

## ON AMOUNT RELATIVE CLAUSES IN ROMANIAN

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### Abstract

Amount Relative clauses (ARs) in Romanian represent a subclass of restrictive relative clauses (RRCs) and free relatives (FRCs), namely they are RRCs and FRCs where the relative term contains a variable of amount. They are introduced by *cât* ‘how much/many’ (and its inflected forms), which acts as a degree operator that binds the variable of amount, by *ce* ‘what’, mainly used in FRCs with quantitative meaning, and by *care* ‘which’, used in contexts with a degree (amount and cardinalities) reading. We are particularly interested in analysing their properties that arise due to the presence of the overt degree operator *cât/câți*. In particular, our study demonstrates that there is a strong correlation between the presence of *cât* and the amount/cardinality reading in this type of RCs.

**Keywords:** relative clauses, amount interpretation, degree operator

### 1. Introduction

In this article, we investigate amount relative clauses (AR) in Romanian. More specifically, we focus on the types of relative clause (RC) constructions that have an ‘amount/cardinality’ reading. The overall aim is to identify core characteristics of ARs in Romanian and to provide empirical evidence in support of analysing these RCs as a distinct class (from the traditionally recognized classes of restrictive vs. non-restrictive RCs).

Amount relatives in Romanian are headed or headless (free) relative clauses that have an ‘amount’ reading and denote properties of amounts/cardinalities. They are mainly introduced by the specific relative determiner *cât* (and the inflected forms for number and gender *câtă* ‘how much<sub>Fsg</sub>’, *câți* ‘how much<sub>Mpl</sub>’, *câte* ‘how much<sub>Fpl</sub>’) which is semantically interpreted as a maximalizing operator on a set of degrees. It has no counterpart in English relative clauses and it secures the amount reading in

all the contexts in which it is used: the DP which is modified by the RC headed by *cât* is interpreted as denoting amounts/cardinalities, not individual entities, in spite of the fact that relativization is based on the idea that a noun phrase is shared between the main clause and the relative clause.

The expectation is that the presence of this overt marker of the amount interpretation will relax the constraints on ARs that were discussed for English (see the diagnostic tests proposed in Carlson 1977 to distinguish between restrictive and non-restrictive). Thus, the formal and semantic characteristics offered by Carlson (1977) to serve as means for identifying ARs in English do not operate in Romanian or operate only in ARs which are not introduced by *cât*. In English, these constraints follow from the absence of specific relative degree determiners. From a comparative perspective, Romanian behaves like other languages that have overt degree operators, such as *ile* in Polish (Tomaszewicz 2013), *kolko* in Bulgarian (Pancheva 2012)<sup>1</sup> or *kolku* in Macedonian (Rett 2006; Grosu 2009b).

## 2. Amount relatives in Romanian

We illustrate Romanian AR in the example below:

- (1) a. Au luat cu mine atâtea cărți *câte* erau pe masă.  
Have taken with me that-many books how-many were on table  
'I took me as many books as there were on the table'.

By examining the example under (1), we notice that the use of *câte* confers an amount interpretation to the relative CP, denoting the maximal number of books that I took with me and that were on the table. The interpretation is based on the fact that the two sets are equated: the number of books I took with me is equal to the number of books that there were on the table (representing also the total number of books). This equivalence is reflected in the correlative-like structure of this construction due to the presence of the correlative terms *atâtea...câte*.

Let us compare the AR in (1) with the RC in (2), in which *câte* 'how many<sub>FemPl</sub>' was replaced with *care* 'which'.

- (2) Au luat cu mine atâtea cărți *care* erau pe masă.  
Have taken with me that-many books which were on table  
'I took me so many books that were on the table'.

<sup>1</sup> These degree operators are mainly used in comparative and superlative constructions (see Pancheva 2012 and Tomaszewicz 2013) or in free relatives.

The interpretation of (2) is different, in the sense that the RC introduced by *care* might be considered ambiguous between two readings: restrictive (*I took with me the many books that were on the table*) and amount (*I took with me as many books as there were on the table*). We claim, however, that this ambiguity is not present and that the relative clause in (2) is a RR.

