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Investigating syntactic effects in NPI illusions in Turkish

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Abstract. Negative Polarity Items (NPIs) are licensed when they are within the scope of negation. Judgment and online reading tasks revealed that comprehenders may show illusory licensing effects in sentences in which the licensing negation is in an illicit position as in **The bills that no senators voted for will ever become law*. Here we investigate whether NPI illusions reported in earlier studies on Turkish would be replicated and whether such effects would differ depending on the syntactic position of the intrusive licensor, i.e., complement vs. adjunct clauses. With a speeded acceptability judgment and two self-paced reading tasks, we show that NPI illusions with complement clauses are replicated in the judgment task and extend to sentences with adjunct clauses, but we find no evidence for illusory effects in online reading tasks.

Keywords. Turkish sentence processing; prospective dependencies; NPI illusions

1. Introduction. Negative polarity items (NPIs) such as *any, ever* or *lift a finger* are licensed when they are within the scope of, e.g., c-commanded by, a negative element such as *no, few* or *rarely* (e.g., Ladusaw 1979). For example, the NPI *ever* in (1a) is licensed by the negative quantifier *no* in the matrix clause. However, *ever* is not licensed in (1b-1c) because *no* in the embedded relative clause fails to take scope over *ever* in (1b) and there is no negative licensor in (1c)[1,2].

(1) a. No bills [that the senators voted for] will *ever* become law.
b. *The bills [that no senators voted for] will *ever* become law.
c. *The bills [that the senators voted for] will *ever* become law.

It has been reported that there is a (fleeting) perception of acceptability in sentences as in (1b) in which there is a potential but structurally inappropriate, intrusive licensor. When speakers are asked to judge the grammaticality of such sentences, they judge them as acceptable more often than their unlicensed versions as in (1c), though not as frequently as their grammatical versions as in (1a). Such illusory effects have also been observed in self-paced reading, eye-tracking and event related potentials (ERPs) in the form of a reduction in disruption that is otherwise found in sentences with an unlicensed NPI.

The first study that demonstrated such illusory NPI licensing effects was by Drenhaus et al. (2005). They investigated the processing of the German NPI *jemals* 'ever' with sentences analogous to those in (1). Their speeded acceptability judgment task showed that German speakers were less accurate in ungrammatical sentences with an intrusive licensor compared to those with no licensor. Similarly, Vasishth et al.'s (2008) eye-tracking study on German NPIs demonstrated slower reading times at the NPI in ungrammatical relative to grammatical sentences, but this slow-down was reduced in sentences with an intrusive licensor. Similar grammaticality and intrusion effects have been reported in processing NPIs in English (e.g., de Dios Flores et al. 2017; Muller 2022; Orth et al. 2020; Parker & Phillips 2011, 2016; Xiang et al. 2009).

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[1] In the linguistic examples in this paper, NPIs will be given in italic and their (intrusive) licensors will be underlined.

[2] Abbreviations in glossing follow the Leipzig convention.

Whereas NPI dependencies in English and German are *retrospective*, i.e., NPI follows its licensor; in languages like Turkish, Japanese and Korean, they are *prospective*, i.e., NPI precedes its licensor. A few studies investigated illusions with prospective NPI licensing (Turkish: Deniz et al. 2024; Yanılmaz & Drury 2018, Japanese: Su & Aparicio 2022, Korean: Lee & Yun 2022; Yun et al. 2018). They employed stimuli in which the intrusive licensor is a verbal negation embedded in a complement clause (cf. Deniz et al. 2024). An example with the Turkish NPI *kimse* 'anybody' is given in (2b), with its licensed and unlicensed versions in (2a) and (2c), respectively.

(2) Turkish (from Yanılmaz & Drury 2018:6)

a. *Kimse* [Ali-nin çalış-tığ-ın]-ı söyle-me-di.
Anybody Ali-GEN work-NMLZ-POSS-ACC say-NEG-PST
'Nobody said that Ali worked.'

b. **Kimse* [Ali-nin çalış-ma-dığ-ın]-ı söyle-di.
Anybody Ali-GEN work-NEG-NMLZ-POSS-ACC say-PST
'Nobody said that Ali didn't work.'

c. **Kimse* [Ali-nin çalış-tığ-ın]-ı söyle-di.
Anybody Ali-GEN work-NMLZ-POSS-ACC say-PST
'Nobody said that Ali worked.'

Results from these studies showed evidence for NPI illusions with untimed acceptability judgments tasks: intrusion sentences were accepted more often than ungrammatical, but less often than grammatical ones. The results from online reading tasks, on the other hand, are inconclusive. A self-paced reading study on the Japanese NPI *daremo* 'anybody' showed no intrusion effects (Su & Aparicio 2022). But an ERP study on the Turkish NPI *kimse* 'anybody' showed similar ERP responses in grammatical and intrusion sentences (Yanılmaz & Drury 2018), and a self-paced reading study on the Korean NPI *amwuto* 'anybody' showed a slow-down in intrusion relative to unlicensed sentences (Lee & Yun 2022). It is not clear how these findings can be explained with accounts that are primarily based on English and German given structural differences in experimental stimuli and contrastive findings in online reading measures.

In this study, we first ask whether NPI illusions reported in earlier studies on Turkish (Deniz et al. 2024; Yanılmaz & Drury 2018) would be replicated. Second, we examine whether the syntactic position of the intrusive licensor, i.e., complement vs. adjunct clause, would modulate illusory effects, i.e., whether illusory effects would be attenuated with adjunct clauses due to their delayed processing (Frazier & Clifton 1996). With a speeded acceptability and two self-paced reading tasks, we show that (i) NPI illusions with complement clauses are replicated, and they extend to sentences with adjunct clauses, (ii) there is no evidence for illusory effects in online reading or (iii) a difference in processing NPI dependencies with complement and adjunct clauses.

