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# Towards an Inferential Lexicon of Event Selecting Predicates for French

Ingrid Falk and Fabienne Martin  
Universität Stuttgart

first.second@ling.uni-stuttgart.de

## Abstract

We present a manually constructed seed lexicon encoding the *inferential profiles* of French event selecting predicates across different uses. The inferential profile (Karttunen, 1971a) of a verb is designed to capture the inferences triggered by the use of this verb in context. It reflects the influence of the clause-embedding verb on the *factuality* of the event described by the embedded clause. The resource developed provides evidence for the following three hypotheses: (i) *French implicative verbs have an aspect dependent profile* (their inferential profile varies with outer aspect), while *factive verbs have an aspect independent profile* (they keep the same inferential profile with both imperfective and perfective aspect); (ii) *implicativity decreases with imperfective aspect*: the inferences triggered by French implicative verbs combined with perfective aspect are often weakened when the same verbs are combined with imperfective aspect; (iii) *implicativity decreases with an animate (deep) subject*: the inferences triggered by a verb which is implicative with an inanimate subject are weakened when the same verb is used with an animate subject. The resource additionally shows that verbs with different inferential profiles display clearly distinct sub-categorisation patterns. In particular, verbs that have both factive and implicative readings are shown to prefer infinitival clauses in their implicative reading, and tensed clauses in their factive reading.

## 1 Introduction

Texts not only describe events, but also encode information conveying whether the events described correspond to real situations in the world, or to uncertain, (im)probable or (im)possible situations. This level of information concerns *event factuality*. The factuality of an event expressed in a clause results from a complex interaction of many different linguistic aspects. It depends, among others, on the explicit polarity and modality markers, as well as on the syntactic and semantic properties of other expressions involved (among them verbal predicates). In this study, we are concerned with one of these parameters, namely the predicates selecting event-denoting arguments (e.g. *manage to P*), which contribute in a crucial way to *lexically* specify event factuality. Saurí and Pustejovsky (2012) call these verbs ‘event selecting predicates’, or ESPs. For example, in “Kim *failed to reschedule* the meeting”, the ESP *fail to* turns the embedded *reschedule*-event into a counter-fact.

In previous work, Saurí and Pustejovsky (2012) encoded into a lexical resource the *inferential profile* of English ESPs, that is, their influence on the factuality of the embedded events, and showed that this resource could successfully be used to automatically assess the factuality of events in English newspaper texts.

Our long-term goal is the automatic detection of event factuality in French texts. Given that Saurí and Pustejovsky (2012)’s representation of event modality and their automatic factuality detection method is language independent, it can also be used for French event factuality detection. We plan to use this approach and describe here our efforts to bootstrap the required lexical ESP resource for French.

The lexical resource built by Saurí and Pustejovsky (2012) for English is not public, and therefore cannot be used as a starting point for a similar French lexicon. Additionally, Romance languages like French raise a further issue, for, as will be shown in Section 3, outer (grammatical) aspect interferes with

the inferential profile of ESPs. To achieve our long-term goal, we therefore firstly need to build a lexical resource providing an inferential profile for French ESPs, starting from a seed set of suitable verbs. This resource should specify the inferences a predicate triggers about the event described in the embedded clause (henceforth *embedded event*). For example, it should specify that the perfective form of *échouer à P* ‘fail to P’ triggers the inference that the embedded event is a counter-fact under positive polarity, whereas the embedded event is entailed when the predicate is used under negative polarity.

One of the challenges raised by such a lexicon concerns the polysemy of ESPs and the fact that their inferential profile is likely to vary with each use and/or syntactic frame. For instance, *Peter didn’t remember to P* and *Peter didn’t remember that P* trigger very different inferences about the embedded event (a counter-fact in the former case, and a fact in the latter). In order to address this challenge, we collected each use for these verbs as they are delineated in available detailed syntactic-semantic valency lexicons for French, and calculated an inferential profile for each of them.<sup>1</sup> The additional advantage of this method is that we can make use of the detailed syntactic-semantic features encoded for each use in these lexicons. Also, it led to the interesting observation that verbs whose inferential profile varies with the reading selected (including its argument structure) are very pervasive among French ESPs, which confirms the need to distinguish between particular senses and/or syntactic frame combinations an ESP may instantiate. It also revealed interesting correlations between inferential profiles on one hand, and particular sets of syntactic/semantic properties on the other.

The paper is structured as follows. We first introduce in Section 2 the two strands of research on which our work is based. We then describe our data and experiments in Section 3 and discuss the resulting findings in Section 4.

## 2 Related Work

We rely on two important bodies of research. The first is centred around FactBank (Saurí and Pustejovsky, 2009, 2012), a corpus of English newspaper texts annotated with information concerning the factuality of events. The second is a long standing research project on English predicates with sentential complements led at Stanford University (Karttunen, 1971b,a; Nairn et al., 2006; Karttunen, 2012; Karttunen et al., 2016). We briefly introduce these lines of research in the following subsections.

### 2.1 FactBank

The English FactBank is built on top of the English TimeBank corpus (Pustejovsky et al., 2005) by adding a level of semantic information. The factuality information encoded in TimeBank and relevant for our work is the ESPs projecting a factual value on the embedded event by means of subordination links (or SLINKs). In TimeBank, a total of 9 488 events across 208 newspaper texts have been manually identified and annotated. FactBank assigns additional factuality information to these events. More specifically, it indicates for each event (i) whether its factuality is assessed by a source different from the text author (which is the case with e.g. *confirm P*, but not with *manage to P*) and (ii) the degree of factuality the new source and the text author attribute to the event (for instance, *Peter affirmed P* presents *P* as certain for Peter, but does not commit the text author to *P* in a specific way). Saurí and Pustejovsky (2009) distinguish six ‘committed’ factuality values (i.e. values to which a source is committed) and one ‘uncommitted’ value, which are shown in Table 1. Saurí and Pustejovsky (2012) present an algorithm, called *DeFacto*, which assigns to each TimeBank event a factuality profile consisting of (i) its factuality value, (ii) the source(s) assigning the factuality value to that event and (iii) the time at which the factuality value assignment takes place. The algorithm assumes that events and relevant sources are already identified and computes the factuality profile of events by modelling the effect of factuality relations across levels of syntactic embedding. It crucially relies on three lexical resources which the authors developed manually for English. The first is a list of negation particles (adverbs, determiners

