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A group of researchers are testing pseudopartitives in Italian: Notional number is not the key to the facts

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The present paper focuses on pseudopartitive constructions headed by quantifier, collective, or container nouns (like *a lot of senators, a group of students, a bottle of pills*) followed by a singular or a plural verb. We compared these structures with superficially similar adnominal structures of the form $NP1_{[-PL]}$ *prep* $NP2_{[PL]}$ (e.g., *the level of the lakes is/are*) in Italian in an acceptability judgment study (Experiment 1), a forced-choice task (Experiment 2), and an eye tracking reading study (Experiment 3). Two major findings were consistent across all studies. First, verb agreement in pseudopartitives always patterned differently from controls. Second, albeit an overall preference for singular verbs was observed, a gradient difference emerged between adnominal controls and pseudopartitives, and among pseudopartitives headed by different nouns. We explain such variability in terms of the availability of a measure interpretation (e.g., pills *in the measure of a bottle* vs. a bottle *containing pills*) which is linked to the type of the pseudopartitive's head noun. While in non-pseudopartitive adnominal structures only one parse is allowed by the grammar, in pseudopartitives a given head noun may admit or block a structural configuration in which the plural feature of the embedded constituent (e.g., *of students*, modifying *a group*) can determine the plurality of the subsequent verb. We conclude that verb agreement in pseudopartitives is a grammatical phenomenon and, as such, it refers to speakers' grammatical competence and cannot be reduced to agreement attraction of the plural intervener.

1. Introduction

Since the pioneering work by Bock and Miller (1991), subject-verb agreement has been investigated in elicited production and comprehension tasks in different languages. Several mistakes in subject-verb agreement production have been attested, as well as pervasive cases of *illusions of grammaticality* in real-time language comprehension. These are exemplified by the key example in (1), which is classically referred to as *number attraction*: in these cases, a plural intervener ($NP_{[PL]}$) follows a singular noun phrase ($NP_{[-PL]}$) and the processing of the plural verb is not disrupted, despite the grammatical anomaly (Phillips et al., 2011).

(1) The key to the cabinets *is/are* rusty.

One way to account for agreement attraction phenomena is to distinguish between competence and performance. Since subject-verb agreement mismatch is ruled out by the grammar, agreement errors like the one exemplified in (1) are attributed to the processor, i.e., are explained in terms of the cognitive processes underlying sentence production or comprehension, or as the effect of interference in the retrieval process.

We focus here on a particular kind of $NP1_{[-PL]}$ *prep* $NP2_{[PL]}$ construction, *pseudopartitives*, exemplified in (2):

(2) A group of senators *is/are* voting against the impeachment.

Despite their superficial similarity with sentences like (1), these constructions are syntactically different and constitute an interesting testing ground for theories of agreement. In these constructions, the verb can agree either with the head (NP1) or the embedded noun (NP2), as has been attested within and across languages. For example, in Italian both singular and plural agreement are allowed by the grammar and attested in production, as shown in the Italian headlines in (3) and (4). In these sentences, the pseudopartitive construction *un milione di dosi* 'a million doses' (in which a singular head (*a million*) embeds a plural *of* constituent (lit: *of doses*)) agrees with a singular or plural verb.

(3) Vaccini, nelle prossime 24 ore *arriveranno* un milione di dosi alle regioni.[1]
Vaccines, in-the next 24 hours arrive.FUT.PL a million of doses to-the regions
'Vaccines, a million of doses will be delivered to the regions within the next 24 hours.'

(4) Nel Lazio *è stato somministrato* quasi un milione di dosi di vaccino.[2]
In Lazio is been inoculated.PST.SG almost one million of doses of vaccine
'In Lazio almost a million of doses of vaccine has been inoculated.'

[1] https://www.open.online/2021/03/22/covid-bollettino-vaccini-22-marzo/, last accessed March 23rd, 2021.
[2] https://www.agi.it/cronaca/news/2021-03-28/lazio-somministrato-quasi-un-milione-dosi-vaccino-11957780/, last accessed March 23rd, 2021.

As for crosslinguistic variation, in some languages (e.g., Russian, Polish) agreement in the plural has become grammaticalized (Franks, 1994); in others, this option seems to be blocked (for microvariation in Romance languages, cf. Lorusso & Franco, 2017).

These structures represent an interesting case for psycholinguistic models of agreement phenomena, and beyond, mainly for two related reasons. First, variability of agreement in pseudopartitives is a grammatical phenomenon and, as such, it refers to speakers' grammatical competence. Thus, it differs from classic agreement attraction phenomena, which represent errors made by the speakers during the production phase, possibly due to a flaw in their performance, or to interference effects in retrieval. Second, pseudopartitives offer more precise and testable predictions of a notion of plurality: this is formalized in terms of the availability of a given syntactic structure – as opposed to the most intuitive concept of *notional plurality* that has informed the debate about agreement attraction so far.

Before turning to our experimental studies (Sections 2 – 4), we provide an overview of some linguistic and psycholinguistic accounts of the relevant constructions (1.1 – 1.2) and a preview of our research questions and experimental findings (1.3).

1.1 Agreement attraction

A robust finding about agreement attraction is that number attraction is typically attraction to a plural, not a singular, noun: while agreement errors like (1) are attested, errors like (5) are less frequent.

(5) *The keys to the cabinet is rusty.

Furthermore, several studies report that the effect of a number attractor in production depends on its hierarchical (not linear) position in the syntactic representation of the sentence (Bock & Cutting, 1992; Vigliocco & Nicol, 1998). According to these findings, a plural noun in an embedded clause, like *books* in (6a), attracts less than a plural noun that is structurally closer to the verb, as in (6b). This happens even though the plural noun *books* in the two sentences is equally linearly adjacent to the verb, and even though the plural verb form is ungrammatical in both cases.

(6) a. The editor <u>who rejected the books</u> was/*were…
b. The editor <u>of the books</u> was/*were…

Other studies focus on the semantic number features of the attractor, testing the impact of notional number on agreement. For example, Humphreys and Bock (2005) used a sentence completion task to compare constructions like (7a), in which a collective interpretation of the noun *gang* was plausible, to constructions like (7b), in which only a distributive (and hence plural) interpretation was plausible. They report more plural verbs in completing (7b) than (7a) (see also Eberhard, 1997).

(7) a. The gang near the motorcycles was/were…
b. The gang on the motorcycles was/were…

Vigliocco (1996) also compared singular head nouns combined with plural modifiers that are typically denoting multiple tokens (e.g., *the label of the bottles*, which implies multiple labels) with similar head nouns more plausibly denoting a single entity (e.g., *the journey on the islands*, which implies one single journey). The former triggered more plural verb forms by Italian speakers compared to the latter, although no effects of distributivity were revealed in an eye tracking reading experiment on similar materials in Spanish (Acuña-Fariña et al., 2014).

From a psycholinguistic perspective, different accounts have been proposed to explain attraction effects in production and comprehension. Since Bock et al. (2001), notional plurality plays a key role in the "Marking and Morphing" model of sentence production (see also Eberhard et al., 2005). During the *marking* stage, a plural noun (like *cabinets* in (1)) might contribute to a bias towards the notional plurality of the head noun, making plural agreement (at the *morphing* stage) more likely. According to cue-based retrieval models (Lewis & Vasishth, 2005, see also Smith & Vasishth, 2020), in sentences like *The key to the cabinets are…*, the PL feature on the verb boosts the activation of the other nouns in the sentence that share this feature (i.e., *cabinets*), causing interference.

Recently, Smith et al. (2018) proposed a critical revision of the "Marking and Morphing" account (cf. also Smith et al., 2021; Villata & Franck, 2020; Villata & Tabor, 2022). The account proposed by Smith et al. (2018) is directly relevant for our purposes since it builds on pseudopartitives. Under it, variability in agreement in production and comprehension is accounted for as the result of a dynamic interplay between semantics and syntax in a *self-organized sentence processing* (SOSP) model. According to the SOSP model, there is no sequential separation between the *marking* stage (which refers to notional number) and the *morphing* stage (which refers to morphosyntactic agreement). Rather, the system dynamically builds treelets (i.e, small pieces of syntactic structure) during incremental processing, leaving space for grammar-flouting interference and local coherence effects (cf. also Hammerley et al., 2019, for an insightful discussion about competing theories of agreement attraction).

1.2 Pseudopartitives and agreement

Pseudopartitives do not really have a dedicated psycholinguistic literature. There is, on the other hand, a considerable tradition of studies on pseudopartitives in linguistics. First, these constructions are contrasted with *partitive* constructions. Partitive constructions (cf. (8a)) involve a quantifier (or a quantified expression) embedding a Determiner Phrase (DP, in this case, *the senators*) that represent the "whole" from which the head of the construct (in this case, *a group*) selects a part (Chierchia, 1998; Zamparelli, 2008). The embedded nominal in pseudopartitive

constructions like (8b) instead is a bare NP, which is "measured" by the DP (*a group (of)*) (Milner, 1978; Schwarzschild, 2006; Selkirk, 1977).

(8) a. A group of *the* senators voted against the impeachment.
b. A group of senators voted against the impeachment.

Second, following the seminal work of Selkirk (1977), agreement alternations in pseudopartitives, such as the one exemplified in (2), have been explained in terms of structural ambiguity, as represented in (9). In (9a), the second NP (*the senators*) is embedded as a modifier of the head noun (*a group*) by means of the preposition *of*. The verb agrees with the singular head of the DP as a whole (*a group*), while the plural feature remains within the embedded NP. In (9b), the embedded NP *senators* (case marked by *of*) is modified by *a group*, yielding an interpretation in which *senators* are "measured" by *a group*. In this case, the plural feature of the second NP percolates to the higher DP, triggering plural agreement on the verb (cf. also Manzini, 2019; Manzini & Franco, 2019).