2. Previous accounts. Different accounts have been proposed to explain the emergence of NPI illusions. One account attributes the illusion to similarity-based interference in dependency formation between the NPI and its licensor under the cue-based memory retrieval mechanism (Lewis & Vasishth 2005). In this account, linguistic representations are stored as feature bundles (e.g., word category, case, number) in memory. Upon processing the probe, retrieval cues are generated and checked against all memory representations. The (target) item(s) with matching features is

then retrieved by an associative, content-addressable process. Crucially, items with similar features to those of the target may interfere in the retrieval process. For NPI illusions, Vasishth et al. (2008) proposed that since there is no negative licensor that matches all retrieval cues of the NPI, i.e., a c-commanding negation, the illusion occurs due to an erroneous retrieval of the intrusive negation whose +*negation* feature results in a partial match with the features of the NPI.

This account, however, is challenged by numerous findings. First, this account relies on general memory principles, and predicts such illusions to occur in all cases with a partial match. However, NPI illusions in English are reported to be selective. Illusions occur (i) with quantificational negation such as *no* but not with verbal negation such as *haven't* (de Dios Flores et al. 2017; Muller 2022; Orth et al. 2020); (ii) with an intrusive licensor embedded in a relative but not in a complement clause (Parker & Phillips 2011), (iii) with short(er) distance between the clause boundary and the licensor (Muller 2022; Parker & Phillips 2011) and (iv) more consistently with *ever* than *any* (Parker & Phillips 2016, cf. Muller 2022). Second, in languages with prospective NPI licensing, the licensor is found in the upcoming material rather than retrieved from memory. It is unclear how to adapt the predictions of the cue-based retrieval mechanism for prospective licensing. Third, the c-command relation is a syntactic requirement of NPI dependencies, but this model does not provide details as to how structural constraints like c-command that encode relations between multiple nodes are encoded and navigated in memory (see Kush 2013).

A second account attributes NPI illusions to semantic/pragmatic factors (Xiang et al. 2009). Comprehenders use the contrastive function of restrictive modifiers such as *tall* in *the tall cup* to infer a contrastive referent such as *a non-tall cup* (Altmann & Steedman 1988). Xiang et al. (2009) argued that the use of restrictive relative clauses in NPI illusion sentences similarly create contrastive implicatures. That is, processing the referent *the bills that no senators voted for* that has the property of 'becoming law' as in (3a) may lead to the inference for a contrastive referent such as *the bills that some senators voted for* that has property of 'not becoming law' as in (3b). The negation in the inference in (3b) may thus license the NPI in some trials, resulting in illusions. Although this account can explain the emergence of NPI illusions selectively with relative clauses in English (Parker & Phillips 2011), it cannot explain illusions that occur with complement clauses in Turkish, Japanese and Korean.

(3) a. *The bills [that no senators voted for] will *ever* become law.
b. The bills [that some senators voted for] will not *ever* become law.

A third account proposes that NPI illusions occur when the parser fails to calculate the scope of negative quantifiers (Orth et al. 2020). Given that quantifiers may give rise to multiple scope interpretations, the parser may make an error in determining the correct interpretation of a negative quantifier phrase such as *no senators* in (3a) and erroneously assign a representation in which *no senators* is raised to a higher position and takes scope over *ever*. This seems promising given the selective nature of illusions with quantificational negation in English (Muller 2022; Orth et al. 2020), but again, it can't explain illusions with intrusive negation on embedded verbs in Turkish, Japanese and Korean that are subject to scope restrictions.

A fourth account considers variants of the noisy channel hypothesis (Levy 2008; Hahn et al. 2022) to explain NPI illusions. In the noisy channel account, the sentence that the comprehender perceives is a noisy signal of the speaker's message. Hence, the comprehender simultaneously considers the input as it is perceived as well as similar strings that may be the intended signal but

misperceived due to noise. Those strings are assigned different probabilities, which may shift over the course of processing the sentence. In acceptability judgment tasks, Zhang & Gibson (2024) found evidence for illusion in intrusion sentences with two quantifiers, i.e., *many* and *few* in (4a). They suggested that illusions emerge in these cases because the parser may entertain possible strings in which the two quantifiers are switched in their positions as in (4b), leading to the licensing of *ever* by the matrix subject *few*. They supported this claim with a recall task in which participants were found to make errors in recognizing the correct position of quantifiers.

(4) a. *Many authors [that few critics recommended] have *ever* received...
b. Few authors [that many critics recommended] have *ever* received...
...acknowledgment for best-selling novel.

Note that evidence for the noisy channel account account in NPI illusions is thus far limited to sentences with two quantifiers. A prediction that follows from this account, however, is that illusions may emerge in different configurations as long as alternative parses in which the NPI can be licensed are available. For our study, this account predicts illusions to occur uniformly, i.e., with complement and adjunct clauses. Aligning with these predictions, results show evidence for illusions with both clauses. We evaluate our findings under this account in General Discussion.

3. NPIs and NPI illusions in Turkish. The negative sensitive elements that create a negative dependency in Turkish can be nouns as in (5a) or adverbs as in (5b) (Görgülü 2020).

(5) (from Görgülü 2020:727)
a. *kimse/hiçkimse* 'anybody/nobody', *hiçbir şey* 'anything/nothing', *hiçbir N* 'any/no N'
b. *hiç* 'never, at all', *asla* 'never', *katiyyen* 'in any way', *sakın* 'never'

The negative sensitive elements in Turkish, henceforth NPIs[3], cannot occur in affirmative sentences, and must be licensed by verbal negation or the negative postposition *-sIz* (Görgülü 2020). Yanılmaz & Drury (2018) conducted an ERP study and a judgment task to investigate NPI illusions in Turkish. Their stimuli had sentences with the NPI *kimse* 'anybody' as the matrix or embedded subject, as in (6). Negation was either on the matrix or embedded verb, or not present.

