Češi vyhráli sjezd i slalom.
   Two Czechs won downhill *i* slalom.
   'Two Czechs won the downhill and the slalom.'
   c. cumulative scenario: A won the downhill, B won the slalom true
   d. distributive scenario: A won both, B won both true

Our article is organized as follows: section 2 discusses the two theoretical approaches to cumulativity asymmetry presented here and our research questions. Section 3 presents the experiment, its design, example items and results aswell. Both descriptive statistics and fixed effects are provided. Lastly, section 4 aims to answer the research questions, summarize the experiment, and provide the results of a small follow-up experiment.

2. Theoretical approaches

Our article is empirically and experimentally focused, but the research questions it pursues are (of course) derived from the theoretical stances to the problem of asymmetry of cumulative readings. We will now discuss the two possible approaches to the asymmetry. At the core level, we can distinguish the two approaches summarized below.[2]

The first approach stems from the work of Kratzer (2000) and can be found as a recent version in Chatain (2021). The main idea of this approach, with respect to the asymmetry, is to rely on thematic role hierarchies. Universal quantifiers (and distributive conjunctions) can be (according to this view) interpreted cumulatively only if they have a lower θ-role than another plural denoting NP. Consider (6): it has only distributive reading for the universal quantifier (or for distributive conjunction if the natural language has dedicated distributive conjunction) because the distributive expression bears a higher thematic role (agens) than the other plural denoting NP in the sentence (*two trees* with the θ-role patiens). But consider (7), here the universal quantifier (or distributive conjunction) bears the patiens θ-role, is lower in the θ-role hierarchy than the other plurality denoting NP and therefore can be interpreted cumulatively. Generally, the thematic role approach predicts that the cumulative reading of the universal quantifier (or distributive conjunction) is not available if the other plural denoting NP has a θ-role ranking lower than the universal quantifier.

(6) Every boy planted two trees.
   a. AGENS (every boy/boy *i* girl) > PATIENS (two trees) only distributive

(7) Two boys planted every tree.
   a. AGENS (two boys) > PATIENS (every tree/tree1 *i* tree2) cumulative possible

The second type of explanation for asymmetry explains it via scope and does not rely on semantic roles. Let's call this approach the derivational hypothesis; the first formulation can be found in Champollion (2010), more recently in Haslinger and Schmitt (2018) (see Dočekal et al. 2023 for experimental support). The derivational explanation of the asymmetry, exemplified in (6) vs. (7) would flow as follows: universal quantifier can be interpreted cumulatively in (7) since it does not c-command the plural expression *two boys*. But in (6) the c-command configuration is reversed, and since the indefinite description is c-commanded by the universal quantifier, the cumulative interpretation is not available. The more general version of the derivational hypothesis works with chains since transformations can change the scope relations. In our experimental work, we scrutinized only base-generated sentences. Therefore, we adhere here to a

[2]We are aware that we simplify here since the theoretical approaches summarized in this section are motivated by more general theoretical goals than to explain just the asymmetry. From this, it follows that our summary is a sort of extraction of the parts of theories that are relevant to our research.

simplified version of the scope/derivational approach (but see Haslinger and Schmitt 2018 for details). See also the closing section of this article for a short explanation of the mechanics of this type of theory that can derive the asymmetry.

2.1. Hypotheses of the experiment

The core idea of our experiment is to test the two kinds of theories discussed in Section 2. In simple transitive clauses discussed above, both approaches yield the same predictions, but once we look into more complex sentences, the predictions of both theories diverge. Since by definition, θ-roles are tied to its predicate, the thematic role approach predicts that the asymmetry should be observed only locally in the sense of arguments of the same predicate. The derivational hypothesis, on the other hand, predicts the existence of asymmetry also at long-distance. We decided to test the distributive conjunctions in the Exceptional Case Marking (ECM) constructions. Czech is a good testing ground for such an experiment since it has a productive inventory of ECM verbs (see Caha 2004) and also has a very prolific distributive conjunction *i* (see Gruet-Škrabalová 2004). We formulate the idea behind the experiment in the form of the research question in (8). The positive answer to the research **question 1** would support the structural theories, and it would directly contradict the strong version of the θ-role approach to the asymmetry. The strong version refers to the idea that θ-roles are the only factor of the asymmetry of the cumulative readings. We note that both Kratzer (2000) and Chatain (2021) are weaker versions of the θ-role approach to the asymmetry problem, but the positive answer to question 1 would go against the grain of their explanations as well.

