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## **Prediction of phonological and gender information:**

### **An event-related potential study in Italian**

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## Abstract

Do people predict different aspects of a predictable word to the same extent? We tested prediction of phonological and gender information by creating phonological and gender mismatches between an article and a predictable noun in Italian. Native Italian speakers read predictive sentence contexts followed by the expected noun (e.g., *un incidente*: ‘accident’) or another plausible, but unexpected noun, either beginning with a different phonological class (consonant vs. vowel, e.g., *uno scontro*: ‘collision’; phonological mismatch) or belonging to a different gender class (e.g., *un’inondazione*: ‘flooding’; gender mismatch). Phonological mismatch articles elicited greater negativity than expected articles at posterior channels around 450 – 800ms post-stimulus. In contrast, gender mismatch articles elicited greater negativity than expected articles at left posterior channels around 250 – 800ms. Unexpected nouns showed an N400 effect followed by frontal positivity relative to expected nouns. The earlier effect for the gender mismatch articles suggests that people are quicker or more likely to pre-activate gender information vs. phonological information of a predictable word. We interpret the results with respect to production-based prediction accounts.

Keywords: Prediction, Sentence comprehension, Event-Related Potentials, N400

## ***1 Introduction***

It has been widely shown that people can predict information about upcoming words during language comprehension when the sentence context allows it (i.e., is predictive; e.g., Altmann & Kamide, 1999; Federmeier & Kutas, 1999; for a review, see Kuperberg & Jaeger, 2016; Pickering & Gambi, 2018). While people can predict various types of information, phonological information is less likely to be predicted compared to semantic information (Ito, Corley, Pickering, Martin, & Nieuwland, 2016). However, it is unclear whether people predict different types of lexical information to the same extent (e.g., gender against phonology). Production-based prediction models (e.g., Pickering & Gambi, 2018) predict that comprehenders are more likely or quicker to predict gender (syntactic) information than phonological information, because pre-activation of lexical representations follows the stages of lexical activation in language production (i.e., semantics - syntax - phonology). We investigated whether people predict phonological and gender information at a similar rate and speed, making use of indefinite articles in Italian.

In Italian, articles are required to agree with the noun they modify both in phonology (if the noun immediately follows the article) and gender (regardless of whether the noun follows the article immediately or after an intervening adjective). Therefore, if semantic context strongly predicts an upcoming noun, the presence of an article that mismatches in phonology or gender may cue comprehenders to a prediction failure and interfere with processing even before a noun occurs. Furthermore, since most modifiers occur after the noun in Italian, the probability of an article being immediately followed by a noun is high (70-87%, estimate from itWaC corpus; Baroni,

Bernardini, Ferraresi, & Zanchetta, 2009). Italian, therefore, provides a good chance to detect effects of both phonological and gender prediction, if these effects are present.

Below, we will first discuss the production-based prediction models and review available evidence before introducing our study.

### ***1.1 Production-based prediction models***

Production-based prediction models (Dell & Chang, 2014; Federmeier, 2007; Huettig, 2015; Pickering & Gambi, 2018; Pickering & Garrod, 2013) propose that people use their production system to pre-activate lexical representations of upcoming words. According to the prediction-by-production mechanism (Pickering & Gambi, 2018; Pickering & Garrod, 2013), people covertly use their production system to implement the most likely upcoming words during comprehension. This approach predicts that lexical representations of upcoming words are pre-activated using the same mechanism that people use to produce words, and such pre-activation follows the same stages as in language production.

According to prominent production models (Dell & O'Seaghdha, 1992; Levelt, Roelofs, & Meyer, 1999), people first activate semantic (conceptual) information of the word they are to produce, retrieve a lemma that corresponds to the concept, which activates the word's syntactic information, and then retrieve phonological information corresponding to the lemma. Accordingly, under the prediction-by-production mechanism, lexical representations of upcoming words are pre-activated in the order of semantics, syntax and phonology. Word production is also resource-intensive, and the stage from conceptual preparation to phonological encoding takes about a few hundred milliseconds (Indefrey & Levelt, 2004). According to prediction-by-production, lexical

representations are pre-activated following a similar time-course. Thus, when there is not enough time or resources, people might not be able to fully implement representations for the predicted word at all stages, and instead they may only pre-activate the information that corresponds to an earlier stage but not the information that corresponds to later stages. Because the activation of phonology follows the activation of syntax in production, people might pre-activate syntactic (gender) information without pre-activating phonological information but, importantly, not vice versa.

## ***1.2 Evidence for prediction during language comprehension***

Many studies have demonstrated that people can predict some information about upcoming words during comprehension. For example, Federmeier and Kutas (1999) found that people predict the semantic category of a predictable word when they read predictive contexts. In their study, participants read sentence contexts that were predictive of a specific word (e.g., “*They wanted to make the hotel look more like a tropical resort. So along the driveway, they planted rows of...*”). These contexts were followed by the expected word (e.g., *palms*), an unexpected word from the same semantic category as the expected word (e.g., *pin*es), or an unexpected word from a different semantic category (e.g., *tulips*). Although both types of unexpected words elicited an N400 effect, unexpected but semantically related words elicited a reduced N400 effect relative to the unexpected and unrelated words, an effect that was greater for items in which 90% of the participants completed the context with the expected word in a separate cloze test, compared to items in which only 59% of participants in the cloze test completed the context with the expected word. This cloze-dependent N400 reduction was taken as evidence for prediction of semantic information. These

results have been replicated and extended in several studies (e.g., Metusalem et al., 2012; Thornhill & Van Petten, 2012; Wlotko & Federmeier, 2015), and evidence for semantic prediction has been found in eye-tracking studies as well (e.g., Altmann & Kamide, 1999; Ito, Corley, & Pickering, 2018; Kukona, Fang, Aicher, Chen, & Magnuson, 2011).

### ***1.3 Prediction of gender information***

While semantic prediction does not necessarily involve prediction of a specific upcoming word (e.g., on hearing the verb *eat*, people may predict an edible object rather than a specific word), in highly predictive sentences people may also predict information that is more specific about an upcoming word, such as its grammatical gender. Wicha, Moreno, and Kutas (2004) had native Spanish speakers read high-cloze sentences (mean cloze probability = 80%) where the expected noun was preceded by either a correctly gender-marked article (e.g., *la*-Feminine *corona*-Feminine; ‘*the crown*’) or an incorrectly gender-marked article (e.g., *el*-Masculine *corona*-Feminine). Gender mismatch articles elicited a widely-distributed late positivity around 500 – 700 ms. This gender mismatch effect at articles was taken as strong evidence for lexical prediction, because this effect cannot be due to the processing of the critical word (e.g., difficulty of integrating the word into the context).

Foucart, Martin, Moreno, and Costa (2014) also found a gender mismatch effect at articles although the ERP reflecting this effect was different from the ERP in Wicha et al. (2004). In their study, articles that mismatched the gender of the expected noun elicited a widely-distributed, long-lasting negativity between 300 – 600 ms compared to expected articles. Using the same manipulation, Martin, Branzi, and Bar (2018) found a

similar negativity for gender mismatch articles in a 300 – 500 ms window. In both studies, the negativity appears to have lasted up to around the onset of the noun (700 ms after the article onset). In Dutch, Otten and Van Berkum (2009) manipulated the gender of articles and found a larger negativity for articles that mismatched the gender of the expected noun in 200 – 600 ms, which was strongest over the right hemisphere.

Gender mismatch effects have also been found in auditory comprehension. Van Berkum, Brown, Zwitserlood, Kooijman, and Hagoort (2005) used gender-marked adjectives in Dutch and found a larger positivity for adjectives whose gender inflection mismatched the expected noun compared to adjectives whose gender inflection matched the expected noun at anterior and right-posterior electrodes in a 50 – 250 ms window relative to the inflection onset (which was 329 ms relative to the acoustic onset of the adjective on average). Otten, Nieuwland, and Van Berkum (2007) also manipulated the gender inflection of Dutch adjectives but found a larger negativity for adjectives with unexpected gender inflection at right-frontal electrodes in a 300 – 600 ms window relative to the adjective onset. While again the particular ERP responses to gender-mismatching articles were inconsistent in terms of the polarity, distribution, and latency, together with the studies that manipulated gender in Spanish, they support some form of gender prediction in language comprehension.

Because these studies differed in a number of ways (e.g., language, modality, word-by-word presentation rates, inclusion of ungrammatical/anomalous sentences), it is unclear what caused the inconsistency between the observed ERP responses. Such inconsistency also raises the question of how robust the reported effects are.

Additionally, a replication attempt of Otten and Van Berkum (2009) by Kochari and



Flecken (2019) failed to find any effects for gender mismatch articles in Dutch. Finally, it is also unclear what these gender-mismatch effects reflect: They may reflect disconfirmation of the predicted noun, or they may reflect reanalysis or revision of the predicted information (because the gender mismatch articles/adjectives signal that the predicted noun will not follow). However, on balance, these results suggest that people often predict the gender of upcoming nouns when the context is highly predictive.

#### ***1.4 Prediction of phonological information***

Evidence for phonological prediction is rather mixed. Some ERP studies adapted the design of Federmeier and Kutas (1999) and found evidence for phonological/orthographic prediction (Ito et al., 2016; Kim & Lai, 2012; Laszlo & Federmeier, 2009). In Laszlo and Federmeier (2009), participants read high-cloze sentences that contained the expected word (e.g., *bank*), an unexpected word (e.g., *bark*) or pseudoword (e.g., *pank*) that was unexpected but orthographically related to the expected word, or a related illegal letter string (e.g., *bxnk*). In the unrelated condition, participants read high-cloze sentences that contained the expected word (e.g., *fall*), an orthographically unrelated word (e.g., *hook*), a pseudoword (e.g., *jank*), or an illegal string (e.g., *tknt*). Laszlo and Federmeier (2009) found reduced N400 effects for unexpected forms that were orthographically related to the expected word compared to unexpected and orthographically unrelated forms (see also Kim & Lai, 2012). The N400 reduction for orthographically related words was dependent on cloze probability (Ito et al., 2016), and the cloze-dependent N400 reduction suggests that people can predict the form of the expected word. Behavioural studies have also found that people can predict fine-grained orthographic information of an upcoming word (Luke & Christianson, 2012, 2015).

While even stronger evidence for prediction would come from studies that find an effect before the expected word is encountered (i.e., similarly to the studies mentioned in the previous section that measured effects on articles preceding the critical noun), studies that investigated prediction using English *a/an* articles have not found consistent results (DeLong, Urbach, & Kutas, 2005; Ito, Martin, & Nieuwland, 2017a; Martin et al., 2013; Nieuwland et al., 2018). In DeLong et al. (2005), participants read sentence contexts that varied in cloze probability (e.g., “*The day was breezy so the boy went outside to fly...*”) and were followed by the most expected article + noun (e.g., *a kite*) or an unexpected article + noun (e.g., *an airplane*). Critically, the expected noun began with a consonant and the unexpected noun with a vowel, or vice versa. Thus, if participants predict phonological information of the expected noun, the phonologically mismatching article (e.g., *an* when *kite* was expected) would disrupt processing already at the article. They found that the N400 amplitude for articles correlated with the cloze probability of the article. However, they found no reliable ERP effect for unexpected articles compared to expected articles.

Martin et al. (2013) adapted this design and had participants read high-cloze sentences (Mean cloze = 69%) that contained an expected or unexpected article + noun. In their study, unexpected articles elicited a larger negativity at frontal-central electrodes after 250 – 400 ms compared to expected articles. The N400-cloze correlation in DeLong et al. (2005) and the negativity for unexpected articles in Martin et al. (2013) were taken as evidence for lexical prediction.

However, neither of these effects was replicated in later studies (Ito et al., 2017a; Nieuwland et al., 2018). Nieuwland et al. (2018) in particular used a large scale

replication including 356 participants across nine laboratories and failed to detect an N400-cloze correlation. An exploratory Bayes factor analysis of the N400-cloze correlation suggested that any effect size for phonological prediction would be quite small. These studies raise the question of how robust the *a/an* article effects are (for more discussions about the replicability of these effects, see DeLong, Urbach, & Kutas, 2017; Ito, Martin, & Nieuwland, 2017b; Nieuwland et al., 2018; Yan, Kuperberg, & Jaeger, 2017). As with gender prediction, there has been inconsistency in the ERPs reported for phonological mismatch.

### ***1.5 Reliability of gender and phonological prediction***

Our review of the literature on gender and phonological prediction has found that prediction-mismatch gender elicits variable ERP effects, and prediction-mismatch phonology does not consistently elicit a reliable ERP effect. While this may suggest both effects can be inconsistent and unreliable, the gender-mismatch effect has been far more reliable across studies compared to the phonological-mismatch effect. Despite some variability, many of the studies manipulating the gender of an article/adjective preceding a predictable noun found a long-lasting negativity starting around 200 - 300 ms relative to the article onset. Compared to that, evidence for phonological prediction demonstrated at pre-nominal articles is much scarcer, which suggests that prediction of phonological information may be less robust compared to prediction of gender information.

One possible reason for the inconsistent and unreliable nature of phonological prediction effects may be that pre-activation of phonological information occurs later in the time course of prediction compared to the pre-activation of gender and semantic

information. This is in line with the finding that people predicted semantic information at a word-by-word reading rate of 500 ms (standard in ERP studies) but predicted both semantic and phonological/orthographic information when they had more time (700 ms) to read each word (Ito et al., 2016). If the prediction of phonological information takes more time than gender and semantic information, then people may fail to reach that stage of predictive processing more often than earlier stages, leading to less phonological prediction overall. Similarly, if the prediction of gender information takes more time than semantic information, then people may fail to pre-activate gender information more often than semantic information, causing it to be somewhat less robust than semantic prediction, but more robust than phonological prediction.

