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Effects of animacy on the processing of morphological Number: a cognitive inheritance?

Abstract

Language encodes into morphology part of the information present in the referential world. Some features are marked in the great majority of languages, such as the numerosity of the referents, that is encoded in morphological Number. Other features do not surface as frequently in morphological markings, yet they are pervasive in natural languages. This is the case of animacy, that can ground Gender systems, as well as constrain the surfacing of Number. The diffusion of numerosity and animacy could mirror their biological salience at the extra-linguistic cognitive level. Human extra-linguistic numerical abilities are phylogenetically ancient and can be observed in animal species, especially when counting salient animate entities such as social companions. Does the saliency of animacy influence the morphological encoding of Number in language processing?

We designed an experiment to test the encoding of morphological Number in language processing in relation to animacy. In Italian, Gender and Number are mandatorily expressed in a fusive morpheme. In some nouns denoting animate referents, Gender encodes the sex of the referents and is semantically interpretable. In some other animate nouns and in inanimate nouns, Gender is not interpretable at the semantic level. We found that it is easier to inflect for Number nouns when the inflectional morpheme is interpretable with respect to a semantic feature related to animacy. We discussed the possibility that the primacy of animacy in counting is mirrored in morphological processing and that morphology is designed to easily express information that is salient from a cognitive point of view.

Keywords: morphological Number, numerical cognition, animacy, gender

1 Introduction

Natural languages communicate information about entities of the referential world most evidently by conveying it through lexical words. Potentially, any meaning can be encoded at the lexical level, and new signs can be added when needed. However, the possibility to convey information about the reference is not confined to the lexicon: also grammaticalised elements, such as morphological values, can bear semantic content. Crucially, the semantic features that can be conveyed through morphology are finite set and cross-linguistically very consistent. For example, the great majority of the languages have verbal tense, aspect and mood paradigms to encode properties of events (156 out of 160 considered languages in the WALS map 21B, by Bickel & Nichols 2013) or number paradigms to encode plurality (968 out of 1066 reported languages in the WALS map 33A by Dryer 2013). Yet, at least to our knowledge, no language shows dedicated morphological values to encode properties like colour, or olfactory information. Why does morphology encode prevalently some meanings and not others? Is there something special about the information on which morphological paradigms are built?

In the framework of the inexhaustible debate on the link between language and thought (among others: Chomsky 1988; Greenberg 1948; Hurford 1987; Hymes 1964; Lucy 1992; Sapir 1921; Whorf 1956), it has been recently proposed that the core structure of the natural languages would stem from processing mechanisms rather than the other way round (Christiansen & Chater 2008) and recent literature has highlighted the role of languages as advanced communicative systems that allow speakers to share information coming from mental experiences, and from the core knowledge systems in particular (e.g. Corballis 2017). The core knowledge systems are a tool-kit of non-verbal cognitive skills that allow humans and animals to represent the most salient aspects of the environment, and to behave accordingly (Cantlon & Brannon 2007; Dehaene 2011; Rugani et al. 2015; Spelke 2000; Starr, Libertus & Brannon, 2013). These skills would have played a crucial role in evolutionary success: they seem to be present soon after birth in humans and to have a phylogenetically ancient origin, as they are mostly shared with non-human animal species. The aspects of the world they represent encompass object representation, numerical abilities, as well as abilities concerning naïve physics, time, space, and motion (Carey 2009; Spelke 2000). Recently, a link has been outlined between this information and the information encoded in morphology and morpho-syntax, suggesting that the information processed by these systems would be so salient to have shaped the grammatical structure of language. In other words, the information encoded in a core linguistic level, such as morphology, would stem from information coming from core knowledge processes (Bickel et al. 2015; Franzon, Zanini & Rugani 2018; Strickland 2017; Zanini et al. 2017).

Among the elements that could allow us to explore the hypothetical link between core grammar and core cognition, Number morphology could offer an especially suitable testbed for several reasons. First, the grammatical encoding of information about numerosity is widespread throughout natural languages (Corbett 2000). The WALS reports that 90.8% of the considered languages have a grammatical device to convey nominal plurality (Dryer 2013). The author points out that the remaining about 10% of the languages is difficult to interpret and could as well display some markings for Number. Moreover, this estimate increases when considering that Number can be marked not only on nouns and pronouns but also on verbs, referring to the numerosity of participants in an action, or to the number of times or places in which an action is performed (Veselinova 2013). The fact that Number morphology is so pervasive across languages may consistently mirror the salience of the information about numerosity at the extra-linguistic cognitive level. A further noteworthy contact point between core grammar and numerical cognition has been suggested starting from the observation of some similarities between the information encoded into morphological systems and the one processed in extra-linguistic numerical cognition: the values of morphological Number systems observed in typology closely resemble the information processed by the non-verbal systems dedicated to number and quantity processing (Franzon et al. 2018). Most literature agrees on the fact that numerical reasoning is handled by two non-verbal numerical cognitive mechanisms: the Object File System (OFS) and the Analogue Magnitude System (AMS) (Feigenson, Dehaene & Spelke 2004). The OFS is founded on the capability of individuating each new object entering into a scene, to which a new file (object file) is assigned and stored in the working memory; its signature is a limit to the number (usually 3 or 4) of object-files that can be simultaneously tracked and stored (among others: Trick & Pylyshyn 1994). The AMS can deal with larger numerosities and its functioning would be ratio-dependent according to Weber's law: it is easier to discriminate between quantities or numerosities when the ratio between them is bigger (among others: Gallistel & Gelman 1992).

