

On the person-number distinction: Subject-verb agreement processing in Italian



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Abstract

Agreement is generally conceived as a syntactic dependency whose computation and comprehension processes deal with agreement features uniformly, without differentiating among them. However, different interpretive properties are associated with Person and Number. While Person expresses the status of an argument with respect to the participants in the speech act (e.g. speaker, addressee), Number refers to the cardinality of the subject argument (e.g. a singular vs. a plural entity). Two self-paced reading experiments were run to investigate the on-line processing of subject-verb agreement in Italian manipulating both the Person and Number Agreement factors. The results revealed a greater processing penalty for Person compared to Number agreement violations, which is interpreted as evidence for a separate access to the two features. Because it disrupts the evaluation of the perspective from which a sentence is reported, a Person violation can generate a more serious perturbation than a Number anomaly, which only changes the Number property of the subject of predication.

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1. Introduction

Together with case marking and word order, agreement is one of the main devices used by languages to signal relations among constituents. Patterns of agreement are subject to a great deal of cross-linguistic variation, ranging from languages where this dependency is poorly signaled, as in English, to languages where it is pervasive, such as Romance languages. Regardless of the structural configuration involved (determiner-noun, adjective-noun or subject-verb) and the language under study, this dependency is generally realized as an identity in agreement features (Person, Number and Gender) between two elements.

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Within derivational theories, standard analyses (cf. Chomsky, 1981, 1995) have emphasized the formal nature of this dependency, which would be computed during the syntactic build-up of the sentence, independently from the thematic roles and discourse functions of the elements involved. Mainstream psycholinguistic models (Frazier and Fodor, 1978; Frazier and Clifton, 1996; Friederici, 2002; Grodzinsky and Friederici, 2006) have supported this view, underscoring the syntactically-driven nature of the mechanisms involved in agreement computation.

As for agreement features, an undifferentiated representation has been generally assumed, despite the intrinsically different information that each of them carries. Recent minimalist analyses have represented Person, Number and Gender as a feature set that during agreement computation is uniformly dealt with by the formal operation Agree (Chomsky, 2000, 2001), which ensures the copying of the relevant feature information from the controller (the subject) to the target (the verb). In processing terms, this has a straightforward consequence: during feature checking, Person, Number and Gender are accessed as a bundle, presumably treated as a unit under this view.

This last assumption is however controversial. Comprehension studies have evidenced a functional dissociation between Number and Gender that emerged for example during pronoun antecedent reactivation (De Vincenzi, 1999; De Vincenzi and Di Domenico, 1999), or during Number and Gender anomaly repair (Barber and Carreiras, 2005; Molinaro et al., 2008). Faussart et al. (1999) reported longer recognition times when words disagreed in Gender than when they disagreed in Number. According to the authors, this pattern reflects the intrinsic interpretive differences existing between the two features. Because Gender is an inherent feature, an anomaly involving this feature would compel the parser to go back to the lexical identification stage, in order to retrieve the correct lexical entry. On the contrary, Number is not stem-inherent, and the detection of an anomaly involving this feature would not imply re-accessing the lexical representation of a word, but only the morphosyntactic context in which it appears.

In addition, production studies have reported greater error rates for Number than for Gender suffixes (Igoa et al., 1999; Vigliocco et al., 1996). An explanation of these findings may be that while Gender is retrieved directly from the lexicon and assigned to phrase structure together with the lemma, Number is derived by rule and its inflection is thus more subject to errors.

1.1. Person and Number agreement

Recent theoretical analyses have underscored the different interpretive properties associated with Person and Number information (Bianchi, 2006; Sigurdsson, 2004). On the one side, Person expresses the status of an argument with respect to the participants in the speech act. Under this assumption, 1st person would indicate identity with (or inclusion of) the speaker, 2nd person identity with (or inclusion of) the addressee, and 3rd person a contextually salient entity that however does not bear either the former or the latter role (Benveniste, 1966; Cysouw, 2003; Jakobson, 1971; Sigurdsson, 2004, 2009, 2012).

For example, in “He buys some apples”, the 3rd person subject indicates that the individual involved in the buying event is contextually relevant, but the event is not reported from his perspective, i.e. he does not contribute to the unfolding of the speech event. Rather, it is a covert speaker that is telling the hearer/reader about what happens. By anchoring discourse roles to the referents indexed by sentential arguments, Person interpretation contributes to the establishment of aspects of the subject of predication related to the speech act participant representation, namely who are the participants and what their roles are in an event, as well as the perspective from which an event is narrated.

In contrast, the contribution of Number to the speech act representation is not as significant. Since this feature encodes the cardinality of the set referred to by the subject argument, its interpretation determines how many referents are involved in e.g. the buying event described above, but it does not change the discourse role of the subject, i.e. the apple buyer.

