REFERENTIAL NUMEROSITY AND MORPHOSYNTACTIC NUMBER AGREEMENT: A PSYCHOLINGUISTIC STUDY ON ITALIAN *QUALCHE*/*ALCUNI*

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Abstract: *The present study aims at shedding new light on the relationship between morphological Number and the numerosity of the referent(s). Previous studies exploiting agreement violations suggested a possible involvement of numerosity processing in the encoding of morphological Number (Carreiras et al., 2010). By employing the two Italian quantifiers* qualche *and* alcuni*, and exploiting their diverging requirements for Number agreement, we developed a picture–phrase matching paradigm. This minimal pair enabled us to test the hypothesis that when the morphological information of Number is incongruent with the numerosity encoded on the whole expression, more processing time is needed. The results are consistent with previous studies, and add evidence to a relationship between certain aspects of language and numerical cognition. Notably, contrary to previous literature, our results were obtained by exploiting well-formed expressions only.*

Keywords: *Number morphology, agreement, numerosity, quantifiers, psycholinguistics, numerical cognition*

1. Introduction

This study explores the relationship between morphosyntactic Number agreement and a contextual property of the referent, i.e. the numerosity. Previous experimental studies (i.e. Carreiras et al., 2010) provided evidence for the involvement of a cognitive elaboration of numerosity in the encoding of morphosyntactic Number (see §1.2). Literature so far has mainly developed violation paradigms as a testing ground; our study aims to investigate this link in well-formed expressions.

In a picture–phrase matching task we contrasted the two Italian quantifiers *qualche* and *alcuni*/*e*. Generally they both denote a plural (paucal) numerosity – e.g. *qualche mela*,

alcune mele 'some/a few apples'; crucially, they diverge in the requirements for Number agreement: *qualche* agrees with a morphologically singular noun, whereas *alcuni*/*e* agrees with a morphologically plural noun. We hypothesize that, in a task of referential numerosity assessment, the mismatch between the value of Number agreement with *qualche*, i.e. singular, and the semantic denotation of the quantification expression as a whole, i.e. plural, would elicit longer response times compared to *alcuni*/*e*. In fact, in the case of *alcuni*/*e* both the value of Number agreement and the semantic denotation consistently refer to a numerosity $n \neq 1$. If this is the case, the presence of a link between Number morphology and (some aspects of) numerical cognition will receive further evidence.

1.1 Morphological Number

Agreement is a phenomenon extensively found in natural languages (Corbett, 2006). It is generally defined as

> a systematic covariance between a semantic or formal property of one element [the controller] and a formal property of another [the target].
>
> (Steele, 1978: 610)

When the value of the controller's property changes, the value of the target's correspondent property changes too, thus establishing an asymmetric relation. In current terms, these properties are often called 'features'.

One of the morphological features that in many languages enter into agreement relations is Number. Despite cross-linguistic differences such as that Number does not have to be necessarily expressed or that it is exclusively a nominal category (Corbett, 2000), it generally conveys information on the numerosity of the referents being denoted. When marked on a noun, the value of morphological Number is usually related to the numerosity of the referent(s) – e.g., a noun marked for singular usually refers to a numerosity $n = 1$. This however is not always the case, and the mapping between a formal feature and the conceptual and referential levels can be less straightforward. Nevertheless, generally, differences in form corresponds to differences in meaning – in numerosity, in the case of Number. Languages can encode this information in different ways, and within the frame of different Number systems, of which the most familiar opposition singular–plural is only one of those documented.

1.2 Morphological Number and numerosity

Given its role in encoding referential numerosity into linguistic form, the parsing of morphological Number may involve some aspects of numerical cognition.[1]

Following this idea, Carreiras et al. (2010) tested the hypothesis that processing Number (agreement) may involve numerosity processing, and therefore should activate brain areas associated to it. The neuroimaging study contrasted grammatical conditions with Number and Gender agreement violations in Spanish (e.g. *el piano* 'the$_{M.SG}$ piano$_{M.SG}$', **los piano* 'the$_{M.PL}$ piano$_{M.SG}$', **la piano* 'the$_{F.SG}$ piano$_{M.SG}$'). The results showed that agreement violations were associated to a general higher activation relative to grammatical conditions.