(9) a. $[_{DP[sg]}$ a group $[_{PP}$ of $[_{NP[pl]}$ senators]]] *is*$_{[sg]}$ voting
b. $[_{DP[pl]}$ $[_{DP[sg]}$ a group] D $[_{NP[pl]}$ of $[_{NP}$ senators]]] *are*$_{[pl]}$ voting

Crucially, the adoption of one or the other syntactic analysis for these constructions also has interpretative consequences (Landman, 2004, 2016; Rothstein, 2009, 2017), which are exemplified in (10). In (10a) the only plausible interpretation is the *measure* one (chickpeas *in the measure of a can*), and both verbal agreements are available. In (10b) the only available interpretation is the *container* interpretation (a can is being referred to, as modified by its content, the chickpeas) which forces a singular verb.

(10) a. Un barattolo di ceci basta/bastano per l' hummus.
One can of chickpeas.PL suffices/suffice for the hummus
'A can of chickpeas is/are enough for the hummus.'

b. Un barattolo di ceci è/*sono nella credenza.
One can of chickpeas.PL is/*are in-the cupboard
'A can of chickpeas is/*are in the cupboard.'

According to Rett (2014, following Landman, 2004), the alternation of container/measure interpretations in pseudopartitives can be viewed as a case of genuine lexical ambiguity of the head nouns in pseudopartitives that trigger one of the two alternative syntactic constructions in (9). Based on two acceptability judgment studies of sentences with container-headed pseudopartitives modified by a relative clause, Duek and Brasoveanu (2015) show that both readings can be simultaneously available in the grammar.

Third, the extent to which the two alternative interpretations are available also depends on the type of head of the pseudopartitive. These are of different kinds: they can be quantificational

measure phrases like *a lot* in (11), collective nouns, implying numerosity, like *group* in (8b), or containers, implying volume, like *box* in (12).

(11) A *lot* of senators voted against the impeachment.

(12) A *box* of ballots got lost in the count.

In the already cited work, Smith et al. (2018) tested English participants in a forced-choice selection task (Staub, 2009) and found that the probability of choosing a plural verb after a pseudopartitive depended on the type of head, with more choices of plural forms after a quantifier head noun, and more selection of singular forms after a container head. In terms of the SOSP model, when processing a sentence like (8b), the morphosyntactic and semantic features of *group* (i.e., syntactically being a noun, morphologically being singular, and semantically having features "related to subjecthood versus quantifierhood") will contribute incrementally to determine the morphosyntactic agreement features of the verb. According to Smith et al., thus, what shapes the participants' agreement preferences in the case of pseudopartitives is the semantics of the head nouns, triggering plurality, beyond their singular morphosyntactic traits.

Mazzaggio et al. (2020, Experiment 1) also reported a difference in subject-verb agreement preferences across different types of pseudopartitives in an acceptability judgment task in Italian. Participants were more likely to accept a sentence with a plural verb when the pseudopartitive's head was a quantifier, compared to the case in which the head was a collective noun, which was most preferred with a singular verb. Moreover, variability in verb agreement preferences emerged across individuals. According to Mazzaggio et al. (2020), the observed agreement alternations in pseudopartitives, both between participants of the same language and across languages, are rooted in syntax as part of linguistic competence, and are traced back to the dual labeling options available for these constructions exemplified in (9). Specifically, the accessibility of the measure phrase reading (i.e., the interpretation in which the measure phrase modifies the lexical noun) is maximally available in the case of quantifiers.

1.3 Experimental questions and predictions

Agreement alternations in pseudopartitives and the phenomenon of agreement attraction introduced in 1.1 and 1.2 seem to share a number of properties. First, agreement attraction is typically attraction to the plural, not to the singular. Similarly, if a plural pseudopartitive head embeds a singular NP, the plural head obligatorily triggers plural agreement, as in (13):[3]

[3] A different question is what justifies the asymmetry just noted between pseudopartitives like (8b) and those like (13). The (standard) answer in linguistic theory is that plurality is a privative feature (Badecker & Kuminiak, 2007, p. 67, for a brief review). Thus singular is not [+SG], but rather absence of the plurality feature, as in the revision of (9b) in (i); this is to be contrasted with the structure in (ii) for the example in (13).

(13) Two cups of milk are/*is needed for this recipe.

Second, the acceptability of plural agreement in pseudopartitives depends on the type of head. Similarly, in agreement attraction, the semantics of the noun phrase (i.e., distributive, as in *the key to the cabinets*, vs. non-distributive, as in *the cage with the gorillas*) modulates the probability of the verb's agreeing with the embedded NP.

In the psycholinguistic literature on agreement attraction, *notional plurality* has been presented as the key factor to explain most of the observed alternations in production. The more the subject DP is perceived as a plural entity, the more likely it will be marked as plural in the marking stage, and thus plural agreement will surface at the morphing stage ("Marking and Morphing" model). As Smith and colleagues (2018) point out, notional plurality is a black box that relies on the intuitive notion of notional number carried by a certain noun or noun phrase. Previous works have measured the "degree" of plurality of a given construction employing questionnaires, thus providing a post hoc explanation of notional plurality effects. Testing pseudopartitive constructions, Smith et al. (2018, pp. 1058–59) provide a more formalized account of notional plurality based on three features, namely, +/− Container, +/− Spatial configuration, and +/− Abstract N2, "placing subject NPs along the semantic feature cline related to subjecthood versus quantifierhood".

Yet, some facts remain without explanation in accounts of agreement in terms of notional plurality. In the first place, cross-linguistic differences need to be considered. While some languages display some variability in subject-verb agreement in the case of collective nouns like *police*, as attested by English (14a), this is not true for all languages. For example, Italian rules out plural subject-verb agreement when the subject is a singular collective noun, as shown in (14b), which is the Italian translation of (14a). In other words, if notional number is invoked (in any form) in Italian, one needs to explain why there is no independent evidence for it in the case of notionally plural and morphologically singular collective nouns.

(14) a. The police has/have interviewed the suspect.
b. La polizia ha/*hanno interrogato il sospettato.

(i) $[_{DP[PL]}\ [_{DP}$ a group] $D_{[PL]}$ $[_{NP[PL]}$ of $[_{NP[PL]}$ senators]]] $are_{[PL]}$ …
(ii) $[_{DP[PL]}\ [_{DP[PL]}$ two cups] $D_{[PL]}$ $[_{NP}$ of $[_{NP}$ milk]]] $are_{[PL]}$ …

In (i), the [PL] property of *senators* is part of the label of the embedded NP and of the DP as a whole – and $DP_{[PL]}$ in turn determines plural agreement with the verb. By contrast, in (ii), the measure phrase *two cups* has a [PL] feature. The latter causes [PL] to become part of the DP label, $DP_{[PL]}$ ultimately determining plural agreement with the verb. Mazzaggio et al. (2020) attribute the obligatoriness of this derivation to a maximization constraint – whereby the computational procedure seeks to maximize (optimize) operations of labelling; see also their discussion of possible formal alternatives.

Another issue concerning the explanation based on notional number ensues from the fact that in languages like Italian, variability is attested even with respect to subject-verb *gender* agreement. This is shown in (15), reported by Mazzaggio et al. (2020, Experiment 2), and in examples like (16a – b),[4] which again come from local newspapers.

(15) Un pizzico di farina è finito/finita nell' impasto.
One pinch.M of flour.F is ended-up.PST.M/F in-the dough
'A pinch of flour ended up in the dough.'

(16) a. Vaccini Emilia-Romagna, *superate* un milione di dosi
Vaccines Emilia-Romagna, exceeded.F.PL one million.M.SG of doses.F.PL
somministrate.[5]
inoculated.F.PL

b. Vaccini: in Emilia-Romagna *superato* un milione di dosi
Vaccines: in Emilia-Romagna exceeded.M.SG one million.M.SG of doses.F.PL
somministrate.[6]
inoculated.F.PL
'In Emilia-Romagna, the doses of vaccine inoculated exceed one million.'

If plural number has an obvious semantic content, it is generally assumed that gender carries no genuine semantic traits in most of the nouns in languages with grammatical gender (Vigliocco & Franck, 1999; Vigliocco et al., 1995). Nonetheless, variability in gender agreement is attested in Italian and in other gender-marked languages (cf. Acuña-Fariña et al., 2014, for Spanish; Slioussar & Malko, 2016, for Russian; Tucker et al., 2021, for Arabic).

In this study, we compare structurally ambiguous pseudopartitives in Italian with superficially similar constructions of the form $NP1_{[-PL]}$ *prep* $NP2_{[PL]}$ that only allow a single grammatical parse. Our first experimental question is whether agreement in pseudopartitives behaves differently from subject-verb agreement in classic $NP1_{[-PL]}$ *prep* $NP2_{[PL]}$ configurations like *The key*$_{[-PL]}$ *to the*

[4] As pointed out by an anonymous reviewer, it is not the case that any crossing of number and gender is possible in (16). Thus the perfect particle 'exceeded' cannot display singular feminine agreement (i) nor plural masculine agreement (ii). In other words, *bona fide* grammatical agreement with N1 vs. N2 is involved in (16), as opposed to some random phenomenon of percolation of notional plurality.

(i) *superata un milione di dosi
exceeded.F.SG one million.M.SG of doses.F.PL

(ii) *superati un milione di dosi
exceeded.M.PL one million.M.SG of doses.F.PL

[5] https://bologna.repubblica.it/cronaca/2021/04/07/news/vaccini_emilia-romagna_raggiunta_la_milionesima_dose-295429862/, last accessed April 8th, 2021.