Crucially, these core numerical abilities can be observed independently from linguistic abilities, such as in educated adult humans when, under specific experimental conditions, language use is prevented (Cordes et al. 2001) or in adult speakers having no number words (Butterworth et al. 2008; Pica et al. 2004); in preverbal infants (deHevia 2011; McCrink & Wynn 2007); and in non-human animals, especially when counting salient animate entities (Agrillo et al. 2014; Rugani et al. 2010, 2015; Vallortigara 2012; Cantlon & Brannon 2006). In this regard, it is worth noticing that numerical abilities are not implemented in an indiscriminate way, but are carried out relatively to some life aspects which are salient from a biological point of view, like estimating quantities of food or counting animate beings, especially if these latter are social companions (Rugani et al. 2010). Interestingly enough, also the surfacing of Number in morphological paradigms can be constrained by many features among which we find the ones related to a hierarchy of animacy (Dixon 1979; Smith-Stark 1974). Animacy has been mostly described as a lexical feature; in fact, it does not surface as diffusely as numerosity in morphological markings. Yet, animacy is pervasive in natural languages (Dahl 2000) and can play a transparent role in shaping morphological paradigms (Corbett 1991). Generally, nouns are more likely to be inflected for Number when the corresponding referents are higher in the animacy hierarchy; according to Corbett (2000) "the singular - plural distinction in a given language must affect a top segment of the Animacy Hierarchy" (Corbett 2000: 56). Scholars have proposed different animacy hierarchies, either grammar-based or semantic-based, all of these placing pronouns and kinship terms on the top and nouns denoting inanimate referents on the lower steps (Dixon 1979; Matasović 2004; Smith-Stark 1974; for a critical discussion, see Corbett 1996 and Brown et al. 2013). These generalizations formalise consistencies observed across natural languages and are to some extent captured in the WALS maps 34A (Haspelmath 2013) and 35A (Daniel 2013). For example, Malay marks Number on personal pronouns but not on nouns, Sarsi marks Number only for kinship terms, Manchu on pronouns and nouns denoting human beings, Comanche marks Number for animate referents, but rarely for inanimate ones.

Could the diffusion of numerosity and the pervasiveness of animacy in morphological paradigms mirror their biological salience and phylogenetic ancestry at the extra-linguistic cognitive level? Does the saliency of animacy influence the morphological encoding of Number in language processing? Unfortunately, up to now the link between numerical cognition and its encoding into language has been mainly investigated by focusing on the lexicon and on words expressing quantities and number such as quantifiers, ordinal and cardinal numbers (e.g. Butterworth et al. 1999; Carey 2004; Clark & Grossman 2007; Gelman & Gallistel 2004; Gordon 2004; Lipton & Spelke 2003; Ochtrup et al. 2013; Pica et al. 2004; Rath et al. 2015; Salillas, Barraza & Carreiras 2015; Semenza 2008; Troiani et al. 2009), while fewer studies have taken into account morphology. However, preliminary results seem promising as they point to the fact that quantity representation is accessed while processing morphological Number. For example, children who speak languages displaying morphological Number values (e.g. singular, plural, dual) have been shown to acquire the relevant number words (such as 'one' or 'two') earlier than children who speak languages without morphological Number values (Almoammer et al. 2013; Marušič et al. 2016; Sarnecka et al. 2007). A study conducted on German by Roettger & Domahs (2015) reported an effect similar to SNARC (spatial-numerical association of response codes) related to morphological Number in performing a series of behavioural tasks. The authors found that words inflected in the singular had a relative left-hand advantage and words in the plural a relative right-hand advantage.

1.1 The study

For the first time we designed an experiment to test the encoding of morphological Number in language processing and its interaction with animacy. In Italian, Gender and Number are mandatorily expressed in a fusive morpheme (e.g. *gatto* 'cat-Masc.Sg'). Yet, while Number is semantically interpretable in almost every noun, the semantic interpretability of Gender is restricted to some lexemes denoting animate referents (1a). More precisely, in some animate nouns, the semantic opposition of the sex of the referents corresponds to the morphological opposition of Gender[1]. However, in some other animate

[1]A clarification is needed here. In general, in Italian, Gender is inherent to nouns (e.g. the noun *sedia* 'chair' is inherently feminine and it cannot take masculine Gender in other contexts). Instead, Gender is contextually assigned in the case of adjectives (e.g. the Gender of an adjective depends on the Gender of its controller: *la sedia nuova* 'the.Fem.Sg chair-Fem.Sg new-Fem.Sg' vs. *il divano nuovo* 'the.Masc.Sg sofa-Masc.Sg new-Masc.Sg).

nouns, Gender does not encode such opposition and thus is not interpretable with respect to the sex of the referent (1b). Lastly, in inanimate nouns, Gender is not related to any semantic feature[2] and thus is not interpretable (1c).

(1)	a.	*gatto*	vs.	*gatta*
		cat-Masc.Sg		cat-Fem.Sg
	b.	*topo*	vs.	Ø
		mouse-Masc.Sg		
	c.	*sasso*	vs.	Ø
		stone-Masc.Sg		

Henceforth, nouns such as the one exemplified in (1a) are referred to as ANIM_G, e.g. animate nouns with semantically interpretable Gender; nouns of the same type of the one illustrated in (1b) are called ANIM_I, e.g. animate nouns with inherent Gender; type (1c) nouns are labelled INANIM, e.g. inanimate nouns. On the basis of the literature mentioned in the introduction (§1), we hypothesised a

However, some animate nouns seem to behave like the adjectives as they alternatively bear masculine Gender with male referents and feminine Gender with female referents (e.g. *il sarto* 'the.Masc.Sg tailor-Masc.Sg vs. *la sarta* 'the.Fem.Sg tailor-Fem.Sg'). Some scholars argue that Gender is inherently assigned to these nouns as well. According to this view, the two nouns will be derivationally and not inflectionally related (Matthews 1974; Thornton 2005; Zamparelli 2008). Conversely, other scholars claim that Gender is contextually assigned to these nouns that can thus be alternatively inflected in the masculine or in the feminine (Di Domenico 1997; Franzon et al. 2013). It is beyond the aims of the present study to take a position in this debate. Rather, we just aimed to verify whether animate nouns showing a masculine/feminine alternation are processed differently from animate nouns which, instead, do not show this possibility.