(8) **Question 1**
Do Czech speakers observe cumulativity asymmetry at long-distance?

While the main research goal of our experiment concerns itself with the empirical testing of the two theories, we also pursued more general questions concerning the current distributivity theories. There is still a divergence in the current approaches to distributivity (ranging from the event-based theories like Champollion (2016) to dynamic accounts like Dotlačil (2012, 2013)), the standard accounts (like Champollion 2016) are still local in the sense that distributivity is explained via the pluralization at the level of the predicate (continuing the classical works on distributivity like Link 1983; Schwarzschild 1996 a.o.). For this reason, examining distributivity/cumulativity acceptance is a fine testing ground for evaluating the locality prediction of the standard distributivity theories. We note that the second question is more exploratory, but no difference in acceptability of the distributive interpretation in the case of local and distance configurations can be problematic for many standard approaches to distributivity. We formulate the research **question 2** in (9).

(9) **Question 2**
How different are monoclausal and long-distance configurations interpretations?

3. Experiment

47 anonymous Czech participants answered 72 questions in a truth value judgement task via Ibex hosted by the Humboldt University's *Institut für deutsche Sprache und Linguistik*. None of the participants were paid or otherwise reimbursed for taking part in the experiment. Their task was to determine whether the presented image corresponded with a sentence in the given context. The null hypothesis stated that the position of *i* in reference to the subject and object does not influence the readings available. We expected that a higher acceptability rate of the cumulative reading of *i* in object position would be observed, rather than in the subject position.

3.1. Design

The design of the experiment followed the structure presented below. The tested sentence was a combination of the factors SUBJ and ECM paired with one of the levels of PIC. Each item contained a D-conjoined NP and another NP conjoined by the *a* 'and' conjunction. The position of the D-conjunction was based on the level of SUBJ. The level WRONG of PIC represented the baseline to which we compared the other levels of PIC; the picture was inherently wrong compared to the tested sentence, be it by the use of wrong verb representation or wrong animal. We used a three-factorial $2 \times 2 \times 3$ design, as detailed in the structure below.

1. Position of D-conjunction — factor SUBJ
    - SUBJTRUE - *i* in subject position
    - SUBJFALSE - *i* in object position
2. Type of structure — factor ECM
    - ECMTRUE - ECM structure
    - ECMFALSE - simple SVO clause
3. Picture condition — factor PIC
    - CUMUL - cumulative picture
    - DISTR - distributive picture
    - WRONG - wrong picture

3.2. Example items

(10) a. Context
Pátá třída základní školy byla na výletě v městské zoologické zahradě.
fifth grade elementary school was on trip at city zoo garden.
Tam se děti mohly na zvířátka dívat a některé nakrmit.
There REFL children could at animals look and some feed
'The fifth grade of an elementary school went on a trip to the city zoo. There, the children could observe the animals and feed some of them.'

(11) a. Sára i Dan viděli Adélu fotit lva a tygra.
Sára *i* Dan see.3PL.PST Adéla.ACC take.picture.INF lion.ACC and tiger.ACC
'Sára and Dan saw Adéla take a picture of a lion and a tiger.'

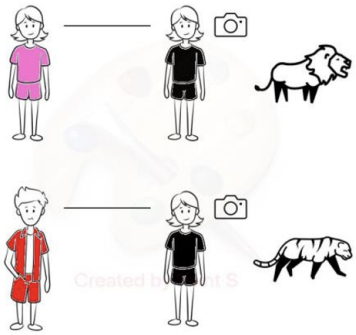

Figure 1: Illustration of item SUBJTRUE & ECMTRUE with PIC CUMUL.

(12) a. Klára a Šimon viděli Tínu natáčet velblouda i žirafu.
Klára and Šimon see.3PL.PST Tína.ACC record.INF camel.ACC *i* giraffe.ACC
'Klára and Šimon saw Tína record a camel and a giraffe.'