Another possible reason for the lack of phonological-mismatch effects relates specifically to the *a/an* manipulation. The *a/an* phonological rule is not realised by agreement between the article and the noun but between the article and the initial phoneme of the next word, and the occurrence of an intervening word is very common in English (67% written, 30% spoken, Ito et al., 2017b; Yan et al., 2017). If people make phonological predictions only for the next upcoming word, then the probability that the expected noun comes directly after the article should play an important role in determining when or whether such phonological information should be pre-activated. Alternatively, since prediction-mismatch *a/an* articles do not necessarily disconfirm the expected noun but do signal that the expected noun does not occur next, they may have different processing consequences than gender mismatch articles which unambiguously signal the occurrence of another noun. For example, if people predict phonological information of the expected noun based on a predictive context and also predict that

noun will occur immediately after the context and an article, articles that phonologically mismatch the expected noun may trigger a reanalysis of the prediction about the position of the expected noun – that is, that the expected noun will occur later. However, if people predict phonological information of the expected noun but do not make a strong prediction that the expected noun occurs immediately after the article, phonologically mismatching articles may not strongly interfere with processing.

## **1.6 The current study**

We investigated prediction of phonological and gender information of upcoming words using indefinite articles in Italian, which agree in both gender and phonology with an immediately following noun. Following previous studies (DeLong et al., 2005; Otten & Van Berkum, 2009; Wicha et al., 2004), we measured ERPs for prediction-match articles and prediction-mismatch articles. Native Italian speakers read high-cloze sentence contexts (e.g., *Il traffico in autostrada è rimasto bloccato a causa di...*; “*The traffic on the motorway came to a standstill because of...*”) followed by the expected article + expected noun (e.g., *un*-Masculine *incidente*-Masculine; ‘*accident*’), a phonological mismatch article + unexpected noun (e.g., *uno*-Masculine *scontro*-Masculine; ‘*collision*’), or a gender mismatch article + unexpected noun (e.g., *un*’-Feminine *inondazione*-Feminine; ‘*flooding*’).

If people predict the expected noun’s gender and phonological information, we expected that both gender mismatch and phonological mismatch articles will elicit a differential ERP relative to the expected article, which may indicate an error signal or reanalysis/revision of the expected noun. In terms of the time-course of prediction, prediction-by-production accounts assume that people predict gender information earlier

than phonological information. Therefore, if people more often predict gender information but not phonological information by the time they encounter the article, we expect to find an earlier ERP effect for gender mismatch articles than for phonological mismatch articles. Additionally, since gender mismatch articles immediately disconfirm an occurrence of the expected noun, but phonological mismatch articles do not (i.e., the expected noun may still occur), the articles may not be used as strong cues to determine the upcoming noun's phonology. If this is the case, we may find different types of ERPs reflecting different types of processes. However, in Italian, the probability that a noun immediately follows an article is high (70-87%), because many adjectives occur post-nominally (Cardinaletti & Giusti, 2011). Thus, it is possible that studies in Italian may be more likely to detect effects of phonology at the article than those in English.

## **2 Methods**

### **2.1 Participants**

Twenty-nine native Italian speakers (Mean age = 27 years,  $SD = 4$  years, 10 males) who reported normal vision and no language or neurological disorders participated in the experiment. Four further participants were tested but were excluded from analysis because their data contained more than 30% of artefact trials. All participants were right-handed. Except for one participant, who was from Switzerland, all participants were from Italy. Participants were tested at the University of Oxford. The study was approved by the ethics committee at the University of Oxford. All participants signed an informed consent form before the participation.

## 2.2 Stimuli

We constructed 126 items (selected from a candidate set of 150 items), which consisted of a sentence context that was predictive towards a specific noun (e.g., *Il traffico in autostrada è rimasto bloccato a causa di...*; “*The traffic on the motorway came to a standstill because of...*”), followed by an indefinite article and a critical noun. In the *expected* condition, the critical noun was the expected noun (e.g., *un*-Masculine *incidente*-Masculine; ‘*accident*’). In the *phonological mismatch* condition, the critical noun was a noun that belonged to a different phonological class to the expected noun, thus requiring an article that mismatched the expected noun in phonology (e.g., *uno*-Masculine *scontro*-Masculine; ‘*collision*’). In the *gender mismatch* condition, the critical noun was a noun that was a different gender to the expected noun, thus requiring an article that mismatched the expected noun in gender (e.g., *un*’-Feminine *inondazione*-Feminine; ‘*flooding*’). Thus, the article mismatched the expected noun in either phonology or gender, and never mismatched in both. Table 1 summarises how the indefinite articles in Italian are conditioned by the phonological information of the next word. While the word after *un* could start with a vowel or a consonant, we only used nouns that started with a vowel to keep the distinction similar to the feminine articles.

Table 1. Gender and phonological constraints for indefinite articles in Italian.

| <b>Article</b> | <b>Gender</b> | <b>Next word’s first phoneme(s)</b>  |
|----------------|---------------|--|
| <i>un</i>      | masculine     | vowel or consonant (except those used for <i>uno</i> )                             |
| <i>uno</i>     | masculine     | /s/ or /z/ followed by a consonant, /f/, /ps/, /pn/, /dz/, /ts/, /ks/, /j/, or /ɲ/ |
| <i>un</i> ’    | feminine      | vowel  |
| <i>una</i>     | feminine      | consonant  |

The mean sentence length for the critical sentences was 16.6 words ( $SD = 5.1$  words). We additionally included 42 filler sentences that had a similar length to the critical sentences ( $M = 16.6$  words,  $SD = 2.6$  words).

We evaluated the predictability of the expected noun in two cloze tests (only the items that yielded a cloze probability of lower than 50% in the first test were included in the second test, following modification). For these tests, we recruited native Italian speakers who were living in the UK ( $N = 20$  for the first test,  $N = 19$  for the second test). Participants saw each sentence context and completed the context with the word or phrase that first came to mind. We excluded the items whose cloze probability (the proportion of participants who completed the context with the expected noun) was less than 50% following the second test. The mean cloze probability for the final set of critical sentences was 81% ( $SD = 17%$ , range = 0-100%)<sup>1</sup> for the expected article and 84% ( $SD = 16%$ , range = 50-100%) for the expected noun. The mean cloze probability for unexpected nouns was 2% ( $SD = 6%$ , range = 0-33%) in the phonological mismatch condition and 2% ( $SD = 6%$ , range = 0-40%) in the gender mismatch condition.

We then evaluated the plausibility of the sentences in each condition in a plausibility rating test. We created three lists for this test, so that participants rated only one of the conditions per item. We added 80 implausible filler sentences to each list, so that participants would not see only plausible sentences. We recruited 10 native Italian speakers who were living in the UK per list. Participants saw each sentence and rated the plausibility of the sentence on a scale from 1 (not plausible at all) to 5 (very

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<sup>1</sup> The article cloze probability was zero for one item, because the expected noun was always preceded by a definite article. The minimum article cloze probability excluding this item was 28% ( $Mean = 81%$ ,  $SD = 16%$ ).



plausible). We excluded the items if the plausibility for the phonological mismatch or gender mismatch condition was lower than 1.5, or if the plausibility rating difference between the phonological mismatch and gender mismatch conditions was larger than 2. We then excluded 2 more items to make the number of items divisible by 3. The mean plausibility was 4.8 ( $SD = .3$ ) for the expected condition, 3.7 ( $SD = 1.0$ ) for the phonological mismatch condition, and 3.6 ( $SD = 1.0$ ) for the gender mismatch condition. A paired  $t$ -test showed no significant difference in plausibility ratings between the phonological mismatch and gender mismatch conditions,  $t(125) = -1.4, p = .16$ . All critical sentences with cloze probability and plausibility rating are available in the Appendix.

### **2.3 Procedure**

The 168 sentences were divided into three lists, so that each list contained the same number of items in each condition and only one condition per item. The sentences were pseudo-randomised, so that participants did not see more than two consecutive sentences in the same condition, with the same article, or with a comprehension question with the same correct answer. Forty-four sentences were followed by a yes-no comprehension question (of those, 32 questions were given after a critical sentence).

Participants were tested in a single session in a soundproof, electrically shielded room. They were seated in a chair in front of a 32" HD LED screen (Samsung Smart TV) positioned approximately 120 cm away and instructed to read the sentences for comprehension while avoiding eye and body movements and blinks. The session began with six practice sentences before presentation of the experimental stimuli to accustom participants to the stimulus presentation.

Each trial began with a fixation cross, and participants pressed an Enter key to start reading the sentence. They silently read sentences word-by-word (300 ms duration, followed by a blank screen of 300 ms duration) from a computer display. The article *un*’ is never separated by a space from the noun in standard writing in Italian, but we presented all occurrences of *un*’ separately from the noun (because *un*’ is one word). When the sentence was followed by a comprehension question, they were asked to respond by pressing 1 for yes and 3 for no. The mean accuracy for the comprehension questions was 89% ( $SD = 4.9$ , range = 79 – 95%). The experiment was divided into four blocks, and participants were encouraged to take a short break between the blocks. The experiment took about 35-55 minutes.

#### ***2.4 Electroencephalogram (EEG) recording and data processing***

The electroencephalogram (EEG) was recorded on a 64-channel ANT Neuro system, mounted in an elastic cap, and referenced to the Cz electrode. Blinks and eye movements were registered by placing an electrode under each eye. Electrode impedance was kept below 20 k $\Omega$  throughout the experiment. The EEG was amplified with an ANT Neuro amplifier and sampled with a frequency of 512 Hz.

We processed the EEG data offline using EEGLAB toolbox (Delorme & Makeig, 2004) and ERPLAB plug-in (Lopez-Calderon & Luck, 2014). Artefact detection/correction was done using algorithms from FASTER (Nolan, Whelan, & Reilly, 2010). Channels with local artefacts were interpolated when possible. EEG data were filtered (0.1 – 40 Hz), segmented into -200 ms to 1000 ms epochs time-locked to the onset of the article or the noun, re-referenced to the average of all channels, and baseline-corrected using the -100 ms to 0 ms time window relative to the target article

or noun onset. Participant-averaged ERPs were formed from trials free of ocular and muscular artefacts. Grand average ERPs were formed using 29 participants for articles and 25 participants for nouns. For the article data, 9.5% of the data were rejected (10.3% for the expected condition, 8.4% for the phonological mismatch condition, and 9.9% for the gender mismatch condition). For the noun data, 11.5% of the data were rejected (11.1% for the expected condition, 11.0% for the phonological mismatch condition, and 12.4% for the gender mismatch condition).

## **2.5 Statistical analysis**

Mean amplitude was computed per condition at 16 medial-central EEG electrodes (F1/F3/FC1/FC3/CP1/CP3/P1/P3 plus right-hemisphere equivalents), in an early time window (250 – 450 ms) and a late time window (450 – 800 ms) for articles, and in an N400 time window (350 – 500 ms) and a frontal positivity time window (500 – 1000 ms) for nouns. We selected the time windows for articles based on visual inspection because ERP effects for prediction-mismatch articles have been found in varied time windows, but these windows capture both an early effect (e.g., Foucart et al., 2014; Martin et al., 2013) and a late effect (e.g., Wicha et al., 2004) found in previous studies. For nouns, we selected these time windows so that the typical peaks of an N400 effect (around 400 ms) and a frontal positivity effect (around 700 – 800 ms) are both captured (Kutas & Hillyard, 1984; Thornhill & Van Petten, 2012; Van Petten & Luka, 2012).

We tested effects of condition and distribution of the effects with linear mixed-effects models using the *nlme* package (Pinheiro, Bates, DebRoy, & Sarkar, 2019; version 3.1-140) in R. The models tested the main effects of condition (expected, phonological mismatch, gender mismatch), hemisphere (left, right), and anteriority

(frontal-central, central-posterior), 2-way interactions of condition by hemisphere and condition by anteriority, and a 3-way interaction of condition by hemisphere by anteriority. We followed up a significant interaction of condition by hemisphere or/and anteriority with linear mixed-effects models testing an effect of condition in each ROI. All models included a by-subject random intercept. All factors (condition, hemisphere and anteriority) were deviation-coded. For condition, the expected condition served as the baseline condition. *P*-values for the follow-up tests were corrected using Bonferroni correction for the number of tests performed.

To confirm the results from the analysis described above, we repeated the same analysis for each 100 ms time bin for 0-600 ms relative to the article onset and 0-800 ms relative to the noun onset. None of the article bins overlap with the noun window, so effects in these time bins are unaffected by the presentation of the noun. We extended the time bin for the noun up to 800 ms after the noun onset to capture a late frontal positivity effect. For this analysis, we corrected for the number of tests performed in each dataset (i.e., article data and noun data) using Bonferroni correction.

### **3 Results**

Grand average ERP waveforms for each condition and scalp distribution of the effects are shown in Figure 1 (articles), Figure 2 (time-course of effects at articles and nouns) and Figure 3 (nouns). Visual inspection of Figure 1 and 2 suggests that phonological mismatch articles elicited a negativity compared to expected articles at posterior channels starting around 450 ms, and gender mismatch articles elicited a negativity compared to expected articles at left posterior channels starting around 250

ms. Figure 3 suggests that unexpected nouns elicited a classic N400 effect, followed by a frontal positivity.