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<sup>1</sup>In this paper, we call *readings* of a verb the different verb-valence pairs *and/or* different senses delineated for a same lemma in these lexicons.

| Contextual factuality |     |     |     |     |     |     |     |     |     |    |    |    |
|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|
|                       | CT  |     |     | PR  |     |     | PS  |     |     | U  |    |    |
| polarity              | +   | -   | u   | +   | -   | u   | +   | -   | u   | +  | -  | u  |
| <i>manage</i>         | CT+ | CT- | CTu | PR+ | PR- | PRu | PS+ | PS- | PSu | Uu | Uu | Uu |
| <i>fail</i>           | CT- | CT+ | CTu | PR- | PR+ | PRu | PS- | PS+ | PSu | Uu | Uu | Uu |

**Table 1:** Sample lexical entries for NSIPs. CT, PR and PS signify certain, probable and possible respectively, U (and/or u) unspecified (unknown or uncommitted)

|                        | Polarity of ESP |          | Signatures             |                     | Sample predicate    |
|------------------------|-----------------|----------|------------------------|---------------------|---------------------|
|                        | +               | -        |                        |                     |                     |
| 2-way<br>implicatives  | +               | -        | ++ --                  | 1 -1                | <i>manage to</i>    |
|                        | -               | +        | +- ++                  | -1 1                | <i>fail to</i>      |
| 1-way<br>+implicatives | +               | <i>n</i> | ++ - <i>n</i>          | 1  <i>n</i>         | <i>force to</i>     |
|                        | -               | <i>n</i> | +- - <i>n</i>          | -1  <i>n</i>        | <i>refuse to</i>    |
| 1-way<br>-implicatives | <i>n</i>        | -        | + <i>n</i>  --         | <i>n</i>  -1        | <i>attempt to</i>   |
|                        | <i>n</i>        | +        | + <i>n</i>  ++         | <i>n</i>  1         | <i>hesitate to</i>  |
| factives               | +               | +        | ++ ++                  | 1 1                 | <i>forget that</i>  |
| counter-factives       | -               | -        | +- --                  | -1 -1               | <i>pretend that</i> |
| Neutral                | <i>n</i>        | <i>n</i> | + <i>n</i>  - <i>n</i> | <i>n</i>   <i>n</i> | <i>want to</i>      |

**Table 2:** Semantic classification of clause-embedding verbs wrt. the effect of the polarity of the main clause (ESP, head row) on the factuality of the embedded clause (embedded event, subsequent rows). *n* stands for none.

and pronouns) which determine the *polarity* of the context while the second resource aims to capture the influence of epistemic *modality* on the event. The third resource is the most complex one and accounts for the influence on the event factuality value in cases where the event is embedded by an ESP. Saurí and Pustejovsky distinguish two kinds of ESPs: *Source Introducing Predicates (SIPs)* introduce a new source in discourse (e.g. *suspect/affirm*); *Non Source Introducing Predicates (NSIPs)* do not (e.g. *manage/fail*). As part of their lexical semantics, SIPs determine (i) the factuality value the new source (the ‘cogniser’) assigns to the event described by the embedded clause, and (ii) the factuality value assigned by the text author (i.e. the ‘anchor’) to the same event. NSIPs, on the other hand, determine event factuality wrt. a unique source, the anchor. In addition, the assessment of event factuality wrt. the relevant source(s) varies with the polarity and modality present in the context of the ESP. Table 1 illustrates the lexicon layout through sample entries for the NSIPs *manage* and *fail*.<sup>2</sup> Given the lexical entry for *fail to* shown in Table 1, the factuality of the *reschedule<sub>e</sub>* event in “Kim *failed to reschedule<sub>e</sub>* the meeting” can be derived as follows. Since in the embedded clause, there are no polarity or modality particles which could influence its factuality, we assume that the contextual factuality of the embedded clause is CT+. The corresponding cell in the *fail to* row in Table 1 is CT-, i.e. the event is counter-factual.

## 2.2 The lexicon resource from the *Language and Natural Reasoning* group (Stanford)

Another strand of research is represented by Nairn et al. (2006). Those authors developed a semantic classification of English event selecting predicates, according to their effect on the factuality of their embedded clauses when used in positive or negative polarity. All those verbs are factive or implicative verbs, and therefore non source introducing predicates.<sup>3</sup> In many cases, a single lemma is assigned different entries varying with the syntactic type of the embedded clause (e.g. *remember that/remember to* are assigned two different entries). This classification is shown in Table 2. We illustrate how the table works through concrete examples.

In example (1), the ESP *fail to* has positive polarity. We obtain the factuality of the embedded event (*reschedule*) by retrieving from the polarity + column in Table 2 the polarity value in the *fail to* row, which is ‘-’, i.e. the meeting is not rescheduled (has factuality CT-). For (2), the factuality

<sup>2</sup>The lexicon layout for SIPs, less relevant for our study, is very similar except that an SIP lexicon entry must also provide factuality values for the cogniser source in addition to the anchor.

<sup>3</sup>Factives are predicates that trigger the same entailment under both positive and negative polarity. Implicatives are non-factive predicates that trigger an entailment under at least one polarity.

must be retrieved from the polarity – column resulting in ‘+’, i.e. a factuality of CT+ (the meeting is rescheduled).

- (1) Kim *failed to reschedule* the meeting.
- (2) Kim did not *fail to reschedule* the meeting.

The effect of a predicate on the factuality of its embedded clause is represented more concisely through a “signature”. For instance, the signature of factive verbs as *forget that* is ‘+ + | – +’ and even more concisely ‘1|1’ (Read: ‘if positive polarity, event happens; if negative polarity, event happens’).