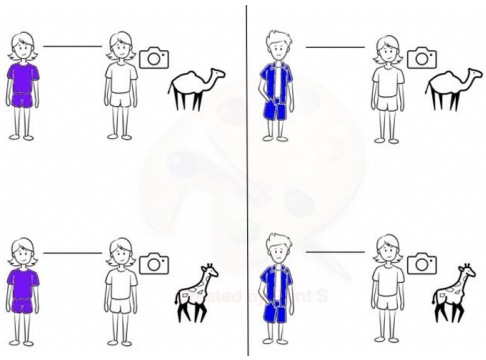

Figure 2: Illustration of item SUBJFALSE & ECMTRUE with PIC DISTR.

(13) a. Milan i Klára viděli černého králíka a bílého králíka.
Milan *i* Klára see.3PL.PST black.ACC rabbit.ACC and white.ACC rabbit.ACC
'Milan and Klára saw a black rabbit and a white rabbit.'

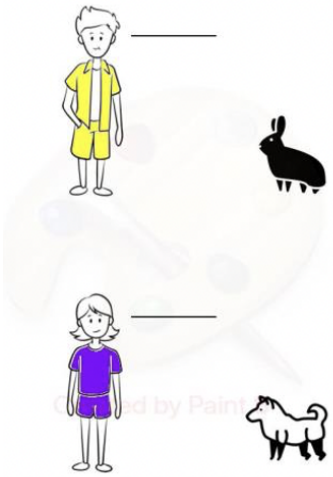

Figure 3: Illustration of item SUBJTRUE & ECMFALSE with PIC WRONG.

3.3. Results

3.3.1. Results: descriptive statistics

The results of the experiment are visualized in Figure 4. The graph is a barplot of responses, and the facets represent the crossing of the factors ECM (the conditions with ECM – ECM: TRUE – or a simple SVO clause – ECM: FALSE) with SUBJ (the distributive conjunction in a subject position – SUBJ: TRUE – vs. non-subject position – SUBJ: FALSE). Green vs. red proportion shows the acceptance of PIC factor with three levels (CUMUL, DISTR, WRONG). As can be seen at the first glance, the reference level (WRONG of PIC) was strongly rejected, while the distributive interpretation (DISTR of PIC) was always accepted. The cumulative interpretation (CUMUL of PIC) is clearly more acceptable than the negative reference level but fares worse than the distributive interpretation of *i*. Moreover, its acceptability decreases if the distributive conjunction appears in the subject position of a simple SVO sentence (ECM: FALSE, SUBJ TRUE).

The descriptive statistics already show that the distributive conjunction (*i*) always allows the distributive interpretation and that its cumulative interpretation is configuration-dependent. These pieces of evidence show that the approaches where distributive interpretation is hard-wired into the meaning of the conjunction are wrong. Next, the degraded cumulative interpretation of *i* proves that the conjunction is not simply ambiguous between the cumulative and distributive interpretations because then we should get approximately similar acceptability both in CUMUL and DIST, contrary to the findings. Therefore *i* is not an ambiguous conjunction similar to English *and* but a genuine distributive conjunction.