[6] https://www.ansa.it/emiliaromagna/notizie/2021/04/07/vaccini-in-e-r-superato-un-milione-di-dosi-somministrate_e362f9f2-4663-47dc-a5cc-897be82c5d91.html, last accessed April 8th, 2021.

cabinets$_{[PL]}$. Despite the surface similarities between these two structures, only one grammatical option (i.e., singular agreement) is allowed by the grammar in the latter case, albeit plural verb agreement might result in speakers' performance from interference effects of the plural attractor. On the contrary, variability in agreement in pseudopartitives is dictated by the availability of two possible parses in the grammar, as seen in (9), thus reflecting speakers' competence. Interestingly, Smith et al. (2018, p. 1068) recognize that "in classical cases" of agreement attraction "there is only one major syntactic structure at play, while in pseudopartitives, there are two". Yet their study does not extend to an experimental comparison between the two. We hypothesize a gradient difference in the acceptability of plural verbs between adnominal controls headed by a singular noun and pseudopartitives, and among pseudopartitives headed by different nouns.

To test this hypothesis, in all the experiments, we compare pseudopartitive constructions to control sentences in which a singular head with a plural modifier is followed by either a singular or a plural verb, as exemplified in (17).

(17) Inesorabilmente, il livello dei laghi si è abbassato/*sono abbassati moltissimo.
Inexorably, the level of-the lakes self is lowered.SG/*are lowered.PL a-lot.
'The level of the lakes inexorably lowered a lot.'

Note that agreement attraction phenomena are not investigated *per se*, but only insofar as they provide a control for the pseudopartitive data, establishing that agreement in pseudopartitives reflects grammatical competence as opposed to a mere processing bias.

A second major comparison carried out in the present study involves the variability in agreement preferences across different kinds of pseudopartitives. Considering the two alternative parses of pseudopartitive constructions, detailed in (9), we ask whether the acceptability of singular or plural verb varies depending on the type of the pseudopartitive's head. As we have discussed, the head determines the accessibility of a measure phrase interpretation as opposed to a container interpretation, as shown in (10a – b). Concerning this question, we compare pseudopartitives introduced by a quantifier, a collective, or a container head followed by a singular/plural verb. We predict the highest compatibility of plural verbs in the case of quantifier heads, and the lowest compatibility in the case of container heads, both in production and comprehension.

To test our two research questions, we carried out three experiments testing Italian speakers' preferences in offline and online tasks, in comprehension, production, and reading.

In Experiment 1, we tested Italian speakers' acceptability of pseudopartitives and surface-similar constructions followed by singular or plural verbs. In Experiment 2, we tested participants' preferences for singular/plural verb after the above-mentioned constructions in a forced-choice task that mimics production. In Experiment 3, we recorded participants' eye movements in reading to gather evidence for local disruption during online sentence processing, if any. In line with previous findings on coordinated subjects (Foppolo & Staub, 2020; Keung & Staub,

2018), we predicted a different pattern of eye gaze during the online processing of putatively ungrammatical sentences, in which the verb erroneously agrees with the intervening noun (as in (17)), as compared to pseudopartitive constructions in which variability within and between subjects and items has been documented, and is rooted in the grammar.

2. Experiment 1: An acceptability judgment task

Experiment 1 is an acceptability judgment study. Its aim is to assess whether, in offline judgments, Italian speakers show a preference for the verb to agree with the singular head or the plural embedded noun by comparing classic adnominal and pseudopartitive constructions. The experiment also tests if a difference emerges among different types of pseudopartitives.

2.1 Methods

2.1.1 Participants

Forty-six Italian monolingual speakers living in Italy participated in this study. All were university students at the University of Milan-Bicocca and received course credits for participation. One additional subject was excluded because they declared themselves to be bilingual.

2.1.2 Procedure

The experiment was implemented on the Ibex Farm platform (Drummond, 2013), and it was administered in one of the laboratories in the Psychology Department at the University of Milan-Bicocca. Participants were asked for their acceptability judgments of Italian sentences on a 7-point Likert scale, with 1 representing completely unacceptable and 7 representing fully acceptable sentences. Participants were instructed to judge the sentences based on their experience as speakers of Italian, not based on prescriptive norms taught in schools. Sentences remained visible on the screen until participants selected their response using the corresponding number key on the keyboard. Six practice items were given at the beginning to familiarize them with the task.

2.1.3 Materials

The experiment comprised a total of 60 experimental items involving pseudopartitive constructions like those in (18 – 20). These varied with respect to the type of head: 20 involved a container noun, like *scatola* ‘box’, as in (18); 20 items involved a collective noun, like *corteo* ‘procession’, as in (19); 20 involved a quantifier measure phrase like *un centinaio* ‘a hundred’, as in (20). All the nouns used as the head of the pseudopartitive were singular and were modified by a plural noun. In addition, we tested 30 sentences involving a singular noun followed by a plural modifier (e.g., *il livello dei laghi* ‘the level of the lakes’, as in (17)) and 30 additional control sentences involving a plural noun followed by a singular modifier (e.g., *i piloti dell’aereo* ‘the pilots of the aircraft’).

Two versions of each sentence were created, one with a singular and one with a plural verb; these were rotated between two lists, so that each participant saw only one version of the same item, for a total of 120 items. Participants were randomly assigned to one of the two lists. A full list of sentences is provided at https://osf.io/jxnsh/?view_only=a4fe2b97f89a4a409bdfe896943fee33.

(18) Secondo il medico legale, *una scatola* di cioccolatini ha/hanno avvelenato
According-to the coroner, a box of chocolates has/have poisoned
la vittima.
the victim
'According to the coroner, a box of chocolates has/have poisoned the victim.'

(19) Coraggiosamente, *un corteo* di manifestanti ha/hanno affrontato la polizia.
Courageously, a procession of protesters has/have confronted the police
'Courageously, a procession of protesters has/have confronted the police.'

(20) Dopo il voto, *un centinaio* di senatori si è dimesso/sono dimessi
After the elections, a hundred of senators self is resigned.SG/are resigned.PL
per protesta.
in protest
'After the elections, a hundred of (the) senators has/have resigned in protest.'

2.2 Results

Figure 1 shows the ratings' distribution for each type of sentence, split by type of head and verb number. In control (singular, plural) conditions, the ratings are as expected: below 2 when a plural verb follows a singular subject, and when a singular verb follows a plural subject; above 6 when a plural verb follows a plural subject, and when a singular verb follows a singular subject. The presence of a plural or singular intervener between the sentential subject and the verb does not modulate this effect. In the case of pseudopartitives, singular agreement is overall preferred to plural agreement, especially when the head is a container or a collective noun (**Figure 1**, left panel). Interestingly, however, the ratings when a plural verb follows a pseudopartitive construction are more variable and not so low (**Figure 1**, right panel). As is evident in the graph, the ratings when the verb is plural vary depending on the type of head, ranging from the lowest rating when the head is a container noun ($M = 2.58$, $SD = 1.12$, $Median = 2$) to middle-scale ratings when the head is a quantifier noun ($M = 4.67$, $SD = 1.28$, $Median = 5$), with collective nouns lying in between ($M = 3.53$, $SD = 1.03$, $Median = 3$).

By inspecting subjects' mean distribution of ratings (**Figure 2**), an interesting variability across participants is revealed in pseudopartitives followed by a plural verb, compared to a singular verb. This is most evident in the case of quantifier head nouns: when these are followed by a plural verb, peaks in the distribution are attested around grades 4 and 6 in the scale.

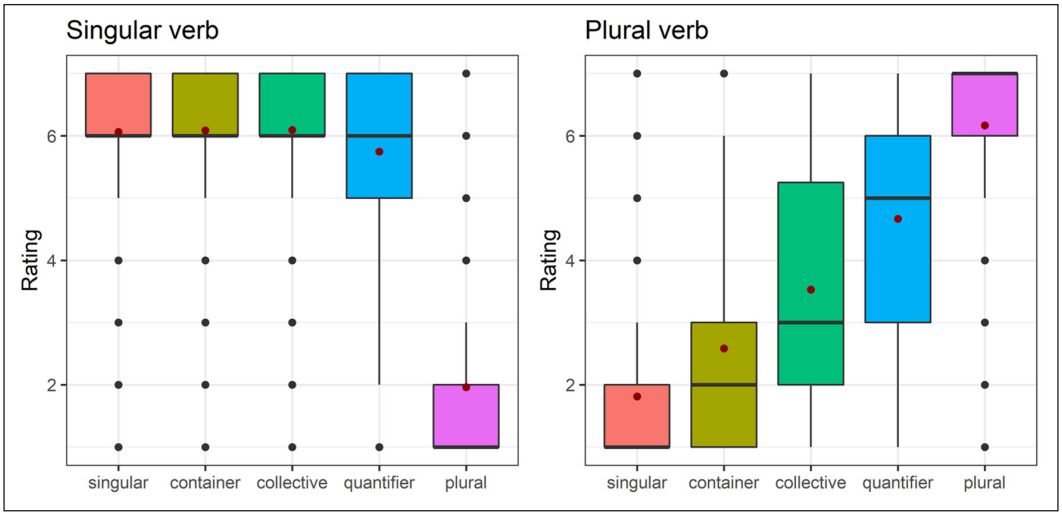

Figure 1: Ratings' distributions as a function of verb number (left panel: singular verb; right panel: plural verb) and head type (from left: singular controls; pseudopartitives with container, collective, and quantifier heads; plural controls). The red dot represents the mean judgments in each condition.