[1] See Feigenson et al. (2004) for a review on the core systems of number.

Crucially, the violations involving Number, relative to those involving Gender, displayed a significantly higher activation of the right parietal areas, namely the intraparietal sulcus (IPS) and the superior parietal gyrus (SPG), recruited for some aspects of numerosity processing.

Overall, the study showed the activation of an area associated to a function not directly related to language (numerosity processing) while performing a linguistic task that, furthermore, apparently does not involve numerosity processing, suggesting a link between Number morphology and numerical cognition.

1.3 Agreement–numerosity mismatches

Given the relations discussed above, it can be equally interesting to explore mismatches between referential numerosity and morphological Number within well-formed expressions. This can be tested in Italian by exploiting quantification expressions (QEs) with *qualche*: despite generally denoting a plural referent, this quantifier requires agreement with a noun inflected in the singular. Quantification expressions can therefore be a suitable testing ground.

Longobardi (1991) identifies two classes of quantifiers in Italian: intrinsic and non-intrinsic. Intrinsic quantifiers are those whose morphosyntactic Number is always singular, but some of which can denote sets with numerosity $n \neq 1$. They are operators that, according to their intrinsic semantics, multiply the number of the values that the bound variable can assume, thus modifying the intrinsic singular denotation of the noun phrase. *Qualche* 'some' belongs to this class. It is therefore used for small plural numerosities, i.e. paucal. However, there are cases where the plurality denoted by *qualche* seems to weaken. In a sentence like (1), the denoted numerosity is not necessarily plural ($n \geq 1$), and, additionally, it does not presuppose $n > 0$.

(1) Se incontri qualche avvocato alla festa, fatti aiutare.
'If you meet an attorney at the party, ask for help'

The interpretation is at least in part connected with contextual semantics and pragmatics, and in this case the speaker does not specify the referent.

Summarising, *qualche* can acquire different meanings, depending on the context[2]:

- Plural *qualche*:

(2) Ho qualche fratello.
'I have some brothers'

- Singular *qualche* (especially in object position with intensional contexts, i.e. as the antecedent of conditionals, future, optative and interrogative clauses, and declarative with epistemic 'must'):

[2] See also Zamparelli (2007) who derives the different meanings of *qualche* from the interaction of a complex DP and pragmatic inferences.

(3) Mario troverà pure qualche donna che lo ami, prima o poi.
'Mario will sooner or later find some woman or other who loved him'

- Indeterminate *un qualche*:

(4) Johnny somigliava a un qualche personaggio di un qualche film.
'Johnny resembled some character from some film'

In Italian there is another quantifier that is used for paucal numerosities, namely *alcuni* (feminine form: *alcune*). As opposed to *qualche*, it is a non-intrinsic quantifier and requires a morphologically plural noun. It cannot acquire the non-plural meanings, nor combine with *un*. Furthermore, *alcuni* as pronominal form (coinciding with the determiner form, differently from *qualche*) can only be partitive in meaning and denote a plurality out of a set of contextually salient entities; it cannot be used in sentences where no partitive coindexation has been set up or can be inferred, and the pronominal form of *qualche*, namely *qualcuno*, has to be used:

(5) *Alcuni devono essersi sposati
*'Some must have gotten married'

(6) Qualcuno deve essersi sposato
'Someone must have gotten married'

Despite their differences, in the most basic interpretation the two quantifiers in their determiner form are equivalent in the denotation of plural (paucal) numerosity. Therefore, these two quantifiers are suitable for investigating the processing effects of diverging Number morphology on the noun they agree with, since *qualche* requires agreement with the singular form.