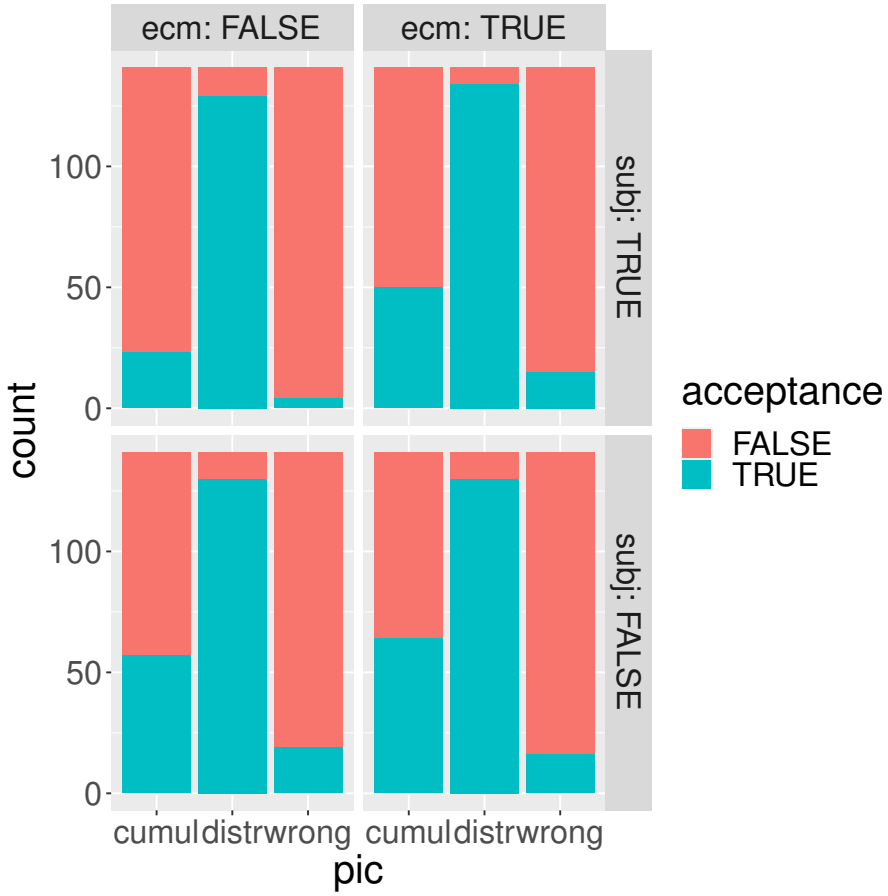

Figure 4: Barplot of responses.

3.3.2. Results: modeling

We analyzed the experiment using generalized logistic mixed models (R package LME4, Bates et al. 2015) with three fixed effects: PIC (DISTRibutive, CUMULative and WRONG, the last being the reference level), ECM (*i* being in ECM or simple SVO clause, ECM: FALSE as the reference level) and SUBJ (*i* in the subject position or not, SUBJ: FALSE as the reference level), and their interaction. The dependent variable was the subject's response. The model also included intercept-only subject and item random effects (more complex models did not converge). In the model, WRONG of PIC was reversed (against the descriptive statistics): with the value true/1 we label the subjects' rejections of the wrong picture in accordance with the subject's correct rejection of the wrong picture for a condition (remember that WRONG was distinctly unacceptable in any reading of the tested sentences). We found the following:

First, the main effects. The cumulative interpretation of *i* in any environment was significantly worse than its correct rejection in WRONG ($\beta = -2.50, z = -7.87, p < 0.001$), while its distributive interpretation was not significantly different from the reference level. The complexity of the clause (simple SVO vs. ECM clauses) was not significant either. Nevertheless, subjects

were sensitive to the syntactic status of *i* (SUBJ: TRUE – $\beta = 1.76, z = 3.07, p < 0.01$) but recall that reference level were simple SVO clauses where *i* was not in the subject position (ECM: FALSE, SUBJ: FALSE). The main effects support the descriptive statistics: *i* is a distributive conjunction, not ambiguous between cumulative and distributive interpretations. Nevertheless, the cumulative interpretation of *i* is more or less accessible depending on its syntactic position. All the details about effects, their interactions, standard errors, and random effects can be found in Table 1.

Fixed effects				
	Estimate	SE	z value	p value
Intercept	2.06	0.28	7.31	< 0.001
PIC:CUMUL	-2.50	0.32	-7.87	< 0.001
PIC:DISTR	0.65	0.41	1.59	> 0.1
ECM:TRUE	0.21	0.37	0.55	> 0.1
SUBJ:TRUE	1.76	0.57	3.07	< 0.01
PIC:CUMUL*ECM:TRUE	0.02	0.45	0.05	> 0.1
PIC:DISTR*ECM:TRUE	-0.21	0.59	-0.36	> 0.1
PIC:CUMUL*SUBJ:TRUE	-3.14	0.65	-4.84	< 0.001
PIC:DISTR*ECM:TRUE	-1.86	0.72	-2.57	< 0.05
ECM:TRUE*SUBJ:TRUE	-1.68	0.69	-2.42	< 0.05
PIC:CUMUL*ECM:TRUE*SUBJ:TRUE	2.59	0.80	3.24	< 0.01
PIC:DISTR*ECM:TRUE*SUBJ:TRUE	2.29	0.97	2.36	< 0.05
Random effects				
	Variance	SD		
subject	0.59	0.77		
item	0.000005	0.0023		

Table 1: Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) for the experiment