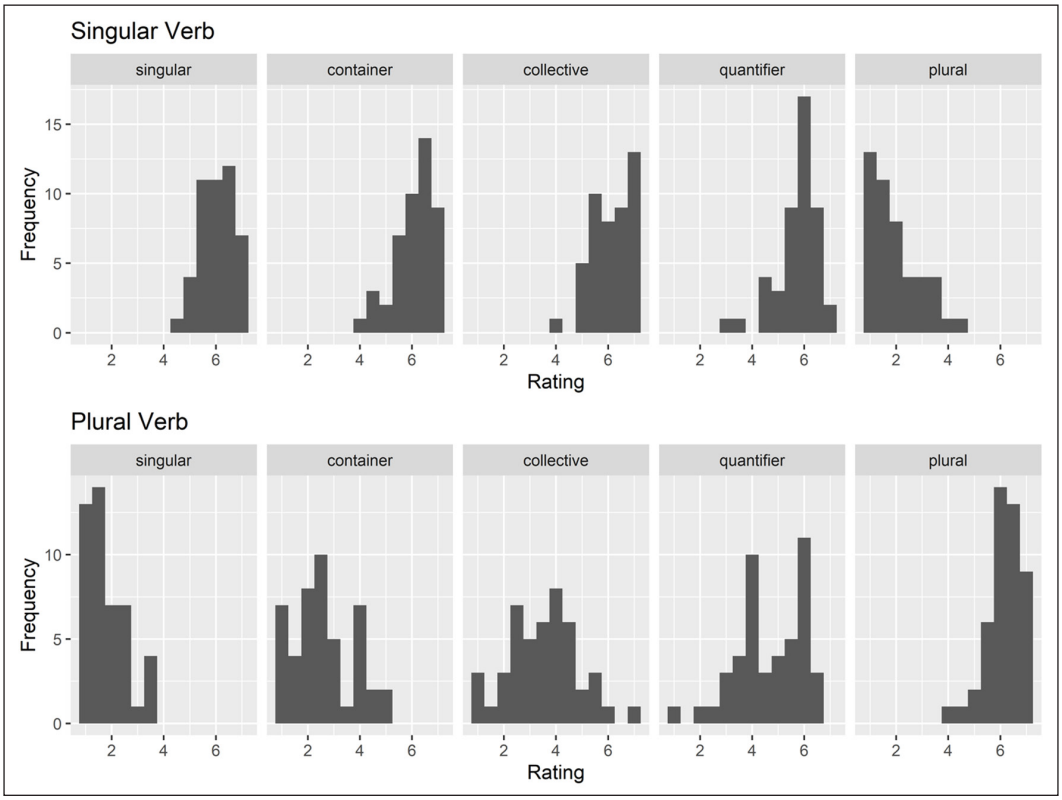

Figure 2: Distributions of participants' average ratings depending on number agreement on the verb (top row: singular verb; bottom row: plural verb), and head type.

We implemented two mixed-effects ordinal regression models with a logit link function, using the *clmm* () function in the *ordinal* package (Christensen, 2018), which is the most suitable to treat ratings that cannot be assumed to represent equally spaced points in an interval scale. We focused on the contrast between singular/plural verbs following singular controls and the different types of pseudopartitives, thus excluding plural controls from the analyses. This choice was made in consideration of the fact that pseudopartitive constructions superficially resemble singular controls: in both constructions, a singular head noun is modified by a plural noun, and then followed by a putatively grammatical singular verb or a putatively ungrammatical plural verb. In a first model, we modeled Ratings as a function of Condition (contrasting pseudopartitives and singular controls, coded as -0.5 and $+0.5$, respectively) and Verb Number (contrasting plural and singular verbs, coded as -0.5 and $+0.5$, respectively), also considering the interaction of these factors. We also included random intercepts for participants and items (including random slopes resulted in a failure of convergence). A general significant difference is revealed between pseudopartitives and controls (Est. $= -0.9662$, Std. Err. $= 0.1237$, z-value $= -7.808$, $p < .0001$), and a significant preference for singular compared to plural verbs (Est. $= 3.7082$, Std. Err. $= 0.0835$, z-value $= 44.410$, $p < .0001$). Furthermore, a significant interaction of Condition and Verb Number emerged (Est. $= 2.1014$, Std.Err. $= 0.1304$, z-value $= 16.112$, $p < .001$): the acceptance rate of plural verbs is higher in pseudopartitives ($M = 3.59$, $SD = 1.09$) than in singular controls ($M = 1.81$, $SD = 0.75$), while singular verbs are overall accepted across conditions ($M = 5.98$, $SD = 0.67$ for pseudopartitives; $M = 6.06$, $SD = 0.64$ for singular controls).

In a second model, we set a backward difference coding schema for factor variables with 4 levels (in our case: singular, container, collective, quantifier), assuming sliding differences from level 1 (singular controls) to level 4 (quantifier-headed pseudopartitives) in their compatibility with a plural verb. This coding schema is summarized in **Table 1** and was applied to all experiments.

Table 1: Contrast set for Head nouns for statistical analyses across different experiments by applying the function *contr.sdif(4)*.

HEAD	**1st contrast L1 vs. L2**	**2nd contrast L3 vs. L2**	**3rd contrast L4 vs. L3**
Singular (L1)	−0.75	−0.5	−0.25
Container (L2)	0.25	−0.5	−0.25
Collective (L3)	0.25	0.5	−0.25
Quantifier (L4)	0.25	0.5	0.75

The second model included Ratings as the dependent variable, Head Type and Verb Number as independent variables (in the contrasts defined above), Head Type by Verb Number interaction, random intercepts for participants and items, and random slopes for participants (including

random slope for items resulted in convergence failure). All contrasts and interactions are fully significant and are summarized in **Table 2**.

Table 2: Output of cumulative link mixed model of Experiment 1 with acceptability Ratings as the dependent variable, Head Type and Verb Number and their interaction as predictors, participants and items as random intercepts, and participants' random slopes. Contrasts as defined in Table 1.

	Estimate	**Std. Error**	**z value**	**p value**
1st contrast	0.5620	0.1467	3.830	**0.0001**
2nd contrast	0.5572	0.1639	3.399	**0.0007**
3rd contrast	0.3819	0.1546	2.471	**0.0135**
Verb	3.3423	0.0789	42.351	$<$ **0.0001**
1st contrast:Verb	-0.9429	0.1665	-5.663	$<$ **0.0001**
2nd contrast:Verb	-0.9812	0.1798	-5.458	$<$ **0.0001**
3rd contrast:Verb	-1.7477	0.1801	-9.706	$<$ **0.0001**

These results show that the preference for singular over plural verbs (i.e., the distance in acceptability scores for plural vs. singular verbs) is significantly reduced for quantifier head nouns, and it is maximal for singular controls, with significant (and graded) differences from singular to container heads, from container heads to collectives and from collectives to quantifier heads.

2.3 Discussion

This first study returned two main findings. First, pseudopartitive constructions, in which a measurement relation links the singular head with the plural (measured) noun, pattern differently from other constructions in which a singular head noun (such as *the level*) is modified by a plural intervener (such as *of the lakes*). In the latter case, the presence of a plural intervener between the subject and the verb does not affect the preference for the singular verb (which is the only grammatical option) and, most importantly, does not alter the acceptability of a plural verb, which remains extremely low overall. In the case of pseudopartitives, instead, although singular agreement is overall preferred over plural agreement, the ratings when a plural verb follows a pseudopartitive construction are less degraded than the singular head controls.

Second, also in line with previous findings, a gradient difference is observed across pseudopartitives depending on the type of head.

These facts speak to the experimental questions outlined above: (i) beyond surface similarities, pseudopartitives are more subject to variability in preferences with respect to other constructions

that are superficially similar but do not involve a measure phrase construction and for which strict rules of subject-verb agreement apply; (ii) the acceptability of pseudopartitives followed by plural verbs does not seem to depend on notional plurality *per se*, as all these constructions are notionally plural in terms of the set they denote. Instead, the variability in participants' judgments seems to depend on the semantic features of the head noun of the pseudopartitive construction (cf. Smith et al., 2018): in the case of container and collective heads, a clear preference emerges for singular verb forms, and this is greater for container heads; this preference is significantly reduced in the case of quantifier headed nouns. Moreover, the acceptance rate of plural verbs gradually increases from singular controls (for which plural verbs are ungrammatical), to containers (for which it remains low), to collectives (for which it improves), to quantifiers (for which the plural verb is not perceived as much degraded, with mean judgments above 4.5).

3. Experiment 2: A forced-choice task

Experiment 2 employs the same material as Experiment 1 adapted to a forced-choice task, which has been claimed to mimic production and has been previously used to test agreement (Smith et al., 2018; Staub, 2009). The aim is to assess the preference of Italian speakers in the selection of a singular/plural verb following the same structures tested in Experiment 1. The task also records participants' RTs during their choice, providing a measure of any source of alleged computational difficulty and/or competition/integration effects during the process of verb selection.

3.1 Methods

3.1.1 Participants

Another group of 54 Italian university students participated in this study and received course credits for participation.

3.1.2 Procedure

The experiment was implemented in PsychoPy3 (https://www.psychopy.org/) and administered online through Pavlovia (https://pavlovia.org/).

3.1.3 Materials

The experiment comprised a total of 168 items: of these, 60 were the same pseudopartitive constructions used in Experiment 1, and 40 were a subset of the singular/plural controls used in the same experiment. An additional set of 68 fillers was added to counterbalance singular and plural verb choices. The fillers were sentences involving universal and existential quantifiers, and conjunctions, and were part of a separate study.