In light of these intrinsic differences, Person and Number can be plausibly regarded as two separate probing phenomena in agreement computation (Sigurdsson and Holmberg, 2008). Crucially, unlike Number, Person agreement computation hinges on the presence of relations between morphosyntactic and left-periphery features, or C-edge linkers, which encode speech participant values, namely the Logophoric speaker (or λ -Agent) and the Logophoric addressee (or λ -Patient) (Sigurdsson, 2012). Crucially, it is in relation to C-edge linkers that grammatical Person features are computed and valued. Sigurdsson (2004, 2012) subdivides clause structure into three layers, each of them encoding specific features: the lexical layer in the vP shell, with event features; the inflectional layer in the IP area, with morphosyntactic features; and the speech event layer within the CP area, with speech act features, i.e. speech participant (λ -Agent and λ -Patient), speech time (S_T) and speech location (S_L) features, as in (1) below. For instance, a matching relation ties lexical to grammatical features, and grammatical features to speech act ones. This way, λ -Agent can be linked to a 1st person pronoun or 1st person verbal morphology, and consequently to a speaker role. This would lead to proper interpretation of Person.

(1) [_{CP} Force.. λ_A λ_P .. Top.. S_T .. S_L [_{IP}..Pers_S..Num_S..M..T..[_{VP}..]]]

No such IP-left periphery connection is necessary for Number, the interpretation of which does not necessitate any direct link with the speech act participant representation of the sentence.

1.2. Person and Number processing

As for Person agreement processing, the existing literature provides a heterogeneous scenario. A recent study on the processing of Person, Number and Gender in Italian (Carminati, 2005) indicates that the penalty for disambiguating the antecedent of a null subject is significantly reduced when the disambiguation relies on Number and Person information together, compared to when only Number information is available. According to the author, this suggests the greater processing salience of the Person feature compared to Number and Gender, in line with Greenberg's (1963) Feature Hierarchy (Person > Number > Gender). However, the fact that Person-only disambiguation was not tested makes Carminati (2005) findings with regard to the greater cognitive salience of Person than Number inconclusive.

The on-line processing of agreement features has been studied also by recording electrophysiological responses (event-related potentials, ERPs) to the reading of sentences displaying subject-verb agreement anomalies. Cross-linguistically, the electrophysiological pattern usually found is that of a positive deflection starting about 600 ms post-stimulus (P600), often preceded by an increased anterior negativity lateralized to the left hemisphere (LAN), arising between 300 and 500 ms post-stimulus (English: Osterhout and Mobley, 1995; Italian: De Vincenzi et al., 2003; Dutch: Hagoort et al., 1993; Hagoort and Brown, 2000; Spanish: Hinojosa et al., 2003; Silva-Pereyra and Carreiras, 2007; German: Rossi et al., 2005). In general, LAN effects have been functionally interpreted as indexing the detection of a syntactic violation (Hagoort et al., 1993, 1999), while difficulties in lexical-semantic processing have been associated with a negative component peaking around 400 ms post-stimulus onset (N400), with a centro-posterior distribution slightly lateralized to the right hemisphere (Kutas and Hillyard, 1980, 1983). P600 effects are observed to syntactic violations of various sorts, as well as to cases of syntactic complexity and ambiguity, and are functionally interpreted as signaling repair and reanalysis processes.

Nevins et al. (2007) found that in Hindi the P600 effect generated by a Gender + Person mismatch had a greater amplitude than the one elicited by single Gender, single Number and Gender + Number mismatches. According to the authors, this modulation in the P600 amplitude should be attributed to the greater cognitive salience that Person has compared to Number and Gender, and thus to the stronger perturbation that Person violations generate, rather than to an enhanced response to multiple violations of agreement features. Similarly to Carminati (2005), a limitation of the study by Nevins et al. (2007) consists in the fact that they only tested Person agreement in combined violations (i.e. Gender + Person), but never in person-only mismatches, as they instead did for Number. This makes it hard to generalize over Person agreement and its cognitive salience.