Let's continue with the interaction effects. We found that speakers strongly dispreferred the cumulative picture if *i* was in the subject position – there is a strong interaction effect of PIC: CUMUL by SUBJ: TRUE, the strongest interaction effect: $\beta = -3.14, z = -4.84, p < 0.001$. This means that speakers (generally non-preferring the cumulative interpretation – see the main effects) rejected the cumulative interpretation of *i* with added interaction coefficient $z = -4.84$ if *i* was in the subject position. But speakers accepted the cumulative interpretation both in simple and ECM constructions to the same extent (the interaction effect between PIC: CUMUL and ECM: TRUE was not significant). The same is true for the distributive interpretation of *i* (again, the interaction between PIC: DISTR and ECM: TRUE is not significant). Recall also that the main effect of ECM was not significant either. The interaction effect can be observed in the Interaction effects graph in Figure 5: the acceptance represents the probability of acceptance yielded by the logistic model (with standard errors).

The results of the experiment show: (i) *i* is a distributive conjunction since main effects of DISTR and CUMUL diverge robustly, DISTR in fact being statistically non-distinguishable from

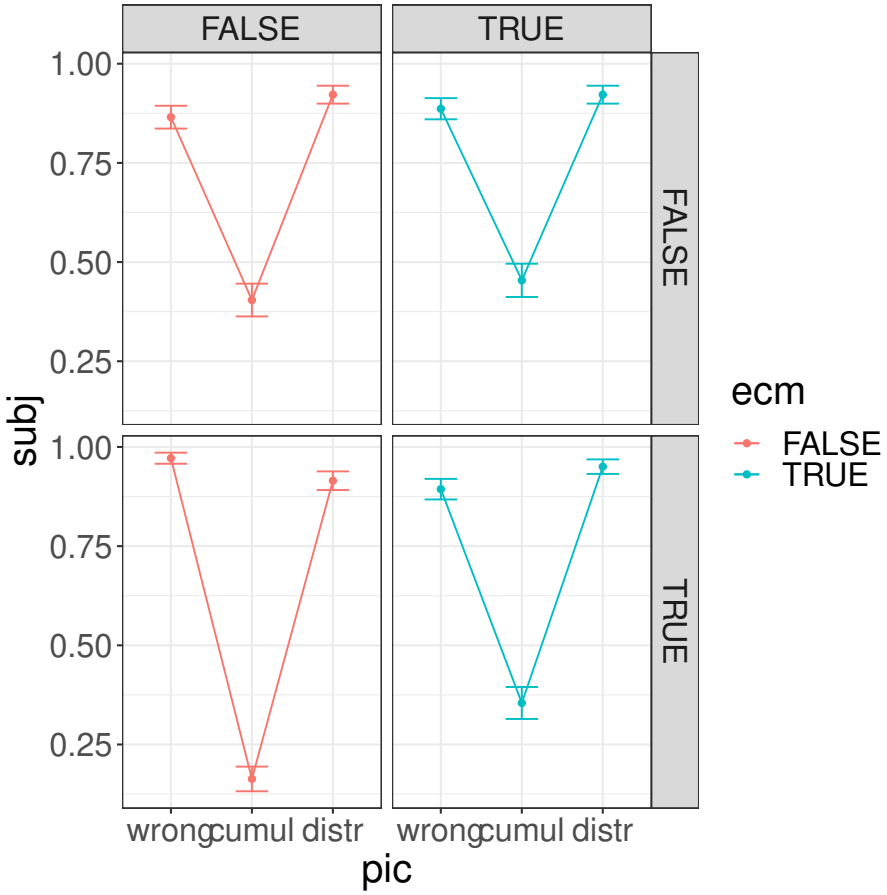

Figure 5: Interaction effects graph.

the reference level (which is true both locally and at distance: the interaction between ECM and DISTR was not significant); (ii) the cumulative interpretation of *i* is much less preferred than its distributive interpretation but its decreased acceptability does not depend on locality (the interaction between CUMUL and ECM was not significant and the main effect of ECM was not significant either); (iii) the cumulative interpretation of *i* is the least acceptable if *i* is in the subject position (the strongest – negative – interaction effect between CUMUL and SUBJ) – the asymmetry of cumulative readings – and the asymmetry is not prohibited by non-locality (non-significance of the interaction between CUMUL and ECM).