[2] According to some scholars, Gender does encode semantic features even in the case of nouns denoting inanimate referents. For example, a set of Italian inanimate nouns can appear in oppositions as *buco* 'hole-Masc.Sg' vs. *buca* 'large hole-Fem.Sg'. These gender oppositions would concern the feature of dimension and the morphological value of Feminine would be linked to an interpretation of [+ large]. Even if this kind of opposition is widely attested in Standard Italian as well as in many Italo-Romance dialects, it seems not to be productive (on this and related points see, among others, Acquaviva 2013). It must be noticed that this type of oppositions was avoided in our experimental design.

cognitive advantage for animate nouns over inanimate nouns whenever speakers inflect them for Number. Two scenarios can be supposed. In the first case, it may be easier to inflect for Number all animate nouns, irrespective of interpretability of their Gender. Then, we would expect that both ANIM_G and ANIM_I nouns will be inflected more accurately than INANIM ones. In the second case, it may be that only animate nouns whose Gender is interpretable at the semantic level are inflected more easily and thus more accurately than both ANIM_I and INANIM in the experimental task. Our working hypotheses are summarised in (2):

(2)	a.	ANIM_G (*gatto*), ANIM_I (*topo*)	>	INANIM (*sasso*)
	b.	ANIM_G (*gatto*)	>	ANIM_I (*topo*), INANIM (*sasso*)

Before illustrating the experimental methodologies, it must be clarified that, in Italian, the Gender of a noun is unambiguously detectable only in phrasal context. For example, both *tavolo* 'table' and *mano* 'hand' share the same feminine final inflectional suffixes: -*o* for the singular and -*i* for the plural (*tavoli* 'tables', *mani* 'hands'). In other words, these two nouns share the same declensional class characterised by a two cell paradigm (singular: -*o*; plural: -*i*). Nevertheless, the first noun triggers masculine agreement (*il tavolo bello* 'the.Masc.Sg table-Masc.Sg nice-Masc.Sg') whereas the second noun triggers feminine agreement (*la mano bella* 'the.Fem.Sg hand-Fem.Sg nice-Fem.Sg'). Traditionally, six declensional classes have been recognised for Italian (for a more extensive description and discussion see, among others: Acquaviva 2009; Aronoff 1994; Corbett 1991). Class I is characterised by a two cell paradigm (singular: -*a*; plural: -*e*) and includes feminine nouns only (e.g. *sedia* - *sedie* 'chair - chairs'). Class II is the class to which the above mentioned nouns *tavolo* and *mano* belong; this class includes masculine nouns except for *mano* that is instead feminine. Even if there is no one-to-one correspondence between declensional classes and Gender in Italian, it is worth noticing that Class I and Class II are the most productive classes in Italian as well as the most transparent with respect to Gender (again, with the sole exception of *mano*).

Further, it must be noticed that Gender and biological sex do not necessarily coincide; for example, some animate nouns trigger masculine agreement but denote female referents (e.g. *il soprano* 'the.Masc.Sg soprano-Masc.Sg'). Yet, even if there is no one-to-one correspondence between declensional classes, grammatical Gender and biological sex and Italian inflectional suffixes are not iconic with respect to animacy, a strong trend is still observable. Prototypically, animate nouns belonging to the declension class I (*-a/-e*) and bearing feminine Gender tend to denote female beings, whereas animate nouns belonging to the declension class II (*-o/-i*) and bearing masculine Gender tend to denote male beings (this and related topics have been extensively discussed in Loporcaro 2018 taking into account the diversity found in the Romance varieties).

2 Method

2.1 Participants

Thirty-six young adult native speakers of Italian took part in the study as volunteers (females = 31; mean age = 21.86; min age = 19; max age = 36; SD = 3.29; mean education = 13.55; min education = 13; max education = 18; SD = 1.29). All participants were right-handed, had normal or corrected-to-normal vision, and had no reported history of neurological or psychiatric impairments, reading or learning disorders. All participants signed a written informed consent before taking part in the study.

2.2 Procedure

Participants were tested in a dimly lit, quiet room. They performed a phrase-completion task on a computer screen. The task was delivered with PsychoPy software (Peirce 2007). Each trial consisted of the following sequence: first, a fixation cross appeared in the centre of the screen; afterwards, a noun phrase made up of two words showed up. One or the other word lacked the inflectional morpheme. The participants were asked to complete the word at issue as accurately and quickly as possible by pressing a button to insert -*o* or another one to insert -*i*. The response keys were counterbalanced across participants. The sentence remained visible until the participant gave a response. After 250 msec a new sentence was presented. For each trial responses times (RT) and accuracy were recorded.

Eight practice trials were administered before the beginning of the experiment to familiarise with the task. Trials were randomly presented for each participant. The overall task lasted about 30 minutes. The task included two breaks, thus the participants had the opportunity to rest every 10 minutes. The participants were instructed to take a break and resume when they preferred.

2.3 Materials

We created 158 experimental trials. For each of the three *Types* illustrated in (1), we selected: 20 animate nouns with interpretable Gender (ANIM_G, *gatto* 'cat'), 19 animate nouns with semantically uninterpretable Gender (ANIM_I, *topo* 'mouse') and 20 inanimate nouns (INANIM, *sasso* 'stone'). Each experimental noun was presented in two conditions of *Number*, namely masculine singular and masculine plural. To keep semantic variability at minimum across conditions, we chose two semantic classes for nouns with animate referents (animals and human roles) and two for nouns with inanimate referents (food and materials). Twenty INANIM nouns with an infrequent plural form were added to prevent participants from focussing on the experimental manipulations. Experimental types of noun are summarised in Table (1).