Silva-Pereyra and Carreiras (2007) did not find any feature hierarchy effect in the processing of person and Number anomalies in Spanish: no significant difference emerged either in the timing or in the topography of the anterior negativity-P600 pattern elicited by the two violations. Moreover, cumulative effects were found for double-violation conditions, which the authors interpreted as evidence for the performance of additive mechanisms in the resolution of the incongruence. However, a possible explanation for the failure to find a difference between person and Number anomalies in Spanish may reside in the way the two features were contrasted. The experimental materials used in the Silva-Pereyra and Carreiras (2007) study consisted of verbs disagreeing in person and Number with 1st and 2nd person subjects, both singular and plural, that is *yo* (I) and *tú* (you_{sg}), and *nosotros* (we) and *ustedes* (you_{pl}). A spurious manipulation may have been carried out with the 2nd person plural pronoun *ustedes*, which is normally used only as a polite form and thus followed by a 3rd person plural verb (e.g. "*ustedes_{2,pl} abren_{3,pl} la puerta*"/you_{2,pl} open_{3,pl} the door). Such constructions have been regarded as unagreement forms (Rivero, 2007), that is to say patterns that superficially mismatch in one feature but nonetheless give rise to a well-formed construction. The processing of unagreement patterns has been found to yield different ERP and eye-movement patterns of responses compared to correct and violated sentences (cf. Mancini et al., 2011a): the presence of such constructions within the experimental materials of Silva-Pereyra and Carreiras (2007) may have thus caused a spurious response and obscured the presence of possible differences.

In a recent ERP study in Spanish, Mancini et al. (2011b) manipulated Person agreement between a singular lexical subject and a second person singular verb, and Number agreement between a singular lexical subject and third person plural verb, in order to produce "pure" violations. Both anomalies produced a P600 effect, but a qualitative dissociation between Person and Number was evident at early stages of processing, with the former violations eliciting an N400 effect and the latter a LAN. These results were taken as evidence for the qualitatively different interpretation procedures associated with Person and Number. According to these authors (but see also: Mancini, 2010; Mancini et al., 2013), while Number information is interpreted in relation to the nominal argument of the dependency, hosted in the morphosyntactic layer of sentence structure, Person is "anchored" to the speech act participant representation. In spite of these interpretive differences, Person and Number agreement processes have something in common: the parser must make sure that feature values in subject and verb morphology are consistent. Therefore, an Agree-like operation is performed during sentence processing to inspect feature congruence between the two elements. Person and Number represent two distinct probes and are dealt with separately by the parser to comply with their different interpretive procedures (Mancini et al., 2013, but see also Sigurdsson and Holmberg, 2008).

Critically, a processing aspect that the studies reviewed above do not highlight concerns whether the involvement of qualitatively different levels of analysis for Person and Number also produces *quantitative* differences in the processing of the two types of agreement violations. In light of this, the present study aims at testing the Person-Number dissociation hypothesis using a different dependent variable, namely reading times. Two experiments are reported in which Person and Number agreement are directly contrasted to evaluate the impact that each type of agreement has on reading. In Experiment 1, Person and Number agreement will be manipulated between a pronominal subject and a verb, while in Experiment 2 a lexical subject will be used.

2. Experiment 1

The goal of Experiment 1 is to compare Person and Number agreement using pronominal subject sentences such as the ones illustrated in Table 1. Similarly to Silva-Pereyra and Carreiras (2007), we will make use of agreement violations within a factorial design in which Person and Number are manipulated to create sentences with Person, Number and Person + Number agreement anomalies, as shown in Table 1.

If the parser differentiates between Person and Number features, an interaction between the two factors is expected to arise, as a consequence of the different impact that violating the two types of agreement has in processing. Based on the feature-anchoring approach described above (Mancini et al., 2013), the reading of a Person violation should cause the breaking of the cross-clause relation that links speech participant features and morphosyntactic Person, with the subsequent impossibility to anchor arguments with specific speech act participant representation “coordinates”, and thus reliably identify the type of participants and their roles (speaker, addressee or third party). For example, in **Io hai letto un libro* (**I_{1.sg} have_{2.sg} read a book*), it is unclear whether the sentence is about a speaker (as signaled by *Io*, I) that reports and performs a reading event, or if an addressee (as indicated by 2nd person singular inflection in the auxiliary “*hai*”) is involved in the same event. The parser will however try to repair this incongruence, which will lead to longer reading times compared to correct sentences. Similarly, encountering a Number agreement violation will trigger repair operations and slower reading times compared to the correct condition. However, the impact of a Number anomaly will not be as strong as the one determined by a Person violation, since inconsistencies related to the numerosity of the subject argument do not affect the speech act participant representation of the sentence. In **Io abbiamo letto un libro* (**I_{1.sg} have_{1.pl} read a book*) the parser will be still able to anchor morphosyntactic information to discourse roles. What is unclear is whether the speaker invoked by both the 1st person singular subject and the 1st person plural auxiliary is reporting and acting by him/herself (as suggested by the subject), or as part of a bigger group (as suggested by the auxiliary verb). Faster reading times may be therefore expected for a Number compared to a Person agreement violation. As for the double-violation sentences, i.e. when both Person and Number are anomalous, reading times on the mismatching verb should differ from Number but not from Person incongruence. On the contrary, if the difference in underlying relations that characterize Person and Number agreement does not correlate with different degrees of difficulty, similar reading disruptions should be observed at anomalous verb position for Person and Number inconsistencies.