To better control for verb length, and to have a unique word in the verb region, all the verbs were turned into simple future, simple past, imperfective, or simple present tense. To exemplify, sentence (19) was turned into (21), in which the compound past tense (*ha/hanno affrontato*) used in Experiment 1 was replaced by a simple future tense (*affronterà/affronteranno*):

(21) Coraggiosamente, *un corteo* di manifestanti affronterà/affronteranno la polizia.
Courageously, a procession of protesters confront.FUT.SG/PL the police
'Courageously, a procession of protesters will confront the police.'

The sentences were shown word by word up to the verb, as in a standard self-paced reading experiment. Participants pressed the space bar to move to the next word until the verb, when the singular/plural verb forms appeared on the screen for selection. The position of the two verb forms on the screen was counterbalanced. Participants made their choice by pressing a left or a right button on their keyboard. Singular verbs were always 2/3 characters shorter than their plural counterpart. Word length was considered in the analyses of RTs.

3.2 Results

Figure 3 (left panel) shows the proportion of singular/plural verb choices. As it is evident, the control conditions patterned as expected: there is a clear preference for a singular verb (94.7%) after a complex NP in which the head is singular and the modifier contains a plural noun (e.g., *the level of the lakes*, cf. (17)), and there is a clear preference for a plural verb (92.5%) after a complex NP in which the head is plural and the modifier contains a singular noun (e.g., *the pilots of the aircraft*). With pseudopartitives, the preference for a singular verb, albeit predominant (86.8%) overall, varies gradually depending on the type of head: plural verbs are selected 24.2% of the time after quantifier head nouns, 9.5% of the time after collective nouns and 5.9% of the time after container nouns.

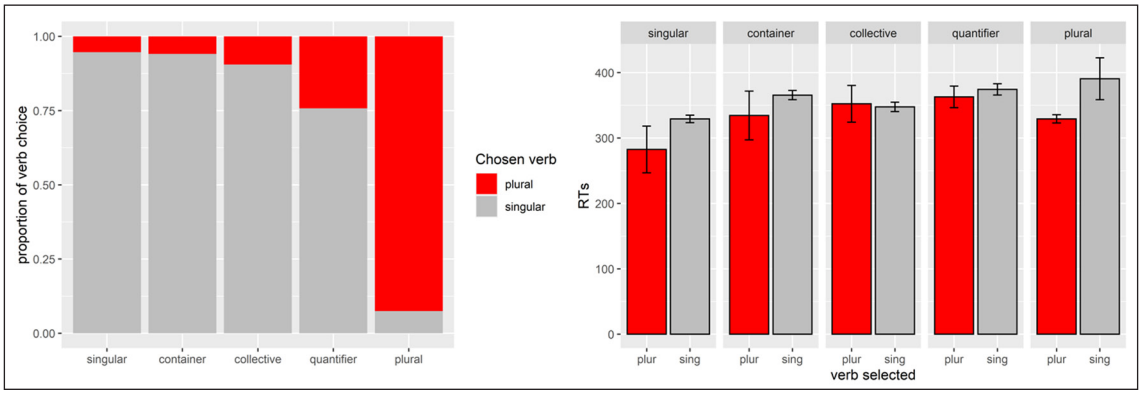

Figure 3: Proportions of verb choice (left panel) and RTs for verb selection (right panel) in the different experimental conditions, depending on the verb selected (singular vs. plural).

For RT analyses, we excluded RT below 150 ms and above 1000 ms (51 trials were excluded on this basis, less than 1% of the data). **Figure 3** (right panel) plots the mean RT for the selection of singular/plural verbs in the different conditions. The plot is only indicative, since few datapoints are included in the bars for plural verbs following pseudopartitives (except for quantifier heads) and singular controls, and for singular verbs following plural controls.

One trial in the singular control condition was excluded due to a typo in the sentence. As done in Experiment 1, we excluded plural controls from the analyses. To analyze the proportion of plural verb forms selected (compared to singular), we ran a first logistic mixed model regression (by means of the *glmer* function in *lmerTest* package) including the selected Verb Form (singular or plural) as the dependent variable, Condition as the independent variable (comparing pseudopartitives to singular controls, coded as -0.5 and $+0.5$ respectively, as done before), random intercepts for participants and items and random slopes for participants (including random slopes for items resulted in convergence failure). A significant difference was revealed, with more plural verbs selected in pseudopartitives than in singular controls (Est. $= -2.0729$, Std. Err. $= 0.5916$, z-value $= -3.504$, p $= 0.0005$). In a second model, we set contrasts as summarized in **Table 1** to compare all the levels of the Head Type variable. The output of the second model is provided in **Table 3**.

Table 3: Output of the logistic mixed model of Experiment 2 with selected Verb Form as the dependent variable, Head Type as a 4-level predictor, and participants and items as random intercepts. For sliding difference contrasts, cf. Table 1.

	Estimate	**Std. Error**	**z value**	**p value**
(intercept)	-3.2052	0.2455	-13.056	$<$**0.0001**
1st contrast	0.1473	0.3228	0.456	0.6484
2nd contrast	0.6180	0.3054	2.023	**0.0431**
3rd contrast	1.6206	0.2815	5.758	$<$**0.0001**

The second model shows that the selection of a plural verb increases gradually from containers to collectives (as revealed by the significant second contrast), and from collectives to containers (as revealed by the significant third contrast).

To analyze RT data, we ran two mixed regression models with RTs (log-transformed) as the dependent variable, Verb Chosen and Condition/Head Type as the independent variables, and their interaction, and random intercepts for participants and items (including random slopes for subjects or items resulted in convergence failure). The first model revealed a significant difference in RTs, showing that decisions in singular controls were faster than in pseudopartitives (1st contrast: Est $= -0.0769$, Std. Err. $= 0.0336$, t-value $= -2.291$, p $= 0.0239$). The second model, in which Head Type was considered as one of the predictors setting the sliding difference

contrasts as defined above, revealed only a significant difference in the first contrast (Est. = 0.1104, Std. Err. = 0.04079, t-value = 2.707, p-value = 0.0079), and a marginal difference in the second contrast (p = 0.0768), but no other significant results. These results, though, are to be taken with caution due to the small number of datapoints in some of the conditions.

3.3 Discussion

This second study returns two main findings, which align with those reported for Experiment 1. First, pseudopartitive constructions, in which a measurement relation links a singular head with a plural (measured) noun, pattern differently from singular controls in which a singular head noun is modified by a plural intervener. In line with the findings of Experiment 1, the presence of a plural intervener between the sentential subject and the verb does not affect the preference for the singular verb (which is the only grammatical option) when the sentential subject is singular. In the case of pseudopartitives, instead, although a singular verb is selected in most cases, the degree to which this choice is made depends on the type of head of the pseudopartitive: the selection of a plural verb is significantly higher when the head noun is a quantifier, and it is the lowest when the head noun is a container, with collectives again lying inbetween. The analysis of RTs also confirms that participants are faster in the case of singular controls compared to pseudopartitives. This is compatible with the idea that only one parse is available for singular controls, while alternative parses can be generated for pseudopartitives, with a different relative probability depending on the head noun.

By means of the different experimental technique employed in Experiment 2, we corroborate previous findings in showing that (i) pseudopartitives are more subject to variability in verb preference compared to other constructions that are superficially similar but for which grammatical rules of subject-verb agreement apply; (ii) speakers' preferences for a singular or plural verb after a pseudopartitive vary depending on the type of head.

4. Experiment 3: Eye tracking in reading

Experiment 3 employs the same material as Experiment 1 but the task, in this case, is a reading task in which participants' eye movements are recorded. The main aim of this last experiment is to compare singular controls, which have a unique grammatical option, with pseudopartitives, for which variability in agreement is attested. One expectation is that disruption effects might be revealed in the case of singular controls followed by a plural verb, due to the fact that this constitutes an ungrammatical sentence. However, previous eye tracking studies do not report clear disruption effects in cases of constructions that allow for variable number agreement. For example, Foppolo and Staub (2020) detected disruption effects in the case of ungrammatical sentences in which a singular verb followed a *conjunction* of singulars (cf. (22a)) but not in the case of singular/plural verbs following a *disjunction* of singulars (cf. (22b)), for which none of the options are ruled out by the grammar:

(22) a. The lawyer *and* the accountant *is/are coming to the meeting.
b. The lawyer *or* the accountant is/are coming to the meeting.

We might expect similar results here, since, in this study too, we are comparing putatively ungrammatical sentences with constructions for which both options of agreement are allowed by the grammar. In any case, by providing online measures of processing, this final study might offer another piece of the puzzle of understanding the underlying processes of agreement selection and the preferences revealed in the previous studies.

4.1 Methods

4.1.1 Participants

Forty-seven Italian monolingual speakers living in Italy participated in this study. All were university students at the University of Milan-Bicocca and received course credits for participation. None of them participated in the other experiments.

4.1.2 Procedure

The experiment was implemented in Experiment Builder (SR Research) and administered in one of the eye tracking labs at the University of Milan-Bicocca using an Eye Link 1000 desktop monocular eye tracker. Stimuli were shown in 20 Courier New Bold white font on a 1920x1080 grey screen while participants were sitting at 60 cm with their chin and forehead on a headrest. Sentences were centered horizontally and appeared on one single row.

Participants were instructed to read the sentences silently at their normal speech rate to comprehend what they were reading. When they finished reading each sentence, they had to press a button on a joystick to move to the next sentence. The back left and right buttons on the joystick also served to select the correct answer to a comprehension question that followed 25% of the trials.

4.1.3 Materials

The experiment material was the same as in Experiment 1. The only change was the addition of some comprehension questions to maintain sustained attention during reading. For the same purpose, the questions tackled different segments in the sentence (initial, middle, or final part), and required a yes/no or a short binary response whose options appeared on the left and right of the screen. Answers were provided by pressing a corresponding left/right key on the rear of the joystick. The position of the correct response was counterbalanced.

