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Processing standard and expletive negation: An eye-tracking study on Italian temporal and causal clauses

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Natural language sometimes expresses negation in rather puzzlingly different forms. Different from Standard Negation (SN), Expletive Negation (EN) involves a negative marker that does not affect the truth conditions of a sentence. The theoretical literature debates whether EN is a semantically empty element or a negative operator. This paper addresses this question by investigating the processing of EN and SN against affirmative sentences through an eye-tracking while reading experiment. EN is presented in Italian temporal clauses (It. *Rimarrò qui finché Gianni **non.EN** verrà alla festa*; Eng. 'I will stay here until Gianni comes to the party.') and SN in Italian causal clauses (It. *Chiara è rimasta in casa perché Marco **non.SN** ha chiamato la pizzeria*; Eng. 'Chiara remained in the house because Marco did not call the pizzeria'). The results reveal distinct processing profiles for EN and SN: (i) both types of negation showed increased processing costs in early measures (gaze duration) on the verb under negation scope; (ii) however, EN differed from SN in late measures, showing no additional processing cost in total reading time compared to affirmative sentences, while SN maintained elevated processing demands. These findings suggest that EN, though not truth-functional, implies early processing cost, which may suggest its lexical non-emptiness and its integration as a syntactic negative operator. Meanwhile, its lack of impact on later measures confirms that the difference from SN emerges at the level of propositional meaning. The study offers empirical evidence on EN and novel insights into the cognitive processing of negation.

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1 Introduction

Negation is far from being a uniform phenomenon, as it exhibits subtle nuances that do not always align with the straightforward logical interpretation commonly associated with its use. In fact, there are non-standard uses of the negative marker, for which its presence fails to affect the truth conditions of the proposition it occurs in. This phenomenon is usually referred to as Expletive Negation (EN). The contrast between Standard Negation (SN) and EN is visible in the following Italian example:

- (1) a. Sono triste perché Gianni **non** verrà alla festa.
 Be-PRES.1SG sad because Gianni NEG come-FUT.3SG to the party.
 ‘I’m sad because Gianni won’t come to the party.’
- b. Rimarrò qui finché Gianni **non** verrà alla festa.
 I.stay-FUT.1SG here until Gianni NEG come-FUT.3SG to the party.
 ‘I will stay here until Gianni comes to the party.’
- c. Rimarrò qui finché Gianni verrà alla festa.
 I.stay-FUT.1SG here until Gianni come-FUT.3SG to the party.
 ‘I will stay here until Gianni comes to the party.’

The negative marker *non* affects the proposition in which it appears in (1a), as its propositional content is that Gianni will **not** come to the party. However, it does not fulfil the same function in (1b), where the propositional content that Gianni will come to the party is not negated, in spite of the presence of *non*. In fact, the negative marker can be omitted altogether, as shown in (1c), without affecting the grammaticality or the propositional meaning of the sentence. Such expletive use of the negative marker has been described in earlier literature using terms such as *pleonastic*, *redundant*, or *non-truth-functional* negation (Jespersen 1917; Horn 1989), reflecting its lack of contribution to the semantics of the sentence, and aside from examples such as (1a–c) in Italian. This type of negation is not limited to examples such as (1a–c) in Italian; it is reported in other sentence types within Italian (Greco 2019a) and in a number of other languages as well (Jin & König 2020).

Interestingly, languages exhibiting EN can be divided into two classes: those with two distinct negative lexical items – one for SN and one for EN – and those with a single negative lexical item used for both functions. Examples of the former include Latin (*non* vs. *ne*) and Greek (*min* and *dhen*), while examples of the latter include Italian (*non*) and German (*nicht*) (see Greco 2020 and references therein).

While the standard use of negation affects the truth-conditions of a given sentence, the expletive use of a negative marker is accounted for in the literature in different ways, mostly analysing it as either a non-negative or a negative element. On the one hand, in the non-negative approach, EN has been traditionally associated with semantic emptiness and vacuity. Approaches

that endorse this view consider EN as a vacuous morpheme that has lost its negative value (Haegeman and Zanuttini 1991; Espinal 1992; Fischer 1992; van der Wouden 1994a; 1994b; Van der Wurff 1999, among others). Espinal (1992), for instance, accounts for the expletive interpretation of negation in terms of Logical Absorption, a structural mechanism that takes place at the Logical Form. Logical Absorption is triggered by the presence of specific lexical items – such as comparative quantifiers of inequality, as well as certain prepositions and verbs (Espinal 1992: 347–348) – that in certain languages license EN incorporation in their representation. Through this operation, EN results as semantically empty. Espinal’s approach ultimately anchors the expletiveness of the negative marker in EN to a structural operation at the Logical Form, through which another element incorporates the logical content of negation.

On the other hand, according to the negative approaches proposed by Abels (2005), Greco (2017; 2019b; 2020), Delfitto et al. (2019), the negative marker of EN always realises a negative operator, but it does not act on the propositional layer and, therefore, it does not affect the truth-value conditions of a given sentence. Specifically, Greco (2017; 2019b; 2020) argues that the twofold interpretation of negation (standard or expletive) is encoded in syntax. The standard reading of negation, which reverses the truth-condition of a sentence, arises when the Negation Phrase (NegP) is merged in the TP-area (Zanuttini 1997) during the vP phase (Chomsky, 2001). Thus, the negative particle has access to the predicative core of the sentence in the case of SN. The expletive reading is instead yielded when NegP is merged in the CP Domain (Left Periphery, c.f. Rizzi 1997; Rizzi & Bocci 2017) when the vP is already closed, meaning that NegP cannot access the predicative domain.¹ In this view, the reading of negation is strictly determined by its structural position, and EN and SN are seen as two manifestations of the same element.

1.1 The case of temporal clauses

EN can be observed in different structures, such as clauses introduced by temporal conjunctions, non-veridical predicates, *unless/without* clauses, comparatives, and exclamative clauses in various languages (Espinal, 2000; Yoon, 2011), and the characterisation of EN is highly dependent on the structure in which it occurs.