2.1. Materials and methods

2.1.1. Participants

60 undergraduate students (40 females, age 18–36, mean = 27) from the University of Siena took voluntarily part in the experiment. They were all native speakers of Italian. They all had normal or corrected-to-normal vision.

2.1.2. Design and materials

Two factors were entered in a 2 × 2 design with Person Agreement (two levels: Correct, Incorrect) and Number Agreement (two levels: Correct, Incorrect) as factors. This resulted in 4 possible combinations: Person and Number

Table 1
Sample of the experimental material for Experiment 1. Critical word in italic.

	Number agreement	
	Agreement	Disagreement
Person agreement		
Agreement	<i>Io ho letto un libro</i> <i>I_{1.sg} have_{1.sg} read a book</i>	<i>*Io abbiamo letto un libro</i> <i>I_{1.sg} have_{1.pl} read a book</i>
Disagreement	<i>*Io hai/ha letto un libro</i> <i>I_{1.sg} have_{2.sg/3sg} read a book</i>	<i>*Io avete/hanno letto un libro</i> <i>I_{1.sg} have_{2.pl/3.pl} read a book</i>

correct (Pcor-Ncor), Person and Number incorrect (Pinc-Ninc), Person correct-Number incorrect (Pcor-Ninc) and Person incorrect-Number correct (Pinc-Ncor) sentences, as shown in Table 1.¹

Twenty-four sentences were created. Each sentence appeared in 4 versions (conditions), each condition being a different combination of the levels of the two factors. All of the sentences had the same syntactic structure, number of constituents (constituent 1: subject; constituent 2: verb; constituent 3: object) and tense. The pronominal subject could vary among the six available in the Italian pronominal system (*io/I*, *tu/you_{sg}*, *lui/he*, *noi/we*, *voi/you_{pl}* and *loro/they*). The mean length in characters of the critical constituent (auxiliary + participle) was the same across the four experimental conditions (10.20 letters, SD: 1.95). Agreement violations were always on the inflected auxiliary. Since for each pronoun two auxiliary options were always available for the Pinc-Ncor and Pinc-Ninc conditions, both forms were used: for example, half of the Person disagreement sentences with the “io” pronoun (1st person singular) were followed by a 2nd person singular auxiliary, and the other half contained a 3rd person singular one (see Table 1). Sentences were counterbalanced between subjects in four stimulus lists that contained only one version of each sentence. Each stimulus list also contained 72 filler items that consisted of grammatical and ungrammatical sentences displaying different instances of agreement between constituents (determiner-noun, reflexive-antecedent and subject-verb patterns in which an intervening mismatching modifier could exert agreement attraction on the verb). The order of sentences within each list was randomized. In total, each participant read 96 sentences.

2.1.3. Procedure

Participants were administered a stationary-window self-paced reading task. Sentences were presented constituent by constituent on a computer screen and participants were asked to read sentences by pressing a button on a keyboard after reading each segment. Some sentences (16 out of 96, both filler and experimental ones) were followed by a comprehension test. Participants answered by pressing one of two lateral keys (corresponding to YES and NO) on a keyboard.

2.1.4. Data analysis

Reading times (in milliseconds) that were higher or lower than 2.5 standard deviations around the mean of each subject in all conditions were removed. This led to 2.3% of removals from constituent 1, 2.7% from constituent 2 and 3.3% from constituent 3. The three constituents were analyzed separately, as shown in (2) below:

- (2) c_1 lo | c_2 ho scritto | c_3 un libro
 $I_{1.sg}$ have_{1.sg} read a book

The analysis was carried out fitting linear mixed-effect models to our data, with Person (correct, incorrect) and Number (correct, incorrect) as predictors. Following the recommendations of Barr et al. (2013), a series of models was built with increasing complexity in the random-effect structure. In particular, a first model including only the by-Subject and by-Item random intercepts was successively compared to a mixed-effect model presenting by-Subject and by-Item random intercepts and slopes, to allow the slope of Person and Number to vary across subjects and items. Due to limitations in the estimation algorithm, the random effect structure of the models was simplified, leading to a maximal converging model including by-Subject and by-Item random intercepts but only a by-Subject random slope. For each pair of models, the results of the likelihood ratio test were applied to evaluate whether the inclusion of additional random-effect parameters provided a better fit of the model to the data. Data analysis was performed using the *lme4* package (Bates et al., 2013) included in the R Statistical Software (R Development Core Team, 2008).