Nairn et al. (2006) compiled a list of roughly 250 English verbs found to carry some kind of implication: a positive or negative entailment, a factive or a counter-factive presupposition<sup>4</sup>. The resource makes a difference between entailments (marked by ‘+’ or ‘–’), and strong inferences (marked by ‘+\*’ or ‘–\*’). More recently, Karttunen et al. (2016) refined the annotation further by using *probabilistic* signatures, allowing to reflect the strength of the inference in a more fine-grained way. Thus, for example, the predicate *be able* is assigned the signature 0.9| – 1, in order to capture the fact that under positive polarity, it triggers a strong (but defeasible) inference rather than an entailment.<sup>5</sup> In Saurí and Pustejovsky’s terms, probabilistic signatures convey less than certain factuality values.<sup>6</sup>

The signatures assigned in the lexical resource from the Stanford group are calculated for the verb combined with the simple past. This choice seems implicitly justified by the fact that for many ESPs, no alternative past tense form is available. For instance, it has been observed for implicative verbs that their progressive form is odd, see e.g. *?John was managing to eat the pizza* (cf. Bhatt, 1999). Also, many factive verbs are stative, and therefore equally odd with the progressive (*\*John was knowing the answer*).

For our experiments, we decided to start with the French counterparts of the English verbs in this resource, assuming that the inferential profile may be roughly extensible to French verbs under their perfective form. We then looked at the sentences in the French TimeBank using these French ESPs. We first briefly introduce the French TimeBank before describing our data, experiments and findings.

### 2.3 The French TimeBank

The French TimeBank (Bittar, 2010; Bittar et al., 2011) is built on the same principles as the English TimeBank, but introduces additional markup language to deal with linguistic phenomena not yet covered and specific to French. Most relevant to this study is the fact that most French ESPs can be fully inflected and fall within the scope of aspectual operators — most French modal auxiliaries, but also most implicative and factive verbs are fully acceptable in their perfective and imperfective forms. For instance, the French counterpart of *manage to*, namely *réussir à*, accepts both the perfective and the imperfective (see e.g. the example (4) below). Probably for this reason, all these verbs are also marked up as events in the French TimeBank; in particular, modal verbs are marked up as events of the ‘modal’ subclass (see Bittar et al. (2011), while in the English TimeBank, modal predicates are not marked up as events. Lastly, the TimeML schema was adapted to represent the grammatical tense/aspect system of French, and to account e.g. for the *imparfait* (the imperfective aspectual morphology), not grammaticalised in English. Since TimeBanks mark up events and (temporal) relations between them, the French TimeBank offers a sample of ESPs used in French newspaper texts, together with some typical embedded events.

Note that the French TimeBank as well as FactBank not only mark up events realised by VPs, but also events realised by NPs. For our experiments, we also annotated the way the verbs under investigation influence the factuality of events described by one of their event-denoting NP arguments. For instance, *Cela a garanti la survie des passagers* ‘this ensured the survival of the passengers’ and *Cela a garanti que les passagers survivent* ‘This ensured that the passengers survived’ both entail that the passengers survived, and the annotation aims to capture parallelisms of this type.

<sup>4</sup>These resources are available at [https://web.stanford.edu/group/csli\\_lnr/Lexical\\_Resources/](https://web.stanford.edu/group/csli_lnr/Lexical_Resources/).

<sup>5</sup>Probabilistic signatures provided in Karttunen et al. (2016) are rough counts based on the inspection of a lot of examples found on the Internet and the COCA corpus (L. Karttunen, p.c.).

<sup>6</sup>However, while in Saurí and Pustejovsky’s annotation, uncertainty is expressed through the two discrete values (PR and PS), probabilistic signatures represent uncertainty on a continuous scale between 0 and 1.

### 3 Towards an ESP lexicon

We started with the observation that the inferential classification developed by Nairn et al. (2006) and described in Section 2.2 can be used to bootstrap an English ESP lexicon. Based on the signature of a predicate and its polarity in a given sentence, we can determine the factuality of the embedded event in that sentence. The classification in Table 2 can be straightforwardly “plugged” into the ESP lexical resources illustrated in Table 1: For a given ESP for which a lexical entry has to be set up (eg. *fail to*), the factuality value conveyed on the embedded event can be retrieved from Table 2 whenever the corresponding table entry is not *n* (neutral). In case it is, this shows that the ESP has no effect on the factuality of the embedded event; its polarity value therefore remains unspecified.

#### 3.1 Our Data

To build our seed lexicon, we started from the ESPs marked up in the French TimeBank. From these predicates, we selected those 49 verbs which occurred as translations of the English ESPs derived from the inferential classification of Nairn et al. (2006). This way, we could use the inferential information from the English classification, and compare it to the French counterparts of these English ESPs. We assigned inferential signatures to each reading of these French ESPs, and this with two research questions in mind:

- i. Does the inferential behaviour (the signature) vary with the animacy of the external argument and/or with outer aspect?
- ii. Can we differentiate the main sub-types of inferential signatures (factive, implicative, etc.) by specific subsets of semantic/syntactic properties?

**Lexical entries.** For the selected 49 verb types we extracted all readings from two French lexicons: “Les Verbes Français”, henceforth LVF (François et al., 2007), and an electronic version of the Lexicon-Grammar tables, henceforth LGMEM (Tolone, 2011; Constant and Tolone, 2010). We chose these resources because they provide detailed morpho-syntactic and semantic descriptions for each reading of a verb rather than giving an (ambiguous) verb type based description. The LVF is based on a traditional French lexicon where the different lexical entries (called here readings, see fn 1) for a verb type have been assigned additional detailed and systematic morpho-syntactic, semantic and valency information. In LGMEM, each verb type is associated with one or more tables which represent its meaning and behaviour with respect to valency. We consider each such lemma-table association to represent a particular reading of the verb. For our seed lexicon, we extracted lexical entries from the LVF and lemma-table pairs from the LGMEM. We merged duplicate entries from the two lexicons. The remaining entries were aligned such that each entry in our lexicon represents a different reading.