Table 1: Types of experimental nouns

<table>
<tr><th>Type</th><th>Num</th><th>Semantic classes</th><th>Gender</th><th>Number</th></tr>
<tr><td>ANIM_G</td><td>20</td><td rowspan="2">humans and animals</td><td>masculine and feminine</td><td rowspan="3">singular and plural</td></tr>
<tr><td>ANIM_I</td><td>19</td><td rowspan="3">only masculine</td></tr>
<tr><td>INANIM 1</td><td>20</td><td rowspan="2">food and materials</td></tr>
<tr><td>INANIM 2</td><td>20</td><td>only singular</td></tr>
</table>

Only non-compounded and non-derived nouns with a regular inflection and belonging to declensional classes I and II were included in the experimental items. Since the experiment was a (reading) task administered visually, nouns whose singular form presents a different number of graphemes with respect to the corresponding plural one were discarded (e.g. *uomo – uomini* ‘man – men’; *sacco – sacchi* ‘bag – bags’). Frequency as collected from the itWaC corpus (Baroni et al. 2009), orthographic length and orthographic neighbourhood of the experimental nouns were controlled and matched across conditions as far as possible. Indeed, effects due to frequency are well-known to affect visual presentation of visual stimuli at least from Forster & Chambers (1973). In particular, the four experimental categories (ANIM_G, ANIM_I, INANIM 1, INANIM 2) did not significantly differ from each other as for masculine singular forms (all $ps > 0.05$).

Further, also the experimental categories were assigned on the basis of quantitative methods by considering the distribution of masculine forms and of feminine forms on the total occurrences. Potentially, it is possible to derive both the masculine and the feminine forms of all nouns denoting an animate referent, given Italian word formation rules (on this point see also §5). This observation may lead to the conclusion that any categorization of Italian nouns as ANIM_G or ANIM_I is inconsistent. To prevent arbitrary classifications, we performed corpus analysis to disentangle well attested forms from hapaxes, jokey saying and innovative/not yet established forms. We considered as ANIM_G only those nouns significantly occurring with a similar frequency (as collected from the itWaC corpus) in the masculine singular and in feminine singular (mean Masc = 13718.25, mean Fem = 10029.95, $t\ (19) = 1.51$, $p > 0.05$); whereas, we considered as ANIM_I only those nouns occurring significantly more in the masculine singular than in the feminine singular (mean Masc = 14356.84, mean Fem = 46.894, $t\ (18) = 0.04$, $p < 0.05$). In other words, the mean ratio of the distribution of ANIM_G masculine forms on the total occurrences is 0.559 (SD = 0.199) and that of the corresponding feminine forms is 0.44 (SD = 0.199); conversely, the mean ratio of the distribution of ANIM_I masculine forms on the total occurrences is 0.986 (SD = 0.024) and that of the corresponding feminine forms is 0.013 (SD = 0.024). Similarly, we did not assign any noun to the category of INANIM 2 (implausible plural) on the basis of their reference to mass entities. In fact, it is well known from the literature that even if the so called mass nouns are inflected in the singular, it is not uncommon for some of them to occur in the plural as well (for Italian see: Acquaviva 2013; Marcantonio & Pretto 2001; for quantitative studies tackling the distribution of mass and count nouns in Italian see: Franzon, Arcara & Zanini 2016; Katz & Zamparelli 2012; Kulkarni, Rothstein & Treves 2013). Instead, we labelled as INANIM 2 those nouns occurring significantly more in the singular than in the plural (as collected from the itWaC corpus; mean Sg = 12638.7, mean Pl = 279.25, $t\ (19) = 3.01$, $p < 0.\ 05$); whereas nouns of the other three categories are evenly distributed between singular and plural occurrences (ANIM_G: mean Sg = 13718.25, mean Pl = 16152.4, $t\ (19) = 0.36$, $p > 0.05$; ANIM_I: mean Sg = 14356.84, mean Pl = 12393.89, $t\ (18) = 0.32$, $p > 0.5$; INANIM 1: mean Sg = 13278.15, mean Pl = 11858.489, $t\ (19) = 0.18$, $p > 0.05$). Given all these constraints and observations, we selected the nouns that best fit the experimental purposes[3]. Experimental nouns are listed in Table (2).

Table 2: **Properties of the experimental nouns**
English translation is given in brackets for the corresponding Italian nouns in the masculine singular.

ANIM_G	English translation	Freq Masc.Sg (-o)	Freq Masc.Pl (-i)	Freq Fem.Sg (-a)	Ort.Lengh	Neighbour.
bidell-o	(janitor)	1067	997	338	6	3
cognat-o	(brother-in-law)	3851	621	1875	6	4
div-o	(movie star)	1991	2165	2616	4	10
maestr-o	(teacher)	56949	25974	12683	6	3
cugin-o	(cousin)	8997	5919	4098	5	6
ragazz-o	(boy)	91821	219653	87236	6	3
suocer-o	(father-in-law)	2613	1030	3764	6	3
nonn-o	(grandfather)	19082	11472	18601	4	5
sart-o	(tailor)	2376	766	815	4	9
serv-o	(servant)	12677	10158	11434	4	9
zi-o	(uncle)	19313	2841	11365	2	3
orfan-o	(orphan)	3507	1685	9758	5	6
gatt-o	(cat)	22226	20884	3726	4	11
sovran-o	(sovereign)	8925	1192	2475	5	4
ballerin-o	(dancer)	2514	2691	4246	8	3
fanciull-o	(child)	6357	5270	7317	8	3
fidanzat-o	(fiancé)	7382	491	10372	8	4
gemell-o	(twin)	1220	4834	541	6	3
vedov-o	(widower)	564	221	6611	5	5
zingar-o	(gypsy)	933	4184	728	6	3
mean		13718.25	16152.4	10029.95	5.4	5
sd		22491.521	48398.716	18842.667	1.535	2.655
ANIM_I	**English translation**	**Freq Masc.Sg (-o)**	**Freq Masc.Pl (-i)**	**Freq Fem.Sg (-a)**	**Ort.Lengh**	**Neighbour.**
sindac-o	(mayor)	124955	24933	42	6	1
magistrat-o	(magistrate)	31395	53157	33	9	1
soldat-o	(soldier)	18884	59860	16	6	6
angel-o	(angel)	17499	15243	60	5	2
parroc-o	(parson)	13649	2481	0	6	1
uccell-o	(bird)	7838	27855	0	6	2