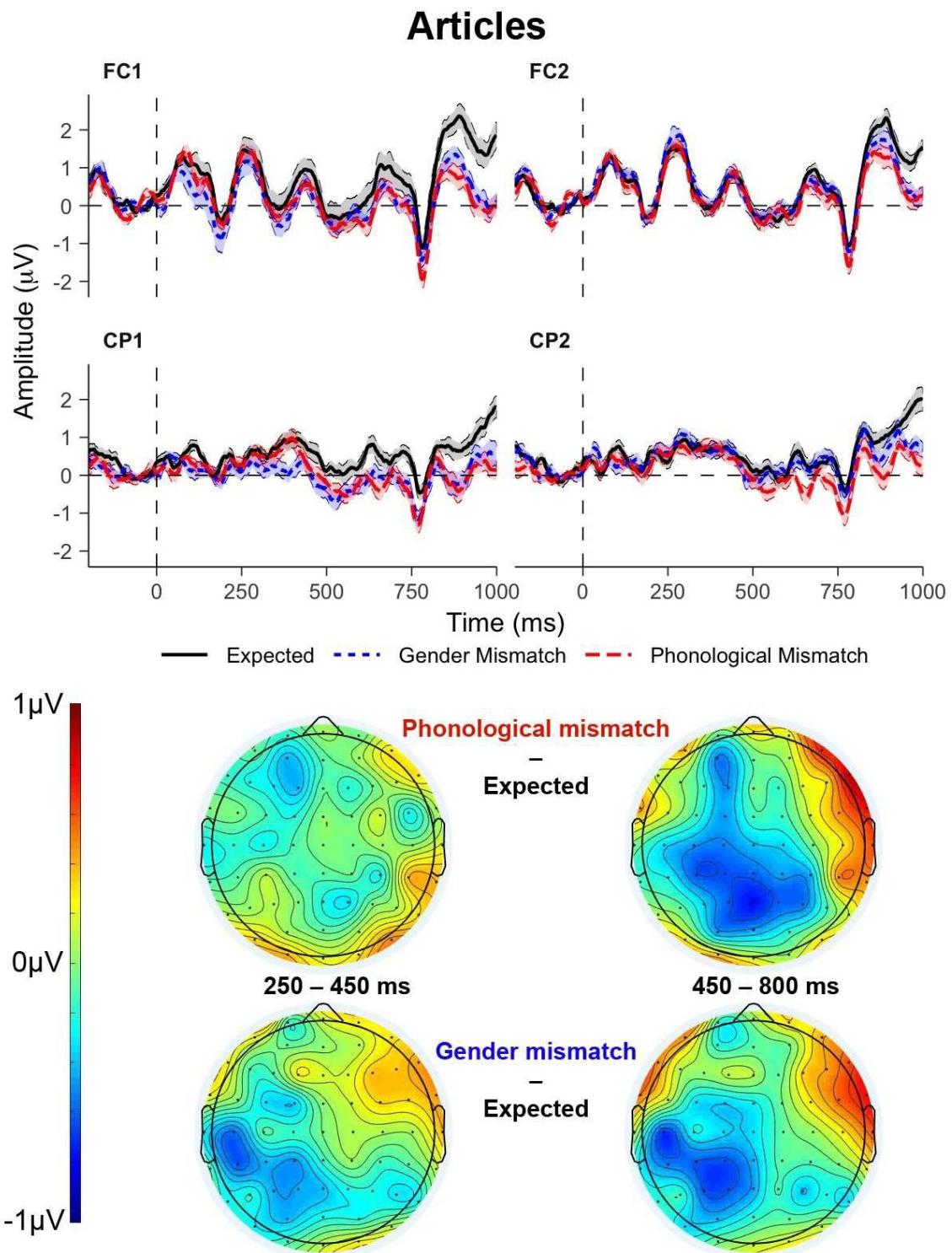


Figure 1. ERPs elicited at the article by each condition at four medial-central electrodes (top panel) and scalp distributions of the ERP effects (the mismatch conditions minus the expected condition) in the early (250 – 450 ms) and late (450 – 800 ms) time

windows (bottom panel). The shaded area in the ERP waveform plots represent standard errors.

### **3.1 Article: 250 – 450 ms**

The analysis revealed a significant interaction of gender mismatch by hemisphere,  $t(308) = 3.6, p < .001$ , and a marginally significant interaction of phonological mismatch by hemisphere,  $t(308) = 1.7, p = .09$ . Follow-up tests for each hemisphere (right, left) revealed a negativity for the gender mismatch condition relative to the expected condition in the left hemisphere,  $t(56) = -2.5, p = .03$  (.08  $\mu\text{V}$  vs. .39  $\mu\text{V}$ ), but there was no effect of phonological mismatch,  $t(56) = -1.0, p = .63$  (.26  $\mu\text{V}$  vs. .39  $\mu\text{V}$ )<sup>2</sup>. In the right hemisphere, neither of the mismatch conditions elicited different ERPs from the expected condition,  $ps > .9$ . Thus, gender mismatch articles elicited a negativity in the left hemisphere relative to the expected articles in the 250 – 450 ms time window, but phonological mismatch articles did not.

### **3.2 Article: 450 – 800 ms**

The analysis revealed significant effects of gender mismatch,  $t(308) = -2.0, p = .047$ , and phonological mismatch,  $t(308) = -3.3, p = .001$ , and a significant gender mismatch by hemisphere interaction,  $t(308) = 2.5, p = .01$ . Follow-up tests for each hemisphere found more negative ERPs in the left hemisphere for the gender mismatch

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<sup>2</sup> Since *un'* is never separated from the immediately following noun unlike *una* in standard writing in Italian, we additionally tested the possibility that the gender mismatch effect was primarily driven by the *un-un'* mismatch, because readers may find it odd to encounter *un'* on its own. To do so, we tested for an interaction of condition (gender mismatch vs. expected) and article mismatch type (*un-un'* vs. *uno-una*) in the left hemisphere ROI, where the gender mismatch effect was statistically significant. There was a significant effect of condition,  $t(84) = -2.5, p = .01$ , but there was only a marginally significant interaction,  $t(84) = -1.8, p = .08$ , suggesting that the gender mismatch effect was similar for both article mismatch types. Follow-up tests revealed a marginally significant effect of condition for the *uno-una* mismatch,  $t(28) = 2.3, p = .06$ , and no significant effect of condition for the *un-un'* mismatch,  $p = .4$ . Thus, these results do not support the possibility that the gender mismatch effect was driven by the unusual separation of *un'* and the noun.

condition,  $t(56) = -3.2, p = .004$  ( $-.30 \mu\text{V}$  vs.  $.07 \mu\text{V}$ ) and for phonological mismatch condition,  $t(56) = -3.7, p = .001$  ( $-.36 \mu\text{V}$  vs.  $.07 \mu\text{V}$ ) relative to the expected condition. The phonological mismatch effect was also marginally significant in the right hemisphere,  $t(56) = -2.0, p = .053$  ( $-.14 \mu\text{V}$  vs.  $.09 \mu\text{V}$ ). Thus, both gender mismatch articles and phonological mismatch articles elicited a negativity relative to the expected articles in the 450 – 800 ms time window. The phonological mismatch effect was slightly more widespread across both hemispheres.

### **3.3 Article: Time bin analysis**

Figure 2 shows topographies of the phonological mismatch and gender mismatch effects at articles and nouns. Table 2 shows the statistical results of the linear mixed-effects models in each 100 ms bin relative to the article onset.

Table 2. Fixed effects of the linear mixed-effects models in each 100 ms bin relative to the article onset.

(Table 2 about here)

The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 0 – 100 ms bin relative to the article onset revealed no significant effect of condition in the frontal or posterior ROI,  $ps > .8$ . The follow-up analysis for the gender/phonological mismatch by anteriority and for the gender mismatch by hemisphere interactions in the 200 – 300 ms bin also revealed no significant effect of condition in the frontal or posterior ROI,  $ps > .5$ . The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 300 – 400 ms bin revealed that the ERP in the posterior ROI was more negative for the gender mismatch



condition relative to the expected condition,  $t(56) = -2.4, p = .04$  (.47  $\mu\text{V}$  vs. .80  $\mu\text{V}$ ), but we found no effect of phonological mismatch,  $p > .9$ . Similarly, the follow-up analysis for the gender mismatch by hemisphere interaction revealed that the ERP in the left hemisphere was more negative for the gender mismatch condition relative to the expected condition,  $t(56) = -2.6, p = .03$  (-.03  $\mu\text{V}$  vs. .31  $\mu\text{V}$ ) but there was no effect of phonological mismatch,  $p = .9$ . Finally, the follow-up analysis for the gender mismatch by hemisphere interaction in the 500 – 600 ms bin revealed that the ERP in the left hemisphere was marginally more negative for the gender mismatch condition,  $t(56) = -2.3, p = .05$  (-.37  $\mu\text{V}$  vs. -.07  $\mu\text{V}$ ) and significantly more negative for the phonological mismatch condition,  $t(56) = -2.6, p = .02$  (-.41  $\mu\text{V}$  vs. -.07  $\mu\text{V}$ ) relative to the expected condition. These analyses confirm that the gender mismatch effect occurred earlier than the phonological mismatch effect at the article.

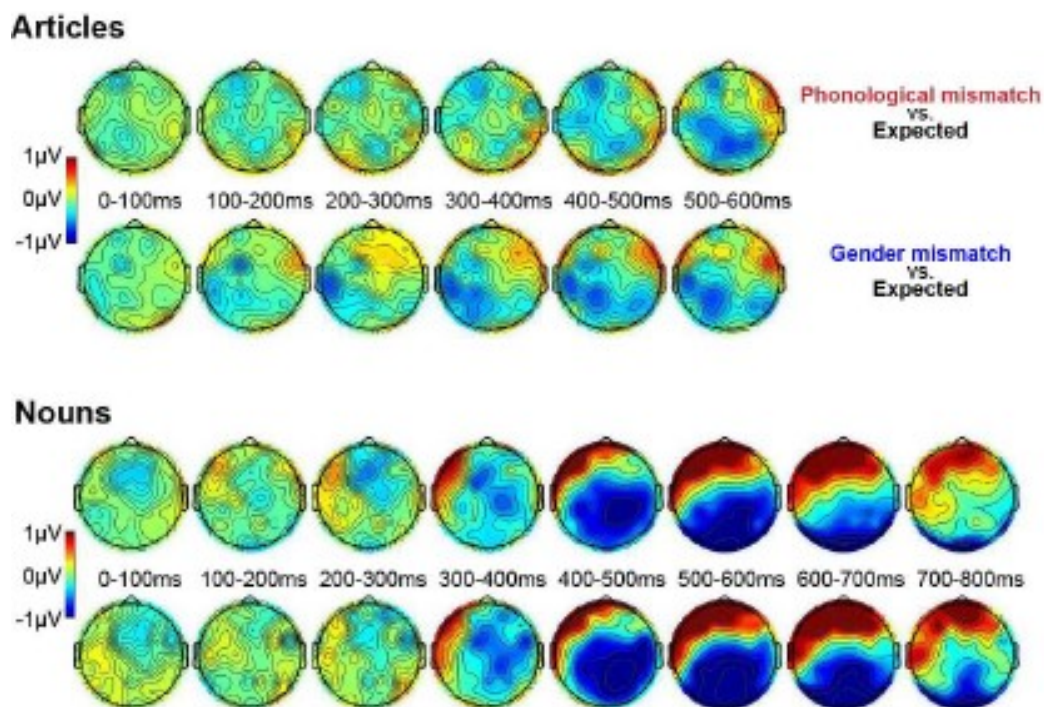


Figure 2. Scalp distributions and time course of the ERP effects at articles (top panel)

and at nouns (bottom panel). In each panel, the upper row shows the difference between the phonological mismatch and expected conditions, and the lower row shows the difference between the gender mismatch and expected conditions.

