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Quantification At a Distance and Grammatical Illusions in French

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Abstract

Recent research in psycholinguistics supports the hypothesis that retrieval from working memory is a key component of establishing syntactic dependencies in comprehension. This can

result in so-called grammatical illusions. These illusions have been modeled as the result of a content-addressable retrieval process in sentence comprehension that allows grammatically inaccessible licensing elements to be reactivated, creating a spurious perception of acceptability. This paper reports five studies which establish the existence of a new grammatical illusion involving quantification at a distance and the licensing of so-called de-NPs in European French. Our results suggest this grammatical illusion is interestingly constrained by syntactic properties of the licensors. Specifically, quantifiers that independently participate in quantification at a distance constructions were seen to create grammatical illusions to a greater extent than other quantifiers which do not participate in that construction. Consistent with previous work on the nature of cues in memory retrieval, we suggest that this is the result of fairly specific abstract syntactic cues that guide retrieval of a licensing element. This paper thus brings further evidence that syntax is crucially used to structure working memory over the course of a parse.

Keywords

Quantification-At-a-Distance, grammatical illusions, cue-based parsing

Contents

1 Introduction

One of the central tasks in language comprehension is the process of establishing linguistic dependencies between elements in a sentence. For example, to understand the sentence *Linda, whose office is near room N400, often drinks herbal tea*, it is necessary to integrate the subject phrase *Linda* with the verb *drinks*. Psycholinguistic research into this basic process suggests that the process of establishing this dependency in comprehension relies on *memory retrieval*: upon reaching the verb, the comprehender uses a set of *retrieval cues* that reactivate the desired dependent in working memory. Generally, this process of cue-based retrieval works via a process of feature matching against the contents of working memory (Lewis & Vasishth 2005, Lewis et al. 2006, van Dyke & McElree 2011, Vasishth et al. 2008). This often means that syntactic constraints on dependency formation are deployed alongside semantic constraints, although there remain substantial open debates about the priority of syntactic cues over semantic or morphological cues to retrieval (Dillon et al. 2013, Jäger et al. 2020).

This mechanism of establishing linguistic dependencies predicts the existence of *illusions of grammaticality* (Phillips et al. 2011). An illusion of grammaticality occurs when an ungrammatical dependency appears well-formed due to the presence of a syntactically inaccessible, but semantically appropriate, licensing element (Vasishth et al. 2008). Grammatical illusions are a case of misalignment between grammaticality and acceptability, and as such, they have been argued to provide a window into the architecture of the language system (Phillips et al. 2011).

In this paper we use offline judgment methodology to establish the existence of a new gram-

matical illusion, illusory *de*-Noun Phrase licensing in French. Across four studies we show that illusory *de*-Noun Phrase licensing in French arises when a licensing quantifier linearly precedes, but does not c-command, the *de*-Noun Phrase. We hypothesize that licensing *de*-NPs in processing involves a memory retrieval operation to identify a licensor. We propose that this retrieval may reactivate a non-local quantifier even if the quantifier is not c-commanding. However, our results suggest this grammatical illusion only arises for quantifiers that, among other things, independently participate in quantification at a distance constructions in French. Our results from *de*-NP illusions thus suggest that these memory retrieval operations are guided by fairly abstract syntactic cues, despite their lack of sensitivity to c-command relations. Building on work on the structure of quantification at a distance and quantifiers in French, we propose that these syntactic cues index the structure of some (but not all) de-NP licensing quantifiers. This thus allows us to tie the varying degrees to which quantifiers give rise to intrusive licensing to other asymmetries in the syntax of these quantifiers.

We now turn to a discussion of grammatical illusions, and present the specific construction we investigate in this paper. Because we will show that syntax is key to understanding our results, we review both descriptive and theoretical work on the relevant grammatical construction. Finally, we discuss relevant approaches to how grammatical illusions have been argued to arise. In section 2, we present our experimental results which (i) establish the existence of this novel grammatical illusion, and (ii) show that it only arises in certain syntactic conditions. In section 3, we discuss our results against the background of previous models of grammatical illusions and the grammatical properties of this construction. This leads us to build on previous accounts to construct our own analysis of how the grammatical illusion we observed arises. Section 4 concludes.

1.1 What's a grammatical illusion?

Broadly speaking, grammatical illusions arise when an ungrammatical sentence sounds acceptable, at least at first blush (Phillips et al. 2011). For instance, consider the examples in (1).

On standard treatments of NPIs (Ladusaw 1979), (1a) is grammatical because the NPI *ever* is in the scope of a downward-entailing operator *no* (i.e. *no* c-commands the NPI). This is not true in (1b), hence the sentence is predicted to be ungrammatical. However, the sentence in (1b) is judged more acceptable than the minimally-different ungrammatical sentence without *no* (1c, cf. the grammatical sentence in 1a); similarly in ERP measures (Drenhaus et al. 2004) and in eye-tracking-measures (Vasishth et al. 2008), less disruption is seen at the NPI in (1b) than (1c). The finding of increased acceptability, and concomitant eased processing, is the evidence for an illusion of grammaticality in (1b).

(1) NPI illusions (examples based on Vasishth et al. 2008)

a. No man who had a beard was ever thrifty.

b. *A man who had no beard was ever thrifty.

c. *A man who had a beard was ever thrifty.

This phenomenon is not limited to NPI licensing. Similar effects obtain with subject-verb agreement in a range of languages (*English:* Wagers et al. 2009; Dillon et al. 2013; *Spanish:* Lago et al. 2015; *Arabic:* Tucker et al. 2015) and reflexive licensing (Parker & Phillips 2017, Sloggett 2017; Jäger et al. 2020). Potentially similar grammatical illusions are found in comparative constructions (Wellwood et al. 2018) and the so-called missing VP illusion (Frazier 1985, Gibson & Thomas 1999).

One way of understanding the NPI illusion, descriptively, is that an item in need of licensing, e.g. *ever* in (1b), spuriously appears to be licensed because the presence of a grammatically inaccessible licensor, e.g. *no* in (1b) somehow creates the illusion of a well-formed dependency between the NPI and the quantifier. One hypothesis for the underlying source of this phenomenon attributes it to a memory retrieval process that is used to establish the dependency between the NPI and its licensor. This hypothesis is rooted in the observation that working memory retrieval processes form an integral part of incremental language processing (McElree et al. 2003, McElree 2006, Lewis et al. 2006, Phillips et al. 2011, Parker & Phillips 2017). Broadly

speaking, these models adopt a content-addressable memory architecture for the parser, and propose that the retrieval mechanism that activates representations when they are necessary during processing operates in a cue-based fashion. This means that in order to retrieve or reactivate some encoding from earlier in the sentence, all representations stored in memory are probed simultaneously to evaluate how well they match a set of features specified by the retrieval 'cues. The degree of match between the retrieval cues determines which representations are likely to be reactivated, as well as how easily this process will proceed.

Content-addressable models of cue-based retrieval have been successful at accounting for many types of grammatical illusions. For example, suppose that the NPI *ever* initiates retrieval in working memory of a licensing element. Plausible retrieval cues for this process are [+Downward Entailing] (i.e. a semantic constraint) and [+c-commanding] (i.e. a syntactic constraint)[1]. In (1b) there is a situation of partial cue match: the inaccessible licensor *no* has the correct semantic feature, but it does not match the syntactic cue. However, this partial feature match makes it possible that the inaccessible licensor will be retrieved from time to time. When it is, the sentence will appear well formed, at least temporarily. There are multiple distinct implementations of this core idea: we refer the reader to Vasishth et al. (2008) and Van Dyke (2007) for two different formalizations of this process.

Because these models attribute the NPI illusion in (1b) to a feature of the working memory systems used to establish linguistic dependencies during parsing, they lead us to expect that these effects should be fairly general across languages and across constructions. For instance, the ungrammatical sentence in (2b) is consistently rated higher than the ungrammatical sentence in (2c) (Wagers et al. 2009, Parker & Phillips 2017, Hammerly et al. 2019). The explanation for this grammatical illusion under the cue-based account is the same: the parser initiates retrieval at the verb for a plural marked, grammatically available agreement controller. In b

[1]We set aside here the question of whether configurational cues such as [+c-commanding] can be straightforwardly specified in a cue-based architecture, but we refer the reader to Cunnings & Sturt 2014, Dillon 2014, Kush et al. 2015, and Kush et al. 2018 for further discussion.

we find a partial feature match to this retrieval probe with the word *cabinets*, thus making the sentence more acceptable even though the word bearing the cue is not in a grammatically-accessible position. Similar effects have been reported across a range of languages, including Spanish (Lago et al. 2015), Turkish (Lago et al. 2019), Armenian (Avetisyan et al. 2020), Arabic (Tucker et al. 2015), and Russian (Slioussar 2018).

(2) a. The keys to the cabinet are on the table.

b. *The key to the cabinets are on the table.

c. *The key to the cabinet are on the table.

Work on these illusions has explored the conditions that give rise to these effects (Parker & Phillips 2016, Orth et al. 2021). For example, Parker & Phillips 2016 have shown that NPI illusions can be turned on or off by modulating the linear distance / time between intrusive licensor and NPI. For instance in (3b), no illusory licensing was observed when a parenthetical, e.g. *as the editors mentioned*, intervened between the *no* and *ever*, but it was observed when the parenthetical was sentence initial (3a).

(3) a. *As the editors mentioned, the authors [that **no** critics recommended for the assignment] have **ever** received a pay raise.

b. *The authors [that **no** critics recommended for the assignment] have, as the editor mentioned, **ever** received a pay raise.

Interestingly, Parker and Phillips found that linear distance / time did not have any effect on agreement attraction: increased acceptability was observed in both (4a) and (4b).

(4) a. *According to the janitor, the key to the **cabinets** probably **were** destroyed by the fire.

b. *The key to the **cabinets**, according to the janitor, probably *were* destroyed by the fire.

They proposed that the difference in illusion profile came down to a difference in memory encoding between syntactic and semantic/pragmatic representations. But they note that

grammatical illusions could, in principle, reflect either an error in how we mentally encode structured linguistic representations in memory, or an error in how we later access information in those representations.

As mentioned, one important feature of the cue-based model is that it predicts that these effects should be rather pervasive across constructions and languages. This is the starting point for our investigation. We look at ungrammatical constructions like (5b) in European French. As in (1), in the examples in (5) there is an element that needs to be licensed; here it is the de-Noun Phrase *de livres* 'de books'. As we detail below, this de-Noun Phrase needs to be licensed by a quantifier, as it is in (5a). Example (5b) provides a sentence that is superficially analogous to the NPI sentence in (1b). Like the more acceptable ungrammatical sentence in (1b), there is an element that needs to be licensed *ever* or *de livres* but the licensor *no* or *beaucoup* though present, is in a grammatically inaccessible position. The analogy between NPI illusions and the configuration in (5b) is not perfect, however. While in an intrusive NPI sentence there is one NPI that needs to be licensed but no accessible licensor, in the French examples here there are two de-NPs in need of licensing and only one licensor.[2]

(5) a. J' ai donné à des associations beaucoup de livres.
I have given to INDEF.PL associations a_lot DE books
I gave away a lot of books to charities.

b. *J'ai donné à beaucoup d'associations de livres.

c. *J'ai donné à des associations de livres.

In this study, our main empirical question is whether speakers of French find the ungrammatical sentence in (5b) significantly more acceptable than the unacceptable/ungrammatical sentence in (5c). Such an effect would constitute a grammatical illusion for de-Noun Phrases analogous to that seen for NPI illusions, insofar as it is the presence of the structurally inac-

[2]We are grateful to an anonymous reviewer for highlighting this fact.

cessible quantifier *beaucoup* that is responsible for this effect. To preview our findings, we find that this is indeed the case, and further ask under what conditions this new grammatical illusion arises. We explore how current models of sentence processing might explain this finding. However, we first turn to a description of the grammatical phenomenon under consideration, because this provides important linguistic context for the studies that follow.

1.2 Quantification At a Distance: generalizations and analyses

Like many languages, European French has several types of Noun Phrases: e.g. definite (6a), indefinite (6b), and quantificational ones (6c).