Moreover, alongside ARs with *cât*, there are also RCs with *care* and *ce* that have only a maximal amount interpretation, and this interpretation is obtained due to additional mechanisms external to the RC (such as the use of the universal *tot* in (3) or of a definite quantitative nominal head, i.e. *vinul* in (4)). If we take, for example, the relative clause in (4), we consider it a genuine AR since it could only refer to the same quantity of wine (identity of quantity), excluding the nonsensical interpretation of drinking the same wine (identity of substance). These ARs are similar to English ARs and are subject to the same constraints.

(3) a. La petrecere o să beau tot *ce* mi se dă.

At party will drink all what me<sub>DAT</sub> SE give

‘At the party, I will drink what I am given’.

(4). Mi-ar trebui o lună să beau vinul *pe care*-l bei tu într-o oră.

Me would take a month to drink wine-the PE which/what CL<sub>III sg</sub> drink you in an hour

‘It would take me a month to drink the wine that you drink in an hour’.

The same amount/cardinality interpretation can also be obtained in free relatives. Free relatives are always definite and as such they behave just like English FRs (are inherently maximal). In combination with degree words like *cât/câți* ‘how much/many’ and *ce* ‘what’ or *oricât/oricâți* ‘no matter how much/many’ and *orice* ‘whatever’ these FRs have a quantitative reading. There are many examples of FRs introduced by *cât/oricât* ‘how-much/no matter how much’.

We illustrate them in (5a-e).

(5) a. *Câți* îl văd, de el se plâng. (Vasile Alecsandri, apud. GLR I, 1966:167)

how-many him<sub>CL</sub> see of him SE complain

‘Anybody who sees him, complains about him’.

b. Am dat pe pere *ce* am luat pe mere.

Have<sub>1sg</sub> given for pears what have<sub>1sg</sub> taken for apples

‘They paid for the pears what they got for the apples’.

c. Poți să-mi ceri *câte/oricâte* cărți dorești.

Can to-meCL ask how many/no matter how many books want

‘You can ask me for no matter how many books you want’.

d. Îți dau *cât/oricât* îmi ceri.

You<sub>CLGen</sub> give how-much/no matter how much ME<sub>CL</sub> ask

‘I can give you as much as you ask’.

e. *Câte* odăi erau în casă nu ajungeau pentru mulțumirea musafirilor.

How many rooms were in house not enough for satisfaction guests

‘The rooms that there were in the house were not enough to satisfy the guests’.

(Cornilescu, 1980/1996: 250)

In the RCs exemplified above, we note that the formal property that helps recognize ARs in which abstraction over a degree variable has operated is the presence of the relative determiner *cât*. *Cât* relatives always have an amount reading, and that is the only reading available for them, as opposed to *care* relatives, which have a restrictive reading (example (2) above).

The facts discussed above suggest that in order to discuss the ARs in Romanian, we should start from the observation that the data in Romanian is specifically structured to accommodate this amount interpretation, mainly because of this specific relative pronoun *cât* (*câtă*, *câți*, *câte*) that Romanian possesses. Consequently, in the next section of this article we will present the properties that characterize this type of RC in Romanian, focusing on the degree word *cât* and on its distribution.

We base our discussion on the approaches w.r.t. amount relatives in Romanian that were proposed in Grosu 2000, 2009a,b, 2013, Herdan 2008 and Kotek 2009.

## 2. Characteristics of amount relative clauses (AR) in Romanian

In this section we examine the syntactic and semantic properties of ARs in Romanian, briefly discussing new empirical data and focusing on the structural differences between English and Romanian.

We start from Carlson's idea that there is a series of diagnostic tests that distinguish between ARs and RRs in English. More specifically, Carlson (1977) discusses three such tests and refers to: 1. the restriction on the relativizers (English ARs only allow *that* or  $\emptyset$  and disallow *wh*-forms, whereas RRs allow a variety of relativizers *who*, *which*, *that*,  $\emptyset$ ) 2. The restriction on the external determiners (ARs in English allow definite and universal determiners, RRs have no such restrictions) and 3. stacking or *iteration* (unlike RRs, ARs may not stack).

A closer examination of the data reveals that Romanian is less constrained by these restrictions. In English, these constraints follow from the absence of specific degree relative determiners. In this article, we will discuss only the restriction on the relativizers (i.e. the relative determiners that introduce the RCs with an amount interpretation).