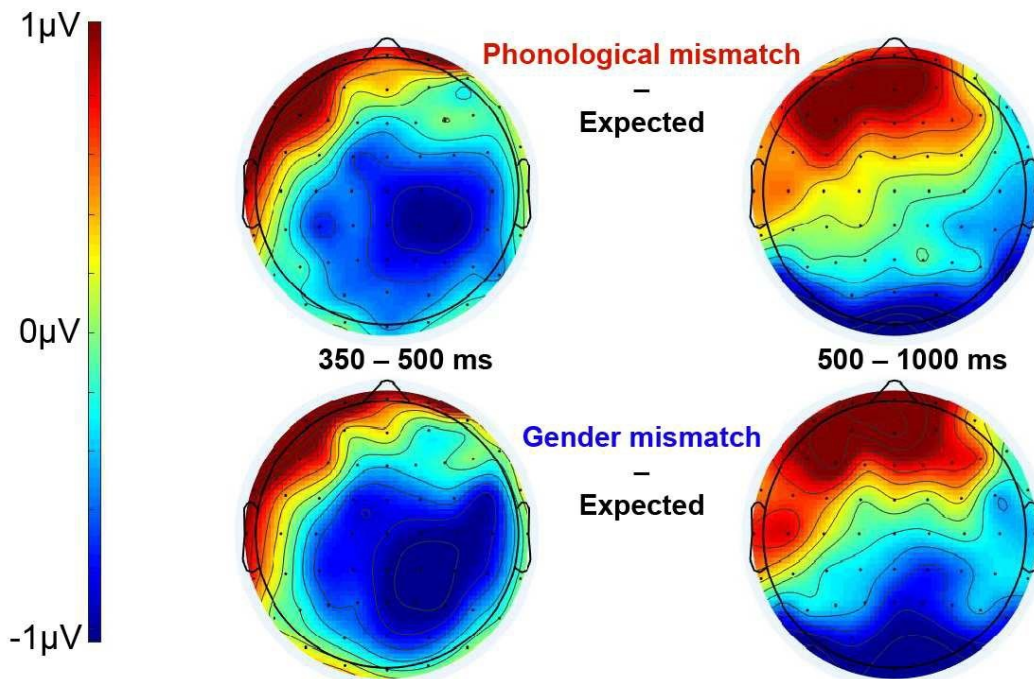
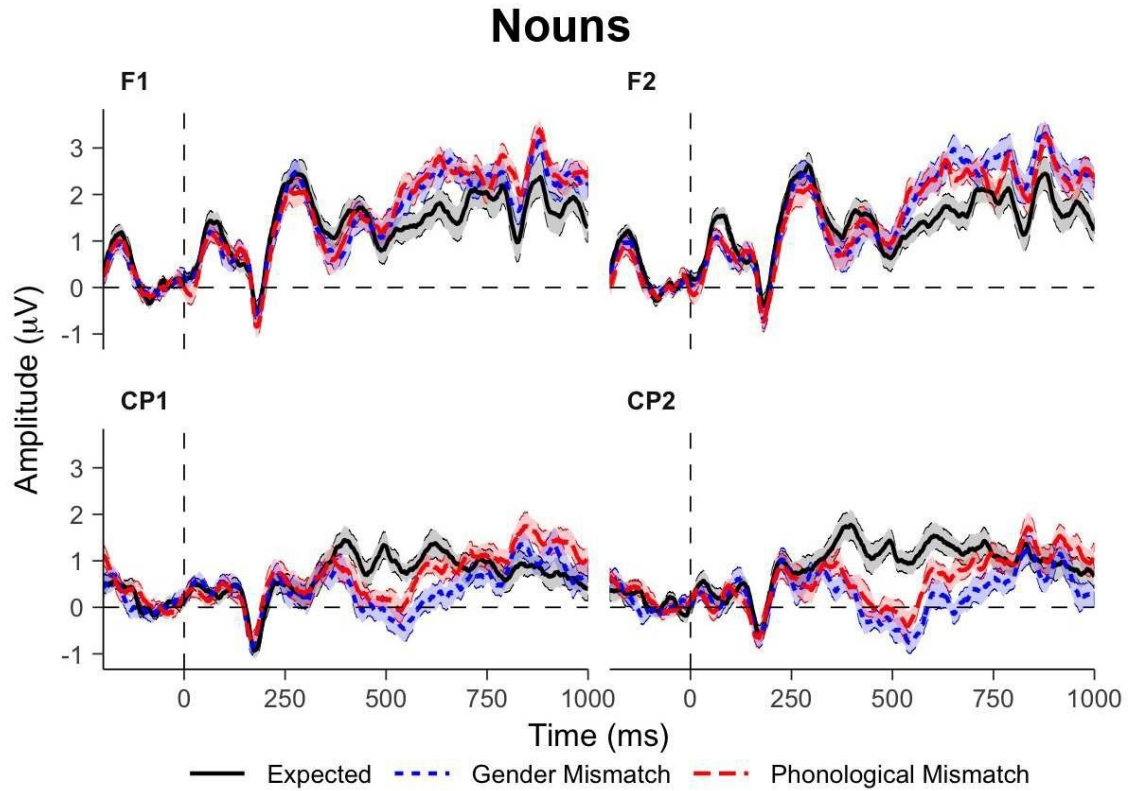


Figure 3. ERPs elicited at the noun by each condition at four medial-central electrodes (top panel) and scalp distributions of the ERP effects (the mismatch conditions minus the expected condition) in the early (350 – 500 ms) and late (500 – 1000 ms) time windows (bottom panel). The shaded area in the ERP waveform plots represent standard errors.

### **3.4 Noun: 350 – 500 ms**

The analysis in the N400 time window revealed significant effects of gender mismatch,  $t(264) = -4.0, p < .001$ , and phonological mismatch,  $t(264) = -3.1, p = .002$ , and significant interactions of gender mismatch by anteriority,  $t(264) = 3.8, p < .001$ , and phonological mismatch by anteriority,  $t(264) = 3.6, p < .001$ . Follow-up tests for frontal and posterior ROIs revealed that the N400 amplitude was larger for the gender mismatch condition,  $t(48) = -5.9, p < .001$  (.04  $\mu\text{V}$  vs. .99  $\mu\text{V}$ ) and for the phonological mismatch condition,  $t(48) = -4.9, p < .001$  (.20  $\mu\text{V}$  vs. .99  $\mu\text{V}$ ) relative to the expected condition at the posterior ROIs. Neither of the mismatch conditions differed from the expected condition at the frontal ROIs,  $ps > .4$ . Thus, both gender mismatch nouns and phonological mismatch nouns elicited a similar N400 effect relative to the expected nouns.

### **3.5 Noun: 500 – 1000 ms**

The analysis in the late frontal positivity time window revealed significant interactions of gender mismatch by anteriority,  $t(264) = 9.4, p < .001$ , and phonological mismatch by anteriority,  $t(264) = 7.9, p < .001$ . Follow-up tests for the frontal ROI and the posterior ROI showed a frontal positivity for both gender mismatch condition,  $t(48) = 2.5, p = .04$  (1.9  $\mu\text{V}$  vs. 1.3  $\mu\text{V}$ ), and phonological mismatch condition,  $t(48) = 2.7, p$

= .02 (1.9  $\mu$ V vs. 1.3  $\mu$ V), relative to the expected condition. In the posterior ROI, the gender mismatch condition elicited a more negative ERP compared to the expected condition,  $t(48) = -3.3, p = .004$  (-.04  $\mu$ V vs. .48  $\mu$ V). The phonological mismatch condition did not differ from the expected condition,  $p = .68$  (.33  $\mu$ V vs. .48  $\mu$ V).

### **3.6 Noun: Time bin analysis**

Table 3 shows the statistical results of the linear mixed-effects models in each 100 ms bin relative to the noun onset.

Table 3. Fixed effects of the linear mixed-effects models in each 100 ms bin relative to the noun onset.

(Table 3 about here)

The follow-up analysis for the gender/phonological mismatch by anteriority interaction and the gender mismatch by hemisphere interaction in the 0 – 100 ms bin relative to the noun onset revealed no significant effect of gender/phonological mismatch in any of the ROIs,  $ps > .1$ . The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 100 – 200 ms bin and in the 200 – 300 ms also revealed no significant effect of gender/phonological mismatch in frontal or posterior ROI,  $ps > .9$ . The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 300 – 400 ms bin revealed that the N400 amplitude in the posterior ROI was marginally larger for the gender mismatch condition relative to the expected condition,  $t(48) = -2.3, p = .05$  (.46  $\mu$ V vs. .80  $\mu$ V), but there was no difference between the phonological mismatch and expected conditions,  $t(48) = -1.9, p = .12$  (.51  $\mu$ V vs. .80  $\mu$ V). The follow-up analysis for the gender/phonological

mismatch by anteriority interaction in the 400 – 500 ms bin revealed that the N400 amplitude in the posterior ROI was larger for the gender mismatch condition,  $t(48) = -6.6, p < .001$  ( $-.21 \mu\text{V}$  vs.  $.93 \mu\text{V}$ ) and for the phonological mismatch condition,  $t(48) = -5.5, p < .001$  ( $-.03 \mu\text{V}$  vs.  $.93 \mu\text{V}$ ) relative to the expected condition. Similarly, the follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 500 – 600 ms bin revealed that the N400 amplitude in the posterior ROI was larger for the gender mismatch condition,  $t(48) = -7.0, p < .001$  ( $-.56 \mu\text{V}$  vs.  $.79 \mu\text{V}$ ) and for the phonological mismatch condition,  $t(48) = -4.9, p < .001$  ( $-.16 \mu\text{V}$  vs.  $.79 \mu\text{V}$ ) relative to the expected condition. The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 600 – 700 ms bin revealed a frontal positivity for the gender mismatch condition,  $t(48) = 2.9, p = .01$  ( $2.0 \mu\text{V}$  vs.  $1.3 \mu\text{V}$ ) and for the phonological mismatch condition,  $t(48) = 3.0, p = .007$  ( $2.0 \mu\text{V}$  vs.  $1.3 \mu\text{V}$ ) relative to the expected condition in the frontal ROI. In the posterior ROI, the ERP was more negative for the gender mismatch condition,  $t(48) = -5.2, p < .001$  ( $-.24 \mu\text{V}$  vs.  $.71 \mu\text{V}$ ) and for the phonological mismatch condition,  $t(48) = -2.6, p = .02$  ( $.22 \mu\text{V}$  vs.  $.71 \mu\text{V}$ ) relative to the expected condition. The follow-up analysis for the gender/phonological mismatch by anteriority interaction in the 700 – 800 ms bin revealed no significant effect of gender/phonological mismatch,  $ps > .2$ . These analyses confirm the largely equivalent N400 effects and frontal positivity effects for both mismatch conditions.

#### **4 Discussion**

We used indefinite articles in Italian and investigated whether people predict phonological and gender information of highly predictable words to the same extent. Hypothesising that people can predict both phonological and gender information, we

expected to find prediction mismatch ERP effects for articles that mismatched in phonology or gender relative to articles that matched the predictable noun in phonology and gender. We also expected that a prediction mismatch effect might occur earlier for gender mismatch articles compared to phonological mismatch articles, because production-based prediction accounts predict that people are more likely or quicker to pre-activate gender information compared to phonological information. In line with this hypothesis, gender mismatch articles elicited an earlier negativity (around 250 ms to 800 ms) than phonological mismatch articles (around 450 ms to 800 ms). Unexpected nouns elicited a larger N400 compared to the expected noun, and this N400 effect was similar for both mismatch conditions, except that the N400 effect in the gender mismatch condition lingered. Unexpected nouns additionally elicited a frontal positivity from around 500 ms to 1000 ms, which was also similar for both mismatch conditions.

#### ***4.1 Prediction of gender information***

The early negativity for gender mismatch articles suggests that participants predicted the gender of the expected noun, and gender mismatch articles disconfirmed the prediction and interfered with processing. This effect was evident before the occurrence of the next noun, even though prediction mismatch articles were grammatical and plausible in each context. Thus, following previous studies (e.g., Van Berkum et al., 2005; Wicha et al., 2004), we suggest that this effect is due to a mismatch between the expected gender and the gender of the presented article. It is unclear whether the long-lasting negativity reflects one single process or multiple processes. When participants predict the gender of the expected noun and encounter a gender mismatch article, the article immediately disconfirms their prediction.

Participants may first detect the mismatch, reanalyse or revise their prediction, and may additionally try to predict another noun. These different processes might all be reflected in the long-lasting negativity.

The gender mismatch effect was similar to the effects found in studies manipulating article gender (Foucart et al., 2014; Martin et al., 2013; Otten et al., 2007; Otten & Van Berkum, 2009) in terms of the time window (around 300 – 600 ms) but not in terms of the scalp distribution of the effect. The gender mismatch effect in our study had a left posterior distribution, whereas it had a broad posterior distribution in Foucart et al. (2014) and Martin et al. (2018), and a right (frontal) distribution in Otten et al. (2007) and Otten and Van Berkum (2009). It is unclear why it had a different distribution from the effects found in other studies. The effect in our study also contrasts with the late positivity (500 – 700 ms) found in Wicha et al. (2004) and the lack of effect in Kochari and Flecken (2019). It was not our aim to elucidate what causes the inconsistency, but the review of evidence suggests that more than one factor might account for the inconsistency (e.g., language, modality, inclusion of ungrammatical sentences, presentation modality/rate). More systematic replication attempts may help shed more light on why these effects appear so variable.

## ***4.2 Prediction of phonological information***

The late negativity for phonological mismatch articles suggests that participants predicted the phonology of the expected noun as well. This response might have indicated detection of a mismatch between the encountered information (e.g., the following noun will start with a consonant) and an expected noun, and/or reanalysis of when the expected noun would occur (e.g., the noun may occur after an adjective).

However, it is unlikely to be related to disconfirmation processes, because unlike gender mismatch articles, phonological mismatch articles do not necessarily disconfirm the expected noun. Previous studies that investigated reanalysis processing consistently found a late posterior positivity – not a negativity – when strongly expected lexical information conflicts with the actual input (Van de Meerendonk, Kolk, Chwilla, & Vissers, 2009). But this late posterior positivity was suggested to indicate monitoring for perception errors and was found only when the actual input was highly implausible (van de Meerendonk, Kolk, Vissers, & Chwilla, 2010). The mismatch articles in our study were all plausible, so the conflict may have been too weak to trigger a reanalysis for perception errors (e.g., participants presumably did not think that they misread the mismatch article for the expected article). On the one hand, the late negativity should have been triggered by a mismatch between the predicted information and the phonological mismatch article, because it was evident before the presentation of the following noun. On the other hand, we are not aware of any similar late negativity that is well-attested in the psycholinguistic literature (except for what we discuss below), so it seems to require further investigation to understand what this late negativity reflects.

The phonological mismatch effect partially replicated the findings of Martin et al. (2013). In their study, English articles that phonologically mismatched an expected noun (e.g., *an* when *kite* was expected) elicited a central-posterior negativity between 440 ms and 670 ms, in addition to a frontal-central negativity between 250 ms and 400 ms relative to expected articles in native English speakers. They interpreted the long-lasting negativity in these windows for phonological mismatch articles as demonstrating that people predict expected nouns. While we did not find an early negativity for



phonological mismatch articles, the late negativity in our study was largely similar to the late negativity in Martin et al. in its time window and distribution. Given the general fragility of phonological prediction in the literature, the effect size of phonological mismatch may have made any early effect difficult to detect in our study, though it is also possible that some reported effects result from a Type II error (neither DeLong et al., 2005, nor Nieuwland et al., 2018, found an ERP difference between expected and unexpected articles in an early window). Certainly, further research will be needed to assess these possibilities.