(6) a. Francis a écrit la lettre.
Francis has written the letter

b. Francis a écrit une lettre.
Francis has written a letter

c. Francis a écrit *beaucoup de lettres.*
Francis has written a_lot DE letters
Francis has written a lot of letters.

Consider the type of NP instanced in (6c). French generalized quantifiers are, at least on the surface, different from their English counterparts in that their restrictor is an NP necessarily marked with the particle 'de' (8a) – a de-NP – that needs to be licensed by a quantifier; this is shown by the unacceptability of (8b).[3]

(8)

[3]Noun phrases with *de* are also found under negation as in (7).

(7) Je n'ai pas envoyé de lettres. 'I have not sent letters'.

However we follow Milner (1978) in assuming that de-NPs licensed by quantifiers and de-NPs licensed by negation should be distinguished as they have different properties (e.g. locality restrictions).

a. *Francis a écrit *beaucoup* *lettres*.
Francis has written a_lot letters
Int. Francis has written a lot of letters.

b. *Francis a écrit *de* *lettres*.
Francis has written DE letters
Int. Francis has written letters.

It will be important to bear in mind that restrictors marked with *de* / *d'* (if followed by a vowel) contrast with phrases headed by an indefinite determiner (e.g. *des* – pronounced [dɛ]) which do not need to be licensed by a quantifier (9a). The determiner *des* does not license de-NPs on its own (9b).

(9) a. Francis a écrit *des* *lettres*.
Francis has written INDEF.PL letters
Francis wrote letters.

b. *Francis a écrit *des* *de* *lettres*.
Francis has written INDEF.PL DE letters

Quantifiers that license de-NPs[4] are listed in Table 1.

[4]The category of what we call '(licensing) quantifiers' is not uncontroversial. In recent work (Kayne 2002), Kayne suggests that they may always be adverbs involved in a complex DP structure. Whatever the correct status of the lexical items listed in Table 1, we continue to use the description 'quantifiers' to refer to them.

Table 1: Quantifiers licensing de-NPs

assez 'enough'	*de plus en plus* 'more and more'
suffisamment 'enough'	*de moins en moins* 'less and less'
trop 'too'	*tellement* 'so much/many'
beaucoup 'a lot'	*le plus* 'the most'
énormément 'a great deal of'	*le moins* 'the least'
pas mal 'quite a few/some'	*plus* 'more'
peu 'little'	*davantage* 'more'
un peu 'a little'	*moins* 'less'
vachement 'a lot' (fam.)	*autant* 'as much/many as'
sacrément 'a lot'	*plein* 'a lot'
drôlement 'a lot'	*quantité* 'many'
guère 'little'	*nombre* 'many'
tant 'so much/many'	

French allows some of these quantifiers to be separated (non-adjacent) from their de-NP restrictor in a construction known as Quantification At a Distance (QAD; Obenauer (1983)); we return to this in more detail below. For example, in (10a) the quantifier *beaucoup* many appears separated from *de livres* books (*cf* 10b). [5]

(10) a. Des gens ont beaucoup lu de livres. Quantification at a distance
INDEF.PL people have many read DE books
Some people have read many books.

[5]Obenauer (1983) and subsequent work report that a QAD construction requires multiple events much like a construction with a VP adverb like *souvent* 'often' or *intensément* 'intensely' (see Burnett (2009) for more detail) whereas local quantification does not have such a requirement.

b. Des gens ont lu beaucoup de livres. Local quantification
INDEF.PL people have read many DE books
Some people have read many books.

However, mere linear precedence does not suffice to license quantification at a distance in French. The syntactic position of the potential licensor in the sentence prior to a de-NP is critical: if the licensing quantifier does not c-command the de-NP (11a) and if it is already associated with another de-NP (11c), then it is reliably judged to be significantly less acceptable than (11b) and (11d) respectively when speakers are given sufficient time to make their judgment.

(11) a. *Les enfants [que je vois peu] lisent de livres.
the children that I see little read DE books
Int. The children that I seldom see read books.

b. Les enfants [que je vois peu] lisent des livres.
the children that I see little read INDF.PL books
The children that I seldom see read books.

c. *Peu de gens ont lu de livres.
few DE people have read DE books
Int. Few people have read books.

d. Peu de gens ont lu des livres.
few DE people have read INDF.PL books
Few people have read books.

Based on these observations, we may formulate the generalization concerning de-NP licensing as in (12).

(12) **Grammatical de-NP licensing generalization**

For every de-NP, there must be one licensing quantifier, such that:

- that quantifier c-commands the de-NP it licenses, and

- it licenses exactly one de-NP.

The generalization in (12) thus correctly rules out (10a/c) as ungrammatical: sentence (10a) is ruled out because the licensing quantifier *peu* does not c-command the de-NP *de livres* and sentence (10c) is ruled out because there are two de-NPs, but only one licensing quantifier.

To what extent the licensing dependency between a quantifier and the de-NP it licenses is similar to the licensing dependency between a negative element and the NPI it licenses? Consider the examples in (13). (13a) repeats the example of the spurious NPI illusion effect from Vasishth et al (2008; translated to English). (13b) presents an example of a comparable configuration with a de-NP. If we suppose that the process of licensing a de-NP that does not have an adjacent quantifier (i.e. one in a QAD configuration) involves a memory retrieval process for a licensor, then there is a clear parallel between the two cases. In (13b), the licensor *beaucoup* should match whatever features code for appropriate quantifiers, but it will not match the appropriate structural features. Therefore, it may be considered a partial match to the retrieval cues that a de-NP uses to find a long-distance quantifier as a licensor.

The cue-based retrieval model of dependency resolution thus predicts that we should see an increase in acceptability in the ungrammatical sentence in (13b) compared to a relevant ungrammatical control sentence, just as we see one in (13a) when the negative element *no* is present albeit in an inaccessible position for the NPI *ever*. Testing this prediction is our first empirical question (Question 1).

(13) a. *A man who had <u>no</u> beard was [ever] thrifty.

A man who had a beard was [ever] thrifty.

b. *J'ai donné à <u>beaucoup</u> d'associations [de livres].

J'ai donné à des associations [de livres].

There are several other features of the French QAD construction, however, that raise very interesting questions from the point of view of real-time dependency resolution. Any of the

quantifiers listed in Table 1 can license an immediately-adjacent de-NP as in (6c and 10c). However, we might also ask: are all of these de-NP licensing quantifiers equally capable of creating illusions of grammaticality? This is our Question 2, and here we draw our inspiration from Xiang et al. (2009) and Xiang et al. (2013), who asked a similar question with NPI licensors. If the answer to Question 2 is negative, then, the final question we would like to answer is what are the properties that make a quantifier eligible to create illusory licensing of de-NPs? This is Question 3, our final question.

It is important to note that not all de-NP-licensing quantifiers listed in Table 1 are created equal: these quantifiers are differentiated syntactically in a number of critical ways listed in (14). These quantifiers may be divided into two classes, which we will call the *beaucoup*-class and and *plein*-class, using prototypical examples of each class as its label. These differences are not apparent in the (simple) cases where quantifier and de-NP are immediately adjacent (6c), but instead refer to the behavior of these quantifiers in other contexts.

(14) Properties of *beaucoup* and *plein* type quantifiers

	beaucoup	plein
quantify at a distance	✓	x
can be used as an object pronoun	✓	x
can be used as an adverb	✓	x

The first crucial difference among de-NP-licensing quantifiers is that only some de-NP licensing quantifiers can appear separated from the de-NP they license in a QAD construction. As previously mentioned, constructions where the de-NP-licensing quantifier is not immediately adjacent to the de-NP it licenses are known as Quantification At a Distance (QAD) (Kayne 1975, Milner 1978, Obenauer 1983, 1994, Boivin 1999, Burnett 2009, 2012, Rizzi 1990, Doetjes 1995, 1997, Authier 2016, Pasquereau 2015, 2016, 2018a). Most of the quantifiers in Table 1 can Quantify At a Distance; for ease of exposition, we will refer to these as +QAD quantifiers (e.g. *beaucoup* 'many' in 15b). However, others cannot, and must be strictly local to the de-NP (-QAD; e.g. *plein* 'many' in 16b).

(15) a. F. a écrit *beaucoup de lettres.*
F. has written a_lot DE letters
Francis has written a lot of letters.

b. F. a *beaucoup* écrit *de lettres.*
F. has a_lot written DE letters
Francis has written a lot of letters.

(16) a. Francis a écrit *plein de*
Francis has written a_lot DE
lettres.
letters
Francis has written a lot of letters.

b. *Francis a *plein* écrit *de*
Francis has a_lot written DE
lettres.
letters

The second crucial difference is that only *beaucoup*-type quantifiers may be used as object pronouns (17).

(17) a. J' ai fait beaucoup/*plein pour les pauvres.
I have done a_lot for the poor
I did a lot for the poor.
b. J'ai beaucoup/*plein fait pour les pauvres.

The third crucial difference among de-NP-licensing quantifiers is that some are (also) VP adverbs while others are not. Kayne (1975) noticed that this property correlated with the ability to participate in QAD constructions. We will refer to this correlation as the 'QAD adverb generalization' which we illustrate with the quantifiers *beaucoup* 'a lot' and *plein* 'a lot': in (18), *beaucoup* may be used as a VP adverb and as quantifier licensing its de-NP restrictor 'at a distance'. On the other hand, the quantifier *plein* 'a lot' cannot be used as a VP adverb, and it cannot quantify at a distance (19).

(18) a. J' ai acheté beaucoup de pommes.
I have bought a_lot DE apples
I bought many apples.

b. J' ai beaucoup acheté de pommes.
I have many bought DE apples
I bought many apples.

c. J' ai beaucoup dormi.
I have a_lot slept
I've slept a lot.

(19) a. J' ai acheté plein de pommes.
I have bought a_lot DE apples
I bought many apples.

b. *J' ai plein acheté de pommes.
I have many bought DE apples
Int. I bought many apples.

c. *J' ai plein dormi.
I have a_lot slept
Intended: I've slept a lot.

The adverb-quantifier generalization has motivated an analysis that takes the correlation between the possibilities to be used as VP adverbs and as distant quantifiers at face value. Under such an analysis, the quantifier is base-generated in the position where it appears and a dependency is established between it and the de-NP. In other words, the local quantification construction and the QAD construction have different underlying structures: the quantifier is a determiner when it appears adjacent to the de-NP and an adverb when it appears in preverbal position. This type of analysis, known as the base-generation analysis, is defended in most

work on this construction (Kayne 1975, Milner 1978, Obenauer 1983, Azoulay-Vicente 1989, Rizzi 1990, Obenauer 1994, Doetjes 1995, 1997, Boivin 1999, Heyd 2003, Mathieu 2005, Burnett 2009, 2012).

An alternative type of account is one in which the QAD structure is derived from the structure where quantifier and de-NP are adjacent. Under a derivational analysis, the quantifier is generated next to de-NP, where it can be pronounced, or it can feed a 'movement' rule and end up being pronounced (and possibly interpreted) in the preverbal position (Milner 1978, Boivin 1999, Kayne 2002, Labelle & Valois 2004, Authier 2016, Pasquereau 2016, 2018b). Crucially, the underlying structure of QAD is one in which the quantifier is adjacent to the de-NP. Authier 2016 offers one movement account. In his account, *beaucoup* may optionally undergo head-movement from the position where it is merged into the structure to [Spec, *v*P] [6]. Kayne (1975) notes a variety of problems for such movement accounts, but we believe that they can be overcome by integrating insights from his later work.

Kayne 2002, 2008 makes the proposal that a sentence like (20a) has the underlying structure in (20b). That is, he proposes that the phrase *beaucoup de livres* contains an adverb *beaucoup* which modifies a silent adjective which itself modifies a silent noun which denotes a quan-

[6]In line with Fukui & Takano 1998, Nakamura 2000, Matushansky 2006, Authier 2016 assumes that head movement is movement of a head to *the specifier* of another head, possibly followed by m-merger of the two heads.

tity.[7,8]

(22) a. J' ai lu beaucoup de livres.