EN is subject to language-specific syntactic constraints and licensing conditions, which differ widely from one language to another, resulting in a language-specific distribution (Jin & König 2020). From this point of view, Italian represents an ideal domain of investigation since it features more than ten types of structures showing EN (Greco 2019a), with different properties. For

¹ In Greco’s terms, this is the mechanism that undergoes the expletive interpretation of negation in a subset of EN clauses, namely the *strong* ones. Whether this mechanism holds for every kind of EN is beyond the scope of the present work.

instance, its optionality: in temporal structures like (1b–c) EN is optional, while it is obligatory in others, like in the case of Italian Surprise Negation sentences (SNEGs), as shown in (2).

- (2) E *(non) mi è scesa dal treno Maria?! (Greco 2020)
 and NEG CL.to_me is got off-the train Mary'
 'Maria got off the train (and that was surprising)'

Among the structures in which EN has been observed in Italian, the specific case taken into consideration for the study presented here is that of temporal clauses introduced by *until*. This type of temporal clause involves a main clause describing an event and a temporal subordinate clause introduced by *finché* (“until”) that specifies the endpoint of the main event in relation to another event following it. We restate the essential data here:

- (3) a. Chiara è rimasta in casa finché Marco **non** ha chiamato
 Chiara stay-PST.3SG in the house until Marco NEG.EN call-PST.3SG
 la pizzeria per la cena.
 the pizzeria for the dinner'
 'Chiara stayed at home until Marco called the pizzeria for dinner'
- b. Chiara è rimasta in casa finché Marco ha chiamato la pizzeria
 Chiara stay-PST.3SG in the house until Marco call-PST.3SG the pizzeria
 per la cena.
 for the dinner
 'Chiara stayed at home until Marco called the pizzeria for dinner'

The connective *finché* establishes a temporal sequencing between events and can trigger the use of EN in the subordinate clause. More specifically, sentences in (3a–b) have the same truth-conditions, regardless of the presence of negation, and both convey the meaning that the action in the main clause – Chiara staying at home – lasts until the event in the temporal subordinate clause happens – Marco making the call. The difference between (3a) and (3b) seems to be that in the presence of EN (3a) and in the presence of a durative predicate as *rimanere* (lit. “to remain”), this sense of the chronological arrangement of events is more strongly perceived.

Semantic analyses of EN in temporal *until*-clauses, as those illustrated in (3), have been conducted within the negative approaches to EN, which argue in favour of an interpretation of EN as full negation. In line with these accounts, we find Cépeda (2017), who examines Spanish *hasta*-clauses (*until*-clauses). Cépeda (2017) provides a viewpoint that sheds light on the interaction between the predicate following the temporal conjunction *hasta* (“until”) and EN. More specifically, EN is interpreted as an operator scoping over the temporal layers of events rather than over complete propositions, based on the idea of semantic negation as a complement function (Keenan & Faltz 1985; Postal 2005; Collins & Postal 2014; Delfitto & Fiorin 2014; Lukyanenko & Blanchette 2025) – an operator that takes an argument and returns its complement.

Relying on the type of predicate in the temporal subordinate clause, she distinguishes two types of *until*-clauses: *punctual*, when the temporal clause describes an achievement (4) (Cépeda 2017: 10, 11), and *coextensive*, when the temporal clause describes an accomplishment (5) (Cépeda 2017:8).

- (4) a. Ana no se irá [hasta que María llegue a la oficina]
 Ana NEG CL go-FUT.3SG until that Maria arrive-PRES.3SG to the office
 ‘Ana won’t leave until Maria arrives at the office.’
- b. Ana no se irá [hasta que María **no** llegue a la oficina]
 Ana NEG CL go-FUT.3SG until that Maria **NEG** arrive-PRES.3SG to the office
 ‘Ana won’t leave until Maria arrives at the office.’
- (5) a. Ana no se irá [hasta que María cante el himno nacional]
 Ana NEG CL go-FUT.3SG until that Maria sing-PRES.3SG the anthem national
 ‘Ana won’t leave until Maria sings the national anthem.’
- b. Ana no se irá [hasta que María **no** cante
 Ana NEG CL go-FUT.3SG until that Maria **NEG** sing-PRES.3SG
 el himno nacional]
 the anthem national
 ‘Ana won’t leave until Maria sings the national anthem.’
 (Lit.: ‘Ana won’t leave until Maria doesn’t sing the national anthem.’)

In both cases, in *hasta*-clauses, EN plays a negative semantic role, stating that the event in the main clause does *not* happen during the time period mentioned in the temporal clause, and limiting the event to the interval specified by the temporal conjunction. This semantic contribution, albeit appearing clearly when the interval expressed by the subordinate *hasta*-clause has a duration (5a–b), is less evident in cases in which the interval is restricted to a time point defined by the achievement (4a–b). Let us illustrate this by discussing the example above.

What (4a) expresses is that Ana will leave *during* the interval starting once Maria arrives at the office or shortly thereafter. The effect of EN in the interpretation of (4b) is to *negate* that Ana will leave exactly *during* the interval in which Maria is arriving at the office, and she will leave *once* Maria has arrived at the office or shortly thereafter. The punctual nature of the predicate “to arrive” hides the difference between (4a) and (4b), feeding the interpretation of the negative marker as expletive (Cépeda 2017: 11). In the case of (5b) instead, even if the semantic apport of EN is the same as in (4b) – namely that the eventuality in the main clause is expected to happen in the interval specified by the temporal conjunction – the contribution of negation emerges more clearly. While the interpretation of (5a) is that Ana will leave *during* the interval starting when Maria starts singing the national anthem; what (5b) expresses is that Ana will leave only when Maria has finished singing, right after Maria has finished singing the national anthem and *not during* (Cépeda 2017: 9).

Following the analysis of Cépeda (2017), the negative contribution of EN affects the temporal layer, specifying the moment in which the action is going to take place and not affecting the truth-conditions of the sentence. Negation is still genuinely negative in nature, but it computes complements of temporal arguments rather than propositional ones. In this sense, the proposal of Cépeda (2017) can be interpreted in analogy to the negative approaches mentioned above, specifically to Greco (2017; 2019b; 2020) and Delfitto et al. (2019), according to which EN does not affect the predicative core of the sentence, but contributes as an instance of negation at a different level.