### ***4.3 Relationship between gender and phonological pre-activation***

Unlike gender mismatch articles, phonological mismatch articles did not elicit a differential ERP from expected articles in an early time window. This finding suggests that people are more likely, or are quicker, to predict gender information compared to phonological information. This is compatible with the proposal that people use their production system to predict upcoming language (Federmeier, 2007; Huettig, 2015; Pickering & Gambi, 2018; Pickering & Garrod, 2013). In this framework, the stages of pre-activating lexical representations of a predictable word mirror the stages of activating lexical representations when people produce a word. In word production, people access a word's lexical representations in the order of semantics, syntax and phonology/orthography (Dell & O'Seaghdha, 1992; Levelt et al., 1999). When there is not sufficient time or processing resources are scarce, predictive processes may be abandoned in the middle of processing, and the representations that correspond to a later stage will fail to be activated, consistent with prior suggestions that predictive processes are not an all-or-none affair (Ito et al., 2016). Thus, in prediction, syntactic information

including a word's grammatical gender should be pre-activated earlier and hence more often pre-activated, compared to the word's phonological information.

If gender information and phonological information had been predicted equally quickly and early, we should have found a different pattern. When people encounter the article, they retrieve its phonological information first, and then the gender information that corresponds to the retrieved phonological information. Thus, if people had predicted both gender and phonological information before they encountered the article, they should have been quicker to detect the phonological mismatch than the gender mismatch. In this scenario, the phonological mismatch effect should have occurred earlier than the gender mismatch effect. Alternatively, people may engage in the same processing after detecting a mismatching article (e.g., reanalysis), as they do when they detect a gender and phonological mismatch at a noun (both mismatch types elicit a P600 effect, cf. Hagoort & Brown, 1999; Martin et al., 2013; Nieuwland et al., 2018). If so, the phonological mismatch should have elicited the same ERPs as the gender mismatch. But since neither of these patterns fit our findings, it is more likely that participants had not yet predicted the phonological information when they retrieved the phonological information of the article but that they had predicted the gender information by the time the gender information of the article was retrieved.

Alternatively, the later onset for the phonological mismatch effect at the article might be because phonological mismatch articles do not disconfirm the predicted noun and may not as strongly interfere with online processing as gender mismatch articles that immediately disconfirm the predicted noun. Like *a/an* articles in English, indefinite articles in Italian need to agree with the next word in phonology, which may not be a

noun. Thus, articles are not a fully reliable cue for the first phoneme of an upcoming noun. However, in Italian, the likelihood of an article to be immediately followed by a noun is high (70-87%). Estimates from English language corpora suggest that *a/an* articles are immediately followed by a noun only 33% of the time both in written American and British English (Ito et al., 2017b), though this probability estimate goes up to 70% in speech (Yan et al., 2017). While we do not interpret our results as suggesting that people are more likely to predict specific words in Italian (e.g., than in English) due to the article properties in Italian, articles in Italian are probably more reliable cues about the first phoneme(s) of the upcoming noun than articles in English, and it is possible that the late negativity we found indicates disconfirmation of the predicted noun.

Another account relates to the possibility of reanalysis/revision of prediction about *when* in the sentence the expected noun occurs. When people encounter a phonological mismatch article and revise their prediction, they may predict that a different noun will follow, or they may predict that the expected noun will occur later. When people encounter a gender mismatch article, only the former is possible. Thus, after detecting the phonological mismatch, people might be uncertain about whether the expected noun will still occur or not, which would delay their reanalysis/revision process as a result.

An interesting question is whether the late negativity for phonological mismatch articles shares some ERP component with the negativity for gender mismatch articles. The effects in the late time window were largely similar in size, although the phonological mismatch effect was more widely distributed over the posterior electrodes

compared to the gender mismatch effect which had a clear left-posterior distribution. These effects could indicate some shared process, as both types of mismatch require detection of the mismatch and revision of predicted information. But these effects could also indicate some distinct process, because people might revise their prediction about when the expected noun occurs when they encounter a phonological mismatch article but not when they encounter a gender mismatch article. The different topographies for gender mismatch and phonological mismatch effects could reflect the distinct processes involved when people detect the mismatch.

The variability of the ERP effects found in the current and previous studies leaves the question of to what extent people predict phonological and gender information of a specific upcoming word in everyday language comprehension. Our sentences included highly predictable words, unlike most sentences that people encounter. Moreover, we used a word-by-word reading paradigm whose pace was much slower than is typical in skilled reading or spoken comprehension, and it may be that this extra time enhances prediction (Pickering & Gambi, 2018). So we cannot conclude that people regularly predict phonological or gender information. However, our aim in this study was to compare the prediction of gender and phonological information when the conditions allow people to predict a specific word (i.e., when people are able to narrow their predictions down to one lexical item and hence the gender/phonological information associated with that specific lexical item could be pre-activated). We take our results to suggest that, when people predict a specific word, they are quicker/more likely to predict gender information compared to phonological information since

production first activates lemmas, which include syntactic information such as gender but not phonological information.

Regardless of the precise processes underlying the different ERPs, the different effects for phonological mismatch articles and gender mismatch articles provide further support for the claim that mismatch effects on articles prior to the occurrence of the (predicted) noun are due to predictive processes. An integration account of these mismatch effects has difficulty explaining why these two sources of information should elicit distinct ERPs. If the mismatch effects on articles had been caused by a difficulty in integrating phonological and gender mismatch articles with the sentence context, both mismatch effects should have resulted in similar ERP effects (i.e., perhaps an N400 effect), because both phonological and gender mismatching articles were equally unlikely to occur at that point. Additionally, our findings are incompatible with the account that people predict the article itself, because in this case, people should have been quicker to detect the phonological mismatch than the gender mismatch when they encountered the article, as they would then access the phonology of the article before accessing its gender.

The findings also argue against any account of prediction in which the comprehender does not predict the article, but predicts the complete lexical entry of the expected noun at once (so that phonology, gender, and semantics would be pre-activated at the same time) or predicts phonology before gender. For example, three of the mechanisms of prediction suggested by Huettig (2015) do not involve production: simple association, in which prediction occurs via lexical priming; more complex combinatorial processes, in which it is based on multiple linguistic constraints; and

event structure, which involves event simulation. These mechanisms do not specify in which order lexical representations are pre-activated, and so would be fully compatible with prediction of the complete lexical entry, unlike prediction-by-production. Our data show that comprehenders activate gender before phonology, just as people do during language production, and so we take them to support a central role for prediction-by-production rather than other mechanisms. However, these additional mechanisms may occur alongside prediction-by-production and may interact with it (e.g., the production system may use combinatorial processes or draw on event simulation).

#### ***4.4 Processing difficulty for unexpected nouns***

Unexpected nouns elicited an N400 effect followed by frontal positivity for both mismatch conditions compared to the expected condition. The N400 effects replicate many previous studies (e.g., Kutas & Hillyard, 1984) and suggest that unexpected nouns were more difficult to integrate into the context compared to expected nouns. A frontal positivity has been found when a strong lexical prediction was violated by another unexpected but plausible word (Van Petten & Luka, 2012), which was also the case in our study. DeLong, Quante, and Kutas (2014) linked the frontal positivity to suppression of a predicted but unencountered word. In our study, it could be that people predicted the expected noun, but as they read another plausible noun, the initially predicted information had to be suppressed so that it would not interfere with ongoing comprehension. Alternatively, the frontal positivity may reflect discourse context updating (Brothers, Swaab, & Traxler, 2015). It is possible that people predicted the expected noun and integrated it into the context as soon as they predicted it, and as they

read another plausible noun, they needed to process the new input and update the current discourse model.

## **5 Conclusion**

Our results suggest that people predict specific lexical information about upcoming words in highly predictive contexts. The negativity for phonological mismatch articles and gender mismatch articles suggests that people can predict both phonological and gender information of a highly predictable word. This negativity occurred earlier for gender mismatch articles than for phonological mismatch articles, suggesting that gender information is more readily or more quickly pre-activated compared to phonological information, in line with production-based prediction accounts. The late negativity for phonological mismatch articles may also suggest that people predict when in the sentence the expected word is likely to occur, because phonological mismatch articles do not disconfirm an occurrence of the expected noun but signal that the expected noun may occur later. The earlier negativity for gender mismatch articles may also indicate a quicker reanalysis or revision of the expected noun, because they immediately disconfirm an occurrence of the expected noun.

## **6 Acknowledgements**

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## 7 Appendix

Critical sentences with target article + noun for each condition (Expected, Phonological mismatch, Gender mismatch) with English translations. The mean plausibility ratings for each condition are shown in brackets after each critical noun. The mean cloze probabilities for the article and the noun are shown in square brackets after each sentence.

1. Il traffico in autostrada è rimasto bloccato a causa di un incidente (4.9)/ uno scontro (4.6)/ un'inondazione (4.4). [article cloze = 100, noun cloze = 100]

*The traffic on the motorway came to a standstill because of an accident/a collision/a flooding.*

2. Dopo il rapimento, la famiglia dell'ostaggio ha lanciato un appello (5)/ uno scongiuro (2.4)/ un'implorazione (2.8). [83, 56]

*After the kidnapping, the family of the hostage sent out an appeal / a prayer / an imploration.*

3. Giulio ha intenzione di chiedere a Maria di sposarlo, e domani andrà in gioielleria a comprare un anello (5)/ uno smeraldo (4.3)/ un'ametista (3.5). [67, 100]

*Giulio intends to ask Maria to marry him, and tomorrow he will go to the jeweller's to buy a ring / an emerald / an amethyst.*

4. Stando ai giornali, i terroristi arrestati ieri stavano già pianificando un attentato (5)/ uno scempio (2.4)/ un'offensiva (3.9). [78, 78]



*According to the papers, the terrorists arrested yesterday were already planning an attack / a massacre / an offensive.*

5. Sarebbe molto più semplice prendere l'aereo, ma sull'isola non hanno ancora costruito un aeroporto (4.8)/ uno scalo (4)/ un'aerostazione (3.8). [89, 89]

*It would be much easier to fly, but on the island they haven't yet built an airport / a terminal / a terminal<sup>3</sup>.*

6. Alcuni dimostranti si sono introdotti nell'edificio e hanno tentato di appiccare un incendio (4.8)/ uno striscione (1.8)/ un'insegna (2.4). [61, 56]

*Some demonstrators broke into the building and attempted to start a fire / affix a banner / hang a sign<sup>4</sup>.*

7. Fin dalla sua prima recita scolastica, Carlo ha sempre saputo di voler diventare un attore (5)/ uno stuntman (4)/ un'icona (2.6). [100, 100]

*Since his first school play, Carlo was sure he wanted to become an actor / a stuntman / an icon.*

8. Luigi è sempre in ritardo e non sa mai che ore siano. Dovremmo regalargli un orologio (5)/ uno smartphone (3.4)/ un'agenda (3). [100, 100]

*Luigi is always late and never knows what time it is. We should buy him a watch / a smartphone / a diary.*

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<sup>3</sup> Both *scalo* and *aerostazione* are best translated in English using the word *terminal*.

<sup>4</sup> In Italian *appiccare un incendio* is an idiomatic expression meaning *to start a fire* or *to set fire to*, but the verb *appiccare* also has the (less frequent) meaning of *to attach*.