I have read many DE books

I read many books.

b. J'ai lu beaucoup MANY NUMBER de livres.

Kayne does not specify what the exact structure of this sentence is, and we do not commit to a particular structure either. Following Kayne 2002, all we commit to is that *beaucoup*-type quantifiers involve a silent adjective and a silent noun. For the sake of making the discussion and the representations we will use to illustrate it more concrete, we use the structure in (23) for +QAD quantifiers, where de-NP is an NP constituent.[9]

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[7]He notes that an alternative to making this hypothesis would be to assume that *peu* [or, we assume, *beaucoup, trop, ...*] is itself a noun. It is not clear though how this alternative hypothesis would handle the fact that *peu*, *beaucoup*, *trop* ... are also all adverbs. We refer the interested reader to this discussion in Kayne 2002: p. 98.

[8]We do not pursue Kayne 2002's movement analysis of QAD since it predicts that *plein* can quantify at a distance which is strongly unacceptable for our informants and the participants in our experiments. Kayne 2002 reports that, according to Viviane Déprez, (20) is judged 'passably acceptable'.

(20) (?) Elle a tout plein acheté de bouquins.
she has every many bought DE books
(Int.) She has bought a great many books.

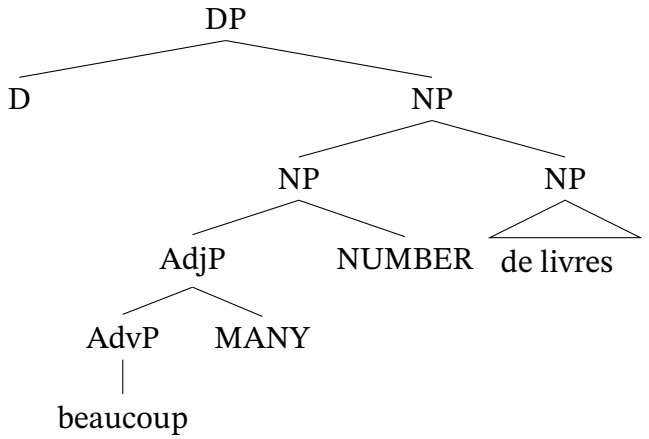
Notice that the sentence does not contain just *plein* but *tout plein*. There is a number of expressions in French that are perfectly acceptable with *tout plein* but not with *plein* or *tout* on their own (21).

(21) a. Merci tout plein. 'Thanks a lot.' *Merci plein. *Merci tout.

b. Il est mignon tout plein. 'He's very cute.' *Il est mignon plein. *Il est mignon tout.

In any case, as our experiments repeatedly show, sentences where *plein*-type quantifiers are separated from de-NP, are judged unacceptable.

[9]In fact, Pesetsky 2013: p. 100 proposes to treat de-NPs in French as genitive case NP, which happens to be realized at the constituent level in French via the preposition *de*.



(23)

We now show how this structure captures the three earlier generalizations. First, +QAD *beaucoup*-quantifiers are always adverbs, whether they appear in local quantification, QAD, or as adverbs. Second, *beaucoup*-type quantifiers have the same distribution as object pronouns because we assume that in an example like (17a/b), the structure of 'bare' *beaucoup* is as in (24)[10]. In (17b) where bare *beaucoup* appears to the left of the verb, we assume following Authier 2016 that Adv has undergone head-movement to [Spec, VP] (or to [Spec, vP] to be more specific, though we do not represent the *v* layer).[11]

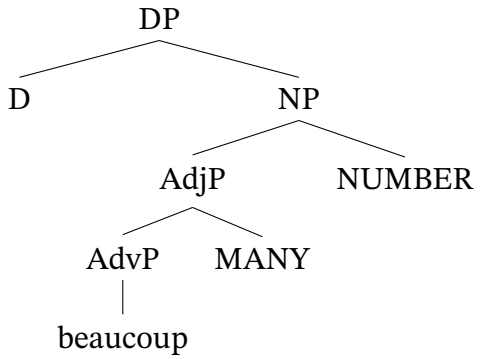
[10]The adverb *beaucoup* could undergo head-movement to D as in Russian (Pesetsky 2013), we leave this issue for further work.

[11]Alternatively, it could be that the *whole DP* has moved to [Spec, vP]. This would be consistent with the fact that the phrase *un peu* 'a little' can quantify at a distance (and be used pronominally in object position and be used as an adverb).

(24) a. J' ai un peu fait de repassage.
I have a little done DE ironing
I have done a little bit of ironing.

b. J' ai fait un peu pour cette cause, mais pas beaucoup.
I have done a little for this cause but not much

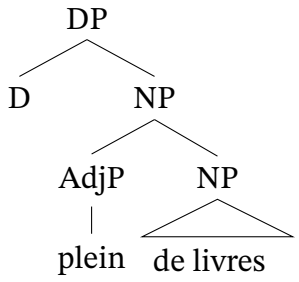
c. J' ai un peu dormi.
I have a little slept
I slept a little.



(25)

Finally, *beaucoup*-type quantifiers can quantify at a distance for the same reason that they can appear without an (overt) restrictor. In QAD, we assume that just the adverb has moved to [Spec, VP].

Kayne does not treat *plein*-type quantifiers as different from *beaucoup*-type quantifiers, which is probably because he assumes that they can quantify at a distance too. However, as our results will show, this is clearly not the case for the participants we tested. We assume that *plein*-type quantifiers are adjectives which directly modify de-NPs (26): this explains why they cannot be used as VP adverbs, why they cannot appear without a de-NP (at least in object position) and why they cannot quantify at a distance if we assume that adjectives cannot move in French.



(26)

This concludes our review of the different grammatical properties of the QAD construction in French , the analyses they have been given and those they could be given. We do not intend to argue for a specific analysis. Instead, we simply want to make use of the insights of these analyses when interpreting the results of our studies.

1.3 The present study

To summarize, in the present study we are interested in asking whether de-NP licensing quantifiers can intrusively license de-NPs, drawing an analogy between this construction and the more widely studied NPI illusion effects. We investigate the acceptability of de-NPs by comparing different kinds of similar dependencies in an attempt to create configurations parallels to those involving NPIs. Across five experiments, we attempt to address three central questions, which we repeat in (27).

(27) Three questions

a. Question 1: Can de-NP-licensing quantifiers intrusively license de-NPs?

b. Question 2: Can all de-NP-licensing quantifiers intrusively license de-NPs?

c. Question 3: What properties of a quantifier are critical for intrusive licensing?

In addressing these three questions in French, we aim to bring a new construction to bear on our understanding of grammatical illusions and on the debate concerning how grammatical illusions arise. We now turn to our experimental investigations in order to answer our three questions. Experiment 1 investigates question 1, and experiments 2-4 investigate questions 2 and 3 by testing intrusive structures with different types of de-NP licensing quantifiers. Experiment 5 explores question 3.

2 Experiments

2.1 Experiment 1

2.1.1 Methods

Participants Forty eight subjects participated in this experiment (30 females, 18 males, aged 15 to 68). They were recruited by word of mouth or via Facebook. Prior to participation in

the experiment, participants filled out a questionnaire aimed at assessing their language background and where they are from. We required that all participants i) self-report as a native speaker of a variety of French spoken in continental France, ii) be less than 70 years old, and iii) judge control grammatical sentences higher than control unacceptable ungrammatical sentences. These exclusion criteria were identical across all experiments. In Experiment 1, a total of seven participants were excluded: four were not native speakers of French and three did not perform well on the control items. All 41 remaining participants self-reported as native speakers of French, and all 41 indicated that French was their dominant daily language. Completion of the survey took approximately 10 minutes.

Materials Eighteen sets of experimental items that consisted of the 3 experimental conditions shown in Table 2 were developed. The experiment contained 3 conditions varying along two factors: grammaticality and presence of a quantifier. The 18 critical experimental items were combined with 23 filler sentences. Fillers included 9 control grammatical sentences with an NPI, 9 ungrammatical control sentences with NPI, and 5 ungrammatical sentences containing quantifiers of the kind used in the experimental items.

Table 2: Design

	description	label
A	grammatical, quantifier present	GRAM
B	ungrammatical, quantifier present	INT
C	ungrammatical, quantifier absent	UNGRAM

The particle *de* in de-NPs has two forms: *de* (pronounced [də]) before a word starting with a consonant and *d'* (pronounced [d]) before a word starting with a vowel. To block for a potential effect of this difference, half of the items contain a quantifier followed by a de-NP in the reduced form (28), and the other half contains a quantifier followed by a de-NP in the full form (29).

(28) Items with reduced de-NP (i.e. d'-NP)

a. GRAM: J' ai donné à **beaucoup d' amis** des livres sur
I have given to many DE friends INDEF.PL books about
la vie de mon oncle qui a passé vingt ans au Vietnam.
the life of my uncle who has spent twenty years in Vietnam
I have given to many friends books about the life of my uncle who spent twenty years in Vietnam.

b. INT: J'ai donné à **beaucoup d'amis de livres** sur la vie de mon oncle qui a passé vingt ans au Vietnam.

c. UNGRAM: J'ai donné à des amis **de livres** sur la vie de mon oncle qui a passé vingt ans au Vietnam.

(29) Item with full de-NP (i.e. de-NP)

a. GRAM: Michel a demandé à **beaucoup de gens** des conseils
Michel has asked to many DE people INDEF.PL advice
concernant le discours qu' il doit prononcer le 14 juillet.
about the speech that he must pronounce the 14 July
Michel has asked to many people advice concerning the speech that he must make on July 14th.

b. INT: Michel a demandé à **beaucoup de gens de conseils** concernant le discours qu'il doit prononcer le 14 juillet.

c. UNGRAM: Michel a demandé à des gens **de conseils** concernant le discours qu'il doit prononcer le 14 juillet.

Six different quantifiers licensing *de* were used in the study. Each quantifier occurred in 3 item sets. They are listed in (30).

(30) Quantifiers used in the study

beaucoup 'much'

trop 'too much/many'

énormément 'a great many'

suffisamment 'sufficiently many/much'

pas mal 'not that few/little'

de plus en plus 'more and more'

All sentences used ditransitive verbs such that the goal or addressee (encoded by a PP headed by *à*) preceded the direct object. The more standard order (object-PP) was not used to avoid having the preposition intervene between the two de-NPs.

Procedure The experiment was developed in Ibex and deployed on the IbexFarm online platform (Drummond (2013)). The experimental items were distributed into 3 Latin Square lists, and each participant was assigned to a different list. For each participant, the order of presentation was randomized.

Each trial consisted of a sentence presented on the screen, then the question with the two response options appeared. Sentences were cut up in chunks. Each chunk appeared for 350ms and a 100ms pause separated each chunk. Participants responded by choosing their desired response using the F and J keys or the mouse. Participants were given 2 seconds to give their judgments. Reaction times were recorded. Participants were instructed to judge whether a sentence was 'acceptable' by replying *oui* 'yes' or *non* 'no' to the question *Avez-vous trouvé cette phrase acceptable ?* 'Did you find this sentence acceptable?'. They were first given 2 examples to introduce them to the task. Then they were given several examples with feedback to illustrate the difference between acceptability and grammaticality - this is important given the strong prescriptive tradition of European French.

Chunked presentation was chosen as opposed to word-by-word in an attempt to not draw

attention to the critical word *de*. We reasoned that displaying *de* on its own would make comprehenders prosodify it differently from the way they would if it were displayed next to the NP it is part of, which could interfere with the results. An example of how items were chunked is given in (31).

(31) a. GRAM: J' ai donné / à beaucoup / d' amis / des livres /
I have given to many DE friends INDEF.PL books
sur la vie / de mon oncle / qui a passé / vingt ans /
on the life of my uncle who has spent twenty years
au Vietnam.
at.the Vietnam

b. INT: J'ai donné / à beaucoup / d'amis / de livres / sur la vie / de mon oncle / qui a passé / vingt ans / au Vietnam.

c. UNGRAM: J'ai donné / à / des amis / de livres / sur la vie / de mon oncle / qui a passé / vingt ans / au Vietnam.