(6) (from Yanılmaz & Drury 2018:6,8)
a. *Kimse* [Ali-nin çalış-(*ma-)dığ-ın]-ı söyle-*(me-)di.
Anybody Ali-GEN work-NEG-NMLZ-POSS-ACC say-NEG-PST
'Nobody said say that Ali worked/didn't work.'
b. Ali [*kimse*-nin çalış-(ma)-dığ-ın]-ı söyle-(me-)di.
Ali anybody-GEN work-NEG-NMLZ-POSS-ACC say-NEG-PST
'Ali said/didn't say that nobody worked.'

The acceptability task showed that grammatical and ungrammatical sentences had high and low acceptance rates, i.e., ∼90% vs. ∼10% respectively. Those with an embedded *kimse* and

[3] Whereas some researchers argued that the elements in (5) are NPIs (e.g., Kelepir 2001), others analysed them as Negative Concord Items (e.g., Görgülü 2020). There is also a debate as to whether they are existential or universal quantifiers (Öney 2024). Without commiting to any of these analyses, we will continue using the term NPI.

negated matrix verb were highly acceptable, i.e. ∼80%, as *kimse* is within the scope of the negation in the matrix clause. The critical intrusion cases were those in which *kimse* was the matrix subject and the negation was on the embedded verb. Such sentences were accepted around 50% of the time, showing evidence for illusion. The ERP study showed P600 and N400-like violation effects for the unlicensed sentences and N400-like violation effects for the critical intrusion sentences with a matrix NPI, showing evidence for online intrusion effects.

It has been reported that embedded NPIs in Turkish can be licensed by a long-distance negation on a neg(ative)-raising matrix verb, e.g., *iste-* 'to want' (Kelepir 2001), and this is reported to be more available with a transparent, non-factive embedded verb, e.g., marked with the nominalizer *-mA* (Kornfilt 1984). This is illustrated in (7).

(7) (from Kelepir 2001:149)
[Hasan-ın *kimse*-yi ara-ma-sın]-ı iste-m-iyor-um.
Hasan-GEN anybody-ACC call-NMLZ-POSS-ACC want-NEG-PROG-1SG
'I don't want Hasan to call anybody.' or 'I want Hasan to not call anybody.'

Deniz et al. (2024) investigated long-distance licensing of the embedded NPI *hiçkimse* 'anybody' with sentences similar to those in (7). They manipulated the transparency of the embedded verb and neg-raising property of the matrix verb in order to (dis)allow long-distance licensing. An untimed acceptability rating task showed higher ratings for intrusion sentences with illicit long-distance licensing, i.e., opaque embedded verb and non-neg-raising matrix verb, replicating illusory effects in Turkish. Note that the NPI *hiçkimse* is within the scope of negation in all of their sentences, which may have overriden the illicitness of their intrusion sentences.

In this study, we investigate NPI illusions in Turkish with two new tasks: speeded acceptability judgment and self-paced reading. We employ stimuli in which the NPI *kimse* is the matrix subject and the intrusive licensor is on the embedded verb. This excludes scope-related explanations of illusory licensing because embedded negation cannot take scope over the matrix clause. We specifically ask whether the syntactic position of the intrusive licensor, i.e., complement or adjunct clauses, modulates illusory effects. It has been shown that the processing of adjuncts such as temporal modifiers is delayed while arguments such as objects are immediately processed (e.g., Frazier & Clifton 1996). In the case of NPI illusions, this may result in a delayed processing of the intrusive negation in an adjunct clause, possibly leading to decreased and/or late illusory effects with adjunct relative to complement clauses. We test this prediction by directly comparing sentences in which the intrusive licensor is in an adjunct or a complement clause.

4. Experiment 1: Speeded Acceptability Judgment Task. Experiment 1 aims to reveal whether NPI illusions in Turkish that were reported with untimed acceptability judgment tasks would be replicated in a speeded acceptability judgment task. Our results show illusory effects with an intrusive licensor that is embedded in a complement as well as an adjunct clause.

4.1. PARTICIPANTS. 50 native speakers of Turkish (M_{age} = 23.9) participated in the task. The participants in Experiment 1 (as well as those in Experiments 2 and 3) were recruited through social media. Each participant were compensated 80 Turkish Lira (∼$3 at the time of the study).

4.2. MATERIALS. The study had a 2x3 design, crossing CLAUSE TYPE of the embedded sentence, i.e., Complement or (temporal) Adjunct clause and LICENSING of the NPI *kimse* in the

matrix subject position, i.e., Licensed with negated matrix verb, Intrusion with negated embedded verb or Unlicensed with no negation, as given in Table 1. The embedded subject was a proper name, *Ayşe*, in half of the items and a generic plural noun, *öğretmenler* 'teachers', in the other half. Licensed sentences are the grammatical baseline and Unlicensed sentences are the ungrammatical baseline. Intrusion sentences are those where we expect illusion.

Condition	Sentence				
Complement, Licensed	*Kimse*	[Ayşe-nin	parti-ye	gel-diğ-in]-e	şaşır-ma-dı.
	Anybody	Ayşe-GEN	party-DAT	come-NMLZ-POSS-DAT	be.surprised-NEG-PST
Complement, Intrusion	**Kimse*	[Ayşe-nin	parti-ye	gel-me-diğ-in]-e	şaşır-dı.
	Anybody	Ayşe-GEN	party-DAT	come-NEG-NMLZ-POSS-DAT	be.surprised-PST
Complement, Unlicensed	**Kimse*	[Ayşe-nin	parti-ye	gel-diğ-in]-e	şaşır-dı.
	Anybody	Ayşe-GEN	party-DAT	come-NMLZ-POSS-DAT	be.surprised-PST
Adjunct, Licensed	*Kimse*	[Ayşe	parti-ye	gel-diğ-in-de]	şaşır-ma-dı.
	Anybody	Ayşe	party-DAT	come-NMLZ-POSS-LOC	be.surprised-NEG-PST
Adjunct, Intrusive	**Kimse*	[Ayşe	parti-ye	gel-me-diğ-in-de]	şaşır-dı.
	Anybody	Ayşe	party-DAT	come-NEG-NMLZ-POSS-LOC	be.surprised-PST
Adjunct, Unlicensed	**Kimse*	[Ayşe	parti-ye	gel-diğ-in-de]	şaşır-dı.
	Anybody	Ayşe	party-DAT	come-NMLZ-POSS-LOC	be.surprised-PST
	'Nobody was surprised {that/when} Ayşe {came/didn't come} to the party.'				