## 2.1 Restriction on relativizers (internal determiners)

In this section, we examine the restriction on the internal determiners. One of the most striking facts associated with the analysis of English ARs is that *wh*-forms, such as appear in RRs, are wholly banned. ARs in English only allow *that* and  $\emptyset$ .

### 2.2.1 'Atât cât' and 'atât care' structures

In Romanian, this lexical restriction does not apply, firstly because all relative determiners introducing ARs in Romanian are overt *wh*-forms inflected for number and gender, and secondly because Romanian does not allow relatives introduced by  $\emptyset$  relativizer<sup>2</sup>. Moreover, as we noted in the introductory section, all Romanian *wh*-forms may introduce RC with an amount/degree reading, with *cât* having only degree reading.

Let us examine the example under (6) and (7):

- (6) Ion a mâncat atâtea prăjituri câte erau pe masă.  
John has eaten that-many cookies how-many were on table  
'John has eaten as many cookies as there were on the table'.

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<sup>2</sup> Relative clauses cannot be introduced by a  $\emptyset$  relativizer in Romanian. Although M. Gheorghe (2003) claims that there is one context that seems to allow a  $\emptyset$  relativizer (i), we consider that this is a case in which *să* is an operator that raises to  $C^0$ :

(i) Voi fi prima  $\emptyset$  să-l felicit.  
Will be first-the to-him<sub>CL</sub> congratulate.  
I will be the first to congratulate him.

- (7) Ion a mâncat atâtea prăjituri care erau pe masă.  
 John has eaten that-many cookies which were on table  
 ‘John has eaten many cookies that were on the table’.

The RC in (6) refers to the quantity/number of cookies on the table and, thus, it gets the amount interpretation of ‘as many cookies as there were on the table’. On the one hand, the use of the degree relative determiner *câte* ‘how many<sub>FEMPI</sub>’ indicates that the set defined by the AR is the maximal set of cookies on the table and that this should be identical to the set denoted by the indefinite DP *atâtea prăjituri*. We point out that the use of *atâtea... câte* indicates a correlation in which the two correlates condition each other. Thus, the RC gets this maximal quantity/amount interpretation of the two equivalent sets due to the presence of the maximalizing operator *cât* used in correlation with *atâtea*.

The RC in (7) gets a different interpretation. Firstly, the use of *atâtea.... care* does not form a correlation and the two terms are independent of each other. Secondly, the term *atâtea* has a different interpretation than in (6) above: *atâtea* means *multe* ‘many’ (a more detailed description of *atât/atâtea/atâtea* ‘that much/many’ is given in the next section). Hence, the RC has a restrictive reading (i.e. John has eaten the many cookies that were on the table), not an amount one (John has eaten as many cookies as there were on the table). The amount interpretation becomes more obvious once we resort to additional mechanisms, such as the use of *exact* ‘exactly’ as in (8) below:

- (8) Ion a mâncat exact atâtea prăjituri care erau pe masă.  
 John has eaten exactly that-many cookies which were on table  
 ‘John has eaten exactly as many cookies as there were on the table’.

## 2.2.2 No ambiguity in Romanian ARs

Now, let us discuss another case of RCs in Romanian in which the interpretation is sensitive to the use of the relativizer. These ARs are the Romanian counterparts of the English examples extensively analysed in Carlson (1977), Heim (1987), Grosu&Landman (1998, 2013) and Herdan (2008). In English, the context in (9) is ambiguous, being interpreted either as a RR or as an AR (a case of identity of substance vs identity of quantity, cf. Carlson, 1977; Heim, 1987 a.o).

- (9) It would take us all year to paint the portraits that John burned in a fit of paranoia.

- a. painting the actual burned canvas (identity of substance → restrictive reading)
- b. paint the amount of portraits (identity of quantity → amount reading)

If we look at similar examples in Romanian, for example (10 and (11) below, we notice that the interpretation is more obvious:

(10) a. Ne-ar lua un an întreg să pictăm portretele *câte* a ars Ion într-un moment de nebunie.

CL<sub>IPL</sub> would take a year whole to paint portraits-the how-many has burnt John in a fit of paranoia

- a. \*painting the actual burned canvas (identity of substance → restrictive reading)
- b. paint the total amount of portraits (identity of quantity → amount reading).

(11) a. Ne-ar lua un an întreg să pictăm portretele *pe care* le-a ars Ion într-un moment de nebunie.