**Annotation.** We obtained  $\approx 930$  readings, which we manually filtered, keeping only the ESP readings. The remaining  $\approx 170$  readings were manually assigned probabilistic signatures (gathered in a file available on line) by an expert (the second author of this paper).<sup>7</sup> The annotation was done on the basis of the sentences by which the LVF exemplifies each delineated use of a verb, and on the inspection of natural occurrences of the relevant form in the internet and corpora (such as Frantext).<sup>8</sup> When the exemplifying sentence contains elements that can affect the event factuality independently from the ESP itself (modal verbs, NPs biased towards a generic interpretation, etc.), these elements were abstracted away for the annotation. We chose probabilistic signatures, since we aimed to distinguish between entailments, graded inferences (strong vs. weak) and the absence of inference (neutral). We distinguished 4 intermediate positive values, namely 0.9 (very likely/almost certain), 0.8 (likely), 0.7 (very possible/almost likely) and 0.6 (quite possible), and 4 intermediate negative values (-0.9 for very unlikely, etc.). However, for the experiments, we only considered 0.9 to indicate a ‘strong inference’, and the values 0.6 to 0.8 were

<sup>7</sup>At <https://docs.google.com/spreadsheets/d/1sgDxfYSh91N0zI2hwfq2bG6TdA7EvusaH15irmWC2QE/edit?usp=sharing>

<sup>8</sup>The exemplifying sentences from the LVF can also be found online at <http://rali.iro.umontreal.ca/rali/?q=en/node/1238>

|  |             |                     |
|--|-------------|---------------------|
| Pierre/cela a obligé Marie à partir.<br>'Peter/something force-PAST-PFV.3SG Mary to go.' |             |                     |
| PFV+anim   | PFV-anim    | IMP                 |
| 0.9  <i>n</i>  | 1  <i>n</i> | <i>n</i>   <i>n</i> |

**Table 3:** Assigned signatures for reading *obliger 02* ('force/oblige').

kept undistinguished from the neutral case (absence of inference).<sup>9</sup>

For Romance languages like French, it is known that inferential profiles vary with outer aspect (Hacquard, 2006). Also, cross-linguistic data tend to suggest that the inferential profile also varies with the animacy of the (deep) subject (Martin and Schäfer, 2012).<sup>10</sup> We therefore distinguished three cases: (i) perfective aspect, animate subject ; (ii) perfective aspect, inanimate subject; (iii) imperfective aspect. Distinguishing again between two types of subject for the imperfective was not justified, since most readings (around 80%) were only compatible with a single type of subject to begin with (either animate, or inanimate, but not both).<sup>11</sup> This reflects the fact that the LVF and the LGLEX often differentiate readings according to the (non)-animacy of the subject. This means that in practice, we typically assigned two signatures instead of three for each reading, namely one for the perfective, either with an animate subject, or with an inanimate one, and one for the imperfective. The third possible case was typically not applicable. So for instance, when a reading compulsorily selects for an animate subject, we assigned one signature for the 'animate perfective' context, and assigned none for the 'inanimate perfective' context (introducing the value NA, for 'not applicable'). In this case, if a signature is assigned for the 'imperfective' context, we know that this imperfective signature is calculated with an animate subject, too.

In the rare case where both types of subjects were possible for a single reading (16% of all readings), we tested the imperfective verb with the subject type that triggers the strongest entailment with the perfective, namely the inanimate subject. Typically, the effect of the subject type on the inference is neutralised with the imperfective.<sup>12</sup>

Table 3 shows the assigned signatures for the reading *02* of the verb *obliger* ('oblige, force') (as delineated in the LVF). We see that, under perfective aspect and with an animate subject, this predicate triggers, under positive polarity, a strong albeit defeasible inference (there is a high probability that the embedded event is a fact). Under negative polarity, no inference is triggered. Under perfective aspect with an inanimate subject, *obliger 02* entails the embedded event under positive polarity, and triggers no inference under negative polarity. Finally, when used with imperfective aspect, *obliger 02* is inferentially neutral, i.e. it triggers no inference about the embedded event (both with animate and inanimate subjects).

Figure 1 gives an overview of the inferences triggered by these 170 readings according to the assigned signatures in the three contexts delineated (PFV+anim: perfective aspect with animate subject; IMP: imperfective aspect with any kind of subject; PFV-anim: perfective aspect with inanimate subject). The figure shows a coloured box for each assigned signature. The columns in the matrix represent the annotated readings (in alphabetic order)<sup>13</sup> and the rows correspond to the aspectual and animacy values used when testing the triggered inferences, namely PFV+anim, IMP and PFV-anim. A white box indicates that the test was not applicable (e.g., the verb is inherently agentive under the relevant reading and

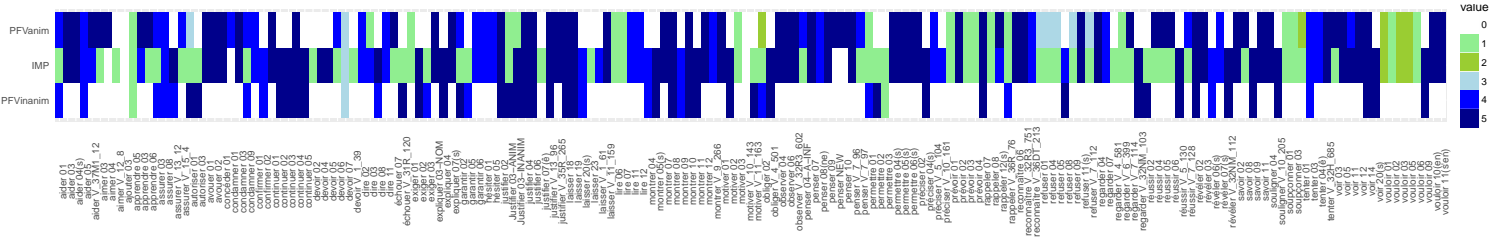
<sup>9</sup>In the future, we plan to develop guidelines and explore automatic methods that could assist and support the manual annotations. However, our manual annotations already sufficed to test interesting hypotheses about the impact of outer aspect, animacy and syntax on the inferential profile of ESPs, as we will see in the next section.