Table 1. An example set of experimental sentences in Experiment 1

Six experimental lists were created in a Latin-square design. Each list included 24 target items (4 per condition) as well as 48 fillers. Half of the fillers were grammatical sentences, and the other half were ungrammatical due to reasons such as agreement errors or tense mismatch. Some fillers had a similar structure to the experimental items and had negated embedded or matrix verb, but no NPI dependency. All the materials, data and codes of analyses for Experiment 1 (and Experiments 2 and 3) can be found at https://osf.io/wq7fk/.

4.3. PROCEDURE. Experiment 1 (and Experiments 2 and 3) was conducted online on PCIbex (Zehr & Schwarz 2018). The participants received the study link from the first author and ran the experiment on their browser. They were instructed to read the sentences that appeared word-by-word on the screen. A fixation cross appeared at the center of the screen for 500 milliseconds (ms) at the beginning of each trial. Each word was visible for 300 ms, separated by a blank screen for 100 ms. At the end of each trial, participants were asked to judge whether or not the sentence was acceptable with a keypress ('F' for acceptable and 'J' for unacceptable) within 3000 ms. They were told to respond as quickly as possible; if no decision was made within 3000 ms, the question disappeared, and the next trial began. Those who missed judgments for three sentences received a warning message, asking them to be faster. There were six practice trials.

4.4. RESULTS. The participants were first inspected for their accuracy in the filler items. Two participants' accuracy was below 70%; hence, they were excluded from the analyses. The mean accuracy of the remaining 48 participants was 86.63%. Table 2 shows the mean percentage of 'acceptable' responses and 1 standard error (SE) of the mean, after exclusions.

The data were analyzed using the R statistical computing software with logistic mixed effects models in the `lme4` package (Bates et al. 2015). The dependent variable was binary acceptability judgments. Fixed effects were CLAUSE TYPE and LICENSING, and random effects were

	Complement	Adjunct
Licensed	88.5% (.03)	85.4% (.03)
Intrusion	15.9% (.03)	13.7% (.03)
Unlicensed	4.7% (.01)	2.1% (.01)

Table 2. Mean percentage of 'acceptable' responses and 1 SE of the mean corrected for between participant variance (in parantheses) in Experiment 1

subject and item. CLAUSE TYPE was coded using sum contrasts. LICENSING was coded using Helmert contrasts, which compared the effects of grammaticality (Licensed vs. Intrusion and Unlicensed) and intrusion (Intrusion vs. Unlicensed). We fit two models: a crossed model and a nested model. The crossed model included both fixed effects and their interaction. The nested model had a main effect of CLAUSE TYPE and separate LICENSING contrasts within the Complement and Adjunct clause conditions. Each model (in Experiments 1-3) included random intercepts for participants and items, and random slopes when models converged (Barr et al. 2013). We report absolute *t*- or *z*-scores; those of 2 or above indicate significance at the α level .05.

The crossed model showed a main effect of grammaticality, with a higher acceptance rate for grammatical than ungrammatical sentences (β = 6.22, *SE* = .57, z = 10.87). There was also an intrusion effect, with a higher acceptance rate for Intrusion than Unlicensed sentences (β = 1.88, *SE* = .61, z = 3.09). There was no effect of CLAUSE TYPE or interactions (β's $\leq$ .48, *SE*'s $\leq$ .29, z's $\leq$ 1.64). The nested model showed for both Complement and Adjunct clauses that grammatical sentences were accepted more often than ungrammatical ones (β's $\geq$ 6.66, *SE*'s $\geq$ .87, z's $\geq$ 7.66), and that Intrusion sentences were accepted more often than Unlicensed ones (β's $\geq$ 1.52, *SE*'s $\geq$ .59, z's $\geq$ 2.57). There was a main effect of CLAUSE TYPE in the nested model, with a higher acceptance rate for Complement than Adjunct clauses (β = .96, *SE* = .43, z = 2.23).

4.5. DISCUSSION. Experiment 1 showed that NPI illusions in Turkish are replicated in a speeded acceptability judgment task. This is in line with results from other languages showing illusions in similar tasks. We also found comparable illusory effects in intrusion sentences with complement and adjunct clauses. It is possible that there is no difference across different clauses, but absence of evidence may also be due to low statistical power. We first want to examine whether this is paralleled in an online reading task in Experiment 2 before discussing possible explanations.

5. Experiment 2: Self-paced reading task on clause type. This experiment investigates word-by-word, online processing of NPI dependencies in Turkish. Whereas some studies revealed illusory effects with prospective dependencies in reading (Korean: Yun et al. 2018, Turkish: Yanılmaz & Drury 2018), others showed such effects only in judgment tasks (Japanese: Su & Aparicio 2022). Experiment 2 aims to reveal whether illusions reported earlier in Turkish would appear in an online reading task. Results show a slow-down with an intrusive licensor, but it is unclear whether this reflects illusory licensing effects or it is due to cost of processing negation.

5.1. PARTICIPANTS. 55 native speakers of Turkish (M_{age} = 24.3) participated in the task. Each participant was compensated 100 Turkish Lira ($\sim$\$3.5 at the time of the study).

5.2. MATERIALS. The materials and experimental design were the same as Experiment 1, except the two additional words added as spillover regions. An adverb was added after the embedded and the matrix verb, e.g., *gerçekten* 'really' and *bence* 'to me', as shown in (8).

(8) a. Complement: *Kimse* [Ayşe-nin parti-ye gel-(*me-)diğ-in]-e...
Anybody Ayşe-GEN party-DAT come-NEG-NMLZ-POSS-DAT

b. Adjunct: *Kimse* [Ayşe parti-ye gel-(*me-)diğ-in-de]...
Anybody Ayşe party-DAT come-NEG-NMLZ-POSS-LOC
...gerçekten şaşır-*(ma)-dı bence.
really be.surprised-NEG-PST to.me
'To me, nobody was really surprised {that/when} Ayşe {came/didn't come} to the party.'