Similar considerations on the interaction between “until”, punctual predicates and negation are found in Tovena (1996) for Italian *finché*-clauses, and in a crosslinguistic analysis between Italian and Spanish *finché/hasta*-clauses in Español-Echevarría & Vegnaduzzo (2000). Tovena (1996) and Español-Echevarría & Vegnaduzzo (2000) similarly fall within the negative approaches according to which EN has a semantic contribution in the interpretation of the sentences in which it occurs. The semantic analyses by Cépeda (2017), Tovena (1996) and Español-Echevarría & Vegnaduzzo (2000) clarify the interaction between the presence of negation following the temporal conjunctions *hasta* in Spanish and *finché* in Italian, in which these structures seem to behave similarly.

The current research aims to investigate the online processing of EN in Italian *finché* temporal clauses (see example 3) to provide insight into the characterisation of EN as an instance of negation with reference to the two main theoretical accounts described above, hence either as a non-negative element or a full negative operator. Our investigation starts from the proposal on EN presented above for temporal clauses, according to which EN is not interpreted as a propositional negation, and tries to contribute to the understanding of it by looking at its effect on sentence processing. In doing so, a comparison with the psycholinguistic literature on SN, where its processing effects have been well-documented, provides a relevant reference point and serves as a baseline for determining whether EN exhibits a similar processing pattern.

1.2 The processing of negation

Studies across various experimental paradigms have shown that negative sentences result in longer processing times and higher error rates compared to their affirmative counterparts (Wason 1965; Trabasso et al. 1971; Clark & Chase 1972; Carpenter & Just 1975; Carpenter et al. 1999; Hasegawa et al. 2002; Kaup et al. 2007). This increased cognitive load shows that SN typically leads to greater processing demands, as established by research in psycholinguistics (Kaup & Dudschig 2020). Beyond sentence-level effects, the integration of SN in sentences exhibits delayed integration patterns (several seconds) at the discourse level (Kaup et al. 2005; 2006; Hasson & Glucksberg 2006; Giora 2006; Lüdtke et al. 2008; Scappini et al. 2015). Crucially, the processing cost associated with negation has been shown to be softened, or even eliminated, by a

more felicitous and coherent pragmatic licensing context introducing the negative sentence (a.o., Nieuwland & Kuperberg 2008; Orenes et al. 2014).

In contrast to the breadth of studies analysing the processing and comprehension of SN, little is known about the processing of EN, although some previous studies have attempted to determine, with reference to the approaches seen above, whether EN sentences are processed as affirmative clauses or as negative clauses.

Experimental data for EN in temporal sentences are provided, for example, by Cépeda & Deprez (2025) for French *avant*-clauses, which show a semantic behaviour compatible with Cépeda's *hasta*-clauses analysis (Cépeda 2017; 2018). The study focuses on the temporal use of *avant*, which shares the same semantics as *before*, hence expressing anteriority. In these contexts, EN optionally occurs in French. As in the case of Spanish *hasta*-clauses (Cépeda 2017; 2018), the distinction between durative and punctual predicates plays a central role in deriving the sentence interpretation, being associated with two different readings of the temporal relation between the events described. This intuition is tested in two experiments with native French speakers. Constructions with an *avant*-clause and durative events, both with and without EN, were used as test sentences. Potential interpretations of the temporal relation between the events were presented after the test sentences in a sentence verification task. Verification statements were designed to test the enforcement of the non-overlapping reading. By responding "Agree", participants confirm that the sentence triggered the non-overlapping reading. Experiments 1 and 2 are identical except for the polarity of the main clause. As predicted by the theoretical analysis and the intuitions behind *avant* + EN constructions, the EN condition yielded a significantly higher rate of agreement in the results. The high preference for the non-overlapping interpretation even in sentences without EN highlights the subtle nature of this instance of non-propositional negation, suggesting that its negative contribution is not always consciously perceived. Interestingly, the extra negation in the main clause in Experiment 2 caused a stronger effect in the preference for the non-overlapping reading. Overall findings highlight that the choice for the non-overlapping reading is not categorical but a rather fine-grained gradient preference, which aligns with the intuitions behind EN. Such outcomes strengthened the claim that EN excludes the possibility of an overlap between the sequencing of the described events, as analogously argued by Cépeda (2017; 2018), hence behaving as full non-propositional negation.

An example of an experimental study on EN for Italian is Greco et al. (2020). The study investigated the elaboration of EN in a specific Italian structure, SNEGs (see 2a), measuring eye movements in a visual world paradigm. The matter at issue was whether EN sentences bore more similarities to affirmative or negative sentences during online processing. Eye movements showed that EN sentences were processed similarly to affirmative sentences, differentiating them from the SN sentences. Even if SNEGs show eye-tracking patterns similar to affirmative sentences, however, they were also associated with higher processing efforts in comprehension compared

to both affirmative and negative sentences, visible in slower response times and lower accuracy. According to the authors, these results suggest that the processing of SNEGs was driven both by the syntactic characterization of EN (merged in the CP domain, causing the inability of EN to affect the propositional interpretation of the sentence, resulting in an affirmative polarity), and by the pragmatic integration corresponding to the effect of EN marker on the implicated meaning (see the original work for the detailed analysis).

Finally, an experimental study of EN in Italian takes into account the very same construction at issue here, temporal *until*-clauses: Porrini and colleagues (2025) investigated the processing of EN in these constructions with offline and online measures: an acceptability judgement and a self-paced reading task (from here on: SPR). The first objective was to assess, through participants' preferences, whether the presence of EN in temporal *until*-clauses conveys a more acceptable interpretation than its affirmative counterpart. Findings outlined that the presence of EN sounds more natural in temporal subordinate clauses,² suggesting that, despite not altering the propositional meaning, the presence of the negative marker still contributes to the naturalness of the sentence, which in turn may be interpreted as EN likely having some semantic contribution within the sentence. Secondly, the processing of EN was tested with an online methodology, namely a masked chunk-by-chunk non-cumulative SPR paradigm. The SPR yielded contrasting results compared to the acceptability ratings, highlighting an increase in reading times (RTs) only in the SN condition. These findings confirm that SN sentences are harder to process compared to affirmative sentences, leading to longer RTs and lower accuracy rates. EN seems not to cause the same processing effort and shows a more similar pattern to affirmative sentences. In sum, despite acceptability judgements emphasising a preference for *until*-sentences with EN compared to those without them, in the SPR, no effect of EN was found, contrary to what happened for SN.