2. Experimental study

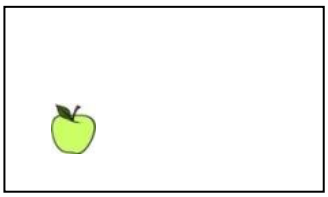
We developed a psycholinguistic experiment in order to test if the value of morphosyntactic Number agreement affects processing in the assessment of referential numerosity. The two quantifiers discussed in §1.3, *qualche* and *alcuni*, were taken as testing ground in order to explore the effect of the mismatch. We predicted that when the morphological Number value (i.e. singular) is not consistent with the numerosity encoded by the QE (i.e. plural), longer times will be elicited. Therefore, the processing of *qualche*+N_{sg} should be slower relative to *alcuni*+N_{pl} when assessing the numerosity of the referent.

2.1 Materials

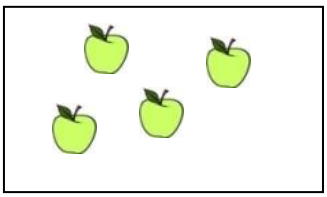
A picture–phrase matching task was developed. Each QE (Q+N) is paired with a picture of the object denoted by the noun; the participant then assesses the truth-value of the phrase relative to the picture. 30 countable, concrete nouns, each referring to an inanimate object, were chosen and matched by frequency as found in corpora – by means of the it-WaC

corpus (Baroni et al., 2009), – by subjective frequency – by means of a dedicated rating study (Zanini, Arcara & Franzon, 2014), in which a sample of Italian native speakers rated the frequency of a list of selected words – and by graphic length. The length of the whole phrase Q+N was also matched.

For each noun, two pictures were created: one for singular conditions, representing one single object, and one for plural conditions, representing four instances of the same object; four was kept as the standard number for plurality, which is compatible with a paucal numerosity. In order to avoid differences in RTs due to how the pictures were structured rather than to the actual experimental conditions, all singular pictures were decentralised. By doing so, none of the pictures in the different conditions was placed at the centre, thus minimising facilitation effects for singular pictures relative to plural pictures (see Figure 1).



Singular condition (n = 1)



Plural condition (n = 4)

Fig. 1: Example of picture stimuli

Each picture was then associated with both QEs, resulting in four different conditions and a set of 120 experimental stimuli. The design is exemplified in Table 1 below:

Picture	QE	Numerosity encoded by the QE	Morphological Number value	Truth value	Condition
Singular	*qualche* + N	plural	singular	F	A
	alcuni/e + N	plural	plural	F	B
Plural	*qualche* + N	plural	singular	T	C
	alcuni/e + N	plural	plural	T	D

Table 1: Experimental conditions

Notably, in the contexts of the experiment, the quantifier *qualche* cannot receive non-plural interpretation. We provide contexts in which both quantifiers receive the plural (paucal) reading, thus excluding any possible semantic ambiguity (see §1.3).

As shown in Table 1, the QEs always encode plurality, but they differ in the formal Number value required for agreement. We predicted that conditions B and D, involving *alcuni*/*e*, require shorter RTs relative to conditions A and C, involving *qualche*. The longer RTs predicted for conditions A and C are possibly due to the resolution of the mismatch between the semantic plural denotation and the singular Number computed from morphosyntactic information.

Singular pictures are always associated to a false truth-value, and plurals to a true value; in order to avoid biases, we introduced 180 filler stimuli to counterbalance each experimental condition, as shown in Table 2 (*un*/*uno*/*una* are the Italian forms of the indefinite article).

Picture	QE	Numerosity encoded by the QE	Morphological Number value	Truth value	Condition
Singular	*un/uno/una* + N	singular	singular	T	filler
	plural bare noun	plural	plural	F	filler
	singular bare noun	singular	singular	T	filler
Plural	*un/uno/una* + N	singular	singular	F	filler
	plural bare noun	plural	plural	T	filler
	singular bare noun	singular	singular	F	filler

Table 2: Filler stimuli

2.2 Method

34 native Italian speakers (age 21–35, 16 females and 18 males) participated in the study. Participants were recruited on a voluntary basis. The tests were carried out at the Department of General Psychology of the University of Padova, Italy.