9. Fabio fu costretto a fermare la moto, perché, nonostante indossasse gli occhiali, un insetto gli era entrato in un occhio (4.9)/ uno spiraglio (2.6)/ un'apertura (3.4). [65, 53]

*Fabio had to stop the motorbike because, despite the fact that he was wearing glasses, an insect had got into his eye / a gap / an opening.*

10. I vicini lo vogliono denunciare. Fossi in lui, mi cercherei un avvocato (4.9)/ uno strizzacervelli (2.6)/ un'alternativa (2.6). [100, 83]

*The neighbours want to sue him. If I were him, I would be looking for a solicitor / a shrink / an alternative.*

11. Per queste due zanne di avorio, i contrabbandieri hanno ucciso un elefante (5)/ uno sciamano (2.7)/ un'indigena (4.2). [94, 89]

*In order to get these two ivory tusks, the poachers killed an elephant / a sciaman / an indigenous woman.*

12. Certamente sono felice di condurre il festival di Sanremo! Anzi, per me è un onore (5)/ uno spasso (4.7)/ un'emozione (4.2). [89, 89]

*Of course I am happy to be hosting the Sanremo festival! Actually, for me it's an honour / a laugh / a thrill.*

13. Sembrava un bel sogno, poi sono accadute cose terribili e allora il sogno è diventato un incubo (5)/ uno sfacelo (3.2)/ un'atrocità (3.5). [100, 100]

*It seemed like a beautiful dream, then terrible things happened and the dream became a nightmare / a disaster / an atrocity.*

14. Il mio contratto di lavoro finisce nel 2018, perciò mi resta soltanto un anno (4.5)/ uno stipendio (2.3)/ un'annualità (4.1). [100, 100]

*My employment contract comes to an end in 2018, so I have only got a year / a salary / an annuity left.*

15. Dopo aver dato un'occhiata alle tubature, abbiamo capito di aver bisogno di chiamare un idraulico (4.7)/ uno sturatore (3.6)/ un'esperta (4.1). [67, 100]

*After checking the pipes, we realised we needed to call a plumber / a drainage specialist / an expert.*

16. I due amanti sapevano che non si sarebbero mai più rivisti e che perciò quel saluto era in realtà un addio (5)/ uno strazio (3.5)/ un'idiozia (2.3). [89, 89]

*The two lovers knew they would have never seen each other again and therefore that goodbye was in fact a farewell / a torture / a folly.*

17. Protoni e neutroni sono particelle che si possono trovare al centro di un atomo (4.4)/ uno spettrogramma (2.4)/ un'antiparticella (1.7). [83, 83]

*Protons and neutrons are particles that can be found at the centre of an atom / a spectrogram / an antiparticle.*

18. Sarà pure un bravo cittadino, ma il fatto che abbia ucciso un uomo fa di lui un assassino (4.3)/ uno squilibrato (4.6)/ un'aberrazione (2.7). [100, 72]

*He may well be a good citizen, but the fact that he killed a man makes him a killer / a madman / an aberration.*

19. Per superare la prova di teoria per la patente, devi sostenere un esame (4.9)/ uno scritto (4.7)/ un'esaminazione (3.2). [76, 82]

*In order to pass the driving theory test, you must sit an exam / a written assessment/ an examination.*

20. Per ricucire questo bottone ti servirà del filo nero e un ago (4.8)/ uno spillo (3)/ un'oretta (2.8). [89, 100]

*To sew back a button you will need black thread and a needle / a sewing pin / an hour.*

21. Un generale è un capo militare al comando di un esercito (5)/ uno squadrone (4.2)/ un'armata (4.5). [76, 71]

*A general is a military chief in charge of an army / a squadron / a legion.*

22. Poiché piove così tanto in questo paese, in borsa tengo sempre un ombrello (5)/ uno spolverino (2.5)/ un'incerata (3.4). [61, 100]

*Since it rains so much in this country, I always keep an umbrella / a trench / a waterproof.*

23. Davide ha ricevuto i risultati del test: ha ottenuto il 99% delle risposte corrette, ha commesso solo un errore (5)/ uno sbaglio (4.8)/ un'imprecisione (4.6). [100, 100]

*Davide got the results of his test: he got 99% of answers correct, he committed only one<sup>5</sup> error / one mistake / one inaccuracy.*

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<sup>5</sup> In Italian, the numeral one and the indefinite article are the same.

24. Abbiamo quasi tutto l'arredamento della camera da letto, ma non abbiamo ancora dove mettere i vestiti: domani andremo a comprare un armadio (5)/ uno stipetto (3.3)/ un'anta (2.1). [83, 100]

*We have almost all the furniture we need for the bedroom, but we still do not have anywhere to put our clothes in: tomorrow we will go and buy a wardrobe / a closet / a wardrobe door.*

25. In caso di incendio, sarebbe opportuno saper usare e aver accesso ad un estintore (4.8)/ uno spengifiamme (3.3)/ un'accetta (2.6). [94, 94]

*In the event of a fire, it would be good to be able to use and have access to an extinguisher / a sprinkler / an axe.*

26. È troppo vasto per essere soltanto un mare - lo definirei piuttosto un oceano (4.5)/ uno spettacolo (1.8)/ un'immensità (2.6). [94, 100]

*It is too vast to be just a sea - I would rather call it an ocean / a spectacle / an immensity.*

27. Sarebbe più facile trovare la pagina di ciascun capitolo, se questo libro avesse un indice (4.8)/ uno stacco (1.5)/ un'impaginazione (3). [78, 100]

*It would be easier to find the page of each chapter, if this book had an index / a break / pagination.*

28. Per travasare il vino dalla damigiana alla bottiglia serve un imbuto (5)/ uno specialista (2.8)/ un'esperta (2). [78, 94]

*To decant wine from a demijohn to a bottle, you need a funnel / a specialist / an expert.*

29. Oggi le galline non hanno fatto nemmeno un uovo (5)/ uno schiamazzo (4)/ un'uscita (2.3). [100, 100]

*Today the hens have not even laid<sup>6</sup> an egg / made a noise / made an outing.*

30. La camera da letto è invasa dalle api, su quell'albero dev'esserci un alveare (4.7)/ uno sciame (3.7)/ un'arnia (2.9). [94, 94]

*The bedroom is full of bees, there must be a nest / a swarm / a beehive on that tree.*

31. I lavoratori scioperano perché il loro stipendio non è alto abbastanza, perciò chiedono un aumento (4.4)/ uno spostamento (2.1)/ un'assemblea (3.4). [88, 100]

*The workers are on strike because their salary is not high enough and so they are asking for a pay rise / a redeployment / an assembly.*

32. Tutti pensavano fosse il suo fidanzato, ma lei continuava a ribadire che lui, per lei, era soltanto un amico (4.6)/ uno spiantato (2.9)/ un'infatuazione (3.4). [100, 100]

*Everybody thought he was her boyfriend, but she kept insisting that he, for her, was just a friend / a deadbeat / an infatuation.*

33. Dovresti trovare un lavoro anche tu, non arriviamo a fine mese con solo uno stipendio (5)/ un salario (4.9)/ una busta paga (4.8). [89, 89]

*You should find a job as well, we cannot make ends meet with just one income / salary / payslip.*

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<sup>6</sup> In Italian, the same verb (*fare*) is used in the expression *to lay an egg, fare un uovo*.

34. Matteo ama scrivere e da grande vuole diventare uno scrittore (4.6)/ un poeta (4.6)/ una celebrità (4.7). [94, 100]

*Matteo loves writing and when he grows up he wants to become a writer / a poet / a celebrity.*

35. Oggi Laura mi è passata davanti senza degnarmi nemmeno di uno sguardo (5)/ un saluto (4.9)/ una parola (4.2). [94, 94]

*Today Laura walked past me without a glance / a greeting / a word.*

36. Per ottenere l'aumento, i sindacati hanno minacciato di organizzare uno sciopero (5)/ un sit-in (4.8)/ una manifestazione (4.7). [94, 94]

*To get the pay rise, the unions threatened to stage a strike / a sit-in / a demonstration.*

37. Ad allenare la nostra Nazionale di calcio ci dovrebbe essere un italiano, non uno straniero (4.5)/ un forestiero (3.6)/ una tedesca (4.2). [89, 89]

*The manager of our national football team should be an italian, not a foreigner / an alien / a german (woman).*

38. I bambini hanno messo del sale nel caffè del loro papà per fargli uno scherzo (5)/ un dispetto (5)/ una birbanteria (4.1). [94, 88]

*The children put salt in their dad's coffee as a joke / a prank / a mischief.*

39. Il bridge è riconosciuto dal comitato olimpico, ma molti ritengono che non sia veramente uno sport (3.9)/ un torneo (3.5)/ una competizione (3.5). [89, 94]

*Bridge is recognised by the Olympic Committee, but many believe it is not really a sport / a tournament / a competition.*

40. Secondo la superstizione, arrivano sette anni di sfortuna ogni volta che si rompe uno specchio (4.8)/ un vetro (3.9)/ una specchiera (4). [94, 100]

*According to superstition, seven years of bad luck will follow anytime someone breaks a mirror / a glass / a dressing mirror.*

41. Il mio medico di base non capiva cosa avessi, per cui mi ha mandato da uno specialista (5)/ un cardiologo (4.7)/ una ginecologa (5). [94, 94]

*My GP could not understand what was wrong with me, so he sent me to a specialist / a cardiologist / a gynecologist.*

42. Nel 2016, sulle coste australiane, due bagnanti sono stati azzannati da uno squalo (4.6)/ un pescecane (4.5)/ una bestia (3.5). [89, 89]

*In 2016, on the Australian coastline, two bathers were killed by a shark / a shark / a monster.*

43. Quando non si riesce a lasciarsi alle spalle un evento traumatico, è consigliabile prendere appuntamento da uno psicologo (4.8)/ un dottore (3.7)/ una psichiatra (4.3). [78, 89]

*When one struggles to get over a traumatic event, it is advisable to get an appointment with a psychologist / a doctor / a psychiatrist.*



44. A Trieste, visto il forte vento, è consigliabile prestare attenzione alla condizione di porte e finestre. Soprattutto in certi vecchi palazzi, è facile che da sotto la porta d'ingresso si senta arrivare uno spiffero (3.9)/ un refole (3)/ una ventata (4.6). [50, 50]

*In Triest, due to the strong wind, it is advisable to pay attention to doors and windows. Especially in some old tenements, it is common to feel a draft / a breeze / gust from under the front door.*

45. Amo la musica ma purtroppo non ho mai avuto l'opportunità di imparare a suonare uno strumento (5)/ un trombone (4.7)/ una chitarra (4.7). [72, 72]

*I love music but unfortunately I have never had the opportunity to learn to play an instrument / a trombone / a guitar.*

46. Con tutti questi animali in giro, oramai questa casa è diventata uno zoo (4.9)/ un serraglio (2.4)/ una fattoria (4.9). [61, 61]

*With all these animals around, this house has become a zoo / a menagerie / a farm.*

47. Mio padre è figlio unico e mia madre ha un fratello, perciò nella mia famiglia ho solo uno zio (5)/ un cugino (2.8)/ una cugina (3.7). [100, 100]

*My father is an only child and my mother has a brother, so in my family I have only one uncle / (male) cousin / (female) cousin.*

48. Il vero nome di quella cantante americana è Stefani Germanotta: Lady GaGa è solo uno pseudonimo (4.9)/ un soprannome (4.4)/ una finzione (4.3). [50, 50]

*The real name of that American singer is Stefani Germanotta: Lady Gaga is just a pseudonym / a nickname / a fiction.*

49. Nell'antica Roma, un liberto era un uomo cui veniva concessa la libertà e che, pertanto, cessava di essere uno schiavo (4.8)/ un servo (5)/ una cosa (4.1). [83, 100]

*In ancient Rome, a freedman was a man who was granted liberty and who, therefore, stopped being a slave / a servant / a thing.*

50. Non ho abbastanza credito telefonico per chiamarla, perciò le farò solo uno squillo (5)/ un biglietto (2.5)/ una cartolina (2.7). [100, 100]

*I do not have enough telephone credit to call her, so I will just give her a ring / a card / a postcard.*

51. L'ufficio postale del mio paese è così piccolo che tengono in attività soltanto uno sportello (4.9)/ un bancomat (3.6)/ una postina (4). [94, 94]

*The post office in my village is so small that they keep only one cashier / ATM / postwoman operative.*

52. Ammetto sia piuttosto costoso, ma c'è un modo per pagarlo meno: se mostri la carta studente sono sicuro che ti concederanno uno sconto (5)/ un voucher (3.1)/ una riduzione (5). [72, 83]

*I will admit that it is quite expensive, but there is a way to pay less for it: if you show your student card, I am sure they will give you a discount / a voucher / a reduction.*

53. Ha preso la laurea in legge l'estate scorsa e ora, per avviare la sua carriera da avvocato, sta facendo un tirocino in uno studio (5)/ un tribunale (5)/ una cooperativa (3.5). [89, 89]

*He got his law degree last summer and now, to begin his career as a solicitor, he is working as a trainee in a law firm / a tribunal / a cooperative.*

54. Per il tuo travestimento da cavaliere avrai bisogno di un'armatura, una spada e uno scudo (5)/ un destriero (4.7)/ una cotta di maglia (4.6). [61, 67]

*To dress up as a knight, you will need an armour, a sword and a shield / a steed / a chainmail.*

55. Lasciare il rubinetto sempre aperto mentre ci si lava i denti è proprio uno spreco (5)/ un peccato (4.3)/ una stupidaggine (4.7). [83, 83]

*Letting the tap run while washing one's teeth is truly a waste / a shame / a stupid thing to do.*

56. Guardo sempre le partite di calcio alla TV, ma un giorno vorrei vederne una dal vivo sugli spalti di uno stadio (4.9)/ un campo (4.4)/ una tribuna (4.7). [89, 94]

*I always watch football matches on TV, but one day I would like to watch one live on the bleachers of a stadium / a ground / a stand.*

57. Il suo livello di sedentarietà è paragonabile a quello di una patella attaccata ad uno scoglio (4.5)/ un faraglione (3.9)/ una barca (3.9). [78, 78]

*His lifestyle is as sedentary as that of a limpet attached to a rock / a cliff / a boat.*

58. Senza sapere se sia fatto di plastica o di vere ossa umane, gli studenti di medicina studiano l'apparato osseo attraverso l'osservazione di uno scheletro (4.2)/ un modello (4.6)/ una riproduzione (3.9). [94, 94]

*Not knowing whether it is made of plastic or real human bones, the medicine students study the bone system by observing a skeleton / a model / a reproduction.*

59. Per aiutare a combattere l'evasione fiscale, è importante che ogni cliente chieda al commerciante uno scontrino (4.9)/ un tagliando (3.1)/ una ricevuta (4.9). [0, 78]

*To help fight tax evasion, it is important for each customer to ask the vendor for a slip / a ticket / a receipt.*

60. Dopo aver lavorato per tanti anni, ora che è in pensione Luigi è entrato in depressione perché sente di non avere più uno scopo (5)/ un proposito (3.9)/ una vita (4.7). [72, 72]

*After working for several years, now that he is retired, Luigi is suffering from depression because he feels like he does not have a goal / a purpose / a life anymore.*

61. I simboli del potere regale sono solitamente una corona e uno scettro (5)/ un mantello (3.9)/ una sfera (2.2). [83, 89]

*The symbols of regal power are usually a crown and a sceptre / a cape / a globe.*