4. Discussion

Now we can summarize the results of our experiment by answering the two research questions. Question 1 is repeated below as (14). The experiment clearly brings lot of material which can help us answer it. Generally, we can answer the question positively: *i* cannot be interpreted cumulatively only if it c-commands the other plural denoting DP (see the effects plot in Fig 5 and recall the strongest interaction effect – negative one – between CUMUL and SUBJ). Another piece of evidence comes from the salient cumulative interpretation of the ECM verbs' objects (recall that the interaction between CUMUL and ECM was not significant). That means that

cumulative readings add up irrespective of particular predicates. The second and first points are direct evidence for the scope-based theories but they are not decisive evidence against the θ-based theories.

(14) **Question 1**
Do Czech speakers observe cumulativity asymmetry at long-distance?

To fully estimate the consequences of our experimental research with respect to the θ-based theory of the asymmetry we constructed a small follow-up experiment. In this experiment, we tested the effect of subject and object position on the availability of cumulative readings with the conditions SUBJ and PIC. In this experiment both, the subject of the matrix and subject of embedded ECM, are agents. This should provide a clearer picture w.r.t. θ-role approach. 13 native speakers of the Czech language succesfully completed the experiment. The design was identical to the first experiment, in that it was a truth value judgement task and participants had to compare the tested sentence to the image presented. Level WRONG of PIC was once again set to be the baseline and the context was identical to the context in the first experiment.

1. Position of D-conjunction — factor SUBJ
   - SUBJTRUE - *i* in subject position
   - SUBJFALSE - *i* in object position
2. Picture condition — factor PIC
   - CUMUL - cumulative picture
   - DISTR - distributive picture
   - WRONG - wrong picture

(15) a. Milan i Tína viděli slona a žirafu pít vodu.
Milan *i* Tína see.3PL.PST elephant.ACC and giraffe.ACC drink.INF water.ACC
'Milan and Tína saw an elefant and a giraffe drink water.'

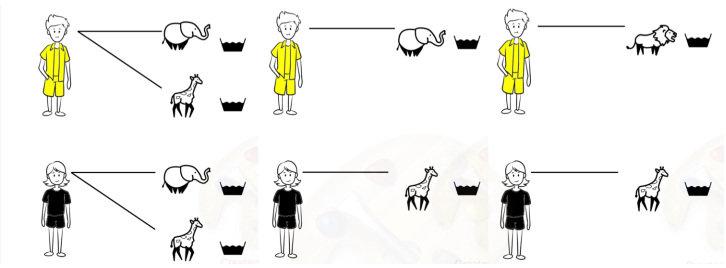

Figure 6: Illustration of item SUBJTRUE with PIC in all levels, DISTR, CUMUL, WRONG respectively.

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The results of the experiment suggest that distributive interpretation is available all-across the board and that θ-roles seem to not affect the cumulativity asymmetry. Cumulative reading was accepted more than the baseline when the D-conjunction was placed in the object position, as we expected in light of the first experiment. The expected observable effect of θ-roles would be similar acceptance of the D-conjunction in SUBJTRUE and SUBJFALSE; however, that is not the case, as can be seen the barplot of acceptance in Figure 7. We used the same model in the follow-up as in the experiment and the inferential statistics output confirms the descriptive statistics: the only significant interaction effect yielded by the model for the follow-up was the negative PIC:CUMUL*SUBJ:TRUE, $z = -2.069, p = 0.039$ – subjects accepted the cumulative interpretation of *i* much better if *i* was in the subject of the predicate embedded under the ECM verb. Since both the subject of the ECM verb and the subject of the embedded predicate bear the identical θ-role, namely agens, we consider this a direct evidence against the strong θ-role approach to the asymmetry.