Analysis The rating data were analyzed using a mixed-effects logistic regression model including condition as a fixed effect. In this experiments and later ones, we attempted to fit the maximum random effects structure justified by the design and simplified the random effects structure until the model converged (Matuschek et al. 2017). All of our code and data are freely available in a OSF repository[12]. Helmert contrast coding was used to decompose the three conditions into two comparisons (Table 3): a grammaticality contrast that compares GRAM against INT+UNGRAM, and an intrusion contrast that compares INT against UNGRAM.

[12]The link of the OSF repository is https://osf.io/sgw48/?view_only=1ff62b0d0ed04467b68ba8f773052013

Table 3: Helmert contrast coding

	grammaticality	intrusion
GRAM	2	0
INT	−1	1
UNGRAM	−1	−1

Predictions We expect to see clear sensitivity to grammatical licensing of de-NPs in the task. Statistically this should result in a significant effect of the 'grammaticality' contrast. If de-NPs are subject to licensing by grammatically inaccessible licensors, we further predict a significant effect of the intrusion contrast.

2.1.2 Results

By-condition average acceptance rates are presented in Table 4, along with by-participant standard errors.

Table 4: Acceptability ('yes' responses) results of experiment 1

Conditions	mean	s.e.
GRAM	0.94	0.01
INT	0.44	0.04
UNGRAM	0.24	0.04

The model revealed a significant effect of grammaticality and a significant effect of intrusion (Table 5).

	β-estimate	s.e.	z-value	p-value
grammaticality	1.41	.12	11.74	$<$ 2e-16
intrusion	.60	+/- .12	5.13	$<$ .001

Table 5: Acceptability, result of model for yes responses

2.1.3 Discussion

We may sum up the results of this experiment as follows. First, we observed a significant effect of grammaticality: only the grammatical baseline does not violate the grammatical rule (12), and so we expected that it would be accepted at the highest rate in the experiment.

In addition, we observed a significant effect of intrusion when comparing the two ungrammatical conditions, intrusion versus the ungrammatical baseline. This suggests that even if a sentence violates the grammatical constraint on licensing de-NPs (12), its acceptability is improved when a grammatically inaccessible quantifier precedes it. The results of this experiment suggest that de-NP licensing is subject to an illusion of grammaticality effect.

In this experiment, we only used *beaucoup*-type quantifiers that can take part in the QAD construction. Based on the results of this experiment alone, we are unable to generalize the grammaticality illusion effect beyond this. It remains unclear whether all licensors can create grammaticality illusions, or if different licensor types behave differently. We test this in experiment 2 by comparing the ability of +QAD and -QAD licensors to create grammaticality illusions.

2.2 Experiment 2

2.2.1 Methods

Participants Seventy four participated in this experiment (60 females, 14 males, aged 18 to 63). They were recruited via the mailing list of the CNRS RISC. Note that participants were reported through the RISC recruitment pool, which does not allow for setting a precise number of subjects. This led to inconsistent sample size across experiments, because we aimed for a specific number of subjects but decided to analyze everyone who managed to take the experiment in the allotted portion of time. A total of 15 participants were excluded according to the exclusion criteria. All 59 remaining participants self-reported as native speakers of French, and all 59 indicated that French was their dominant daily language. Completion of the survey took

approximately 15 minutes.

Materials Thirty sets of experimental items consisting of 5 experimental conditions were developed. The 5 conditions vary along three factors: grammaticality, acceptability, and whether the quantifier can move (+QAD) or not (-QAD). There is just one ungrammatical condition because in that condition, no quantifier is present; the manipulation of the +/-QAD factor is meaningless for this condition.

The 30 critical experimental items were combined with 40 filler sentences. Fillers included 15 grammatical sentences with NPI, 15 ungrammatical, unacceptable sentences with NPI, and 6 ungrammatical, unacceptable sentences containing quantifiers of the kind used in the experimental items, and 4 sentences that the experimenter was interested in having rated for independent reasons.

To couterbalance a potential effect of the form of the particle *de* (i.e. [də] or [d]), half of the items contain a quantifier followed by a de-NP in the reduced form (32), and the other half contains a quantifier followed by a de-NP in the full form (33).

(32) Items with reduced de-NP

a. GRAM+QAD: J' ai donné à **beaucoup** d' amis des livres sur la
I have given to many DE friends INDEF.PL books on the
vie de mon oncle qui a passé vingt ans au Vietnam.
life of my uncle who has spent twenty years in Vietnam
I have given to many friends books about the life of my grand-father who spent twenty years in Vietnam.

b. INT+QAD: J'ai donné à beaucoup d'amis de livres sur la vie de mon oncle qui a passé vingt ans au Vietnam.

c. UNGRAM: J'ai donné à des amis de livres sur la vie de mon oncle qui a passé vingt ans au Vietnam.

d. GRAM-QAD: J'ai donné à plein d'amis des livres sur la vie de mon oncle qui a passé vingt ans au Vietnam.[13]

e. INT-QAD: J'ai donné à plein d'amis de livres sur la vie de mon oncle qui a passé vingt ans au Vietnam.

(33) Items with full de-NP

a. GRAM+QAD: Michel a demandé à beaucoup de gens des conseils
Michel has asked to many DE people INDEF.PL advice
concernant le discours qu 'il doit prononcer le 14 juillet.
concerning the speech that he must pronounce the 14 July
Michel has asked to many people advice concerning the speech that he must make on July 14th.

b. INT+QAD: Michel a demandé à beaucoup de gens de conseils concernant le discours qu'il doit prononcer le 14 juillet.

c. UNGRAM: Michel a demandé à des gens de conseils concernant le discours qu'il doit prononcer le 14 juillet.

d. GRAM-QAD: Michel a demandé à plein de gens des conseils concernant le discours qu'il doit prononcer le 14 juillet.

e. INT-QAD: Michel a demandé à plein de gens de conseils concernant le discours qu'il doit prononcer le 14 juillet.

Six different quantifiers licensing *de* were used in the study. Each quantifier occurred in 10 item sets. They are listed in (34).

[13] I have given to many friends books about the life of my grand-father who spent twenty years in Vietnam.

(34) Quantifiers used in the study

+QAD	-QAD
beaucoup 'much'	*plein* 'much'
suffisamment 'sufficiently many/much'	*quantité* 'much'
de plus en plus 'more and more'	*nombre* 'much'

As in experiment 1, all sentences used ditransitive verbs such that the goal or addressee (encoded by a PP headed by *à*) preceded the direct object.

Predictions It is expected that the results from experiment 1 will be replicated. Furthermore, if the type of quantifier matters, then we expect to see more illusions for +QAD quantifiers than for -QAD quantifiers.

Procedure The same procedure as in experiment 1 was used.

2.2.2 Results

By-condition average ratings of sentences found acceptable for all experimental conditions are presented in Table 6 along with by-participant standard errors.

Table 6: Condition means and standard errors

	Acceptability	
Conditions	mean	s.e.
GRAM+QAD	.87	.02
GRAM-QAD	.89	.02
UNGRAM	.22	.03
INT+QAD	.35	.04
INT-QAD	.25	.03

We performed two statistical analyses on this design, each addressing a different research question. We ran mixed-effects models with the dependent variable "response" and fitting random slopes/intercepts by subject and item following the method outlined for experiment 1 (Matuschek et al. 2017).

The first question was whether the type of quantifier (+QAD/-QAD) had a differential effect on acceptability in grammatical and ungrammatical sentences. To test this question, we left out the non-illusory ungrammatical baseline condition, and analyzed the remaining four conditions as a 2x2 design crossing quantifier type (+QAD/-QAD) with grammaticality (grammatical/ungrammatical). We fit a single logistic regression model with each of these factors (sum-coded as in Table 7), and their interaction with glmer optimizer *bobyqa*.

Table 7: Contrast coding, model 1

	grammaticality	QAD
GRAM+QAD	.5	.5
GRAM-QAD	.5	−.5
INT+QAD	−.5	.5
INT-QAD	−.5	−.5

This model revealed a significant effect of grammaticality and an interaction of grammaticality and QAD (Table 8). Descriptively, the interaction appears to be driven by the lower ratings in the -QAD intrusive condition relative to the +QAD intrusive condition.

	β-estimate	s.e.	z-value	p-value
gram	3.53	.34	10.42	$<$ 2e-16
QAD	0.23	.17	1.31	0.19
gram× QAD	−.8	.34	−2.37	$<$ .05

Table 8: Results of the mixed-effects logistic regression testing for an interaction of grammaticality and quantifier type.

The second question was whether there was illusory licensing present in both the +QAD and -QAD intrusive licensing conditions. To test this question, we used treatment contrasts (Table 9) to compare each of the four quantified conditions to the ungrammatical baseline.

We fit a single logistic regression model with the factor condition as fixed effect and random intercepts by subject and item with glmer optimizer *bobyqa*. This model shows that while we find evidence of intrusive licensing in the +QAD conditions, we found no such evidence in the -QAD conditions (Table 10).

Table 9: Contrast coding, model 2

	GRAM+QAD	INT+QAD	GRAM-QAD	INT-QAD
GRAM+QAD	1	0	0	0
GRAM-QAD	0	0	1	0
UNGRAM	0	0	0	0
INT+QAD	0	1	0	0
INT-QAD	0	0	0	1

	β-estimate	s.e.	z-value	p-value
GRAM+QAD > UNGRAM	3.57	.23	15.68	< 2e-16
GRAM-QAD> UNGRAM	3.72	.23	15.79	< 2e-16
INT+QAD > UNGRAM	.73	.18	3.95	< .001
INT-QAD > UNGRAM	.16	.19	.84	.40

Table 10: Results of the mixed-effects logistic regression testing for differences from the UNGRAM baseline condition.

2.2.3 Discussion

The results of experiments 1 were replicated. Quantifiers gave rise to intrusive licensing of de-NP. However experiment 2 revealed an interaction of intrusion and ±QAD: intrusive sentences containing a +QAD quantifier were rated significantly higher than those containing a −QAD quantifier, which were not themselves rated significantly higher than the ungrammatical sentences.

The absence of a significant difference between the INT-QAD and UNGRAM conditions does not necessarily mean that only +QAD quantifiers display illusions of grammaticality. Rather, this result shows that the boost in acceptability we observed in experiment 2 is stronger with +QAD quantifiers than with -QAD quantifiers. Importantly, we cannot conclude that there is no illusion of grammaticality at all for -QAD quantifiers.

In experiment 3, we confirmed this pattern holds in offline judgments using Likert scale responses.

2.3 Experiment 3

2.3.1 Methods

Experiment 3 is an offline replication of experiment 2. Sentences were presented whole and with no time limit, participants had to press the space bar to get to the next screen where a Likert scale was given and participants could click on any one number from 1 to 7 to rate the acceptability of the sentence they had just seen on the previous screen.

Participants Fifty seven people participated in this experiment (43 females, 14 males, aged 18 to 69). They were recruited via the CNRS RISC mailing list. A total of 4 participants were excluded according to the same criteria as in experiments 1 and 2. Prior to participation in the experiment, participants filled out a questionnaire aimed at assessing their language background and where they are from. All 53 remaining participants self-reported as native speakers of French, and all 53 indicated that French was their dominant daily language.

Materials The material and design are identical to those used in Experiment 2.

Predictions The predictions were identical to Experiment 2.

Procedure Sentences were presented whole. Subjects read them for as long as they wanted and took as long as they wanted to judge them. A Likert scale was used from 1 to 7.

2.3.2 Results

By-condition average ratings for all experimental conditions are presented in Table 11, along with by-participant standard errors. Table 11 gives the results in percentages of sentences found acceptable.

We performed two statistical analyses on this design, each addressing a different research question. We ran two mixed-effects models with the dependent variable "response" and fitting

Table 11: Condition means and standard errors

	Acceptability	
Conditions	mean	s.e.
GRAM+QAD	5.73	.11
GRAM-QAD	5.87	.14
UNGRAM	2.49	.18
INT+QAD	2.87	.17
INT-QAD	2.62	.17

random slopes/intercepts by subject and item. Both models were performed using a cumulative logistic regression using the ordinal package in R.[14]

The first question was whether the type of quantifier (+QAD/-QAD) had a differential effect on acceptability in grammatical and ungrammatical sentences. To test this question, we left out the non-illusory ungrammatical baseline condition, and analyzed the remaining four conditions as a 2x2 design crossing quantifier type (+QAD/-QAD) with grammaticality (grammatical/ungrammatical). We fit a single regression model with each of these factors (sum-coded as in Table 7), and their interaction as fixed effects. The results of this model (Table 12) revealed a significant effect of grammaticality and an interaction of grammaticality and QAD. Descriptively, the interaction appears to be driven by the lower ratings in the -QAD intrusive condition relative to the +QAD intrusive condition.