Comparisons among experimental conditions were carried out using different linear mixed-effect models, which differed in the reference level chosen to derive the intercept. To evaluate the effect of the Number-, Person- and Person-Number Incorrect sentences relative to their correct counterpart, the intercept was set to the Person-Number Correct condition. To assess whether the effect of Person-Incorrect and Number-Incorrect stimuli differed with one another, the intercept was set to the Person-Incorrect condition. Finally, to assess the effect of Person-Number Incorrect sentences relative to Person-Incorrect and Number-Incorrect ones, the former condition was chosen as intercept. For each comparison, we report the intercept, the estimated regression coefficient (Estimate), standard error (SE) and *t*- and *p*-values in the text. Mean reading times per constituent (together with their standard error) are reported in Table 2. For both experiments, only significant results are reported, non-significant and marginally significant results will be reported only when relevant to the issues addressed in the study.

¹ Note that in the remainder of the text, the term “Person-Incorrect” will be used to refer to the Pinc-Ncor condition, “Number-Incorrect” to the Pcor-Ninc condition. Similarly, “Person-Number Incorrect” and “Person-Number Correct” will indicate Pinc-Ninc and Pcor-Ncor conditions, respectively.

Table 2

Mean reading times (in milliseconds) averaged across participants for Experiment 1. Standard error in parenthesis. (Pcor = Person Correct; Pinc = Person Incorrect; Ncor = Number Correct; Ninc = Number Incorrect).

		Number agreement	
		Ncor	Ninc
Person agreement			
Constituent 1	Pcor	492 (10.09)	504 (10.53)
	Pinc	495 (10.60)	493 (9.88)
Constituent 2	Pcor	626 (11.36)	674 (13.08)
	Pinc	684 (13.58)	690 (14.53)
Constituent 3	Pcor	613 (11.12)	639 (12.72)
	Pinc	646 (12.68)	637 (12.24)

3. Results

Participants correctly answered comprehension questions in 96% (SD: 1.27) of the cases.

Constituent 1. No significant effect was observed at this position.

Constituent 2. Relative to the Person-Number Correct verb, a significant increase in reading times was observed for both Person-Incorrect (Intercept: 627 ms, Estimate: 62 ms, SE: 14.38, $t = 4.34$, $p = .001$) and Number-Incorrect verbs (Intercept: 627 ms, Estimate: 51 ms, SE: 14.28, $t = 3.58$, $p = .001$), as well as for Person-Number incorrect ones (Intercept: 627 ms, Estimate: 67 ms, SE: 14.30, $t = 4.64$, $p = .001$) as shown in Fig. 1. However, Person-Number Incorrect sentences were not found to differ from either Person- or Number-Incorrect sentences.

Constituent 3. Similarly to Constituent 2, in the last segment of the sentence a significant increase in reading times was observed compared to correct sentences for Person-Incorrect (Intercept: 616 ms, Estimate: 37 ms, SE: 13.04, $t = 2.84$, $p = .01$), Number-Incorrect (Intercept: 616 ms, Estimate: 29 ms, SE: 13.04, $t = 2.20$, $p = .03$) and Person-Number Incorrect (Intercept: 616 ms, Estimate: 25 ms, SE: 13.02, $t = 1.94$, $p = .05$). No difference emerged among the three types of agreement violations.

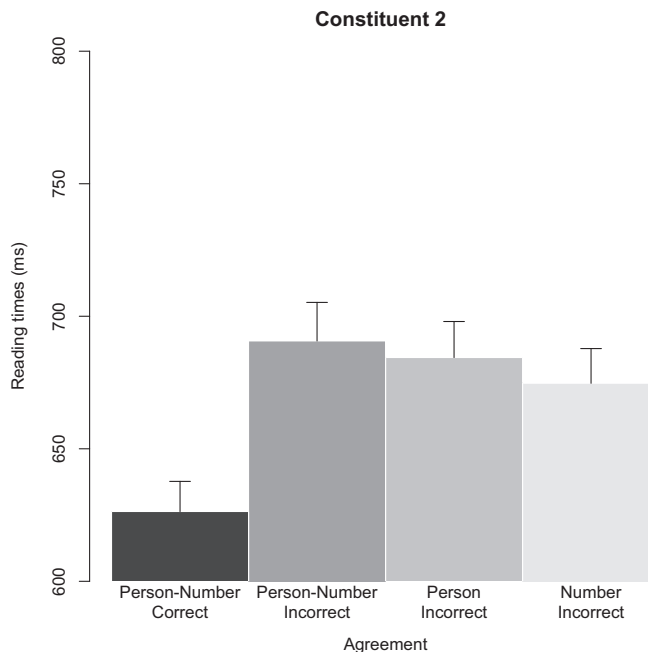


Fig. 1. Experiment 1: mean reading times for the four experimental conditions in Constituent 2.