Although they provide us with precious insight into our research question, these results unveil the need to adopt a different methodology to deeply understand the role of EN in temporal subordinate clauses. In fact, SPR results may be influenced by methodological limitations. As highlighted by Paolazzi et al. (2022), the reading elicited in a SPR paradigm differs from natural reading conditions. Precisely, participants are required to proceed incrementally from left to right and are not allowed to re-read previous segments of the stimulus, even if those segments

² To ensure the result was not driven by frequency alone, we conducted an exploratory corpus search in itTenTen20 (via Sketch Engine) to estimate the relative frequency of *finché* vs. *finché non* in Italian. The query returned 409,273 occurrences for *finché* and 210,613 for strings matching *finché (0–6 tokens) non* within a sentence, to account for possible nouns and modifiers (including smaller tokens, like articles and prepositions) that could appear in between *finché* and *non*. However, we are aware that, even within the same sentence, the latter query may also capture cases where *non* belongs to a different clause (e.g., embedded structures). For this reason, this search may only be indicative of the relative frequency of *finché* versus *finché non*. A summary of the results, with the description of the queries, can be found on OSF (osf.io/abwx3).

are difficult to process. Although being well-suited for early processing analysis, SPR may yield imprecise results for late processes.

1.3 The present study

The present study aims to assess the role of EN during the online processing of Italian *finché*-temporal clauses (see C epeda 2018 for a discussion on the Spanish equivalent *hasta que*), using an eye-tracking paradigm.

The choice of employing eye-tracking within the reading paradigm is motivated by limitations intrinsic to the SPR paradigm. Eye-tracking instead recreates a more natural reading condition, thanks to which it can return a more complete and fine-grained measure of processing difficulty even for late-stage processing (Rayner 1998; Clifton et al. 2007). Eye movements are recorded both with precise spatial (position in the text) and temporal (first reading and re-reading) resolution, the latter allowing a distinction between early measures – typically associated with initial lexical integration – and late measures – reflecting comprehension difficulty, including meaning integration.

The outcome will be interpreted in light of the theoretical frameworks presented previously. Findings in the processing cost associated with the comprehension of EN in temporal clauses would provide an initial insight to inform theoretical approaches to the phenomenon of EN (outlined in Section 1) and assess whether EN can be considered as an instance or subtype of negation. In relation to these accounts, we also expect two possible outcomes in terms of processing.

- I. The processing of EN sentences (as exemplified in 3a) may show no difference compared to sentences without EN (see 3b) since, following the non-negative approaches, the negative morpheme, being empty, should not convey any negative contribution to the sentence, with no increasing cost on processing, as usually required by negation.
- II. Alternatively, we might observe an effect of EN in the processing of sentences like (3a), which would suggest that it is interpreted as expressing negation.

The conclusions drawn from the analyses by C epeda (2017) and Tovenia (1996) on temporal *until*-clauses predict output (II) – namely a difference in the processing of negative temporal *until*-clauses (3a, with EN) compared to their affirmative counterparts (3b). In line with these two proposals, the difference between negative and affirmative temporal clauses might stem from the semantic contribution of EN at the temporal layer. However, in view of the previous experimental findings on SNEGs reported by Greco et al. (2020) and on temporal *finch e*-clauses (Porrini et al. 2025), the potential effect of EN in processing is likely to be different from that of SN. With reference to eye-tracking measures, we predict that this difference might be seen

through EN having the same effect as SN on early measures, but not on late measures: an early processing cost could reflect the integration of a negative operator, regardless of whether negation is standard or expletive, as it is assumed to be semantically contentful in both cases. Given that in the case of EN the negation is not active on the predicative core of the sentence, however, its presence should not lead to additional effort in the later stages of sentence comprehension, when the effect of negation on the truth conditions of the sentence needs to be assessed. Thus, we can rephrase (II) as:

- III. EN is expected to behave similarly to SN during the initial stages of lexical integration, while diverging at later stages when truth-value conditions of the sentence need to be assessed.

In order to reach the above-mentioned objectives, EN sentences will be analysed in comparison with SN sentences.

2 Methods

2.1 Participants

Sixty-nine adult native speakers of Italian participated in the experiment. They were all recruited at the University of Pavia and at IUSS Pavia, in the north of Italy, where the experiment took place. Three participants who were raised bilingual, one person with ADHD and three subjects who did not complete the reading session were excluded from data analysis. The remaining 60 participants (age range: 18–34; mean age: 24; 35 males, 25 females) declared no history of language or learning disorders, as well as normal or corrected-to-normal vision. Forty participants were either from or spent most of their lives in the north of Italy, whereas nine participants were from the south of Italy, and the remainder of the sample was either from the central area (nine participants) or from the two major Italian islands (two participants). Within the task, some comprehension questions were used as exclusion criteria to ensure that participants were paying attention to the task. No participant performed below the threshold (75%) and thus none was excluded.

2.2 Materials

The same stimuli as Porrini et al. (2025) experiment were used, with the only modification being that the final prepositional phrase was cut from the critical sentences for them to fit in a one-line text. An example of a critical item in each condition is presented in **Table 1**. Critical items were arranged in a 2×2 design, thus presenting 4 conditions, with sentence type (causal/temporal) negation status (absence or presence of the negative marker *non*, leading to affirmative/negative sentences) as independent variables. This design allowed us to investigate the negation effect

not only for EN (presented in the temporal negative condition) but also for SN (presented in the causal negative condition) and possibly evaluate each effect's magnitude compared to the corresponding affirmative counterpart.

Temporal Negative (TN)
<p><i>Chiara è rimasta in casa finché Marco non ha chiamato la pizzeria.</i> Chiara stay-PST.3SG in house until Marco NEG call-PST.3SG the pizzeria. ‘Chiara remained in the house until Marco called the pizzeria’</p>
Temporal Affirmative (TA)
<p><i>Chiara è rimasta in casa finché Marcello ha chiamato la pizzeria.</i> Chiara stay-PST.3SG in house until Marcello call-PST.3SG the pizzeria. ‘Chiara remained in the house until Marcello called the pizzeria’</p>
Casual Negative (CN)
<p><i>Chiara è rimasta in casa perché Marco non ha chiamato la pizzeria.</i> Chiara stay-PST.3SG in house because Marco NEG call-PST.3SG the pizzeria. ‘Chiara remained in the house because Marco did not call the pizzeria’</p>
Causal Affirmative (CA)
<p><i>Chiara è rimasta in casa perché Marcello ha chiamato la pizzeria.</i> Chiara stay-PST.3SG in house because Marcello call-PST.3SG the pizzeria. ‘Chiara remained in the house because Marcello called the pizzeria’</p>

Table 1: Example sentences in each condition.