[3] It must be noted that nouns of the category ANIM_G vary semantically less than those of the category ANIM_I since the former mainly refer to humans while the latter refer both to humans and animals. We applied quantitative methodologies to trace the best possible categorisation for the experimental purposes, as explained in §2.3. It is not surprising that there is a high probability that a noun occurring equally in the masculine and in the feminine (and thus having interpretable gender) denotes a human referent. Indeed, features linked to human references are set in the top segments of the animacy hierarchy and are the more prone to constrain Gender (and Number) systems (Corbett 1991; Matasović 2004). In this sense, we think that our selection of the experimental nouns is genuine and reflects a general language property. Such a distribution, though, was taken into account when discussing experimental results (see §3).

grill-o	(cricket)	5554	1472	0	5	4
squal-o	(shark)	3645	3585	2	5	1
insett-o	(bug)	3448	12161	5	6	4
corv-o	(crow)	2261	1876	54	4	11
cign-o	(swan)	2176	1500	2	4	2
fabbr-o	(blacksmith)	2137	998	0	5	3
leopard-o	(leopard)	2189	544	7	7	2
architett-o	(architect)	23371	12828	24	9	4
cangur-o	(kangaroo)	891	823	14	6	1
camell-o	(camel)	2532	2318	136	7	2
struzz-o	(ostrich)	1656	1087	11	6	3
merl-o	(blackbird)	1397	1098	146	4	4
top-o	(mouse)	7303	11665	339	3	11
mean		14356.84	12393.89	46.894	5.736	3.421
sd		28166.52	17646.88	82.848	1.557	3.005

INANIM 1	**English translation**	**Freq Masc.Sg (-o)**	**Freq Masc.Pl (-i)**	**Freq Fem.Sg (-a)**	**Ort.Lengh**	**Neighbour.**
vetr-o	(glass)	30587	10435	NA	4	6
nastr-o	(ribbon)	14008	6834	NA	5	4
cavol-o	(cabbage)	11140	3509	NA	5	2
sass-o	(stone)	7691	8378	NA	4	9
muscol-o	(muscle)	5386	16694	NA	6	1
tartuf-o	(truffle)	4497	2774	NA	6	1
rubin-o	(ruby)	4188	526	NA	5	3
sciropp-o	(syrup)	2667	648	NA	7	1
smerald-o	(emerald)	1796	597	NA	7	1
cedr-o	(citron)	1472	879	NA	4	3
biscott-o	(biscuit)	1410	6228	NA	7	1
carciof-o	(artichoke)	1257	3152	NA	7	1
cib-o	(food)	58426	22444	NA	3	8
cuscin-o	(pillow)	4652	2.798	NA	6	1
gelat-o	(ice-cream)	9630	3725	NA	5	10
pel-o	(hair)	15521	5512	NA	3	15
sold-o	(coin)	5316	122470	NA	4	5
tappet-o	(carpet)	12658	4971	NA	6	2
tub-o	(tube)	13831	8822	NA	3	7
tesor-o	(treasure)	59430	8569	NA	5	2
mean		13278.15	11858.489		5.1	4.15
sd		17094.601	26641.294		1.372	3.897

INANIM 2	**English translation**	**Freq Masc.Sg (-o)**	**Freq Masc.Pl (-i)**	**Freq Fem.Sg (-a)**	**Ort.Lengh**	**Neighbour.**
burr-o	(butter)	22036	32	NA	4	3
amiant-o	(asbestos)	18707	63	NA	6	0
ossigen-o	(oxygen)	16392	31	NA	7	1
metan-o	(methane)	11523	3	NA	5	3
asfalt-o	(asphalt)	11007	280	NA	6	2

brod-o	(soup)	10803	225	NA	4	6
azot-o	(nitrogen)	7919	4	NA	4	1
acet-o	(vinegar)	7309	324	NA	4	3
ozon-o	(ozone)	6658	3	NA	4	1
zolf-o	(sulphur)	5321	41	NA	4	3
or-o	(gold)	86433	2522	NA	2	11
fien-o	(hay)	3587	66	NA	4	3
orz-o	(barley)	3380	19	NA	3	7
lard-o	(lard)	3180	20	NA	4	9
clor-o	(chlorine)	2838	8	NA	4	2
tim-o	(thyme)	2517	55	NA	3	10
argent-o	(silver)	28102	1321	NA	6	3
zenzer-o	(ginger)	1811	1	NA	6	0
origan-o	(oregano)	1646	1	NA	6	1
amid-o	(starch)	1605	566	NA	4	7
mean		12638.7	279.25		4.5	3.8
sd		18899.535	611.991		1.277	3.349

Each experimental trial consists of a phrase in which the content noun lacking the final inflectional morpheme (e.g. -*o* for masculine singular and -*i* for masculine plural) was preceded by the demonstrative *questo* ‘this’ to constrain agreement in the masculine singular and *questi* ‘these’ to constrain agreement in the masculine plural. 220 filler trials were added to avoid perseveration strategies in the participants’ performance. 110 filler trials required completion on the demonstrative instead and, among these, 60 nouns did not belong to declensional classes I and II, but to classes less transparent with respect to Gender (e.g. *fantasma* ‘ghost’ which ends in -*a* but triggers masculine agreement or *cane* ‘dog’ which ends in the opaque suffix -*e*). The other 110 filler trials required completion on the content nouns but these latter, differently form the experimental trials, trigger feminine agreement although not belonging to declension Class I (e.g. *mano - mani* ‘hand - hands’ belonging to Class II -*o*/-*i*; *l’ipotesi – le ipotesi* ‘the.Fem.Sg hypothesis - the.Fem.Pl hypotheses’, invariable). Experimental and filler trials are summarised in Table (3).