3.1. Summary of results: Experiment 1

The goal of Experiment 1 was to compare Person and Number Agreement to see whether quantitative differences could be found in the processing of the two types of dependencies. As expected, the data revealed the presence of strong Person and Number Agreement effects, indicating that readers were aware of the agreement manipulations. However, the failure to find a difference between Person-Incorrect and Number-Incorrect sentences, as well as among the three anomalous sentences, seems to suggest that no functional difference can be drawn between the two types of agreement violations. In this respect, these data converge with findings from [Silva-Pereyra and Carreiras \(2007\)](#) in Spanish, in which neither qualitative nor quantitative ERP differences were found between the two types of agreement.

One caveat needs to be pointed out in the discussion of these data, namely that the failure to find a significant difference between Person and Number Agreement may be ascribed to the type of stimuli utilized. It is indeed known that pronominal forms are each characterized by a different underlying representation in terms of type and Number of speech participants ([Benveniste, 1966](#); [Harley and Ritter, 2002](#)). While I and You_{sg} entail unique speech participants with specific roles in discourse – a speaker and an addressee, respectively – 3rd person (both pronominal and lexical) indicates exclusion of both speaker and addressee, as it indexes a contextually salient individual that does not have any active role in the unfolding speech event ([Bianchi, 2006](#)). This distinction emerges even more clearly in plural forms. As a matter of fact, the uniqueness of I and You_{sg} prevents the I–We and You_{sg}–You_{pl} alternations from representing true pluralizations, i.e. shifts from a singular individual with a specific role to a multiplication of identical speakers and addressees. As a matter of fact, We and You_{pl} refer to composite groups respectively formed by a speaker and associate (i.e. We = I + You_{sg} or he/she) and an addressee and associate (You_{pl} = You_{sg} + he/she). It follows that a true pluralization can be produced only with 3rd person, which permits shifting from an individual to a multitude of individual equally deprived of speech role. In light of this, the distinction both in numerosity and speech roles of the I–We and You_{sg}–You_{pl} alternations used to create Number violations in Experiment 1 may have produced a spurious response, obscuring possible differences between person and Number violations.

4. Experiment 2

The goal of Experiment 2 is to overcome the potential confound highlighted above by testing Person and Number Agreement in a cleaner experimental design. Critically, a “pure” Person manipulation should contrast a non speech-participant and a speech-participant form (e.g. 3rd person vs. 2nd person), whereas a “pure” Number violation can be reliably produced only with 3rd person forms (e.g. singular vs. plural). This balance can be achieved by using lexical subjects, which enable us to keep the underlying feature make-up of the subject argument constant across the experimental material (a non-participant entity). If Person disagreement more severely affects agreement processing, longer RTs are expected not only for Person-Incorrect sentences, but also for the Person-Number Incorrect relative to Number-Incorrect sentences.

4.1. Materials and methods

4.1.1. Participants

78 undergraduate students (52 females, age 19–35, mean = 27) from the University of Siena took voluntarily part in the experiment. They were all native speakers of Italian. They all had normal or corrected-to-normal vision. None of them had participated in Experiment 1.

4.1.2. Design and materials

The same design, number and type of experimental and filler sentences as in Experiment 1 were used, except that now critical sentences display a lexical subject in Constituent 1 position (see [Table 3](#)).

Table 3
Sample of the experiment material for Experiment 2. Critical word in italic.

	Number	
	Ncor	Ninc
Person		
Pcor	Il giornalista <i>ha</i> scritto un libro The journalist _{3.sg} has _{3.sg} written a book	*Il giornalista <i>hanno</i> scritto un libro The journalist _{3.sg} have _{3.pl} written a book
Pinc	*Il giornalista <i>hai/ho</i> scritto un libro *The journalist _{3.sg} have _{2.sg/1.sg} written a book	*Il giornalista <i>avete/abbiamo</i> scritto un libro *The journalist _{3.sg} have _{2.pl/1.pl} written a book

Table 4

Mean reading times averaged across participants for Experiment 2 (Standard Error in parenthesis). (Pcor = Person Correct; Pinc = Person Incorrect; Ncor = Number Correct; Ninc = Number Incorrect).

		Number agreement	
		Ncor	Ninc
Person agreement			
Constituent 1	Pcor	613 (13.55)	615 (13.38)
	Pinc	619 (13.68)	627 (13.79)
Constituent 2	Pcor	743 (14.15)	797 (14.98)
	Pinc	831 (16.79)	824 (16.45)
Constituent 3	Pcor	721 (14.29)	725 (13.10)
	Pinc	773 (14.72)	751 (14.13)

Half of the sentences contained a 3rd person singular subject, while the other half had a 3rd person plural one. Half of the sentences in the Person-Incorrect condition contained a 1st person value on the verb, while the other half contained a 2nd person value.

4.1.3. Procedure

The procedure was the same as in Experiment 1.