The number of experimental, filler and practice sentences was the same as in Experiment 1.

5.3. PROCEDURE. The participants were instructed to read the sentences word-by-word, in stationary window, and answer the following comprehension questions. Each trial started with a fixation cross at the center of the screen, and the participants were asked to hit the space bar to see the next word. Every sentence was followed by a yes/no comprehension question answered with a keypress ('F' for 'yes' and 'J' for 'no'). The number of 'yes' and 'no' answers was balanced.

5.4. RESULTS. All participants had 75% or above accuracy in the filler items; thus, no participant was excluded from the analysis. The overall accuracy was 93.1%. Reaction times (RTs) that are below 100 ms and above 3000 ms were removed from the dataset, leading to a loss of 2.3% of overall data. Trials with an incorrect answer were also removed, resulting in a loss of 6.49% of overall data. Figure 1 shows the mean RTs and 1 SE of the mean, after the exclusions.

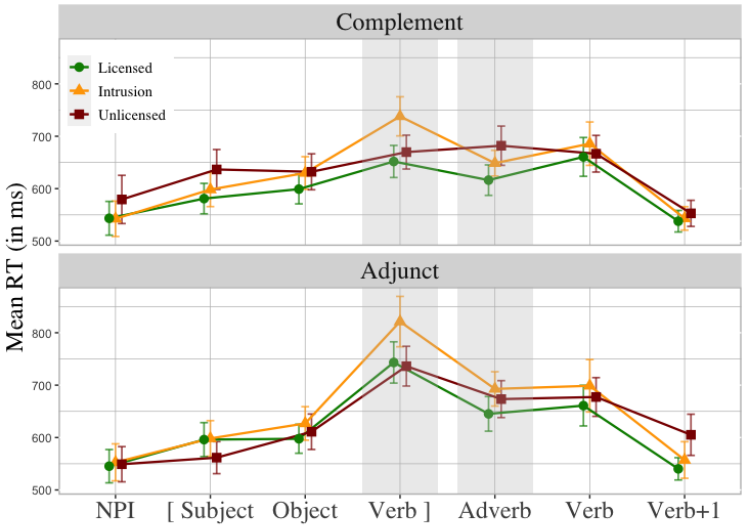

Figure 1. Average raw RTs for the experimental sentences in Experiment 2. Error bars represent 1 SE of the mean corrected for between participant variance.

The RT data were log-transformed and analyzed with linear mixed effects models in the `lme4` package (Bates et al. 2015). The critical regions were embedded verb (4th word), matrix verb (6th word) and their spillover regions (5th, 7th words). In the experimental sentences, the only difference at the embedded verb region is the presence of negation in Intrusion vs. its absence in Licensed and Unlicensed conditions. The point at which (un)grammaticality of the sentences

is realized is the matrix verb. Thus, different comparisons were checked at the embedded and matrix verb regions. For the embedded verb regions, fixed effects were CLAUSE TYPE and EMBEDDED NEGATION. Both were coded using sum contrasts. EMBEDDED NEGATION compared Intrusion vs. Licensed and Unlicensed conditions. For the matrix verb region, fixed effects were CLAUSE TYPE and LICENSING. Similar to Experiment 1, LICENSING were coded using Helmert contrasts, comparing the effects of grammaticality (Licensed vs. Intrusion and Unlicensed) and intrusion (Intrusion vs. Unlicensed). As in Experiment 1, both a crossed model and a nested model were fit for each region. The crossed models included fixed effects and their interactions. The nested models included a main effect of CLAUSE TYPE and separate EMBEDDED NEGATION or LICENSING contrasts for the Complement and Adjunct clause conditions. Trial number was included as a predictor in all the models. The rest of the model specifications were the same as in Experiment 1. The analyses on comprehension accuracy included LICENSING and CLAUSE TYPE as fixed effects and followed the same steps.

For the embedded verb region, there were main effects of CLAUSE TYPE in crossed and nested models, with slower RTs in Adjunct than Complement clauses (β's $\geq$ .07, *SE*'s $\geq$ .02, *t*'s $\geq$ 3.41). The crossed model showed a main effect of EMBEDDED NEGATION, with slower RTs in Intrusion than Licensed and Unlicensed conditions (β = 0.10, *SE* = .03, *t* = 3.52). There was no interaction (β = 0.20, *SE* = .05, *t* = .33). The nested model also showed a slow-down in Intrusion conditions within both Complement and Adjunct clauses (β's $\geq$ .09, *SE*'s $\geq$ .04, *t*'s $\geq$ 2.13). For the spillover of the embedded verb, the crossed model showed a slow-down in Intrusion conditions (β = .05, β = .02, *t* = 2.41). The nested model showed a slow-down in Intrusion conditions with Adjunct (β = .06, β = .03, *t* = 2.37), but not with Complement clauses (β = .02, *SE* = .03, *t* = .99). There were no effects of CLAUSE TYPE or an interaction (β's $\leq$ .02, *SE*'s $\leq$ .02, *t*'s $\leq$ 1.14). There were no effects in the matrix verb (β's $\leq$ .02, *SE*'s $\leq$ .03, *t*'s $\leq$ .79), its spillover (β's $\leq$ .06, *SE*'s $\leq$ .03, *t*'s $\leq$ 1.81) or in comprehension accuracy (β's $\leq$ .77, *SE*'s $\leq$ .55, *z*'s $\leq$ 1.41).