Table 3: **Experimental and filler trials**

Trials			**Key to press**
Experimental	*Questo gatt-_*	'This cat-_'	O for Masc.Sg
Experimental	*Questi gatt-_*	'These cat-_'	I for Masc.Pl
Filler	*Quest-_ fantasma*	'This-_ ghost'	O for Masc.Sg
Filler	*Quest-_ cane*	'This-_ dog'	O for Masc.Sg
Filler	*Questa ipotes-_*	'This hypothesis-_'	I for Fem.Sg
Filler	*Queste nav-_*	'These ship-_'	I for Fem.Pl

2.4 Data analysis

Data were analysed by means of the R software for statistical analysis (R core team 2014). We used generalized linear mixed models (Baayen, Davidson & Bates 2008) to investigate the influence of the type of the stimuli as well as other variables such as frequency on the response times and on the accuracy with which participants completed the task. We fitted two models, one for RTs (Model 1) and one for accuracy (Model 2; see §3 for more details on the two models), in which *Absolute frequency*, *Type* (ANIM_G, ANIM_I, INANIM), *Animacy* (animate, inanimate), *Number* (singular, plural) and the interactions *Type* x *Number* and *Animacy* x *Number* were added as fixed effects.

3 Results

As a convention, response times shorter than 200 msec and longer than 2000 msec were discarded. Trials involving inanimate nouns with implausible plurals (e.g. mass nouns) were not considered in the analysis. Rough means on response times (RTs) are reported in Table (4) and the result of the corresponding model are summarised in Table (5). The analysis revealed a main effects of *Frequency* (the more frequent a noun the faster it was completed), *Number* (singulars were completed faster than plurals) and *Animacy* (animates were completed faster than inanimates). We observed also the interaction *Number* x *Animacy* (inanimate plural nouns were completed slower), but no *Type* effect.

Table 4: **Mean response times (RTs)**
The standard deviations (SDs) are given in brackets.

	Singular	Plural
Animate	1054.939 (387.334)	1093.049 (394.009)
Inanimate	1078.532 (402.985)	1210.722 (474.919)

Table 5: Summary of Model 1 (RTs)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	1105.5470	32.54351	2623	33.97135	0.0000
Frequency	-0.0011	0.00022	2262	-4.97362	0.0000 *
Animacy_inanimate	108.9177	15.36830	2623	7.08717	0.0000 *
Number_Sg	-42.8439	14.65413	2262	-2.92368	0.0035 *
Animacy_inanimate x Number_Sg	-84.1292	20.70054	2262	-4.06411	0.0000 *

Rough means on accuracy[4] are reported in Table (6) and the results of the corresponding model are summarised in Table (7) and plotted in Figure (1). The analysis revealed no effect of *Frequency*, but a main effect of *Type*: ANIM_G trials were completed more accurately than both ANIM_I and INANIM ones. No main effect of *Number* was found, nevertheless the interaction *Type* x *Number* reached significance: singular ANIM_I trials were completed more accurately than plural ANIM_I and the same trend was observed for INANIM trials. Conversely, no difference between singular and plural trials was found in the ANIM_G condition.

[4] Given the task explained in §2.3, accuracy errors consisted in pressing the wrong key to insert the final inflectional morpheme. They were made every time the O key (instead of the I key) was pressed to complete phrases such as *questi gatt-* 'these cats' and every time the I key (instead of the O key) was pressed to complete phrases such as *questo gatt-* 'this cat'.

Table 6: Mean accuracy
The standard deviations (SDs) are given in brackets.

	Singular	Plural
ANIM_G	0.952 (0.213)	0.957 (0.202)
ANIM_I	0.958 (0.2)	0.908 (0.289)
INANIM	0.958 (0.199)	0.933 (0.249)

Table 7: Summary of Model 2 (accuracy)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.9552212	0.012132315	1968	78.73363	0.0000
TypeAnim_i	-0.0488176	0.012341895	1968	-3.95544	0.0001*
TypeInanim	-0.0241507	0.012146503	1968	-1.98828	0.0469*
TypeAnim_i x NumberSg	0.0556736	0.017424384	1957	3.19515	0.0014*
TypeInanim x NumberSg	0.0304845	0.017188911	1957	1.77350	0.0763