4.1.4. Data analysis

Reading times (in milliseconds) were analyzed for each constituent separately, as in (3) below:

- (3) c_1 Il giornalista | c_2 ha scritto | c_3 un articolo
The journalist_{3,pl} has_{3,pl} written an article

Reading times that were higher or lower than 2.5 standard deviations around the mean of each subject in all conditions were removed, which led to a 1.5% of removals for constituent 1, 3.7% for constituent 2 and 2.7% for constituent 3. Reading times were analyzed by using the same statistical tests as in Experiment 1.²

Table 4 reports mean reading times (together with their standard error) averaged across participants, while the statistics resulting from the linear mixed-effect model analysis are reported in the text.

5. Results

Participants answered 94% (SD: 1.27) of the comprehension questions correctly.

Constituent 1. No significant effect emerged in this segment.

Constituent 2. Relative to Person-Number Correct sentences, a significant increase in reading times was found for Person-Incorrect (Intercept: 749 ms, Estimate: 96 ms, SE: 15.86, $t = 6.06$, $p = .001$), Number-Incorrect (Estimate: 59 ms, SE: 15.75, $t = 3.73$, $p = .001$) and Person-Number Incorrect ones (Intercept: 749 ms, Estimate: 90 ms, SE: 15.85, $t = 5.70$, $p = .001$), as Fig. 2 illustrates. Reading times for Number-Incorrect verbs were significantly faster compared to Person-Incorrect (Intercept: 845 ms, Estimate: -37 ms, SE: 15.90, $t = -2.34$, $p = .01$). Similarly, Number-Incorrect verbs elicited significantly faster reading times than Person-Number Incorrect ones (Intercept: 838 ms, Estimate: -31 ms, SE: 15.91, $t = -1.98$, $p = .05$).

² Because the length of the critical segment had not been balanced across conditions, in the analysis of Experiment 2 we also included Length (centered) in the fixed-effect structure of models that we tested. This was done in order to control for possible confounding interaction of Length and the two factors of interest, i.e. Person and Number Agreement. A step-wise procedure was followed so that pairs of models with gradually increasing complexity in the fixed-effect term were compared: from a simpler model in which only Person and Number agreement were included as interaction contrast (Person \times Number), to more complex ones in which Length was also included, first as a sum contrast (Person \times Number + Length) and then as interaction contrast (Person \times Number \times Length). Length was also introduced in the random-effects structure of the models, when including the slopes of the interaction between subject/items and Person/Number Agreement. However, limitations in the estimation algorithm caused these models not to converge. A simpler model was therefore adopted. As expected, longer segments were found to elicit significantly longer reading times compared to shorter segments (Intercept: 749 ms, Estimate: 9 ms, SE: 4.12, $t = 2.37$). However, neither a three- nor two-way interaction between the Length and the Person and Number Agreement factors was found.

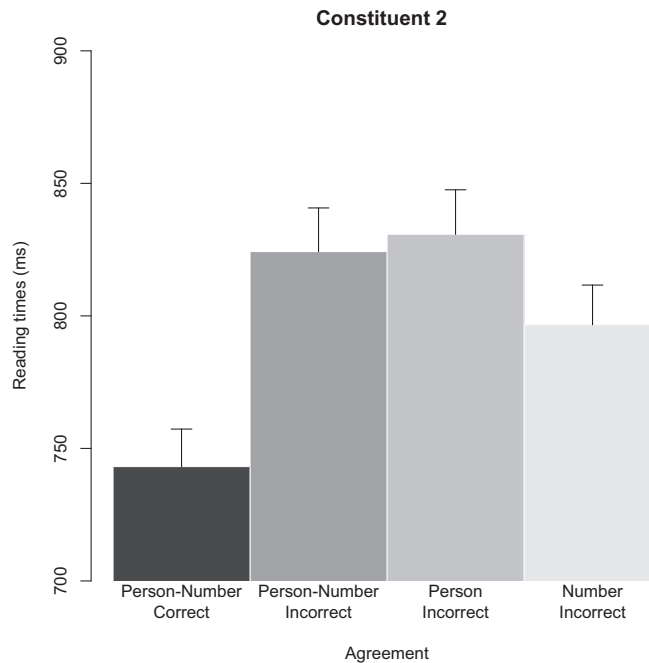


Fig. 2. Experiment 2: mean reading times for the four experimental conditions in Constituent 2.

Constituent 3. At sentence-final position, the Person-Incorrect condition yielded significantly longer reading times compared to the Person-Number correct one (Intercept: 730 ms, Estimate: 48 ms, SE: 14.52, $t = 3.23$, $p = .01$). Number-Incorrect sentences were found to elicit significantly faster reading times than Person-Incorrect (Intercept: 776 ms, Estimate: -44 ms, SE: 14.49, $t = -2.98$, $p = .01$). The comparison between Number-Incorrect and Person-Number Incorrect sentences revealed a trend toward significance, with the former condition eliciting faster reading times (Intercept: 759 ms, Estimate: -25 ms, SE: 14.49, $t = 1.78$, $p = .07$).