5.5. DISCUSSION. Experiment 2 showed a slow-down with negated embedded verbs in intrusion sentences with both complement and adjunct clauses. This effect persisted in the spillover region of the embedded verb with adjunct clauses. This slow-down could reflect online illusory effects or it may be due to the cost of processing embedded negation. Experiment 3 aims to disentagle these two possibilities by comparing the processing of embedded negation in sentences with and without an NPI. Moreover, Experiment 2 did not show a grammaticality effect that is usually observed in the form of a slow-down in ungrammatical sentences. Effects in self-paced reading tasks may sometimes be non-local, i.e., they may appear in later regions. Experiment 3 will look into this possibility by having two additional spill-over regions.

6. Experiment 3: Self-paced reading task on negation. Recall that there was a slow-down on negated embedded verbs in Experiment 2, but this may show online illusory effects or the cost of processing embedded negation. The goal of Experiment 3 is to disentangle these two possibilities by directly comparing sentences with an NPI and negation (i.e., those with Adjunct clauses in Experiments 1 and 2) with baseline sentences that have only negation. Results show a slow-down at the negated embedded verb in both NPI and baseline sentences, suggesting that the slow-down is due to the cost of processing negation and does not reflect online illusory effects. This experiment was pre-registered at https://osf.io/haev9.

6.1. PARTICIPANTS. We conducted a power analysis based on the embedded negation effect in the Adjunct clause conditions in Experiment 2 using the `simr` package (Green & MacLeod 2016) in R. A total of 1000 simulations showed that the same effect could be replicated with a sample size of 96 participants, with a power of 80.2% [95% Confidence Interval: 77.6-82.6%]. Thus, this experiment recruited 100 subjects (M_{age} = 26.5). Each participant received 120 Turkish Lira (∼$3.5 at the time of the study) for compensation.

6.2. MATERIALS. The study had a 2x3 design, crossing PRESENCE OF NPI, i.e., NPI *kimse* or a generic plural noun such as *konuklar* 'guests' in the matrix subject position, and NEGATION, i.e., negated matrix verb, negated embedded verb or no negation, as given in (9). Whereas NEGATION creates Licensed, Intrusion and Unlicensed conditions for the sentences with an NPI as in (9a), it creates baseline conditions with negation for sentences with no NPI as in (9b). Differently from Experiment 2, the sentences in Experiment 3 had an adverb after the embedded subject, *habersizce* 'unexpectedly', to disambiguate the sentences towards the presence of an embedded clause before the embedded verb, and two additional spillover regions after the matrix verb, *(oradaki) söylentilerin aksine* 'contrary to the rumours (there)', to reveal non-local effects that may not have been observed at the matrix verb and its spillover in Experiment 2.

(9) a. NPI: *Kimse* [Ayşe habersiz-ce parti-ye gel-(*<u>me</u>-)diğ-in-de]...
Nobody Ayşe unannounced-ADV party-DAT come-NEG-NMLZ-POSS-LOC

b. NoNPI: Konuk-lar [Ayşe habersiz-ce parti-ye gel-(*<u>me</u>-)diğ-in-de]...
Guest-PL Ayşe unannounced-ADV party-DAT come-NEG-NMLZ-POSS-LOC
...gerçekten şaşır-*(<u>ma</u>)-dı orada-ki söylenti-ler-in aksine.
really be.surprised-NEG-PST there-REL rumour-PL-GEN contrary.to
'{Nobody/Guests} was really surprised when Ayşe {came/didn't come} to the party unexpectedly, contrary to the rumours there.'

The number of experimental, filler and practice sentences was the same as in Experiment 1. Differently from Experiments 1 and 2, there were 38 grammatical and 10 ungrammatical filler sentences. This was done to decrease the number of ungrammatical sentences throughout the experiment.

6.3. PROCEDURE. The procedure was the same as in Experiment 2.

6.4. RESULTS. All participants had 75% or above accuracy in the filler items; thus, no participant was excluded from the analysis. The overall accuracy in the fillers was 91.3%. RTs that are below 100 ms and above 3000 ms were removed from the dataset, leading to a loss of .23% of overall data. Trials with an incorrect answer were also removed, resulting in a loss of 8.61% of overall data. Figure 2 shows the mean RTs and 1 SE for the experimental conditions by PRESENCE OF NPI and NEGATION, after the exclusions.

The critical regions were the embedded (5th word) and matrix verb (7th word), and their spillover regions (6th, 8th-10th words). As in Experiment 2, fixed effects were different for embedded and matrix verb regions. For the embedded verb and its spillover region, fixed effects were PRESENCE OF NPI and EMBEDDED NEGATION that were coded with sum contrasts. EMBEDDED NEGATION compared Neg(ated) Embedded vs. Neg(ated) Matrix and No Neg(ation) conditions. For the matrix verb and its spillover regions, fixed effects were PRESENCE OF NPI and MATRIX