Since *finché* in Italian can have either a coextensive (“as long as”) or a delimitative (“until”) meaning, our temporal sentences comprised a durative verb (*è rimasto/a*, “stayed”) in the main clause to constrain the expletive interpretation of the subsequent negative particle (Delfitto, 2020), and an achievement verb in perfect form (*ha chiamato*, “has called”) to force the punctual interpretation of EN (à la Tovenà 1996; Español-Echevarría & Vegnaduzzo 2000; Cépeda 2017; 2018; Cépeda & Deprez 2025).³

In order to use the exact same structure to test SN, the subordinating conjunction was switched to *perché* (“because”), thus requiring an additional affirmative causal clause for comparison. In

³ It is worth noting the potential ambiguity between coextensive and delimitative meaning has been avoided by employing perfective constructions. More specifically, as an anonymous reviewer pointed out, the aspectual properties of the main clause verb play a crucial role in restricting or permitting the expletive reading of *non* in the subordinate clause. With non-perfective aspect, as in *Rimarrò qui finché Marco non piangerà* (“I will stay here until Marco cries”), the standard negation reading becomes available, where the subordinate clause can be interpreted as ‘for all the time he is not crying’.

the affirmative sentences, the proper noun in the subordinate clause was lengthened by one syllable to balance out the missing negative marker *non* immediately preceding the noun. A total of 28 critical sentences were spaced out by 68 fillers and then arranged in 4 counterbalanced lists. Finally, to ensure that participants were reading for comprehension, one quarter of the items (all filler sentences) were followed by yes/no comprehension questions.⁴

The full set of stimuli for this experiment can be found in our online repository at the following link: osf.io/abwx3.

2.3 Procedure

The experiment was implemented on an EyeLink 1000 (SR Research), and data were collected from the dominant eye at a sample rate of 1000 Hz. Participants were seated at approximately 60 cm from the screen (1980 × 1080) with a chin rest to minimise head movement. Calibration was conducted on a 9-point grid at the beginning of the experiment and repeated if necessary. All the sentences were written in a 24-point Courier New font, in black text on a light grey background, and were presented in a random order. Participants were instructed to read each sentence silently and then press the spacebar on a keyboard when ready to move on to the next sentence. Whenever a question came up, they had to press either a red (no) or a green (yes) key to move forward. The reading session consisted of two screens of written instructions, a practice block comprising 4 trials (of which 2 were followed by comprehension questions), 2 experimental blocks for the participants to take a break if needed, and one final screen announcing the end of the experiment.

3 Data analysis

Five Areas of Interest (AoI) were taken into consideration for data analysis:

1. The past participle of the verb of the main clause (*rimasto/a*);
2. The conjunction (*perché* for causal sentences, *finché* for temporal ones);
3. The negative marker (*non*), which could only be analysed in the negative sentences (conditions CN and TN, containing respectively SN and EN);

⁴ Sentences containing simple negation were included in the filler items. Of the 26 items that were followed by a yes/no question, 18 contained the negative marker *non*. It is noted here that the overall accuracy on comprehension questions overall was 92.6%, with no participant below 80%, signalling that participants were paying attention to the task. Furthermore, the accuracy on comprehension questions following sentences that contained a negation was 91.6%, ensuring that participants were accurately comprehending negation.

4. The full verb of the subordinate clause (e.g., *ha iniziato*), which in negative sentences is under the scope of negation;
5. The last word of each sentence, which corresponds to the direct object of the verb in the subordinate clause.

More specifically, the verb of the matrix clause (AoI 1) is considered for the relation it entails with EN according to semantic approaches, such as Cépeda's (2017) explanation of temporal sentences described above. The conjunction (AoI 2) is taken into account to observe any possible effect stemming from the difference in sentence type. Finally, AoIs 3 and 4 account for the (expletive) negative clause, while AoI 5 accounts for any possible end-of-sentence effects. As for the metrics, in line with our predictions, for AoIs 3 and 4 we extracted both early (Gaze duration, i.e., the sum of the durations of all fixations made on an AoI till the eye goes past it to the right) and late measures (Total reading time, i.e., sum of the durations of fixations made on an AoI), along with Regression in (the number of regressive fixation on an AoI) and Visit (the number of times the eye enters the AoI) count to observe possible revisiting of critical areas. Additionally, for AoI 3 (the negative marker), we extracted the Skipping rate, which accounts for the expected skipping of short and frequent (function) words and on AoI 4 we extracted Regression path duration (the sum of the durations of all fixations made from the entry to an AoI till its exit from the right, including any regressive fixations to previous material and excluding any later re-visit to the AoI after following its exit) as a measure of sentence processing difficulty. Given that they were presented before the critical area introducing negation, for AoIs 1 and 2, we extracted only late measures (Total reading time, Regression in count and Visit count). For AoI 5, we focused only on Total reading time, Regression path duration, and Regression out (the number of regressive launches from an AoI) count to examine potential wrap-up effects. A schematic summary of the dependent variables extracted for each AoI, together with the experimental predictions made for each, can be found in the Supplementary Materials. These predictions are grounded in previous empirical findings in the eye-tracking literature, which show that each measure indexes different processing stages, and in the theoretical assumptions motivating the present study.

Regarding our data analysis approach, generalised linear mixed models (GLMMs) with a Poisson distribution were used for discrete count variables, including Visit count, and Regression in and out count. For the Skipping rate in AoI 3, we applied a GLMM with a binomial distribution. Reading time (RT) measures, which included Gaze duration, Total reading time, and Regression path duration, were analysed using linear mixed-effects models (LMMs) after log-transforming the RTs. The fixed factors for each model were sentence type (causal vs. temporal) and negation status (affirmative vs. negative). Since EN and SN appeared in two distinct sentence types

(temporal and causal, respectively), a direct comparison was not considered appropriate. Any observed differences in reaction times could stem from varying processing demands associated with each sentence type rather than being attributable to the type of negation. Therefore, the effect of negation status (sum-coded as -1 negative and $+1$ positive) was examined separately for each sentence type by coding sentence type as a factorial variable and treating first temporal and then causal sentences as a reference level in separate analyses. The interaction between sentence type and negation status was also included in the fixed structure. The only exception to this line of reasoning was the glms fitted for AoI 3, which, since this area was not presented in affirmative sentences, only included sentence type as a fixed factor, with causal sentences as a reference level. The random structure of each model was then established using a data-driven approach, starting with the maximal random effects model (following Barr et al. 2013), which included random intercepts and slopes for participant and item variability. As these models resulted in singular fits, we followed the parsimonious model-selection approach advocated by Bates and colleagues (2015), guided by the results of a randomised principal component analysis (rePCA).