5.1. Summary of results: Experiment 2

In Experiment 2, the reading of Person-anomalous verbs was found to give rise to quantitatively different reading times compared to Number-anomalous verbs, but not to Person-and-Number violated ones. Importantly, this effect emerged both at the critical point and in the following segment, thus indicating that the disruption of a violation involving Person Agreement spills over the anomalous point and reaches subsequent positions.

Taken together, these results point toward the presence of distinct degrees of complexity for Person and Number Agreement, with the former generating greater processing difficulty than the latter type of agreement. We believe that this complexity may be due to the different levels of analysis on which the interpretation of Person Agreement taps (i.e. the morphosyntactic and the speech act participant representation ones). This is discussed more in depth below.

6. General discussion

The purpose of the present study was to investigate whether different degrees of complexity could be associated with the processing of Person and Number, in view of the different interpretive properties attributed to the two features (Bianchi, 2006; Mancini et al., 2013; Sigurdsson, 2004, 2009, 2012; Sigurdsson and Holmberg, 2008).

The data have showed that the behavioral response to an agreement violation can *quantitatively* change as a function of the feature being manipulated. This modulation is clearly visible in the difference found between Person and Number Agreement violations in Experiment 2. What this pattern of data reveals is the presence of a greater cognitive penalty induced by anomalies involving the Person feature relative to violations of Number agreement. In other words, after encountering a Person anomaly, the performance of repair operations appears to be more costly than in the presence of a Number violation. This fits well and complements previous ERP data from Spanish (Mancini et al., 2011b) and Hindi (Nevins et al., 2007) that showed qualitatively distinct patterns for the two types of disagreement, as well behavioral data

from Italian (Carminati, 2005), but is clearly divergent from the Spanish data reported by Silva-Pereyra and Carreiras (2007). In our view, the different results between the second Experiment reported here and Silva-Pereyra and Carreiras's (2007) study cannot be ascribed to differences between the two languages tested, as both Italian and Spanish are richly inflected languages with similar characteristics. This divergence may be due to the different composition of the experimental materials, as already hypothesized above and by Mancini et al. (2011b).

Why should the parser distinguish between Person and Number, and why should a Person violation be perceived as more severe than a Number violation? We propose that the dissociation between the two features may result from their inherently different anchoring requirements that the two features impose for their interpretation (Bianchi, 2006; Mancini et al., 2013; Sigurdsson, 2004, 2009, 2012, Sigurdsson and Holmberg, 2008) and that are likely to influence the way the parser deals with Person and Number agreement anomalies. Whenever the anchoring between the morphosyntactic and the speech act participant representation that characterizes Person Agreement is broken, as in “**Il giornalista_{3.sg} hai_{2.sg} scritto un articolo*” (*The journalist_{3.sg} have written_{2.sg} an article), the parser cannot reliably associate arguments with speech participants and their roles, therefore failing to identify whether the subject of predication is about a third party or an addressee involved in a writing event. Unlike Person, Number does not rely on a direct morphosyntax-speech act representation anchoring. In “**il giornalista_{3.sg} hanno_{3.pl} scritto un articolo*”, what is unclear is how many journalists are involved in the writing event, but regardless of their number, the event being reported is about a third party involved in a writing event. It follows that, while still disrupting processing, a Number anomaly does so less radically. The shorter latencies and the more circumscribed effect of Number compared to Person violations may therefore index an easier retrieval of the right cue to repair the broken agreement dependency and allow the assignment of a coherent interpretation to the sentence.

Crucially, such a distinction fits with findings from Italian (De Vincenzi et al., 2003) showing that Number agreement violations are more easily and more quickly “fixed” compared to semantic-pragmatic violations, as well as with previous studies comparing e.g. Gender and Number agreement that pointed to the relevance of feature interpretive requirements to interpret agreement dependencies (De Vincenzi, 1999; De Vincenzi and Di Domenico, 1999; Faussart et al., 1999). As suggested by Faussart et al. (1999), while repairing a Number mismatch involves reprocessing inflectional information on the controller, fixing a Gender anomaly requires accessing information that is encoded outside of the morphosyntactic dimension, namely the lexical representation of the sentence. Under this view, Gender and Person agreement anomalies may be expected to pattern partially alike, with respect to self-paced reading, since their effects seem to involve other levels of analysis besides the morphosyntactic one, namely, the lexical and the discourse ones respectively.

To conclude, these data point toward a theoretical and psycholinguistic description of agreement computation that goes beyond a simple feature-checking mechanism: a more articulated account is proposed that centers around core properties of the elements involved in a dependency, such as their role in the speech event and their being singular or plural entities.

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