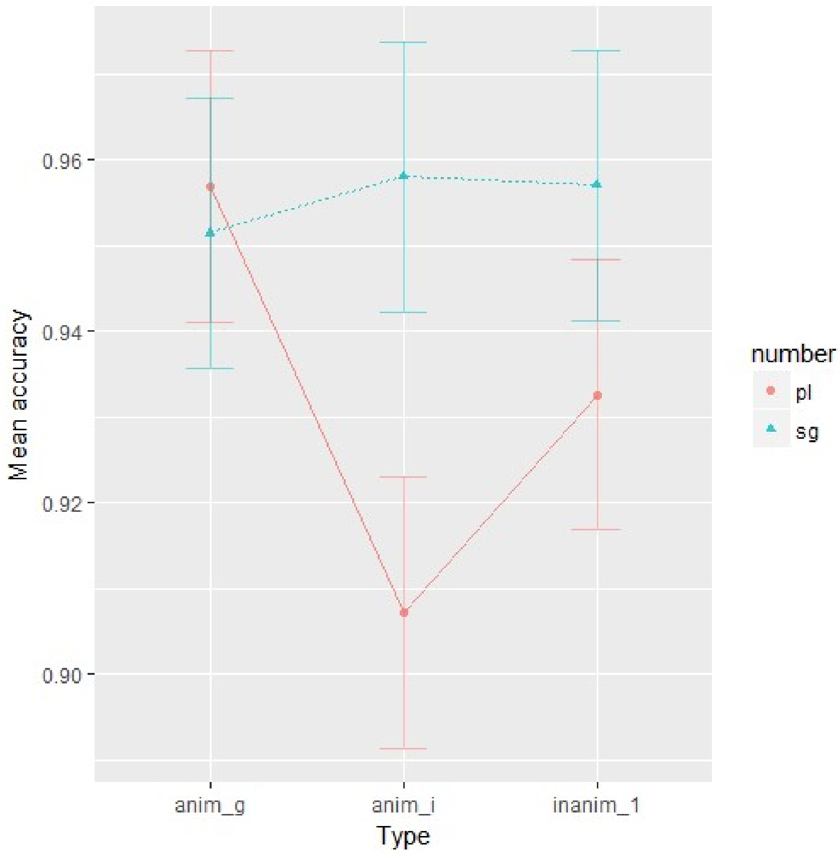

Figure 1: **Accuracy in the completion of ANIM_G, ANIM_I and INANIM trials**

4 Discussion

We designed an experimental task to observe whether it was easier to inflect for Number nouns denoting animate referents than nouns denoting inanimate referents. To this purpose, young adult Italian speakers were asked to complete as fast and as accurately as possible a set of nouns lacking the inflectional morpheme. Our working hypotheses, summarised in (2, §1.1) and repeated here in (3), concerned not only the interaction between Number and animacy (3a), but also the interaction between Number and the semantic interpretability of Gender as related to animacy (3b). We predicted that the primacy of animacy in Number inflection could involve either all nouns denoting animate referents irrespective of the semantic interpretability of their Gender (3a) or only those nouns denoting animate referents and with an interpretable Gender (3b).

(3)	a.	ANIM_G (*gatto*), ANIM_I (*topo*)	>	INANIM (*sasso*)
	b.	ANIM_G (*gatto*)	>	ANIM_I (*topo*), INANIM (*sasso*)

Results show two different patterns with respect to the type of the investigated dependent variable: RTs or accuracy. First of all, in both cases, we did observe an effect of animacy, thus providing evidence in favour of the idea that assign the Number value on nouns denoting animate referents is an easier task (at least for young adult Italian speakers). However, while an overall effect of animacy matching the scenario in (3a) emerged when considering the RTs, an effect related to the interpretability of animacy in accordance with scenario in (3b) better explained participants' performance on accuracy. Moreover, frequency and Number significantly predicted the RTs, consistently with findings across the psycholinguistic literature. Intriguingly, though, these predictors lacked significance when examining accuracy.

On the one hand it is not surprising that different effects can be traced back to different variables, on the other hand such differences need an explanation. Here, we tentatively suggest that the pattern exemplified in (3a) may resemble a general inter-linguistic effect. In other words, the results obtained for the RTs can be explained assuming some primacy of animacy in assigning morphological Number values, irrespective of the interpretability of Gender values and, thus, irrespective of whether the inflectional paradigm is semantically transparent in relation to Gender. Taking this reasoning to the extreme, it may be hypothesised that it is easier (e.g. faster) to assign the Number value on nouns denoting animate referents regardless of how morphological Gender shapes or does not shape a Number paradigm and thus independently from the language at issue. Conversely, results on accuracy seem to be more sensitive to the way a Number paradigm is shaped. In this latter case, the performance cannot be explained as an effect of animacy alone since it seems easier (e.g. more effortless in terms of precision) to assign the Number value on nouns when the inflectional morpheme is interpretable with respect to a semantic feature related to animacy, as sketched in (3b). This effect depends on how a particular paradigm is built and on the interpretability of the morphological values; thus, it may be a Gender-related and language-specific effect.

It could be objected that the semantic interpretability of Gender is not accountable for the pattern we found as nouns of the category ANIM_G vary semantically less than those of the category ANIM_I (see Note 3, §2.3). Since the former mainly refer to humans while the latter refer both to humans and animals, it could be that our results reflect more a human vs. non-human distinction rather than a more general interpretable vs. uninterpretable Gender difference. First of all, since nouns denoting human referents are included in both categories, a difference between these latter should be unexpected. Yet, since a significant difference between the two categories both including human referents is observed, it can be argued that this pattern is more likely to reflect an interpretable vs. uninterpretable Gender distinction. Secondly, it must be remarked that our experimental stimuli categorisation was conducted using quantitative methodologies and thus may genuinely reflect a general language property, namely the fact that nouns occurring equally in the masculine and in the feminine (and thus having interpretable gender) are more likely to denote human referents. Indeed, features linked to human references are set in the top segments of the animacy hierarchy and are the more liable to shape morphological systems (Corbett 1991; Matasović 2004). Since Gender interpretability and human reference seem to covary arguing that our results reflect a human vs. non-human distinction is not challenging with respect to the tentative interpretation we gave. In fact, semantic interpretability of morphemes may speed up linguistic processing – and thus verbal communication – especially when morphological paradigms encode cognitively salient information (such as numerosity, animacy, relatedness to humans).

If we are on the right track in interpreting our findings, new light can be shed on the relationship between numerical cognition, morphological Number and linguistic diversity. On the one hand, our results suggest that numerical cognition is mirrored in the morphological processing of Number by highlighting some parallelism between the primacy of animacy in counting and the primacy of animacy in inflecting nouns for morphological Number. This interpretation is in accordance with those hypotheses claiming that the foundations of language lay on core cognition rather than the other way round, along the lines explored by recent frameworks on biology and language evolution (for a review see Corballis 2017; for a different perspective see also Everaert et al. 2017; Everett 2017; Overmann 2015). Here, we suggest that cognition seems to design morphology, Number morphology in particular, to quickly express information that is salient from a biological point of view such as numerosity (especially when this latter is related to animate referents). In this regard, it is trivial recalling here that, by definition, a morphological paradigm entails an opposition of at least two values; in other words, Number morphology systematically encodes different numerosities onto different values. Precisely, as the exponents of these values are mostly phonologically short and are mostly mandatorily expressed (Dressler 1989), they can convey information about numerosity systematically and thus efficiently. In addition, since number as a real-world category is inherently structured, learning theory predicts that morphological Number hierarchy as reported in linguistic typology should emerge naturally and universally in language, as a consequence of reflecting these real-life contingencies (Malouf, Ackerman & Seyfarth 2015).