62. Avevano assegnato il posto vicino al finestrino ad Anna, ma dato che lei non ha preferenze, le ho proposto uno scambio (5)/ un cambio (5)/ una sostituzione (4.1). [50, 56]

*We had reserved the seat next to the window for Anna, but since she does not have a preference, I have suggested an exchange / a change / a substitution.*

63. Spero proprio che il vicino smetta di cantare sotto la doccia la mattina, perché ad ascoltarlo è proprio uno strazio (4.6)/ un calvario (4.5)/ una tortura (4.9). [50, 50]

*I really hope the neighbour will stop singing while he takes a shower in the mornings, because listening to him is really a pain / an ordeal / a torture.*

64. Ieri mattina ho visitato Hyde Park a Londra, mi sono seduto su una panchina sotto ad un albero e ho visto un animale arrampicarsi sui rami. Era sicuramente uno scoiattolo (5)/ un roditore (4.3)/ una bestiola (3.4). [100, 94]

*Yesterday morning I visited Hyde Park in London, I sat down on a bench under a tree and saw an animal climbing on the branches. It must have been a squirrel / a rodent / a small creature.*

65. Roberta aveva in mente di preparare un piatto di spaghetti aglio e olio per cena, ma di aglio nel frigorifero non ce n'era neanche uno spicchio (5)/ un po' (4.6)/ una traccia (4.6). [61, 61]

*Roberta was planning to cook spaghetti with garlic and oil for dinner, but in the fridge there was not even a clove / a little bit / a trace of it.*

66. Il Natale scorso ha nevicato tanto e i bambini si sono divertiti un sacco a scendere dalla collina su uno slittino (5)/ un bob (4.5)/ una slitta (5). [53, 53]

*Last Christmas it snowed a lot and the children had lots of fun coming down the hill on a slide / a bob / a sledge.*

67. La Sicilia è separata dalla Calabria da uno stretto (4.9)/ un braccio di mare (4)/ una traversata (2.8). [88, 88]

*Sicily is divided from Calabria by a strait / a stretch of sea / a sea crossing.*

68. Andare al lavoro in bicicletta con una ventiquattre è scomodo: è molto meglio mettere le proprie cose in uno zaino (4.9)/ un cestino (3.5)/ una tracolla (4.9). [61, 61]

*Cycling to work with a briefcase is inconvenient: it is much better to put one's things in a backpack / a basket / a shoulder bag.*

69. Forse l'osso è fratturato. Per esserne certi, le faranno una radiografia (4.9)/ un'analisi (2.8)/ uno screening (3.4). [100, 50]

*The bone may be broken. To be sure, they will do an X-ray / a test / a screening.*

70. Nonostante l'età, ha una pelle perfetta e liscia, senza neppure una ruga (4.9)/ un'imperfezione (4.9)/ uno sfregio (3). [67, 67]

*Despite her age, her skin is perfect and smooth, without even a wrinkle / an imperfection / a scar.*

71. Abbiamo preparato un buonissimo ciambellone! Se ti va, te ne taglio una fetta (5)/ un'estremità (2.6)/ uno spizzico (1.9). [83, 83]

*We have made a delicious cake! If you'd like, I can cut you a slice / an end / a morsel.*

72. Il terremoto ha distrutto ogni cosa, ma finalmente la terra sembra aver smesso di tremare: non abbiamo più avvertito nemmeno una scossa (5)/ un'esplosione (1.9)/ uno spavento (1.5). [94, 94]

*The earthquake destroyed everything, but it looks like the ground has finally stopped shaking: we have not felt a single tremor / explosion / scare.*

73. Il modo perfetto di passare Ferragosto è cantare una canzone attorno al fuoco in spiaggia al suono di una chitarra (4.9)/ un'armonica (4.3)/ uno zingano (2.3). [94, 94]

*The perfect way to spend Ferragosto<sup>7</sup> is to sing a song while sitting around a fire on the beach and listening to the sound of a guitar / a harmonica / a gypsy.*

74. Ogni sera il nonno si siede di fianco al nostro letto e ci racconta sempre una storia (5)/ un'avventura (4.3)/ uno scherzo (3). [89, 100]

*Every evening our grandfather sits by our bed and always tells us a story / an adventure / a joke.*

75. Prima di sposarsi, vogliono assicurarsi di avere un tetto sopra la testa: per questo si compreranno una casa (4.9)/ un'abitazione (4.5)/ uno stabile (2.8). [72, 83]

*Before getting married, they want to make sure they'll have a roof over their heads: for this reason, they will buy a house / a dwelling / a unit.*

76. La raccolta fondi mira ad offrire un'istruzione gratuita a tutti i bambini del villaggio e verrà usata per costruire una scuola (5)/ un'accademia (3.9)/ uno studentato (3.8). [89, 89]

*The fundraising is aimed at offering a free education to all children in the village and it will be used to build a school / an academy / a student hall.*

77. Non sono mai stato negli Stati Uniti e quindi per pianificare il mio primo viaggio ho deciso di comprarmi una guida (5)/ un'assicurazione (2.5)/ uno stradario (3.9). [94, 72]

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<sup>7</sup> Italian public holiday, celebrated on the 15th of August.

*I have never been to the United States, so to plan my first trip I have decided to buy a guide / an insurance / a road atlas.*

78. Il rapinatore era armato: aveva con sé una pistola (5)/ un'accetta (4.2)/ uno sfollagente (3). [83, 83]

*The robber was armed: he had a gun / an axe / a truncheon with him.*

79. Per l'otto marzo, è tradizione regalare ad ogni amica una mimosa (4.4)/ un'emozione (2.1)/ uno sfizio (1.6). [78, 78]

*On the 8th of March, it is tradition to give a mimosa flower / an emotion / a treat as a gift to each of your female friends.*

80. Il terzo anno di quella scuola elementare ha solo 15 alunni: per quello li hanno messi tutti in una classe (4.5)/ un'aula (5)/ uno stanzino (3.4). [72, 61]

*The third year in that primary school is made up of only 15 pupils: for that reason, they all sit in the same class / classroom / boxroom.*

81. Non ho nulla con cui scrivere - potresti prestarmi una penna (4.9)/ un'ocra (1.6)/ uno stilo (3.2)? [78, 89]

*I do not have anything to write with - could you lend me a pen / an ochre (pencil) / a stylus?*

82. Per il compleanno di Anna vorremmo organizzare una festa (5)/ un'uscita (4.8)/ uno spettacolo (4). [100, 94]

*For Anna's birthday, we would like to organize a party / an outing / a show.*



83. Vorrebbe andare in campeggio il prossimo weekend, ma la vedo dura considerato che non riesce neppure a montare una tenda (4.9)/ un'asticella (4.6)/ uno sgabello (4.4).

[83, 94]

*He would like to go camping next weekend, but I think it is unlikely given he cannot even assemble a tent / a pole / a stool.*

84. Il bagno è troppo piccolo, perciò, anziché una vasca, abbiamo installato una doccia (5)/ un'asciugatrice (1.5)/ uno scaldabagno (1.8). [83, 100]

*The bathroom is too small, so, instead of a bath, we have had a shower / a dryer / a boiler installed.*

85. Amo nuotare! Per questo, appena avremo un giardino più grande, farò in modo di costruirci una piscina (5)/ un'olimpionica (3.5)/ uno stagno (1.9). [94, 100]

*I love swimming! For this reason, as soon as we will have a bigger garden, I will have a swimming pool / an olympic (pool) / a pond built.*

86. Dopo la mia prima orribile esperienza con il mal di mare, ho deciso di non mettere più piede sopra una barca (4.9)/ un'imbarcazione (5)/ uno yacht (4.7). [83, 72]

*After my first terrible experience with sea sickness, I decided to never again get on board a boat / a vessel / a yacht.*

87. Così come ogni cittadina cristiana ha almeno una chiesa, così ogni cittadina musulmana ha una moschea (4.6)/ un'università (1.5)/ uno speziale (1.8). [83, 100]

*In the same way as every Christian town has at least one church, every Muslim town has a mosque / a university / an apothecary.*

88. Era una giornata caldissima in India. Marco era assetato, ma siccome gli era stato sconsigliato di bere l'acqua corrente, decise di comprarne invece una bottiglia (4.6)/ un'esagerazione (2)/ uno scatolone (2.6). [88, 88]

*It was a really hot day in India. Marco was thirsty, but since he had been advised against drinking tap water, he instead decided to buy a bottle / a lot / a boxful (of water).*

89. Lavare i piatti è un lavoro tedioso e prende un sacco di tempo - quanto mi piacerebbe avere una lavastoviglie (4.9)/ un'aiutante (4.6)/ uno sguattero (4). [89, 94]

*Doing the dishes is a tedious job and it takes up so much time - I would really like to have a dishwasher / a helper / a kitchen boy.*

90. Nello studentato non puoi affittare un intero appartamento ma solamente una stanza (4.8)/ un'ala (2)/ uno studio (3.1). [100, 76]

*In the student halls, you cannot rent an entire apartment but only a room / a wing / a study.*

91. Per fare in modo che queste eccellenti fotografie raggiungano il vasto pubblico, allestiremo una mostra (5)/ un'asta (3)/ uno striscione (2.5). [89, 89]

*In order for these excellent pictures to reach the public at large, we will put up an exhibition / an auction / a banner.*

92. Con tutto questo inquinamento luminoso, in cielo non si vede neppure una stella (5)/ un'eclissi (3.5)/ uno scintillio (3.4). [100, 100]

*Because of light pollution, one cannot even see a star / an eclipse / a sparkle in the sky.*

93. Vista la situazione politica attuale, spero proprio non scoppi una guerra (4.9)/ un'insurrezione (4.4)/ uno scandalo (4.7). [88, 71]

*Given the current political climate, I really hope a war / a revolt / a scandal will not break out.*

94. Un villaggio è parecchio meno popoloso di una città (4.7)/ un'urbe (4.1)/ uno stato (3.9). [83, 83]

*A village is much less populous than a town / a city / a state.*

95. La ringraziamo per aver scelto il nostro hotel. Ci dica cosa desidera prenotare - una familiare, una doppia o una singola (4.8)/ un'isola (1.9)/ uno chalet (3.8). [100, 94]

*We thank you for choosing our hotel. Let us know what you would like to book - a family (room), a double, or a single (room) / an island / a chalet.*

96. Avete lavorato ininterrottamente per quasi quattro ore, dovrete concedervi una pausa (5)/ un'aranciata (3.3)/ uno spuntino (4.9). [94, 94]

*You have worked non-stop for almost four hours, you should allow yourself a break / an orange soda / a snack.*

97. Ci sono fenomeni cui non è possibile dare solo una spiegazione (4.7)/ un'occhiata (2.6)/ uno sguardo (2.6). [89, 89]

*There are phenomena that cannot be given only one explanation / glance / look.*

98. Ancora non sapevo esattamente che cosa aspettarmi, ma in qualche modo me n'ero già fatto un'idea (4.2)/ una ragione (3.9)/ un abbozzo (2.7). [78, 89]

*I still did not know exactly what to expect, but somehow I had already formed an idea / reached acceptance / developed<sup>8</sup> a sketch.*

99. Mentre cercava di prendere il miele, venne punto da un'ape (5)/ una spina (2.5)/ un istrice (3.2). [89, 94]

*While he was trying to get the honey, he was pricked by a bee / a thorn / a porcupine.*

100. La scritta sulla sabbia, tracciata proprio in riva al mare, fu subito cancellata appena arrivò un'onda (5)/ una marea (3.6)/ un addetto (1.8). [44, 89]

*The writing on the sand, which had been left right by the shoreline, was erased immediately as soon as a wave/ a tide / a staff member arrived.*

101. Nonostante si fosse recato all'asta con l'intenzione di tornare a casa a mani vuote, cambiò idea e, alla vista di un vecchio baule, lanciò un'offerta (4.9)/ una proposta (3.5)/ un urlo (2.6). [67, 78]

*Although he had gone to the auction with the intention of not buying anything, he changed his mind and, when he saw an old chest, he erupted in an offer / a proposal / a scream.*

102. Mentre esploravo i fondi marini, ho trovato una perla all'interno di un'ostrica (4.7)/ una conchiglia (4.4)/ un anfratto (4.2). [61, 61]

*As I was exploring the sea bed, I found a pearl inside an oyster / a shell / a cavity.*

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<sup>8</sup> The English translation has three different verbs, but in the Italian version the light verb *fare* (to do) works with all three continuations.