4.2 Results

No participant was excluded due to inaccurate answers to the comprehension questions (accuracy was above 92% overall; the lowest individual participants' accuracy was 85%). Eye data were

first processed in Dataviewer (SR Research) performing a 4-stage cleaning process as described in EyeLink Data Viewer User's Manual Document (Version 3.1.97) to remove short fixations (shorter than 80 ms in step 1, shorter than 40 ms in step 2 and shorter than 140 ms in steps 3 and 4), as well as fixation larger than 800 ms. We also removed all fixations falling outside any of the interest areas (5730 overall); individual eye fixations that were less than 80 ms in duration and within one grade of a previous or subsequent fixation were incorporated into their neighboring fixation (969 overall). For regression analyses, trials were excluded if a word was skipped during first pass reading of the verb region. On this basis, 260 trials were removed, corresponding to less than 1% of all datapoints. For first pass reading, trials were excluded if a later region was visited before the first fixation entered the verb region in the sentence, leading to an exclusion of 82 trials. No participant was excluded due to data loss above the threshold set at 20%. In addition, 4 trials were excluded due to a typo in the sentence.

For each sentence, five regions of interest were created: R1 corresponds to the lead-in adverbial or propositional phrase; R2 corresponds to the first NP (head) of the sentential subject; R3 corresponds to the second NP (embedded modifier); R4 corresponds to the verb (aux + past participle) and R5 to the final phrase. To exemplify, sentence (21) above was segmented as in **Table 4**:

Table 4: Definition of the interesting regions for statistical analyses in Experiment 3.

R1	**R2**	**R3**	**R4**	**R5**
Coraggiosamente,	un corteo	di manifestanti	ha/hanno affrontato	la polizia

We considered four standard eye movement measures for analyses. *First pass reading time*, which is the sum of all eye fixation durations on the region during participants' first reading of the sentence, i.e., before leaving the region to the left or right. The variable that was used for this analysis is IA FIRST RUN DWELL TIME in the interest area report generated by Dataviewer, removing all trials in which later regions were visited before entering the verb region, as detailed above. *Go past time*, which is the sum of all fixation durations beginning with the first on the region, also including any regressive re-reading of earlier material and any re-reading of the critical region itself. The variable that was used for this analysis is IA REGRESSION PATH DURATION. *Total reading time*, which is the sum of the duration across all fixations that fell in the current interest area during the trial. The variable that was used for this analysis is IA DWELL TIME. *Regression probability*, which is the probability of a regressive eye movement during first pass reading, i.e., the probability of a leftward saccade out of the region, rather than a forward saccade. The variable that was used for this analysis is IA REGRESSION OUT.

Given that the sentences differed in length, all analyses of reading times include the length of the strings in characters as a covariate in the analyses.

All analyses focus on R4, which includes the number marked auxiliary *be/have* and the past participle. This corresponds to the region in which a possible mismatch in subject-verb agreement surfaces. The different eye tracking measures recorded in this region for controls and pseudopartitives are plotted in **Figure 4**.

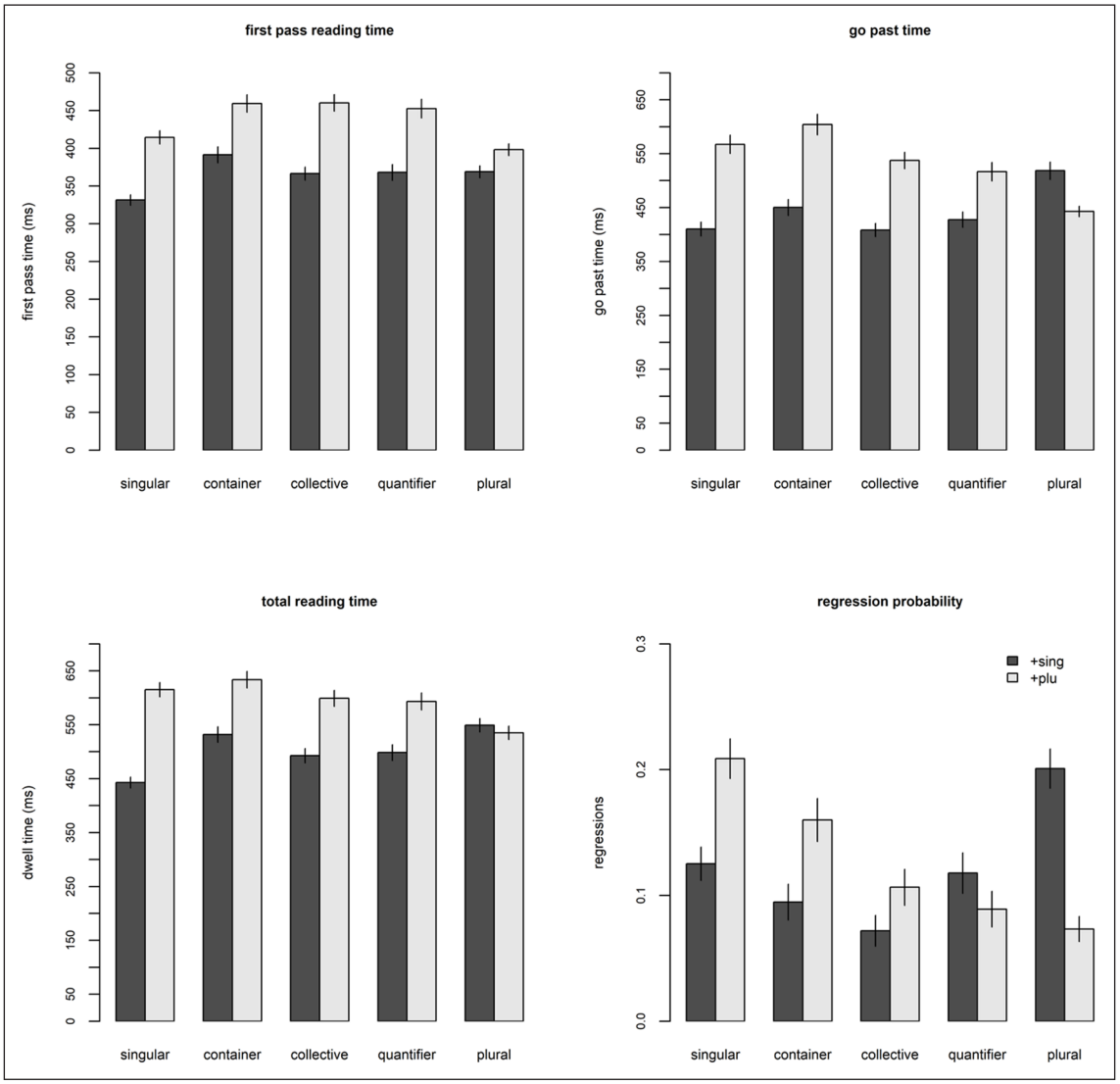

Figure 4: First pass reading time (top, left), go past time (top, right), total reading time (bottom, left), and regression probability (bottom, right) in the verb region for each of the experimental conditions. Black bars correspond to plural verbs, light grey bars correspond to singular verbs. Note that in the figure no adjustment was made for the length of the region, which is always three characters longer in the plural compared to the singular.

First, controls pattern as expected: signals of disruption, across all measures, are detected when a plural verb follows a singular subject and when a singular verb follows a plural subject, despite the presence of a plural/singular modifier. Similarly, some evidence for disruption is visible in some of the measures when a plural verb follows a pseudopartitive. This confirms an overall preference for singular agreement in the case of pseudopartitives, although the size and the pattern of the effects in the case of pseudopartitives followed by a plural verb seem to differ from the pattern observed in the case of singular sentences. Also, a difference seems to emerge among different types of pseudopartitives.

We explored these effects in statistical analyses. We ran two models for each of the eye tracking measures specified above, setting the contrasts for the critical variables (Condition/ Head Type and Verb Number) as detailed for Experiment 1. All *p*-values reported in the outputs of the models are based on the Satterthwaite approximation to the denominator degrees of freedom, as implemented in the *lmerTest* package (Kuznetsova et al., 2017; Luke, 2017). As in the previous experiments, we modeled contrasts to compare singular controls to pseudopartitives in the first model, and sliding different contrasts in the second model, as detailed in 2.2.

Statistical analyses of the reading time measures (first pass, go past, and total reading times) and regression probability were carried out using mixed-effects linear and logistic regression models, respectively. In all models, the fixed effect's structure includes Length of the region (centered), Trial order, Condition/Head Type, and Verb Number, as well as the interaction of Condition/Head Type and Verb Number. Random intercepts for participants and items were always included (adding random slopes resulted in a failure of convergence in some of the models; for consistency, we never included them).

Apart from the significant effects of region Length and Verb Number (and, in some cases, of Trial order), which were expected and consistent across most measures, the most theoretically relevant results are discussed below.

With respect to the first model, which compares singular controls to pseudopartitives, the most relevant results are the following (the output of all models is available in the R script in the OSF repository). Total time measures reveal a significant interaction of Condition and Verb Number (Est. = −0.1109, Std. Err. = 0.0296, t-value = −3.748, p = 0.0002), also evident in **Figure 4**: the overall time spent on the verb region is much greater for singular controls when the verb is plural, compared to when it is singular, while the difference between reading measures for singular and plural verbs is reduced in pseudopartitives. The probability of regressions is significantly higher in singular controls compared to pseudopartitives (Est. = 0.5409, Std. Err. = 0.1461, z-value = 3.701, p = 0.0002), independently of verb number. In addition, the interaction with verb number suggests that the disruption observed in the case of plural verbs tends to be significantly greater for singular controls compared to pseudopartitives (p = 0.073).