<sup>10</sup>The sentences tested were mostly active, but some of them were passive. It is the animacy of the external argument (deep subject) that has been shown to matter for the inferential profile of ESPs.

<sup>11</sup>131 out of 168 annotated readings were acceptable with either an animate or an inanimate subject (but not both) in the perfective. Only 27 (16%) of these 168 readings which were assigned a signature with the imperfective were acceptable with both an animate and an inanimate subject.

<sup>12</sup>See the examples (7)-(9) below for an illustration.

<sup>13</sup>In the readings labelled with a simple number (e.g. *aider 01*), the number is the one given in the LVF lexicon, accessible online at <http://rali.iro.umontreal.ca/rali/?q=en/node/1238>. When the readings are labelled as in *lemma\_V.T.R*, they are extracted from the Lexicon-Grammar tables. *T* designates the table name and *R* the row the verb occurred in.



**Figure 1:** Inferences triggered by French readings when used with perfective aspect and animate or inanimate subject or with imperfective aspect.

| col | description                         | sample sign.      | #sign. | inferential classes                    |
|-----|-------------------------------------|-------------------|--------|--|
| 5   | max inference                       | $1 1, 1  - 1$     | 177    | (counter-)factives, 2-way implicatives |
| 4   | max under 1 polarity                | $1 n, 0.9  - 1$   | 77     | 1-way implicatives                     |
| 3   | strong, not max, under 2 polarities | $0.9  - 0.9$      | 9      | 2-way quasi implicatives               |
| 2   | strong, not max, under 1 polarity   | $0.9 n, n  - 0.9$ | 8      | 1-way quasi implicatives               |
| 1   | neutral, no inference               | $n n$             | 78     | neutral                                |
| 0   | not applicable or not grammatical   | NA or UNGR        | 161    |  |

**Table 4:** Overview of mappings between colours, strength of inference, signature and inferential classes.

is therefore not annotated with an inanimate subject), or returns agrammaticality (e.g., the verbal reading combined with perfective aspect generates an ungrammatical sentence). As just mentioned above, a very large number of readings have either a signature for the PFV+anim context, or one for the PFV-inanim one, but not for both. In the IMP contexts, almost all readings were assigned a signature, since we did not differentiate between subject types in this context. Interestingly, more signatures are assigned in the PFV+anim context than in the PFV-inanim context, which suggests that a substantial number of ESPs tend to be inherently agentive.

The colours reflect the “strength” of the triggered inference. The strongest inference (value 5) is triggered whenever the signature shows a maximal (deterministic) inference (1 or  $-1$ ) under both polarities (i.e. signatures of the type  $x|y$  with  $|x| = |y| = 1$ ). These correspond to the classes of factives, counter-factives and 2-way implicatives displayed in Table 2. Weaker inferences (value 4) are reflected by signatures where there is a maximal inference (1 or  $-1$ ) under at least one polarity (signatures  $x|y$  where  $|x| = 1$  or  $|y| = 1$ , 1-way implicatives in Table 2). The next value (3) on the inference scale represent (‘2-way quasi-implicative’) signatures where there is a strong, albeit not maximal and thus defeasible, inference under both polarities ( $|x| = |y| = 0.9$ <sup>14</sup>). Even weaker inferences (value 2, ‘1-way quasi-implicative’) are those where at least under one polarity the reading is associated with a strong inference ( $|x| = 0.9$  or  $|y| = 0.9$ ). Finally, the absence of inference (or neutral inference, value 1) is represented by  $n$ . Table 4 sums up the mapping between colours, strength of inference, signatures and inferential classes. As shown by the general colour pattern, inferences under perfective aspect tend to be stronger than those under imperfective (and this even for many implicative verbs), an observation confirmed by a closer look at the data, as we will see in Section 4.

## 4 Results and discussion

We first compared the signatures of the French predicates with their rough English counterparts classified by Nairn et al. (2006). We found that in many cases, the signatures of the English predicates matched those of their French counterparts under their perfective form. For example, the implicative signature ‘ $1| - 1$ ’ of *manage to* is inherited by its translation *réussir à* combined with a past perfective

<sup>14</sup>We only distinguish between maximal, strong and neutral inferences, with signature values  $|x| = 1$ ,  $|x| = 0.9$  and  $x = 0$  respectively. As mentioned before, the annotation has been performed also using intermediate values, which we aim to use in later work.



|                    | with IMP PFV signature | IMP sign $\neq$ PFV sign |
|--------------------|------------------------|--------------------------|
| Factives under PFV | 54                     | 2 (4%)                   |
| Implic. under PFV  | 77                     | 36 (48%)                 |

**Table 5:** Influence of outer aspect on factivity.

morphology.<sup>15</sup> Second, we aimed to test three hypotheses about the semantic and syntactic properties that potentially contribute to drive the inferential profile of the readings:

1. *implicative verbs have an aspect dependent profile* (their inferential profile varies with outer aspect); *factive verbs have an aspect independent profile* (they keep the same inferential profile with both imperfective and perfective aspect);
2. *implicativity decreases with imperfective aspect*, i.e., the inferences triggered by a verb which is implicative combined with perfective aspect are weakened when the same verb combines with imperfective aspect;
3. *implicativity decreases with an animate subject*, i.e., the inferences triggered by a verb which is implicative with an inanimate subject are weakened when the same verb is used with an animate subject.

Based on counts, we could find evidence in our data supporting the three hypotheses.