The task was structured as follows (see Fig. 2): at each trial, after an initial frame with a fixation point, the participants were presented a picture, followed by a very short blank, and then the QE (Q+N) was displayed. Participants were asked to respond as soon as they could after the presentation of the phrase, by pressing a specific key if the numerosity denoted by the QE matched the referential numerosity of the preceding picture, otherwise they had to press another key. Response keys were counterbalanced across participants. RTs measurement was triggered as soon as the phrase was displayed. An inter-trial blank followed the phrase frame before starting a new trial. The presentation of the stimuli was randomized for each subject. Every subject was trained with 24 trials before starting the actual experiment. Each word of the training was matched with a congruent picture, and the QEs to assess were of the same kind of those used in the task. The experiment was administered by using DMDX. The task took about 30 minutes, with a short break in the middle of the session.

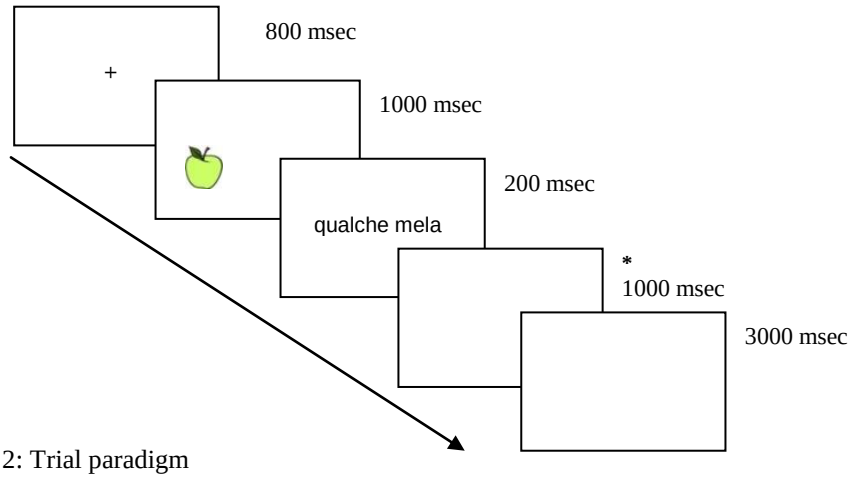


Fig. 2: Trial paradigm

2.3 Results

Table 3 shows the results obtained (only correct answers have been considered):

	TRUE	*FALSE*	*mean*	*sd*
***qualche*+N_{sg}**	863.32 (97%)	874.17 (94%)	868.75	224.70
***alcuni*+N_{pl}**	798.51 (98%)	835.26 (97%)	816.88	227.15

Table 3: Response times (msec) and accuracy scores (%)

An ANOVA both by subject and by item was carried out.[3] A significant main effect $F_1(1, 33) = 57.81$, $p < .001$ and $F_2(1, 29) = 54.70$, $p < .001$ was found for QE: the RTs for conditions with *qualche* + N_{sg} (mean = 868.75 msec; sd = 224.70) were significantly longer than for conditions with *alcuni*/*e* + N_{pl} (mean = 816.88 msec; sd = 227.15), regardless of its truth-value. No interactions QE–truth value were found. No significant effects were found for accuracy.

	RESPONSE TIMES	
	by subject	*by item*
QE effect	$F_1(1, 33) = 57.81$, $p < 0.001$ *	$F_2(1, 29) = 54.70$, $p < 0.001$ *
truth effect	$F_1(1, 33) = 2.55$, $p = 0.12$	$F_2(1, 29) = 8.69$, $p = 0.006$ *
QE–truth interaction	$F_1(1, 33) = 5.23$, $p = 0.029$ *	$F_2(1, 29) = 2.76$, $p = 0.108$
	ACCURACY	
	by subject	*by item*
QE effect	$F_1(1, 33) = 2.18$, $p = 0.149$	$F_2(1, 29) = 8.86$, $p = 0.006$ *
truth effect	$F_1(1, 33) = 2.81$, $p = 0.103$	$F_2(1, 29) = 24.44$, $p < 0.001$ *
QE–truth interaction	$F_1(1, 33) = 0.31$, $p = 0.581$	$F_2(1, 29) = 3.66$, $p = 0.066$

Table 4: ANOVAs for RTs and accuracy. * = statistically significant

[3] Outliers were not filtered out in these analyses. We carried out additional analyses on filtered data, obtaining the same results.