	β-estimate	s.e.	z-value	p-value
grammaticality	2.25	.19	11.79	$<$ 2e-16
QAD	.01	.12	.08	.93
gram×QAD	$-.39$	.14	-2.68	$< .05$

Table 12: Results of the mixed-effects regression testing for an interaction of grammaticality and quantifier type.

The second question was whether there was illusory licensing present in both the +QAD

[14] Liddell & Kruschke (2018) have pointed out that ordinal data such as Likert scale acceptability judgements should not be analyzed with models that assume continuous underlying distributions (thanks to an anonymous reviewer for bringing this to our attention).

and -QAD intrusive licensing conditions. To test this question, we used the same treatment coding scheme we used in Experiment 2. The results of this model (Table 13) suggest that there is intrusive licensing in both ungrammatical intrusive conditions.

	β-estimate	s.e.	z-value	p-value
GRAM+QAD	2.44	.23	10.78	< 2e-16
GRAM-QAD	2.65	.24	10.95	< 2e-16
INT+QAD	.46	.14	3.32	< .001
INT-QAD	.25	.11	2.24	< .05

Table 13: Results of the mixed-effects logistic regression testing for differences from the UN-GRAM baseline condition.

2.3.3 Discussion

In Experiment 3, the results of experiment 1 and 2 were replicated in offline judgments. This is quite surprising if grammatical illusions are acceptability raises that are observable online but disappear offline, as has been observed repeatedly for intrusive NPI licensing for instance (Parker 2014: p. 270).

However, there is reason to doubt that such an asymmetry between online and offline judgments should be considered a necessary condition for a contrast in acceptability to qualify as a grammatical illusion. First other mismatches between ungrammaticality and unacceptability have been observed offline e.g. logophlexives (Sloggett 2017) and comparative illusions (Wellwood et al. 2018). Second, more recent discussions of the offline / online distinction cast it primarily as a difference in the signal-to-noise ratio of different judgment modes, with faster judgments being more prone to errors Lewis & Phillips 2015, Parker 2019. On this view, we might not expect illusions to always disappear in offline (e.g. 'untimed') judgment tasks. From this perspective, what matters in whether an illusory pattern is revealed is the relative signal to noise ratio in the judgments. This can vary as a number of factors: strength of the illusion (Dillon et al. 2017), and time taken to process the sentence (Parker 2019), to name two.

To summarise, we observed in experiment 1 that the presence of an intrusive quantifier in an ungrammatical sentence (35) significantly improves its acceptability, however we found in experiments 2 and 3 that this effect is stronger with +QAD quantifiers than with −QAD quantifiers.

(35) INT+QAD: J' ai donné à **beaucoup** d' amis de livres sur la
I have given to many DE friends DE books on the
vie de mon oncle qui a passé vingt ans au Vietnam.
life of my uncle who has spent twenty years in Vietnam

In these 3 experiments, we used ditransitive verbs and a marked word order where the indirect object preceded the direct object. Although we attempted to justify this word order by making the direct object heavy, it remains somewhat marked. In Experiment 4, we tested for grammatical illusions effects in a different, less marked construction to test whether the marked word order influenced our results. An example is given in (36). In this configuration, the intrusive quantifier is associated with the subject of the sentence.

(36) INT+QAD: Beaucoup de gens ont lu de livres sur la
many DE people have read DE books on the
vie de mon oncle qui a passé vingt ans au Vietnam.
life of my uncle who has spent twenty years in Vietnam

2.4 Experiment 4

In this section, we report both our original Experiment 4, as well as a direct replication that we ran in response to concerns that our original study was underpowered. In what follows, we will refer to our original experiment as Replication 1, and the direct replication as Replication 2. Given this, we will first present the design of the experiment, which is shared across both runs. Then we will report the participants and results separately for each replication.

2.4.1 Methods

Same as for experiments 1 and 2.

Materials Thirty sets of experimental items that consisted of the 5 experimental conditions shown in (37) were developed. The experiment contains 5 conditions varying along three factors: grammaticality, acceptability, and whether the quantifier can move (+QAD) or not (-QAD). The design is the same as experiment 2 except that the quantifier phrases are in subject position and the unlicensed de-NP is in object position (32).

The 30 critical experimental items were combined with 37 filler sentences. Fillers included 12 grammatical sentences with NPI, 6 ungrammatical, unacceptable sentences containing quantifiers of the kind used in the experimental items, and 19 sentences from an unrelated experiment. We used the same quantifiers as in Experiments 2 and 3.

(37) a. GRAM+QAD: **Beaucoup de gens** ont envoyé [**des** invitations]
many DE people have sent INDEF.PL invitations
pour mon anniversaire.
for my birthday
Many people have sent out invitations for my birthday.

b. INT+QAD: **Beaucoup de gens** ont envoyé [**d'** invitations] pour mon anniversaire.

c. UNGRAM: **Des gens** ont envoyé [**d'** invitations] pour mon anniversaire.

d. GRAM-QAD: **Plein de** gens ont envoyé [**des** invitations] pour mon anniversaire.

e. INT-QAD: **Plein de** gens ont envoyé [**d'**invitations] pour mon anniversaire.

Predictions The predictions were identical to those in Experiments 2 and 3.

Procedure We used the same procedure as in Experiment 2.

2.4.2 Replication 1

Participants Sixty two people participated in this experiment (49 females, 13 males, aged 16 to 67). They were recruited via the CNRS RISC mailing list. A total of 6 participants were excluded according to the same criteria as the previous experiments. Prior to participation in the experiment, participants filled out a questionnaire aimed at assessing their language background and where they are from. All 56 remaining participants self-reported as native speakers of French, and all 56 indicated that French was their dominant daily language.

Results By-condition average ratings for all experimental conditions are presented in Table 14, along with by-participant standard errors.

Table 14: Condition means and standard errors

	Acceptability	
Conditions	mean	s.e.
GRAM+QAD	.87	.02
GRAM-QAD	.90	.01
UNGRAM	.33	.03
INT+QAD	.42	.04
INT-QAD	.33	.04

We conducted the same two analyses as in Experiment 2. The model that tested for an interaction of grammaticality and quantifier type revealed a significant effect of grammaticality, and a marginal interaction of QAD and grammaticality (Table 15).

	β-estimate	s.e.	z-value	p-value
gram	3.68	.37	9.86	$<$ 2e-16
QAD	0.14	.27	.53	.59
gram$\times$ QAD	-0.87	.45	-1.92	.05

Table 15: Results of the mixed-effects logistic regression testing for an interaction of grammaticality and quantifier type.

We then asked whether there was illusory licensing present in both the +QAD and -QAD

intrusive licensing conditions. To test this question, we used the same treatment-coded mixed effects logistic regression analysis as in Experiments 2 and 3. This model revealed a significant effect of intrusion in the INT+QAD condition, but no reliable effect in the INT-QAD condition (Table 16).

	β-estimate	s.e.	z-value	p-value
GRAM+QAD > UNGRAM	3.57	.25	14.06	< 2e-16
GRAM-QAD> UNGRAM	3.92	.27	14.28	< 2e-16
INT+QAD > UNGRAM	.46	.19	2.42	< .02
INT-QAD > UNGRAM	.01	.19	.07	.94

Table 16: Results of the mixed-effects logistic regression testing for differences from the UNGRAM baseline condition.

Replication 1 found only a marginal interaction of grammaticality and QAD, which is neither strong evidence for nor against the presence of this interaction. It seems likely that Replication 1 was simply underpowered to detect an interaction. Because of the theoretical importance of this effect, we ran a direct replication.

2.4.3 Replication 2

Participants One hundred twenty six people participated in this experiment (106 females, 20 males, aged 18 to 67). Participants were recruited from among one of the authors' relatives in Nantes and first-year students at the Université de Poitiers, France. A total of 24 participants were excluded according to the criteria at the beginning of section 2. As in other experiments, participants filled out a questionnaire prior to taking the experiment. All 102 remaining participants self-reported as native speakers of French, and all 102 indicated that French was their dominant daily language.[15]

[15]The difference in magnitude in the number of participants between replication 1 and replication 2 is due to the way participants were recruited. For replication 1, participants were all

Results By-condition average ratings for all experimental conditions are presented in Table 17, along with by-participant standard errors.

Table 17: Condition means and standard errors

	Acceptability	
Conditions	mean	s.e.
GRAM+QAD	.94	.01
GRAM-QAD	.93	.01
UNGRAM	.32	.02
INT+QAD	.51	.03
INT-QAD	.34	.03

We performed the same statistical analyses as in Replication 1. This model testing for an interaction of grammaticality and quantifier type revealed a significant effect of grammaticality, a significant effect of QAD and a significant interaction of grammaticality and QAD (Table 18). Descriptively, the interaction appears to be driven by the lower ratings in the -QAD intrusive condition relative to the QAD intrusive condition.

	β-estimate	s.e.	z-value	p-value
gram	3.91	.32	12.31	$<$ 2e-16
QAD	0.61	.17	3.45	$<$ .001
gram$\times$ QAD	-0.70	.34	-2.1	$<$ .05

Table 18: Results of the mixed-effects logistic regression testing for an interaction of grammaticality and quantifier type.

The model testing for differences from the UNGRAM baseline condition revealed evidence of intrusive licensing in the INT+QAD condition, but again, no such evidence in the INT-QAD condition (Table 19).

recruited using the CNRS RISC mailing listto which anyone can sign up and which plateaud at 62 participants after a few weeks. For replication 2, participants were initially recruited by word-of-mouth from among one of the authors' family which plateaud at 36 participants after a few weeks, and then from this author's students which increased the number of participants to 126 overnight at which point the experiment was stopped.

	β-estimate	s.e.	z-value	p-value
GRAM+QAD > UNGRAM	4.23	.23	19.11	< 2e-16
GRAM-QAD> UNGRAM	4.00	.21	19.40	< 2e-16
INT+QAD > UNGRAM	.98	.14	7.23	< .001
INT-QAD > UNGRAM	.13	.14	.98	.33

Table 19: Results of the mixed-effects logistic regression testing for differences from the UNGRAM baseline condition.

2.4.4 Discussion

Overall, the two experiments reported here suggest that de-NPs can be intrusively licensed by a subject quantifier and that this effect is significantly stronger if this quantifier is +QAD.[16] However, this effect was only marginal in Replication 1. It is not clear why replication 1 did not show this effect. In all likelihood, it was simply underpowered to detect the effect. Note that we used a different construction in Experiment 4, which could have contributed to a smaller effect size by putting more linear or syntactic distance between the intrusive quantifier and the

[16]An anonymous reviewer to a conference abstract suggested that perhaps the interaction we observed was not due to the syntactic differences between *beaucoup* and *plein* -type quantifiers, but perhaps to a difference in what type of variable they can bind. The suggestion does not elaborate further but we suppose the reviewer had the following scenario in mind. In Obenauer 1983, Doetjes 1997, Burnett 2009 (among others), it is argued that +QAD quantifiers bind an event variable when they appear preverbally. Indeed it has been entertained that illusory sentences in experiments 1-3 could be analysed as one in which the quantifier (although appearing in object position) is in fact structurally preverbal, an underlying structure that is obscured because participles can undergo 'short movement' in French (Pollock 1989). Under such an analysis, whether the quantifier appears adjacent to the de-NP or preverbally, it always binds an event variable.

(38) J'ai mangé beaucoup ~~mangé~~ de pommes.

Here is how this challenge might be answered. First, it is not clear how the possibility to bind event variables would give rise to de-NP licensing illusions, no linking hypothesis has been proposed. But even if this were a viable idea, the fact that quantifiers in subject position can give rise to d'illusions would be completely unpredicted.

de-NP.