**Implicatives, but not factives, have an aspect dependent profile.** Factive predicates are predicates that trigger the same entailment under both positive and negative polarity, i.e. these predicates have either signature  $1|1$  or  $-1|-1$ . Implicatives are non-factive predicates that trigger an entailment under at least one polarity (among the potential implicative signatures, we find e.g.  $1|-1$ ,  $1|n$ ,  $-0.7|-1$ ). Table 5 shows that of the 54 readings that were factive with perfective aspect, only 2 had a different signature with imperfective aspect. On the other hand, for the readings that were implicative with the perfective, almost half of them (36 out of 77 or 48%) had a different signature with the imperfective aspect (are only considered here readings for which a signature could be assigned with both perfective and imperfective aspect). In other words, outer aspect has virtually *no* influence on factivity. This is reflected in Fig. 1 by the fact that the cells with the darkest colour in the PFV+anim row keep this darkest colour in the IMP row. By contrast, the inferential profile of implicative verbs tends to change with aspect, supporting our hypothesis 1.

**Implicativity decreases with imperfective aspect.** For French, it is standardly assumed that implicative verbs keep their entailment with the perfective (see e.g. Hacquard 2006). Our data challenge this assumption, and support the alternative hypothesis that implicativity tends to decrease with imperfective aspect. This hypothesis is illustrated by the data in examples 3 and 4, with the verb *réussir* ‘manage to’, that has an implicative profile when combined with perfective aspect.<sup>16</sup> Recall that implicatives trigger a maximal inference under at least one polarity, i.e. at least under one polarity the signature is  $max = 1$  or  $max = -1$ .<sup>17</sup>

(3) *A ce moment-là, elle a réussi à s'enfuir. #Et pourtant, elle ne s'est pas enfuie du tout.*  
 at that moment she manage-PST-PFV.3SG to escape and nevertheless she  
 NEG escape-PST-PFV.3SG at all  
 ‘At that moment, she managed to escape. And nevertheless, she didn’t escape at all.’

(4) *A ce moment-là, elle réussissait (encore) à s'enfuir. OK Et pourtant, elle ne s'est pas enfuie du tout/ elle n'essayait même pas de le*  
 at that moment she manage-IMP.3SG (still) to escape and nevertheless,  
 she NEG escape-PST-PFV.3SG at all she NEG try-PST-IMP.3SG even NEG to it

<sup>15</sup>Our translation approach raised additional issues detailed in Falk and Martin (2017).

<sup>16</sup>The examples are made up for illustration purposes. This use of *réussir* corresponds to the readings 05 and 06 in the LVF.

<sup>17</sup>Therefore, an implicative signature  $max|x$  or  $x|max$  describes a stronger inference than signatures  $a|x$  or  $x|a$  with  $|a| < 1$  or  $a = n$ .

*faire!*

do

‘At that moment, she ‘was (still) managing’ to escape. And nevertheless, she didn’t escape at all/ she wasn’t even trying to do so.’

In this example, the same predicate is used in two contexts that mainly differ by the aspect morphology on the verb: perfective in (3) and imperfective in (4). However, in (3), *réussir* triggers an entailment, whereas the inference triggered in (4) is defeasible (both through a perfective and an imperfective denial).<sup>18</sup>

The sceptical reader could argue that in (4), the imperfective sentence is the consequent of an implicit conditional (*A ce moment-là, il réussissait à s’enfuir s’il le voulait* ‘At that moment, he manage-PST-IMP.3SG to flee if he want-PST-IMP.3SG to’). The absence of entailment would then reflect the fact that this implicit conditional is counter-factual, rather than the influence of aspect on the inferential profile of *réussir*.<sup>19</sup> However, this objection does not apply to the example (6) below, where a conditional antecedent cannot be felicitously added. Additionally, (6) contains a past progressive, which, contrary to the imperfective, is not a necessary ingredient of counter-factuality (Iatridou, 2000, 257). The sentence in (6) therefore contains a run-of-the-mill imperfective, and, again, the actuality entailment triggered with the perfective in (5) is lost.

- (5) *Ana a réussi à gagner la partie #quand tout à coup, son rival*  
Ana manage-PST-PFV.3SG to win the game when all of a sudden her opponent  
*l’a faite échec et mat.*  
her make-PST-PFV.3SG chess and mat  
‘Ana managed to win the game when all of a sudden, her opponent gave her checkmate.’

- (6) *Ana était en train de réussir à gagner la partie quand tout à coup, son rival*  
Ana manage-PST-PROG.3SG to win the game when all of a sudden her opponent  
*l’a faite échec et mat.*  
her make-PST-PFV.3SG chess and mat  
‘Ana ‘was managing’ to win the game when all of a sudden, her opponent checkmated her.’

As shown in Table 6, we found strong support in our data for the hypothesis that the inferential behaviour of *réussir* follows a more general pattern. That is, in general, the inferences characteristic of implicative readings are in fact conditional on the presence of perfective aspect in languages like French, and tend to be weakened or even vanish with imperfective aspect.<sup>20</sup> In almost all cases (34 out of 36) where a reading was implicative with a perfective and triggered a different inference with the imperfective, the inference triggered with the imperfective was weaker than the one triggered with the perfective. Table 7 shows some more examples (from the LVF) where the inferential profile varies with the aspect used. Also, the examples below for the verb *refuser* ‘to refuse’ illustrate the general fact that even when the perfective

<sup>18</sup>Hacquard (2006, 71) claims that the imperfective form of *réussir* is implicative on the basis of the oddity of sentences like *Darcy réussissait à soulever cette table, #mais il ne la soulevait pas*. (‘Darcy manage-PST-IMP.3SG to lift this table, but wasn’t lifting it’). We agree with Hacquard’s judgment, but we think that the problem partly comes from the absence of any adverbial providing a reference time combined with the presence of the imperfective in the second clause. A sentence like *A ce moment-là, Darcy réussissait clairement à soulever cette table. Et pourtant, il n’essayait même pas de la soulever* (‘At that moment, Darcy clearly manage-PST-IMP.3SG to lift to lift this table. And nevertheless, he wasn’t even trying to do so.’) is completely acceptable.