For RT data trimming, we employed a model criticism approach following an initial mild trimming step (Baayen & Milin 2010). In the first stage, RTs below 80 ms and above 1000 ms were excluded to filter out anticipatory and excessively delayed responses. After log-transforming the reaction times and fitting the model, standardised residuals were computed by dividing each residual by the standard deviation of the residuals. These standardised residuals were then examined to identify potential outliers. Specifically, any data points with standardised residuals exceeding an absolute value of 2.5 were flagged. Since none of the models produced more than 3% of observations with residuals surpassing this threshold, no further data trimming was deemed necessary.

4 Results

For the sake of conciseness, only measures that produced statistically significant effects will be discussed thoroughly in the results section. The full analysis script with results can, however, be found in our online repository on OSF (osf.io/abwx3).

AoI 1 and 2. None of the extracted measures produced significant effects in these areas.

AoI 3. For RT measures, we found no significant effects on the negative particle *non* in the models analysing RT measures, with only a marginally significant effect for Gaze duration ($\beta = 0.06$, $p = 0.089$), signalling a trend of longer RTs on the negative marker in temporal sentences (i.e., EN). As for discrete variables, however, *non* in temporal sentences had significantly fewer visits ($\beta = -0.190$, $p = 0.025$), although no effect is seen for Skipping rate ($\beta = -0.131$, $p = 0.121$) or Regression in count ($\beta = -0.096$, $p = 0.505$). The differences in Visit count, Skipping

rate and Regression in count between the two conditions under examination can be appreciated by looking at **Figure 1**.

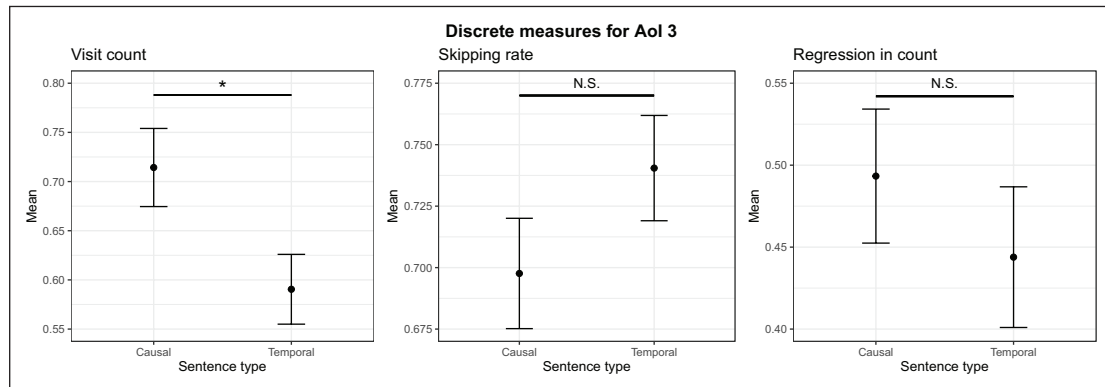


Figure 1: Mean Visit count (left), mean proportion of Skipping (centre) and mean number of Regressions in count (right) on the negative marker in causal and temporal sentences, with error bars based on standard errors.

AoI 4. This interest area consisted of the full verb, which could be under the scope of negation, composed of two separate words, an auxiliary and a past participle. The analyses of all RT measures for this area all produced significant effects. For Gaze duration, an effect of negation is seen: negative sentences had longer RTs on the verb. This effect is observed for both causal sentences presenting SN ($\beta = -0.075, p < 0.001$) and temporal sentences presenting EN ($\beta = -0.054, p < 0.001$). The same effect is seen for Regression path duration (for causal as reference: $\beta = -0.075, p < 0.001$; for temporal as reference: $\beta = -0.056, p < 0.001$). However, the effect found in Regression path duration seems to be driven by Gaze duration itself, as the difference between Regression path duration and Gaze duration did not reach 60 milliseconds in any of the four conditions, and can therefore be considered negligible. When it comes to Total reading time, an effect of negation is only seen for causal sentences ($\beta = -0.041, p = 0.013$), but not for temporal ones ($\beta = -0.002, p = 0.919$). In addition, in both models an effect of sentence type (for causal as reference: $\beta = -0.070, p = 0.003$; for temporal as reference: $\beta = 0.007, p = 0.022$) and a marginally significant interaction between negation status and sentence type models (for causal as reference: $\beta = 0.040, p = 0.090$; for temporal as reference: $\beta = -0.004, p = 0.077$) can be found. The differences between the four conditions on Gaze duration, Regression path duration and Total reading time are shown in **Figure 2**.

The results for discrete variables provide additional information, enriching the processing picture provided by RTs. In fact, for Visit Count, the only significant effect found is an effect of negation status in the model taking temporal sentences (those presenting EN in the negative condition) as reference ($\beta = 0.048, p = 0.044$), with the verb in affirmative sentences being

visited more, while no effect is seen in the causal model (that is, the one pertaining to sentences containing SN in their negative condition). The same effect of negation status in the temporal sentences is replicated for Regression in count ($\beta = 0.101, p = 0.016$).