CL<sub>IPL</sub> would take a year whole to paint portraits-the PE which has burnt John in a fit of paranoia

- a. painting the actual burned canvas (identity of substance → restrictive reading)
- b. paint the total amount of portraits (identity of quantity → amount reading is not available).

If we compare the examples under (10) and (11), we observe that this ambiguity is not found in *cât* RCs, since the use of *cât* disambiguates the reading towards an AR interpretation and signals abstraction over degrees (amount or cardinalities).

Therefore the RC with *cât* is always interpreted as denoting amount, whereas the RC with *care* is restrictive.

## 2.2 Amount relatives with ‘care’

There are also the cases briefly discussed in the introduction in which the RCs introduced by the relativizer *care* have only an amount reading, not a restrictive one. If we take a closer look at these RCs in (12a-b) and (13), we see that they could only refer to the same quantity of wine (identity of quantity), not to the same wine (identity of substance) in both *care* and *cât* constructions.

(12) a. Îmi ia o lună să beau vinul *pe care-l* bei tu într-o oră.  
To me takes a month to drink wine-the PE which/what CL<sub>III</sub> sg drink  
you in an hour

‘It takes me a month to drink the wine that you drink in an hour’.

b. Îmi ia o lună să beau atâta vin *cât* bei tu într-o oră.

To me takes a month to drink wine how-much drink you in an hour

‘It takes me a month to drink the wine that you drink in an hour’.

(13). La Paște o să beau și eu vinul pe care-l bea toată lumea.

‘At Easter I will drink the wine that everybody drinks’.

a. ??? the same wine: At Easter, I will drink the same wine that everybody drinks. (\*restrictive reading, identity of substance)

b. the same amount of wine: At Easter, I will drink the same amount of wine as the amount of wine that everybody drinks. (√ amount reading, identity of quantity)

An identity of substance reading (i.e. drinking the very same wine) in *care* ‘which’ RC as in (12a) and (13a) would be nonsensical.

### 2.3 Free relatives with an amount interpretation

Let us turn to free relatives now. In Romanian, amount free relative clauses are either introduced by (ori)*cât* (‘(no matter) how much’ and its variants) or by (ori)*ce* ‘(what)ever’ and are interpreted as having a quantitative reading:

(16) a. Ți dau *cât* îmi ceri.

You<sub>CLGen</sub> give how-much ME<sub>CL</sub> ask

‘I can give you as much as you ask’

b. Poți să-mi ceri oricâte cărți dorești.

Can ask-me as many books you want

‘You can ask me for as many books as you want’.

c. Cu ce bani ai dat pe mașină îți luai un apartament.

With what money have paid for car you take an apartment

‘With the money you paid for the car you could have bought an apartment’.



d. Ce a luat pe mere a dat pe pere.

What has taken for apples has given for pears

‘He lost on the swings what he gained on the roundabouts’.

We mention that the constraints on the relativizer that we discussed in this article are not meant to be relevant for free relatives (in English, the diagnostic tests proposed in Carlson 1977 cannot tell amount free relatives from other free relatives).

Carlson’s (1977) diagnostic test referring to the relativizer restriction, more specifically to the ban on *wh*-forms in ARs, does not lead to the same results as in English. In Romanian, all the relativizers are *wh*-forms and, from the data analysed in this section, we have seen that all may be used to introduce ARs. Moreover, there is a specialized relativizer that introduces only degree/amount relatives, namely the degree word *cât/câți*. In the case of the other *wh*-forms *care* and *ce*, we need additional mechanisms external to RC to obtain the amount/cardinality reading (i.e. the presence of a maximalizing marker outside the RC).

### 3. Crosslinguistic data on the use of degree words

Romanian is not unique in using a specialized degree operator that secures an amount interpretation in the RC it introduces. Degree operators are also used in Polish (cf. Szczegielniak 2005; Herdan 2008; Tomaszewicz 2013), which has a specific relativizer for modifying amounts, *ile* (how-much)<sup>3</sup>, in Bulgarian, which has *kolko* ‘how much’ (used in free relatives and interrogatives, cf. Pancheva, 2012) or in Macedonian, which has *kolku* ‘how much’ with the same distribution as its equivalent in Bulgarian (cf. Rett, 2006; Grosu, 2009b).