As Table 4 shows, only the QE effect for RTs could be generalised, since it is the only parameter for which the two analyses (by subject and by item) yielded a significant result.

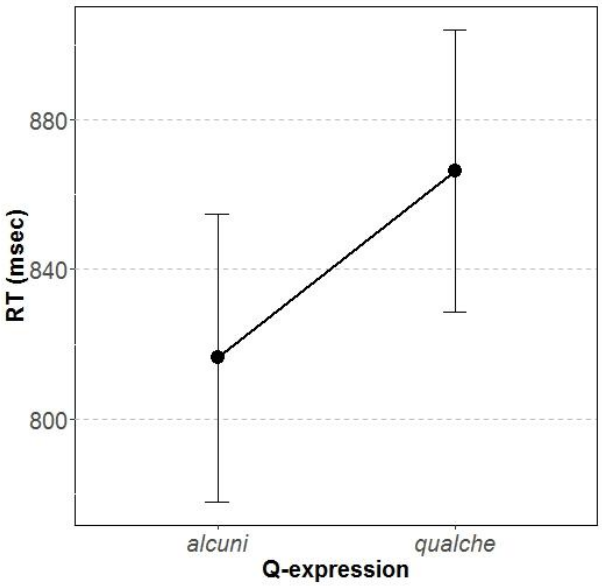


Fig. 3: Main effect for QE. Standard error bars are included; note that, in a within-subject analysis, overlapping bars do not imply a non-significant effect.

3. Discussion

The results are consistent with our experimental hypothesis. In conditions where the value of morphological Number is congruent with the semantic encoding of numerosity, the processing is faster than in conditions displaying a mismatch. When the noun agrees with *qualche*, the mismatch between the morphological value of singular and the semantic encoding of plurality of the QE leads to a conflict of information when assessing the truth-value: the resolution of such conflict results in longer response times. If there is no inherent lexical difference and there are no relevant differences in how the two quantifiers are processed, it is likely that what affects processing in the picture–phrase matching task is the morphological value of Number. This result cannot be explained without postulating an interaction between extra-linguistic information and information encoded in the language.

As mentioned in §1.2, the literature provides evidence that morphosyntactic Number is somehow linked to a non-linguistic elaboration of numerosity. Our results, consistently with previous studies, point to the fact that the value of morphological Number does play a role in a task requiring the assessment of the numerosity of the referent. The results may also suggest that pieces of information on numerosity extracted from linguistic and extra-linguistic sources are then cognitively processed similarly, resulting in higher processing cost when there are inconsistencies. Notably, these results were found without exploiting a violation paradigm. Thus, the link between Number morphology and numerical cognition is not to be ascribed to artificial effects of the task.

4. Conclusions

We developed a behavioural experiment in order to explore the link between morphosyntactic Number and referential numerosity. By contrasting the value of morphological Number with a semantic encoding of numerosity we found that longer response times were elicited in conditions in which Number and encoded numerosity were not congruent. These results provide further evidence in favour of a link between the elaboration of contextual numerosity and Number morphology. The data of this study, taken together with findings from the literature (i.e. Carreiras et al., 2010), seem to suggest an interface between the cognition of numerosity and Number morphology; this interface seems to play a role even when performing linguistic tasks. Electrophysiological techniques can enlighten on the time course in which these pieces of information are integrated, and when the mismatches are detected and resolved. This study can therefore suggest new lines of research on the interface between language and numerical cognition.

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