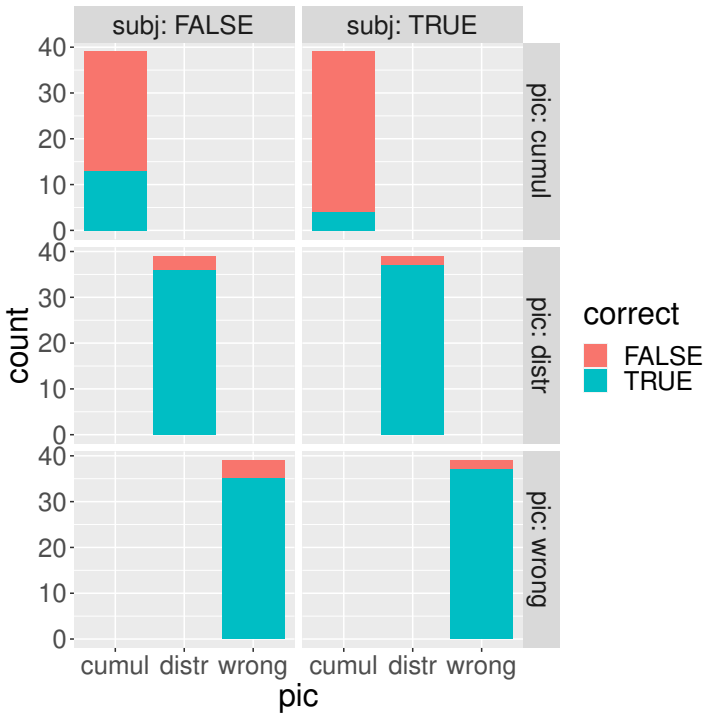

Figure 7: Barplot of responses.

The research question 2, repeated below as (16) concerns the distributivity interpretation and its eventual interaction with the depth of *i* embedding. The data from the experiment and their statistical analysis give us some clues about the possible answers to the question. First, it seems that speakers of Czech accept the distributive interpretation both locally and at long-distance (recall that main effect of DISTR did not differ from the baseline and the main effect covers all the tested conditions; moreover the interaction of DISTR by ECM was not significant). This is just an empirical summary but it goes against the grain of theories where the distributivity is derived with the help of a distributive operator, which scopes over the verbal predicate (be it classical theories like Bennett 1974; Link 1983; Schwarzschild 1996; Winter 2001 or more modern ones like Champollion 2016). What seems to be more promising with this kind of data

are the dynamic approaches like PCDRT (see Dotlačil 2012, 2013 a.o.) where the distributivity is freed from being an operator located in syntax and where it quantifies over some abstract formalizations of the pluralities, the sets of assignment functions in PCDRT e.g.

(16) **Question 2**
How different are monoclausal and long-distance configurations interpretations?

4.1. Summary and open questions

Let us now summarize the results of our experiment and introduce some open questions which it naturally yields. First, *i* is a distributive functional element, like English distributive quantifier *each*, which in some configurations allows to be interpreted cumulatively. The experimental data are supportive of configuration based theories where the asymmetry is explained via scope relations. Namely, we believe that the pattern we experimentally confirmed follows from the plural projection framework (Haslinger and Schmitt 2018; Schmitt 2019) where the asymmetry is interpreted in a way that cumulativity is in fact integral part of a semantic composition. The plural projection framework claims that: (i) there are pluralities of any semantic type; (ii) in a semantic composition the part structure of the denotation of a plural expression projects to the denotations of dominating node (the part structure can be cumulative, distributive, etc.); (iii) universal quantifiers (and distributive conjunctions – in our case) block the cumulative composition rule and yield maximal plural set (non-cumulative plurality); (iv) but this plural set is again input to the cumulative composition. Therefore, the asymmetry is expected: the pluralities in the scope of the distributive element (quantifier or conjunction) must be interpreted distributively (with respect to the element) but the plural expressions outscoping the distributive element can be interpreted cumulatively (because of the cumulative composition rule).

At the end, there of course remain some open questions. The first one comes from the model of the experiment: we found a curious positive three-way interaction between CUMUL, ECM and SUBJ (see Table 1 for the values) which shows that subjects accepted the cumulative picture for *i* in the subject of an ECM predicate ([NP *i* NP V [V NumP]]) more than if *i* appeared in the subject of a simple clause ([NP *i* NP V NumP]). This is intriguing since such pattern is unpredictable in any current theories of the asymmetry: all the theories predict just the distributive reading and therefore are not able to explain any preference like this one. We do not have any reasonable explanation for such behavior. Many other open questions appear with respect to the research question 2. Our experiment clearly supports the non-standard theories of distributivity, but we leave proper research in this direction for future work.

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