For example, the RCs in Polish, mostly those used in comparative constructions, contain a certain relativizer for modifying amounts, *ile*, by which we know that those are ‘degree relative clauses’. This type of RCs can also participate in correlative structures. Correlativization shows that *ile*-relative clauses modify degrees - in the matrix clause the degree variable it abstracts over is picked up by a degree demonstrative *tylę* (‘that much/many’), (17a), and not by a regular demonstrative referring to individuals, (17b) vs. (17c).

(17) a. Jan kupił tylę pomidorow. (+ a pointing gesture) (Tomaszewicz, 2013)

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<sup>3</sup> This degree operator is mainly used in comparative and superlative constructions (see Pancheva, 2012).

Jan bought that-many<sub>DEM</sub> tomatoes

‘Jan bought that many tomatoes.’

b. Jan kupił Marii tyle pomidorow, ile/\*ktore *pro* mógł kupić.

Jan bought for-Maria that-many<sub>DEM</sub> tomatoes how-many/which could buy

‘Jan bought Maria as many tomatoes as he could buy.’

c. Jan kupił Marii te pomidory, ktore *pro* mógł kupić.

Jan bought for-Maria that-many<sub>DEM</sub> tomatoes which could buy

‘Jan bought Maria those tomatoes that he could buy.’

For the amount reading in Polish, both the quantity demonstrative *tyle* and the relativizer *ile* have to be used, similar to *atât...cât* ‘that-much... how-much’ constructions in Romanian:

(18) Jan wypił tyle szampana, ile wylano na podłogę tego wieczoru.

Jan drank that-much<sub>DEM</sub> champagne how-much spilled.<sub>Imprs</sub> on floor that evening.

‘Jan drank as much champagne as they spilled on the floor that evening.’

The Romanian *cât* is also similar to the Bulgarian *kolko* (Cf. *Dictionarul limbii române*, Tomul I, Partea II, 1940:192) or to the Macedonian *kolku* used in free relatives:

(19) a. *otide kolko otide* (Bulgarian)

merse cât merse (Romanian)

walked how-much walked

‘He walked and walked’

b. Mojot багаж тежи kolku što тежи (i) tvojoy. (Macedonian; Grosu, 2009b)

my+the luggage weighs how-much that weighs (and) yours+the

‘My luggage weighs as much as yours does’.

The crosslinguistic data discussed above illustrate amount/degree clauses introduced by degree operators. An in-depth analysis of the distribution of overtly expressed degree operators in degree clauses could lead to a parametrized typology of the languages analysed here, allowing us to group them in English-type languages (with no overt degree

operators) and Romanian-type languages (with overt degree operators). We leave this investigation for further research.

#### 4. Conclusions

The concluding remarks of this article about the amount relative clauses (ARs) in Romanian are the following:

1. ARs in Romanian represent a subclass of RRCs and FRCs, namely they are RRCs and FRCs where the relative term contains a variable of amount.

2. Romanian ARs are mainly introduced by *cât* which acts as a degree operator binding the variable of amount, with no counterpart in English. In fact, all the relative constructions with *cât* are analysed as amount relative clauses (both in dependent and independent RCs).

3. Besides *cât* ARs, there are also *care* and *ce* ARs. The use of *care/ce* is limited to certain contexts in which maximality applies outside of the RC due to the presence of (maximal) external determiners, such as the universal in *toți (studenții) care...* ‘all the students which...’, *tot ce* ‘all what’ or to the nature of the nominal head (definite mass nouns, i.e. *vinul pe care...* ‘the wine which’). These RCs can only be interpreted as predicates of amounts.

4. The relative determiners *ce* ‘what’/*care* ‘which’ are also used in FRCs with quantitative meaning. FRs are definite and are always maximal, and just like in English maximality applies outside.

5. With respect to the constraints that were proposed by Carlson (1977) as means of identifying ARs in English, we concluded that these do not operate in Romanian. More specifically, ARs in Romanian are not sensitive to the relativizer used (all relative determiners in Romanian are wh-words; in English, wh-forms are ruled out). This arises due to the presence of the overt degree operator *cât/câți*. Although the relative *cât* (or its derivatives) has no counterpart in English, it behaves like other overt relative degree operators e.g. *ile* in Polish comparative/degree constructions or *kolko* in Bulgarian free relatives. However, this similarity is left for further research. Such an approach could be the basis for proposing a parametrized typology resulting in English-type languages (no overt degree operator) and Romanian-type languages (with overt degree operator).