<sup>19</sup>In French, counter-factual conditionals typically have the *conditionnel* in the consequent (and the *imparfait* in the antecedent). However, it is also possible to have an *imparfait* in both the antecedent and consequent, as also the case in Italian, cf. Ippolito (2003).

<sup>20</sup>Among the 41 readings that remain implicative with imperfective aspect, most do not express what we call below the actualisation of a causal factor for the truth of *p*, and are therefore not expected to lose their entailment with the imperfective. This is for instance the case of *montrer* 04, 09, 11, 12, V-9-266 ‘show’, *penser* 07, 09, 09 ‘think’, *vouloir* 09 ‘want’. Also, quite a few of these readings are reflexive (7), a factor that seems to interfere with the inferential profile, too.

|   |   |            |
|---|---|------------|
| IMP $\rightsquigarrow$ weaker inference | IMP $\rightsquigarrow$ stronger inference | no change  |
| 44.2% (34)                              | 2.6% (2)                                  | 53.2% (41) |

**Table 6:** Inferential behaviour of the 77 readings which are implicative with a perfective. For 34 of them (44.2%), the inference triggered with perfective aspect is stronger than with imperfective aspect.

| reading                            | translation               | ASPECT USED |     |
|------------------------------------|---------------------------|-------------|-----|
|                                    |                           | PFV         | IMP |
| <i>assurer 03 (la victoire)</i>    | ‘ensure (the victory)’    | 1 n         | n n |
| <i>échouer 07 (à persuader x)’</i> | ‘fail (to persuade x)’    | -1 1        | n n |
| <i>motiver 03 (x à venir)</i>      | ‘motivate (x to come)’    | 0.7 -0.7    | n n |
| <i>penser 04 (à divorcer)</i>      | ‘think (about divorcing)’ | -0.7 -1     | n n |

**Table 7:** Examples of verbs whose inferential profile varies with the outer aspect used.

verb triggers an entailment with an inanimate subject *only*, this entailment is lost in the IMP even when combined with such an inanimate subject.<sup>21</sup>

- (7) *Pierre a refusé/refusait que j’ouvre le tiroir, OK mais je*  
 Pierre refuse-PST-PFV/PST-IMP.3SG that I open the drawer but I  
*l’ai ouvert quand même.*  
 it open-PST-PFV.1SG nevertheless  
 ‘Pierre refused to let me open the drawer, but I opened it nevertheless.’
- (8) *Le tiroir a refusé de s’ouvrir, #mais finalement, il*  
 the drawer refuse-PST-PFV.3SG to REFL open but at the end it  
*s’est ouvert quand même.*  
 REFL open-PST-PFV.3SG nevertheless  
 ‘The drawer refused to open, but at the end, it opened nevertheless.’
- (9) *Le tiroir refusait de s’ouvrir, OK mais finalement, il*  
 the drawer refuse-PST-IMP.3SG to REFL open but at the end it  
*s’est ouvert quand même/ en forçant un peu Ana l’ouvrirait*  
 REFL open-PST-PFV.3SG nevertheless in forcing a bit Ana it open-PST-IMP.3SG  
*sans problème.*  
 without problem  
 ‘The drawer ‘was refusing’ to open, but at the end, it opened nevertheless/by forcing a bit Ana was opening it without difficulty.’

Why do implicative verbs (contrary to factive verbs) lose their entailment when combined with IMP? Recent analyses of implicative verbs by Baglini and Francez (2016) and Nadathur (2016) can help to explain this observation. According to Baglini & Francez’ analysis, a *manage p* statement *presupposes* familiarity with a causally necessary but insufficient condition *A* for the truth of *p*, and *asserts* that *A* actually caused the truth of *p*. Nadathur extends a modified version of this analysis to the whole class of implicative verbs. The important point for us is that under these analyses, implicative verbs have an at-issue component (and on this point, they drastically differ from the traditional analysis held e.g. by Karttunen (1971a), according to which implicative verbs like *manage to P* make no truth-conditional contribution beyond that of their embedded clause). Under these new analyses, implicative verbs assert what we propose to call an ‘actualisation event’, namely the obtaining/actualisation of the causal factor *A* for the truth of *p*. Given the ‘imperfective paradox’ (Dowty, 1977), the imperfective form of such verbs unsurprisingly *suspends* the actualisation event – similarly to what happens with the imperfective form

<sup>21</sup>The use of *refuser* with animate subject illustrated in (4) corresponds to the LVF reading 09, and its use with inanimate subject illustrated in (8) corresponds to the LVF reading 08.

of overtly causative verbs (e.g. *Trump was causing a new catastrophe when Pence stopped him* does not entail the occurrence of a new catastrophe).

On the other hand, factive verbs like *savoir que p* ‘know that *p*’ do not assert the obtaining of a causal factor for the truth of *p*, but rather a mental state having *p* as its object. We therefore do not expect aspect to interfere with their inferential profile.

**Implicativity decreases with an animate subject.** We showed through the example in Table 3 (*Pierre/cela a obligé Marie à partir* ‘Peter/something force-PFV-3SG Mary to go’) that the inference triggered by the perfective form of *obliger* 02 (‘oblige/force’) when used with an animate subject (signature 0.9|*n*) is weaker than with an inanimate subject (signature 1|*n*). This example also instantiates a more general pattern observed in our data. Firstly, if only coloured boxes in Fig. 1 are considered, the ‘PFV-anim’ row contains altogether darker colours (representing stronger inferences) than the ‘PFV+anim’. This is reflected in the respective average inference value for these two contexts: 4.53 for PFV-anim v. 3.92 for PFV+anim. Secondly, the same pattern is confirmed when we look at particular verbs under their different readings. Among the 49 verbs in our inferential lexicon, 13 received a signature in both PFV+anim and PFV-anim contexts. For 8 of these 13 verbs, the readings with inanimate subjects were found to trigger stronger inferences than those with an animate subject.