Stepping back, four out of five experiments (1, 2, 3, 4.2) revealed statistically significant evidence that +QAD quantifiers cause more interference than -QAD quantifiers. A simple memory retrieval account such as the one sketched in section 1.2 cannot derive this asymmetry given that -QAD and +QAD quantifiers occupy the same position in the string, are in the same constituent, and have the same [+de-NP] cue given that they both license de-NPs. Because de-NP illusions are restricted to those quantifiers that can independently move, we explore the possibility that this effect could be the result of a repair process that capitalizes on this grammatical option.

2.5 Interim discussion: de-NP illusory licensing and retrieval

2.5.1 Retrieval hypothesis

Our experiments until now suggest two empirical generalizations. One, de-NP licensing is subject to illusions of grammaticality in a way that mirrors NPI illusions, at least in judgment measures. Two, we saw larger de-NP illusions for +QAD quantifier than for -QAD quantifiers. This pattern may be accommodated in the cue-based parsing framework, with certain modifications.

A memory-retrieval account for these de-NP grammatical illusions might go as follows. If the parser reaches a de-NP that has an immediately preceding licensor, no memory retrieval is necessary. However, when the parser encounters a de-NP that does not have an immediately local quantifier licensing it, the parser executes a memory retrieval operation for a licening quantifier that matches the retrieval cues. When the target of the retrieval matches the retrieval cues, it is activated. If the target is not in a structural position to grammatically license the de-NP, as in our intrusive conditions, a partial match with the features may nevertheless give rise to the illusion of licensing and grammaticality. A pressing question for this account, however, is what exactly these retrieval cues are. A different but equally well motivated hypothesis could be repair.

2.5.2 Alternative hypothesis: repair

Until now, we have largely focused on the hypothesis that these errors are driven by memory retrieval errors. However, competing hypotheses exist to explain these effects that merit consideration. One alternative explanation for our grammatical illusions is based on the idea that comprehenders receive imperfect input and may use information beyond the grammar per se (e.g. knowledge of the speech production system, knowledge of real world plausibility and probability) to arrive at an understanding of the speaker's intended message (Frazier & Clifton Jr 2015). A similar idea is at the core of the so-called Noisy Channel model of sentence comprehension (Levy 2008, Gibson et al. 2013), although these approaches differ in the implementation of this leading idea and in what factors are presumed to be relevant for this covert repair process.

Support for this view comes from findings that suggest that comprehenders are at times willing to consider certain imperfect input (mismatch ellipsis (39), doubled quantifiers, doubled negation) as syntactic blends, and assign the input both a relatively acceptable rating (compared to undiagnosable or irreparable ungrammatical counterparts) and an interpretation supported by the repair (see Frazier 2015 for an overview). For instance Arregui et al. 2006 found that speakers rated the ellipsis cases in (39b-d) as a function of the number of repairs necessary to repair the antecedent so that it may serve as the antecedent for VP ellipsis.

(39) a. None of the astronomers saw the comet, /but John did. (Available verb phrase)

b. Seeing the comet was nearly impossible, /but John did. (Embedded verb phrase)

c. The comet was nearly impossible to see, /but John did. (Verb phrase with trace)

d. The comet was nearly unseeable, /but John did. (Negative adjective)

From this perspective, we could imagine an alternative account of our core findings. When processing ungrammatical sentences containing a de-NP and a quantifier in an inaccessible position, comprehenders would first recognize that the sentence is ill-formed, and attempt to

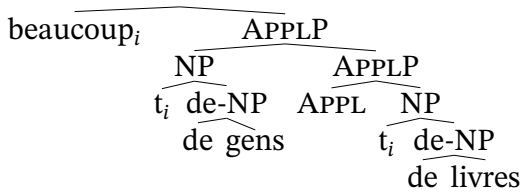
repair the input to a form that would license two de-NPs. Subsequent to this repair, comprehenders would interpret the repaired structure. We discuss another type of repair account in section 3.4.

The correlation we observe between participating in QAD constructions and spurious licensing receives a natural interpretation under this perspective. One repair account of INT+QAD sentences might go as follows: +QAD quantifiers are covertly reanalyzed as binding both de-NPs (40a) and a co-indexed bound trace is inserted next to each one. We illustrate this in (40b).[17] This explains the correlation between +QAD quantifiers and *de*-NP illusions, because only +QAD quantifiers can establish long-distance dependencies whereas -QAD quantifiers cannot.

(40) a. $[\![\text{beaucoup}]\!]=$

the function BCP, defined as follows: Let s, t $\in \mathbb{N}$ such that 0<s, t< $|E^x|$, For all R$\in$ $\mathcal{P}(E^x x E^x)$, $BCP_{s,t}(R)=1$ iff $|Dom(R)| > s_x$ & $|Ran(R)| > t_x$

b. Q in goal position



The repair account makes a signature, distinct prediction: *de*-NP illusions should be assigned a particular interpretation where *beaucoup* modifies both de-NPs. Given our specific hypothesis, this predicts that a spuriously licensed de-NP is interpreted as bound by the quantifier. Thus according to this repair hypothesis, each de-NP is indexed to the quantifier, which

[17]We hasten to clarify two things. First, this account is agnostic as to whether the dependency between the quantifier and the de-NP is obtained via movement of the quantifier or via binding. How the dependency is established is irrelevant for our repair account, what matters is that such a dependency is obtained. Secondly, in the cases where the quantifier is in the indirect object argument, we assume that the quantifier takes scope over both de-NPs but remains within APPLP.

might lead us to expect an interpretation where each de-NP is alternately interpreted as being a restrictor of the quantifier it is bound by. In other words, according to this repair hypothesis, a sentence like (41) should be given a doubly quantified interpretation.[18]

(41) J' ai donné à beaucoup d' associations de livres.
I have given to a_lot DE charities DE books
Predicted interpretation: I gave many books to many charities.

According to our extension of Burnett 2009's analysis, the truth conditions of (41) would be as in (42).

(42) ⟦J'ai donné à beaucoup d' associations de livres⟧=1
iff |{x:giving(I,x,y) & associations(y) & books(x)}| $>s_x$ & |{y:giving(I,x,y) & associations(y) & books(x)}| $> t_x$

We now turn to an experiment that tests whether this predicted interpretation occurs for *de*-NP illusions.

2.6 Experiment 5

2.6.1 Methods

We used the same methods as for experiments 1, 2, and 4: RSVP. In addition, we asked participants to choose between two paraphrases of the sentence they had just seen: one corresponding to a sentence where the object is quantified and one corresponding to a sentence where the object is interpreted as a plural indefinite. This reformulation judgment task was inspired by the

[18]There are of course a number of alternative ways that a repair operation might apply to an ungrammatical structure without actually predicting a doubly-quantified interpretation. We discuss these in section 3. We now turn to the results of our investigation of the hypothesized repair operation.

methodology used in a study by Frazier & Clifton (2011) on the interpretation of sentences containing doubled quantifiers e.g. *many* and *often* in *Many students often turn in their assignments late*.[19] We adopted this methodology because our study was very similar to Frazier and Clifton (2015).

Each sentence was presented in chunk in RSVP in the center of the screen. Compared to the previous experiment we gave more time per chunk (440ms per chunk with 150ms pause in between) because the task was different and, after receiving feedback from participants, we decided that it was necessary for them to have more time to be able to form a meaning for the sentences. After the sentence to be judged had been displayed, two paraphrases were displayed and the participant had 2 seconds to choose the better paraphrase (see below for more detail). In addition, for each experimental item, we added an acceptability judgment question so that we could check whether the acceptability of an illusory de-NP structure and its interpretation are correlated.

Participants 135 people participated in this experiment (104 females, 31 males, aged 18 to 72). They were recruited via the mailing list of the CNRS RISC, social media and word of mouth. We excluded 6 people because they did not meet our exclusion criteria (criterion 3 does not apply here). The remaining 129 all reported they spoke French natively.

Procedure and Materials In this experiment, participants were asked to give 2 judgments for each sentence that they had seen: one reformulation judgement where they had to choose between two paraphrases of the sentence they had just seen and one acceptability judgement. After a sentence from one of the experimental conditions in (43) was displayed, a blank screen was displayed for 2 seconds (in an effort to prevent rote learning), and then a screen with the question and the reformulation choices in (44) appeared. Participants had been instructed that

[19] In their experiments, subjects are asked to choose one of two paraphrases, e.g. the number of students who turn in their assignments late is large or the number of students who frequently turn in their assignments late is large.

each displayed sentence was an utterance said by one of two characters, Jean or Marie. The name of the speaker was displayed at the beginning of each sentence.

(43) a. GRAM: MARIE: Michel a demandé à beaucoup de gens des conseils à propos du discours qu'il doit faire le 14 juillet.

b. INT: MARIE: Michel a demandé à beaucoup de gens de conseils à propos du discours qu'il doit faire le 14 juillet.

(44) D'après ce que vous avez compris de l'énoncé de Marie: 'According to your interpretation of what Marie said:'

a. A: Michel a demandé au moins un conseil à chaque personne. 'Michel asked for at least one piece of advice from everyone.'

b. B: Michel a demandé une grande quantité de conseils à chaque personne. 'Michel asked for a great deal of advice from everyone.'

Before the experiment started, participants were given two practice examples for which they had to choose the best paraphrase and tell whether it was acceptable or not. After their answer, they were given feedback. None of the two examples used in the training phase had to do with quantification or phrase licensing. Then the experiment started. The experimental phase proper consisted of 5 examples: 3 beginning examples + 2 experimental items proper (more detail below on why we chose to have only 2 items tested per participant) + 1 filler. The first three (grammatical) examples (45-47) were given (in the same order) to all participants at the beginning. They were designed to calibrate the judgment scale.

(45) MARIE: M. Dupont a distribué à plein d'étudiants plein de tracts pour les prochaines élections présidentielles.

a. D'après ce que vous avez compris de l'énoncé de Marie:

A. Chaque étudiant a reçu au moins un tract.

B. Chaque étudiant a reçu une grande quantité de tracts.

b. Trouvez-vous l'énoncé de Marie acceptable ?

A. Oui.

B. Non.

(46) JEAN: Tous les élèves ont fait signer leur photo de classe à des professeurs.

a. D'après ce que vous avez compris de l'énoncé de Jean:

A. Chaque élève a fait signer sa photo de classe à au moins un professeur.

B. Chaque élève a fait signer sa photo de classe à un grand nombre de professeurs.

b. Trouvez-vous l'énoncé de Jean acceptable ?

A. Oui.

B. Non.

(47) JEAN: Le professeur a distribué à plein d'étudiants des affiches faisant la publicité d'un forum professionnel.

a. D'après ce que vous avez compris de l'énoncé de Jean:

A. Chaque étudiant a reçu au moins une affiche.

B. Chaque étudiant a reçu une grande quantité d'affiches.

b. Trouvez-vous l'énoncé de Jean acceptable ?

A. Oui.

B. Non.

Then participants saw three more items: the 2 experimental items proper (GRAM and INT), and 1 filler item containing a completely different structure[20]. Twenty sets of experimental items that consisted of 2 experimental conditions (GRAM, INT) were developed.

[20]The extra item contained the phrase *je doute que oui* lit. 'I doubt that yes' as in (48). For a different project, we were interested in knowing whether there was a correlation between the acceptability of the sequence *je doute que oui* and the interpretation of *je doute* 'I doubt' as *je ne suis pas sûr* 'I am not sure' as opposed to *je ne pense pas* 'I don't think'.

Five different +QAD quantifiers licensing *de* were used in the study. Each quantifier occurred in 4 item sets. They are listed in (49) along with the corresponding phrases which were used in the B alternatives on the question screen.