The pattern observed in the second model reveals other significant differences among different types of sentences, albeit some interactions and comparisons did not reach full significance. The output of the second model for all measures is reported in **Table 5**.

Table 5: Output of mixed-effects models for Experiment 3. Sliding different contrasts for Head Type set as in Table 1.

Effect	**Estimate**	**SE**	***t*/*z*-value**	***p* value**
FIRST PASS READING TIME				
(Intercept)	5.8746	0.0372	157.759	< **0.0001**
Length.cent	0.0467	0.0039	11.845	< **0.0001**
Trial Order	−0.0004	0.0002	−1.851	*0.0642*
Verb Number	−0.0676	0.0174	−3.896	**0.0001**
1st contrast (2–1)	−0.0573	0.0324	1.769	*0.0807*
2nd contrast (3–2)	−0.0438	0.0346	−1.264	0.2100
3rd contrast (4–3)	−0.0082	0.0352	0.233	0.8165
1st contrast:Verb	0.0291	0.0359	0.809	0.4186
2nd contrast:Verb	−0.0487	0.0389	−1.254	0.2099
3rd contrast:Verb	0.0224	0.0397	0.564	0.5730
GO PAST READING TIME				
(Intercept)	6.0475	0.0452	133.839	< **0.0001**
Length.cent	0.0430	0.0048	9.025	< **0.0001**
Trial Order	−0.0009	0.0002	−4.147	< **0.0001**
Verb Number	−0.1346	0.0204	−6.592	< **0.0001**
1st contrast (2–1)	0.0331	0.0392	0.844	0.4009
2nd contrast (3–2)	−0.0985	0.0420	−2.346	**0.0214**
3rd contrast (4–3)	0.0122	0.0427	0.287	0.7750
1st contrast:Verb	0.0176	0.0414	0.425	0.6712
2nd contrast:Verb	0.0084	0.0448	0.187	0.8520
3rd contrast:Verb	0.0790	0.0458	1.725	*0.0846*
TOTAL READING TIME				
(Intercept)	6.222	0.0451	138.027	< **0.0001**
Length.cent	0.0460	0.0054	8.581	< **0.0001**

(Contd.)

Effect	Estimate	SE	*t*/*z*-value	*p* value
Trial Order	−0.0014	0.0002	−6.761	**<0.0001**
Verb Number	−0.1060	0.0207	−5.107	**<0.0001**
1st contrast (2–1)	0.0521	0.0446	1.170	0.2455
2nd contrast (3–2)	−0.0901	0.0477	−1.890	*0.0624*
3rd contrast (4–3)	0.0226	0.0485	0.466	0.6424
1st contrast:Verb	0.1041	0.0381	2.736	**0.0063**
2nd contrast:Verb	0.0037	0.0411	0.089	0.9292
3rd contrast:Verb	0.0144	0.0420	0.343	0.7313
REGRESSIONS OUT				
(Intercept)	−2.3609	0.1525	−15.484	**<0.0001**
Length.cent	−0.0071	0.0230	−0.308	0.7583
Trial Order	−0.0049	0.0015	−3.245	**0.0012**
Verb Number	−0.3629	0.1278	−2.840	**0.0045**
1st contrast (2–1)	−0.3563	0.1821	−1.957	*0.0504*
2nd contrast (3–2)	−0.4127	0.2081	−1.983	**0.0474**
3rd contrast (4–3)	0.1736	0.2156	0.805	0.4207
1st contrast:Verb	0.0012	0.2719	0.004	0.9965
2nd contrast:Verb	0.2327	0.3277	0.710	0.4777
3rd contrast:Verb	0.7529	0.3437	2.191	**0.0285**

The first contrast is between singular controls and the container-headed pseudopartitives. Across the different measures, there is some indication of a difference between the two sentence types: in first pass and regression probability, there is a tendency towards a difference, with shorter reading times, but a higher probability of regressions, in singular controls; in total reading time, the interaction with Verb Number is fully significant, consistent with bigger disruption effects in the case of singular controls when the verb is plural, compared to when it is singular: such a difference is reduced in the case of container-headed pseudopartitives. The second contrast is between container-headed and collective-headed pseudopartitives. Our prediction was that the availability of a measure-phrase interpretation is bigger for the latter compared to the former. A difference clearly emerges in regression and go past measures, and a tendency towards significance is revealed in total reading time: these show that the time spent in the verb region is overall shorter for collective heads than container heads, and the probability of regression is lower in the former compared to the latter. The third contrast is between collective-headed and quantifier-headed pseudopartitives. Our prediction was that the availability of a measure phrase

interpretation is maximal in the latter, consistent with higher acceptability of plural agreement. Although this contrast is never significant across any of the measures, the interaction with verb number is fully significant in regressions: in the case of quantifier heads, the plural verb triggers less regressive eye movements, compared to singular verbs, while an opposite trend is found for collective heads. This result is compatible with the hypothesis that the availability of a measure phrase interpretation, compatible with plural agreement, is higher in the case of quantifier-headed pseudopartitives.

4.3 Discussion

This third study provides online measures of the processing of pseudopartitive constructions during reading. What emerges, once again, is that these structures display a different behavior from superficially similar, but syntactically different, constructions. This even though, in all cases, a singular head noun is followed by a plural intervener and the singular verb is the putatively grammatical option.

First, the results suggest that readers experience greater difficulty when encountering a plural verb after a singular subject followed by a plural modifier, compared to pseudopartitive constructions. In the latter, the disruption in reading when encountering a plural verb is significantly reduced. This suggests that pseudopartitive constructions are parsed differently from singular controls. Second, although there is a putative overall preference for singular agreement in the case of pseudopartitives, some difference is again found across different head types when followed by a plural verb: reduced disruption effects emerged in collective compared to container-headed pseudopartitives, and reverse effects in the case of quantifier heads, for which the accessibility of the measure interpretation is maximal.

In general, the eye tracking data are consistent with the optionality of singular verb agreement in the case of pseudopartitives, for which two alternative structures are available in the grammar. As for the fact that some of the contrasts did not return fully significant effects, this might be due to the fact that, as discussed above, disruption effects tend to be milder, if not absent, when variable agreement is allowed in the grammar, compared to ungrammatical cases. This is what emerges in our study as well: greater disruption effects are revealed for singular controls followed by a plural verb: only in this case does the grammar allow for a single parse in which the verb must be singular, despite the plural intervener.

5. General discussion

In this paper, we tested Italian pseudopartitive constructions, like *a group of students*, in which a singular head noun embedding a plural modifier yields variable singular/plural agreement with the verb that follows. We compared these structures with adnominal modification structures of

the type NP1$_{[-PL]}$ *prep* NP2$_{[PL]}$. These have been extensively documented in the psycholinguistic literature on agreement attraction, in which a plural modifier might interfere in the process of subject-verb agreement with the singular head noun, possibly resulting in number attraction to the verb (in production) or an illusion of grammaticality with a plural verb (in comprehension).

Our aim was twofold. First, we aimed to assess whether agreement in pseudopartitives displays different behaviors compared to classic NP1$_{[-PL]}$ *prep* NP2$_{[PL]}$ configurations tested in offline and online tasks. Second, we aimed to investigate the source of the agreement variability reported in the literature within the class of pseudopartitives headed by different nouns (collectives, containers, and quantifiers). We hypothesized that variable agreement in pseudopartitives ensues from the availability, in the grammar, of two alternative parses, and thus is rooted in speakers' competence. Thus, we predicted that the process of agreement, in this case, would be radically different from the agreement process of structures in which a single parse is allowed by the grammar, and in which interference errors might affect speakers' performance. Specifically, we predicted the acceptability of a plural verb would increase significantly from singular controls, in which singular verb is the only grammatical option, to pseudopartitives, which instead allow for variable agreement. Moreover, across pseudopartitives, we predicted the acceptability of a plural verb would increase from container, to collective, to quantifier heads, as a consequence of the increased availability of the measure interpretation, which is maximal in quantifier heads. The reasoning behind this expectation is the following: in the case of singular controls, even if there might be an effect of agreement attraction of the plural intervener, the plural verb should be ruled out by the grammar. In pseudopartitives, the availability of the measure interpretation (triggering plural agreement on the verb), should be maximally available for quantifier heads, and gradually decline from quantifiers, to collectives, to containers, and so should the acceptability of a plural verb. The alternative container interpretation (triggering singular agreement on the verb), conversely, should be maximally available for container heads, and decline from containers, to collectives, to quantifiers, and so should the preference for a singular verb. If, instead, variability in agreement in the case of pseudopartitives was solely determined by the effect of agreement attraction of a plural intervener, no gradience effects should be detected, given that all the structures tested are of the form NP1$_{[-PL]}$ *prep* NP2$_{[PL],}$ in which a plural intervener should exercise comparable effects of attraction.

To address these questions, we compared adnominal modification structures across different studies: an acceptability judgment study, a forced-choice production study, and an eye tracking reading study.

First of all, our results across the three experiments consistently show different patterns of response between pseudopartitives and non-pseudopartitive adnominal structures, despite their superficial similarity. In comprehension, graded acceptability (in Experiment 1) and reduced disruption effects in reading (Experiment 3) are displayed by pseudopartitives followed by a

plural verb, compared to singular controls. As expected, categorical rejections and clear effects of disruption characterize sentences where a plural verb follows a singular subject, for which plural agreement is ungrammatical despite the plural modifier. In production (Experiment 2), a greater number of plural verbs were chosen in pseudopartitives compared to singular controls. These results suggest that variable agreement in pseudopartitives cannot be reduced to effects of a plural intervener as in agreement attraction, providing psycholinguistic corroboration for the linguistically motivated conclusion that the two phenomena are set apart by several considerations.