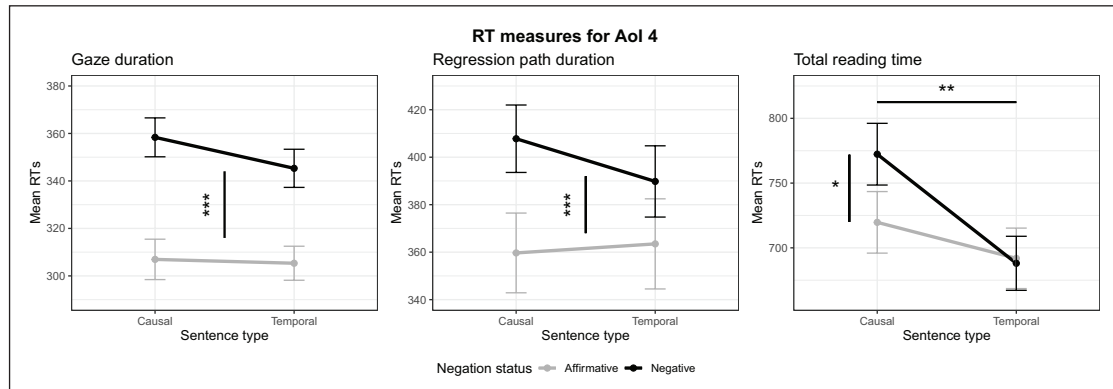


Figure 2: Mean RTs for Gaze duration (left), Regression path duration (centre) and Total reading time (right) on the full verb in negative and affirmative causal (i.e., SN) and temporal sentences (i.e., EN), with error bars based on standard errors.

AoI 5. For the last word, no significant effects were found in the models analysing Total reading time or Regression out count. As for Regression path duration, an effect of sentence type was detected, which was mirrored in both models, showing that the duration of regression paths starting from the last word was longer for causal sentences than for temporal ones ($\beta = |0.068|, p = 0.021$).

5 Discussion

The eye-tracking results reveal different processing patterns for negation across the two sentence structures analysed, namely causal and temporal clauses, licensing respectively either standard (SN) or expletive negation (EN). For SN, the pattern that emerges is much in line with previous research by other scholars (Wason 1965; Trabasso et al., 1971; Clark and Chase 1972; Carpenter and Just 1975; Carpenter et al., 1999; Hasegawa et al., 2002; Kaup et al., 2007) when a coherent pragmatic licensing context is missing (see Nieuwland & Kuperberg 2008; Orenes et al. 2014) as well as with the previous SPR study using the same stimuli (Porrini et al. 2025): on the verb (AoI 4) in the scope of negation gaze duration, total reading time and regression path duration were all longer in negative sentences compared to affirmative ones. For EN, only some of the effects are replicated: the same effects are seen for gaze and regression path duration, but not for total reading time, where no effect of expletive negation is seen. In addition to this, for temporal sentences, the number of visits and regressions in on the verb from the left were higher in the affirmative condition as opposed to the negative one, where EN was presented. No similar effect

is found in causal sentences (presenting SN), suggesting that the difference between the two types of negation can be seen in re-reading behaviour.

Compared to previous studies utilising a SPR methodology, the advantage of implementing an eye-tracking paradigm is that it captures different stages and nuances of sentence processing. Namely, the detection of eye movements during online reading enables a distinction between early measures – typically associated with the initial lexical integration – and late measures – reflecting comprehension difficulty, including meaning integration, which was crucial to our initial predictions. Furthermore, it allows us to assess the effects of both types of negation based on reading patterns observed through multiple measures, rather than relying on single p-values in our interpretation of the results. Going back to the patterns outlined above, for SN, the present eye-tracking findings not only replicate previous results but also provide a more fine-grained picture of its processing. In particular, the predicted increase in both early and late RT measures on the verb in the scope of negation (AoI 4), despite no differences in the number of visits and regressions, suggests that processing the (standard) negation of the predicate demands more cognitive effort than affirmative sentences.

A comparable initial effort is observed in early measures for EN for the same AoI (the verb in the subordinate clause); however, such an effect is not maintained in late measures. An increase of the RTs for gaze duration – immediate lexical access and early word processing – was predicted by our initial hypotheses, and it is observed on the verb (AoI 4) for EN compared to its affirmative counterpart. The similarity between SN and EN in terms of early measures appears to rule out the semantic emptiness of EN, thus agreeing with the so-called negative approaches (Abels 2005; Greco 2017; 2019b; 2020; Delfitto et al. 2019). These approaches postulate that while on the one hand EN and SN both represent a negative entry, on the other, the negative operator affects the predicative core of the sentence only in the latter case. Again, in line with these theories and with our experimental prediction, we found that EN and SN exhibit distinct processing patterns at later stages of processing, with EN not showing extra processing cost compared to affirmative sentences in late RT measures such as total reading time. This might suggest that the presence of the negative marker in its expletive use causes no extra processing cost when dealing with entire sentence comprehension and meaning integration. It must be noted that, contrary to our prediction, for regression path duration, EN and SN also showed similar processing patterns. As outlined in the results section, this result seems to be mainly driven by the high correlation between gaze duration (an early processing measure) and regression path duration, and is thus not interpreted as a late-stage processing effect.

In addition to the effects found in the critical area presented after introducing negation, namely AoI 4, no significant effects were found on the two initial portions of our experimental sentences: the verb in the main clause (AoI 1) or the *finché* and *perché* conjunctions (AoI 2). This is of particular interest for our temporal sentences, as it suggests that no reanalysis of the temporal

relation between main and subordinate clause occurred after reaching the negation, and that the semantic contribution of EN did not need to be reassessed after reaching the negative marker and the verb in the subordinate clause, as might have been the case if the negation was initially assumed to be standard, and only later the negative marker was reanalysed as a semantically empty expletive element, in line with non-negative accounts of EN.