(49) Quantifiers used in the study

beaucoup 'much'	une grande quantité de 'a large quantity of'
trop 'too much'	un nombre excessif de 'an excessive number of'
énormément 'very much'	un très grand nombre de 'a very large number of'
suffisamment 'sufficiently much'	une quantité raisonnable de 'a reasonable quantity of'
pas mal 'much'	un nombre conséquent de 'a significant number of'

Whereas in previous experiments, we compared grammatical items to their ungrammatical counterparts and to their intrusive counterparts (across +QAD and -QAD levels in experiments 2-4), here we chose to only compare +QAD grammatical and +QAD intrusive items, i.e. we chose to design an experiment with just two conditions. Furthermore, we chose to have just one observation per condition. We chose to only present two conditions because our repair hypothesis makes interpretive predictions for grammatical and intrusive +QAD sentences only (not for ungrammatical sentences of the type we used in previous experiments). After receiving feedback from participants in a test-run of the experiment, we chose to present only one item per condition because we did not want participants to develop a response strategy, hence the

(48) Jean: Louise pense que Thomas a bien pensé à envoyer son dossier à temps mais je doute que oui.

a. D'après ce que vous avez compris de l'énoncé de Jean:
A. Je ne suis pas sûr que Tom ait pensé à envoyer son dossier à temps.
B. Je pense que Tom n'a pas pensé à envoyer son dossier à temps.

b. Trouvez-vous l'énoncé de Jean acceptable ?
A. Oui.
B. Non.

high number of participants for this experiment.

Predictions The repair hypothesis predicts that the illusory de-NP conditions should be interpreted as a doubly quantified construction.

2.6.2 Results

By-condition average number of doubly-quantified interpretations for all experimental conditions are presented in Table 20, along with by-participant standard errors.

Table 20: Condition means and standard errors in number of doubly quantified (B) responses

	Doubly quantified int.	
Conditions	mean	s.e.
GRAM	.43	.04
INT	.53	.04

We ran a mixed-effects model with the dependent variable 'response' taking the factor 'condition' as a fixed effect (sum-coded as in Table 21) and fitting random intercepts by subject. The difference was not significant at the 0.05 level (β = .21 (+/- .13), z = 1.62, p = .1).

Table 21: Contrast coding

	grammaticality
GRAM	-1
INT	1

Post-hoc analysis It is possible that the predicted interpretation only arises when participants experience a grammatical illusion. To test this possibility, we ran a post-hoc analysis only on those trials that were judged acceptable. We report below the interpretation results for

items that were judged acceptable only (N=59[21]).

Table 22: Condition means and standard errors in number of doubly quantified (B) responses for items judged acceptable only

	Doubly quantified int.	
Conditions	mean	s.e.
GRAM	.51	.06
INT	.59	.06

We ran a mixed-effects model with the dependent variable 'response' taking the factor 'condition' as a fixed effect (sum-coded as in Table 21) and fitting random intercepts by subject. Again, the difference between the two conditions was not significant ($\beta = .28$ (+/- .16), z = 1.7, p = .08).

2.6.3 Discussion

We saw an effect in the predicted direction: the doubly-quantified interpretation was chosen more for the intrusive condition than for the grammatical condition. This is compatible with the predictions of the repair hypothesis in section 2.5.2 However this effect was not statistically significant, and so we cannot draw clear conclusions. We did observe a small, numerical trend in the predicted direction, so we cannot rule out the hypothesis that illusory sentences are assigned a doubly quantified interpretation. This is not a clear outcome either way, but we report it in the interest of fully documenting the results of our research project. With respect to the question of doubly-quantified interpretations, we simply do not have evidence for it yet, so we will not draw strong claims one way or another.[22] As a consequence, we continue to

[21]Only 59 participants (out of 129) judged both the GRAM and INT sentences acceptable AND responded to the interpretation question for both items within the two-second time window.

[22]Heather Burnett (p.c.) commented that perhaps the reason we failed to obtain a significant contrast is to be blamed on the vagueness of *beaucoup* and that perhaps further work could use

develop the cue-based account to model our findings, while bearing in mind that future work might yet provide evidence for a repair-based account.

3 General discussion

3.1 Our findings in light of the debate between retrieval and repair

We repeat the three central questions that guided our investigation in (50).

(50) Three questions

a. Question 1: Can de-NP-licensing quantifiers intrusively license de-NPs?

b. Question 2: Can all de-NP-licensing quantifiers intrusively license de-NPs?

c. Question 3: What properties of a quantifier are critical for intrusive licensing?

We found a grammatical illusion in four experiments: the presence of a de-NP-licensing quantifier raises the acceptability of an ungrammatical sentence even if the quantifier is not accessible grammatically. However we found that not all de-NP-licensing quantifiers give rise to the grammatical illusion to the same extent. We established that quantifiers that can be grammatically separated from their de-NP restrictor (i.e. +QAD quantifiers) intrusively license grammatically-unlicensed de-NPs to a significantly greater extent than quantifiers that must appear adjacent to the de-NP they license in the grammar (-QAD quantifiers).

We entertained two hypotheses for the mechanism that underlies this effect. Under the cue-based retrieval account (sketched in section 2.5.1), non-locally licensed de-NPs trigger retrieval in memory for a licensing quantifier that matches the retrieval cues. When an element in memory matches the retrieval cues, it may be reactivated. If a licensing element is not in a

quantifiers that have linguistically instanced points of comparison (i.e. *plus que* 'more than'), which yield sharper truth conditions for the doubly quantified meaning and might therefore provide a better test. An anonymous reviewer stresses that experiment 5 has very low statistical power and that consequently a null result is not entirely surprising.

structural position to grammatically license the de-NP, as in our intrusive conditions, a partial match may suffice for it to be reactivated, giving rise to the illusion of licensing and grammaticality. In addition to this account, we explored a repair-based account in terms of structural reanalysis (section 2.5.2). This account has the strength of correctly predicting the interaction between the type of quantifiers (+QAD or -QAD) and improved acceptability of the INT sentences, but we failed to observe clear evidence for the the predicted interpretive effect in experiment 5.[23]

On a cue-based account, one important question is how the difference between +QAD and -QAD quantifiers arises. The failure to observe illusory licensing with -QAD suggests that they do not constitute a strong partial feature match with the demands of an unlicensed de-NP. Below, we suggest that this supports a view of memory retrieval processes where what guides the retrieval is the structure of the quantifiers themselves.

3.2 Parsing de-Noun Phrases in a cue-based architecture

We interpret the 'd'illusion' effect as a grammaticality illusion arising from the dynamics of a cue-based processing system. We turn now to a more detailed sketch of the process of parsing de-NPs from this perspective.

[23]Of course there are alternative repair accounts such that our failure to observe the predicted effect do not falsify repair accounts in general. A repair account with no interpretative prediction might go as follows: the processor first indexes the first de-NP it encounters as the restrictor of the quantifier and, when it encounters the second de-NP, it revises that assignment to assign the quantifier to the second restrictor. This reassignment mechanism would be similar to the one Fodor (1978) proposes to explain the interpretive ambiguity of English examples as in (51) between the interpretation in a, b, and c.

(51) To whom did you say that Father wrote?

a. You said to whom [that Father wrote]?

b. You said [that Father wrote to whom]?

c. To whom$_i$ did you say t$_i$ [that Father wrote t$_i$]?

We couch our account in the Lewis and Vasishth's (2005) cue-based parsing model, one prominent account of cue-based parsing that is implemented in the ACT-R cognitive architecture (Adaptive Character of Thought–Rational, Anderson 1990, Lewis and Vasishth 2005, Vasishth 2008). The Lewis and Vasishth model proposes that the parser proceeds in a left corner fashion, that is, encoding constituents into working memory as soon as any bottom-up evidence for those constituents becomes available. As the parser proceeds through a sentence, the corresponding phrase marker is split into its major constituents, which are subsequently encoded as 'chunks' in working memory. These chunks encode the major features of each constituent (such as its major syntactic category, its lexical head, and any relevant morphosyntactic features), along with the links between constituents in the parse tree. On this model, one of the key processing bottlenecks during incremental syntactic processing is reaccessing or retrieving these constituent encodings from working memory when they are necessary. Retrieval, in this context, refers to the process of reactivating a constituent from working memory, and moving it into an active working memory store or *focus of attention*, where it can undergo active processing. Retrieval of constituents from working memory proceeds via the use of retrieval cues, features of the to-be-retrieved constituent. A core component of this model, and others like it, is the claim that the size of the focus of attention is limited, that is, only some of the information processed up to a certain point can be maintained in an active state (McElree et al. 2003, Lewis & Vasishth 2005). Older information is stored in a passive memory store and must therefore be retrieved if needed. Parsing in this model involves continuously shunting information in and out of active memory stores in order to form dependencies during processing. In this model grammatical illusions arise as a result of the retrieval of irrelevant chunks that partially match the retrieval cues of the item in the focus of attention.

In such a model, one possibility is that de-NPs licensed by a string-adjacent quantifier (e.g. de-NP_1 in 52a and de-NP_2 in 52b) might be special because in that case, both licensor and licensee are in the $\boxed{\text{focus of attention}}$, which means that parsing this configuration need not rely on memory retrieval processes to establish the dependency.

(52) a. J' ai écrit $\boxed{\underline{\text{beaucoup}}\ [\text{de lettres}]_{de-NP_1}}$.

I have written a_lot DE letters

I wrote many letters.

b.*J'ai écrit à $\boxed{\underline{\text{beaucoup}}\ [\text{de gens}]_{de-NP_2}}$ de lettres.

However, de-NPs that are not immediately adjacent to their licensing licensing quantifiers (e.g. de-NP$_3$ in 53a and de-NP$_4$ in 53b) should, on this theory, require a cue-based memory retrieval operation to establish the dependency. This follows from the assumption that the material that intervenes between the licensing quantifier and the de-NP needs to make use of the limited focus of attention, and so the quantifier must be reactivated from memory when it is needed later on to process the dependent de-NP. On this view, only non-locally-licensed de-NPs trigger cue-based retrieval.

(53) a. J' ai $\underline{\text{beaucoup}}$ écrit $\boxed{[\text{de lettres}]_{de-NP_3}}$.

I have a_lot written DE letters

I wrote many letters.

b.*J'ai écrit à $\underline{\text{beaucoup}}$ de gens $\boxed{[\text{de lettres}]_{de-NP_4}}$.

From this perspective, an important question is what information is used to retrieve the licensing quantifier. The cues are standardly assumed to involve the features that are necessary to license the element currently being processed, but the retrieval cues need not stand in a one-to-one relationship with the grammatical features necessary to license an element in memory (Dillon et al. 2013, Dillon 2014, Kush et al. 2015, 2018, Lewis & Vasishth 2005). For the case at hand, the retrieval cues must minimally distinguish +QAD quantifiers from -QAD quantifiers, such that retrieval operations will selectively activate +QAD quantifiers. On this account, the intrusive +QAD quantifiers in our intrusive sentences partially match the retrieval cues used to reactivate potential de-NP licensors in memory, which leads to some probability of accidentally reactivating the intrusive +QAD quantifier. This in turns results in an illusion of grammatical-

ity (Phillips et al. 2011, Vasishth et al. 2008). In contrast -QAD quantifiers do not give create a similar grammatical illusion, since they do not match the cues for licensors that can license de-NPs at a distance.

What cues might plausibly distinguish +QAD from -QAD quantifiers in memory? Recall that *beaucoup*-type quantifiers have a complex layered underlying structure, namely [NP+AdjP+AdvP]. This is motivated by the observation that +QAD quantifiers like *beaucoup* have three different uses – VP adverbs, pronouns, determiners – and that this has been argued to reflect an underlying structure where items like *beaucoup* are adverbs that can modify a silent adjective MANY modifying a silent noun NUMBER (Kayne 2002). By contrast, *plein*-type quantifiers are adjectives (e.g. AdjP) which cannot stand on their own, and need to modify an NP. A retrieval operation that needs to selectively activate +QAD quantifiers may plausibly index this categorical difference by deploying a categorical retrieval cue such as [NP+AdjP+AdvP]. With such a cue only *beaucoup*-type quantifiers will be retrieved since only they have an underlying structure that matches this cue.