#### Bibliography

- Carlson, Gregory. 1977. Amount Relatives. In *Language*, 53:520-542.  
Cornilescu, Alexandra. 1980/1996. *Montague Grammar and The Analysis of Relative Clauses*, Editura Universității din București.

- David, Lorena. 2012. *Free Relative clauses in English and Romanian*. PhD dissertation. University of Bucharest.
- Dictionarul limbii române*, Tomul I, Partea II, 1940.
- GA 1963 – *Gramatica limbii române*. 1963 (edited by Alexandru Graur), București, Editura Academiei.
- GALR 2005/2008 – Valeria Guțu Romalo (ed.). 2005. *Gramatica limbii române* (new & revised edition: 2008), București, Editura Academiei Române.
- GBLR 2010 – Gabriela Pană Dindelegan (ed.), 2010, *Gramatica de bază a limbii române*, București, Editura Univers Enciclopedic Gold.
- Gheorghe, M. 2004. *Propozitia relativă*. București, Editura Paralela 45.
- Grosu, A. 2000. Type resolution in relative constructions. Feature marking and dependency encoding. In Alexiadou & Wilder eds., *The syntax of relative clauses*, John Benjamins.
- Grosu, A. 2002. Strange relatives at the interface of two millennia. State-of-the-Article, *GLoT International* 6,6, 145-167.
- Grosu, A. 2004. The syntax-semantics of modal existential wh constructions. In *Balkan syntax and semantics*, ed. Olga Mišeska Tomić, 405–438. Amsterdam: John Benjamins.
- Grosu, A. 2005. Unbounded dependencies (ms). In *The Essential Grammar of the Romanian Language*. <http://www.linguist.univ-paris-diderot.fr/~essromgram/>
- Grosu, A. 2005. Unbounded dependencies (ms). In *The Essential Grammar of the Romanian Language*. <http://www.linguist.univ-paris-diderot.fr/~essromgram/>
- Grosu, A. 2009a. Two kinds of degree-denoting relatives: Hebrew versus Romanian. *Brill's Annual of Afroasiatic Languages and Linguistics*, vol. 1.
- Grosu, A. 2009b. Romanian 'unexpected' relatives, in *Revue Roumaine de Linguistique*, vol. LIV, No 1, January-March 2009.
- Grosu, A. F. Landman. 1998. Strange Relatives of the Third Kind. *Natural Language Semantics*.
- Grosu, A. F. Landman. 2013. Amount relatives. To appear as Chapter 7 of *The Blackwell Companion to Syntax II* (SynCom II).
- Heim, Irene. 1987. Where does the definiteness restriction apply? Evidence from the definiteness of variables. In *The representation of (in)definiteness*, eds. E. Reuland and A. ter Meulen, 21-42. Cambridge, MA: MIT Press.
- Herdan, S. 2008. *Degree and amounts in Relative Clauses*. PhD thesis, University of Connecticut, ProQuest LLC.
- Kotek, Hadas. 2009. Degree Relatives, Definiteness and shifted Reference. In: *Proceedings of the North Eastern Linguistic Society (NELS) 40*. MIT, 13 November 2009.
- Pancheva, and B. Tomaszewicz. 2012. "Cross-Linguistic Differences in Superlative Movement out of Nominal Phrases" *WCCFL* 30.
- Rett, Jessica. 2006. How many maximizes in the Balkan Sprachbund. In M. Gibson and J. Howell (eds.), *Proceedings of SALT XVI*, 190-207. Ithaca, NY: CLC Publications.
- Szczegielniac, Adam. 2005. Relativization that you did... In *MIT Occasional Papers in Linguistics*, 24. (PhD thesis defended at Harvard in 2004 under the title *Relativization and Ellipsis*) [http://www.people.fas.harvard.edu/~szczeg/papers/dissertation\\_web.pdf](http://www.people.fas.harvard.edu/~szczeg/papers/dissertation_web.pdf)
- Tomaszewicz, Barbara. 2013. "Degree relative clauses and superlatives in Polish", *FASL 22 - Formal Approaches to Slavic Linguistics*, McMaster University, Hamilton, Ontario, Canada. [Handout]