On the other hand, it is undeniable that, to some extent, natural languages are different from each other and that differences are related also to grammar and (Number) morphology and not only to the lexicon. What are the sources of linguistic diversity if cognitive constraints are the same for every language and every speaker? While linguistic typology traditionally had a main focus on language universals (Greenberg 1963; Comrie 1981), the emphasis has been now shifted on linguistic diversity as a basic property of human language (Evans & Levinson 2009). Tracing the origins of language variation and change transcends the purposes of this paper; yet, our results suggest that cross-linguistic divergences may lie at the root of genuinely linguistic, paradigmatic issues rather than in core cognition issues dealing with how speakers conceive the surrounding world. Ultimately, if it is true that core cognition seems to cross-linguistically constrain what information can be encoded onto morphological values, it is also true that morphology works autonomously as for the way such information can be encoded and structured in different paradigms.

5 Conclusions and future directions

In this paper we explored the idea that morphological processing mirrors core cognitive processing, by addressing the relationship between numerical cognition, Number morphology, and animacy. Indeed, we found that the primacy of animacy in counting seems to have a counterpart in morphological processing, suggesting that (Number) morphology is designed to easily express information that is salient from a biological point of view. Our results consistently pointed to some primacy of animacy in assigning Number values; however, they must be partially traced back to language-specific effects. In particular, the following questions must be tackled by testing other languages with different Number paradigms: can animacy effects be replicated in other Number paradigms either with transparent or non-transparent Gender inflection? Can similar effects be found for other features that are encoded in morphology? Are those features salient from a cognitive point of view?

For example, in Bulgarian, animacy does not affect the declensional system. However, semantic features related to sex do: in the masculine plural, the nouns that do not denote male human referents have a special Number form (count plural). Similarly, in the complex declension system of Polish, masculine plural nouns denoting male humans are inflected differently from all other masculine plural nouns. These observations may lead to a broader question that has not directly been tackled in this study, and that can however benefit from some observation about the effects of some structural properties of languages. Natural languages, and especially morphology, do not encode all the information present in a referential entity, but just a part of it. This reduction of information may be very drastic, to the point of encoding into binary oppositions some features that are far more complex or fuzzy. For example, Number morphology most frequently surfaces as the binary opposition ‘one’(singular) vs. ‘different from one’(plural), but the numerosities that can be perceived and conceived are more diverse than that, as shown in the Introduction (§1). An effect of this reduction of complexity is a more economic communication of some types of information, namely the ones that have likely been salient at some point of our evolutionary life. However, the role of morphology, and especially of inflection, is also functional, because it provides the agreement features that are required to build relations between words, in order to create larger syntactic units. Thus, the presence of morphology in a sentence can sometimes be requested only for functional purposes. Since it is not always possible to assign to a morpheme a value based on a referential property, a morpheme of the inflectional paradigm can be available as a default to perform functional-only operations. When a morpheme is used as a default, it is, in principle, not interpretable at the semantic level. For example, in Number morphology the singular is the most often used value when it is not possible to refer to a referential numerosity, as in the case of mass nouns, whereas other values in Number paradigms are more likely to be semantically interpretable with respect to the numerosity they denote (Franzon et al. 2018; Zanini et al. 2018; Arcara et al., 2018).

In languages like Italian, the default value for animate nouns with interpretable gender is the masculine, which is also the value used to encode a male referent. The clash of interpretability between the formal value and its semantic content seems to be the origin of the idea that some linguistic systems do not seem to match the requirements called for male and female equality, as emerged from the current debate about the “gender fairness” of language. On the one hand grammatical Gender and declensional classes are abstract formalisations, and their role in the sentence is functional. On the other hand, these grammatical features encode a meaning that speakers are still able to recall as so strictly linked to the referential world to force the interpretability of the morpheme also at the semantic level. In this sense, potentially, the grammatical Gender of every Italian animate noun could be interpretable and, potentially, the masculine and the feminine form of every Italian animate noun could be derived. Nevertheless, while some possibilities are established, others are not attested at all, and few others may lead to change of the Italian system. In fact, declension systems can, to a certain extent, reflect cultural aspects of the community of speakers (Social gender in the sense of Aikhenvald 2012; see also Corbett 1991). Even if, in our opinion, the linguistic choice of a default value is mostly explainable by principles of information optimization, the issue has a practical side, which is more pertinent to the domain of sociolinguistics than to morphology, though. Debate on the non-sexist usage of language is very heated in present-day Italy and the guidelines for non-sexist usage of the Italian language insist on respecting a one-to-one correspondence between the grammatical Gender and the sex of the human referent encouraging the use of innovative forms such as *sindaca* 'mayor-Fem.Sg' (compared to the corresponding well attested *sindaco* 'mayor-Masc.Sg') on the basis of established pairs such as *maestro – maestra* 'teacher-Masc.Sg – teacher-Fem.Sg' (Cancelleria Federale 2012; Robustelli 2014; Sabatini 1987; Thornton 2004; 2016).

The fact that issues like the one illustrated above inflame the current debates and may lead to language change reflects the salience of some features over others in shaping morphological paradigms. Since Saussure (1916) it is out of question that linguistic signs are arbitrary functions between forms and meanings. Yet, morphology allows to explore a slightly different perspective: some meanings tend to find their way to be encoded more than others. Further studies on this topic can help us in figuring out whether *some* among these functions are less arbitrary and more salient than others and the role of the core cognition in mapping them.

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