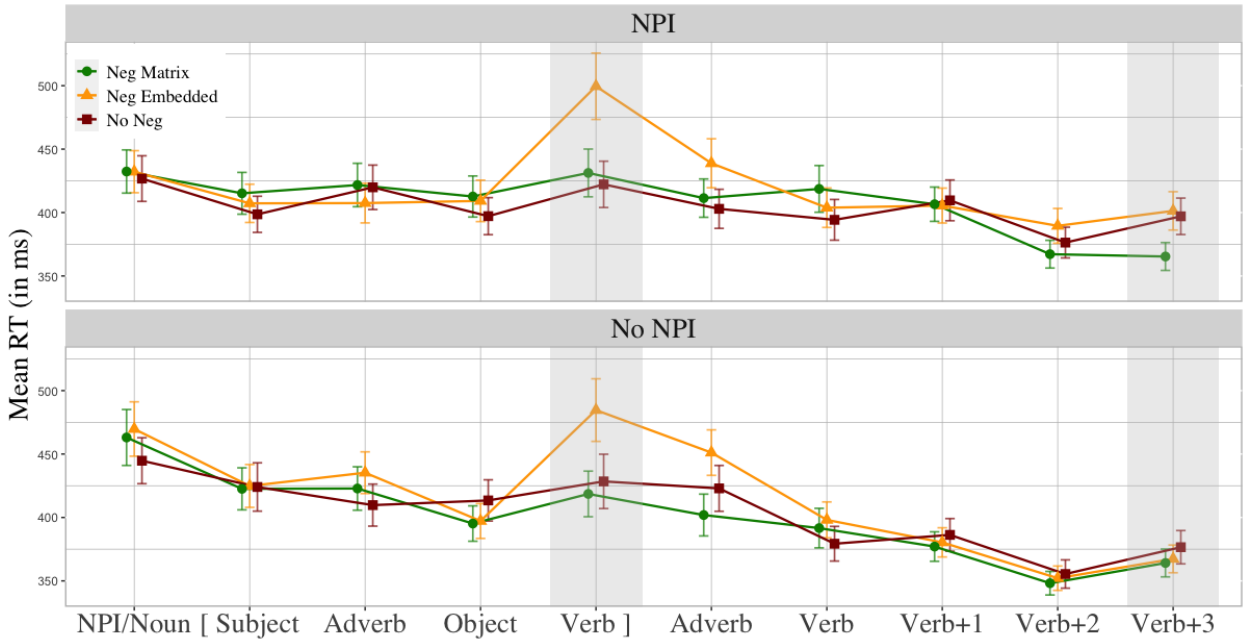

Figure 2. Average raw RTs for the experimental sentences in Experiment 3. Error bars represent 1 SE of the mean corrected for between participant variance.

NEGATION. MATRIX NEGATION was coded using Helmert contrasts, comparing effects of matrix negation (Neg Matrix vs. Neg Embedded and No Neg) and no negation (Neg Embedded vs. No Neg). The crossed models included fixed effects and their interactions. The nested models included a main effect of PRESENCE OF NPI and separate EMBEDDED NEGATION or MATRIX NEGATION contrasts for the NPI and NoNPI conditions. The analysis steps for the RTs and comprehension accuracy were the same as in Experiment 2.

For the embedded verb region, the crossed model showed a main effect of EMBEDDED NEGATION, with slower RTs in Neg Embedded than in Neg Matrix and No Neg conditions (β = .09, *SE* = .02, t = 4.49). The nested model also showed slow-downs in Neg Embedded conditions within both NPI and NoNPI conditions (β's $\geq$ .08, *SE*'s $\geq$ .03, t's $\geq$ 3.14). There were no effects of PRESENCE OF NPI or an interaction (β's $\leq$ .01, *SE*'s $\leq$ .01, t's $\leq$ .86). Similarly, for the spillover of the embedded verb region, the crossed model showed a slow-down in Neg Embedded conditions (β = .07, *SE* = .02, t = 4.32) and the nested model showed slow-downs in Neg Embedded conditions within both NPI and NoNPI conditions (β's $\geq$ .04, *SE*'s $\geq$ .02, t's $\geq$ 2.30). There were no effects of PRESENCE OF NPI or an interaction (β's $\leq$ .04, *SE*'s $\leq$ .03, t's $\leq$ 1.71).

For the matrix verb region, the crossed model showed effects of no negation, with slower RTs in Neg Embedded than No Neg conditions (β = .03, *SE* = .02, t = 2.38). The nested model also showed a slow-down in Neg Embedded conditions within NoNPI (β = .04, *SE* = .02, t = 2.59), but not in NPI conditions (β = .02, *SE* = .03, t = .90). There were no other effects or interactions (β's $\leq$ .02, *SE*'s $\leq$ .02, t's $\leq$ 1.54). For the first spillover of the matrix verb, i.e., verb+1, there were main effects of PRESENCE OF NPI, with slower RTs in NPI than in NoNPI conditions in both crossed and nested models (β's $\geq$ .04, *SE*'s $\geq$ .02, t's $\geq$ 3.96). There were no other effects or interactions (β's $\leq$ .01, *SE*'s $\leq$ .03, t's $\leq$ .69). For the second spillover of the matrix

verb, i.e., verb+2, there were again slow-downs in NPI conditions in both models (β's $\geq$ .04, *SE*'s $\geq$ .01, *t*'s $\geq$ 3.62). There was also a marginal main effect of matrix negation, with slower RTs in Neg Embedded and No Neg conditions than in Matrix Neg conditions (β = .03, *SE* = .02, *t* = 1.94). There were no other effects or interactions (β's $\leq$ .03, *SE*'s $\leq$ .02, *t*'s $\leq$ 1.56). For the third spillover of the matrix verb, i.e., verb+3, both models again showed slow-downs in NPI conditions (β's $\geq$ .03, *SE*'s $\geq$ .01, *t*'s $\geq$ 2.39). The crossed model showed a main effect of matrix negation, with slower RTs in Neg Embedded and No Neg conditions (β = .03, *SE* = .01, *t* = 3.09) as well as an interaction between PRESENCE OF NPI and matrix negation (β = .06, *SE* = .02, *t* = 2.73). The nested model revealed a slow-down in Neg Embedded and No Neg within the NPI (β = .06, *SE* = .02, *t* = 4.14), but not the NoNPI conditions (β = .004, *SE* = .02, *t* = .26). There were no other effects or interactions (β's $\leq$ .007, *SE*'s $\leq$ .01, *t*'s $\leq$ .50). There were no effects in comprehension accuracy (β's $\leq$ .14, *SE*'s $\leq$ .15, *z*'s $\leq$ .94) or in RTs of comprehension accuracy (β's $\leq$ .02, *SE*'s $\leq$ .02, *t*'s $\leq$ 1.48).

6.5. DISCUSSION. Experiment 3 showed a slow-down with negated embedded verbs in sentences with an NPI as well as baseline sentences with negation only. This effect was present in the embedded verb and its spillover, and it persisted in the matrix verb region in baseline sentences. This confirms that slow-downs with negated embedded verb reflect the cost of processing negation rather than online illusory effects. Experiment 3 also showed a grammaticality effect with a slow-down in ungrammatical NPI sentences, i.e., those with an intrusive or no licensor; but this effect was small and reached significance only at the sentence-final region.