It is important to note that the categorical retrieval cue we propose here is related to, but distinct from, the grammatical constraints on phrases that can license de-NPs. It is not the case that only quantifiers that match the [NP+AdjP+AdvP] categorical feature can license de-NPs: it is possible for -QAD quantifiers that are local to a de-NP to license it, and those quantifiers do not match this feature. Instead, the suggestion we make here is that this cue is selectively deployed when it is necessary to retrieve a long-distance licensor, because it is a useful feature that the parser can exploit to identify quantifiers that can license at a distance. This gives this cue utility as a feature that is diagnostic of those quantifiers that can license at a distance, and so could be profitably used by a parser that can recognize when it needs to selectively activate a grammatical element that can license de-NPs licensors at a distance.

One outstanding issue is how such a system could distinguish between c-commanding +QAD quantifiers and non-c-commanding, or intrusive, +QAD quantifiers. The issue of how to encode relational information like c-command in a cue-based retrieval architecture remains

an outstanding theoretical issue that we cannot resolve on the basis of the present data (Alcocer & Phillips 2012, Franck & Wagers 2020, Kush 2013, Kush et al. 2015, Wagers 2008). For example, Kush and colleagues (2015) propose that the parser can actively track c-commanding quantifier phrases by marking them with a feature that they call ACCESSIBLE, which is dynamically updated on individual quantifier phrases over the course of a parse so that all and only the c-commanding QPs bear this feature at any point in an incremental parse (see Kush (2013), Kush et al. (2015) for more details). In the context of the current proposal, ACCESSIBLE could be used to distinguish grammatical from intrusive +QAD quantifiers. It is also possible that the c-command relationship can be implicitly encoded in the resting activation of different phrases in memory, or in some other type of context features that are associated with phrases when they are encoded in memory: see Franck & Wagers (2020) and Wagers (2008) for an in-depth discussion of these issues.

Stepping back, the present data are naturally explained by a cue-based parsing architecture that attempts to retrieve long-distance QPs using both abstract categorical cues (which selectively activate +QAD licensors) and relational cues (which selectively activate c-commanding phrases). Intrusive licensing, on this view, arises as a function of the partial match between non-c-commanding +QAD quantifiers and these retrieval cues. Non c-commmanding -QAD quantifiers, on the other hand, match neither cue, and hence show a much smaller illusion of grammaticality.

3.3 On the interpretation of illusory structures

One important question concerning the cue-based retrieval account of illusory de-NP licensing is what types of interpretations this parsing process would ultimately license. The question of how illusory licensing relates to interpretation has been studied with regard to agreement attraction phenomena.

One natural possibility is that if an illusory licensor is retrieved, it is capable of forming a dependency that can then be interpreted. This possibility was invested by Parker, Schlueter and

Lau (2019). In their study, they had participants read sentences that contained illusory agreement configurations, followed by a 2 alternative forced-choice (2AFC) judgment about which adjective better continued the sentence. For example, a participant would read *the bed by the lamps undoubtedly were quite...* and then be asked to decide whether *comfortable* or *bright* was a better continuation of the sentence. Parker and colleagues reasoned that if the agreement illusion led participants to treat the distractor *lamps* as the thematic subject of the sentence, then there should be an increase in rate of *bright* responses in their 2AFC task. They found evidence of this prediction, but the overall magnitude of the effect was quite small relative to the rate of agreement attraction (Schlueter et al. 2019). Parker and colleagues concluded that agreement attraction did not routinely result in a direct thematic realignment of the sentence. Instead, they concluded, that the retrieval mechanism is often deployed as a 'low-level rechecking' mechanism that monitors the well-formedness of the parse and does not generally have interpretive consequences. However, a number of other studies do suggest that the number marking on a distractor can influence the overall interpretation of an agreement attraction configuration by increasing the probability that participants will interpret a grammatically singular head noun as notionally plural (Brehm et al. 2019, Patson & Husband 2016).

In the case of illusory de-NP licensing, we failed to find any evidence for the predicted double quantification interpretation of the repair-based account. However, this could be for several reasons. First, and perhaps most straightforwardly, we may have simply lacked the statistical power to detect an effect. As an anonymous reviewer correctly points out, this is a live possibility and so this null result should be interpreted with caution. In addition to this, if Parker and colleagues' generalization about illusory agreement phenomena generalizes to de-NP illusions, then we might not expect incorrect retrievals to result in any interpretive consequence. It is possible that the retrieval processes we described above are deployed as a superficial or low-level rechecking process, allowing easy integration of the de-NP and high sentence acceptability, but without directly guiding its interpretation. In other words, it may be that de-NP illusions reflect a process that monitors wellformedness at the syntactic level, but does not have any impact on

the semantic interpretation of the de-NP.

3.4 Alternative approaches to illusory de-NP licensing

There are a number of alternative approaches that might account for the data we have presented.

One important alternative analysis of this effect is suggested by noisy-channel models of sentence interpretation. As reviewed above, the noisy channel approach allows for comprehenders to achieve a non-literal interpretation of linguistic input by positing that comprehenders may entertain edits to the form of a sentence that strike a balance between faithfulness to the input and plausible, likely analyses of that input. This approach might allow a simple repair strategy for the present cases: participants could simply correct an ungrammatical *de* to a grammatical *des*, which would only require the insertion of a single segment. This would result in an unlicensed de-NP being converted into an indefinite plural NP.

This repair strategy could apply to both fully ungrammatical sentences, and sentences where the ungrammatical de-NP is subject to illusory licensing effects. So one challenge for such an approach is to explain why this repair is more likely specifically in intrusive contexts. Furthermore, this model must explain why this is more likely with intrusive +QAD quantifiers. But it is difficult to see how the presence of an intrusive quantifier makes it more likely that comprehenders will entertain the *de* to *des* edit, since indefinite plurals marked with *des* do not need to cooccur with either type of quantifier. Thus, while we certainly cannot rule out the possibility that comprehenders are simply interpreting an ungrammatical de-NP as an indefinite plural marked with *des*, it is at present unclear how this hypothesis captures the full distribution of illusory de-NP licensing.

Another possibility is that comprehenders consider an edit to the input that places the +QAD intrusive quantifier in a c-commanding position where it could license the ungrammatical de-NP: i.e. the input sentence *J'ai donné à* ***beaucoup d'amis de livres*** would be edited to *J'ai beaucoup donné à* ***d'amis de livres***. This edit would allow the critical quantifier to license

the unlicensed de-NP in the input, and would only be possible with +QAD quantifier. But this edit creates a second unlicensed de-NP (i.e. *d'amis*). Since this edit does not yield a grammatical sentence, it is unclear how it would explain the intrusive licensing effects we observed in our experiments. In addition, a noisy-channel correction that places a +QAD quantifier in a c-commanding position predicts that the de-NP should be interpreted the same in grammatical sentences and intrusive sentences, which we failed to find any evidence for in Experiment 5. While we cannot categorically rule out the possibility of a noisy channel-style explanation of our results, it also seems fair to say that further elaboration of this model to account for the full range of the present findings is necessary.

3.5 Avenues for future research

One central contribution of this work is the establishment of illusory de-NP licensing in French, which we have analyzed in terms on an independently motivated cue-based parsing architecture. However, there remain many important questions that are beyond the scope of the present work, which remain for future research.

One of the most important questions is how the distribution of illusory de-NP licensing compares to other well documented grammatical illusions, such as agreement attraction phenomena or illusory NPI licensing. Of particular importance for future work is a careful comparison of illusory NPI licensing and illusory de-NP licensing. Although illusory NPI licensing has sometimes been argued to reflect the same cue-driven illusory licensing that we have advanced here (Vasishth et al. 2008), subsequent research into the mechanisms underlying illusory NPI licensing suggests a different analysis. For example, Xiang and colleagues (2013) show that illusory NPI licensing, but not agreement attraction, correlates across individuals with their score on the Communication Subscale of the Autism Quotient (Baron-Cohen et al. 2001, Xiang et al. 2013), which they interpret as evidence that NPI illusions are driven by a pragmatic rescuing strategy (for related claims about NPI illusions, see Xiang et al. 2009, Mendia et al. 2018). Importantly, NPI illusions are also observed in contexts where the NPI precedes its illu-

sory licensor, as in Turkish (Yanilmaz & Drury 2018); accounts that rely on memory retrieval do not straightforwardly predict the effect when the NPI precedes the intrusive licensor. More recently, it has been shown that NPI illusions are selectively triggered by intrusive quantifiers, suggesting a more limited distribution of NPI illusion effects than predicted on cue-based retrieval accounts of this phenomenon (Orth et al. 2021, de Dios Flores 2021, Muller & Phillips 2020). These relatively restricted distributions suggest a different underlying mechanism for NPI licensing, such as illusory licensing driven by overapplication of a quantifier-raising process (Orth et al. 2021), or difficulty integrating the NPI into the immediately post-relative clause context (Muller & Phillips 2020). Like NPI illusions, de-NP illusions involve intrusion from a grammatically inaccessible quantifier. This similarity suggests that it may be possible to understand both de-NP illusions and NPI illusions as reflecting a common underlying source, distinct from the analysis in terms of cue-based retrieval that we offered above. For example, Orth and colleagues' model of NPI illusions that attributes them to fleeting, ungrammatical quantifier-raising processes might extend to cover illusory de-NP licensing, if we suppose that only +QAD quantifiers may participate in covert quantifier raising.

Given all of this, a clear direction for future research is determining the scope of de-NP illusions, with an eye to establishing whether they are relatively unselective (as predicted on a cue-based retrieval account), or more selective (as might be expected if they are more similar to NPI illusions). If de-NP illusions prove to be a rather general phenomenon, then this would lend support to the cue-based account we have articulated in some detail here. However, if the distribution of de-NP illusions turns out to be more restricted, then this would lend support to other analyses of this effect, for example in terms of a fleeting consideration of an ungrammatical quantifier-raising process (Orth et al. 2021).

One possible way to distinguish these broad approaches might be to investigate how many de-NPs a single intrusive licensor can license. In our experiments we only tested sentences with 2 de-NPs, only one of which was not grammatically licensed. But it is possible to create sentences with three or even four de-NPs, only one of which is actually licensed. On a cue-based

approach, each non-locally licensed de-NP launches its own retrieval to identify a quantifier. Without any constraints on the number of times a quantifier can be partially matched and by these retrieval operations, this approach predicts that each de-NP should be subject to illusory licensing on its own. On the other hand, if this effect reflects fleeting uncertainty about the structure (Orth et al. 2021) or the context (Muller & Phillips 2020), then we might expect that unlicensed de-NPs after the first would be less subject to illusory licensing, as the structure and incremental context of the unfolding sentence becomes clearer.

(54) 3 de-NPs

a. **Beaucoup de gens** ont laissé des enfants utiliser des armes à feu.
a_lot DE people have let INDEF.PL children use INDEF.PL firearms
Many people have let children use firearms.

b.***Beaucoup de gens** ont laissé **d'enfants** utiliser **d'armes à feu**.

c.*Des gens ont laissé **d'enfants** utiliser d'armes à feu.

(55) 4 de-NPs

a. **Beaucoup d' hommes politiques** ont laissé des gens laisser des
a_lot DE men political have let INDEF.PL people let INDEF.PL
enfants utiliser des armes à feu.
children use INDEF.PL firearms
Many politicians have let people let children use firearms.

b.***Beaucoup d' hommes politiques** ont laissé **de gens** laisser **d'enfants** utiliser **d' armes à feu.**

c.*Des hommes politiques ont laissé **de gens** laisser **d' enfants** utiliser **d' armes à feu**.

4 Conclusion

We have presented the results of five studies which demonstrate the existence of a novel grammatical illusion in European French. The distribution of de-NP illusions in French demonstrates that illusory licensing phenomena are not triggered to the same magnitude by the presence of lexical de-NP licensors in linearly preceding material. Instead, we observed that structural conditions had an effect on spurious de-phrase licensing; the quantifiers must be, in principle, able to participate in QAD dependencies. We have analyzed this in terms of a cue-based parser that uses syntactic category to identify a licensor in memory, creating partial feature matches and illusory licensing only with quantifiers that can participate in +QAD dependencies. However, further work is necessary to further delineate the scope of de-NP illusions in European French.

Data-availability statement

All original data (stimuli, results, script) discussed in this article are available on this paper's OSF repository.

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