Concerning the effects on the negative marker itself (AoI 3), interestingly, no significant difference in skipping rate between the two sentence types was attested. This suggests that despite the inherent negative semantics of the temporal conjunction *finché* (see 1.1) and the naturalness of EN in such constructions (as attested in Porrini et al. 2025), the presence of *non* following *finché* was not more expected than after *perché* to a degree that could be captured through this measure. The unexpected trend found for gaze duration on the same AoI, with longer reading times on *non* in the temporal sentences than in the causal one, further suggests that the negative marker was not strongly expected after *finché*.⁵ Our analysis of AoI 3, however, revealed a lower visit count in the EN condition. This finding potentially suggests that negation requires more cognitive resources when it is standard, especially at later stages of processing. Nevertheless, as it was not paired with a significance on the measure counting regressions, it must be taken cautiously. Additionally, it must be noted that comparing the negative particle directly in two sentence types is not without its issues, as any significant effects found might be due to differences in processing effort required by the sentence types, and not necessarily by the type of negation used. The result must be considered also in combination with the effects of sentence type detected on total reading times on AoI 4 and for regression path duration on the last word (AoI 5), both suggesting that causal sentences require more effort than temporal ones. While no immediate effort is observed on the conjunction itself (AoI 2), our results highlight a general difference in processing effort between causal and temporal clauses later in the sentence, independent of the presence of negation (standard or expletive). This finding does not affect our conclusions with respect to EN or SN, as the experimental design allowed us to assess the cost of these two types of negation relative to their affirmative counterparts. Thus, any differences between causal and temporal sentences should not influence our interpretation of the effects of negation. Nonetheless, it warrants a brief discussion. While the difference may be attributed to differences in the processing effort necessary to correctly interpret causal and temporal relations between clauses, we would refrain from claiming that causal relationships are inherently more difficult to interpret than temporal ones. In fact, in a previous study using the same stimuli (Porrini et al. 2025), native speakers rated the temporal versions of the sentences as more natural than the causal ones. This was likely due to the need to construct sentences that were coherent in both their affirmative and negative forms. As a result, the causal sentences did not always

⁵ See footnote 2 for a discussion on the frequency of *finché* vs. *finché non*.

describe events where the matrix clause followed directly from the subordinate clause, which may have made the causal link less salient in some cases, making the causal sentences less natural and, consequently, potentially harder to process.

The acceptability ratings collected in the study by Porrini and colleagues (2025) might also provide an explanation for another reading pattern detected in the present study. Namely, in temporal sentences (i.e., those presenting EN in their negative condition), participants visited the verb (AoI 4) significantly more in the affirmative condition. This might be explained by the fact that the results of the acceptability judgment task showed that Italian native speakers find temporal sentences containing the negative marker (with EN) more natural than their affirmative counterparts. This might have led to increased re-reading behaviour on the verb when the negative marker is absent.

Overall, our findings provide support for negative accounts of EN. Furthermore, the results are compatible with the view of EN as an instance of a complement function that does not alter the truth-condition of the sentence in which it appears, but rather, acts at a different level of meaning (a.o., Greco 2017; 2019b; 2020; Delfitto et al. 2019; for EN in temporal clauses: Tovená 1996; Español-Echevarría & Vegnaduzzo 2000; Cépeda 2017). Although further research needs to be conducted to address this issue, it could be argued that the early and late processing profiles we observed for the two types of negation reflect their different roles within the syntactic structure (Greco 2020). As mentioned in the introduction, both EN and SN involve the integration of a NegP into the sentence structure, with SN involved in the TP domain, and thus affecting the predicative core of the sentence directly, while EN is involved in the CP domain, when the predicative relations have already been established. The early measures, where the presence of both EN and SN caused an effect compared to affirmative sentences, may reflect this shared need to integrate the negation structurally, regardless of whether NegP operates on TP or CP. In contrast, the difference observed in late measures – where only SN incurred a greater processing cost compared to its affirmative counterpart, while EN did not – may be attributed to the differences between these structural positions: only when negation operates on the TP layer, thus having access to the predication, it contributes to the propositional content reversing the truth conditions of the clause, which may entail greater integration effort at later stages of interpretation. On the other hand, when negation operates on the CP domain, without affecting the truth conditions of the proposition, no effort at later stages is expected, reducing processing effort for EN compared to SN. As we have seen in the Introduction, some semantic approaches to EN view it as a constraint on the temporal sequence of the two events described in the sentence (Cépeda 2017). While it is not possible to draw predictions about the processing effort associated with such a difference, our results show no significant effect on the verb of the matrix clause (AoI 1), signalling that in our stimuli the relation established by the presence of EN in the *finché*-clause does not entail a differential processing cost associated with the main event.

5.1 Conclusions and future directions

The present findings contribute to a growing body of literature on the processing of different types of negation and, importantly, offer novel insights into expletive negation specifically, an instance of negation often overlooked in the experimental literature. Our results provide empirical support for the view that EN, despite not altering the truth conditions of a sentence, is not semantically empty, as shown by its effect on early reading measures. At the same time, the absence of effects in later measures suggests that EN may impose lower integration costs compared to SN, in line with the so-called “negative” approaches (a.o., Greco 2017; 2019b; 2020; Delfitto et al. 2019). These findings open several avenues for future research, as they constitute an initial attempt to address theoretical questions on EN through an eye-tracking while reading paradigm. First, our study presented EN within a specific linguistic context, namely, temporal subordinate clauses introduced by *finché* and containing punctual verbs; it remains an open question whether similar effects would be observed in the same sentence type with durative verbs. In fact, it has been noted that temporal connectives like *finché* (“until”) can give rise to ambiguous interpretations depending on the aspectual properties of the verb (see Tovena 1996), potentially licensing or blocking EN. The present study was designed to compare EN and SN, with the aim of providing a first theoretically informed, nuanced and cohesive account of EN processing by bridging theories on negation and what we know of SN processing. Therefore, our current stimuli did not permit us to investigate the additional question of EN in relation to verb aspect. Future research could systematically investigate how verb aspect and predicate type modulate the availability of an expletive negative reading by manipulating such factors within sentences presenting EN, rather than comparing EN to SN. Such experimental work would significantly advance our understanding of this phenomenon.

Lastly, while our study constitutes an important step in assessing the online processing cost of expletive negation and highlights the value of using fine-grained methodologies such as eye-tracking to capture the complexity of this phenomenon, further research is needed to explore how EN is processed in a broader range of linguistic contexts and across different languages.

Abbreviations

CL	clitic
FUT	future
NEG	negation
PRES	present
PST	past
SG	singular
1	first person
3	third person

Data availability

The experimental stimuli, the dataset containing the results of the experiment and the full analysis script can be found in our online repository on OSF (osf.io/abwx3).

Ethics and consent

The study was approved by the Ethics Committee of the University of Pavia (protocol number: 27), and all participants provided informed consent.

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Competing interests

The authors have no competing interests to declare.

Authors' contributions

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Formal analysis: A.T.P.;

Investigation: A.T.P., A.Z., V.D., M.G.;

Writing – original draft: A.Z., V.D.;

Writing – review & editing: A.T.P., M.G.;

Supervision: M.G.;

Funding acquisition: M.G.

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