103. Dopo anni passati lontano dai riflettori, la famosa attrice ha finalmente rilasciato un'intervista (5)/ una dichiarazione (5)/ un autoritratto (3.2). [89, 94]

*After years spent away from the spotlight, the famous actress has finally released an interview / a statement / a self-portrait.*

104. Per far luce sugli eventi, la Procura di Milano ha avviato un'inchiesta (5)/ una ricerca (4)/ un accertamento (3.8). [83, 50]

*To shed some light on the events, the Public Prosecution Office in Milan has begun an investigation / a search / an assessment.*

105. Il rischio maggiore è che dei batteri entrino nella ferita e provochino un'infezione (5)/ una cancrena (4.1)/ un ascesso (4.1). [83, 100]

*The major risk is that bacteria may enter the wound and cause an infection / gangrene / an abscess.*

106. I primi casi di Ebola sono stati isolati per evitare che il contagio si trasformi in un'epidemia (4.6)/ una catastrofe (4.4)/ un eccidio (3). [72, 100]

*The first cases of Ebola were put in isolation to avoid contagion giving rise to an epidemic / a catastrophe / a massacre.*

107. Il cane ha posato la zampa sul cemento fresco del vialetto, lasciando un'impronta (5)/ una traccia (4.6)/ un incavo (3.5). [61, 83]

*The dog placed its paw on the freshly poured concrete on the footpath, leaving an imprint / a trace / a groove.*

108. Abbiamo diversi tipi di agrumi: preferiresti preparare una limonata o un'aranciata (4.3)/ una cedrata (4.5)/ un aperol spritz (3.3). [78, 89]

*We have several different kinds of citrus fruit: would you prefer a lemon soda or an orange soda / a citron soda / an aperol spritz.*

109. La fotografia è - così come la pittura e la scultura - un'arte (4.9)/ una vocazione (4)/ un espediente (2.7). [78, 100]

*Photography - just like painting and sculpture - is an art / a vocation / a device.*

110. Stamattina Marica si è recata in banca, ma la fila era lunghissima ed ha deciso che non valeva la pena di aspettare dato che allo sportello voleva chiedere solo un'informazione (5)/ una cosa (5)/ un opuscolo (4.8). [94, 94]

*This morning Marica went to the bank, but the queue was very long and she decided that it was not worth waiting given that she only wanted to ask for a piece of information / a thing / a brochure at the counter.*

111. Di solito, in italiano le parole che finiscono con la A sono femminili, ma non la parola 'profeta'. In questo caso, si tratta di un'eccezione (4.9)/ una particolarità (3.4)/ un irregolare (4.4). [56, 56]

*Usually, in Italian, words that end in A are feminine, but not the word 'profeta'. In this case, we have an exception / an oddity / an irregular (noun).*

112. Il registro delle presenze di quest'alunno è quasi immacolato: in tutto l'anno, ha fatto solo un'assenza (4.8)/ una vacanza (3.4)/ un esame (2). [67, 83]

*The attendance record for this pupil is almost complete: throughout the whole year, he has had only one absence / holiday / exam.*

113. L'UNICEF costruisce scuole nei paesi sottosviluppati per assicurarsi che ogni bambino riceva un'istruzione (4.8)/ una possibilità (4.5)/ un aiuto (4.5). [94, 83]

*UNICEF builds schools in underdeveloped countries to ensure each child receives an education / a chance / some help.*

114. Appena lo vide accasciarsi a terra, si affrettò a digitare 118 sul cellulare per chiamare i soccorsi e poco dopo sentirono la sirena di un'ambulanza (5)/ una volante (3.8)/ un allarme (4.2). [39, 83]

*As soon as (s)he saw him collapsing to the ground, (s)he hurried to dial 118 on his/her mobile to call the emergency services and soon after they heard the siren of an ambulance / a police car / an alarm.*

115. Dopo giorni di cammino in mezzo al deserto, trovarono dell'acqua da bere e una palma sotto cui riposarsi: infatti, avevano trovato un'oasi (5)/ una sorgente (3.7)/ un eremo (2.2). [72, 89]

*After walking for days in the desert, they found drinking water and a palm tree under which they could rest: indeed, they had found an oasis / a spring / a hermitage.*

116. È già successo in passato: se continuerà a piovere così tanto, il fiume esonderà e provocherà un'inondazione (4.9)/ una frana (4.3)/ un allagamento (4.7). [67, 56]

*It has already happened in the past: if it keeps raining so much, the river will break its banks and cause a flooding / a landslide / a flood.*

117. Durante la seconda guerra mondiale, Italia e Germania strinsero un'alleanza (4.9)/ una coalizione (3.7)/ un accordo (4.9). [61, 72]

*During the Second World War, Italy and Germany were united in an alliance / a coalition / an agreement.*

118. I carcerati hanno deciso di rubare le chiavi custodite dal secondino per scappare e quindi effettuare un'evasione (4.3)/ una rapina (4.2)/ un illecito (3.2). [50, 50]

*The inmates decided to steal the keys kept by the prison guard to escape and thus attempt an evasion / a robbery / a crime.*

119. La Sardegna, così come la Sicilia, la Corsica, Malta e Cipro, è un'isola (4.6)/ una meraviglia (4.8)/ un eden (3.1). [94, 100]

*Sardinia, like Sicily, Corsica, Malta and Cyprus, is an island / a marvel / a paradise.*

120. Il sapere umano può venir catalogato nei numerosissimi volumi di un'enciclopedia (4.8)/ una biblioteca (3.6)/ un archivio (3.3). [67, 78]

*Human knowledge can be catalogued in the multitude of volumes of an encyclopedia / a library / an archive.*

121. Non se la sentono di organizzare da soli il viaggio in Cina, quindi si sono rivolti ad un'agenzia (5)/ una guida (4)/ un esperto (4.6). [72, 89]

*They do not want to organise the trip to China on their own, so they have asked an agency / a guide / an expert.*



122. Non sono convinto che il mio articolo possa piacere, perciò vorrei la tua opinione e mi chiedevo se potessi dargli un'occhiata (3.6)/ una letta (2.9)/ un apporto (1.8). [78, 83]

*I am not sure people will like my article, so I would like your opinion and I was wondering if you could give it a look / a read / a contribution.*

123. Questa sera il chirurgo e i suoi assistenti effettueranno un'operazione (4.6)/ una ricostruzione (4.4)/ un intervento (5). [28, 50]

*This evening the surgeon and his assistants will carry out an operation / a reconstruction / a surgery.*

124. Nei parcogiochi per bambini, oltre a scendere da uno scivolo, ci si può dondolare su un'altalena (5)/ una giostra (3.4)/ un aeroplanino (3.1). [100, 100]

*In playgrounds, as well as coming down a slide, you can rock on a swing / a merry-go-round / an airplane.*

125. Non è un Martini se non viene servito insieme ad un'oliva (4.7)/ una guarnizione (2.2)/ un antipasto (3.6). [59, 71]

*It is not a Martini unless it is served with an olive / a garnish / an appetizer.*

126. Al comizio erano presenti più o meno una cinquantina di persone. Dire che ce n'erano migliaia è decisamente un'esagerazione (5)/ una bugia (4.8)/ un errore (4.9). [56, 50]

*About fifty people were present at the public speech. Claiming there were thousands is definitely an exaggeration / a lie / a mistake.*

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Table 2. Fixed effects of the linear mixed-effects models in each 100 ms bin relative to the article onset.

| Fixed effects                                | Time bin (ms) | 0-100    |                | 100-200  |                | 200-300  |                | 300-400  |                | 400-500  |                | 500-600  |                |
|--|---------------|----------|----------------|----------|----------------|----------|----------------|----------|----------------|----------|----------------|----------|----------------|
|  |               | <i>t</i> | <i>p</i>       | <i>t</i> | <i>p</i>       | <i>t</i> | <i>p</i>       | <i>t</i> | <i>p</i>       | <i>t</i> | <i>p</i>       | <i>t</i> | <i>p</i>       |
| (Intercept)                                  |               | 5.2      | <b>&lt;.01</b> | 3.3      | <b>&lt;.01</b> | 5.5      | <b>&lt;.01</b> | 4.8      | <b>&lt;.01</b> | 5.1      | <b>&lt;.01</b> | -3.9     | <b>&lt;.01</b> |
| Gender mismatch                              |               | -.92     | .36            | -1.4     | .16            | -.03     | .98            | -1.2     | .25            | -1.9     | .05            | -1.5     | .15            |
| Phonological mismatch                        |               | -.82     | .41            | -1.4     | .18            | -.41     | .69            | -.76     | .45            | -1.9     | .06            | -2.4     | <b>.02</b>     |
| Anteriority                                  |               | 5.8      | <b>&lt;.01</b> | .44      | .66            | 2.8      | <b>&lt;.01</b> | -4.1     | <b>&lt;.01</b> | -.56     | .57            | -3.2     | <b>&lt;.01</b> |
| Gender mismatch:Anteriority                  |               | 5.5      | <b>&lt;.01</b> | 1.5      | .14            | 4.6      | <b>&lt;.01</b> | -2.0     | <b>.04</b>     | 1.7      | .08            | -.01     | .99            |
| Phonological mismatch:Anteriority            |               | 6.1      | <b>&lt;.01</b> | -.01     | 1.0            | 2.5      | <b>.01</b>     | -4.8     | <b>&lt;.01</b> | -.50     | .61            | -.61     | .54            |
| Hemisphere                                   |               | -.45     | .65            | .55      | .58            | 1.5      | .13            | 1.4      | .17            | .40      | .69            | .28      | .78            |
| Gender mismatch:Hemisphere                   |               | .71      | .48            | 1.87     | .06            | 3.1      | <b>&lt;.01</b> | 3.6      | <b>&lt;.01</b> | 1.9      | .07            | 2.0      | <b>.05</b>     |
| Phonological mismatch:Hemisphere             |               | .46      | .65            | .78      | .44            | 1.6      | .11            | 1.5      | .14            | .85      | .40            | 1.3      | .21            |
| Anteriority:Hemisphere                       |               | .49      | .62            | .14      | .89            | -.36     | .72            | .34      | .73            | <.01     | 1.0            | .15      | .88            |
| Gender mismatch:Anteriority:Hemisphere       |               | .61      | .54            | .58      | .56            | -.12     | .90            | .53      | .60            | .25      | .81            | -.43     | .67            |
| Phonological mismatch:Anteriority:Hemisphere |               | .13      | .89            | .54      | .59            | .35      | .73            | 1.4      | .15            | 1.2      | .25            | 1.3      | .18            |

Note: *t* = *t*-value (df = 308), *p* = *p*-value; *p*-values that are smaller than .05 are in bold. The follow-up analyses revealed a significant effect of gender mismatch in the 300 – 400 ms and 500 – 600 ms bins, and a significant effect of phonological mismatch in the 500 – 600 ms bin.

Table 3. Fixed effects of the linear mixed-effects models in each 100 ms bin relative to the noun onset.

| Fixed effects                                | Time bin (ms) | 0-100    |          | 100-200  |          | 200-300  |          | 300-400  |          | 400-500  |          | 500-600  |          | 600-700  |          | 700-800  |          |
|--|---------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
|  |               | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> | <i>t</i> | <i>p</i> |
| (Intercept)                                  |               | 4.7      | <.01     | 1.1      | .28      | 7.2      | <.01     | 6.5      | <.01     | 5.5      | <.01     | 4.8      | <.01     | 7.0      | <.01     | 8.1      | <.01     |
| Gender mismatch                              |               | -.27     | .79      | .28      | .78      | -.14     | .89      | -2.0     | .05      | -4.5     | <.01     | -3.6     | <.01     | -.87     | .39      | .29      | .77      |
| Phonological mismatch                        |               | -1.6     | .11      | -.33     | .74      | -.50     | .61      | -1.6     | .12      | -3.5     | <.01     | -1.7     | .09      | .86      | .39      | 1.4      | .17      |
| Anteriority                                  |               | 7.9      | <.01     | 2.5      | .01      | 8.3      | <.01     | 2.0      | .04      | 1.1      | .29      | 1.2      | .24      | 2.7      | .01      | 5.0      | <.01     |
| Gender mismatch:Anteriority                  |               | 5.9      | <.01     | 2.9      | <.01     | 8.0      | <.01     | 2.5      | .01      | 5.5      | <.01     | 9.7      | <.01     | 1.7      | <.01     | 8.2      | <.01     |
| Phonological mismatch:Anteriority            |               | 6.0      | <.01     | 2.9      | <.01     | 7.2      | <.01     | 2.6      | .01      | 5.2      | <.01     | 8.3      | <.01     | 8.6      | <.01     | 6.8      | <.01     |
| Hemisphere                                   |               | -1.1     | .28      | .49      | .62      | 1.9      | .06      | 1.7      | .09      | .29      | .77      | .34      | .73      | 1.1      | .28      | 1.3      | .20      |
| Gender mismatch:Hemisphere                   |               | -2.5     | .01      | .41      | .68      | 1.6      | .11      | .41      | .68      | -1.5     | .13      | -1.1     | .28      | -.19     | .85      | .49      | .63      |
| Phonological mismatch:Hemisphere             |               | -.84     | .40      | .01      | .99      | 1.3      | .21      | .99      | .32      | -1.1     | .26      | -1.2     | .23      | -.30     | .76      | .46      | .65      |
| Anteriority:Hemisphere                       |               | .97      | .33      | -.04     | .97      | -1.2     | .24      | -.47     | .64      | -.77     | .44      | -.65     | .52      | -.32     | .75      | -.44     | .66      |
| Gender mismatch:Anteriority:Hemisphere       |               | .80      | .42      | -.49     | .62      | -1.1     | .29      | -.23     | .82      | -.37     | .71      | -.51     | .61      | -.08     | .94      | .38      | .71      |
| Phonological mismatch:Anteriority:Hemisphere |               | .40      | .69      | -.33     | .75      | -1.2     | .25      | -.34     | .74      | -.72     | .47      | -.82     | .41      | -.65     | .52      | -.36     | .72      |

Note: *t* = *t*-value (df = 264), *p* = *p*-value; *p*-values that are smaller than .05 are in bold. The follow-up analyses revealed significant N400 effects for both mismatch conditions in the 400 – 700 ms bins, and significant frontal positivity for both mismatch conditions in the 600 – 700 ms bin. Additionally, there was a marginally significant N400 effect for the gender mismatch condition in the 300 – 400 ms bin.

## Highlights

- An ERP study on prediction of phonological and gender information during reading.
- Evidence for prediction of phonological and gender information on article before noun.
- An earlier prediction mismatch effect for gender vs. phonological mismatch.
- The time-course of prediction is in line with prediction-by-production theory.