7. General discussion. This study investigated whether NPI illusions in Turkish that were previously reported would be replicated with two new methodologies: speeded acceptability judgment and self-paced reading tasks. Our results replicated earlier findings and showed further evidence for illusions in the speeded acceptability judgment paradigm. However, we found no evidence for illusory effects in the self-paced reading tasks. We also investigated whether the syntactic environment of the intrusive licensor, i.e., complement vs. adjunct clauses, would modulate illusory effects. We found that NPI illusions in the judgment task extend to cases with an adjunct clause, but there was no evidence for a difference between complement and adjunct clauses.

Previous studies showed that NPI illusions in Turkish emerge in untimed acceptability judgments (Yanılmaz & Drury 2018) and acceptability ratings (Deniz et al. 2024). The present study replicated these with a speeded acceptability task. In Yanılmaz & Drury's (2018) acceptability task, intrusion sentences were accepted around 50% of the time, but this was decreased to 15% in this study. The two studies are similar in terms of the proportion of grammatical and ungrammatical items (50-50%) and not having comprehension questions. Moreover, Yanılmaz & Drury's study found the strongest illusory effects with their shortest sentences that had only one word less than ours. Acceptance rates in the present study are more similar to those reported in other languages. Still, different acceptability rates across the two studies require further exploration.

Studies on English and German showed evidence for illusory effects in reading tasks with a reduced slow-down in intrusion relative to unlicensed sentences (e.g., Parker & Phillips 2016; Vasishth et al. 2008). However, there was no evidence for NPI illusions in a self-paced reading task on Japanese (Su & Aparicio 2022). Similar to Japanese, our two self-paced reading tasks on Turkish showed no evidence for illusory effects. That is, we observed no differences in reading intrusion vs. unlicensed sentences at the matrix verb, i.e., the point at which the grammaticality of the sentence is resolved. This may be due to the low statistical power of our studies or there

may truly be no illusory effects in online reading in Turkish. High-powered crosslinguistic studies could provide more conclusive findings on the time-course of NPI illusions.

We observed a slow-down at the negated embedded verb in intrusion sentences in Experiment 2, but a direct comparison of sentences with and without NPIs in Experiment 3 revealed that there was a slow-down at the negated embedded verb in baseline sentences with no NPIs as well. This suggests that the slow-down is due to the cost of embedded negation rather than illusory effects. Unlike negation on embedded verbs, negation did not cause extra processing difficulty on the matrix verb. One possibility could be that negated embedded clauses create an alternative, i.e., an affirmative embedded clause, which results in increased processing difficulty. We leave investigations of the source of difficulty with embedded negation to future work.

In Experiments 1 and 2 we compared sentences in which the intrusive licensor was in a complement or an adjunct clause. We predicted that the delayed processing of adjuncts (Frazier & Clifton 1996), and hence the delayed integration of intrusive negation in adjuncts into the sentence, may lead to decreased illusory effects in judgment and/or delayed illusory effects in reading tasks. This prediction was not borne out. The judgment task showed comparable illusions across complement and adjunct clauses. The lack of evidence for a difference between the two clause types may be an issue of statistical power. With this possibility in mind, we will consider the memory-based noisy channel account, which could uniformly explain illusory effects with different clause types. Before this, we turn to why other accounts cannot explain our findings.

The present study and more broadly, those on languages with prospective NPI licensing (Turkish: Deniz et al. 2024; Yanılmaz & Drury 2018; Japanese: Su & Aparicio 2022; Korean: Lee & Yun 2022; Yun et al. 2018), showed evidence for NPI illusions, but their findings are challenging for current accounts. First, the cue-based retrieval account relies on general memory retrieval mechanisms in building retrospective NPI dependencies (Vasishth et al. 2008), but it does not explain how NPI dependencies lead to illusions or are even built when the licensor follows the negation as in Turkish. Second, the scope miscalculation account predicts illusions only with negative quantifiers (Orth et al. 2020) due to erraneous quantifier raising as in English and German (e.g., Drenhaus et al. 2005; Parker & Phillips 2016), but languages like Turkish showed illusions with verbal negation, e.g., *-mA*. Third, semantic/pragmatic accounts (Xiang et al. 2009) predicts illusions only with an intrusive licensor in a relative clause due to the negation in the contrastive inference of restrictive relative clauses, but other languages like Turkish showed illusions with complement clauses, and the current study further extends it to adjunct clauses.

NPI illusions in Turkish (and possibly those in Japanese and Korean) could be explained with the noisy channel account (Levy 2008). Recall that under this account, comprehenders consider alternative strings to the original input as a result of noise in comprehension. Zhang & Gibson (2024) presented evidence that comprehenders may consider alternative strings in which the quantificational matrix subject is switched with the quantificational embedded subject. The argument was that alternative strings may allow for the licensing of the NPI that would otherwise be unlicensed. Extending positional switches to cases with non-quantificational subjects, we argue that in their judgments of the intrusion sentences, comprehenders of the present study could have entertained a possible parse in which the NPI *kimse* in the matrix subject position and the noun phrase in the embedded subject position as in (10a) are switched. The resulting string, as given in (10b), would thus allow for the licensing of *kimse* by the embedded negation.

(10) a. **Kimse* [Ayşe parti-ye gel-me-diğ-in-de] şaşır-dı.
Anybody Ayşe party-DAT come-NEG-NMLZ-POSS-LOC be.surprised-PST
'Anybody was surprised when Ayşe didn't come to the party.'

b. Ayşe [*kimse* parti-ye gel-me-diğ-in-de] şaşır-dı.
Ayşe *anybody* party-DAT come-NEG-NMLZ-POSS-LOC be.surprised-PST
'Ayşe was surprised when anybody didn't come to the party.'

However, we have no direct evidence to support this prediction, nor does this directly account for the presence of illusory effects in judgment but not online reading tasks. One possibility is that alternative strings (e.g., those with positional switches) are given enough weight to cause illusions only when comprehenders make an explicit judgment. We leave these to future work.

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