Further evidence supporting this hypothesis is related to source introducing predicates (SIPs, defined in Section 2.1). SIPs typically trigger no or only weak inferences on the (non-)occurrence of the embedded event in the world of evaluation (for instance, *Peter believed that P* does not say much about whether *P* is a fact in the actual world — it mainly indicates that Peter believes *P* to be sure). Of the 13 predicates with SIP readings, 10 also had readings with an inanimate subject. Unsurprisingly, all of these 10 inanimate readings were not SIP readings anymore (since the inanimate subject cannot be a cogniser), but more interestingly, they have then an implicative or quasi-implicative reading. For example, in *Pierre a garanti le succès de l’affaire* ‘Peter promised success for the business’, *garantir* 06 (with animate subject) introduces a new source and therefore tells us nothing about the embedded event in the actual world. On the other hand, in *Cela a garanti notre survie* ‘This ensured our survival’, *garantir* 05 (with inanimate subject) is *not* an SIP reading, and is implicative.<sup>22</sup>

Differently from implicative verbs that often can take either an animate or inanimate subject, factive predicates seem to require an animate subject much more forcefully. Out of the 42 readings with a factive signature with an animate subject, only 9 readings are acceptable with an inanimate subject. This restriction imposed on the animacy of the subject by factive verbs probably simply reflects the fact that these predicates are inherently attitude verbs.

**Syntactic type of embedded clauses.** For English, it has often been pointed out that factives and implicatives show different sub-categorisation patterns. White (2014) mentions that for verbs that have both factive and implicative readings, the factive reading is often associated with a tensed (*that*-) clause (as e.g. *remember that*) whereas the implicative reading is associated with an infinitival clause (as e.g. *remember to*). For implicative verbs, it has often been observed (by e.g. Landau, 2001) that they typically do not take finite (*that*-) clauses (cf. e.g. *\*manage/dare that*), but often select infinitival (*to*-) clauses. However, to our knowledge, there is no study confirming these correlations by empirical evidence.

Given that similar correlations are expected to hold for French, we therefore looked at the type of embedded clauses associated with the readings in our French inferential lexicon. More specifically, we checked, for each reading, whether it can sub-categorise the infinitival and tensed clauses listed in Table 8. We firstly extracted this information from our two French valency lexicons. However, since the data collected this way was not completely reliable, we manually corrected the classification thus obtained.

In our data, 20 verbs had both factive (41) and implicative (45) readings. Figure 2 shows that there are very clear differences in the types of embedded clauses accepted by implicative vs. factive readings of these ‘inferentially polysemous verbs’: implicative readings tend to be associated with infinitival clauses and to reject tensed clauses, while factive readings show the inverse pattern.

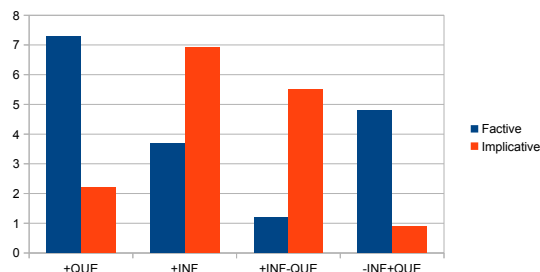
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<sup>22</sup>Examples taken from the LVF.

|             |   | example   | translation                   |
|-------------|---|---|-------------------------------|
| infinitival | <b>aInf</b><br><b>deInf</b><br><b>inf</b> | Il <i>autorise</i> Pierre <b>à sortir</b> .     | 'He allows Pierre to go out.' |
|             |   | Le tiroir <i>refuse</i> <b>de s'ouvrir</b> .    | 'The drawer refuses to open.' |
|             |   | Il <i>regarde</i> la pluie <b>tomber</b> .      | 'He watches the rain fall.'   |
| finite      | <b>que</b>                                | Il <i>pense</i> <b>que Pierre est sincère</b> . | 'He thinks Peter is sincere.' |

**Table 8:** Types of infinitival and finite embedded clauses for French observed for our data (sample phrases taken from LVF).

|           | implic. r. (45) | factive r. (41) |
|-----------|-----------------|-----------------|
| +INF      | 69%             | 37%             |
| +QUE      | 22%             | 73%             |
| +INF –QUE | 55%             | 12%             |
| –INF +QUE | 9%              | 48%             |



**Figure 2:** Factive and implicative verbs display different syntactic patterns with respect to the types of sub-categorised embedded clauses.

## 5 Conclusion and outlook

In this work, we developed a seed lexicon associating readings of French clause-embedding verbs with three different probabilistic inferential signatures, varying with outer aspect and the animacy of the subject. Through these inferential signatures, we concisely represent the inferences that can be drawn from the use of a clause-embedding predicate about the event expressed by the embedded clause given the polarity used. The experiments performed on the collected data support three hypotheses. Firstly, they show that in French where most ESPs have perfective and imperfective forms, implicativity, but not factivity, depends on perfective aspect. Interestingly, this hypothesis seems extendable to other Romance languages like Spanish, where implicative verbs also seem to lose the actuality entailment obtained with the perfective when they are used imperfectively, see the contrast below:

- (10) *Ana logró ganar la partida #cuando, de repente, su rival*  
 Ana manage-PST-PFV.3SG win the game when all of a sudden her opponent  
*le dio jaque mate.*  
 her give-PST-PFV.3SG chess mat  
 'Ana managed to win the game when all of a sudden, her opponent checkmated her.'
- (11) *Ana estaba logrando ganar la partida OK cuando, de repente, su*  
 Ana manage-PST-PROG.3SG win the game when all of a sudden her  
*rival le dio jaque mate.*  
 opponent her give-PST-PFV.3SG chess mat  
 'Ana 'was managing' to win the game when all of a sudden, her opponent checkmated her.'

Secondly, they show that implicativity, but not factivity, tends to decrease with the animacy of the subject. Thirdly, they indicate that verbs with both a factive and an implicative reading tend to accept infinitival clauses and to reject tensed clauses under their implicative readings, while they show the inverse pattern under their factive readings.

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