As we have seen, one key factor in psycholinguistic analyses of agreement attraction is notional number. Despite its intuitive appeal, and especially the important heuristic role it played in agreement attraction, notional number suffers from several drawbacks. One is its *post hoc* nature, considering that gradients of semantic plurality are inferred *post hoc* and not predicted from some general definition of the concept itself (though see Smith et al., 2018). Another problem springs from its language-specific nature. Recall that Italian does not allow a plural verb after collective singulars like *committee*; under an all-encompassing concept of notional number, this language-specific behavior is unexpected. Furthermore, agreement attraction effects involve gender as well as number (cf. also Slioussar & Malko, 2016; Tucker et al., 2021). This reduces the appeal of an explanation based on semantic plurality, which cannot be easily extended to explain variability in gender agreement.

For pseudopartitive constructions, the linguistic literature suggests a more *predictive* approach to variability in the acceptance of plural agreement. In essence, variability in agreement is based on the polysemy of the head nouns (e.g., *bottle*), which can trigger a measure interpretation of the whole DP (pills *in the measure of a bottle*) – as opposed to, say, a container interpretation (a bottle *containing pills*), cf. (10) above. This results in distinct syntactic representations in which the singular/plural features of the head (*bottle*) or the embedded noun (*pills*) can determine verb number, cf. (9) above.

Therefore, we predicted a positive correlation between the degree of acceptability of plural agreement and the degree of accessibility of the measure construal of the pseudopartitive's head. More precisely, we predicted that the measure interpretation is most readily available with quantificational heads (numerical heads like *un centinaio di* 'a hundred (of)', +Q), and a gradient (increasing) availability of a measure construal moving from containers (*a box of chocolates*), to collectives (*a group of students*), to quantifiers (*a lot of senators*), despite the presence, in all these cases, of a plural embedded noun which presupposes several chocolates, students and senators, respectively. We are aware that this is the very same gradient that the concept of "notional plurality" tries to describe and to account for – as stressed by the consistency of our empirical results with those of previous literature. We suggest, however, that notional plurality remains an *a posteriori* notion (whatever is observed to trigger more plural agreement is higher on the scale

of notional plurality). In contrast, the independently definable notion of measure interpretation, and its connection to a specialized syntax, may provide a *predictive* analytical grid to account for the observed variability.

This prediction was supported by our experimental data: a different pattern emerged in our experiments across pseudopartitives headed by different heads, particularly between quantifiers and the other heads. In Experiments 1 and 2, the general preference for singular verbs following a pseudopartitive construction was less consistent in the case of pseudopartitives with quantifier heads. In the rating study (Experiment 1), the plural verb with quantifier heads is not perceived as much degraded, with mean judgments above 4.5 and with a portion of subjects consistently rating it around 6. Furthermore, the acceptance rate of plural verb forms decreases from quantifier heads to collectives and finally to containers. In the forced-choice task (Experiment 2), the proportion of plural verbs is the highest when the head noun is a quantifier phrase, and it is the lowest when the head noun is a container phrase. In the reading study (Experiment 3), regressive eye movements were more likely when a singular verb was encountered after a quantifier-headed pseudopartitive. When the pseudopartitive's head was a collective or a container noun, instead, regressions were more likely on the plural than the singular verb. Overall, our results seem to us conclusive with regards to the grammar-based nature of pseudopartitive agreement, and their distance from other agreement phenomena that reflect an underlying mechanism of continuous number valuation, such as the one captured by psycholinguistic accounts of agreement attraction (cf. Hammerly et al., 2019). Specifically, our proposal is that plural verb agreement depends on a syntactic process whereby the root category of the pseudopartitive is labeled by a plural embedded property. This, in turn, corresponds to an interpretation of the head of the construction as a measure phrase in which the plural modifier determines plural agreement. We are not tackling here the question of which system of semantic features (if any) may be used to capture the relative accessibility of a measure reading on the cline quantifiers > collections > containers, as this is beyond the scope of the present paper. By default, we may describe the cline in terms of the features $+/-$Q, $+/-$collective, $+/-$container – noting that at least the first two are almost certainly independently needed in grammatical systems.

Also, the present study does not provide empirical evidence to endorse or develop any specific analysis of agreement attraction – not even restricted to agreement attraction triggered by plural PP modifiers. Nevertheless, it is legitimate to inquire whether, based on the results concerning pseudopartitives, we can make further inroads into agreement attraction, and the intuitive concept of notional plurality. We believe that the present line of research shows the usefulness of factoring the informal notion of semantic plurality into more easily formalizable, and therefore testable, components.

To take a concrete example, one of the factors that favor agreement attraction is the presence of a context where, despite the singular head noun, the NP (as a whole) denotes a multiplicity of

entities by virtue of a distributive interpretation induced by the modifier, as discussed in relation to sentences (7a – b). Distributivity is not formally triggered, but pragmatically triggered (i.e., inferred from the context, our knowledge of the world, etc.). In the classical *the key to the cabinets* example, our knowledge of the world suggests that it is highly likely that there are multiple keys, as many as there are cabinets. In other words, a distributive universal is implied (*the key to each of the cabinets*), yielding more (production) errors than intrinsically non-distributive examples like *the cage of the gorillas*, which implies one single entity (cf. Eberhard, 1999, a.o.). In other instances, this distributive interpretation is forced, as in (23), where our mental encyclopedia includes the information that there are as many flags as nations. At the same time, singular agreement is required by the grammar.

(23) The flag of the member nations was/*were flying in front of the building.

On the contrary, examples of the type in (24) (after Wagers et al., 2009), which also induce agreement attraction effects, do not imply plurality (here, of athletes).[7] This contrast further strengthens the point made here. In pseudopartitives, plurality is *syntactically* determined. In examples like (23) the interference of world knowledge or pragmatics on syntactic computation seems to be the key to the explanation (as is assumed in the "Marking and Morphing" model). In (24), the different syntactic context (involving a relative clause modifier) may entail different consequences for processing.

(24) The coaches [who the athlete knows/*know] cheated.

A final question is which processing model, or models, best captures the various aspects of agreement attraction or agreement variability phenomena. Recall that Smith et al. (2018) abandon the original "Marking and Morphing" proposal in favor of a *self-organized sentence processing* framework. At the same time, Villata and Tabor (2022) elaborate on the SOSP model by applying it to syntactic movement in islands, characterized by gradient grammaticality judgments. Therefore, in principle, even assuming the present syntactic construal of pseudopartitives, one could apply SOSP to formalize the agreement alternation in pseudopartitives, as they are characterized by gradient acceptability/production of plural agreement with singular-headed subjects. The probability of implementing a given parse depends on the pseudopartitive's head, which determines the probability of the plural feature associated with the embedded noun becoming available in the root node of the complex nominal. For example, in a dynamic model like SOSP, one possibility is that, when encountering a pseudopartitive construction, the (bottom-up) parser starts building treelets that are compatible with the head noun that is encountered, adjusting the strength of the different possible connections among the elements

[7] We thank an anonymous reviewer for pointing out the relevance of this type of example.

based on the incoming material. The observed gradient accessibility of the plural features across different kinds of pseudopartitives can be interpreted as the likelihood of accessing one, or the other, or both, alternative parses available for a pseudopartitive in the grammar: the way in which the nodes are combined in the treelets is determined by the head noun, which in turn determines the strength and the accessibility of the +/−PL features associated with the head or the embedded noun to predict and/or determine agreement on the other elements in the sentence. This, in turn, might explain why the disruption effects in reading a plural verb are the most reduced when the head is a quantifier, and why these are maximal in the case of singular controls. In the latter, but not in the former, the only available (and grammatical) parse is the one in which the first (singular) NP attaches as the specifier of the S node (as the sentential subject), carrying its −PL feature with it. In this structure, the plural features of the second NP remain within the modifier phrase and, from this embedded position, they can at most exercise an effect of interference (i.e., attraction to the plural, since at some point in the parse the feature +PL was encountered). Indeed, they cannot contribute directly to determining plural agreement on the verb, given the strength of the connection between the node in which the subject NP attaches to the higher nodes, carrying its −PL feature, which determines agreement.

While these issues are left open here, the present research leads us to conclude that a proper understanding of agreement attraction requires breaking down this set of phenomena into their analytical components. This also includes all the different aspects of the speaker's competence that are involved in the process (e.g., syntactic, pragmatic, semantic), assuming that these components do affect sentence processing, both in production and comprehension.

Data accessibility statement

The list of the stimuli and all the scripts and workspace for the analyses for all the experiments are available at https://osf.io/jxnsh/?view_only=a4fe2b97f89a4a409bdfe896943fee33.

Ethics and consent

The experiments were conducted in accordance with the Declaration of Helsinki, as last revised. Informed consent was obtained from all participants prior to experimentation, based on a detailed description of the experimental procedure, the reward scheme, and our use of the submitted data. The procedure was approved by the departmental Ethics Committee of the University of Milan-Bicocca on the Use of Humans as Experimental Subjects (Commissione per la Valutazione della Ricerca, CRIP) under approval protocol RM-2019-213.

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Competing interests

The authors have no competing interests to declare.

Author contributions

All authors conceptualized the experiment and decided on the methodology. F.F. took the lead on experimental implementation, data collection, data analysis, data curation, and writing of the manuscript. All authors revised the manuscript. M.R.M. acquired funding and supervised the whole project. All authors are responsible for the content of the report.

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